REGISTERED PROFESSIONAL ENGINEER
SAMUEL XIAOCHUN YAO
No. 53793
DATE SIGNED:
05/26/2017
CIVIL
STATE OF CALIFORNIA

Summary Report On Interim Inspection, Testing, and Preliminary Analysis of Alameda Piers 1, 2, and 3

26 May 2017

SGH Project 167543

SIMPSON GUMPERTZ & HEGER

Engineering of Structures
and Building Enclosures

PREPARED FOR:

City of Alameda
950 West Mall Square
Alameda, CA 94501

PREPARED BY:

500 12th Street, Suite 270
Oakland, CA 94607
Tel: 510.457.4600
Fax: 510.457.4599

Table of Contents

CONTENTS **Page**

APPENDICES

1. INTRODUCTION

1.1 Purpose

This report provides a summary of the field inspection, engineering investigations, preliminary analyses, and assessments of Alameda Point Piers 1, 2, and 3 in accordance with the scope of work in the Service Provider Agreement with City of Alameda dated 20 July 2016. The work is intended to ensure adequacy in permanently mooring the MARAD Ready Reserve Fleet. The engineering assessment is intended to identify any issues pertaining to the structural capacity of the piers and mooring system and to assist the budgeting and planning of the City.

1.2 Scope of Work

The City of Alameda retained Simpson Gumpertz & Heger Inc. (SGH) to perform an interim inspection, testing, preliminary analyses, and reporting for rehabilitation of Alameda Piers 1, 2, and 3. The work includes the following services:

- An above and below-water inspection of Piers 1, 2, and 3.
- Material tests gathered from select locations within the project.
- Geotechnical investigation of Piers 1, 2, and 3 for purposes of structural assessment.
- Preliminary analysis of Piers 1, 2, and 3 which includes mooring and structural assessment.
- Repair and replacement recommendations for applicable piers.
- A report documenting findings and summary of the project.

The report herein is meant to provide a structural condition assessment and recommended improvements to Piers 1, 2, and 3 at Alameda Point for the purpose of adequately mooring the MARAD Ready Reserve Fleet.

The analyses and assessment of the facility were performed in accordance with the MARAD lease requirements (Appendix H), UFC 4-152-01, “Unified Facilities Criteria, Design: Piers and Wharves,” and UFC 4-159-03, “Unified Facilities Criteria, Design: Moorings.” These documents were used as the basis for determining fitness-of-purpose of the piers at Alameda Point.

2. DESCRIPTION OF FACILITY

2.1 General

Piers 1, 2, and 3 were originally constructed in the 1940's as part of the Alameda Naval Air Station. All piers were oriented in an east-west direction, with the head of the piers at the west end. The inner 1,000 ft of Pier 2 was initially constructed around 1940. Construction of Pier 3 followed soon after in 1943. Pier 1 was constructed about three years after Pier 3, in 1946.

Pier 2 was extended by 210 ft in 1977. At that time the mooring dolphin at the head of Pier 2 was also constructed. In 1980, Pier 1 was substantially rebuilt. Other minor construction and utility modification projects have been done on the piers since their original construction.

The Navy berthed carriers and other vessels at the piers from 1940 to 1995. Piers 2 and 3 served as carrier piers. Pier 1 is smaller and we understand this pier served smaller vessels. The carrier pier designation signifies that they provide more utilities and utility capacity including steam. Also, the carrier pier designation implies that the piers were originally designed for heavy vehicle, crane and deck live loads, and large mooring forces. The piers have been subjected to the marine environment for many years and, as a consequence, have deteriorated to some extent.

In the mid-1990s as part of the Base Realignment and Closure (BRAC), the Navy ceased operations in Alameda and vacated the Naval Air Station.

2.1.1 Pier 1

Pier 1 is a cellular type sheet pile pier that is approximately 660 ft long by 53 ft wide. The rebuilding of the pier in 1980 consisted of constructing a system with king piles with infill concrete panels exterior to the existing cellular panels. Concrete was placed between the new and existing structures. The south side of the pier consists of king piles nominally spaced 6 ft-8 in. o.c. with profiled precast concrete panels between. The north side consists of king piles with the same 6 ft-8 in. spacing supporting flat concrete panels. The king piles on opposing sides are connected with a 3 in. diameter tie rod. The interior of Pier 1 is filled with sand.

The deck is typically made out of 7-1/2 in. thick concrete slab panels about 20 ft wide by 20 ft long. There is an existing pile cap with an additional newer pile cap from 1980 over the king piles and precast panels. A rubble mound breakwater extends west from the west end of the pier but was not assessed within this report.

2.1.2 Pier 2

Pier 2 is a typical concrete pile and deck pier. The original pier was about 1000 ft long by 80 ft wide. The original pier consisted of an 8 in. concrete slab supported by transverse concrete bents spaced 12 ft o.c. The bents are supported by 20 in. square precast piles with eight piles per bent. The extension is an additional 210 ft long by 80 ft wide with bents being supported by 18 in. square precast, prestressed piles. The lateral support is provided by precast concrete batter piles where the load path goes from the mooring hardware to the deck, from the deck to the pile cap, and from the pile cap to the batter piles. Through the length of the pier, there are two batter piles per bent excluding the end of the addition, where there are four batter piles per bent. There are approximately 858 plumb piles and 216 batter piles total.

A mooring dolphin is located approximately 150 ft west of the pier. The dolphin is supported by thirty-eight 24 in. square precast, prestressed concrete vertical and batter piles total.

2.1.3 Pier 3

Pier 3 is a typical concrete pile and deck pier. The pier is approximately 1100 ft long by 150 ft wide. The reinforced concrete slab is 26 in. thick at the outer most region thinning to 10 in. thick at the center. The deck is supported by 20 in. square precast concrete piles with 28 in. square jackets covering the top 13 ft of the pile. Rows of nineteen and eight piles alternate every 6 ft along the length of the pier. The lateral support is provided by precast concrete batter piles where the load path goes from the mooring hardware to the deck, and from the deck directly to the batter piles.

2.2 Mooring Hardware

Pier 1 mooring hardware consists of large bollards with horns and 42 in. cleats located throughout the pier with varying spacing. The south side has nine bollards and eight cleats, alternating between the two. The north side has two bollards and eight cleats. The mooring hardware is located on the innermost (original construction) concrete cap with the exception of two bollards, one on the north side and one on the south side being placed on the newer concrete cap.

Pier 2 and 3 mooring hardware is typically located between bents, spaced three bents apart, or 36 ft. The arrangement consists of one bollard for every two cleats, placing the bollards about 108 ft apart. Additional bollards are placed as necessary in several locations along the north and south side of Pier 2.

The nominal capacity of the bollards and cleats are calculated to be 70 kips and 40 kips respectively. These calculated capacities are consistent with UFC 4-159-03 Table 6-11 as well as the values in the previous condition report “Condition Assessment Report for Pier 1, Pier 2, & Pier 3” by Moffat & Nichol.

3. ABOVE AND BELOW WATER PIER INSPECTION

3.1 Above Water Inspection

SGH performed a multiday inspection including visual inspection of all structural components accessible for Piers 1, 2, and 3. The team was led by Rune Iversen, P.E. in the period between July and December 2016. We recorded and documented damage to pile caps, piles, soffit, and exterior deck facing overall assessment of the facility. We assigned pile ratings to visually inspected piles above water to accompany any ratings assigned in the underwater inspection. We utilized the extents of the damage to evaluate the structure in the preliminary analysis. SGH conducted a topside inspection as well for all piers to inspect mooring hardware and surface damage to the deck and curbs. The mooring hardware was assessed and rated in accordance with UFC 4-159-03 “Unified Facilities Criteria, Design: Mooring”.

3.2 Below-Water Inspection

Shoreline Engineering, Inc. (Shoreline) provided an underwater engineering inspection of Piers 1, 2, and 3. The inspection consisted of a Level I inspection for 100% of accessible piles. A rating was assigned to every pile inspected with the deficiencies noted for the given pile. A Level II inspection was conducted for specific piles which were chosen representative of the overall pile conditions of the pier. A Level II inspection consisted of marine growth being removed at three elevations of the piles and concrete panels. Thickness measurements of the steel piles and sheet piles were within the Level II inspection scope as well and conducted as stipulated. Level III inspection of a select few Level II locations were chosen to perform further investigation. Level III consisted of concrete cores being taken at eleven piles above the waterline, at mid-water depth, and 3 ft below the mudline from Pier 2 and one pile at three similar elevations for Pier 3.

3.3 Inspection Summary

From the inspection, SGH came to the following conclusions:

Pier 1 is in satisfactory condition, but should have maintenance performed to ensure it retains the intended capacity of the structure. The maintenance should include cleaning and recoating of the king piles and repair of the sheet pile bulkhead towards the apron.

The conditions of Pier 2 vary from satisfactory to severe, depending on the structural components and areas. Many piles in Bents 19 to 54 are in poor condition, while the concrete deck and piles outside of Bents 19 to 54 are generally in satisfactory condition. Repairs and maintenance should be considered for piles within Bents 19 to 54 for future long term mooring of the vessels. Load restrictions should be considered until repairs have been completed. Mooring hardware rated Severe should be avoided until repairs have made.

Pier 3 is in satisfactory condition with a limited number of piles showing deterioration. Accessibility of the piles was limited and therefore the condition was assessed from inspected piles. Mooring hardware rated Severe should be avoided until repairs have been made.

There were multiple cracks and spalls of concrete decks of the three piers. Although the cracks and spalls at the present time do not noticeably affect the structural capacity of the piers, we recommend that maintenance repair be conducted for long term durability and operations of the piers.

Appendix A provides detailed inspection results.

4. MATERIAL TESTING

SGH performed material testing of the piers to understand the state of the concrete in both the piles and deck of the piers and to identify the deterioration mechanism in the piles. A bulk of the pile concrete damage was located at Pier 2, therefore a majority of the pile concrete core samples were taken from Pier 2. The concrete cores were taken from the following structural components of the piers:

- We selected eleven piles in Pier 2 that represent the overall conditions of the piles at the pier. The current conditions of these piles range from the most deteriorated to moderately deteriorated to good piles. Three concrete cores were taken from each selected pile at varying elevation: one at the splash zone, one within the water column, and one below the mudline.

- We took three concrete cores from one selected pile (i.e., Pile 30-A) in Pier 3 for comparison with those in Pier 2. The three cores were taken from the pile at varying depth in the splash zone, water column, and below the mudline.

- Two samples were taken from both sides (i.e. east end and west end) for each pier deck to be representative of the deck.

The concrete cores were taken to an independent concrete testing laboratory at Applied Materials & Engineering, Inc. (AME) in Oakland. AME conducted the following tests on every core sample:

- Concrete compressive strength tests per ASTM C42.

- Chloride content analyses at varying depths of the concrete cores to determine the extent of the chloride penetration into the concrete piles.

- Petrographic analyses using microscopic examination in order to determine the causes and extent of damages to the concrete piles of Pier 2.

The concrete test results are reported in Appendix B. The following sections provide a summary of the test results and conclusions.

4.1 Concrete Compressive Strength

The concrete strength of the cores from the piles ranges from 5990 to 11350 psi with an average compressive strength of 7924 psi. The concrete strength of the cores from the deck of Pier 2 ranges from 3870 psi to 6260 psi with an average compressive strength of 4992 psi. In general, the test data indicated that the concrete strength meets and exceeds the design requirements.

4.2 Chloride Content in Piles

Chloride ions (salts) were measured in 1/2 in. increments up to 4 in. from the pile surface. The test indicated that salts in the concrete exceed the threshold value to initiate corrosion of reinforcing steel bars in the piles in all of the cases that AME tested. The chloride content within the piles is most significant in the splash zone above the water line.

4.3 Deterioration Mechanism of Piles in Pier 2

The piles in Pier 2 were subjected to significant seawater attack. As a result, the concrete surface softened and cracks extended to concrete depths of approximately 5 in. These cracks made the concrete more permeable to penetration of seawater, which led to two additional deterioration mechanisms, i.e., alkali-silica reaction between the aggregates in the concrete pile and alkalis in seawater, and sulfate attack on the concrete. All these chemical reactions caused more cracks in the concrete and disintegrated the concrete near the surface, although the concrete away from the surface of the piles still has high strength. The concrete deterioration of the piles in Pier 2 is most significant in the water column, less in the splash zone above the water line, and even lesser in the pile segment below the mudline.

5. GEOTECHNICAL INVESTIGATION

5.1 Pier 1

SGH evaluated Pier 1 for geotechnical capacity due to the construction of the structure being a segmental cofferdam. The retention of fill within the pier and uneven soil elevations between the north and south sides justify investigation for stability and bearing capacity. The soil on the south side of the pier was dredged for berthing of large vessels, therefore creating a difference of 15 ft from the north side. When lateral load calculations were investigated for the pier, the tie-rod was checked with internal soil pressures from the soil fill within the cofferdam. Analyses were conducted for both Mean Low Low Water (MLLW) and Mean High High Water (MHHW), with MHHW controlling. All relevant analysis can be seen in Appendix C for Pier 1 calculations.

5.2 Piers 2 and 3

ENGEO provided a geotechnical report of the soil in the project area to accurately model the soil in relation to the piles. The report permitted SGH to input proper soil springs for the model of Piers 2 and 3. ENGEO provided the ultimate tension capacities of the piles for different soil regions to check for pile pullout under mooring loads. The ENGEO report can be found in Appendix C.

5.3 Geotechnical Results

The geotechnical evaluation of Pier 1 indicated the structure was sufficient both in sliding and overturning stability. The factor of safety for sliding stability after evaluation was 6 while the factor of safety for overturning was 4. The bearing capacity factor of safety was 2.28, within the acceptable range. The geotechnical evaluation of Pier 2 and 3 indicated the ultimate tension capacity of the 1980 Pier 2 addition provides the least capacity. In accordance with UFC 3-220-01 which supersedes UFC 3-220-01A, the pier requires a safety factor during extreme events of 1.7. Pier 2 at the lowest capacity section under extreme conditions provides a tension safety factor of 1.75, exceeding the minimum required factor of safety.

6. PRELIMINARY ANALYSIS

6.1 Mooring Assessment

SGH utilized OPTIMOOR Version 6.2.9 (Catenary & Dynamic Model) for all mooring analyses presented herein. This program is a proprietary product developed and distributed by Tension Technology International, Inc. of Weston Massachusetts. OPTIMOOR is well accepted in the marine structures industry as a tool for mooring analyses and is based on OCIMF recommendations and procedures.

The mooring analysis was conducted under the Facility Design Criteria for Mooring Service: Type IV in accordance with UFC 4-159-03. A Type IV designation is reserved for permanently moored vessels and the facility is evaluated for a 100 year return event.

6.1.1 Environmental Conditions

6.1.1.1 Wind

Wind data was obtained from the National Oceanic and Atmosphere Administration (NOAA) data base for the station located at the former Alameda Naval Air Station (station ID GHCND:USW00023239). The station provided wind data from 1948 – 1990 allowing for a probabilistic analysis to be performed. Through statistical analysis, wind loads in a 100 year storm was attained in accordance with UFC requirements for a permanently moored vessel. For the dynamic mooring analysis, SGH used a frequency domain model incorporating the Davenport spectrum to develop a time history of wind velocities that would fluctuate around the 1 hour averaged storm wind velocity. The time history would allow instantaneous velocities to reach peak wind speeds of 70.5 mph, equal to gusts with a 100 year return period. The time history was created for a 15 min. in duration to allow for adequate time to develop all possible loads. This wind time history was then used in OPTIMOOR to perform the dynamic mooring analysis.

For comparison, a static mooring analysis was performed as a back-check. For the static analysis, the 30 second time averaged velocity (60.8 mph) was used in the assessment of the mooring conditions.

6.1.1.2 Current

Due to the sheltering nature of the piers location, no currents were included in the mooring analysis.

6.1.1.3 Wave

Due to the sheltering nature of the piers location, no wave spectrum was included in the mooring analysis.

6.1.1.4 Tide

During the analysis, wind was the predominant factor in loading. Therefore, tide was neglected and the draft was set constant over the time domain analysis.

6.1.2 Mooring Load Cases

Variables considered for the mooring analysis of each of the five vessel included the combinations of the following:

- Zero current within the facility.
- Constant tide level during storm.
- Nested vessels, both two and three together when applicable.
- All wind directions (at 5-degree increments).
- Static and dynamic analyses for determined worst case direction.

6.1.3 Mooring Arrangements

SGH used possible schematics of mooring arrangements and line information provided by MARAD. We completed the analysis with the information provided as well as field verification to represent accurate mooring conditions. The field verification included line type, fairlead, and winch locations on the vessel as well as the cleat and bollard locations at the berths. These mooring configurations, including number and type of lines, are provided in Appendix D for all vessels considered.

6.1.4 Moored Vessel Parameters

The MARAD Ready Reserve Fleet currently reside in five berths along Piers 1, 2, and 3. The north face of Pier 3 is occupied by the museum vessel the U.S.S Hornet. Eight MARAD vessels are currently moored and expected in the remaining berths. At both Piers 2 and 3, nested mooring arrangements are used with two and three vessels being moored together at one berth.

Vessel parameters for the moored vessels considered were obtained from numerous sources including the project Request for Proposal, the Naval Vessel Register, and correspondence with MARAD.

A brief description of each vessel follows:

- Cape Orlando – A 20,731 DWT Roll-on/Roll-off cargo vessel (593 ft length between perpendiculars (LBP) by 92 ft beam) with a maximum draft of 30 ft. For analysis purposes, the vessel was modelled with the observed draft of 19 ft-4 in. from site visits. The mooring lines used comprised of three separate types of lines with varying circumferences: SuperDan lines with a breaking strength of 181,000 lbs, Jetkore lines with two circumferences and breaking strengths of 120,000 lbs and 211,000 lbs, and a smaller line, Plasma lineswith a breaking strength of 221,000 lbs.

- Algol & Capella – Each vessel is an identical 32,295 DWT Roll-on/Roll-off cargo vessel (880 ft LBP by 105.5 ft beam) with a maximum draft of 37 ft. Due to dredged depth limitations at the berths, a draft of 26 ft-6 in. was observed. The primary mooring lines used for these vessels are 12 Strand Dacron lines with a breaking strength of 249,000 lbs. There were several lines observed to be parallel braid and nylon that were modelled with 218,000 lbs and 103,000 lbs breakings strength respectively.

- Admiral William M. Callaghan – A 13,717 DWT Roll-on/Roll-off cargo vessel (626.5 ft LBP by 92 ft beam) with a maximum draft of 29 ft. The observed draft was 20 ft-6 in. from site visits. The primary mooring lines were 8 Strand poly-blend with a breaking strength of 217,000 lbs. A smaller line, an Esterlin 8 braid line with a breaking strength of 217,000 lbs was used sparingly.

- The Gem State, Grand Canyon State, and Keystone State – Three identical 17,729 DWT Crane Ship (633 ft LBP by 76.8 ft beam) with a maximum draft of 34 ft. The observed draft at berth was taken as 18 ft. The primary mooring lines used are

8 Strand Nylon plaited rope with a breaking strength of 225,000 lbs. Smaller Proton-8 lines were used as well with a breaking strength of 156,000 lbs.

- Cape Henry – A 32,956 DWT Roll-on/Roll-off cargo vessel (650 ft LBP by 105.8 ft beam) with a maximum draft of 35 ft. The observed draft of the vessel upon site visits was 19 ft-8 in. The primary mooring line used was a plaited polypropylene line with a breaking strength of 156,000 lbs. A smaller variant of the polypropylene was used with a breaking strength of 123,000 lbs.

- Cape Mohican – A 39,026 DWT Barge Ship (721.5 ft LBP by 106 ft beam) with a max draft of 39 ft. Due to the Mohican not currently being berthed in Alameda, the draft was assumed to be similar to Cape Henry at 19 ft-8 in. The primary mooring lines are varying circumference Samson double braided polyester line with a breaking strength of 343,000 lbs and 470,000 lbs.

All vessel information can be found in Appendix D within the Vessel Data section for each configuration.

6.2 Structural Assessment

6.2.1 Structural Loads

The facility is required to meet all requirements presented specified in the MARAD lease requirements. The lease stipulates the following criteria be evaluated for the facility:

- 425 psf live load.
- HS20-44 truck load.
- Local fire truck load.
- 4000 lb. fork lift.
- Safe working load of mooring equipment.

The requirements herein presented all pertain to the scope of work with evaluating the facility for structural adequacy for lay berthing of the Ready Reserve Fleet.

6.2.1.1 Vertical Loads

The vertical loads considered for structural analysis of the piers were self-weight dead load, 425 psf live load, and a standard HS20-44 truck described in Appendix E. A local fire truck of the City of Alameda was considered, but after investigation, the HS20-44 prompted larger loads to the pier and would be the governing live load. A 4000 lb forklift is specifically designated as a live load under MARAD lease requirements, but the load demand produced by a HS20-44 surpasses the loads by the forklift. The truck axial load was then placed to induce the largest stress on the system.

6.2.1.2 Horizontal Loads

The MARAD lease states that mooring hardware be maintained to work at safe working loads, therefore, the maximum working load of the bollard and cleats, 70 kips and 40 kips respectively, were used in the analysis. We assumed the mooring load to be supported between the two surrounding bents, therefore the load evenly distributed to two bents for analysis. Currents and waves were neglected due to the project site being located within a breakwater protected region with little to no current present. The waves within the harbor are long duration, small amplitude waves and therefore do not provide noticeable loading. Wind load on moored vessels was considered. Breasting loads were evaluated for the various vessels and though local breasting loads were high, globally applying the maximum working load of the mooring equipment governed the analysis. Seismic loading was not considered in the analysis of the structure in accordance with the contract scope of work.

6.2.1.3 Load Combinations

Using UFC 4-152-01, load combinations were assessed to provide governing cases for facility assessment. Table 1, which is provided in UFC 4-152-01, provides load combinations for situations when the pier is vacant, berthing, and mooring. The loading combinations identified as critical were Vacant 2(b), Mooring 5(e), and Mooring 7(g). The aforementioned cases were selected due to the weighting of Live Loads and Wind Loads on Vessels.

Table 1: Load Combinations per UFC 4-152-01

Table 3-6 Load Combinations – LRFD

VACANT	1(a)	2(b)	3(c)	4(d)	5(e)	6(f)	7(g)	8(h)
D	1.4	1.2	1.2	1.2	1.2	1.2	0.9	0.9
L	0	1.6	1	0	1	1	0	0
B	1.4	1.2	1.2	1.2	1.2	1.2	0.9	0.9
Be	0	0	0	0	0	0	0	0
C	1.4	1.2	1.2	1.2	1.2	1.2	0.9	0.9
Cs	0	0	0	0	0	0	0	0
E	0	1.6	0	0	0	0	1.6	1.6
EQ	0	0	0	0	0	1	0	1
W	0	0	0	0.8	1.6	0	1.6	0
Ws	0	0	0	0	0	0	0	0
RST	0	1.2	0	0	0	0	0	0
Ice	0	0.2	0	0	1	0	1	0

BERTHING	1(a)	2(b)	3(c)	4(d)	5(e)	6(f)	7(g)	8(h)
D		1.2	1.2		1.2	1.2		
L		1.6	1		1	1		
B		1.2	1.2		1.2	1.2		
Be		1.6	1		1	1		
C		1.2	1.2		1.2	1.2		
Cs		0	0		0	0		
E		1.6	0		0	0		
EQ		0	0		0	1		
W		0	0		1.6	0		
Ws		0	0		0	0		
RST		1.2	0		0	0		
Ice		0.2	0		1	0		

MOORING	1(a)	2(b)	3(c)	4(d)	5(e)	6(f)	7(g)	8(h)
D	1.4	1.2	1.2	1.2	1.2	1.2	0.9	0.9
L	0	1.6	1	0	1	1	0	0
B	1.4	1.2	1.2	1.2	1.2	1.2	0.9	0.9
Be	0	0	0	0	0	0	0	0
C	1.4	1.2	1.2	1.2	1.2	1.2	0.9	0.9
Cs	1.4	1.2	1.2	1.2	1.2	1.2	0.9	0.9
E	0	1.6	0	0	0	0	1.6	1.6
EQ	0	0	0	0	0	1	0	1
W	0	0	0	0.8	1.6	0	1.6	0
Ws	0	0	0	0.8	1.6	0	1.6	0
RST	0	1.2	0	0	0	0	0	0
Ice	0	0.2	0	0	1	0	1	0

(a) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 1
(b) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 2
(c) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 3a
(d) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 3b
(e) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 4
(f) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 5
(g) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 6
(h) *ASCE 7-02 Min Design Loads for Bldgs and Other Structures*, 2.3.2 Eqn 7

6.2.2 Load Resisting System

6.2.2.1 Vertical Loads

The structural analysis of Piers 1, 2, and 3 consisted of SGH investigating each component of the load resisting system to ensure sufficient capacity. The vertical loads sustained by the deck were analyzed for bending and shear. All piles were checked for tension and compression. The structural system was then evaluated for adequate capacity during vertical loads with varying scenarios of pile failure. Schematics of the analysis scenarios for Pier 2 can be observed in Appendix E.

In Pier 1, the additional pile cap overlaying the king pile connects to the existing pile cap which distributes the load from the deck to the full system. The deck directly rests on interior soil and therefore can accommodated large vertical loads. The bearing capacity of the structure was taken as the entire footprint of the system.

Pier 2 includes a pile cap which transfers the deck load to the pile cap to the piles. The pile cap was evaluated for vertical resistance before the load was transferred to the plumb piles.

The deck for Pier 3 reduces in thickness from the outer regions toward the center requiring investigation for both deck thicknesses. There is no pile cap and therefore the deck load is transferred directly to the piles.

6.2.2.2 Horizontal Loads

The horizontal loads on the structural system start from the loads being placed on the mooring hardware. The mooring hardware was assumed to take the total load without failure. The anchoring bolts were then evaluated to take the maximum working load considered for the bollard or cleat as this would be the source of failure. The load would then be transferred from the anchors to the deck. Due to locations of the mooring hardware, the load was anticipated to be distributed between two bents, though load is possibly transferred further.

In Pier 1, the lateral load is not transferred to the deck but rather stays within the exterior pile cap and transferred to the interior tie-rods that connect the king piles. To be conservative, we assumed the load to be completely taken by the tie-rod and not within the cofferdam sheet piles. It was assumed if the tie-rod adequately withstood the complete load with a large factor of safety, the system, including the sheet piles, would be sufficient. Pier 2 transferred the load to the pile cap before the batter piles were engaged. Pier 3 directly transferred the load to the batter piles.

6.3 Results

6.3.1 Mooring Assessment

The mooring analysis shows that the safe working loads of the mooring hardware at the piers are below the calculated load demands from a 100-year storm in all the mooring configurations analyzed in this study. A summary of the total loads on the vessels as well as the maximum loads on the mooring points for each vessel configuration is given in Appendix D. The maximum mooring point loads range from 156 kips for the 3 State Class vessels moored together to 449 kips for the Cape Henry.

It is apparent from observation of the mooring arrangements that the maximum mooring point loads could be reduced with an optimization of the mooring arrangements, as well as by use of the same type and strength of mooring lines for each vessel. However, it is beyond the scope of this analysis to develop fully optimized mooring arrangements for the vessels. It should also be noted that the loads considered for this analysis are extreme storm loads, and that the mooring arrangements seem to be functioning adequately under more normal conditions. The structural analysis also shows that all piers are able to support higher loads than the safe working loads of the current mooring hardware when deteriorated structural components are repaired or replaced per recommendations of this report. An upgrade of the mooring hardware to stronger units is therefore a viable option for increasing the mooring capacity of the piers.

6.3.2 Structural Assessment

After analysis was concluded for Piers 1, 2, and 3, it was determined that all undamaged sections would be acceptable under the MARAD lease requirements. The sustained loads imposed on each pier was well below the allowable load the pier can sustain.

Pier 1, in current condition, is satisfactory for future operations with large vessels. Cosmetic damage to several bases of the mooring hardware as well as delamination to patches of the exterior pile cap face are present but do not result in lowered capacity of the structure. The lateral and vertical load resisting system provided sufficient Demand to Capacity ratios (DCRs) with conservative assumptions in-place. The sheet piles provide additional lateral capacity that was not accounted for allowing for mooring under harsher conditions to be possible.

A range of scenarios were evaluated for Pier 2 due to the severity of the piles upon inspection. The scenarios included changing which pile had failed and whether the bent would still have sufficient capacity with the applied loads. The modelled possibilities can be seen for Pier 2 in Appendix E. Pile failure was assumed to be zero capacity of the pile. We concluded that when pile failure resulted in consecutive large spans (i.e., 16+ ft), the pile cap could not sustain the resulting tributary forces. A single long span with adjacent short spans is capable of withstanding the loads. Pile capacities were checked with model results to confirm adequate capacity when undamaged. Under modelled loads, piles with moderate to no damage are adequate for MARAD requirements. The structural capacity of Pier 2 when incorporating lateral loads was done under the assumption that batter piles were contributing full capacity.

Our structural inspection of Alameda Piers concluded that Pier 3 is in satisfactory condition with all of the bents meeting the failure criteria. Spalling of the curbs due to corrosion of conduit and reinforcing steel, and occasional deck spalls were evident but did not reduce the functionality of the pier or prove to be critical to the structural capacity. Pier 3 was evaluated for several pile failure scenarios and checked against the design criteria. Our structural analyses indicated that the pier would maintain its functionality even if individual piles fail. We cannot identify a realistic failure scenario at Pier 3. Therefore, the pier should remain adequate for future use of large vessels.

7. CONCLUSIONS AND RECOMMENDATIONS

Pier 1 is in satisfactory condition with no structural repairs required to continue to berth the MARAD Ready Reserve Fleet apart from an upgrade and reassessment of the mooring system on the Pier. Slight cosmetic damage was noted during the inspection of the pile cap, but the damage does not structurally compromise the system. Mooring hardware pedestals had signs of deterioration but did not compromise the anchoring system. Most of the steel piles lost protective painting in the splash/tidal zone, we therefore recommend that a protective coating with proven performance records for marine applications in splash/tidal zone of steel piles, such as Interzone 954 (Appendix G), be applied to the steel piles.

From the inspection, SGH noted Pier 2 contains regions of heavily damaged plumb and batter piles within the midsection of the pier. Due to a wide range of damage, it is not possible to accurately predict the remaining capacity of these sections and therefore we modelled the piles rated Severe with no capacity. Repair or replacement of plumb piles to restore capacity to meet the MARAD requirements are highly advised. The analysis of the pier for lateral capacity shows a need for repair of batter piles rated Severe in locations where bents are near a bollard. The distribution of load to multiple bents is only permissible when surrounding bent's batter piles are intact. The current system will not withstand maximum working loads on the mooring equipment without a properly working lateral load resisting system. Therefore, selected bents in close proximity of bollards should be targeted as a higher priority for repairs.

Pier 3 is in satisfactory condition for mooring of MARAD vessels. In only two instances, a batter pile in immediate proximity to a bollard is damaged and should be replaced if heavy use is expected. The overall structure is in acceptable working condition for future mooring of vessels including heavy deck loads.

7.1 Pier 2 Repair Options

Table 1 presents several repair options developed by SGH for Pier 2. These repair options are presented in elevation and plan view in Appendix F. All options include batter piles only in proximity to bollards and the associated plumb pile regardless of Major or Severe rating. In calculating the option cost, a market nominal fee of mobilization and demobilization has been assigned to all options. All options have been assigned a 45% contingency as well for any unseen circumstances. Cost assumptions and calculations can be viewed in Appendix F.

Table 1: Pile Repair Options

No.	Description	# of Piles	Cost
Option 1	Repair All Piles to Retain Original Capacity (neglecting rail load piles)	339	$13,235,200
Option 2	Repair Severe Piles to Retain Original Capacity	256	$10,062,400
Option 3	Repair All Piles (except Pile Rows C and F)	167	$6,568,600
Option 4	Repair All Severe Piles (except Pile Rows C and F)	139	$5,539,300
Option 5	Repair All Southern Piles (except Pile Row F)	73	$2,873,600
Option 6	Repair All Severe Southern Piles (except Pile Row F)	60	$2,407,500

Figure 1: Pile Repair Jacket Option

7.2 Replacement Option

An alternative option to repairing the existing piles is to replace the piles completely with new piles strategically located. This option would include opening the deck near the existing pile cap, driving a new 24 in. octagonal precast concrete pile, then tie the new pile into the existing pile cap. Replacing piles is ideal when the bent is severely damaged and requires complete restoration. Twenty nine (29) instances of five (5) evenly distributed piles at 18 ft for a single bent for Pier 2 will sustain the required loads and bring the bent back to safe working capacity. Thirty two (32) piles in addition to the bent replacement will require replacement to ensure sufficient capacity throughout the pier. Replacing piles to restore the pier to original capacity has been determined to cost approximately $9.9M. This includes batter piles only in proximity to bollards and the associated plumb pile regardless of Major or Severe rating. In calculating the option cost, a market nominal fee of mobilization and demobilization has been assigned as well as environmental/ regulatory support fees. The total has been assigned a 45% contingency as well for any unseen circumstances. A replacement plan view of Pier 2 as well as calculation assumptions can be seen in Appendix F.

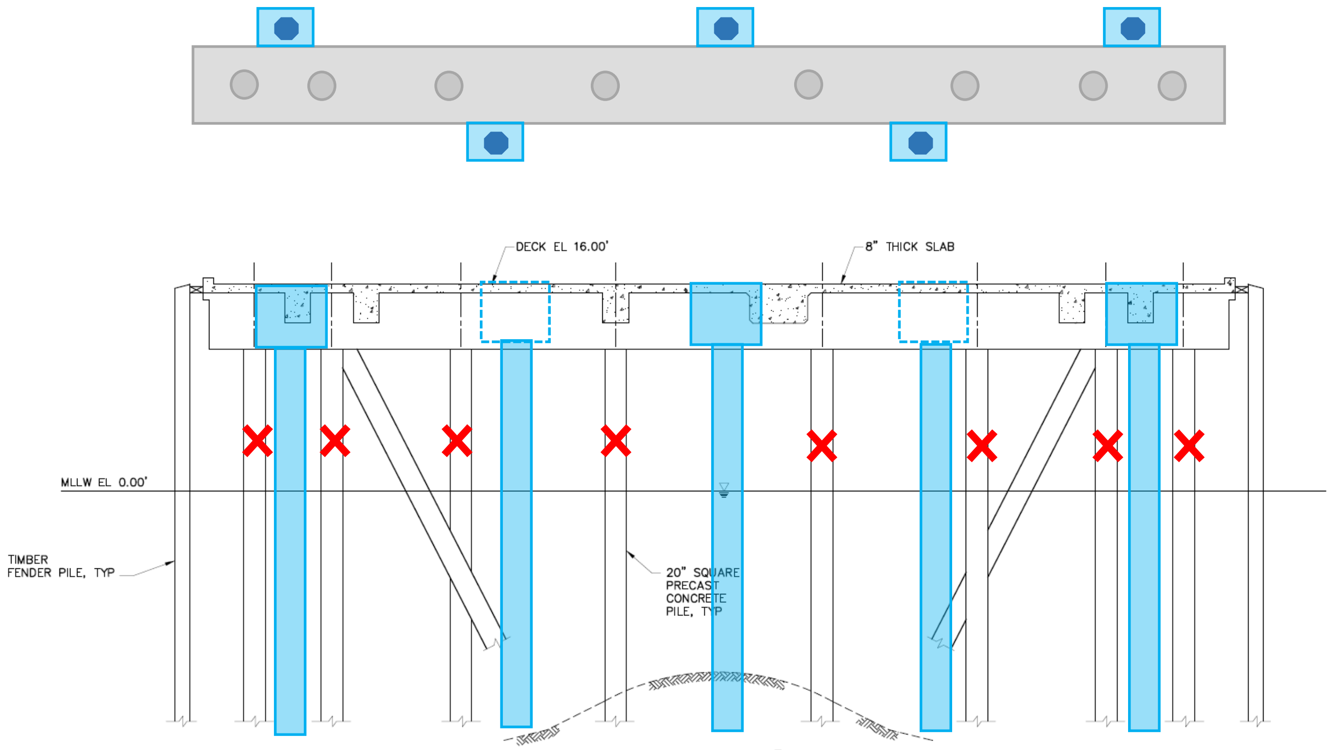


Figure 2: Pile Replacement Schematic

7.3 Upgrading Mooring Bollards

To increase the mooring capacity of the piers, new bollards can be installed. New 100 MT mooring bollards can be installed for a cost of approximately $21,000 each. SGH recommends replacement of mooring hardware should include locations where the mooring hardware is in use and rated Severe. Locations of severe hardware are provided in Appendix A in the form of tables and figures.

8. SUMMARY

Based upon the inspection, tests, condition assessment, and preliminary engineering analysis of Alameda Point Piers 1, 2, and 3, we reached the following conclusions:

Pier 1 is generally in satisfactory condition to meet the MARAD lease requirements. The current mooring hardware on the pier does not meet the structural design requirement for the mooring of Cape Orlando at the pier during a 100-year storm, although it is capable of supporting mooring loads under less demanding conditions. The pier is capable of withstanding the required deck loads from the MARAD lease requirements. Maintenance of the king piles such as cleaning and new coating is recommended to retain the capacity and durability of the pier for future operations. SGH recommends that the pier be inspected on a five (5) year interval and be reevaluated at that time.

Certain regions of Pier 2 are not capable of meeting MARAD lease requirements due to concrete pile deterioration. The damaged regions are within Bents 19 – 54 of the pier. The test of concrete core samples from the piles showed that concrete deterioration in many piles is in advanced stage, resulting in weakening and spalling of the concrete. However, the concrete deterioration is generally limited to a few inches from the surface of concrete, and the internal concrete at the core of piles still maintains reasonably strong strength. Repair or replacement of piles will be necessary for continued operations of the pier for the MARAD lease. The current mooring hardware on the pier does not meet the structural design requirement for the mooring of the MARAD vessels currently moored at the pier during a 100-year storm, although it is capable of supporting mooring loads under less demanding conditions. In addition, damaged mooring hardware should be avoided until repairs are conducted. SGH recommends the damaged region within bents 19-54 be inspected every two (2) years until maintenance has been provided. Upon completion of repair or replacement, the pier can be elevated to a satisfactory rating and be inspected on a five (5) year interval.

Pier 3 is in satisfactory condition from the inspection. The current mooring hardware on the pier does not meet the structural design requirement for the mooring of the Cape Henry currently moored at the pier during a 100-year storm, although it is capable of supporting mooring loads under less demanding conditions. The pier is capable of withstanding the required deck loads from the MARAD lease requirements. Slight pile deterioration was noted, but it does not structurally compromise the overall structural capacity for the anticipated operational loads. Damaged mooring hardware should be avoided until repairs are conducted. Further detailed inspections of the pier and maintenance should be considered to fully establish the condition of the pier.

There were multiple cracks and spalls of concrete decks of the three piers. Although the cracks and spalls at the present time do not noticeably effect the structural capacity of the piers, it is recommended that maintenance repair be conducted for long term durability and operations of the piers. SGH believes the piers may handle the mooring of the MARAD Ready Reserve Fleet under current mooring hardware through optimization of line arrangement.

In general, the Alameda Point Piers are in a condition that reflects the age of the facility. The future intended uses will dictate the extent of damage repair. Proper maintenance of the piers should be considered and implemented to prolong the integrity and durability of the structures for future uses.

I:\OAK\Projects\2016\167543.00-ALPR\WP\001SXYao-R-167543.00.els.docx

APPENDIX A

Above and Below-water Investigation Report

1. INTRODUCTION AND SUMMARY

The structural inspection of Alameda Point Piers 1, 2, and 3 is part of a larger effort to evaluate the Piers for compliance with MARAD's lease requirements for the site. As the evaluation of the piers is limited to the structural capacities of the piers, the inspection was focused on the various structural elements. Worth noting is that the fender system was not a part of the inspection or evaluation of the piers.

The evaluation of the capacities of the piers is focused on the ability to resist two types of loads: vertical loads from vehicles on top of the piers and lateral loads from mooring and breasting forces from the vessels moored at the piers. The vertical capacity is defined by the deck, pile caps, and plumb piles. The horizontal capacity is defined by the mooring hardware, adjacent deck, pile caps, and batter piles. The inspection therefore focused on these areas, and while deterioration was observed and recorded on other parts of the structure, this report will not go into detail on any of these

In summary the piers are in the following condition:

- Pier 1 is in overall Satisfactory condition with only minor repairs suggested. No immediate repairs are needed for structural reasons.
- Pier 2 is on overall Poor condition and is in need of extensive repair.
- Pier 3 is in overall Satisfactory condition with no immediate needs for repair.

2. DESCRIPTION OF FACILITY

Piers 1, 2 and 3 were originally constructed in the 1940s as part of the Alameda Naval Air Station. All piers were oriented in an east-west direction, with the head of the piers at the west end. The inner 1,000 feet of Pier 2 was initially constructed around 1940. Construction of Pier 3 followed soon after in 1943. Pier 1 was constructed about 3 years after Pier 3 (in 1946). Pier 2 was extended by 210 feet in 1977. At that time the mooring dolphin at the head of Pier 2 was also constructed. In 1980, Pier 1 was substantially rebuilt. Other minor construction and utility modification projects have been done on the piers since their original construction.

The Navy berthed carriers and other vessels at the piers from 1940 through 1995. Piers 2 and 3 served as carrier piers. Pier 1 is smaller and it is assumed this pier served smaller vessels. The carrier pier designation signifies that they provide more utilities and utility capacity including steam. Also, the carrier pier designation implies that the piers were originally designed for heavy vehicle, crane and deck live load, and large mooring forces. The piers have been subjected to the marine environment for many years and as a consequence have deteriorated. In the mid-1990s as part of the Base Realignment and Closure (BRAC), the Navy ceased operations at Alameda and vacated the Naval Air Station.

2.1.1 Pier 1

Pier 1 is a cellular type sheet pile pier that is approximately 660 ft. long by 53 ft. wide. The rebuilding of the pier in 1980 consisted of constructing a king pile with infill concrete panel system exterior to the existing cellular panels. Concrete was placed between the new and existing structures. The south side of the pier consists of king piles nominally spaced 6 ft. 8 in. on center with profiled precast concrete panels between. The north side consists of king piles with the same 6 ft. 8 in spacing supporting flat concrete panels. The king piles on opposing side are connected with a 3 in diameter tie rod. The interior of Pier 1 is filled with sand. The deck is typically made out of 7 ½ in. thick concrete slab panels about 20 ft. wide by 20 ft. long. There is an existing pile cap with a new additional pile cap over the king piles and precast panels. A rubble mound breakwater extends west from the west end of the pier. The south side of the pier is faced with timber fender piles spaced 6 ft. 8 in. on center.

2.1.2 Pier 2

Pier 2 is a typical concrete pile and deck pier. The original pier was about 1000 ft. long by 80 ft. wide. The original pier consisted of an 8 in. concrete slab supported by transverse concrete bents spaced 12 feet apart. The bents are supported by 20 in. square piles with eight (8) piles per bent. The extension is an additional 210 ft. long by 80 ft. wide with the bents being supported by 18 in. square precast, prestressed piles. The lateral support is provided by precast concrete batter piles. Through the length of the pier, there are two (2) batter piles per bent except for the end of the addition, where there are four (4) batter piles per bent. There are approximately 858 plumb piles and 216 batter piles total.

A mooring dolphin is located approximately 150 ft. west of the pier. The dolphin is supported by forty-eight (48) 24 in. square precast, prestressed concrete vertical and batter piles total.

2.1.3 Pier 3

Pier 3 is a typical concrete pile and deck pier. The pier is approximately 1100 ft. long by 150 ft. wide. The reinforced concrete slab is 26 in. thick at the outboard region thinning to 10 in. thick at the center. The deck is supported by 18 in. square precast concrete piles with 28 in. square jackets covering the top 13 feet. Rows of nineteen (19) and nine (9) piles alternate every six feet along the length of the pier. There are batter piles at every bent to support berthing loads with an approximate total of 3000 concrete files.

3. INSPECTION METHODOLOGY

The inspection of the piers at Alameda point consisted of both above water and underwater inspections of Piers 1, 2, and 3. The following was the complete scope of inspection:

Pier 1:

- Above water inspection of all king piles and concrete panels
- Topside inspection of deck, curb, and all mooring hardware
- Level I underwater inspection of all king piles and concrete panels
- Level II underwater inspection of 4 king piles and at every 100 ft of the concrete panels
- Level III underwater inspection consisting of ultrasonic thickness measurements of the king piles at 16 locations

Pier 2:

- Above water inspection of all concrete piles, deck soffit, and pile caps
- Topside inspection of deck, curb, and all mooring hardware
- Level I underwater inspection of all concrete piles
- Level II underwater inspection of approximately 20% of all concrete piles (214 piles)
- Level III underwater inspection consisting of extracting concrete cores from 11 piles, at 3 locations at each pile (3 ft below mudline, at mid-water level, and at the waterline)

Pier 3:

- Above water inspection of the piles observable from the outside of the wharf, deck soffit, and pile caps
- Topside inspection of deck, curb, and all mooring hardware
- Level III underwater inspection consisting of extracting concrete cores from 1 pile, at 3 locations (3 ft below mudline, at mid-water level, and at the waterline)

All inspection work was conducted in accordance with ASCE Standard Practice Manual No. 101, “Underwater Investigations” as well as Manual of Practice No. 130, “Waterfront Facilities Inspection and Assessment”. The above water and underwater structural inspection of the piers was conducted in the period between July and December 2016.

4. INSPECTION RESULTS

A summary of the inspection results for the different components of the piers is presented in the following. Details of the condition and the results can be found in the pictures in Appendix A, the figures in Appendix B and the Underwater Inspection Report in Appendix C.

4.1 Pier 1

4.1.1 Steel King Piles

The steel king piles are in overall fair condition with minor to moderate coating loss and surface corrosion. The coating loss and surface corrosion is concentrated in a 2-3 ft wide band around the high water line (Photo 1).

4.1.2 Concrete Panels

The concrete panels are generally in satisfactory condition with only minor cracking (Photo 2).

4.1.3 Deck and Pile Caps

The concrete deck at Pier 1 is in overall satisfactory condition. The deck shows hairline cracks throughout most parts of the deck, but these can most probably be attributed to shrinkage (Photo 3). The pile cap connecting the king piles is in overall fair condition, with the lip overhanging the king piles and concrete infill panels being broken off in several locations (Photo 4). This damage can be considered to be mostly cosmetic.

4.1.4 Mooring Hardware

The mooring hardware at Pier 1 is in fair to good condition. Most of the mooring hardware itself is in good condition with minor instances of coating loss and corrosion. The bases show minor to moderate deterioration, with the most common defect being that concrete on the land side of the cleats and bollards often is spalled off (Photo 5). This deterioration does not have much, if any, direct impact of the capacity of the mooring hardware. There are two new bollards installed at Pier 1, and these bollards are in good condition with no signs of deterioration (Photo 6). The detailed ratings of the inspection of the mooring hardware are presented in Table 1.

Table 1 – Pier 1 Mooring Hardware Ratings

				Rating		
Station	Location	Mooring Type	In Use	Mooring Equipment	Mooring Base	Note:
7+38	N	Bollard	-	MN	MN	New
7+18	S	Bollard	-	MN	MD	
7+00	S	Cleat	-	MN	MN	
6+66	N	Cleat	-	MN	MN	
6+40	S	Bollard	Y	MN	MD	
6+14	S	Cleat	Y	MN	MD	
5+88	N	Cleat	-	MN	MN	
5+61	S	Bollard	-	MN	MD	
5+40	S	Cleat	-	MN	MN	
5+10	N	Cleat	-	MN	MD	
4+84	N	Cleat	-	MN	MN	
4+87	S	Bollard	-	MN	MD	
4+56	S	Cleat	-	MN	MN	
4+38	S	Bollard	-	MN	MD	
4+32	N	Cleat	-	MN	MD	
4+06	N	Cleat	-	MN	MN	
3+79	S	Cleat	-	MN	MN	
3+53	N	Cleat	-	MN	MN	
3+28	N	Bollard	-	MN	MD	
3+28	S	Bollard	Y	MN	MD	
3+00	S	Cleat	Y	MN	MN	
2+76	N	Cleat	-	MN	MN	
2+50	S	Bollard	-	MN	MD	
2+23	S	Cleat	-	MN	MN	
2+00	N	Cleat	-	MN	MN	
1+71	S	Bollard	Y	MN	MD	
1+46	S	Cleat	-	MN	MN	
1+42	S	Bollard	Y	MN	MD	New

Location: N – North, S – South, Ratings: MN – Minor, MD – Moderate, MJ – Major, S - Severe

4.1.5 Curbs

The curbs at Pier 1 are in overall satisfactory condition with a few isolated areas of open and closed spalling (Photo 7).

4.1.6 Sheet Pile Wall

The sheet pile wall between the Pier and the marginal wharf is in poor condition due to extensive corrosion with multiple areas of complete section loss (Photo 8).

4.2 Pier 2

4.2.1 Piles

The condition of Pier 2 varies greatly along the length of the Pier, with the outer, newer portion from Bent 1 through 18 being in good condition, Bents 19-54 being in serious to critical condition, and Bents 54 through 102 being in Fair condition.

The piles at the original part of Pier 2 between Bents 19 and 54 are overall in serious to critical condition. Two major types of damage have been discovered during the inspection.

The most widespread type of damage was observed during the underwater inspection as well as during the parts of the above water inspection that were conducted during low tide levels. This damage seems to be due to a combination of chemical attack and alkali-silica reaction, resulting in softening of the concrete, saltwater ingress, and finally corrosion of the reinforcing steel. This damage is observed throughout the pier, but with the worst damage observed between Bents 19 and 54 of the original pier. This damage is described in more detail in the underwater inspection report and is supported by the concrete testing that was done on 11 piles at Pier 2. For this testing 3 cores were extracted from each pile. The details from the testing of the concrete are contained in the concrete testing report. In summary, the piles suffer from a combination of alkali –silica reaction, sulfate attack, and chloride ingress with following corrosion of reinforcing steel.

In addition, several piles towards the end of the original pier (Bent 19) show damage related to corrosion of reinforcing steel in the splash zone. Over time chlorides from the salt water have migrated through the concrete to the reinforcing steel, initiating corrosion. Once corrosion starts, the piles will over time develop cracks and subsequent spalls. The piles exhibit various stages of this type of damage (Photo 9 through Photo 13).

The piles of the newer extension of the pier (Bents 1 through 18) are generally in good condition with little or no signs of deterioration.

4.2.2 Soffit and pile caps

The soffit and pile caps at Pier 2 are in overall satisfactory condition with only a few isolated instances of corrosion related damage. It should be noted that the pile caps have been cut out at several locations adjacent to manholes that give access to the utility trench that runs the entire length of the pier, causing a discontinuity in the pile cap at these bents.

4.2.3 Deck

The concrete deck at Pier 2 is in overall satisfactory condition (Photo 14). The deck shows hairline cracks throughout most parts of the deck, but these can be attributed to shrinkage and the age of the pier. There are also limited areas of delamination and spalling at the deck, often located around expansion or construction joints in the deck (Photo 15).

4.2.4 Mooring hardware

The mooring hardware at Pier 2 ranges from fair to serious condition. Most of the cleats and bollards are in fair to good condition with minor to moderate instances of coating loss and corrosion (Photo 16). One cleat is rated Serious as it is broken (Photo 17). The bases of 10 out of 73 pieces of mooring hardware is rated Serious due to spalling and corrosion of the confining reinforcing steel of the outboard edge of the base (Photo 18). Otherwise the bases show minor to moderate deterioration.

There are three new bollards installed at Pier 2. These are all in good condition with no significant signs of deterioration or wear (Photo 19). The detailed ratings of the inspection of the mooring hardware are presented in Table 2.

Table 2 – Pier 2 Mooring Hardware Ratings

				Rating		
Bent	Location	Mooring Type	In Use	Mooring Equipment	Mooring Base	Note:
1-2	A	Bollard	Y	MN	MN	
1-2	D-E	Bollard	-	MN	MN	
1-2	H	Bollard	-	MN	MD	
3-4	A	Cleat	-	MN	MN	
3-4	H	Cleat	Y	MN	MN	
6-7	A	Cleat	-	MN	MN	
7-8	H	Cleat	Y	MN	MD	
10-11	A	Bollard	Y	MN	MN	

				Rating		
Bent	Location	Mooring Type	In Use	Mooring Equipment	Mooring Base	Note:
11-12	H	Bollard	-	MN	MD	
12-13	A	Cleat	-	MN	MN	
13-14	H	Cleat	-	MN	MN	
14-15	A	Bollard	Y	MN	MD	
16-17	A	Cleat	-	MN	MN	
17-18	H	Cleat	-	MN	MN	
20-21	A	Bollard	Y	MN	MD	
20-21	H	Bollard	-	MN	MN	
23-24	A	Cleat	Y	MD	MN	
23-24	H	Cleat	-	MN	MN	
26-27	A	Cleat	-	MN	MN	
26-27	H	Cleat	-	MN	MN	
29-30	A	Bollard	-	MN	MN	
29-30	H	Bollard	Y	MN	MN	
32-33	A	Bollard	-	MN	MN	New
32-33	H	Cleat	-	MN	MD	
35-36	A	Bollard	Y	MN	MN	New
35-36	H	Cleat	-	MN	MN	
38-39	A	Bollard	Y	MN	S	Avoid/Repair
38-39	H	Bollard	Y	MN	S	Avoid/Repair
41-42	A	Bollard	-	MN	MN	New
41-42	H	Cleat	-	S	S	Avoid/Repair
44-45	A	Cleat	-	MN	MD	
44-45	H	Cleat	-	MN	MN	
45	H	Bollard	Y	MN	MN	New
46	H	Bollard	Y	MN	MN	New
47-48	A	Bollard	-	MN	MN	
47-48	H	Bollard	Y	MN	MN	
50-51	A	Cleat	-	MN	MN	
50-51	H	Cleat	Y	MN	MN	
53-54	A	Cleat	-	MN	MN	
53-54	H	Cleat	-	MN	MD	
56-57	A	Bollard	-	MN	MN	
56-57	H	Bollard	Y	MN	MN	
59	H	Cleat	-	MN	MN	
59-60	A	Cleat	-	MN	MN	
62	H	Cleat	-	MN	MN	
62-63	A	Cleat	-	MN	MN	
65	H	Bollard	Y	MN	MN	
65-66	A	Bollard	-	MN	MD	

				Rating		
Bent	Location	Mooring Type	In Use	Mooring Equipment	Mooring Base	Note:
68	H	Cleat	-	MN	MN	
68-69	A	Cleat	-	MN	MN	
71	H	Cleat	-	MN	MN	
71-72	A	Cleat	-	MN	S	
74	H	Bollard	-	MN	S	
74-75	A	Bollard	-	MN	MN	
77	H	Cleat	-	MN	S	
77-78	A	Cleat	-	MN	S	
80-81	A	Cleat	Y	MN	MD	
80-81	H	Cleat	Y	MN	S	Avoid/Repair
83-84	A	Bollard	Y	MN	MN	
83-84	H	Bollard	-	MN	MN	
86	H	Cleat	-	MN	MD	
86-87	A	Cleat	-	MN	MN	
89	H	Cleat	Y	MN	MN	
89-90	A	Cleat	Y	MN	MN	
92-93	A	Bollard	-	MN	S	
92-93	H	Bollard	Y	MN	MN	
95	A	Cleat	Y	MN	MD	
95	H	Cleat	Y	MN	MN	
98	A	Cleat	Y	MN	MD	
98	H	Cleat	-	MN	MN	
101	H	Bollard	Y	MN	MN	
103-104	H	Cleat	-	MN	MN	
105-106	H	Bollard	Y	MN	S	Avoid/Repair

Location: A - Pile line A, H – Pile Line H, Ratings: MN – Minor, MD – Moderate, MJ – Major, S - Severe

4.2.5 Curbs

The curbs at Pier 2 are in fair to poor condition. About 20% of the length of the curb around the wharf has large cracks and open spalls, mainly due to corrosion of embedded reinforcing steel and conduit in the curbs (Photo 20). The curb deterioration has no structural significance with the exception of the cases where the spalling extends in front of mooring points.

4.3 Pier 3

4.3.1 Piles

Approximately 800 piles were inspected during the above water inspection of Pier 3. Most of these piles were observed from the outside of the pier. Due to the pile extensions present on this pier, very few piles could be inspected to include any parts of the concrete pile that extends down to the mudline. Overall, the inspected piles are in fair to satisfactory condition. Out of the inspected piles, 29 are rated Major or Severe, mostly due to deterioration of the upper pile extensions (Photo 21 and Photo 22).

4.3.2 Soffit

With the exception of the edge of the deck soffit, the deck soffit at Pier 3 is on overall fair condition with little or no signs of damage apart from hairline cracks with efflorescence in the soffit under the pier (Photo 23). There is widespread cracking and spalling including exposed reinforcing steel of the lower edge of the face of the deck (Photo 24).

4.3.3 Deck

The concrete deck at Pier 3 is in overall satisfactory condition. The deck shows hairline cracks throughout most parts of the deck, but these can most probably be attributed to shrinkage and the age of the pier.

4.3.4 Mooring hardware

The mooring hardware at Pier 3 is overall in fair to poor condition. Most of the actual mooring fittings are rated Minor with minor to moderate instances of coating loss and corrosion (Photo 25). The bases of 17 out of 75 pieces of mooring hardware are rated Severe due to spalling and corrosion of the confining reinforcing steel of the outboard edge of the base (Photo 26 and Photo 27). Otherwise the bases show minor to moderate deterioration. The detailed ratings of the inspection of the mooring hardware are presented in Table 3.

Table 3 – Pier 3 Mooring Hardware Ratings

				Rating		
Bent	Pile Line	Mooring Type	In Use	Mooring Equipment	Mooring Base	Note:
1	C	Bollard	-	MN	S	
1	H	Cleat	-	MN	MN	
1	L	Cleat	-	MN	MD	
1	Q	Bollard	-	MN	S	
2-3	A	Bollard	-	MN	MD	
2-3	S	Bollard	-	MN	MD	
5-6	A	Cleat	-	MN	Mn	
5-6	S	Cleat	-	MN	MD	

				Rating		
Bent	Pile Line	Mooring Type	In Use	Mooring Equipment	Mooring Base	Note:
8-9	A	Cleat	-	MN	MN	
8-9	S	Cleat	-	MN	S	
11-12	A	Bollard	Y	MN	MN	
11-12	S	Bollard	Y	MN	S	Avoid/Repair
14-15	A	Cleat	Y	MN	MN	
14-15	S	Cleat	Y	MN	MN	
17-18	A	Cleat	Y	MN	MN	
17-18	S	Cleat	Y	MN	MN	
20-21	A	Bollard	Y	MN	S	Avoid/Repair
20-21	S	Bollard	Y	MN	MD	
23-24	A	Cleat	Y	MN	MN	
23-24	S	Cleat	-	MN	MN	
26-27	A	Cleat	-	MN	S	
26-27	S	Cleat	-	MN	MN	
29-30	A	Bollard	Y	MN	MN	
29-30	S	Bollard	Y	MN	S	Avoid/Repair
32-33	A	Cleat	Y	MN	MN	
32-33	S	Cleat	Y	MN	S	Avoid/Repair
35-36	A	Cleat	-	MN	MN	
35-36	S	Cleat	-	MN	MN	
38-39	A	Bollard	Y	MN	S	Avoid/Repair
38-39	S	Bollard	Y	MN	S	Avoid/Repair
41-42	A	Cleat	-	MN	MD	
41-42	S	Cleat	-	MN	MN	
44-45	A	Cleat	-	MN	MN	
44-45	S	Cleat	-	MN	MN	
47-48	A	Bollard	-	MN	MD	
47-48	S	Bollard	-	MN	S	
50-51	A	Cleat	-	MN	MN	
50-51	S	Cleat	-	MN	MN	
53-54	A	Cleat	-	MN	MN	
53-54	S	Cleat	-	MN	MN	
56-57	A	Bollard	Y	MN	MN	
56-57	S	Bollard	-	MN	S	
59-60	A	Cleat	Y	MN	MN	
59-60	S	Cleat	-	MN	MD	
62-63	A	Cleat	Y	MN	MD	
62-63	S	Cleat	-	MN	MN	
65-66	A	Bollard	Y	MN	MD	
65-66	S	Bollard	Y	MN	MD	

				Rating		
Bent	Pile Line	Mooring Type	In Use	Mooring Equipment	Mooring Base	Note:
68-69	A	Cleat	-	MN	MD	
68-69	S	Cleat	Y	MN	MN	
71-72	A	Cleat	Y	MN	MN	
71-72	S	Cleat	-	MN	MD	
74-75	A	Bollard	Y	MN	MN	
74-75	S	Bollard	-	MN	S	
77-78	A	Cleat	Y	MN	MN	
77-78	S	Cleat	-	MN	MD	
80-81	A	Cleat	-	MN	MN	
80-81	S	Cleat	-	MN	MN	
83-84	A	Bollard	Y	MN	MN	
83-84	S	Bollard	Y	MN	S	Avoid/Repair
86-87	A	Cleat	-	MN	MN	
86-87	S	Cleat	-	MN	MD	
89-90	A	Cleat	-	MN	MN	
89-90	S	Cleat	-	N/A	S	
93-94	A	Bollard	-	MN	MN	
93-94	S	Bollard	-	MD	S	
95-96	A	Cleat	-	MN	MN	
95-96	S	Cleat	Y	MN	MN	
98-99	Wharf	Cleat	-	MN	MN	
98-99	S	Cleat	-	MN	MN	
101-102	S	Bollard	-	MN	MD	
104-105	S	Cleat	-	MD	MN	
108-109	S	Cleat	-	MN	MD	
110-111	S	Bollard	-	MN	S	
113-114	S	Cleat	-	MN	MD	

Location: A - Pile line A, S – Pile Line S, Ratings: MN – Minor, MD – Moderate, MJ – Major, S - Severe

4.3.5 Curbs

The curbs at Pier 3 are in fair to poor condition. About 30% of the length of the curb around the wharf has large cracks and open spalls, mainly due to corrosion of embedded reinforcing steel and conduit in the curbs (Photo 28).

5. CONCLUSIONS AND RECOMMENDATIONS

A summary of the conclusions and recommendations are given below. More detailed recommendations for repair are given in the project report.

5.1 Pier 1

Pier 1 is in overall satisfactory condition, but is in need of maintenance to ensure it retains its intended capacity. The steel king piles should be cleaned and recoated. The sheet pile bulkhead towards the apron is in poor condition and should be repaired to ensure that the structural integrity of the access to the pier is not compromised.

5.2 Pier 2

Pier 2 is in poor to critical condition. There is widespread deterioration of the piles of the pier, especially between Bents 19 and 54. Repairs are necessary to ensure that the structural integrity of the pier is not compromised further and load restrictions of the pier should be considered until repairs have been made. Any mooring hardware rated Severe should not be used until repairs have been made.

5.3 Pier 3

Pier 3 is in overall satisfactory condition based on the areas that were inspected. Only a limited number of piles have been inspected, and there is some deterioration noted at this time. The deterioration is not widespread at the moment. Any mooring hardware rated Severe should not be used until repairs have been made.

Appendix A – Photos

Photo 1 - Typical above water condition of king piles at Pier 1

Photo 2 - Typical condition of concrete panels at Pier 1

Photo 3 - Typical condition of deck at Pier 1

Photo 4 – Spalled lip of pile cap at Pier 1

Photo 5 - Typical condition of mooring bollard and base at Pier 1

Photo 6 - Typical condition new mooring bollard at Pier 1

Photo 7 - Typical condition curb and new mooring bollard at Pier 1

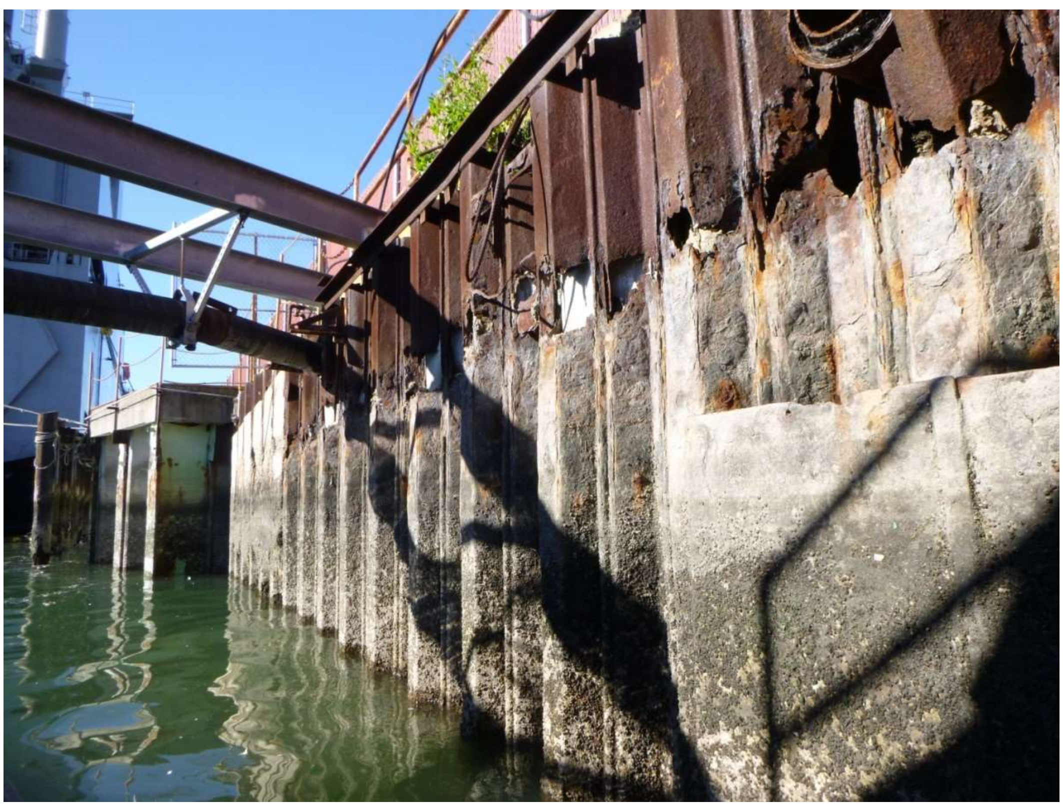


Photo 8 – Deteriorated sheet pile wall at Pier 1

Photo 9 – Pile rated Major due to corrosion spalling at Pier 2

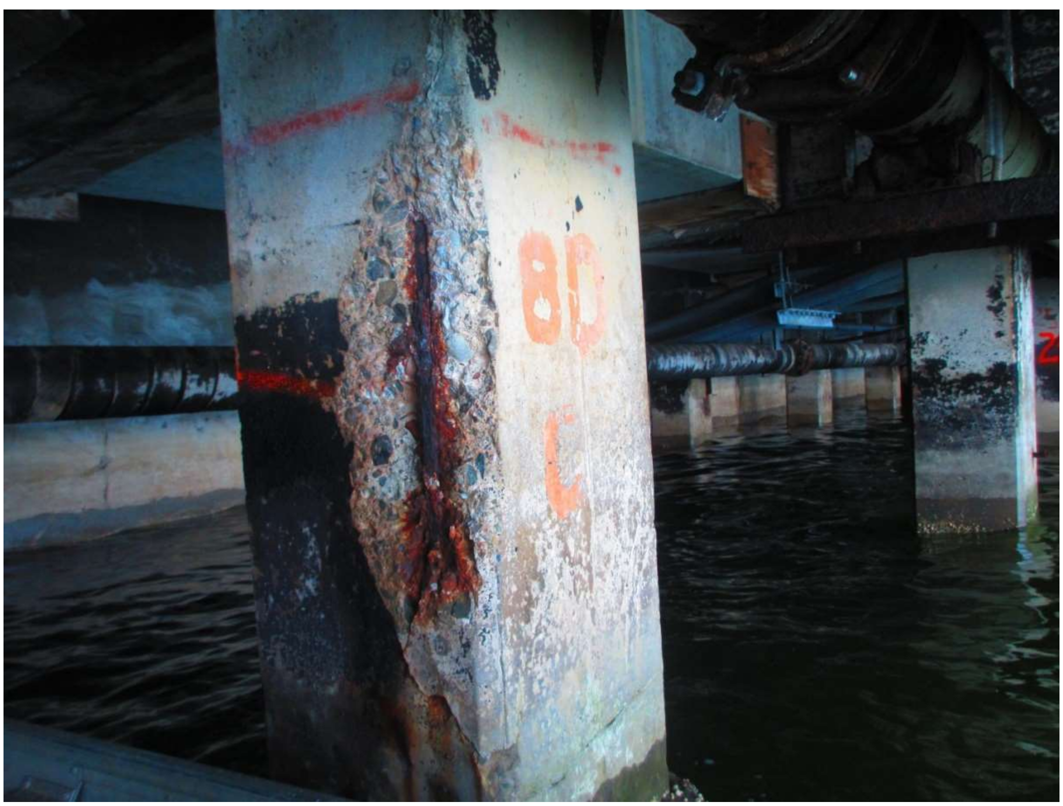


Photo 10 – Pile rated Severe due to corrosion spalling at Pier 2

Photo 11 – Pile rated Severe due to corrosion spalling at Pier 2

Photo 12 – Pile rated Severe due to impact damage at Pier 2

Photo 13 – Pile rated Major due to corrosion spalling at Pier 2

Photo 14 - Typical condition of deck at Pier 2

Photo 15 - Spalling of deck at expansion joint at Pier 2

Photo 16 - Typical condition of mooring bollard and base at Pier 2

Photo 17 – Broken cleat at Pier 2

Photo 18 – Spalling in front of mooring bollard base at Pier 2

Photo 19 – New bollards at Pier 2

Photo 20 – Spalling of curb at Pier 2

Photo 21 – Corrosion cracking of pile extension at Pier 3

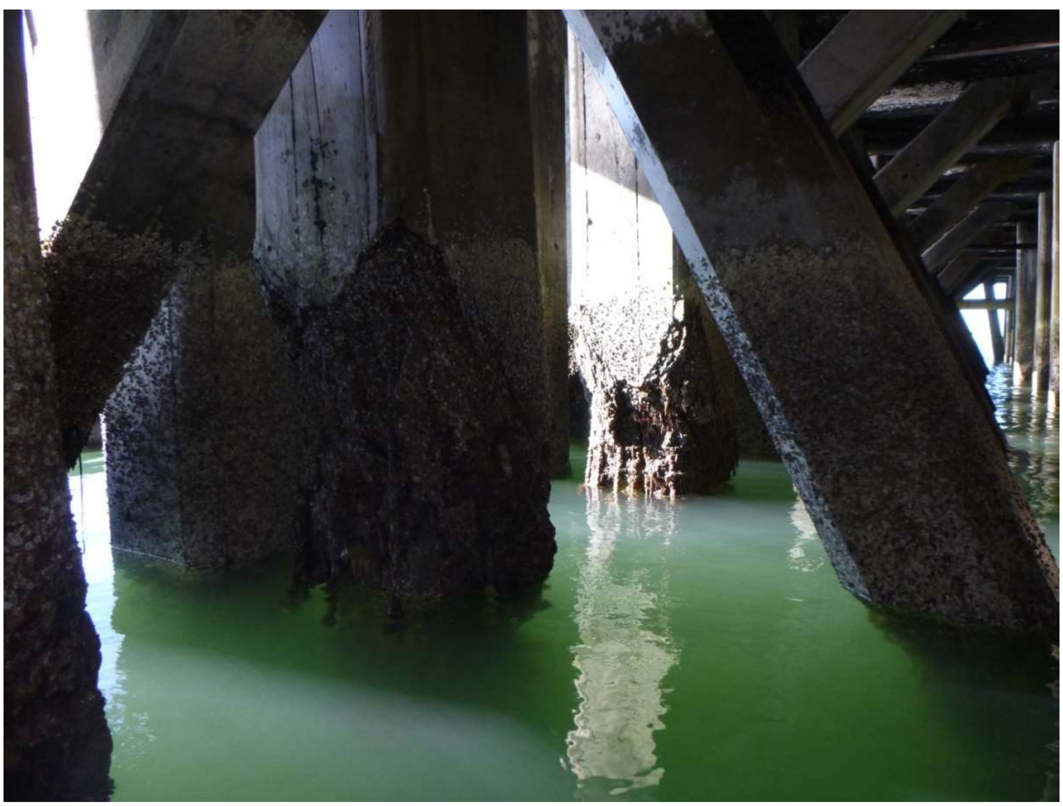


Photo 22 – Deterioration of lower part of pile extension at Pier 3

Photo 23 – Efflorescence at soffit of Pier 3

Photo 24 – Corrosion spalling of deck edge at Pier 3

Photo 25 – Typical condition of mooring hardware at Pier 3

Photo 26 – Corrosion spalling of concrete at mooring hardware at Pier 3


Photo 27 – Corrosion spalling of concrete at mooring hardware at Pier 3

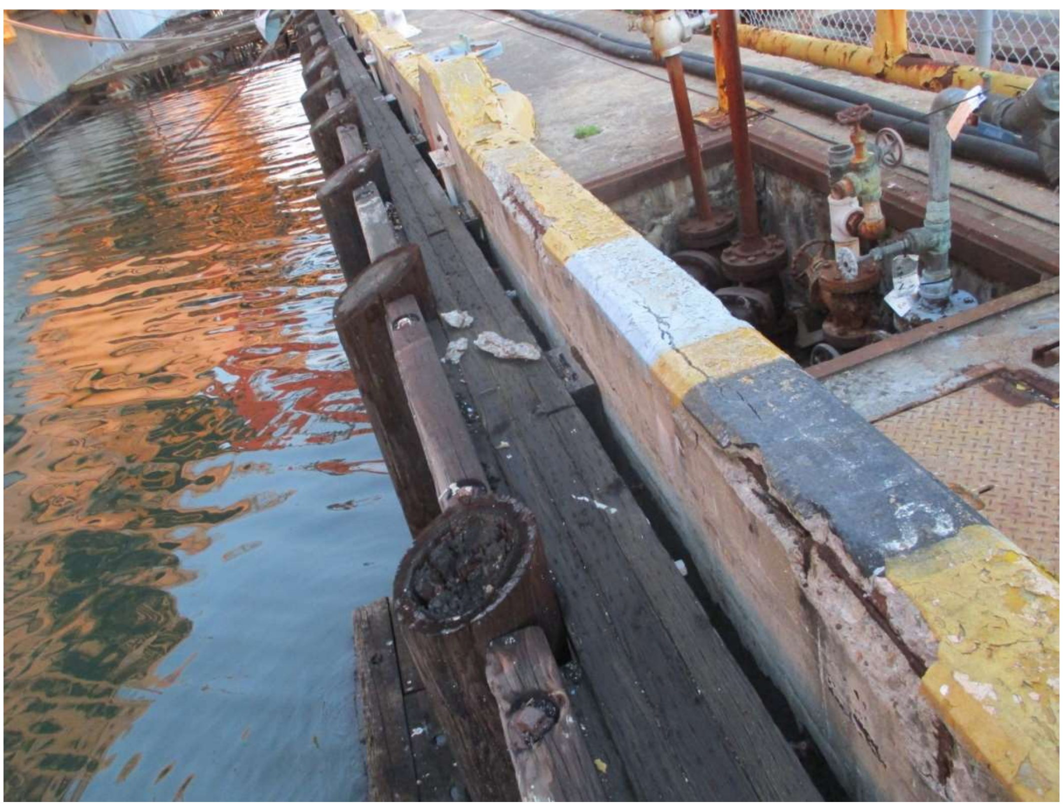


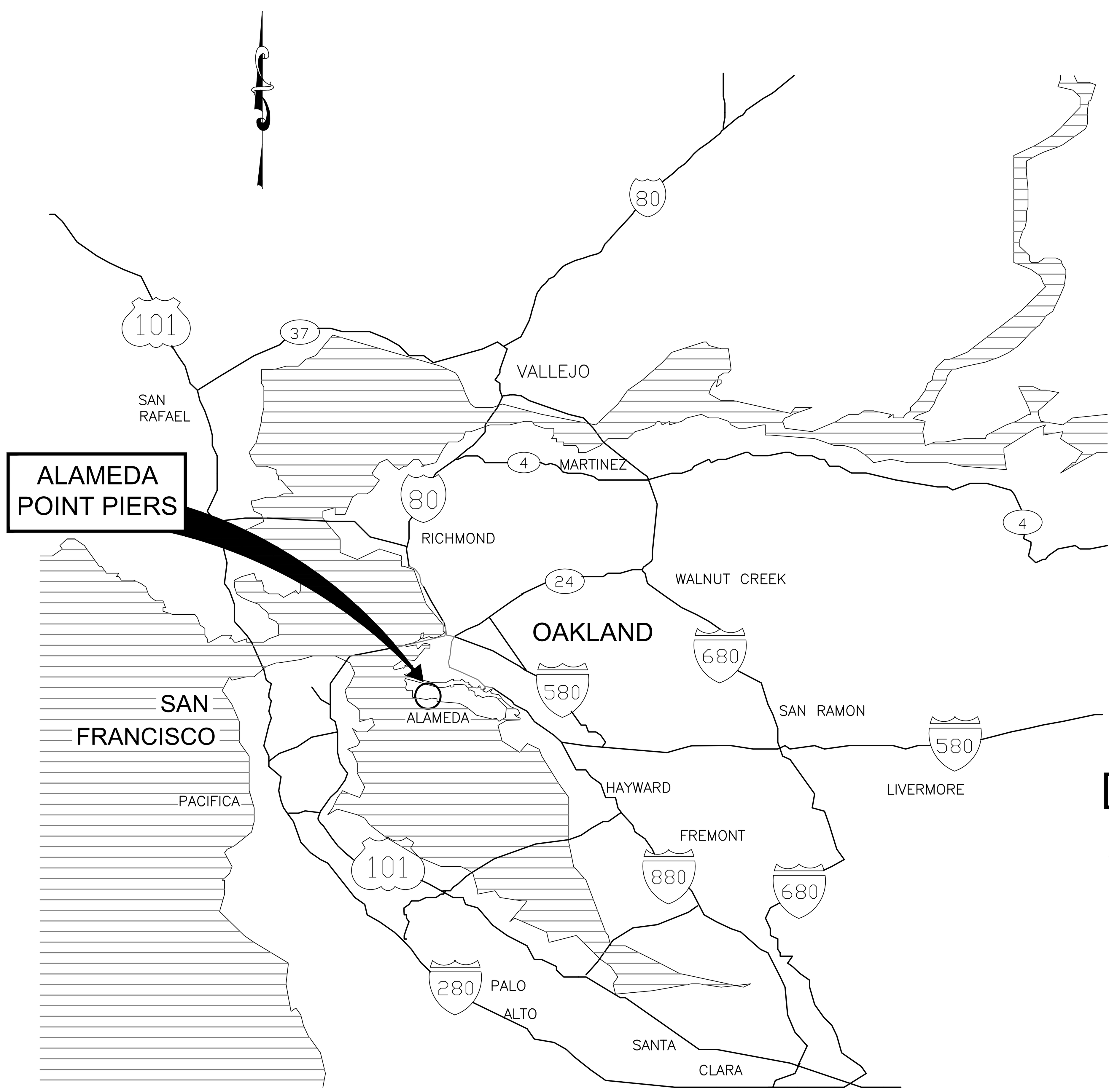
Photo 28 – Corrosion spalling of curb at Pier 3

Appendix B – Figures

ALAMEDA POINT PIERS 1, 2, & 3

STRUCTURAL INSPECTION FINDINGS

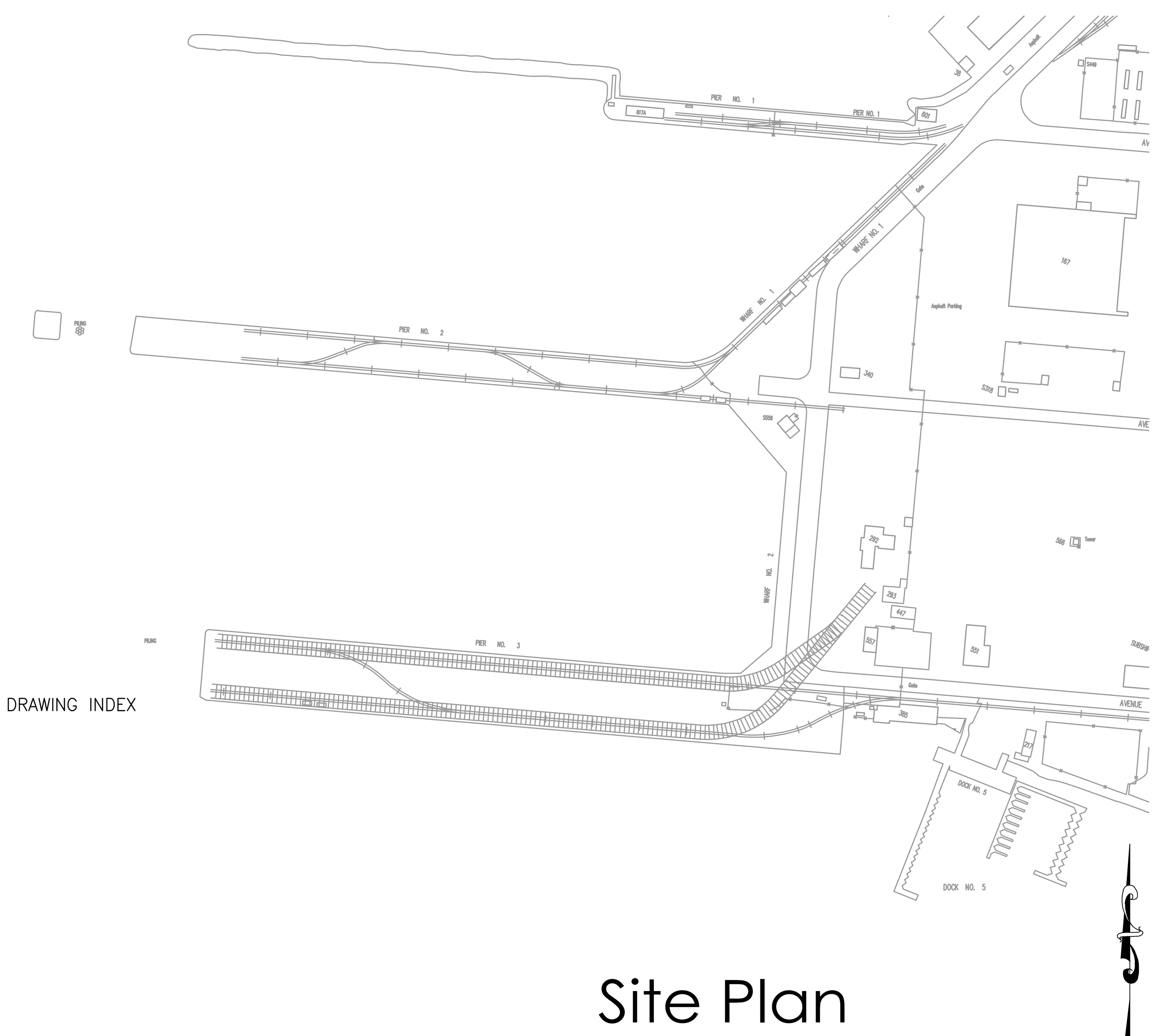
ALAMEDA, CALIFORNIA



Vicinity Map

Drawing Index

DRAWING NO.	SHEET TITLE
G1	TITLE SHEET, VICINITY MAP, SITE MAP, & DRAWING INDEX
P1–01	PIER 1 DECK INSPECTION PLAN
P1–02	PIER 1 PILE INSPECTION PLAN
P1–03	PIER 1 TYPICAL SECTION
P2–01	PIER 2 DECK INSPECTION PLAN
P2–02	PIER 2 PILE INSPECTION PLAN
P2–03	PIER 2 TYPICAL SECTION
P3–01	PIER 3 DECK INPECTION PLAN
P3–02	PIER 3 DECK INSPECTION PLAN
P3–03	PIER 3 PILE INSPECTION PLAN
P3–04	PIER 3 PILE INSPECTION PLAN
P3–05	PIER 3 TYPICAL SECTION



Site Plan

SIMPSON GUMPERTZ & HEGER
Engineering of Structures
and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS
ALAMEDA, CA

Project

TITLE SHEET, VICINITY MAP, SITE MAP & DRAWING INDEX

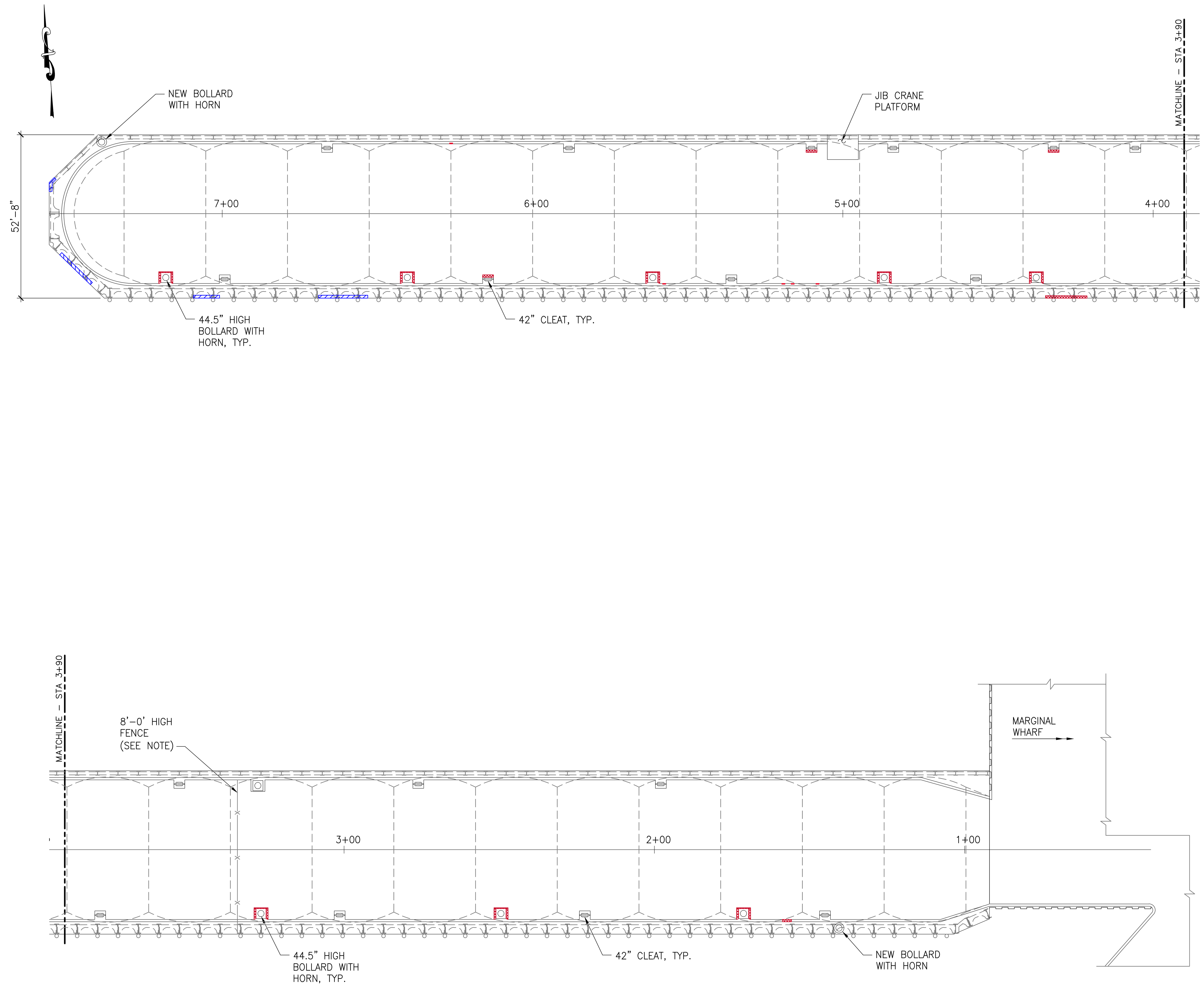
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	NONE

Drawing No.

G1

Seal



LEGEND

- 44.5" HIGH BOLLARD WITH HORN
- 42" CLEAT
- OPEN SPALL
- DELAMINATION
- MOORING HARDWARE RATED SEVERE
- MOORING HARDWARE IN USE RATED SEVERE

GRAPHIC SCALE

30 0 30 60

1" = 30'

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

PIER 1 DECK INSPECTION PLAN

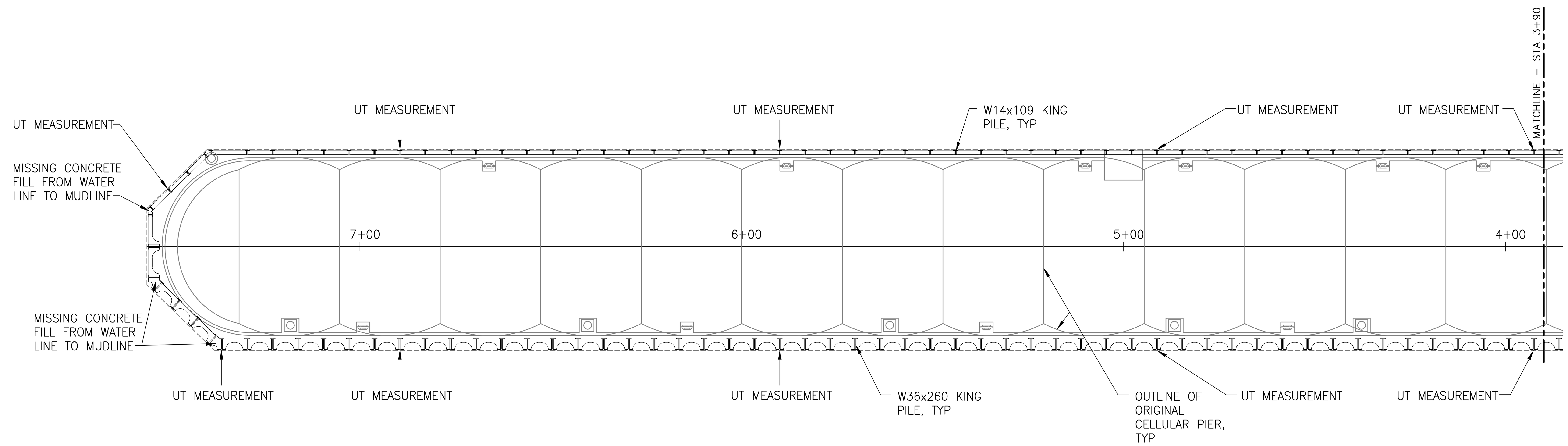
Drawing Title

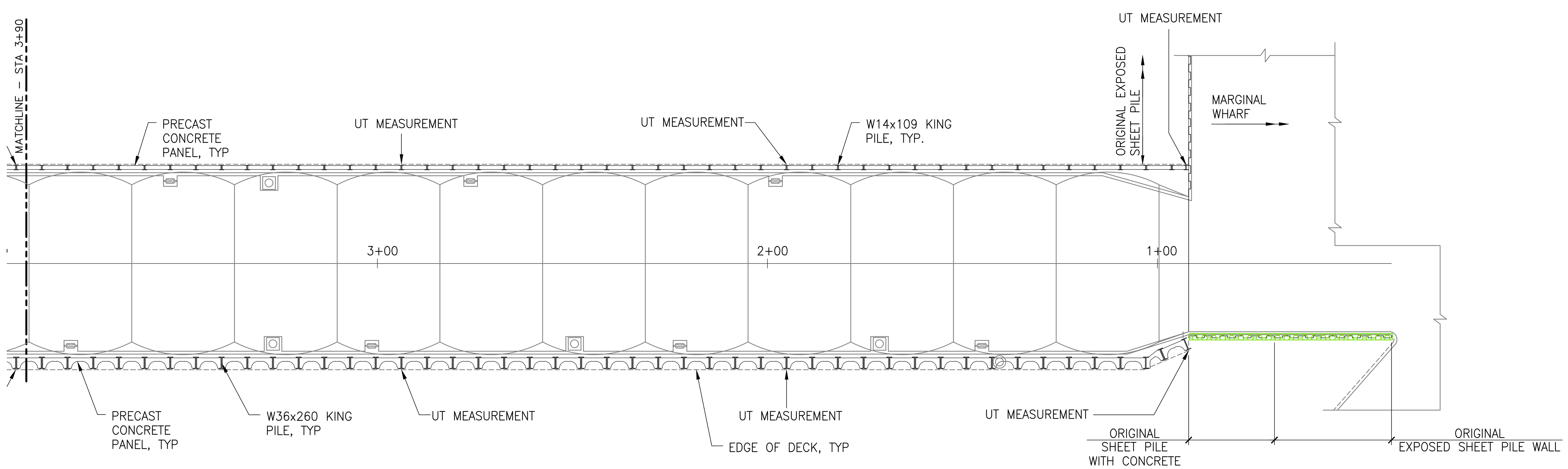
Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

P1-01

Seal





LEGEND

CONCRETE PANELS
RATED SEVERE
STEEL PILE RATED SEVERE
STEEL PILE RATED MAJOR
STEEL PILE RATED MODERATE
CORROSION OF SHEET PILE

NOTES

FENDER PILES NOT SHOWN FOR CLARITY

GRAPHIC SCALE

30 0 30 60

1" = 30'

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

PIER 1 PILE INSPECTION PLAN

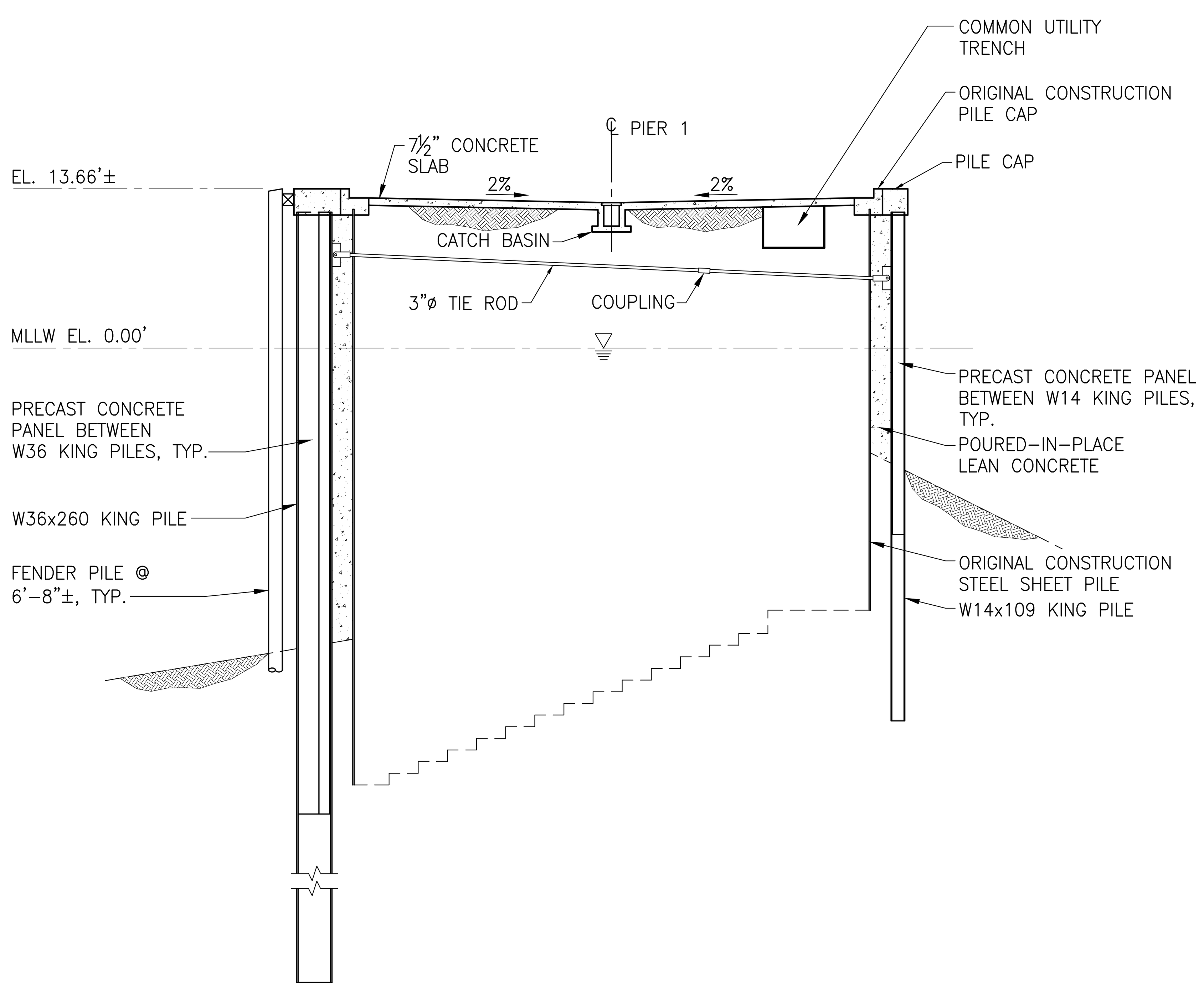
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

P1-02

Seal



5 TYPICAL TRANSVERSE SECTION (LOOKING WEST)

SCALE: 1"=10'-0"

ALPR_P1-03_D01 TYPICAL SECTION

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures
Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com
Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS
ALAMEDA, CA

Project

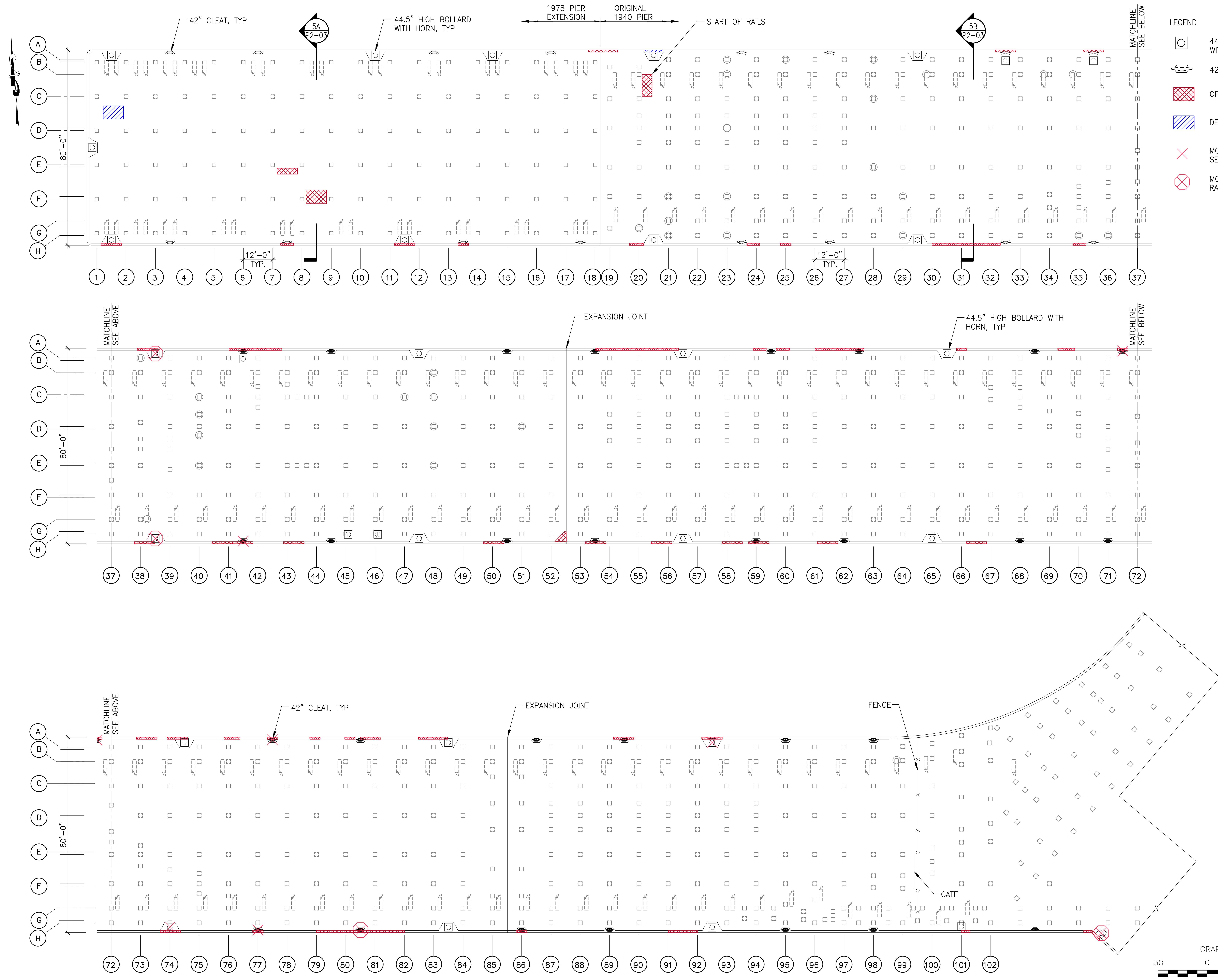
PIER 1 TYPICAL SECTION

Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.
P1-03

Seal



LEGEND

- 44.5" HIGH BOLLARD WITH HORN
- 42" CLEAT
- OPEN SPALL
- DELAMINATION
- MOORING HARDWARE RATED SEVERE
- MOORING HARDWARE IN USE RATED SEVERE

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS
ALAMEDA, CA

Project

PIER 2 DECK INSPECTION PLAN

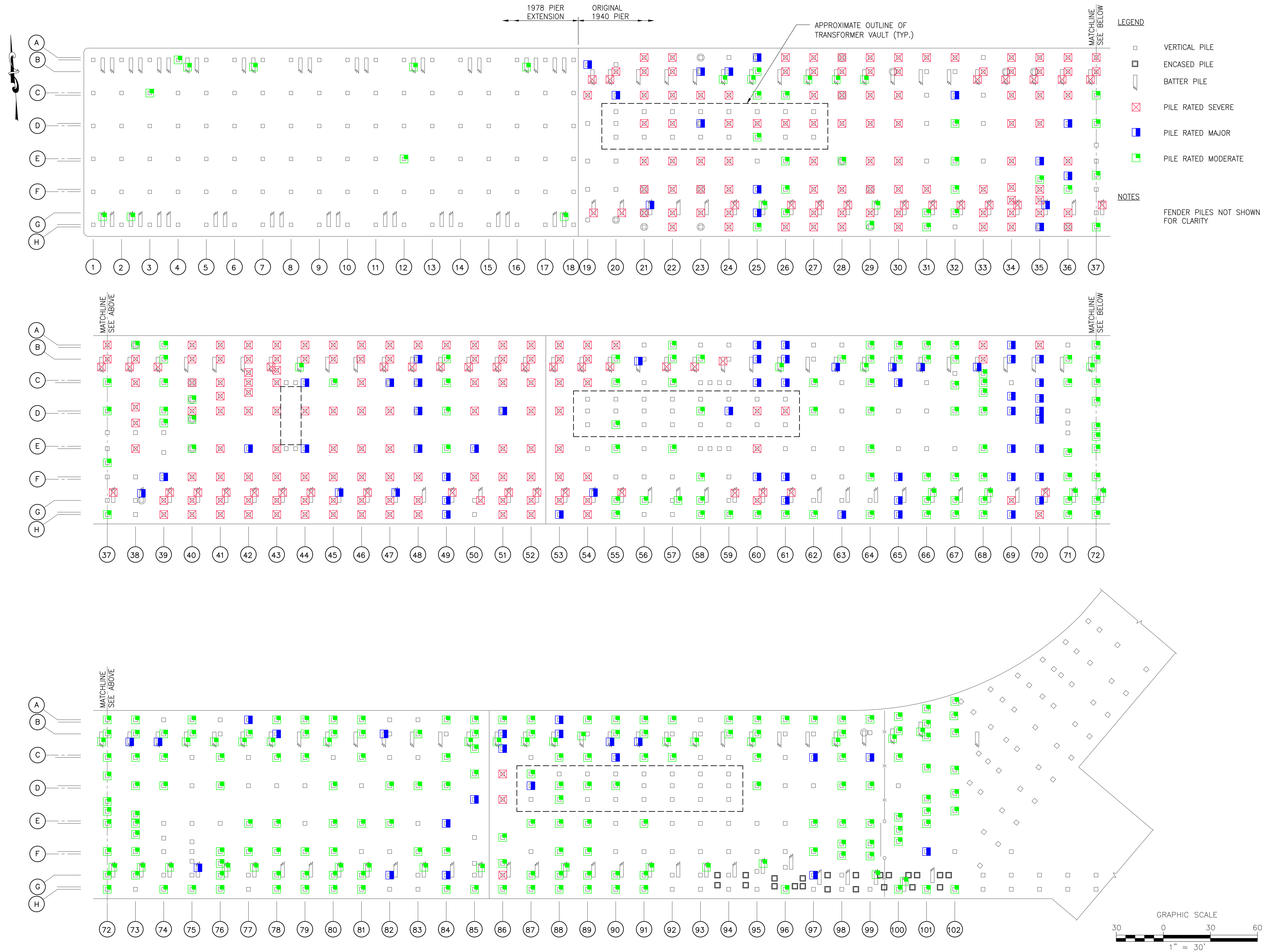
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	**Approved**	**Scale**
JRT	WMB	AS NOTED

Drawing No.

P2-01

Seal



SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures
Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com
Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

PIER 2 PILE INSPECTION PLAN

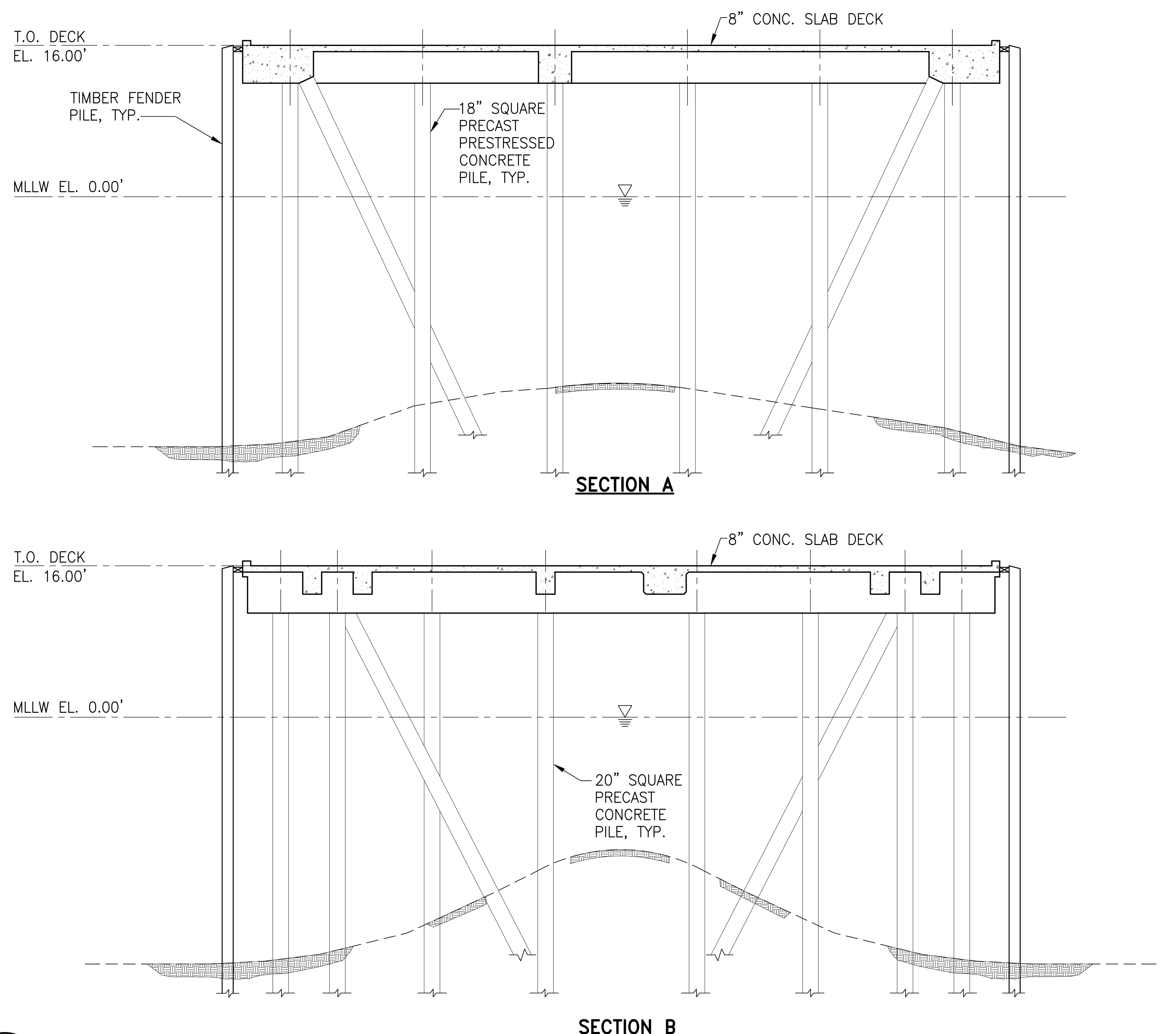
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

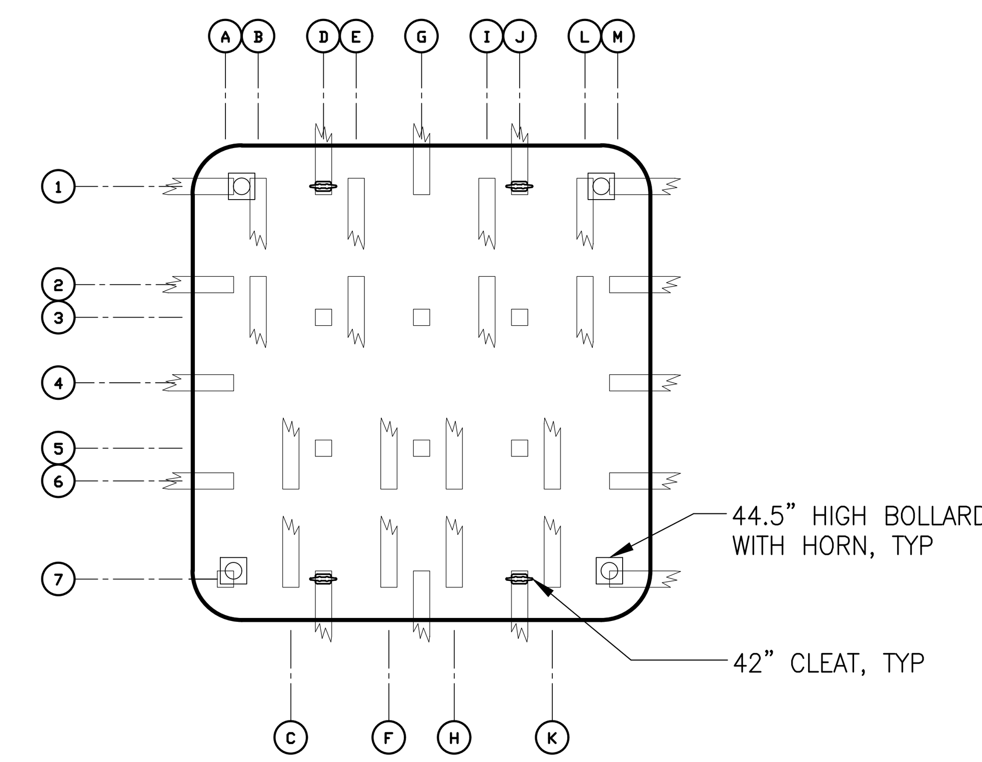
P2-02

Seal



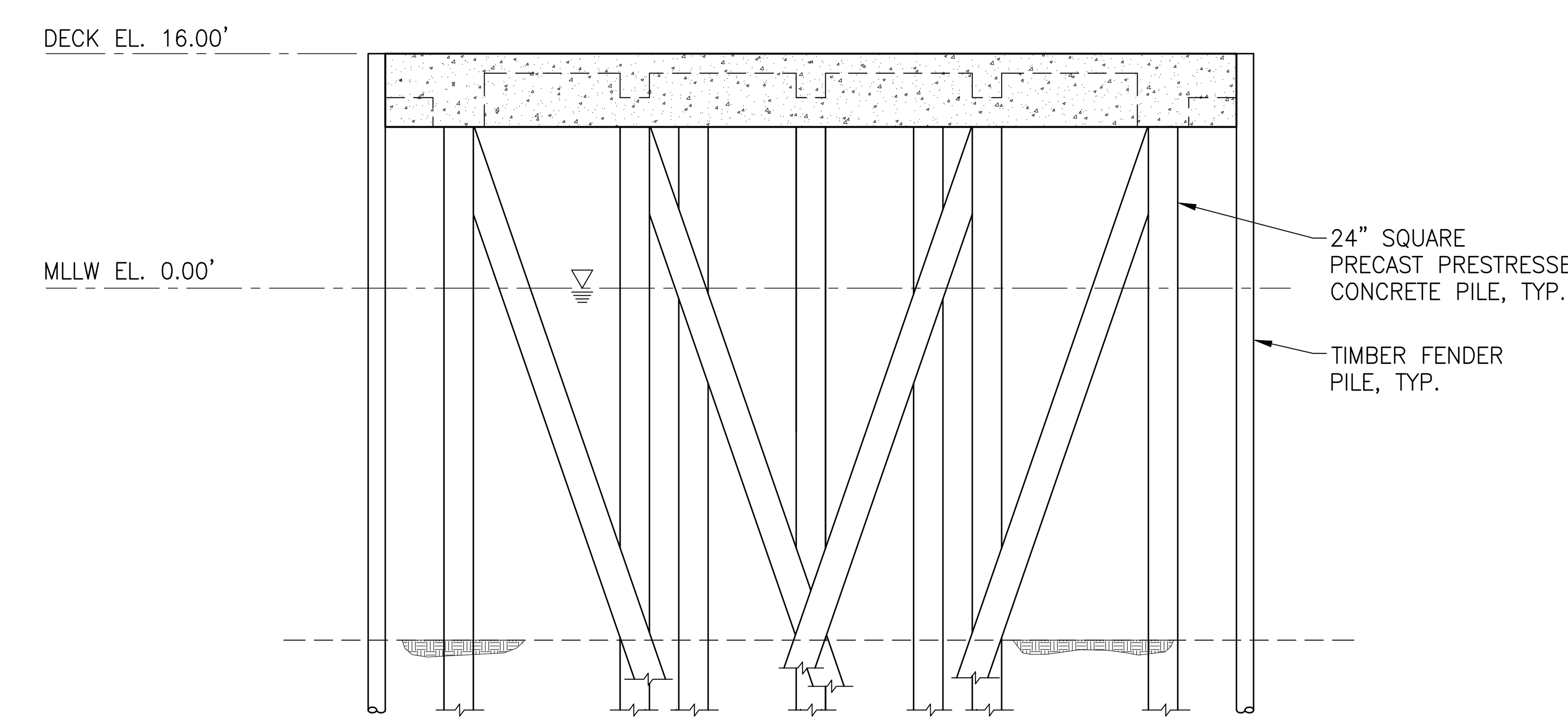
5 TYPICAL SECTION

SCALE: 1"=10'–0"



3 PLAN

SCALE: 1"=20'–0"



7 TYPICAL TRANSVERSE SECTION

SCALE: 1"=10'–0"

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT
PIERS 1, 2, & 3
INSPECTIONS
ALAMEDA, CA

Project

PIER 2
TYPICAL SECTION

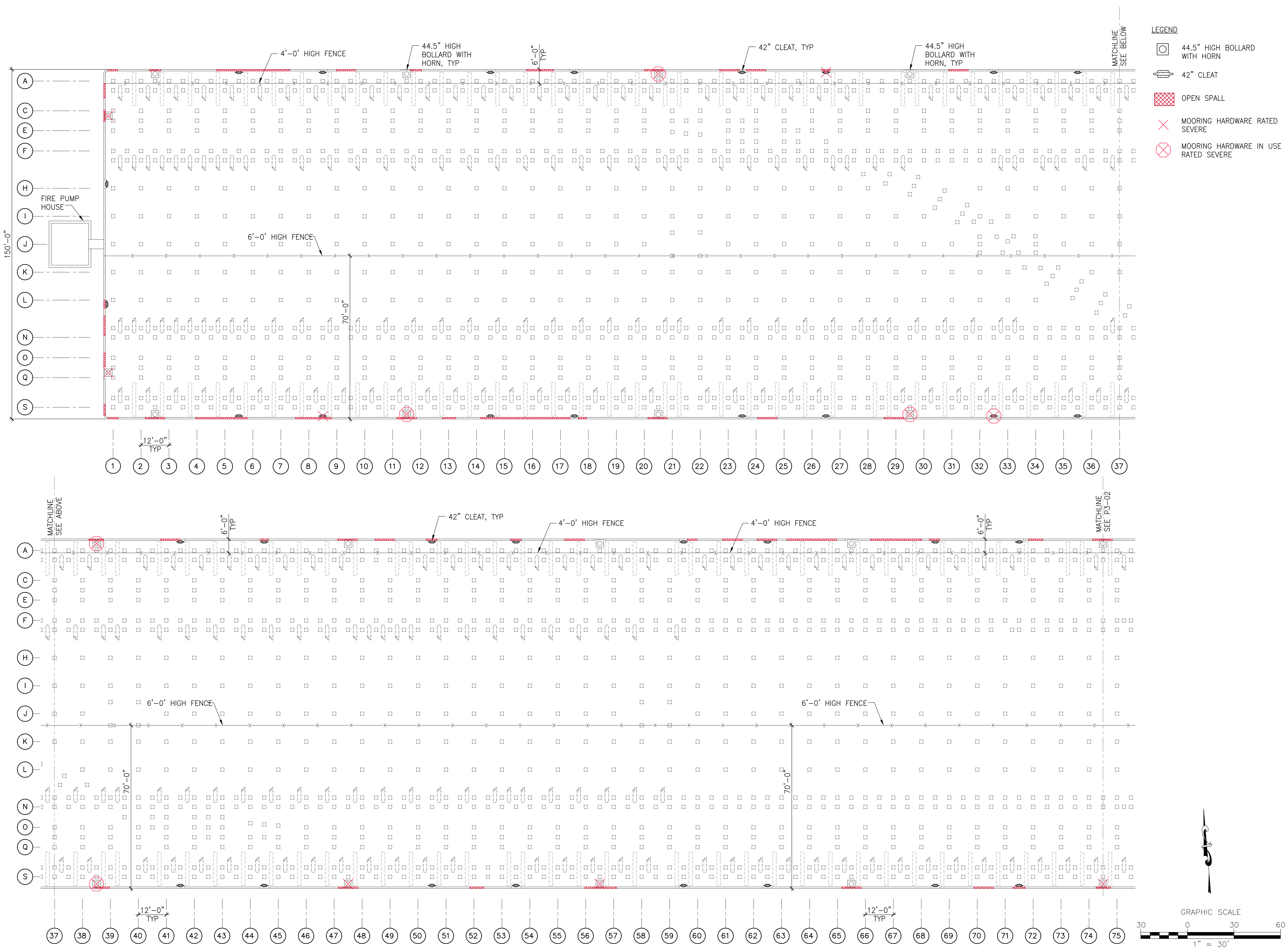
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

P2-03

Seal



SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS
ALAMEDA, CA

Project

PIER 3 DECK INSPECTION PLAN

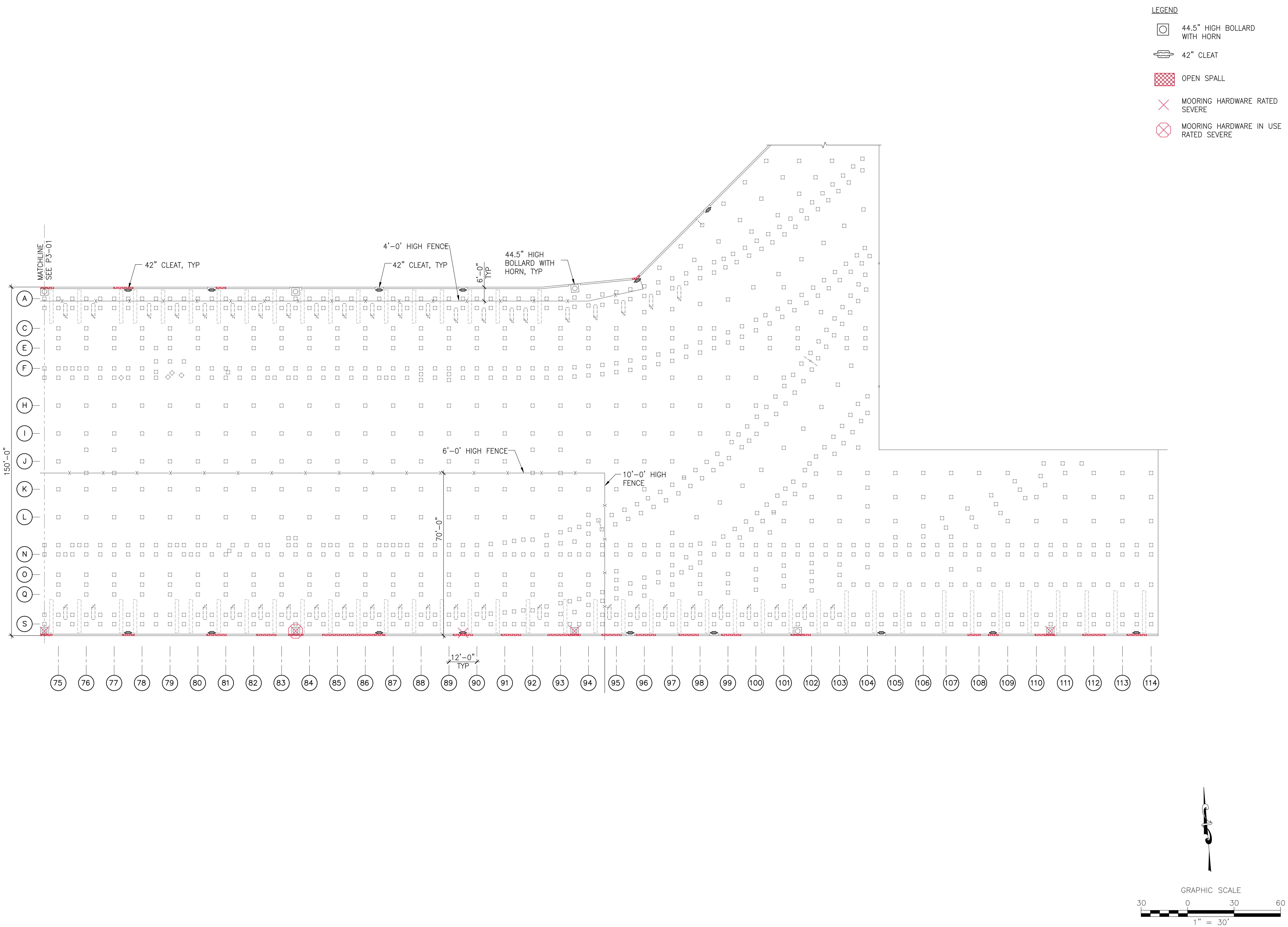
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	**Approved**	**Scale**
JRT	WMB	AS NOTED

Seal

Drawing No.

P3-01



SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

PIER 3 DECK INSPECTION PLAN

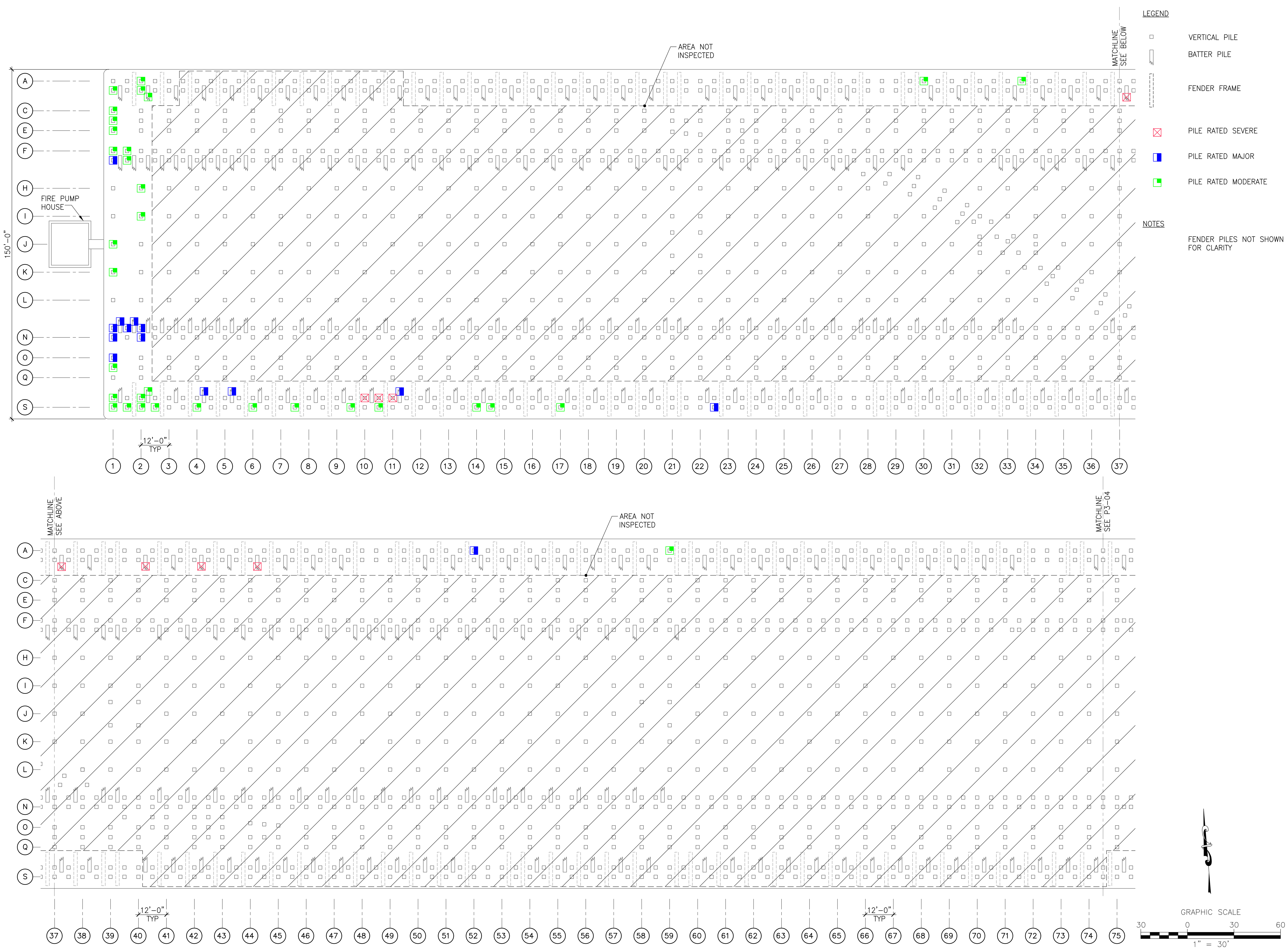
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

P3-02

Seal



SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

PIER 3 PILE INSPECTION PLAN

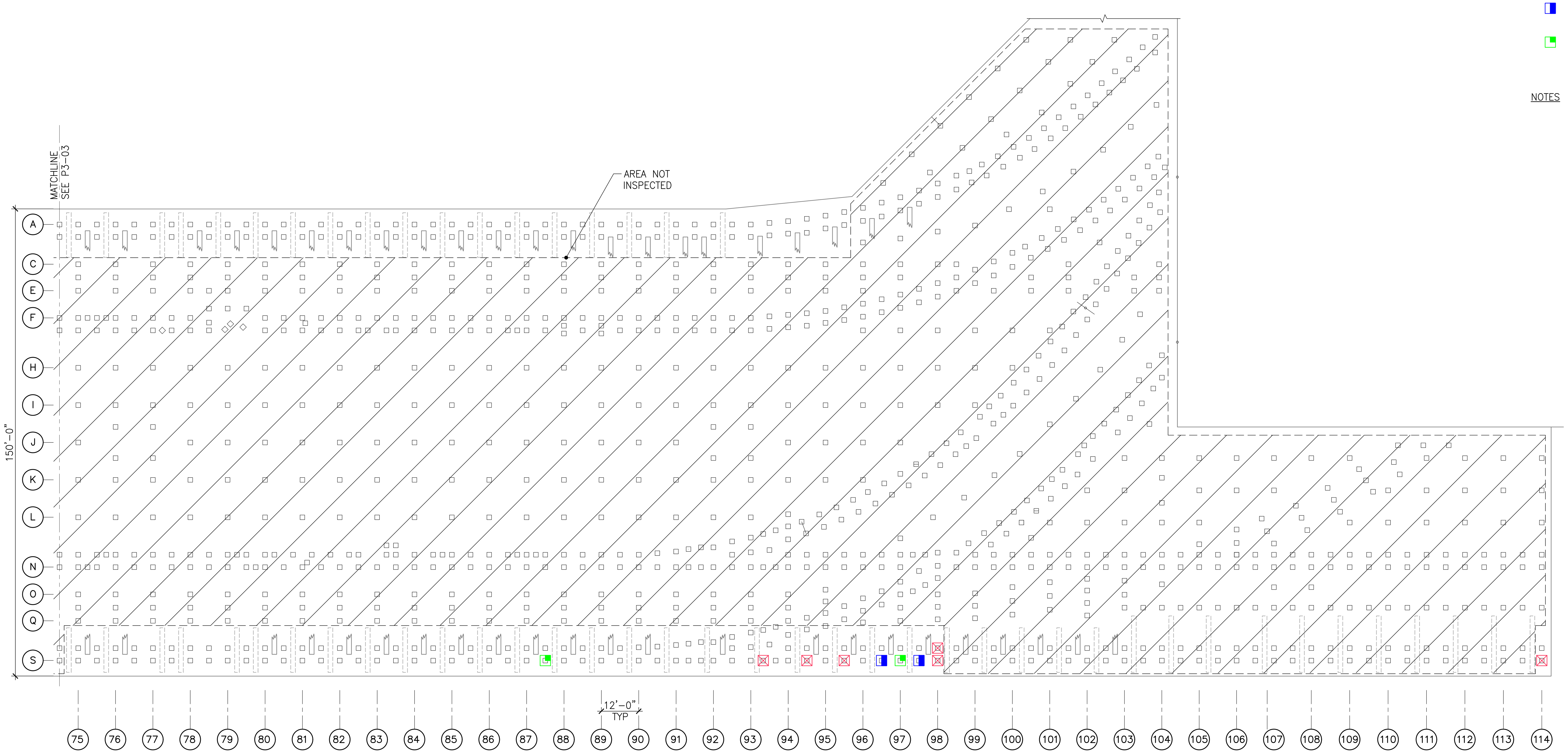
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

P3-03

Seal



LEGEND

- VERTICAL PILE
- BATTER PILE
- FENDER FRAME
- PILE RATED SEVERE
- PILE RATED MAJOR
- PILE RATED MODERATE

NOTES

FENDER PILES NOT SHOWN FOR CLARITY

GRAPHIC SCALE

30 0 30 60

1" = 30'

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

PIER 3 PILE INSPECTION PLAN

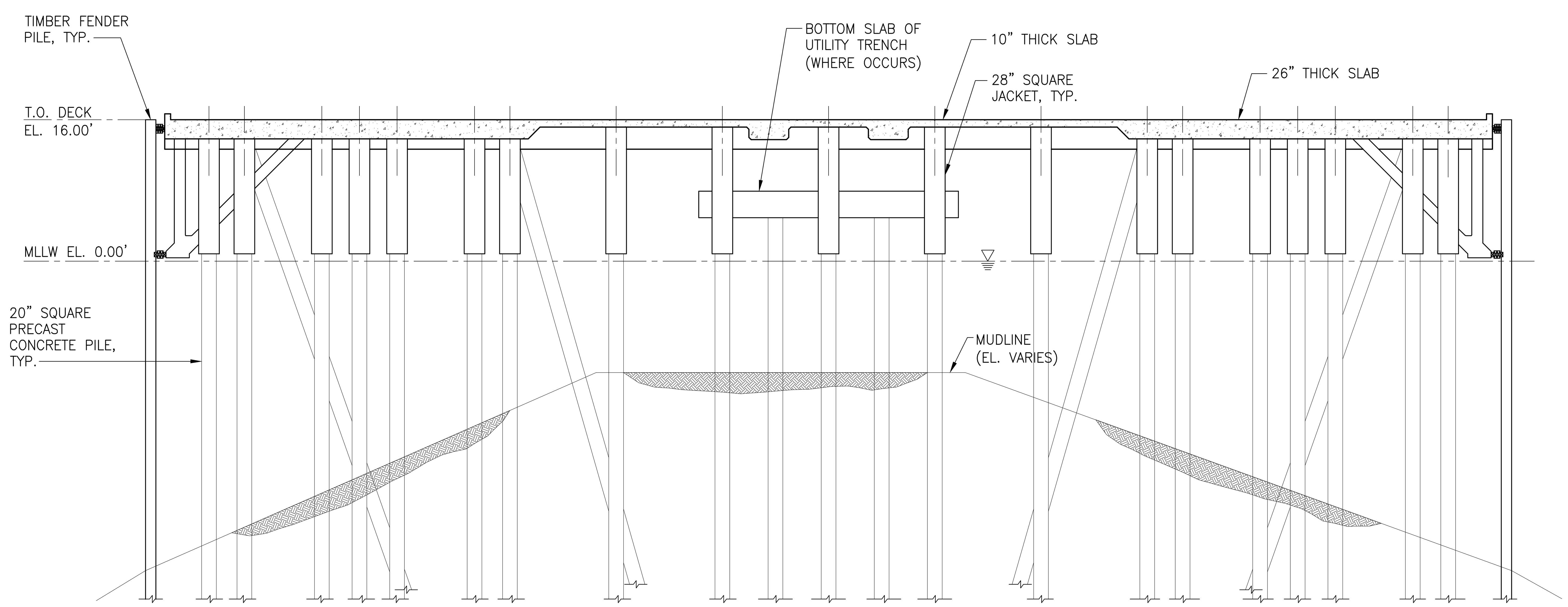
Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

P3-04

Seal



5 TYPICAL TRANSVERSE SECTION (LOOKING WEST)

SCALE: 1"=10'-0"

ALPR_P3-05_001 TYPICAL SECTION

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT
PIERS 1, 2, & 3
INSPECTIONS
ALAMEDA, CA

Project

PIER 3
TYPICAL SECTION

Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	Approved	Scale
JRT	WMB	AS NOTED

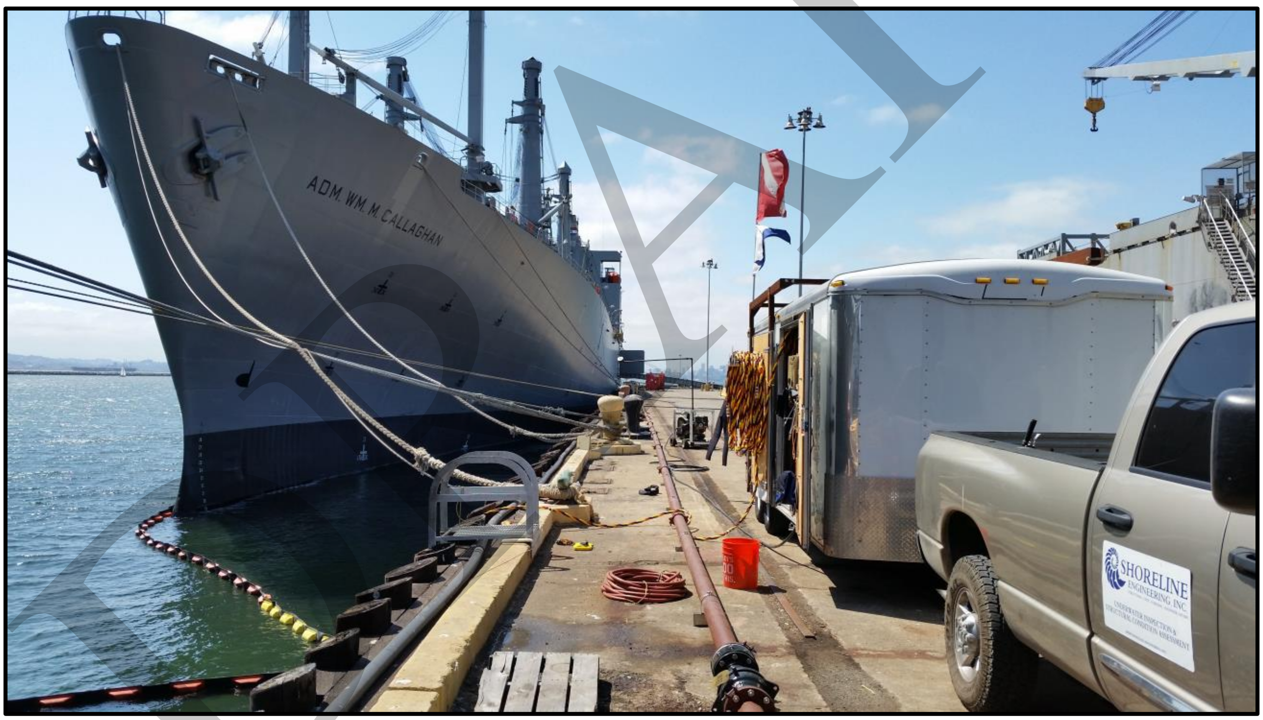
Seal

Drawing No.

P3-05

Appendix C – Underwater Inspection

Alameda Point Piers
2016 Underwater
Structural Condition Assessment



For:
SIMPSON GUMPERTZ & HEGER, INC.
500 12th Street, Suite 270
Oakland, CA 94607

January 20, 2017
Shoreline Project #420-05

EXECUTIVE SUMMARY

Shoreline Engineering, Inc. (Shoreline) was retained by Simpson Gumpertz and Heger, Inc. (SGH) to perform underwater inspections of the below water structural elements of Piers 1 & 2 at Alameda Point in Alameda, California. The inspection work was conducted from August 18, 2016 through December 7, 2016. The primary goal of this work was to document the current condition of the below water structural elements of the piers. This report details the findings and recommendations of the field investigations conducted by Shoreline.

FINDINGS

The below water structural elements of Pier 1 are generally in satisfactory condition. Minor to moderate corrosion of the steel king piles was noted in the tidal and splash zones. Below water, the pile coating is generally intact and the piles are in good condition. Only minor defects were found on the concrete infill panels. The older section of steel sheet pile between the marginal wharf and the pier on the south side is severely deteriorated with holes and visible loss of fill.

Pier 2 was originally constructed in the 1940s but was extended approximately 210 feet in the 1970s. A mooring dolphin was added to the west of the pier at that same time. The original pier is supported by conventionally reinforced concrete piles (Bents 19-102). The extension and mooring dolphin are supported by prestressed concrete piles. The original piles are in poor to serious condition due to chemical attack in the lower tidal zone and continually submerged zone. Table 1 shows the number of piles by rating for each of the different areas of the pier and mooring dolphin.

Table 1 - Pier 2 Pile Quantities by Rating

Structure	No Defect	Minor	Moderate	Major	Severe	Totals
Original Pier (1940s)	294	3	300	90	263	950
Extension (1970s) (Prestressed)	142	2	6	0	0	150
Dolphin	31	2	4	0	0	37
Totals	467	7	310	90	263	1137

RECOMMENDATIONS

Pier 1 is in satisfactory condition. The steel king piles with corrosion and coating loss should be cleaned and recoated above water and in the tidal zone. A cathodic protection system should be considered to prolong the service life of the structure. The original steel sheet pile wall located on the south side between the pier and the marginal wharf should be considered for repair.

The original (1940s) piles at Pier 2 are in poor to critical condition. The piles rated major and severe should be repaired as soon as possible to restore the load bearing capacity of the structure. Load restrictions should be considered until repairs completed.

The last underwater inspection of Pier 3 was performed in 2007. It was a partial inspection and only included nine of 114 pile bents. The ASCE recommends concrete pile supported structures in fair condition be inspected every three years. It is recommended that a more comprehensive structural inspection of Pier 3 be performed as soon as possible.

It is unknown when the last inspection of the marginal wharf inshore of Piers 1-3 was performed. Due to the aggressive chemical attack noted at the piles on Pier 2, it is recommended that a comprehensive structural condition inspection and assessment be performed including above and below water investigations.

This report only addresses the below water findings of the underwater inspections performed by Shoreline. Refer to SGH's structural condition assessment report for Pier 1, Pier 2, and Pier 3 for additional information.

TABLE OF CONTENTS

1.0 INTRODUCTION

Piers 1, 2, and 3 at Alameda Point were originally constructed in the 1940s on what was formerly the Alameda Naval Air Station. The majority of the space is currently leased by the U.S. Maritime Administration (MARAD). The north side of Pier 1 is currently occupied by Power Engineering Contractors and the north side of Pier 3 is the site of the USS Hornet Museum.

The City of Alameda contracted with Simpson Gumpertz and Heger, Inc. (SGH) to provide Phase 1, "Interim Inspection, Testing, Preliminary Analyses and Reporting Services" for the Rehabilitation of Piers 1, 2, and 3. The primary goal of this work is to document the current condition of the piers, perform analyses, and determine recommendations for repair. Shoreline Engineering, Inc. (Shoreline) was retained by SGH to perform the underwater portions of the inspection work.

Shoreline conducted the underwater inspection work from August 18, 2016 through December 7, 2016. This report documents the current condition of the below water structural elements of Alameda Point Piers 1 and 2.

Figures which graphically present the inspection findings are provided in Appendix A. Representative photographs of conditions observed at the pier are provided in Appendix B. Pile inspection data is provided in Appendix C. Condition assessment rating criteria is provided in Appendix D. References used during this investigation are provided in Appendix E.

1.1 Facility Description

Pier 1 was originally constructed in 1946 as a cellular sheet pile structure. In the late 1980s the pier was substantially rehabilitated by installing steel king piles with concrete infill panels outside of the cellular sheet pile structure (Photo 1). The Pier is approximately 660 feet long and 53 feet wide with king piles nominally spaced at approximately 6'-8" center-to-center. The king piles at the south side of the pier are W36x260 sections and the king piles on the north side of the pier are W14x109 sections. The concrete infill panels on the south side of the structure are scalloped and on the north side they are flat (Photos 2 and 3). There is a short section of the original steel sheet pile bulkhead still visible between the start of the king pile bulkhead and the marginal wharf on the south side of the pier. The concrete deck is approximately 8 inches thick. There is a timber fender system on the south side of the pier.

Pier 2 was originally constructed in the early 1940s with conventional precast concrete piles. In the early 1970s the pier was extended approximately 210 feet. A mooring dolphin was also installed approximately 150 feet west of the extension. Both the extended portion of the pier and the mooring dolphin are supported by precast, prestressed concrete piles.

The older portion of Pier 2 is approximately 1000 feet long by 80 feet wide and is supported by pile bents typically spaced 12 feet apart consisting of eight, 20 in. square piles plumb piles and two batter piles. The newer extension is approximately 210 feet long by 80 feet wide. The extension is supported by pile bents consisting of six, 18 in. square piles per bent. A timber fender system is present on both sides of the pier.

Pier 3 was originally constructed in the 1940s and is approximately 1100 feet long by 150 feet wide. It is supported by conventionally reinforced concrete piles with cast-in-place concrete extensions from the low water line to the bottom of the deck. The concrete deck is approximately 26 inches thick at the outer sides of the pier under the crane rails and 10 inches thick at the center. A timber fender system is present on both sides of the pier.

1.2 Inspection Scope

For this project Shoreline performed the underwater inspection of Piers 1 and 2 and performed the deck coring at Piers 1, 2, and 3. The levels of effort for each pier are detailed in Table 1.

Table 2 - Inspection Quantities

Facility	Level I	Level II	Level III
Pier 1			
Sheet Piles	100%	2 meas. per side (4 total)	2 meas. per side (4 total)
King Piles	100%	10%	5%
Concrete Infill Panels	100%	Every 100 Linear Feet	N/A
Deck Coring	0%	0%	2 cores
Pier 2			
1940's Concrete Piles	100%	20%	11 piles (3 cores/pile)
Prestressed Piles at 1970s extension and Mooring Dolphin	100%	10%	0%
Deck Coring	0%	0%	2 cores
Pier 3			
Concrete Piles	0%	0%	1 pile (3 cores)
Deck Coring	0%	0%	2 cores

The timber fender piles were not included in the scope of the inspection; however, it was noted that the timber fender system at all three piers is generally in poor to serious condition with many broken, missing, and severely deteriorated elements. In several areas, the timber fender system is in an active state of collapse.

1.3 Inspection Methodology

The underwater inspection was conducted by a three-person dive team led by a California Registered Civil Engineer with experience in underwater inspections nationwide and internationally. All Shoreline divers are commercially certified in accordance with OSHA and Association of Diving Contractors International (ADCI) diving guidelines. The dive mode for this project was Surface-Supplied Air (SSA) diving using commercial diving equipment staged from a Shoreline dive trailer.

All inspection work was performed in accordance with the guidelines outlined in the American Society of Civil Engineers (ASCE) "Underwater Investigations - Standard Practice Manual". The underwater inspection work included a 100% Level I visual and tactile inspection of all below water structural elements from the mudline to +3 MLLW.

Level II inspections consisted of an in-depth examination of the selected elements including the removal of marine growth at three locations. The mechanical removal of the marine growth from the selected surfaces was performed in the tidal zone, at mid-depth, and approximately 3 ft. above the mudline. For steel elements, the Level III inspection included ultrasonic thickness measurements and electrical potential readings (CP readings) at each Level II location.

Thirty-six core samples were taken from twelve concrete piles, eleven piles were cored at Pier 2 and one pile was cored at Pier 3 to provide a comparison between the two structures. A 4.5 in. diameter diamond core bit was used to extract core samples from three locations on each pile, one in the tidal zone, one at mid-water, and one three feet below the mudline. Additionally, two core samples were extracted from the deck of each pier.

1.4 Previous Inspections

In 2007 partial underwater inspections of Piers 1, 2, and 3 were conducted. Pier 1 was noted to be in generally good condition. The piles supporting the older section of Pier 2 were noted to be in poor condition with chemical deterioration and loss of concrete observed on a large number of piles. The piles supporting the 1970s extension to Pier 2 were noted to be in good condition. Pier 3 was noted to be in fair condition. Chemical attack was not observed at the piles inspected on Pier 3.

2.0 STRUCTURAL INVESTIGATION FINDINGS

The underwater visibility during the inspection was typically less than five feet with no current. Hard and soft marine growth up to six inches thick was typically found below water (Photo 4). A commercial pressure washer was employed to remove the growth at Level II inspection locations (Photo 5).

2.1 Pier 1

2.1.1 Sheet Piles

The steel sheet pile wall on the south side of the pier between the marginal wharf and the pier is in poor condition with severely corroded steel, holes in the sheet piles, and loss of fill (Photos 6 and 7).

2.1.2 Steel King Piles

The steel king piles are typically in good condition below water. Pile coatings are generally intact but several isolated areas of coating loss and corrosion were noted (Photos 8 and 9). In the tidal zone and atmospheric zone there is significant coating loss and minor to moderate corrosion (Photo 10). Ultrasonic thickness (UT) measurements and electrical potential readings were recorded at all Level III locations (Photos 11 and 12). Refer to Appendix C for Level III inspection data. UT readings generally indicate little to no loss of cross section at the areas measured. There is no cathodic protection (CP) system in place at Pier 1 and the electrical potential readings confirm that the steel is unprotected.

2.1.3 Concrete Infill Panels

The concrete infill panels are generally in good condition with only minor cracking observed in a few locations. The plastic guides installed between the king piles and the infill panels are generally in place; however, in several locations they are displaced (Photo 13).

At the offshore end of the pier at corners 6+52, 6+75, and 6+92 concrete fills the void between the two king piles at each corner. This concrete extends from the deck to the lower tidal zone. Below water, the inner two flanges of the king piles are visible. At corner 6+75 there is a gap between these two flanges with minor fill loss (Photo 14).

2.1.4 Deck Coring

Core samples were extracted from two locations on the deck. One on the north side near the gangway to the floating docks and one near the offshore end of the pier. Both core samples were approximately 8 in. long and came out as one piece (Photo 15). Soil was encountered immediately below the deck with no voids noted between the fill and bottom surface of the deck.

2.2 Pier 2

2.2.1 1940s Concrete Piles

The original conventionally-reinforced, precast, concrete piles at Pier 2 are generally in poor to serious condition. A number of piles near the offshore end of the original pier (Bent 19) and scattered throughout the pier have deterioration due to corrosion of the reinforcing steel which presents as corrosion cracking and spalling in the splash and tidal zones. Refer to SGH's report for the above water inspection findings.

In the lower tidal zone and continually submerged zone many piles exhibit deterioration due to chemical attack. The deterioration is present throughout the pier and is considerably pronounced in the zone between Bents 19-54. In most cases the piles look good above water; however, the concrete becomes soft in the lower tidal zone, and in general, this condition continues to just above the mudline. The piles typically appeared to be in better condition near the mudline but some piles have exposed rebar that extends below the mudline (Photo 16).

As the concrete becomes soft the corners tend to round off and no longer maintain the chamfered edge seen on intact piles (Photo 17). Based on the rating criteria, rounding up to one inch deep indicates a “Moderate” pile (Photo 18). Rounding greater than one inch deep with no exposed rebar indicates a “Major” pile (Photo 19). Once rebar becomes exposed the pile is considered to be “Severe” (Photo 20).

The compromised concrete no longer provides adequate protection for the steel reinforcing which then begins to corrode. The chemical deterioration causes internal stresses within the concrete which leads to cracking and further deterioration. As the steel reinforcing corrodes the corrosion byproducts expand within the concrete causing tremendous internal stress within the pile. As these processes continue the outer protective layer of the pile (concrete cover) cracks and eventually spalls off. This leaves the reinforcing steel open to rapid deterioration due to corrosion.

Concrete encasement repairs are present on a number of piles (Photo 21). In some cases, the encasements do not extend below the mudline and the original pile is visible below the encasement. Several of these previously repaired piles are rated major or severe due to deficiencies below the encasements (Photo 22).

2.2.2 1970s Prestressed Concrete Piles

The prestressed piles supporting the extension to Pier 2 (Bents 1-18) and the Mooring Dolphin are generally in good condition with only minor defects noted below water (Photo 23).

2.2.3 Concrete Pile Coring

Core samples were removed from 11 piles at Pier 2 (33 core samples)(Photo 24). Refer SGH’s report for a discussion of the findings from the chloride intrusion analysis, petrographic analysis, and compressive strength testing.

2.2.4 Deck Coring

Core samples were extracted from two locations on the deck. One was taken from the north side of the pier close to the concrete curb between Bents 37 & 38 and the other from the south side between Bents 91 & 92. The core samples were approximately 8 in. long and came out as one piece (Photo 25). Both core samples went through the full section of the deck.

2.3 Pier 3

2.3.1 Concrete Piles

The concrete piles at Pier 3 were not included in the scope of the underwater inspection. SGH performed an inspection of the piles located around the perimeter of the pier that were visible by boat. The piles at Pier 3 have a larger concrete extension cast on top of the original piles (Photo 26). The extensions typically extend below the waterline making visual inspection of the original piles difficult at all but the very lowest tides. During the course of the inspection several piles were noted to be in severe condition due to chemical attack. Refer to SGH’s above water inspection report for additional information.

2.3.2 Concrete Pile Coring

The original scope of work for the underwater coring was altered to facilitate a comparison of the piles supporting Piers 2 and 3. Three core samples were taken from Pile 30-A at Pier 3 to determine the severity of chemical attack.

2.3.3 Deck Coring

Core samples were extracted from two locations on the deck. Both cores were taken near the offshore end of the pier, one on the north side and one on the south side. The core samples were approximately 10 in. long and each came out as one piece (Photo 27). Due to the increased thickness of the deck at the coring locations, both core samples did not penetrate through the full section of the deck.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Pier 1

3.1.1 Sheet Piles

Previous repairs have been made in the area where the old sheet pile bulkhead is visible. No repair drawings were available for review and it is not clear what the extent of the repairs included. It is recommended that additional investigations be performed in this area to determine the extent of the repairs previously performed and assess whether additional repairs are warranted. Until this work is performed, this area should be monitored.

3.1.2 Steel King Piles

The steel king piles should be cleaned and recoated above water and in the tidal zone to prolong the service life of the structure. Installation of a cathodic protection system should be considered to prolong the service life of these members below water.

3.1.3 Concrete Infill Panels

No repairs are recommended at this time for the concrete infill panels.

3.1.4 Inspection Cycle

The findings of the above water inspection performed by SGH should be combined with the underwater inspection findings and a combined rating should be established. Based on the combined rating, a global Condition Assessment Rating (CAR) should be assigned and used to determine the next underwater inspection cycle.

3.2 Pier 2

3.2.1 1940s Concrete Piles

The piles supporting the original portion of Pier 2 are in poor to serious condition. Their load bearing capacity is reduced due to deficiencies above and below water. Significant chemical deterioration is present throughout this area of the pier. The piles rated major and severe should be repaired as soon as possible to restore the load bearing capacity of the structure. Load restrictions should be considered until repairs complete. Refer to SGH's report for additional information.

3.2.2 1970s Prestressed Concrete Piles

The prestressed piles supporting the extension to Pier 2 and the Mooring Dolphin are in satisfactory condition and no repairs are recommended at this time.

3.2.3 Concrete Pile Coring

Refer SGH's report for a discussion of the findings from the chloride intrusion analysis, petrographic analysis, and compressive strength testing.

3.2.4 Inspection Cycle

The findings of the above water inspection performed by SGH should be combined with the underwater inspection findings and a combined rating should be established. Based on the combined rating, a global Condition Assessment Rating (CAR) should be assigned and used to determine the next underwater inspection cycle.

3.3 Pier 3

3.3.1 Concrete Piles

The concrete piles at Pier 3 were not included in the scope of the underwater inspection. SGH performed an inspection of the piles located around the perimeter of the pier that were visible by boat. The piles at

Pier 3 have a larger concrete extension cast on top of the original piles. The extensions typically extend below the waterline making visual inspection of the original piles difficult at all but the very lowest tides. During the course of the inspection several piles were noted to be in severe condition due to chemical attack and corrosion cracking. Refer to SGH's above water inspection report for additional information.

3.3.2 Concrete Pile Coring

Refer SGH's report for a discussion of the findings from the chloride intrusion analysis, petrographic analysis, and compressive strength testing.

3.3.3 Inspection Cycle

The last underwater inspection of Pier 3 was performed in 2007 and was only a partial inspection. The recommended inspection interval, per ASCE 101 - Table 2-2, reinforced concrete located in an aggressive environment, rated Fair, is three years. Based on the observed deterioration, it is recommended that a more comprehensive inspection of the piles supporting Pier 3 be performed. Due to the large number of piles, it is recommended that the inspection include a representative sample of the total number of piles as well as piles located in areas of more concentrated loading.

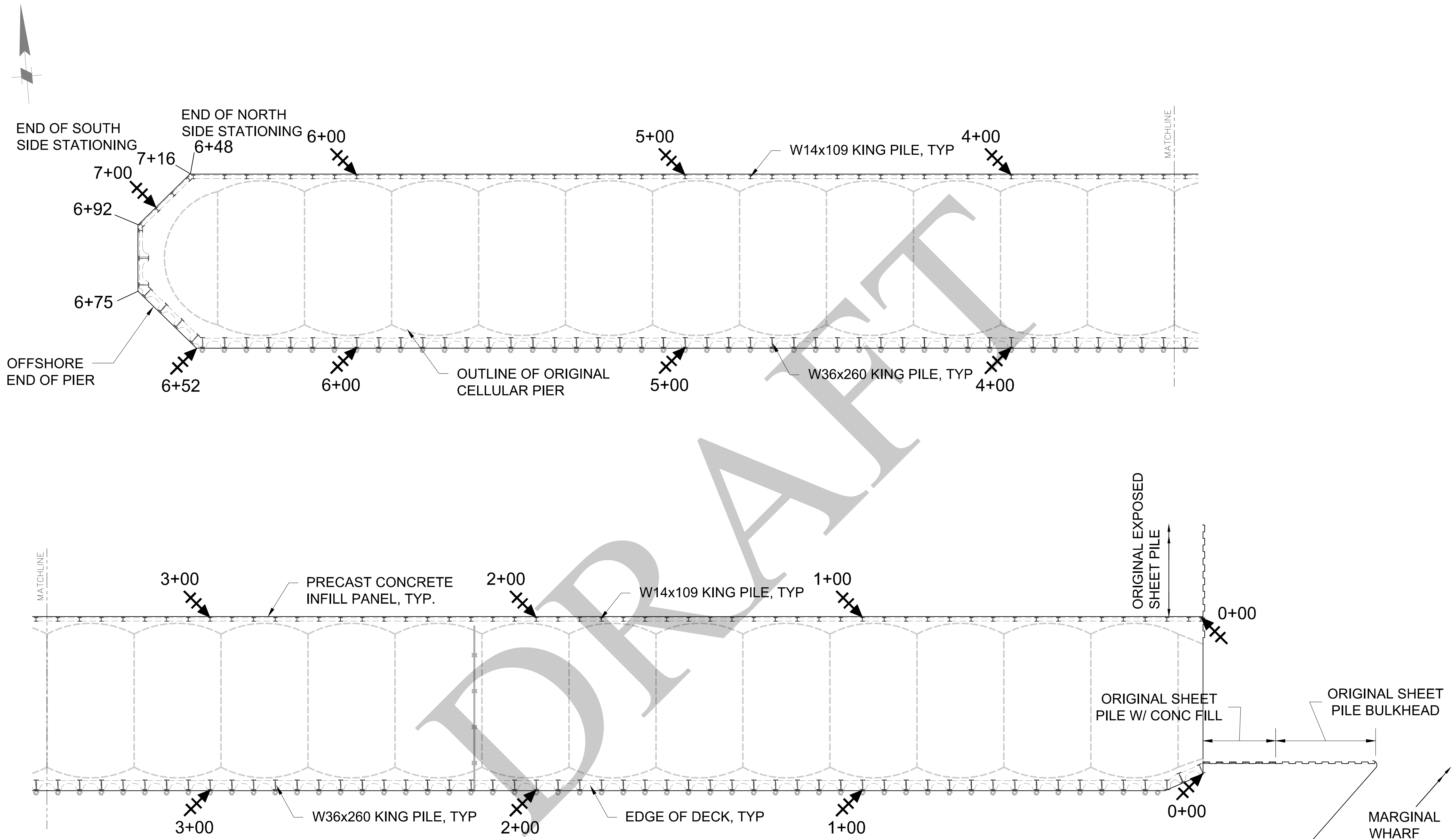
3.4 Limitations & General Conditions

Professional services provided by Shoreline have been provided in accordance with methods and procedures recommended by respected national and regional organizations, including the American Society of Civil Engineers and the California Building Standards Commission (California Building Code). The degree of care provided is consistent with the level of skill that is ordinarily exercised under similar circumstances by responsible engineers currently practicing in this, or similar, area/s of professional practice at the time the work on the project was performed.

The report has been prepared exclusively for SGH and is to be used solely for the purposes of providing a structural condition assessment of the structural elements from +3 MLLW to the mudline. The report has not been prepared for the use by other parties, and the report may not contain sufficient information for use by other parties or other uses not described in the report.

The recommendations contained in the structural condition assessment rely on information provided by SGH. Shoreline makes no warranty as to the accuracy and correctness of such provided information.

Appendix A – Figures



PIER 1 PLAN

1" = 30'-0"

S□M□OLS LE□END□

□□□□ STATION

LE□EL III INSPECTION □□T AND CP

GRAPHIC SCALE

30 0 30 60

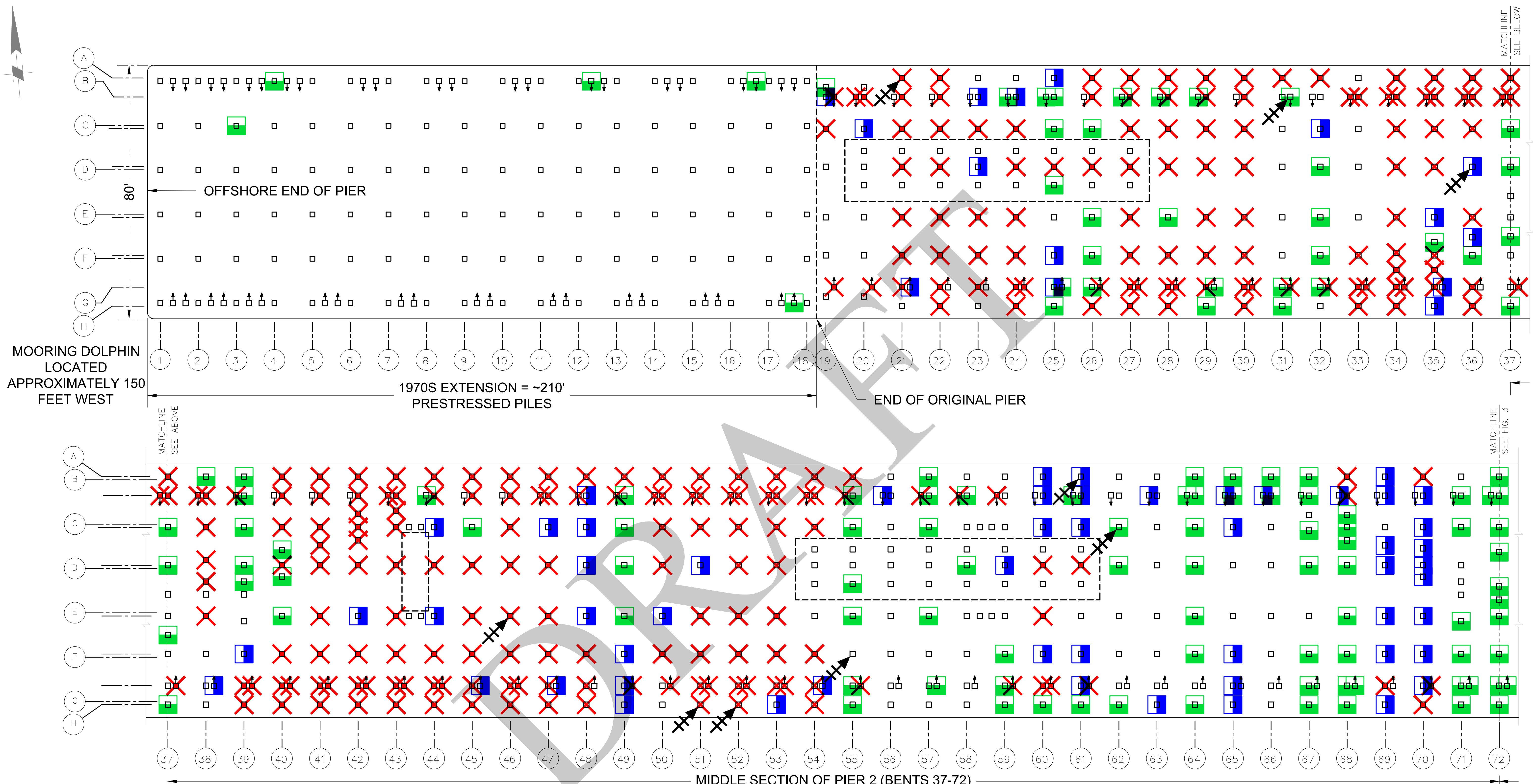
1" = 30'

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

ALAMEDA POINT PIERS 1, 2 & 3 CONDITION ASSESSMENT

PIER 1
INSPECTION PLAN, SHEET 1 OF 1

FIG. 1



PIER 2 PLAN

1" = 30'-0"

S□M□OLS LE□END□

- PILE RATED NO DEFECT OR MINOR
- □ATTER PILE RATED NO DEFECT OR MINOR
- PILE RATED MODERATE
- PILE RATED MA□OR
- PILE RATED SE□ERE
- LE□EL III INSPECTION □CONCRETE CORIN□

GRAPHIC SCALE

30 0 30 60

1" = 30'

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

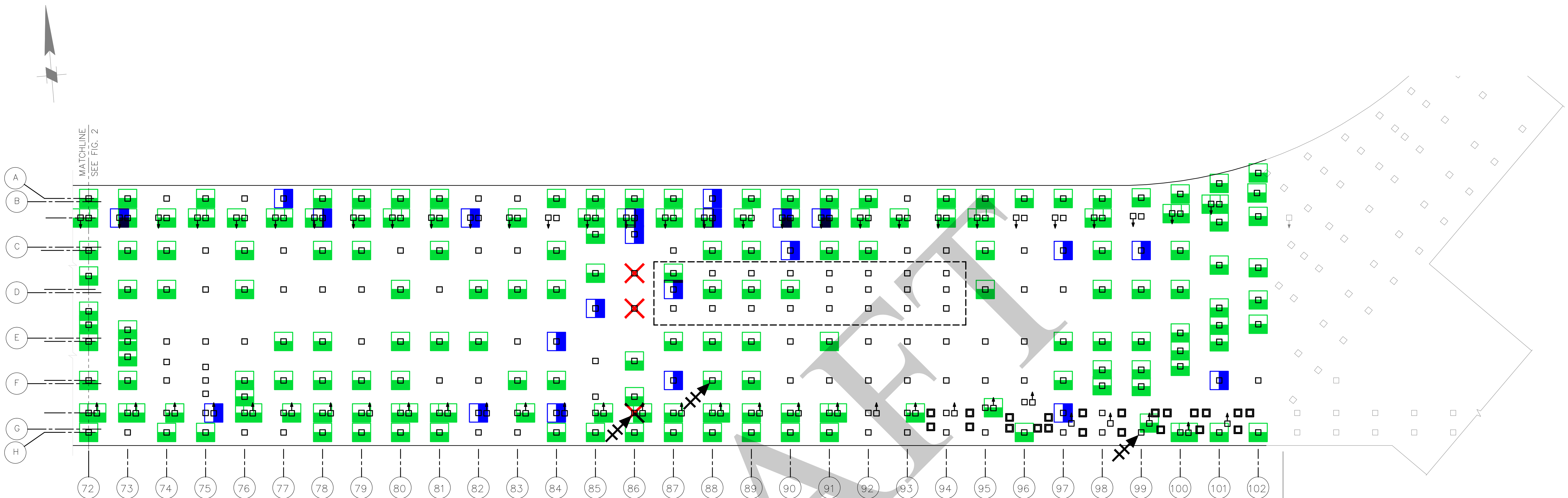
ALAMEDA POINT PIERS 1, 2 & 3 CONDITION ASSESSMENT

PIER 2

PILE INSPECTION PLAN, SHEET 1 OF 2

FIG. 2

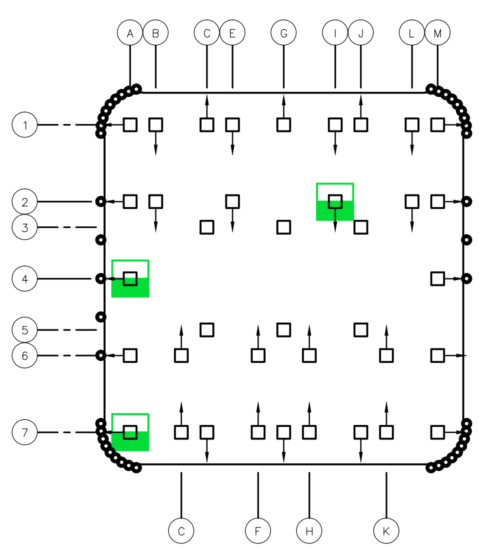
PRELIMINARY DRAFT - 20 JANUARY 2017



INSHORE SECTION OF PIER 2 (BENTS 72-102)

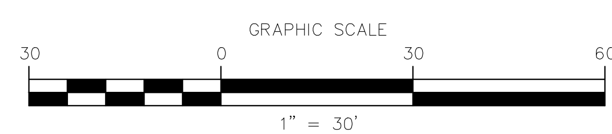
PIER 2 PLAN

1" = 30'-0"



MOORING DOLPHIN PLAN

1" = 30'-0"



S□M□OLS LE□END□

- PILE RATED NO DEFECT OR MINOR
- □ATTER PILE RATED NO DEFECT OR MINOR
- PILE RATED MODERATE
- PILE RATED MA□OR
- PILE RATED SE□ERE
- LE□EL III INSPECTION □CONCRETE CORIN□

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

ALAMEDA POINT PIERS 1, 2 & 3 CONDITION ASSESSMENT	FIG. 3
PIER 2 PILE INSPECTION PLAN, SHEET 2 OF 2	

PRELIMINARY DRAFT - 20 JANUARY 2017

Appendix B – Photographs

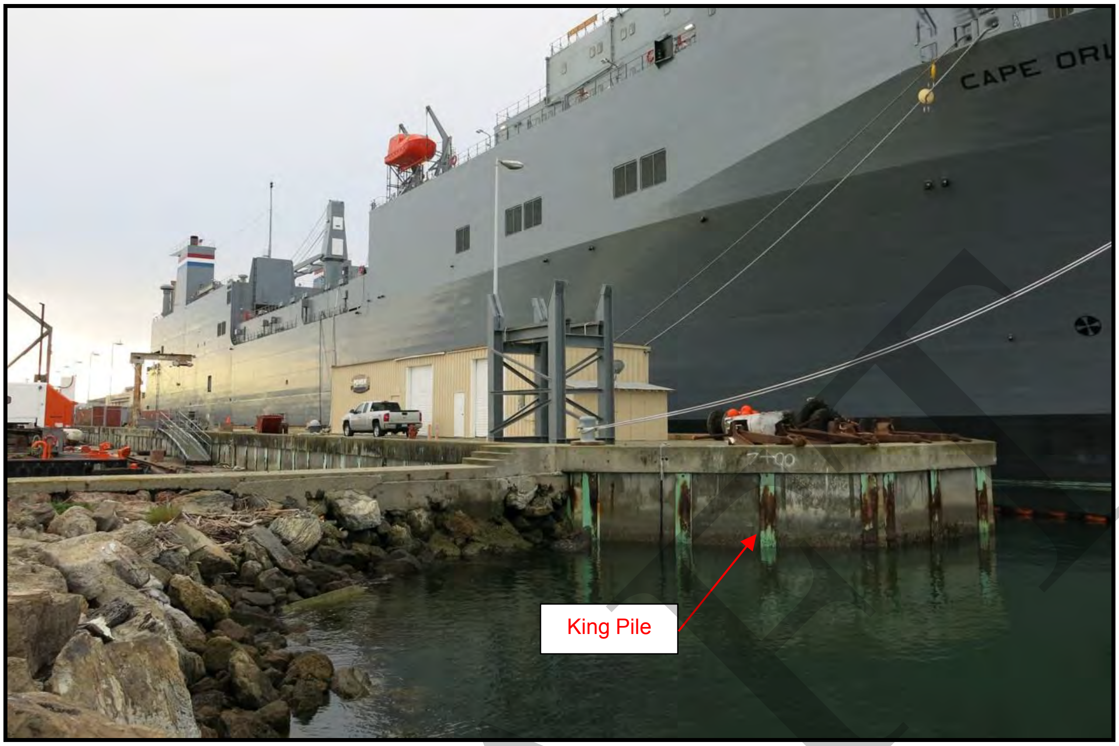


Photo 1: West end of Pier 1 looking east.

Photo 2: Scalloped concrete infill panels at south side of Pier 1.

Photo 3: Flat concrete infill panels at north side of Pier 1.

Photo 4: Typical marine growth on structural piles.

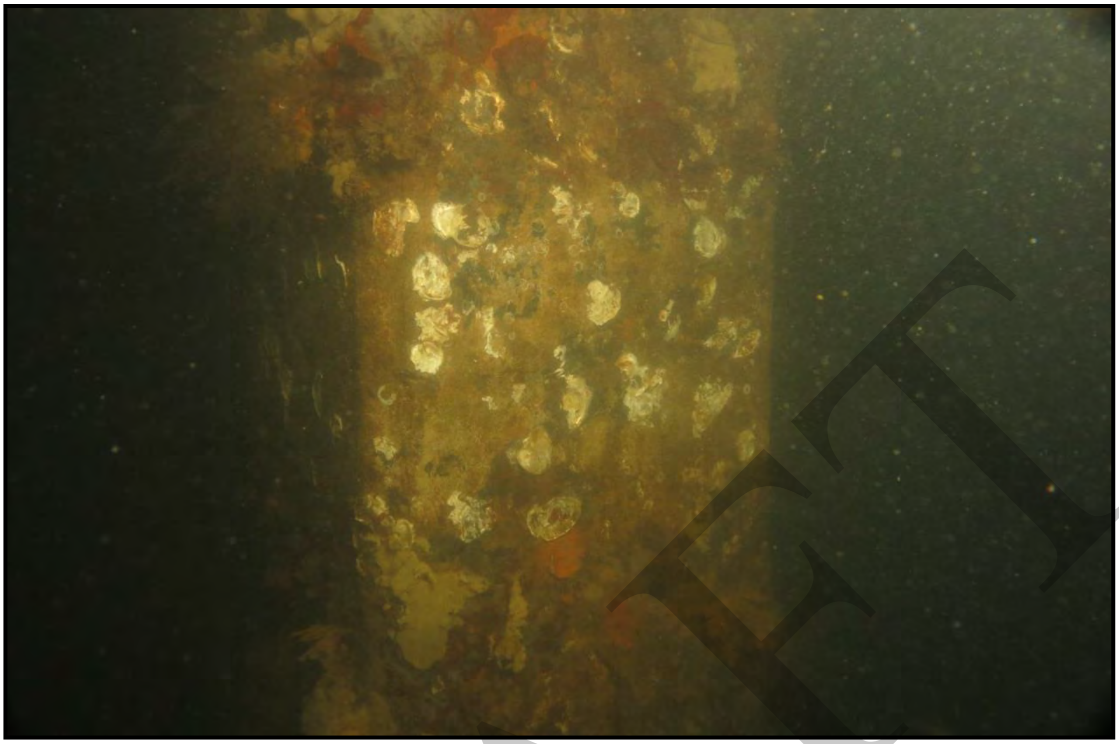


Photo 5: Typical Level II location with marine growth removed.

Photo 6: Original steel sheet pile wall at south side of Pier 1.

Photo 7: Original steel sheet pile wall at south side of Pier 1.

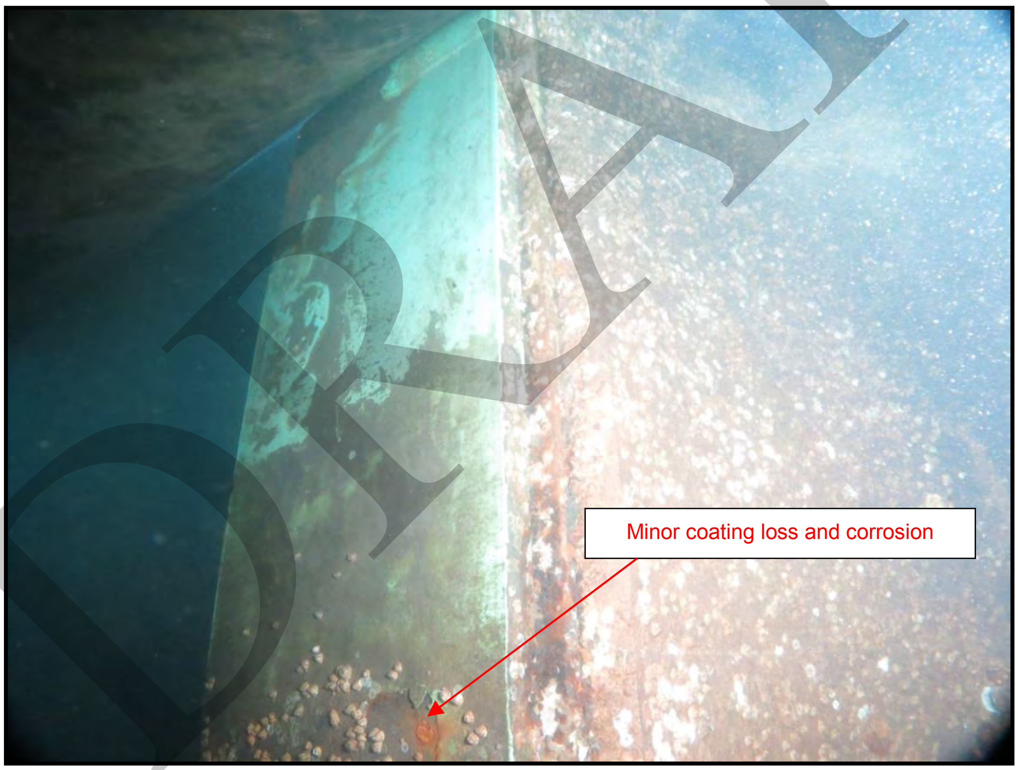


Photo 8: Steel king pile with substantially intact coating below water.

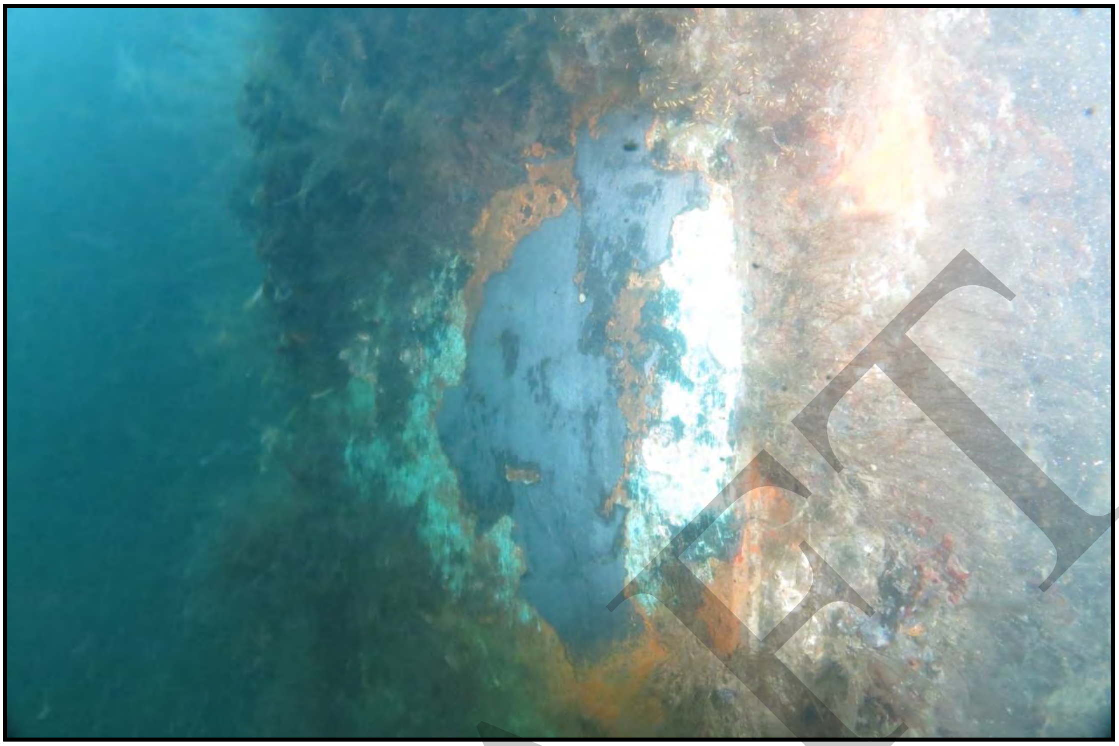


Photo 9: Coating loss and corrosion on steel king pile at Pier 1.

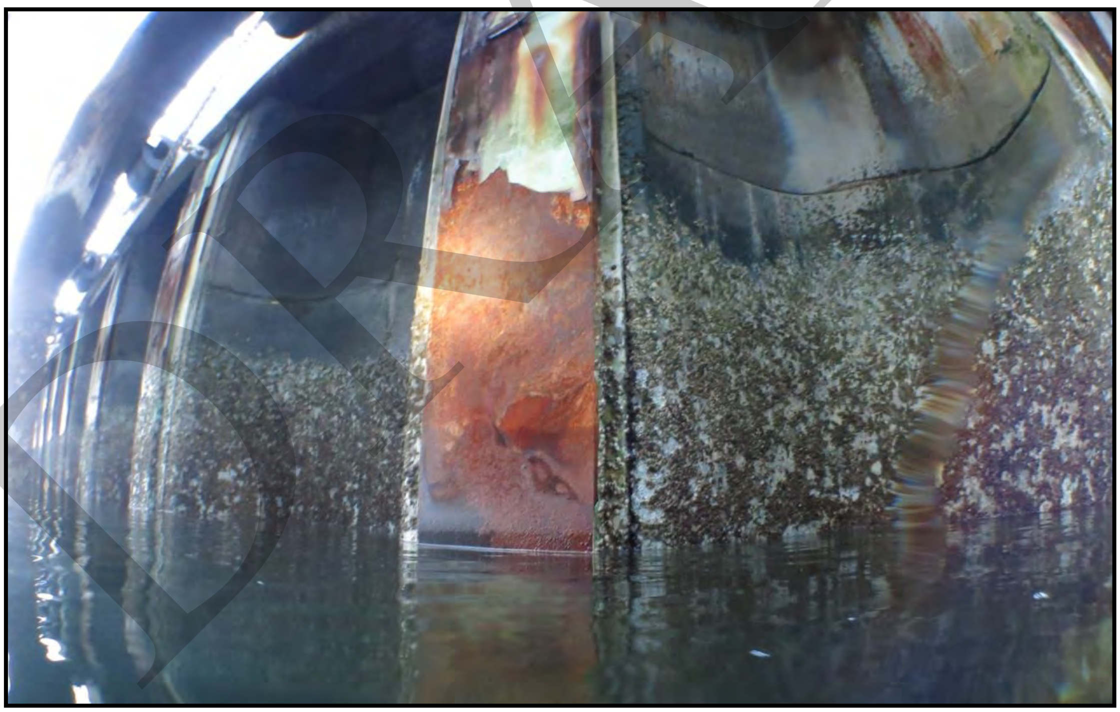


Photo 10: Coating loss and corrosion on steel king pile at Pier 1.

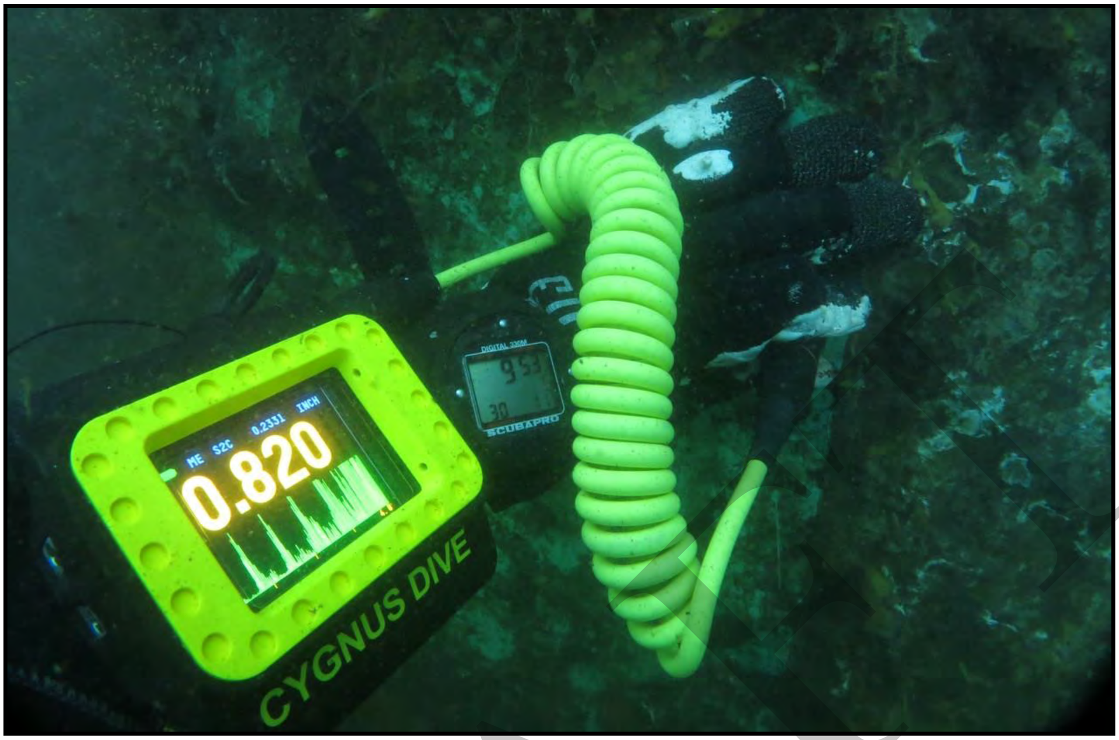


Photo 11: Ultrasonic thickness measurement at steel king pile on Pier 1.

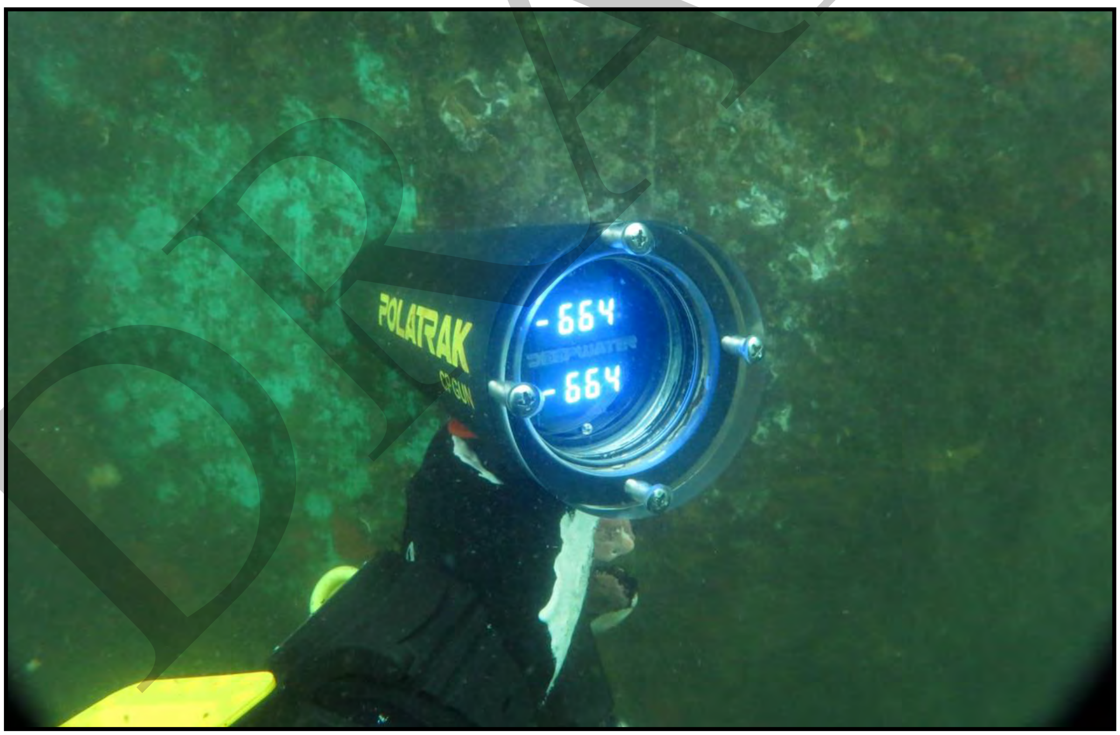


Photo 12: Electrical potential measurement at steel king pile at Pier 1.

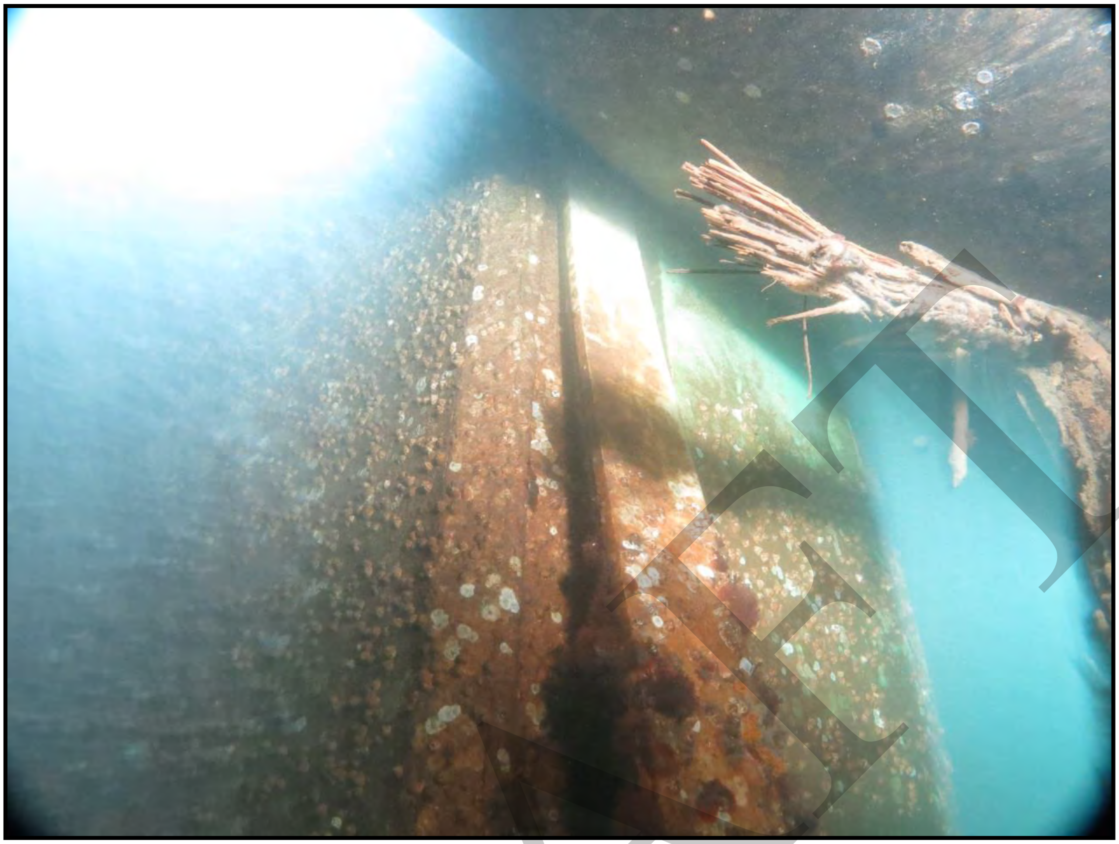


Photo 13: Displaced plastic guide between king pile and concrete infill panel.

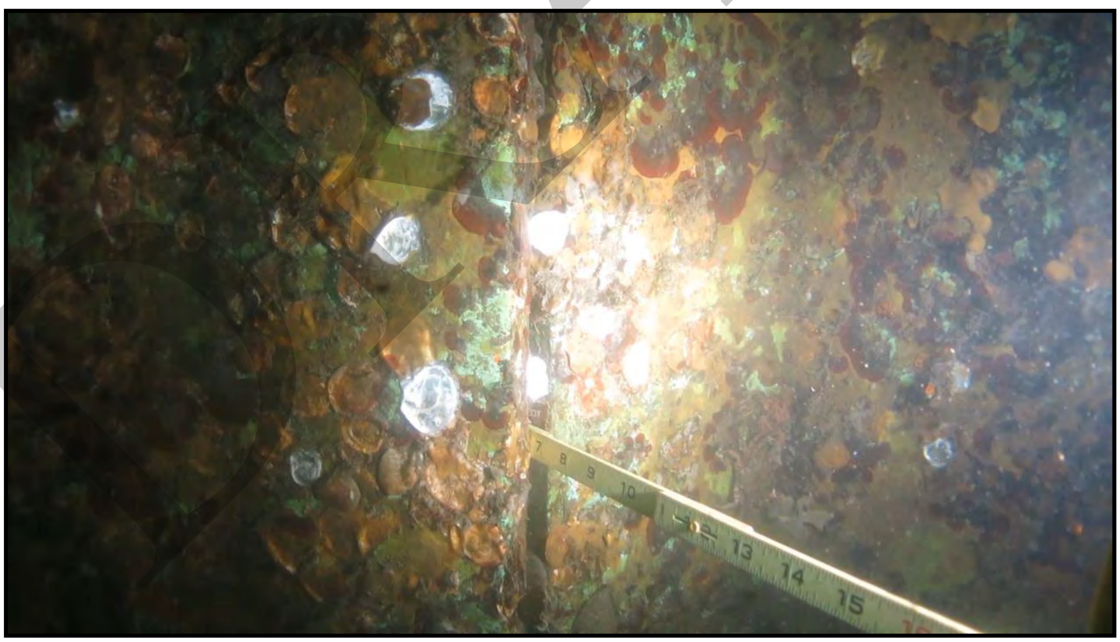


Photo 14: Gap between inner flanges of steel king piles at Corner 6+75 at the west end of Pier 1.

Photo 15: Concrete core sample taken from Pier 1 deck.

Photo 16: Pier 2, Pile 43-H - Exposed reinforcing near the mudline.

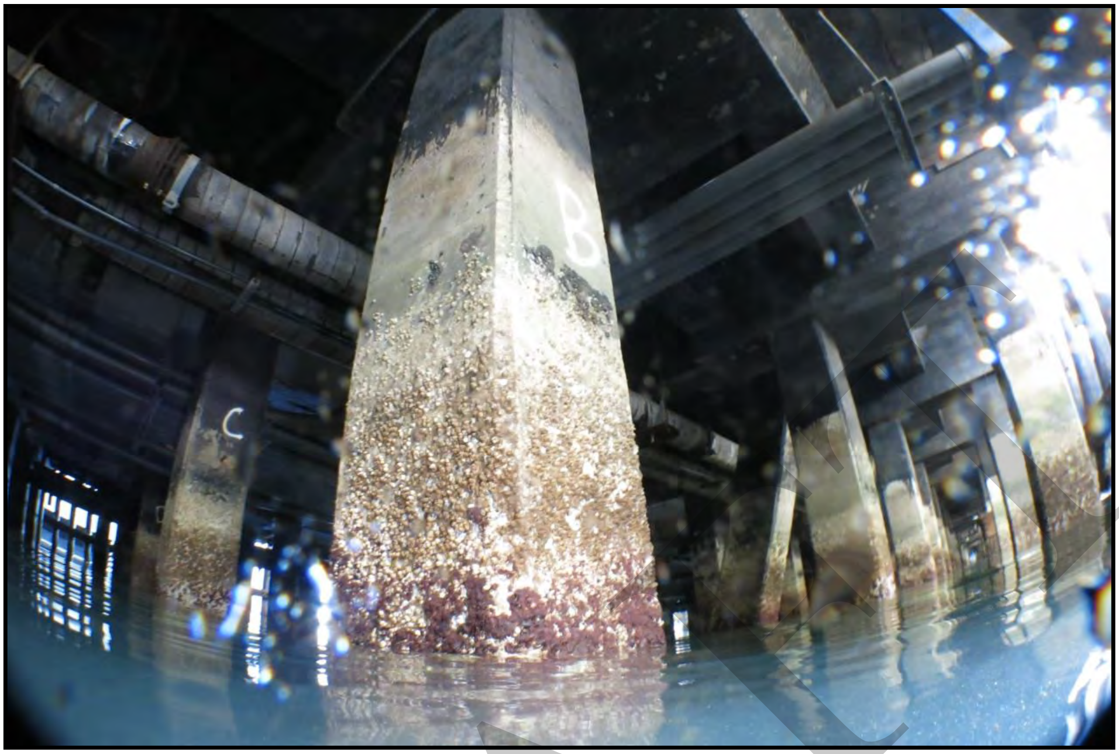


Photo 17: Typical square pile with chamfered corners.

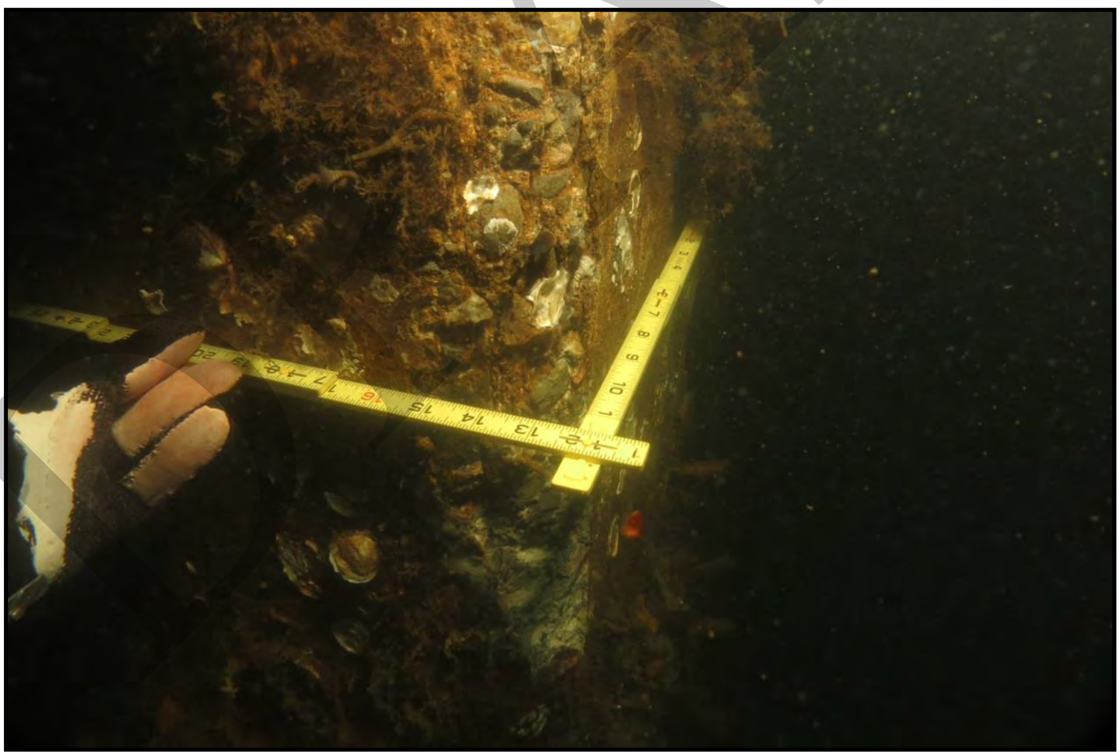


Photo 18: Minor rounding of corner due to chemical deterioration.

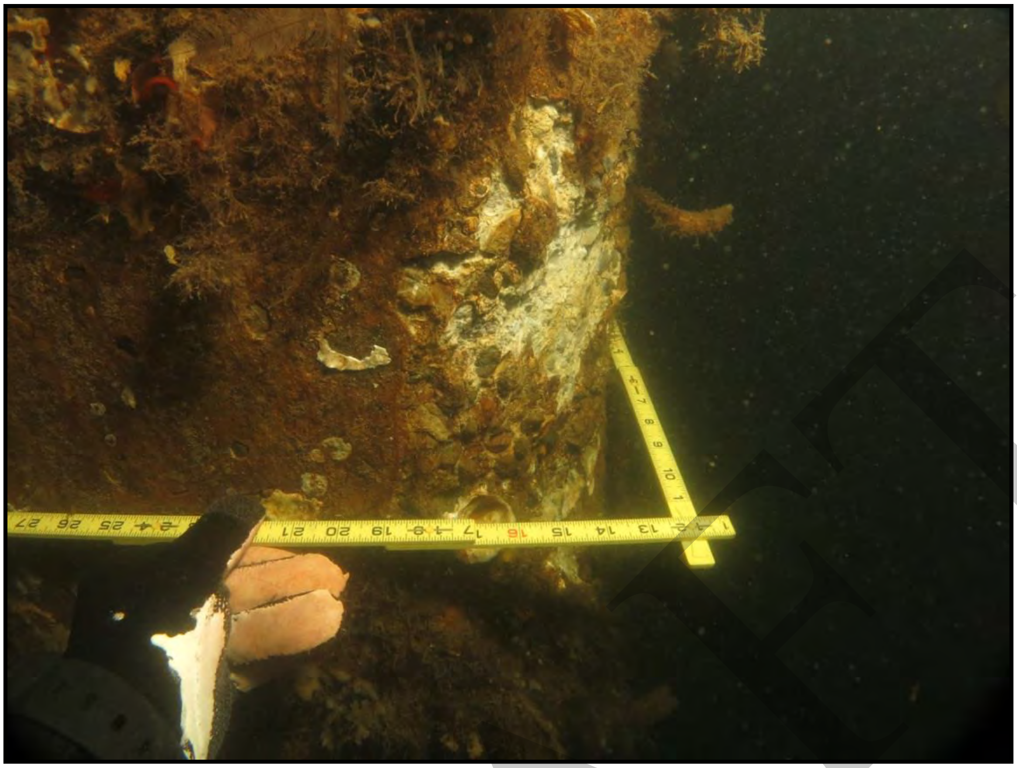


Photo 19: Major rounding of corner due to chemical deterioration.

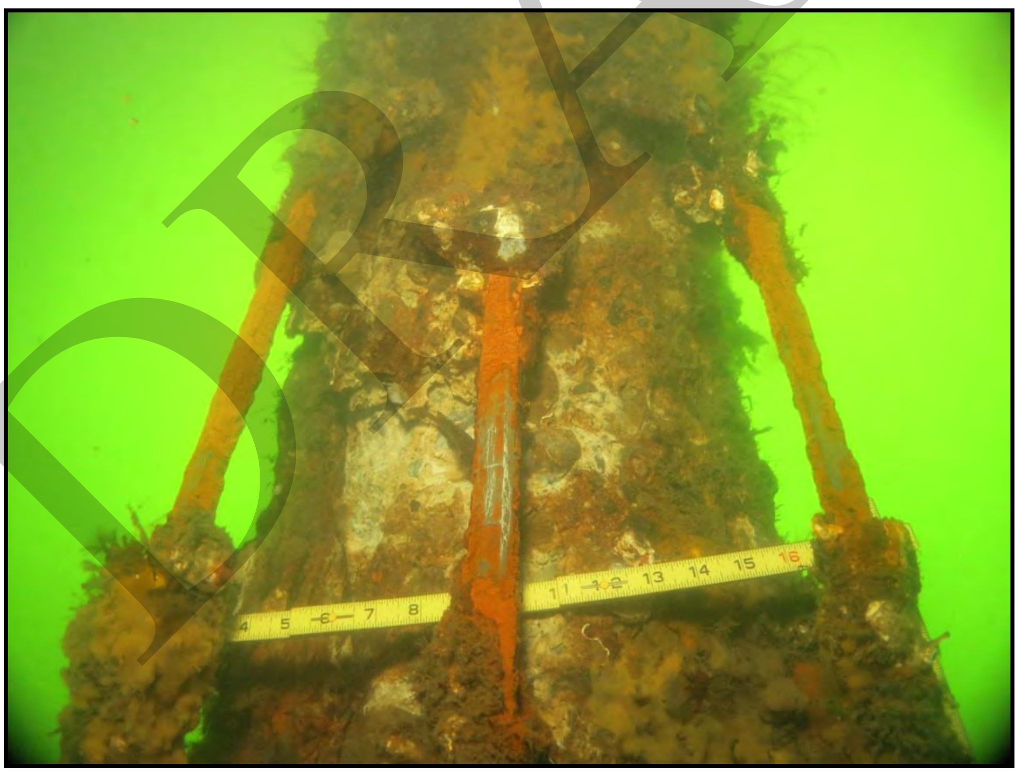


Photo 20: Severe loss of concrete section due to chemical deterioration with exposed reinforcing.

Photo 21: Typical concrete encasement installed on concrete pile at Pier 2.

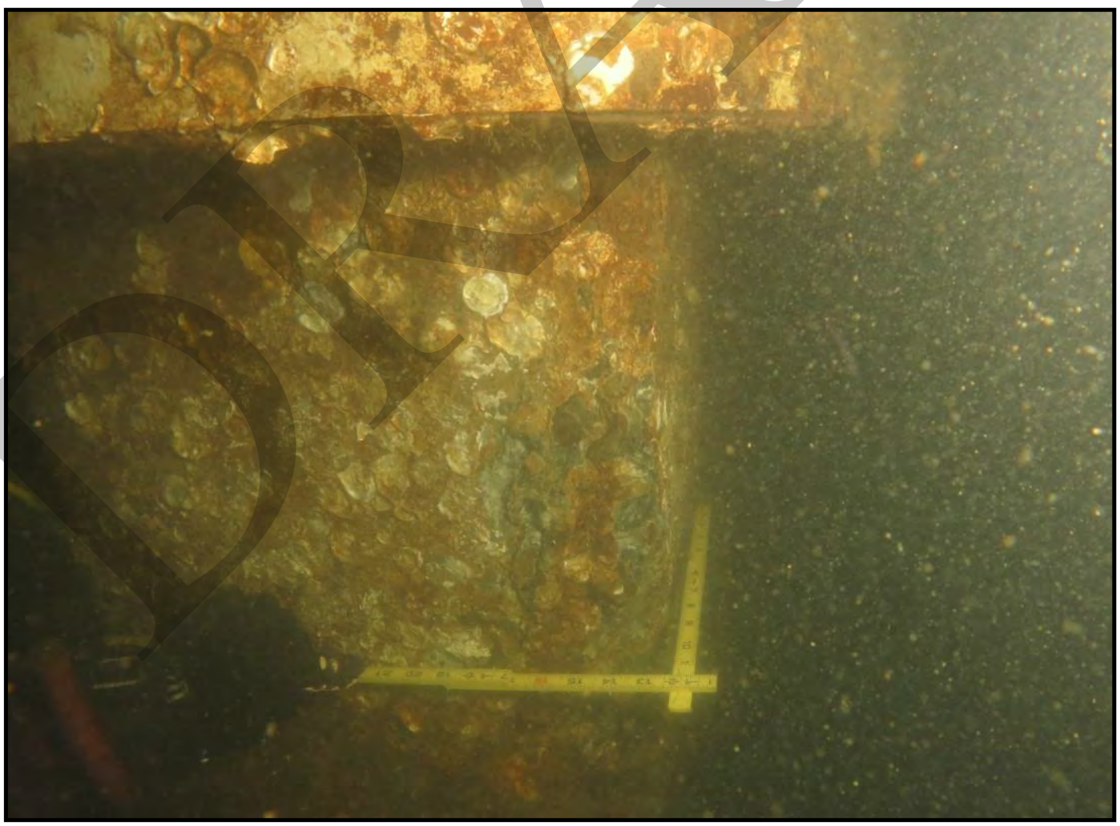


Photo 22: Deterioration of original concrete pile exposed below encasement repair.

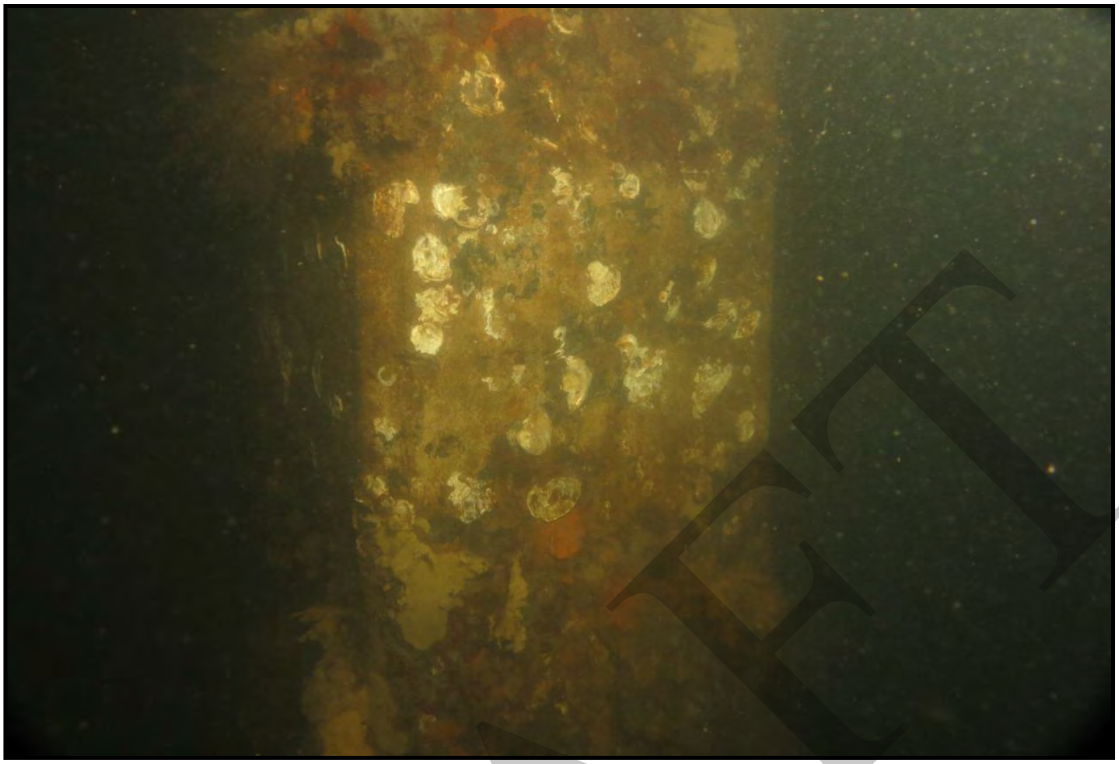


Photo 23: Typical Level II inspection location on a prestressed pile.

Photo 24: Typical concrete core sample extracted from Pier 2 (wrapped in plastic prior to packaging for delivery to the testing lab).

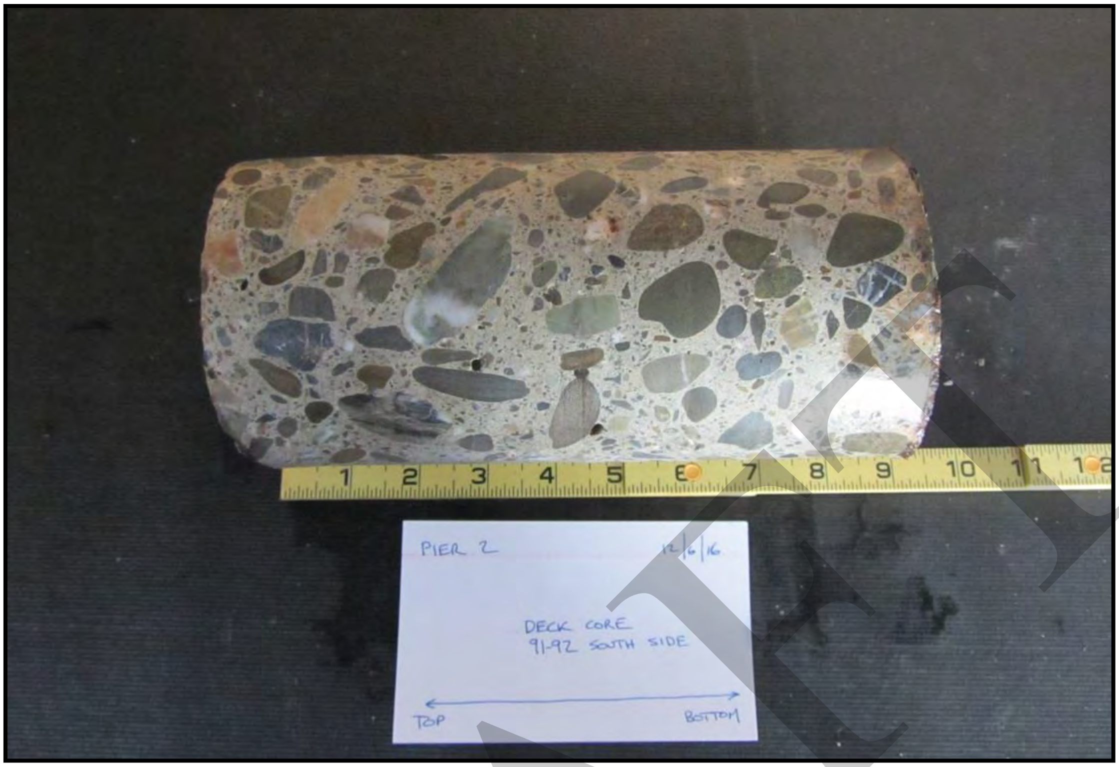


Photo 25: Core sample removed from the deck of Pier 2.

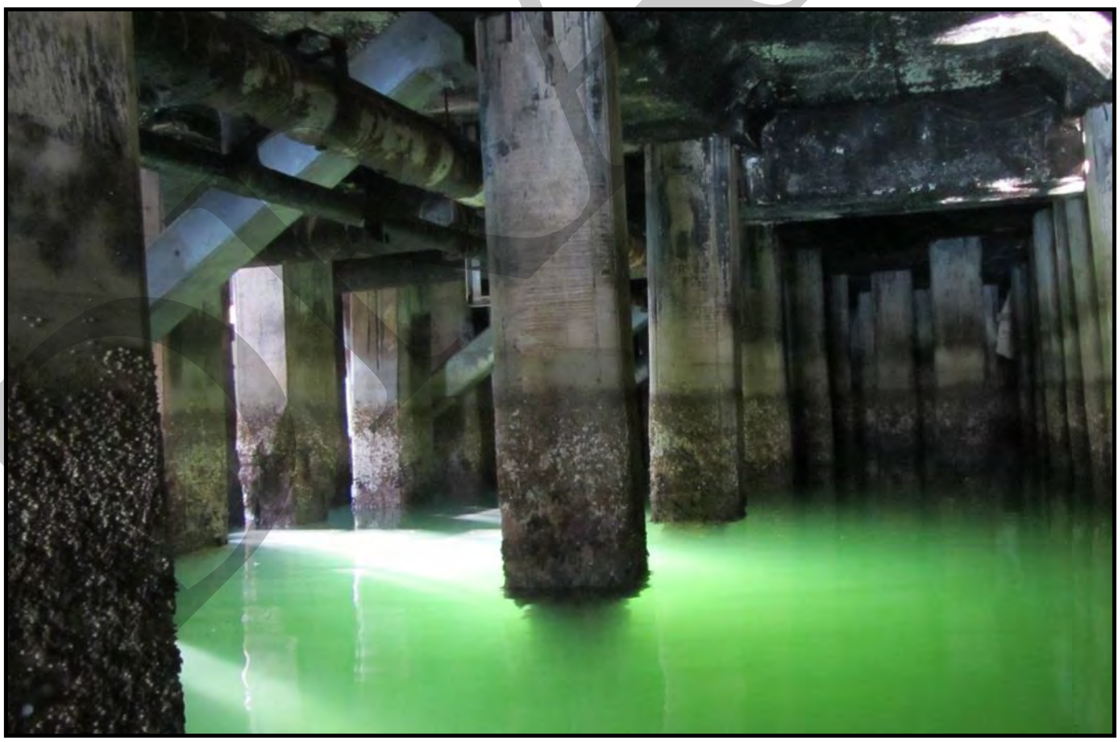


Photo 26: Pier 3 pile with larger extension cast on top of original pile (original pile visible below water).

Photo 27: Core sample from deck of Pier 3.

Appendix C – Inspection Data

Pile Ratings:

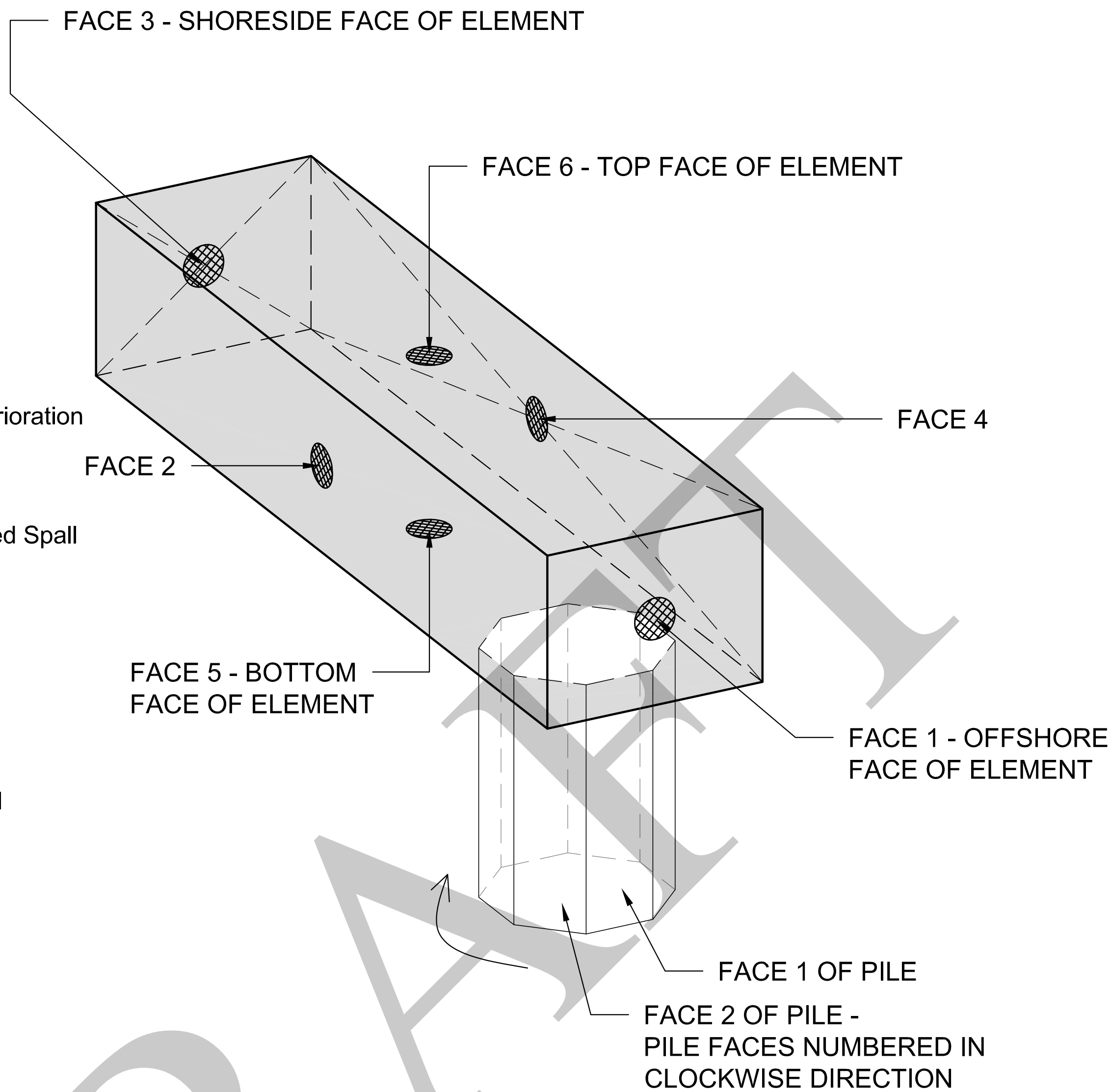
NI = Not Inspected
ND = No Defect
MN = Minor
MD = Moderate
MJ = Major
SV = Severe

Abbreviations:

AW = Above Water
CCR = Corrosion Crack
CHEM DET = Chemical Deterioration
CL = Coating Loss
CORN = Corner
CRK = Crack
Delam = Delamination / Closed Spall
ENC = Encasement
EXP = Exposed
Full HT = Full Height
H-CRK = Horizontal Crack
HC = Horizontal Crack
HL = Hairline
MB = Marine Borers
MD = Moderate
MECH SP = Mechanical Spall
Mid = Mid-Pile
MJ = Major
MJ RND = Major Rounding
ML = Mudline
MN = Minor
MN RND = Minor Rounding
ND = No Defect
NI = Not Inspected
OCS = Open Corrosion Spall
REINF. = Reinforcing Steel
SL = Section Loss
STR CR = Structural or Horizontal Crack
SV = Severe
TZ = Tidal Zone
V-CRK = Vertical Crack
WL = Waterline

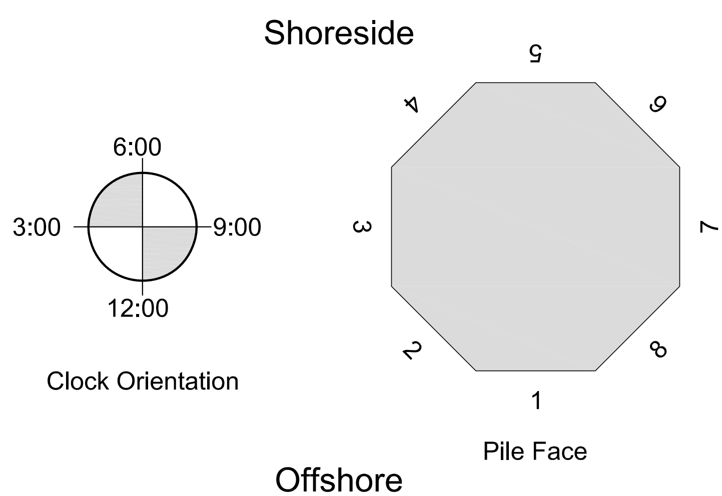
Pile Defect Locations:

Top Elev. = Approximate distance from Top of defect to top of pile
Pile Face = For octagonal piles the face(s) where the defect is found (ex. F3 = Face 3). Similar for square piles. For round piles defects are referenced to clock orientation or compass orientation.
Corners = Defects located on the corner between two pile faces are referenced by a C and the two face numbers (ex. C4/5 = corner between Face 4 and Face 5)



Element Location Key

Scale: NTS



Plan - Pile Face Orientation

Scale: NTS

Shoreline Engineering, Inc
Structural / Civil / Forensic / Engineer-Divers
505 Harbor Street
Morro Bay, CA 93442
(805) 772-6466 v
(805) 772-6467 f
e-mail: info@shoreline-engineering.net

ELEMENT AND DEFECT LOCATION KEY

PRELIMINARY DRAFT - 20 JANUARY 2017

SGH, Inc.
Alameda Point Pier Inspections
Underwater Inspection

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

Underwater Inspection (LIII)
Steel King Piles / Conc Panels
***Structure:* PIER 1 - South Side**

Sheet: **2 SHTS**
Job #: **420-05**
Date: **10/9/2016**

Notes: **MG** Tender: **AH** Diver: **JB**

Station	**WL UTM READING (IN)**		**CP (-mV)**	**Notes**
0+00	OF:	1.400/1.400/1.400	631	~20% coating loss
	Web:	0.820/0.820/0.820	(Ag/AgCl)	~40% coating loss
	IF:	1.420/1.420/1.415	Seawater	no coating loss
Deck-WL	**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft): 8.5	OF:			Shallow water - readings at ML and WL only
Time of day: 1:19 PM	Web:			
Date: 10/9/2016	IF:			
Pneumo	**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft) **10'**	OF:	1.440/1.440/1.440	630	no coating loss
Time of day: **1:28 PM**	Web:	0.825/0.820/0.825	(Ag/AgCl)	no coating loss
Date: **10/9/2016**	IF:	1.415/1.415/1.415	Seawater	no coating loss
Station	**WL UTM READING**		**CP (-mV)**	**Notes**
1+00	OF:	1.495/1.495/1.490	642	no coating loss
	Web:	Inaccessible	(Ag/AgCl)	
	IF:	Inaccessible	Seawater	
Deck-WL	**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft): **8.5'**	OF:	1.460/1.455/1.455	643	no coating loss
Time of day: **1:19 PM**	Web:	Inaccessible	(Ag/AgCl)	
Date: **10/9/2016**	IF:	Inaccessible	Seawater	
Pneumo	**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft) **23'**	OF:	1.470/1.470/1.470	640	no coating loss
Time of day: **1:31 PM**	Web:	Inaccessible	(Ag/AgCl)	
Date: **10/9/2016**	IF:	Inaccessible	Seawater	
Station	**WL UTM READING**		**CP (-mV)**	**Notes**
2+00	OF:	1.400/1.400/1.400	644	no coating loss
	Web:	Inaccessible	(Ag/AgCl)	
	IF:	Inaccessible	Seawater	
Deck-WL	**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft): **8.1'**	OF:	1.425/1.425/1.425	646	no coating loss
Time of day: **1:41 PM**	Web:	Inaccessible	(Ag/AgCl)	
Date: **10/9/2016**	IF:	Inaccessible	Seawater	
Pneumo	**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft) **26'**	OF:	1.420/1.420/1.420	646	no coating loss
Time of day: **1:41 PM**	Web:	Inaccessible	(Ag/AgCl)	
Date: **10/9/2016**	IF:	Inaccessible	Seawater	
Station	**WL UTM READING**		**CP (-mV)**	**Notes**
3+00	OF:	1.435/1.435/1.435	647	Coating Intact, concrete firm
	Web:	Inaccessible	(Ag/AgCl)	
	IF:	Inaccessible	Seawater	
Deck-WL	**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft): **7.2'**	OF:	1.435/1.435/1.440	648	Coating Intact, concrete firm
Time of day: **10:16 AM**	Web:	Inaccessible	(Ag/AgCl)	
Date: **10/9/2016**	IF:	Inaccessible	Seawater	
Pneumo	**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft) **29'**	OF:	1.425/1.425/1.425	649	less than 5% coating loss, concrete firm
Time of day: **10:16 AM**	Web:	Inaccessible	(Ag/AgCl)	
Date: **10/9/2016**	IF:	Inaccessible	Seawater	

SGH, Inc.
Alameda Point Pier Inspections
Underwater Inspection

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

Underwater Inspection (LIII)
Steel King Piles / Conc Panels

Sheet: **2 SHTS**
Job #: **420-05**
Date: **10/9/2016**

Notes: **MG** Tender: **AH** Diver: **JB**

Structure: **PIER 1 - South Side**

Station		WL UTM READING		CP (-mV)	Notes
4+00		OF:	1.455/1.450/1.455	641	Coating Intact, concrete hard
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.6'	OF:	1.435/1.430/1.435	641	Coating Intact, concrete hard
Time of day:	10:42 AM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/9/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	30'	OF:	1.430/1.430/1.430	643	Coating Intact, concrete hard
Time of day:	10:40 AM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/9/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
5+00		OF:	1.415/1.415/1.415	645	Coating Intact, concrete hard
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.7'	OF:	1.400/1.400/1.400	647	less than 5% CL, concrete firm
Time of day:	10:59 AM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/9/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	30'	OF:	1.395/1.395/1.395	648	Coating Intact, concrete firm
Time of day:	10:59 AM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/9/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
6+00		OF:	1.450/ 1.455/1.455	658	Coating Intact, concrete hard
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.9'	OF:	1.455/1.455/1.450	657	Coating Intact, concrete firm
Time of day:	11:30 AM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/9/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	29'	OF:	1.445/1.445/1.450	658	Coating Intact, concrete hard
Time of day:	11:25 AM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/9/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
7+00		OF:	0.815/0.815/0.815	659	10%-15% CL, concrete hard, MN piting
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	8.0'	OF:			
Time of day:	11:58 AM	Web:	Inaccessible		
Date:	10/9/2016	IF:	Inaccessible		
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	10'	OF:	0.830/0.830/0.825	664	Coating Intact, concrete hard
Time of day:	11:59 AM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/9/2016	IF:	Inaccessible	Seawater	

Corner at 6+52, 6+75, 6+92
End at 7+16

SGH, Inc.
Alameda Point Pier Inspections
Underwater Inspection

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

Underwater Inspection (LIII)		Sheet:	**2 SHTS**
Steel King Piles / Conc Panels		Job #:	**420-05**
Structure: **PIER 1 - North Side**		Date:	**10/8/2016**

Notes: **MG** Tender: **AH** Diver: **JB**

Station		WL UTM READING (IN)		CP (-mV)	Notes
0+00		OF:	0.815/0.820/0.820	619	~10% coating loss
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.4	OF:			Shallow water - readings at ML and WL only
Time of day:	1:56 PM	Web:			
Date:	10/8/2016	IF:			
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	5	OF:	0.825/0.820/0.820	623	<5% coating loss
Time of day:	2:05 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
1+00		OF:	0.815/0.815/0.805	845	70% coating loss
		Web:	Inaccessible	(Ag/AgCl)	CP @ 0+95 = -663, @ 1+05 = -848, @ 1+10 = -652
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.4	OF:	0.820/0.825/0.820	846	no coating loss
Time of day:	1:56 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	12	OF:	0.820/0.820/0.825	846	no coating loss
Time of day:	1:54 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
2+00		OF:	0.815/0.820/0.815	662	10-20% coating loss
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.6	OF:	0.810/0.815/0.810	663	<5% coating loss
Time of day:	1:37 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	13	OF:	0.820/0.815/0.810	662	no coating loss
Time of day:	1:43 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
3+00		OF:	0.810/0.815/0.815	664	60% coating loss
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.6	OF:	0.815/0.815/0.820	666	Coating Intact
Time of day:	1:37 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	15	OF:	0.820/0.820/0.825	664	<5% coating loss
Time of day:	1:37 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	

SGH, Inc.
Alameda Point Pier Inspections
Underwater Inspection

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

Underwater Inspection (LIII)
Steel King Piles / Conc Panels

Sheet: 2 SHTS
Job #: 420-05
Date: 10/8/2016

Notes: MG | Tender: AH | Diver: JB

Structure: **PIER 1 - North Side**

Station		WL UTM READING		CP (-mV)	Notes
4+00		OF:	0.830/0.815/0.825	655	<5% coating loss
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.8	OF:	0.815/0.810/0.820	656	Coating Intact
Time of day:	1:30 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	16	OF:	0.820/0.820/0.815	654	Coating Intact with minor blistering
Time of day:	1:30 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
5+00		OF:	0.810/0.820/0.810	671	Coating Intact
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.8	OF:	0.815/0.825/0.820	672	Coating Intact
Time of day:	1:07 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	14	OF:	0.820/0.825/0.815	671	Coating Intact
Time of day:	1:07 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Station		**WL UTM READING**		**CP (-mV)**	**Notes**
6+00		OF:	0.850/0.845/0.845	675	<5% coating loss with minor blistering
		Web:	Inaccessible	(Ag/AgCl)	
		IF:	Inaccessible	Seawater	
Deck-WL		**MID UTM READING**		**CP (-mV)**	**Notes**
Height (ft):	7.8	OF:	0.825/0.830/0.840	673	Coating Intact
Time of day:	1:17 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	
Pneumo		**ML UTM READING**		**CP (-mV)**	**Notes**
Depth (ft)	12	OF:	0.850/0.830/0.825	673	Coating Intact
Time of day:	1:17 PM	Web:	Inaccessible	(Ag/AgCl)	
Date:	10/8/2016	IF:	Inaccessible	Seawater	

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2 - PRESTRESSED	1-A		ND							27
PIER 2 - PRESTRESSED	1-C		ND							27
PIER 2 - PRESTRESSED	1-D		ND							27
PIER 2 - PRESTRESSED	1-E		ND							27
PIER 2 - PRESTRESSED	1-F		ND							27
PIER 2 - PRESTRESSED	1-H	2	ND						WL=H, MID=F, ML=H	26
PIER 2 - PRESTRESSED	1.3-A BAT		ND							27
PIER 2 - PRESTRESSED	1.3-H BAT		ND							
PIER 2 - PRESTRESSED	1.7-A BAT		ND							27
PIER 2 - PRESTRESSED	1.7-H BAT		ND							
PIER 2 - PRESTRESSED	2-A		ND							
PIER 2 - PRESTRESSED	2-C		ND							
PIER 2 - PRESTRESSED	2-D		ND							
PIER 2 - PRESTRESSED	2-E		ND							
PIER 2 - PRESTRESSED	2-F		ND							
PIER 2 - PRESTRESSED	2-H		ND							
PIER 2 - PRESTRESSED	2.3-A BAT		ND							
PIER 2 - PRESTRESSED	2.3-H BAT		ND							
PIER 2 - PRESTRESSED	2.7-A BAT		ND							
PIER 2 - PRESTRESSED	2.7-H BAT		ND							
PIER 2 - PRESTRESSED	3-A		ND							
PIER 2 - PRESTRESSED	3-C	2	MD	MECH SP		Tidal Zone	C2/3		3X4X1 INCH DEEP SPALL, WL=H, MID=H, ML=F	23
PIER 2 - PRESTRESSED	3-D		ND							
PIER 2 - PRESTRESSED	3-E		ND							
PIER 2 - PRESTRESSED	3-F		ND							
PIER 2 - PRESTRESSED	3-H		ND							
PIER 2 - PRESTRESSED	3.3-A BAT		ND							
PIER 2 - PRESTRESSED	3.3-H BAT		ND							
PIER 2 - PRESTRESSED	3.7-A BAT		ND							
PIER 2 - PRESTRESSED	3.7-H BAT		ND							
PIER 2 - PRESTRESSED	4-A		MD	MECH SP		Tidal Zone	C2/3		3X3X1 INCH DEEP	
PIER 2 - PRESTRESSED	4-C		ND							
PIER 2 - PRESTRESSED	4-D		ND							
PIER 2 - PRESTRESSED	4-E		ND							
PIER 2 - PRESTRESSED	4-F	2	ND						WL=H, MID=F, ML=H	24
PIER 2 - PRESTRESSED	4-H		ND							
PIER 2 - PRESTRESSED	4.3-A BAT	2	ND						ML=H, MID=F, ML=H	23
PIER 2 - PRESTRESSED	4.7-A BAT		ND							
PIER 2 - PRESTRESSED	5-A		ND							23
PIER 2 - PRESTRESSED	5-C		ND							23
PIER 2 - PRESTRESSED	5-D		ND							21
PIER 2 - PRESTRESSED	5-E		ND							21
PIER 2 - PRESTRESSED	5-F		ND							22
PIER 2 - PRESTRESSED	5-H		ND							25
PIER 2 - PRESTRESSED	5.3-H BAT		ND							
PIER 2 - PRESTRESSED	5.7-H BAT		ND							
PIER 2 - PRESTRESSED	6-A		ND							
PIER 2 - PRESTRESSED	6-C		ND							
PIER 2 - PRESTRESSED	6-D		ND							
PIER 2 - PRESTRESSED	6-E	2	ND						ML=H, MID=H, WL=F	20
PIER 2 - PRESTRESSED	6-F		ND							

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2 - PRESTRESSED	6-H		ND							
PIER 2 - PRESTRESSED	6.3-A BAT		ND							
PIER 2 - PRESTRESSED	6.7-A BAT		ND							
PIER 2 - PRESTRESSED	7-A		ND							
PIER 2 - PRESTRESSED	7-C		ND							
PIER 2 - PRESTRESSED	7-D	2	ND						ML=H, MID=H, WL=H	21
PIER 2 - PRESTRESSED	7-E		ND							
PIER 2 - PRESTRESSED	7-F		ND							
PIER 2 - PRESTRESSED	7-H		ND							
PIER 2 - PRESTRESSED	7.3-H BAT		ND							
PIER 2 - PRESTRESSED	7.7-H BAT		ND							
PIER 2 - PRESTRESSED	8-A	2	ND						ML=H, MID=H, WL= H	27
PIER 2 - PRESTRESSED	8-C		ND							
PIER 2 - PRESTRESSED	8-D		ND							
PIER 2 - PRESTRESSED	8-E		ND							
PIER 2 - PRESTRESSED	8-F		ND							
PIER 2 - PRESTRESSED	8-H		ND							
PIER 2 - PRESTRESSED	8.3-A BAT		ND							
PIER 2 - PRESTRESSED	8.7-A BAT		ND							
PIER 2 - PRESTRESSED	9-A		ND							26
PIER 2 - PRESTRESSED	9-C		ND							
PIER 2 - PRESTRESSED	9-D		ND							
PIER 2 - PRESTRESSED	9-E		ND							
PIER 2 - PRESTRESSED	9-F		ND							
PIER 2 - PRESTRESSED	9-H	2	ND						ML=F, MID=H, WL=H	23
PIER 2 - PRESTRESSED	9.3-H BAT		ND							
PIER 2 - PRESTRESSED	9.7-H BAT		ND							
PIER 2 - PRESTRESSED	10-A		ND							24
PIER 2 - PRESTRESSED	10-C		ND							20
PIER 2 - PRESTRESSED	10-D		ND							18
PIER 2 - PRESTRESSED	10-E		ND							19
PIER 2 - PRESTRESSED	10-F		ND							21
PIER 2 - PRESTRESSED	10-H		ND							23
PIER 2 - PRESTRESSED	10.3-A BAT		ND							
PIER 2 - PRESTRESSED	10.7-A BAT		ND							
PIER 2 - PRESTRESSED	11-A		ND							
PIER 2 - PRESTRESSED	11-C	2	ND						ML=F, MID=F, WL=F	21
PIER 2 - PRESTRESSED	11-D		ND							
PIER 2 - PRESTRESSED	11-E		ND							
PIER 2 - PRESTRESSED	11-F		ND							
PIER 2 - PRESTRESSED	11-H		ND							
PIER 2 - PRESTRESSED	11.3-H BAT		ND							
PIER 2 - PRESTRESSED	11.7-H BAT		ND							
PIER 2 - PRESTRESSED	12-A		ND							25
PIER 2 - PRESTRESSED	12-C		ND							
PIER 2 - PRESTRESSED	12-D		ND							
PIER 2 - PRESTRESSED	12-E		MD	H-CRK	≤1/32	Mid-water	2		@-7' 10:49, <1/32 PHOTO	
PIER 2 - PRESTRESSED	12-F	2	ND						ML=H, MID=H, WL=H	22
PIER 2 - PRESTRESSED	12-H		ND							
PIER 2 - PRESTRESSED	12.3-A BAT		MD	MECH SP		Tidal Zone	C3/4		6"X4"X1" DEEP	
PIER 2 - PRESTRESSED	12.7-A BAT		ND							

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2 - PRESTRESSED	13-A		ND							26
PIER 2 - PRESTRESSED	13-C		ND							
PIER 2 - PRESTRESSED	13-D		ND							
PIER 2 - PRESTRESSED	13-E		ND							
PIER 2 - PRESTRESSED	13-F		ND							
PIER 2 - PRESTRESSED	13-H	2	ND						ML=H, MID=F, WL=H	24
PIER 2 - PRESTRESSED	13.3-H BAT		ND							
PIER 2 - PRESTRESSED	13.7-H BAT		ND							
PIER 2 - PRESTRESSED	14-A		ND							
PIER 2 - PRESTRESSED	14-C		ND							
PIER 2 - PRESTRESSED	14-D		ND							
PIER 2 - PRESTRESSED	14-E		ND							
PIER 2 - PRESTRESSED	14-F		ND							
PIER 2 - PRESTRESSED	14-H		ND							
PIER 2 - PRESTRESSED	14.3-A BAT		ND							
PIER 2 - PRESTRESSED	14.7-A BAT	2	MN	ABRASION		Tidal Zone	C3/4		ML=F, MID=F, WL= H ABRASION 6"X6"X1" DEEP 1' BELOW WL	24
PIER 2 - PRESTRESSED	15-A		ND							26
PIER 2 - PRESTRESSED	15-C		ND							21
PIER 2 - PRESTRESSED	15-D		ND							18
PIER 2 - PRESTRESSED	15-E		ND							18
PIER 2 - PRESTRESSED	15-F		ND							21
PIER 2 - PRESTRESSED	15-H		ND							25
PIER 2 - PRESTRESSED	15.3-H BAT		ND							
PIER 2 - PRESTRESSED	15.7-H BAT		ND							
PIER 2 - PRESTRESSED	16-A		ND							
PIER 2 - PRESTRESSED	16-C		ND							
PIER 2 - PRESTRESSED	16-D	2	ND						ML=H, MID=F, WL= H	18
PIER 2 - PRESTRESSED	16-E		ND							
PIER 2 - PRESTRESSED	16-F		ND							
PIER 2 - PRESTRESSED	16-H		ND							
PIER 2 - PRESTRESSED	16.3-A BAT		MN	ABRASION					MN ABRASION	
PIER 2 - PRESTRESSED	16.7-A BAT		MD	ABRASION					ABRASION 5"X7"X1.5" DEEP	
PIER 2 - PRESTRESSED	17-A		ND							26
PIER 2 - PRESTRESSED	17-C		ND							
PIER 2 - PRESTRESSED	17-D		ND							
PIER 2 - PRESTRESSED	17-E	2	ND						ML=H, MID=F, WL=H	16
PIER 2 - PRESTRESSED	17-F		ND							
PIER 2 - PRESTRESSED	17-H		ND							
PIER 2 - PRESTRESSED	17.3-A BAT		ND							
PIER 2 - PRESTRESSED	17.3-H BAT		ND							
PIER 2 - PRESTRESSED	17.7-A BAT		ND							
PIER 2 - PRESTRESSED	17.7-H BAT		MD	ABRASION		AW	C2/3		UP TO 1.5" DEEP ABRASION	
PIER 2 - PRESTRESSED	18-A		ND							
PIER 2 - PRESTRESSED	18-C	2	ND						ML=H, MID=H, WL=H	21
PIER 2 - PRESTRESSED	18-D		ND							
PIER 2 - PRESTRESSED	18-E		ND							
PIER 2 - PRESTRESSED	18-F		ND							
PIER 2 - PRESTRESSED	18-H		ND							
PIER 2	19-A.5		MD	MECH SP		Mid-water	C2/3		8"X6"X1"DEEP NO EXPOSED BAR @-10 SOFTER CONCRETE	
PIER 2	19-B		MJ	OCS	Exposed Reinf.	AW				
PIER 2	19-C		SV	CHEM DET	Exposed Reinf.	Full HT			>50% SL PHOTO FACE 2 @-6'	

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	19-D	2	ND						ML=MS, MID=F, WL=S	15
PIER 2	19-E		ND							
PIER 2	19-F		ND							
PIER 2	19-G.5		ND							
PIER 2	19.2-B BAT		SV	CHEM DET	Exposed Reinf.	Mid-water	C3/4			
PIER 2	19.2-G BAT		SV	CHEM DET	Exposed Reinf.	Mid-ML	Multiple		MULT BARS EXPOSED	18
PIER 2	19.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	20-A.5		ND							
PIER 2	20-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		50% SL AT MID-PILE, MULT BARS EXPOSED	22
PIER 2	20-C	2	MJ	CHEM DET	MJ RND	AW-TZ	Multiple		ML=MS, MID=F W/MECH SPALL, WL=S	18
PIER 2	20-C.5		ND							
PIER 2	20-D		MN	MECH SP			C2/3		SPALL AT TOP OF PILE 8"HX6"WX0.75"D	
PIER 2	20-D.5		ND							13
PIER 2	20-E		ND							
PIER 2	20-F		ND						CCS AW	
PIER 2	20-G.5		ND					Yes	ENC 5' BC TO ML	
PIER 2	20.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		EXPOSED BARS -4' TO -16'	18
PIER 2	20.8-B BAT		ND							
PIER 2	21-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			25
PIER 2	21-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			23
PIER 2	21-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	21-C.5	2	ND						BOTTOM OF VAULT AT -5', ML=F, MID=F, -6'=F	15
PIER 2	21-D		SV	CHEM DET	Exposed Reinf.	Full HT	Multiple			14
PIER 2	21-D.5		ND						STL BEAM ABOVE PILES	
PIER 2	21-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	21-F		SV	CHEM DET	Exposed Reinf.	Mudline	Multiple	Yes	ENC 2' BC TO -16'	19
PIER 2	21-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			22
PIER 2	21-H		ND					Yes	ENC 5' BC TO ML	23
PIER 2	21.2-G BAT		MJ	CHEM DET	MJ RND	Mudline	C4/1	Yes	ENC 5' BC TO -16', SL C1/4 18"HX4"WX3/4"D	19
PIER 2	21.8-B BAT		ND							
PIER 2	22-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			24
PIER 2	22-B	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		ML=F, MID=S, WL=S	21
PIER 2	22-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	22-C.5		ND							
PIER 2	22-D		SV	CHEM DET	Exposed Reinf.	Full HT	Multiple			14
PIER 2	22-D.5	2	ND						ML=F, MID=MS, -6'=F	12
PIER 2	22-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		20-30% SL @ MID	17
PIER 2	22-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			17
PIER 2	22-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			22
PIER 2	22-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		20-30% SL @ MID	23
PIER 2	22.2-G BAT		ND							
PIER 2	22.8-B BAT		ND							
PIER 2	23-A		ND					Yes	ENC 5' BC TO -28'	26
PIER 2	23-B		MJ	CHEM DET	MJ RND	Mudline	C3/4	Yes	ENC 5' BC TO -22'	24
PIER 2	23-C	2	SV	CHEM DET	Exposed Reinf.		Multiple		ML=S, 60% SL AT MID, WL=MS	18
PIER 2	23-C.5		ND							
PIER 2	23-D		MJ	CHEM DET	MJ RND	Mudline	Multiple	Yes	ENC FROM CAP TO -14', ROUNDED CORNERS UP TO 4"D	12
PIER 2	23-D.5		ND							
PIER 2	23-E	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		ML=S, MID=S, WL=S	12
PIER 2	23-F		SV	CHEM DET	Exposed Reinf.	Mudline	Multiple	Yes	ENC 6' BC TO -17'	18
PIER 2	23-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			23

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	23-H		ND					Yes	ENC 4' BC TO 6" ABOVE ML	24
PIER 2	23.2-G BAT		ND							
PIER 2	23.8-B BAT		MD	V-CRK	>1/8	AW	4		H-CRK F4 1/8"W @-4' @1558, V-CRK F4 3' BC 30"H X 1/8"W	
PIER 2	24-A		ND						MJ ABOVE WATER	26
PIER 2	24-B		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		H-CRK F1234 1/8"w @ -24'	22
PIER 2	24-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			17
PIER 2	24-C.5		ND							
PIER 2	24-D	2	SV	CHEM DET	Exposed Reinf.	Full HT	Multiple		ML=S, MID=S, -7'=S	12
PIER 2	24-D.5		ND							
PIER 2	24-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			14
PIER 2	24-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			19
PIER 2	24-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		30% SL @ -7'	21
PIER 2	24-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			24
PIER 2	24.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	24.8-B BAT	2	MD	V-CRK	≤1/16	Mid-water	2			19
PIER 2	25-A		MJ	OCS	Exposed Reinf.	AW	C1/2	Yes	ENC 7' BELOW CAP ENDS AT -24', OCS 3'HX14"WX4" DEEP 3' BELOW CAP,	27
PIER 2	25-B	2	MD	CHEM DET	MN RND	Full HT	Multiple		CORROSION CRK AW 1/16"	24
PIER 2	25-C		MD	CHEM DET	MN RND	Mid-ML	Multiple			19
PIER 2	25-C.5		ND							16
PIER 2	25-D		SV	CHEM DET	Exposed Reinf.	Full HT	Multiple			12
PIER 2	25-D.5	2	MD	V-CRK	≤1/8	Full HT	3			12
PIER 2	25-E		ND							14
PIER 2	25-F		MJ	CHEM DET	MJ RND	Mid-water	Multiple		HEAVY ROUNDING OF CORNERS	19
PIER 2	25-G		MJ	CHEM DET	MJ RND	Mudline	Multiple	Yes	ENC 4' BELOW CAP TO -24'	24
PIER 2	25-H		MD	CHEM DET	MN RND	TZ-ML	Multiple			25
PIER 2	25.2-G BAT		MD	CHEM DET	MN RND	Mid-water	C4/1			19
PIER 2	25.8-B BAT		ND							
PIER 2	26-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	26-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			25
PIER 2	26-C	2	MD	MECH SP		Mudline	4		SPALL 6"X6"X1.5" DEEP ML=MS, MID=F,WL=F	20
PIER 2	26-C.5		ND							
PIER 2	26-D	2	SV	CHEM DET	Exposed Reinf.	Full HT	Multiple			14
PIER 2	26-D.5		ND							
PIER 2	26-E		MD	CHEM DET	MN RND	TZ-ML	C2/3			
PIER 2	26-F		MD	V-CRK	≤1/16	Mid-water	C1/2		MN ROUNDING	
PIER 2	26-G		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK MULTIPLE CORNERS 1/16" MID, MN ROUNDING AT ML	
PIER 2	26-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	26.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	26.8-B BAT		MD	CHEM DET	MN RND	TZ-Mid	C4/1			
PIER 2	27-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	27-B		SV	CHEM DET	Exposed Reinf.	TZ-Mid	Multiple		PHOTO, GETS BETTER NEAR ML	
PIER 2	27-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	27-C.5	2	ND						ML=F, MID=MS, WL=MS	16
PIER 2	27-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	27-D.5		ND							
PIER 2	27-E	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			13
PIER 2	27-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			-4
PIER 2	27-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	27-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			26
PIER 2	27.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	27.8-B BAT		MD	CHEM DET	MN RND	Mid-water	C1/2			

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	28-A		SV	BROKEN	Exposed Reinf.	AW		Yes	ENCASED 6' BELOW CAP TO -29'	27
PIER 2	28-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	28-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	28-D		SV	CHEM DET	Exposed Reinf.	Mudline	Multiple		ENCASED 4' BELOW CAP TO 15'	15
PIER 2	28-E	2	MD	V-CRK	≤1/8	Mudline	Multiple	Yes	ENCASED TO 2' ABOVE ML, ML=F	14
PIER 2	28-F	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			17
PIER 2	28-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	28-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	28.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	28.8-B BAT		MD	CHEM DET	MN RND	Mid-water	C4/1			
PIER 2	29-A	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			25
PIER 2	29-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	29-C	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			19
PIER 2	29-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	29-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	29-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple	Yes	ENCASED FROM -19' TO 4' BELOW CAP	19
PIER 2	29-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	29-H		MD	CHEM DET	MN RND	Mudline	C3/4	Yes	ENCASED 6' BELOW CAP TO 1' ABOVE ML, CRACKING UP TO 1/16" C3/4	
PIER 2	29.2-G BAT		MD	CHEM DET	MN RND	Mid-water	Multiple			
PIER 2	29.8-B BAT		ND					Yes	ENCASED 7' BELOW CAP TO -12'	
PIER 2	30-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			26
PIER 2	30-B	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			24
PIER 2	30-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			17
PIER 2	30-D	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	30-E	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	30-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			19
PIER 2	30-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			24
PIER 2	30-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			26
PIER 2	30.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			19
PIER 2	31-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	31-B		MN						MN VOIDS FACE 1 MID PILE	
PIER 2	31-C	2	ND						ML=F, MID=F, WL=F	19
PIER 2	31-D		ND							
PIER 2	31-E		ND							
PIER 2	31-F		ND							
PIER 2	31-G		MD	CHEM DET	MN RND	Mid-water	C1/2			
PIER 2	31-H		MD	V-CRK	≤1/16	Mid-water	C2/3			
PIER 2	31.2-B BAT	2	MD	H-CRK	≤1/16	Varies	Multiple		H-CRK MID AND ML AND WL, ML=F, MID=F, WL=F	19
PIER 2	31.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-Mid	Multiple			
PIER 2	31.8-B BAT		ND							
PIER 2	32-A	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			27
PIER 2	32-B		ND							
PIER 2	32-C		MJ	CHEM DET	≤1/4	Mid-water	Multiple		V-CRK C2/3 UP TO 1/4" MID	
PIER 2	32-D	2	MD	CHEM DET	MN RND	Mid-water	C2/3		ML=F, MID=F, WL=F	15
PIER 2	32-E	2	MD	CHEM DET	MN RND	Mid-water	C2/3		ML=MS, MID=F, WL=F	15
PIER 2	32-F		MD	V-CRK	≤1/16	Mid-water	C2/3			
PIER 2	32-G		MD	V-CRK	≤1/16	Mid-water	C2/3			
PIER 2	32-H		ND							
PIER 2	32.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	32.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-Mid	Multiple			
PIER 2	33-A		ND							

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	33-B	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		PHOTO	23
PIER 2	33-C	2	ND						ML=F, MID=F,WL=F	18
PIER 2	33-D		ND							
PIER 2	33-E		ND							
PIER 2	33-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	33-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	33-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	33.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	33.8-B BAT		SV	CHEM DET	Exposed Reinf.	Mudline	Multiple	YES	ENC= -19' TO 6' BELOW CAP, CHEM DET. BELOW ENC.	18
PIER 2	34-A	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			27
PIER 2	34-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	34-C	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	34-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	34-E	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	34-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	34-F.5		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	34-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	34-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	34.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	34.8-B BAT		SV	CHEM DET	Exposed Reinf.	Mudline	Multiple	YES	ENC= -19' TO 1' BELOW CAP, DEFECTS BELOW ENC.	23
PIER 2	35-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			26
PIER 2	35-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			23
PIER 2	35-C	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			16
PIER 2	35-D	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	35-E		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			15
PIER 2	35-E.8		MD	CHEM DET	MN RND	Mid-water	C3/4			15
PIER 2	35-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	35-F.5		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			21
PIER 2	35-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			23
PIER 2	35-H		MJ	CHEM DET	MJ RND	Mudline	Multiple	YES	ENC= 5' BELOW CAP TO -25', DEFECTS BELOW ENC	26
PIER 2	35.2-G BAT		MJ	CHEM DET	MJ RND	TZ-Mid	C3/4			17
PIER 2	35.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	36-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	36-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	36-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	36-D		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	36-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	36-E.5		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	36-F	2	MD	CHEM DET	MN RND	TZ-ML	Multiple			16
PIER 2	36-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	36-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple	Yes	ENC= -'25 TO 5' BELOW CAP, DEFECT BELOW ENC	26
PIER 2	36.2-G BAT		ND							
PIER 2	36.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	37-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	37-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	37-C		MD	V-CRK	≤1/8	Mid-ML	C2/3			
PIER 2	37-D		MD	V-CRK	≤1/8	Mid-water	C2/3			
PIER 2	37-D.5		ND							
PIER 2	37-E	2	ND						ML=H, MID= MS, WL=H	-4
PIER 2	37-E.5		MD	V-CRK	≤1/8	Mid-ML	C2/3			
PIER 2	37-F		ND							

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	37-G	2	ND						ML=H, MID=H, WL,H	22
PIER 2	37-H	2	MD	CHEM DET	MN RND	Mid-ML	Multiple		ML=S, MID=S,WL=F	23
PIER 2	37.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	37.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	38-A		MD	V-CRK	≤1/16	Mudline	Multiple	Yes	ENC= 6' BELOWCAP TO -28', MN RND BELOW ENC	24
PIER 2	38-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	38-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	38-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	38-D.3		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	38-D.5		ND							
PIER 2	38-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	38-F		ND							
PIER 2	38-G		ND							
PIER 2	38-H		ND							
PIER 2	38.2-G BAT		MJ	CHEM DET	MJ RND	Mudline	Multiple	Yes	ENC= 7' BELOW CAP TO -19', DEFECTS BELOW CAP	17
PIER 2	38.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	39-A		MD	V-CRK	≤1/16	TZ-Mid	C2/3			
PIER 2	39-B		MD	V-CRK	≤1/8	TZ-Mid	C4/1			
PIER 2	39-C		MD	V-CRK	≤1/16	Mid-ML	Multiple			
PIER 2	39-D		MD	V-CRK	≤1/8	Mid-water	Multiple			
PIER 2	39-D.3		MD	V-CRK	≤1/16	Mid-water	C1/2			
PIER 2	39-D.5		ND							
PIER 2	39-E.2	2	ND						ML=F, MID=F, WL=F	13
PIER 2	39-F	2	MJ	CHEM DET	MJ RND	Mid-ML	Multiple		WL=H, MID=S, ML=S	17
PIER 2	39-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	39-H	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=F, MID=S, ML=MS, CRK AT ML 1/4" WIDE 3' H	23
PIER 2	39.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	39.8-B BAT		ND							
PIER 2	40-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL MULTIPLE EXP. BAR	
PIER 2	40-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	40-C		SV	CHEM DET	Exposed Reinf.	Mudline	Multiple	YES	ENC=WL TO -15', DEFECT BELOW ENC.	15
PIER 2	40-C.7		MD	CHEM DET	MN RND	Mudline	Multiple	Yes	ENC= -15' TO 5' BELOW CAP, DEFECT BELOW ENC	14
PIER 2	40-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	40-D.2		MD	CHEM DET	MN RND	Mudline	Multiple	Yes	ENC=-14 TO 8' BELOW CAP, DEFECT BELOW CAP	12
PIER 2	40-E		MD	CHEM DET	MN RND	Mudline	Multiple	Yes	ENC=-1' TO -15'	13
PIER 2	40-F	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		ML=S, MID=S, WL=S	16
PIER 2	40-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	40-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	40.2-G BAT	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, MID=S, ML=S	16
PIER 2	40.8-B BAT		ND							20
PIER 2	41-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			27
PIER 2	41-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			21
PIER 2	41-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			16
PIER 2	41-C.5		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			14
PIER 2	41-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			13
PIER 2	41-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	41-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	41-G	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, H-CRK AT WL 3/16"W F4, MID=S, ML=S	22
PIER 2	41-H	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, MID=S, ML=S, 20-30% SL AT ML	23
PIER 2	41.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			20
PIER 2	41.8-B BAT		ND							

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	42-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	42-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	42-B.5		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL W/ MULTIPLE EXP. BAR	
PIER 2	42-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL W/ MULTIPLE EXP. BAR	
PIER 2	42-C.3		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	42-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL W/ MULTIPLE EXP. BAR	
PIER 2	42-E	2	MJ	CHEM DET	≤1/8	TZ-ML	Multiple		WL=F, MD=S, ML=S, 1/8" vertical crack @ ML c3/4, Chem starts 7	15
PIER 2	42-F	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S (-5), MD=S, ML=F	19
PIER 2	42-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	42-H	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=H, MD=S, ML=S	25
PIER 2	42.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	42.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	43-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL, MULT EXP BARS	
PIER 2	43-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL EXP STIRRUPS MULT EXP BARS @ ML	
PIER 2	43-B.5		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	43-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	43-D	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, MD=S, ML=S	13
PIER 2	43-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	43-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	43-G	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, MD=S, ML=S 1/16" crack @ ML, Chem ends 5' from ML	24
PIER 2	43-H	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, MD=S, ML=S, MULT EXP BARS, SV SL	26
PIER 2	43.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	43.3-C		ND						ONLY CONNECTED TO VAULT NEAR CAP	
PIER 2	43.3-E		ND						ONLY CONNECTED TO VAULT NEAR CAP	
PIER 2	43.7-C		ND						ONLY CONNECTED TO VAULT NEAR CAP	
PIER 2	43.7-E		ND						ONLY CONNECTED TO VAULT NEAR CAP	
PIER 2	43.8-B BAT		MD	V-CRK	≤1/8	TZ-Mid	C4/1			
PIER 2	44-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	44-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	44-C	2	MJ	CHEM DET	≤1/8	TZ-ML	Multiple		WL=F, MD=S , ML=MS , Chem starts @ -6' and ends 3' from ML	17
PIER 2	44-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	44-E	2	MJ	CHEM DET	≤1/16	TZ-ML	Multiple		WL=MS, MD=S , ML=S, Chem starts @ -4' and ends 3' from ML, Multi vert. cracks @ MD & ML up to 1/16"	14
PIER 2	44-F	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, MD=S, ML=S, Chem starts @ -6' and ends 3' from ML	18
PIER 2	44-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	44-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	44.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	44.8-B BAT		ND							
PIER 2	45-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			25
PIER 2	45-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			23
PIER 2	45-C	2	MD	CHEM DET	≤1/16	TZ-ML	Multiple		WL=F, MD=S , ML= ,Chem starts @ -5' and ends @ -3 from ML, Rounding @ corners <1" D	17
PIER 2	45-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			14
PIER 2	45-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			15
PIER 2	45-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	45-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL, 5 BARS EXP	23
PIER 2	45-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			25
PIER 2	45.2-G BAT	2	MJ	CHEM DET	≤1/8	TZ-ML	Multiple		WL=F, MD=S, ML=S, Chem starts @ -6' and ends -3 from ML, Mult. Cracks up to 1/8 @ MD & ML	18
PIER 2	45.8-B BAT		ND							
PIER 2	46-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	46-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL, 8 BARS EXP	

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	46-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	46-D	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=F, MD=S, ML=S, Chem starts @ -5' and ends -3' from ML	15
PIER 2	46-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	46-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	46-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	46-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	46.2-G BAT	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=F, MD=S, ML=MS , Chem starts @ -6' and ends 2' from ML	23
PIER 2	46.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	47-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	47-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		5 BARS EXP - SV SL	
PIER 2	47-C	2	MJ	CHEM DET	MJ RND	Mudline	C2/3	Yes	Enc 8' below cap and end @ -19', -19'=S, ML=S, Chem starts below Enc and ends @ ML	18
PIER 2	47-D	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S, MD=S, ML=S, Chem Starts -4' and ends @ ML	15
PIER 2	47-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		4 BARS EXP - SV SL	
PIER 2	47-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	47-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	47-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		7 BARS EXP - SV SL	
PIER 2	47.2-G BAT		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	47.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	48-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		4 BARS EXP - SV SL, BARS EXP AT ML	
PIER 2	48-B		MJ	CHEM DET	MJ RND	Mudline	Multiple	Yes	ENC 10' BELOW CAP TO -23'	23
PIER 2	48-C		MJ	CHEM DET	MJ RND	Mudline	C2/3	Yes	ENC 10' BELOW CAP TO -19'	18
PIER 2	48-D	2	MJ	CHEM DET	MJ RND	Mudline	Multiple	Yes	Enc is 6' below cap and ends @ -17', void 8" in bottom of Enc., 1/8' cracking below Enc. to ML	15
PIER 2	48-E	2	MJ	CHEM DET	MJ RND	Mudline	C2/3	Yes	Enc is 6' below cap and end @ -17', ML=S	21
PIER 2	48-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	48-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	48-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		4 EXP BARS AT ML	
PIER 2	48.2-G BAT		ND							
PIER 2	48.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	49-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		SV SL - 5 EXP BARS	
PIER 2	49-B		MD	CHEM DET	≤1/8	TZ-Mid	C1/2		MN RND TZ-ML MULT CORN	
PIER 2	49-C		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	49-D	2	MD	CHEM DET	≤1/16	Mid-ML	C2/3		WL=F, MD=S, ML=S, Horizontal crack face 4 <1/16", rounding of corners @ corner 2/3	20
PIER 2	49-E		MD	CHEM DET	≤1/8	Tidal Zone	Multiple		MN RND TZ-ML	
PIER 2	49-F	2	MJ	CHEM DET	≤1/8	Mid-ML	Multiple		WL=F , MD=S, ML=S , MN RND starts @ MID and ends @ ML, Rounding of corners @ MID-ML, 1/8" VCRK C2/3 AT -7'	26
PIER 2	49-G		MJ	CHEM DET	MJ RND	Mid-ML	Multiple			
PIER 2	49-H		MJ	CHEM DET	MJ RND	Mid-ML	Multiple			
PIER 2	49.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	49.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			17
PIER 2	50-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			24
PIER 2	50-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			22
PIER 2	50-C	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=F, MD=S, ML=S, Chem starts @ -6' and ends @ ML	22
PIER 2	50-D	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=F, MD=S, ML=S, Chem starts @ -6' and ends 2' from ML	21
PIER 2	50-E	2	MJ	CHEM DET	MJ RND	Mid-ML	Multiple		WL=H , MD=S , ML=S ,Chem MID-ML, MJ RND AT MID, 1/16 vertical cracking @ MD	20
PIER 2	50-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			18
PIER 2	50-G		ND							22
PIER 2	50-H		ND							25
PIER 2	50.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	50.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	51-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		2 EXP BARS MJ SECTION LOSS	

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	51-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		3 EXP BARS SV SECTION LOSS	
PIER 2	51-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	51-D	2	MJ	CHEM DET	MJ RND	Mudline	C2/3	Yes	Enc is 6' below cap and ends @ -16' , 1/16" cracking on face 4, ML=S	19
PIER 2	51-E	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL= H, MD=S, ML=S, Chem starts -4' and ends @ ML	18
PIER 2	51-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		3 EXP BARS SV SECTION LOSS	
PIER 2	51-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		4 EXP BARS	
PIER 2	51-H	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL= H, MD=S, ML=S, Chem starts -4' and ends @ ML, multiple stirrups exposed	28
PIER 2	51.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	51.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	52-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	52-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	52-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	52-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	52-E	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=H, MD=S, ML=S, Chem starts @ -4' and ends @ ML	19
PIER 2	52-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	52-G	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=H, MD=S, ML=S, Chem starts @ -4' and ends @ ML, multiple stirrup exposed	28
PIER 2	52-H	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=H, MD=S, ML=S, Chem starts @ -4' and ends @ ML	31
PIER 2	52.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	52.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	53-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	53-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	53-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	53-D		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		4 BARS EXP SV SL	
PIER 2	53-E		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	53-F	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL= H, MD=S, ML=S, Chem starts @ -4' and ends @ ML	17
PIER 2	53-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	53-H		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	53.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	53.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	54-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	54-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	54-C		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	54-C.5		ND							
PIER 2	54-D		ND							
PIER 2	54-D.5		ND							
PIER 2	54-E	2	ND						WL=F, MID=F, ML=H	13
PIER 2	54-F		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	54-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	54-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	54.2-G BAT	2	MJ	CHEM DET	MJ RND	TZ-ML	Multiple		WL=H, MID=MS W/ 2" D ROUNDING & H-CRK 1/8"W F2, ML=MS W/ 1/8" V-CRK F2	17
PIER 2	54.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		6 EXP BARS SVR SL	
PIER 2	55-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			24
PIER 2	55-B		MD	V-CRK	≤1/16	Mid-water	C2/3			21
PIER 2	55-C	2	MD	V-CRK	≤1/8	Mid-water	4		ML=H ND, MID=F W/V-CRK F4 1/8"W, WL=H ND	15
PIER 2	55-C.5		ND							13
PIER 2	55-D		ND							12
PIER 2	55-D.5	2	MD	CHEM DET	MN RND	Mid-ML	Multiple		TOP=H, MID=MS W/MN ROUNDING, ML=F	13
PIER 2	55-E		MD	CHEM DET	MN RND	TZ-ML	Multiple			12
PIER 2	55-F		ND							17
PIER 2	55-G		MD	CHEM DET	MN RND	Mudline	Multiple			22
PIER 2	55-H	2	MD	H-CRK	≤1/8	Mid-water	4		WL=H ND, MID=H W/DIAG CRK 1/8"W F4, ML=H ND	24

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	55.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			17
PIER 2	55.8-B BAT		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	56-A		ND							
PIER 2	56-B		ND							
PIER 2	56-C		ND							
PIER 2	56-C.5		ND							
PIER 2	56-D		ND							
PIER 2	56-D.5		ND							
PIER 2	56-E		ND							
PIER 2	56-F	2	ND						WL=H ND, MID=F ND, ML=H ND	17
PIER 2	56-G	2	MD	V-CRK	≤1/32	Mid-water	Multiple		ML=F ND, MID=F W/ V-CRK 1/32"W MULT FACES, WL=H ND	21
PIER 2	56-H		ND							
PIER 2	56.2-G BAT		ND							
PIER 2	56.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	57-A		MD	V-CRK	≤1/8	TZ-Mid	C2/3			
PIER 2	57-B		MD	V-CRK	>1/8	TZ-ML	C2/3			
PIER 2	57-C		MD	V-CRK	≤1/16	Mid-ML	C4/1			
PIER 2	57-C.5		ND							
PIER 2	57-D		ND							
PIER 2	57-D.5		ND							
PIER 2	57-E	2	MD	V-CRK	≤1/4	Mudline	C2/3		WL=H, MD=H, ML=H	11
PIER 2	57-F		ND							
PIER 2	57-G	2	ND						WL=H ND, MID=H ND, ML=H ND	22
PIER 2	57-H		ND							
PIER 2	57.2-G BAT	2	MD	V-CRK	≤1/8	Mid-water	C3/4		ML=H ND, MID=F W/V-CRK C3/4 1/8"W, WL=F ND	17
PIER 2	57.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	58-A		ND							
PIER 2	58-B		MD	V-CRK	≤1/16	TZ-ML	C4/1			
PIER 2	58-C		ND							
PIER 2	58-C.5	2	ND						TOP @ -5'=F, MD=F, ML=F	11
PIER 2	58-D	2	MD	V-CRK	≤1/8	Mid-water			TOP @ -5'=F, MD=F,ML=H	10
PIER 2	58-D.5		ND							
PIER 2	58-E		ND							
PIER 2	58-F		ND							
PIER 2	58-G		ND							
PIER 2	58-H		ND							
PIER 2	58.2-C		ND							
PIER 2	58.2-E		ND							
PIER 2	58.2-G BAT		ND							
PIER 2	58.8-B BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		6 EXP BARS, EXTENDS INTO ML	
PIER 2	58.8-C		ND							
PIER 2	58.8-E		ND							
PIER 2	59-A		ND							
PIER 2	59-B		ND							
PIER 2	59-C		ND							
PIER 2	59-C.5		ND							
PIER 2	59-D		MJ	CHEM DET	MJ RND	Mid-water	C3/4			
PIER 2	59-D.5		ND							
PIER 2	59-E		ND							
PIER 2	59-F	2	MD	V-CRK	≤1/4	Tidal Zone			WL=F 3/16" vertical cracking, MD=MS, ML=F	16
PIER 2	59-G	2	MD	V-CRK	≤1/32	Mid-water	Multiple		WL=F ,MD= F,ML=F, Honeycombing @ ML	22

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	59-H	2	MD	V-CRK	≤1/4	Mid-ML	C2/3		WL=F, MD=MS,ML=F, 1/4" vertical crack c2/3 from MD-ML	24
PIER 2	59.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		CHEM DET EXT INTO ML	21
PIER 2	59.8-B BAT		ND							
PIER 2	60-A	2	MJ	CHEM DET	MJ RND	Mid-water	C2/3		WL=H, MD=F, 1/16" vertical crack c2/3, spall c2/3 10"W x 3"D (-5' to -12'), ML=F	28
PIER 2	60-B		MJ	CHEM DET	MJ RND	TZ-Mid	C2/3			25
PIER 2	60-C		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			19
PIER 2	60-C.5		ND							16
PIER 2	60-D		SV	CHEM DET	Exposed Reinf.	TZ-Mid	Multiple			13
PIER 2	60-D.5		ND							13
PIER 2	60-E	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=H, MD=S, ML=F, Chem starts @ -7' and ends 5' from ML	15
PIER 2	60-F		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			17
PIER 2	60-G		SV	CHEM DET	Exposed Reinf.	TZ-Mid	Multiple			24
PIER 2	60-H	2	MD	V-CRK	≤1/4	Mid-ML	C1/2		WL=F, MD=F, M=F	24
PIER 2	60.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	60.8-B BAT	2	MD	CHEM DET	≤1/16	Mudline	C4/1		WL=F, MD=MS, ML=S, <1/16" chem. cracking	17
PIER 2	61-A		MJ	CHEM DET	MJ RND	Mid-water	Multiple			
PIER 2	61-B		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	61-C		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	61-C.5		ND							
PIER 2	61-D		SV	CHEM DET	Exposed Reinf.	Full HT	Multiple			
PIER 2	61-D.5	2	ND						top @ -7'= H, MD=MS, ML=MS	13
PIER 2	61-E		ND							
PIER 2	61-F		MD	V-CRK	>1/8	Mid-ML	C2/3		V-CRK C2/3 3/16" ML-MID	
PIER 2	61-G		MJ	CHEM DET	MJ RND	TZ-Mid	C2/3			
PIER 2	61-H		MD	V-CRK	≤1/16	Mid-water	C2/3			
PIER 2	61.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	61.8-B BAT		ND							
PIER 2	62-A		ND							
PIER 2	62-B		ND							
PIER 2	62-C	2	MD	V-CRK	≤1/32		C2/3		WL=H, MD=MS, Honeycombing c3/4, ML=H	19
PIER 2	62-D	2	MD	V-CRK	≤1/16	Mid-water	C2/3		WL=H, MD=S, 1/16" vert. cracking c2/3, ML=H	17
PIER 2	62-E		ND							
PIER 2	62-F		ND							
PIER 2	62-G		ND							
PIER 2	62-H		MD	CHEM DET	MN RND	Tidal Zone	C1/2			
PIER 2	62.2-G BAT		ND							
PIER 2	62.8-B BAT		MJ	CHEM DET	MJ RND	Mid-ML	Multiple			
PIER 2	63-A	2	MN	MECH SP		Tidal Zone	4		WL=F, Mech. Spall face 4 (4" dia., 3/4" D), MD=MS, ML=F	27
PIER 2	63-B	2	MD	V-CRK	≤1/16	Mid-ML	C1/2		WL=F, MD=S, Vert. cracking c1/2 <1/16", ML=H, Horizontal crack face 1 <1/16" w/ minor spalling	25
PIER 2	63-C		ND							
PIER 2	63-D		ND							
PIER 2	63-E		ND							
PIER 2	63-F		ND							
PIER 2	63-G		ND							
PIER 2	63-H		MJ	CHEM DET	MJ RND	Mid-water	C2/3		V-CRK TZ-ML 1/8" C2/3	
PIER 2	63.2-G BAT		ND						LARGE TIMBER CAMEL BETWEEN BENT 63-65	
PIER 2	63.8-B BAT	2	MD	V-CRK	≤1/16	Mid-water	C4/1		WL=H, MD=S vert. <1/16" vert. cracking c1/4,ML=MS	21
PIER 2	64-A	2	MD	V-CRK	≤1/16		C2/3		WL=F, MD=MS, vert. cracking 1/16" c2/3, ML=F	27
PIER 2	64-B		MD	CHEM DET	MN RND	Mid-water	C2/3			
PIER 2	64-C	2	MD	V-CRK	≤1/16		C2/3		WL=H, MD=S, vert. cracking 1/16" c2/3, spalling 1" deep, ML=H	21

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	64-D		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	64-E		MD	CHEM DET	MN RND	Mid-water	Multiple			
PIER 2	64-F		MD	CHEM DET	MN RND	Mid-water	Multiple			
PIER 2	64-G		ND							
PIER 2	64-H		MD	V-CRK	≤1/8	TZ-ML	C1/2			
PIER 2	64.2-G BAT		ND							
PIER 2	64.8-B BAT		MJ	CHEM DET	MJ RND	TZ-Mid	Multiple			
PIER 2	65-A		MD	CHEM DET	MN RND	Mudline	C4/1			27
PIER 2	65-B	2	MD	V-CRK	≤1/32	Mid-water	C3/4		WL=H, MD=F, vert. cracking c3/4 <1/32", ML=F	25
PIER 2	65-C	2	MJ	CHEM DET	MJ RND		C2/3		WL=H, MD=S, rounding up to 2" deep, vert. cracking 1/16", ML=F	20
PIER 2	65-D		ND							16
PIER 2	65-E		ND							16
PIER 2	65-F		MJ	CHEM DET	MJ RND	TZ-Mid	Multiple			19
PIER 2	65-G		MJ	CHEM DET	MJ RND	Mid-water	Multiple			23
PIER 2	65-H		MJ	CHEM DET	MJ RND	TZ-Mid	Multiple			26
PIER 2	65.2-G BAT		ND							
PIER 2	65.8-B BAT	2	MJ	CHEM DET	MJ RND	Mid-ML	Multiple		WL=H, MD=S, Heavy rounding @ c1/2 and c2/3, ML=S, Chem starts @ and ends -5 from ML	20
PIER 2	66-A	2	MD	CHEM DET	MN RND	Mid-ML	C1/2		WL=H, MD=S, vert. cracking up to 1/8" c1/2, ML=H	27
PIER 2	66-B	2	MD	CHEM DET	MN RND	Mid-ML	Multiple		WL=H, MD=S, vert. cracking 1/16", ML=S, vert. cracking 1/16"	26
PIER 2	66-C		ND							
PIER 2	66-D		ND							
PIER 2	66-E		ND							
PIER 2	66-F		MD	CHEM DET	MN RND	Mid-ML	Multiple			
PIER 2	66-G		MD	CHEM DET	MN RND	Mid-ML	Multiple			
PIER 2	66-H		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	66.2-G BAT		MD	CHEM DET	MN RND	Mid-ML	C1/2			
PIER 2	66.8-B BAT		ND							-4
PIER 2	67-A	2	MD	V-CRK	≤1/16	Mid-water	C1/2		WL=H, MD=S, vert. cracking <1/16" c1/2, ML=H	27
PIER 2	67-B	2	MD	V-CRK	≤1/16	Mid-water	C1/2		WL=H, MD=MS, vert. cracking <1/16", ML=F	24
PIER 2	67-B.6		ND							
PIER 2	67-C		MD	V-CRK	≤1/16	Mid-water	C2/3			
PIER 2	67-D		MD	CHEM DET	MN RND	Mid-water	C2/3			
PIER 2	67-E		ND							
PIER 2	67-F		MD	CHEM DET	MN RND	Mid-water	C2/3			
PIER 2	67-G		MD	CHEM DET	MN RND	Mid-water	C2/3			
PIER 2	67-H		MD	V-CRK	≤1/8	TZ-ML	C2/3			
PIER 2	67.2-G BAT		ND							
PIER 2	67.8-B BAT		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	68-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	68-B		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	68-B.6		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	68-C		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	68-C.3		MD	CHEM DET	MN RND	Mid-water	Multiple			
PIER 2	68-D	2	MD	V-CRK	≤1/16	Mid-water	C1/2		WL= H, MD=MS, vert. cracking c1/2 up to 1/16", ML=H, Minor honeycoming @ ML	15
PIER 2	68-E	2	MD	V-CRK	≤1/16	Mid-water	C2/3		WL=H, MD=MS, vert. cracking on c2/3 up to 1/16", ML= F	16
PIER 2	68-F	2	MD	V-CRK	≤1/16	Mid-water	C1/2		WL=H, MD=F, vert. cracking @ c1/2 <1/16" ML=H, minor honeycoming @ c3/4	20
PIER 2	68-G		MD	V-CRK	≤1/16	TZ-Mid	C1/2			
PIER 2	68-H		MD	V-CRK	≤1/8	TZ-Mid	C1/2			
PIER 2	68.2-G BAT		MD	CHEM DET	MN RND	Mid-ML	C1/2			
PIER 2	68.8-B BAT		ND							
PIER 2	69-A		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	69-B		MJ	CHEM DET	MJ RND	Mid-water	Multiple			
PIER 2	69-C		ND							
PIER 2	69-C.5	2	MJ	CHEM DET	MJ RND	Mid-water	Multiple		WL=H ,MD=S, vert. cracking <1/16" ,ML=MS ,	16
PIER 2	69-D	2	MJ	CHEM DET	MJ RND	Mid-water	Multiple		WL=H ,MD=S, rounding of corners ,ML=F ,	15
PIER 2	69-E	2	MJ	CHEM DET	MJ RND	Mid-water	Multiple		WL=H, MD=S w/ Heavy rounding of corners (-5' to -16'), ML=H	16
PIER 2	69-F		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	69-G		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	69-H		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			
PIER 2	69.2-G BAT		ND							
PIER 2	69.8-B BAT		ND							
PIER 2	70-A		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			28
PIER 2	70-B		MJ	CHEM DET	MJ RND	TZ-Mid	C1/2			24
PIER 2	70-C		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			19
PIER 2	70-C.5	2	MJ	CHEM DET	MJ RND	Mid-water	Multiple		WL=H, minor honeycombing c3/4, MD=S, rounding @ multiple corners, ML=H	16
PIER 2	70-D	2	MJ	CHEM DET	MJ RND	Mid-water	Multiple		WL=H, MD=S, vert. cracking up to 1/16", ML=F	16
PIER 2	70-D.2		MJ	CHEM DET	MJ RND	TZ-ML	C1/2			13
PIER 2	70-E		MJ	CHEM DET	MJ RND	TZ-Mid	Multiple			17
PIER 2	70-F		MJ	CHEM DET	MJ RND	TZ-Mid	Multiple			20
PIER 2	70-G		MJ	CHEM DET	MJ RND	TZ-Mid	Multiple			25
PIER 2	70-H		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			27
PIER 2	70.2-G BAT		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	70.8-B BAT		ND							
PIER 2	71-A		ND							
PIER 2	71-B	2	MD	V-CRK	≤1/32	Mid-water	Multiple		WL=H, MD=MS w/ vert. cracking up to 1/32 @ multiple corners, ML=F w/ minor honeycoming @ c3/4	24
PIER 2	71-C	2	MD	CHEM DET	MN RND	Mid-water	C2/3		WL=H, MD=MS, rounding @ c2/3 up to 1" D, ML=F	20
PIER 2	71-D		ND							
PIER 2	71-D.4		ND							
PIER 2	71-D.6		ND							
PIER 2	71-E		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	71-F		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	71-G		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK 1/8" MID-ML C1/4	
PIER 2	71-H		MD	CHEM DET	MN RND	Mid-ML	C1/2			
PIER 2	71.2-G BAT		MD	CHEM DET	MN RND	Mid-ML	C2/3			
PIER 2	71.8-B BAT		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK 1/8"W MULT CORN TZ-ML	
PIER 2	72-A	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=F ND, MID=S W/ MN RND, ML=F ND	29
PIER 2	72-B		MD	CHEM DET	MN RND	TZ-Mid	Multiple		V-CRK 1/8"W MULT CORN TZ-MID	
PIER 2	72-C		MD	V-CRK	≤1/4	TZ-ML	Multiple		V-CRK UP TO 3/16"W MULT CORN TZ-ML	
PIER 2	72-C.7		MD	V-CRK	≤1/8	TZ-ML	Multiple		V-CRK 1/8"W MULT CORN TZ-ML	
PIER 2	72-D.5		MD	V-CRK	≤1/8	Mid-ML	Multiple		V-CRK 1/8"W MULT CORN MID-ML	
PIER 2	72-D.7		MD	V-CRK	≤1/4	TZ-ML	Multiple		V-CRK UP TO 3/16"W MULT CORN TZ-ML	
PIER 2	72-E	2	MD	CHEM DET	MN RND	Mid-ML	Multiple		WL=F, MID=S 1/8"W V-CRK C2/3 W/ 1"D RND, ML=MS 1"D RND C1/4	16
PIER 2	72-F		MD	CHEM DET	MN RND	Mid-water	Multiple		V-CRK 1/8"W MULT CORN TZ-ML	
PIER 2	72-G		MD	V-CRK	≤1/16	TZ-Mid	Multiple			
PIER 2	72-H		MD	CHEM DET	MN RND	Mid-ML	Multiple		V-CRK 1/8"W MULT CORN MID-ML	
PIER 2	72.2-G BAT		MD	V-CRK	≤1/8	Mid-water	Multiple			
PIER 2	72.8-B BAT	2	MJ	V-CRK	≤1/4	Mid-water	Multiple		WL=F ND, MID=S ROUNDING TO 1"D 1/4" V-CRK C1/2, ML=F ND	20
PIER 2	73-A		MD	CHEM DET	MN RND	Mid-ML	Multiple		V-CRK UP TO 3/16"W MULT CORN TZ-ML	
PIER 2	73-B		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	73-C		MD	CHEM DET	MN RND	Tidal Zone	Multiple			
PIER 2	73-D		MD	CHEM DET	MN RND	Mid-ML	Multiple			

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	73-D.7	2	MD	V-CRK	≤1/8	Mid-water	4		WL=H ND, MID=F 1/8" V-CRK F4, ML=F ND	15
PIER 2	73-E		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	73-E.3	2	MD	V-CRK	≤1/8	Mid-water	4		ML=H ND, MID=S 1/8"W V-CRK F4, WL=F ND	15
PIER 2	73-F		MD	CHEM DET	MN RND	Mid-water	C1/2		V-CRK 1/8"W C3/4 MID	
PIER 2	73-G		MD	V-CRK	≤1/4	Mid-water	C1/2			
PIER 2	73-H		ND						LEAKY PIPE BETWEEN 72-73	
PIER 2	73.2-G BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	73.8-B BAT		ND							
PIER 2	74-A		ND							
PIER 2	74-B		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 3/16"W TZ-ML	
PIER 2	74-C	2	MD	CHEM DET	MN RND	Mudline	Multiple		WL=H ND, MID=F ND, ML=MS minor rounding @ multi. corners	21
PIER 2	74-D	2	MD	V-CRK	Hairline	Mid-water	C1/2		WL=H, MD=MS ,ML=F	18
PIER 2	74-E		ND							
PIER 2	74-E.5		ND							
PIER 2	74-F		ND							
PIER 2	74-G		ND							
PIER 2	74-H		MD	V-CRK	≤1/4	Mid-ML	C2/3		V-CRK UP TO 3/16"W C2/3 MID-ML	
PIER 2	74.2-G BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	74.8-B BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple		V-CRK UP TO 1/8"W MULT CORN TZ-MID	
PIER 2	75-A		MD	V-CRK	≤1/8	TZ-Mid	C2/3		V-CRK UP TO 1/8"W C2/3 MID	26
PIER 2	75-B	2	MD	V-CRK	≤1/8	Mid-water	C2/3		WL=F ND, MID=S 1/8" V-CRK C2/3 <1" RND, ML=H ND	26
PIER 2	75-C		ND							19
PIER 2	75-D		ND							15
PIER 2	75-E	2	ND						WL=H ND, MID=F ND, ML=MS ND	15
PIER 2	75-E.7		ND							15
PIER 2	75-F		ND							18
PIER 2	75-F.3		ND							21
PIER 2	75-G		ND							23
PIER 2	75-H		MD	V-CRK	≤1/16	Mid-water	C1/2		V-CRK 1/16"W C1/2 MID	24
PIER 2	75.2-G BAT		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		2.5"D RND MULT CORN AT MID-PILE	
PIER 2	75.8-B BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	76-A	2	ND						WL=F ND, MID=F ND, ML=F ND	28
PIER 2	76-B		ND							
PIER 2	76-C		MD	V-CRK	≤1/4	Mid-ML	C1/2		V-CRK 3/16'W C1/2 MID-ML	
PIER 2	76-D	2	MD	V-CRK	≤1/4	Mid-water	C2/3		WL=MS MN RND MULT CORN, MID=S 3/16" V-CRK C2/3 W/ MN SPALLING, ML=MS W/ MN RND MULT CORN	17
PIER 2	76-E		ND							
PIER 2	76-F	2	MD	V-CRK	Hairline	Mid-water	C1/2		WL=F ND, MID=S HL V-CRK C1/2 W/MN SPALLING 1/2"DX1"W, ML=F ND	20
PIER 2	76-F.5		MD	V-CRK	≤1/8	Mid-ML	C1/2			
PIER 2	76-G		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK 1/8"W MULT CORN TZ-ML	
PIER 2	76-H		ND							
PIER 2	76.2-G BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	76.8-B BAT		MD	CHEM DET	MN RND	Mid-water	C3/4			
PIER 2	77-A		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		MJ RND (UP TO 3" D) V-CRK UP TO 3/16" TZ-ML	
PIER 2	77-B		MD	V-CRK	≤1/16	Mid-water	C2/3			
PIER 2	77-C		ND							
PIER 2	77-D		ND							
PIER 2	77-E		MD	V-CRK	≤1/16	TZ-Mid	Multiple			
PIER 2	77-F	2	MD	V-CRK	≤1/8	Mid-water	Multiple		WL=F MID=MS, V-CRK <1/8" MULT. CORNERS ML=H	21
PIER 2	77-G		ND							
PIER 2	77-H	2	ND						WL=F MID=F ML=F	27

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	77.2-G BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	77.8-B BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	78-A		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK 3/16"W MULT CORN TZ-ML	
PIER 2	78-B		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		RND UP TO 3"D MID-ML	
PIER 2	78-C		MD	CHEM DET	MN RND	Mid-ML	Multiple		V-CRK 3/16"W MULT CORN MID-ML	
PIER 2	78-D		ND							
PIER 2	78-E	2	MD	CHEM DET	MN RND	Mid-water	C2/3		WL=H MID= MS, V-CRK <1/16" ML=F	17
PIER 2	78-F	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H MID= MS, V-CRK <1/16" ML=F	18
PIER 2	78-G		MD	CHEM DET	MN RND	Mudline	Multiple		V=CRK 1/8"W MULT CORN ML	
PIER 2	78-H	2	MD	V-CRK	>1/8	Mid-water	C2/3		WL=F MID=F, V-CRK c2/3 up to 3/16" ML= H, MN RND	26
PIER 2	78.2-G BAT		ND							
PIER 2	78.8-B BAT		ND							
PIER 2	79-A		MD	V-CRK	>1/8	TZ-ML	Multiple			
PIER 2	79-B		MD	V-CRK	≤1/8	TZ-Mid	C2/3			
PIER 2	79-C		MD	V-CRK	≤1/8	TZ-Mid	C2/3			
PIER 2	79-D		ND							
PIER 2	79-E		ND							
PIER 2	79-F		MD	V-CRK	≤1/8	TZ-Mid	C2/3			
PIER 2	79-G	2	MD	V-CRK	Hairline	Mid-water	C2/3		WL=H MID=MS, V-CRK HL c2/3 ML=MS, MN HC	24
PIER 2	79-H	2	MD	V-CRK	≤1/8	Mid-ML	C2/3		WL=H MID=F, V-CRK UP TO 1/8" ML=H, vert. cracking <1/32" c2/3	26
PIER 2	79.2-G BAT		ND							
PIER 2	79.8-B BAT		MD	MECH SP		Mid-water	C3/4		-12' @1011 3"HX2"WX1"D	
PIER 2	80-A		MD	CHEM DET	MN RND	Mid-ML	C2/3			25
PIER 2	80-B		MD	V-CRK	≤1/8	TZ-ML	Multiple		V-CRK 1/8"W MULT CORN	23
PIER 2	80-C		ND							19
PIER 2	80-D		MD	CHEM DET	MN RND	TZ-ML	Multiple			16
PIER 2	80-E	2	MD	V-CRK	≤1/4	Mid-water	Multiple		WL=H MID=S, V-CRK <3/16" (-5' TO -11') ML=H	17
PIER 2	80-F	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H MID=H, V-CRK UP TO 1/16" ML=F	19
PIER 2	80-G		MD	V-CRK	≤1/8	Mid-ML	C4/1		V-CRK 1/8"W C4/1 MID-ML	25
PIER 2	80-H		MD	V-CRK	≤1/4	TZ-ML	Multiple		V-CRK UP TO 3/16"W MULT CORN TZ-ML	25
PIER 2	80.2-G BAT	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H MID=H,V-CRK <1/16" ML=H ,V-CRK HL	19
PIER 2	80.8-B BAT		ND							
PIER 2	81-A		MD	V-CRK	≤1/16	Mid-water	C2/3			
PIER 2	81-B		MD	CHEM DET	MN RND	TZ-Mid	C2/3			
PIER 2	81-C		MD	CHEM DET	MN RND	TZ-Mid	C3/4			
PIER 2	81-D		ND							
PIER 2	81-E		MD	V-CRK	≤1/4	Mid-water	C2/3		V-CRK 3/16"W C2/3 MID	
PIER 2	81-F	2	ND						WL=H MID=MS ML=MS	20
PIER 2	81-G	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H MID=MS, V-CRK UP TO 1/16", MD ROUNDING ML=F	22
PIER 2	81-H		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK 1/8"W C2/3 MID-ML	
PIER 2	81.2-G BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple		V-CRK 1/8"W C2/3 TZ	
PIER 2	81.8-B BAT		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		MJ RND (UP TO 3" D)	
PIER 2	82-A		ND							
PIER 2	82-B		ND							
PIER 2	82-C		ND							
PIER 2	82-D	2	MD	CHEM DET	MN RND		C2/3		WL=H MID=MS, V-CRK <1/16" ML=F	18
PIER 2	82-E	2	MD	V-CRK	Hairline	Mid-water	Multiple		WL=H MID=F, V-CRK HL MULT. CORNERS ML=F	16
PIER 2	82-F		ND							
PIER 2	82-G		MJ	CHEM DET	MJ RND	TZ-ML	C2/3		MJ RND (UP TO 3" D)	
PIER 2	82-H		ND							26
PIER 2	82.2-G BAT		ND							

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	82.8-B BAT		ND							20
PIER 2	83-A		ND							27
PIER 2	83-B		MD	CHEM DET	MN RND	Mid-ML	Multiple		V-CRK UP TO 3/16"	24
PIER 2	83-C	2	ND						WL=H MID=MS ML=F	21
PIER 2	83-D	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=F MID=F, ML=F	19
PIER 2	83-E	2	ND						WL=H MID=MS ML=H	17
PIER 2	83-F		MD	CHEM DET	MN RND	TZ-ML	C4/1			18
PIER 2	83-G		ND							24
PIER 2	83-H		ND							26
PIER 2	83.2-G BAT		MD	V-CRK	≤1/8	TZ-ML	C2/3			19
PIER 2	83.8-B BAT		ND							
PIER 2	84-A		MD	CHEM DET	MN RND	Mid-ML	C2/3		V-CRK UP TO 3/16" C2/3 TZ-ML	
PIER 2	84-B		ND							
PIER 2	84-C		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	84-D		MD	CHEM DET	MN RND	TZ-ML	C2/3		V-CRK UP TO 1/8" C2/3	
PIER 2	84-E	2	MJ	CHEM DET	MJ RND	Mid-water	Multiple		WL=F MID=MS, CHEM DET. 2" D ML=H	17
PIER 2	84-F		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 3/16"	
PIER 2	84-G	2	MJ	CHEM DET	MJ RND	TZ-ML	Multiple		WL=H, MN ROUNDING MID=MS, CHEM DET. 2" D ML=F	25
PIER 2	84-H		MD	V-CRK	≤1/8	TZ-ML	C4/1			
PIER 2	84.2-G BAT		ND							
PIER 2	84.8-B BAT		MD	CHEM DET	MN RND	Mid-ML	Multiple			
PIER 2	85-A		MD	CHEM DET	MN RND	Mid-water	Multiple		V-CRK UP TO 1/8" FROM TZ-ML	
PIER 2	85-B		MD	CHEM DET	MN RND	Mid-ML	Multiple			
PIER 2	85-B.5		MD	CHEM DET	MN RND	Mid-ML	Multiple			
PIER 2	85-C.5		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	85-D.5	2	MJ	CHEM DET	MJ RND	Mid-water	Multiple		WL=H MID=MS, CHEM DET. <3" D (-5' TO -15') ML=F	15
PIER 2	85-E.5		ND							
PIER 2	85-F.5		ND							
PIER 2	85-G		ND							
PIER 2	85-H		MD	CHEM DET	MN RND	Mid-water	Multiple			
PIER 2	85.2-G BAT	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=F MID=F, V-CRK UP TO 1/16" ML=F	19
PIER 2	85.8-B BAT		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 1/8"	
PIER 2	86-A		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 1/8"	
PIER 2	86-B		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		MJ RND (3" D) @ TZ-ML	
PIER 2	86-B.5		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		MJ RND (4" D) STARTS @ TZ AND ENDS @ -23'	24
PIER 2	86-C.5		SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple			
PIER 2	86-D.5	2	SV	CHEM DET	Exposed Reinf.	Mid-water	Multiple		WL=H MID= ML=MS, CHEM DET. (-4' TO ML) ML=S	14
PIER 2	86-E.5	2	MD	V-CRK	≤1/8	TZ-ML	Multiple		WL=H MID=MS ,V-CRK UP TO 1/8" , CHEM DET. STARTS @ -5' AND ENDS @ -16' ML=F	18
PIER 2	86-F.5		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 1/8"	
PIER 2	86-G	2	SV	CHEM DET	Exposed Reinf.	TZ-ML	Multiple		WL=S MID=S ML=MS, V-CRK HL	26
PIER 2	86-H		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CR UP T0 1/8"	
PIER 2	86.2-G BAT		MD	CHEM DET	MN RND	TZ-Mid	Multiple		V-CRK UP TO 1/8" C3/4	
PIER 2	86.8-B BAT		MD	V-CRK	≤1/8	TZ-ML	Multiple			
PIER 2	87-A		MD	CHEM DET	MN RND	Mid-water	Multiple		1/8" V-CRK FROM TZ-ML	
PIER 2	87-B		MD	CHEM DET	MN RND	TZ-ML	Multiple		3/16" V-CRK FROM TZ-ML	
PIER 2	87-C	2	ND						ML=MS ND, MID=MS ND, WL=H	20
PIER 2	87-C.5		MD	CHEM DET	MN RND	Full HT	Multiple			
PIER 2	87-D		MJ	CHEM DET	MJ RND	Full HT	Multiple			
PIER 2	87-D.5		ND							
PIER 2	87-E	2	MD	CHEM DET	MN RND	Mid-ML	Multiple		WL=H ND, MID=MS MN RND MULT CORNERS, ML=MS MN RND C2/3	14
PIER 2	87-F		MJ	CHEM DET	MJ RND	TZ-ML	Multiple			

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	87-G		MD	CHEM DET	MN RND	TZ-ML				
PIER 2	87-H	2	MD	CHEM DET	MN RND	Mid-ML	C1/2		WL=H ND, MID=MS MN RND C1/2, ML=F MN RND C1/2	27
PIER 2	87.2-G BAT		ND							
PIER 2	87.8-B BAT	2	MD	CHEM DET	MN RND	Mid-water	C3/4		WL=H ND, MID=S V-CRK 1/18" CORNER 1/4, ML=H	19
PIER 2	88-A		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		V-CRK UP TO 3/16"	
PIER 2	88-B		MJ	CHEM DET	MJ RND	TZ-ML	Multiple		4"D RND C1/2 & C2/3 AT ML, V-CRK UP TO 1/4"W MULT CORN AT TZ-MID	
PIER 2	88-C		MD	CHEM DET	MN RND	TZ-Mid	Multiple		V-CRK UP TO 3/16"W MULT CORN AT TZ-MID	
PIER 2	88-C.5		ND							
PIER 2	88-D		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	88-D.5	2	MD	V-CRK	≤1/8	TZ-Mid	Multiple		ML=H ND, MID=H V-CRK 1/8"W F1, WL=H V-CRK 1/8"W F3	12
PIER 2	88-E		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	88-F		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 3/16"W MULT CORN TZ-MID	
PIER 2	88-G		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 3/16"W C2/3 MID-ML	23
PIER 2	88-H		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 1/8"W MULT CORN MID-PILE	27
PIER 2	88.2-G BAT		MD	CHEM DET	MN RND	Tidal Zone	Multiple			
PIER 2	88.8-B BAT		MD	CHEM DET	MN RND	Mid-ML	Multiple			
PIER 2	89-A		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 1/8"W C1/2 & C2/3 TZ-ML	27
PIER 2	89-B		ND							25
PIER 2	89-C		MD	CHEM DET	MN RND	TZ-ML	Multiple			19
PIER 2	89-C.5		ND							17
PIER 2	89-D	2	MD	CHEM DET	MN RND	TZ-Mid	Multiple		TOP=MS @ -10' @1427 CHEM DET MULT CORN, MID=MS MN RND MULT CORN, ML=H ND	14
PIER 2	89-D.5		ND							13
PIER 2	89-E		MD	CHEM DET	MN RND	Mid-ML	C1/2			13
PIER 2	89-F	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H ND, MID=MS CHEM DET MULT CORN, ML=H ND	18
PIER 2	89-G	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H ND, MID=F CHEM DET MULT CORN, ML=H ND	24
PIER 2	89-H		MD	V-CRK	≤1/16	TZ-ML	C2/3			27
PIER 2	89.2-G BAT		ND							19
PIER 2	89.8-B BAT		MJ	CHEM DET	MJ RND	Mid-ML	Multiple		2"D RND C1/4 AND C3/4 MID-PILE	
PIER 2	90-A		MD	CHEM DET	MN RND	Mid-ML	Multiple		V-CRK UP TO 1/16"W MULT CORN MID-ML	
PIER 2	90-B		MD	CHEM DET	MN RND	TZ-ML	Multiple		1/8" C1/2 AND C2/3 AT MID-ML	
PIER 2	90-C	2	MJ	CHEM DET	MJ RND	TZ-Mid	Multiple		ML=H ND, MID=S 2"D RND, WL=S MN RND MULT CORN	20
PIER 2	90-C.5	2	ND						WL=H ND, MID=H ND, ML=H ND	17
PIER 2	90-D		MD	CHEM DET	MN RND	Tidal Zone	Multiple		AT TOP OF PILE BELOW CAP	
PIER 2	90-D.5		ND							
PIER 2	90-E		ND							
PIER 2	90-F		ND							
PIER 2	90-G		MD	CHEM DET	MN RND	TZ-Mid	C1/2			
PIER 2	90-H		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK UP TO 1/16"W MULT CORN MID-ML	
PIER 2	90.2-G BAT		ND							
PIER 2	90.8-B BAT		MJ	CHEM DET	MJ RND		Multiple		2.5"D RND C1/4 MID-PILE	
PIER 2	91-A		MD	V-CRK	≤1/16	TZ-ML	C2/3			
PIER 2	91-B		MD	V-CRK	≤1/16	TZ-ML	C2/3			
PIER 2	91-C		MD	V-CRK	≤1/16	TZ-Mid	C2/3			
PIER 2	91-C.5		ND							
PIER 2	91-D		ND							
PIER 2	91-D.5	2	ND						TOP=H ND @-8' @1514, MID=H ND, ML=H ND	15
PIER 2	91-E	2	MD	V-CRK	≤1/16	TZ-Mid	Multiple		ML=H ND, MID=F V-CRK 1/16"W MULT FACES, WL=H V-CRK HL F3	15
PIER 2	91-F		ND							
PIER 2	91-G		MD	CHEM DET	MN RND		Multiple		V-CRK 3/16"W C1/4 IN TZ	
PIER 2	91-H	2	MD	CHEM DET	MN RND	Mid-ML	Multiple		WL=H ND, MID=MS MN RND MULT CORN, ML=F MN RND C1/2	26
PIER 2	91.2-G BAT		MD	V-CRK	≤1/16	TZ-ML	Multiple			

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	91.8-B BAT		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	92-A		MD	V-CRK	≤1/16	TZ-ML	C2/3			
PIER 2	92-B		ND							
PIER 2	92-C		MD	V-CRK	≤1/16	TZ-ML	C2/3		V-CRK 1/16"W C2/3	19
PIER 2	92-C.5		ND							
PIER 2	92-D	2	ND						TOP=H ND @-8 @1546, MID=H ND, ML=H ND	15
PIER 2	92-D.5		ND							
PIER 2	92-E		ND							
PIER 2	92-F		ND							
PIER 2	92-G	2	ND						WL=H ND, MID=F ND, ML=H ND	23
PIER 2	92-H		ND							
PIER 2	92.2-G BAT		ND							
PIER 2	92.8-B BAT		MD	CHEM DET	MN RND	TZ-ML	C4/1			
PIER 2	93-A		ND							
PIER 2	93-B		ND							
PIER 2	93-C	2	ND						WL=H ND, MID=MS ND, ML=H ND	20
PIER 2	93-C.5		ND							
PIER 2	93-D		ND							
PIER 2	93-D.5		ND							
PIER 2	93-E		ND							
PIER 2	93-F	2	ND						WL=H ND, MID=H ND, ML=H ND	19
PIER 2	93-G		ND							
PIER 2	93-H		ND							
PIER 2	93.2-G BAT	2	MD	CHEM DET	MN RND	Tidal Zone	C4/1		ML=H ND, MID=H ND, WL=F MN RND C1/4	19
PIER 2	93.5-G		ND							
PIER 2	93.5-H		ND							
PIER 2	93.8-B BAT		ND							
PIER 2	94-A	2	MD	V-CRK	≤1/8	TZ-Mid	Multiple		WL=S V-CRK UP TO 1/8"W MULT CORN, MID=MS V-CRK UP TO 1/8"W MULT CORN, ML=H ND	28
PIER 2	94-B	2	MD	V-CRK	≤1/16	TZ-Mid	Multiple		WL=MS V-CRK 1/16"W C2/3, MID=F V-CRK 1/32"W C1/2, ML=H ND	26
PIER 2	94-C		ND							
PIER 2	94-C.5	2	ND						16.25 sq, TOP=H -3@0916 ND, MID=H REPAIRED MECH SPALL F2, ML=F ND	17
PIER 2	94-D		ND							
PIER 2	94-D.5		ND						16.25" sq, TOP OF PILE AT -4'	13
PIER 2	94-E		ND							
PIER 2	94-F		ND							
PIER 2	94-G		ND							
PIER 2	94-H		ND							
PIER 2	94.2-G BAT		ND							
PIER 2	94.5-G		ND						EXT TOP TO WL	
PIER 2	94.5-H		ND						EXT TOP TO WL	
PIER 2	94.8-B BAT	2	MD	V-CRK	≤1/16	TZ-Mid	Multiple		ML=H ND, MID=MS V-CRK 1/16"W MULT CORN, WL=MS V-CRK UP TO 1/16"W MULT CORN	17
PIER 2	95-A		MD	V-CRK	≤1/16	TZ-Mid	C2/3		V-CRK 1/16"W @WL C2/3	28
PIER 2	95-B		MD	V-CRK	Hairline	TZ-Mid	C2/3			25
PIER 2	95-C	2	MD	V-CRK	≤1/16	TZ-Mid	Multiple		WL=MS MN RND MULT CORN, MID=MS V-CRK UP TO 1/16"W C2/3, ML=H ND	19
PIER 2	95-D		MD	V-CRK	≤1/16	TZ-Mid	C2/3			15
PIER 2	95-E		ND						20.5" sq	14
PIER 2	95-F		ND						20.5" sq	17
PIER 2	95-G		ND							24
PIER 2	95-H		ND							25
PIER 2	95.2-G BAT		MD	CHEM DET	MN RND	TZ-ML	Multiple			

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	95.5-G		ND						EXT TOP TO WL @0927 (28X28)	
PIER 2	95.5-H		ND						EXT TOP TO WL @0927, ML TO -15' EXT SECTION AT ML W/ NO GROUT IN ANNULUS (video: 0931-0938/10min on 26349)(28X28X4)	25
PIER 2	95.8-B BAT		ND							
PIER 2	96-A	2	MD	V-CRK	≤1/16	Mid-ML	C1/2		VIDEO FROM FLOAT, ML=MS V-CRK 1/32"W C1/2, MID=F V-CRK 1/16"W C1/2, WL=H ND	28
PIER 2	96-B	2	ND						WL=MS ND, MID=F ND, ML=H ND	24
PIER 2	96-C		ND							
PIER 2	96-D	2	ND						WL=F ND, MID=F ND, ML=F ND	16
PIER 2	96-E		ND							
PIER 2	96-F		ND							
PIER 2	96-G		ND							
PIER 2	96-H		MD	V-CRK	≤1/16	Mudline			V-CRK 1/16"W C1/2	
PIER 2	96.2-G BAT		ND							
PIER 2	96.4-H		ND						EXT 2' ABOVE WL	
PIER 2	96.6-G		ND						EXT TOP TO WL	-1
PIER 2	96.6-H		ND						EXT TOP TO WL	
PIER 2	96.8-B BAT		ND							
PIER 2	97-A		MD	CHEM DET	MN RND	TZ-ML	Multiple			27
PIER 2	97-B		ND							
PIER 2	97-C	2	MJ	CHEM DET	≤1/4	TZ-Mid	Multiple		WL=MS V-CRK UP TO 1/4"W MULT CORN, MID=S CHEM DET MULT CORN HEAVY RND -10' TO WL W/ 1/4" V-CRKS NO EXP REINF, ML=F ND	19
PIER 2	97-D		ND							
PIER 2	97-E	2	MD	V-CRK	≤1/8	Mid-water	C2/3		WL=H ND, MID=MS V-CRK UP TO 1/8"W C2/3, ML=F ND	14
PIER 2	97-F		MD	CHEM DET	MN RND	Tidal Zone	Multiple			
PIER 2	97-G		MJ	CHEM DET	MJ RND	Tidal Zone	Multiple		2.5" D RND C1/4	
PIER 2	97-H		ND							
PIER 2	97.2-G.5 BAT		ND							
PIER 2	97.5-G		ND						EXT TOP TO WL	
PIER 2	97.5-H		ND						EXT TOP TO WL	
PIER 2	97.8-B BAT		MD	CHEM DET	MN RND	TZ-ML	C1/2			
PIER 2	98-A	2	MD	V-CRK	≤1/32	Mid-water	C2/3		WL=F ND, MID=F V-CRK 1/32"W C2/3, ML=F ND	28
PIER 2	98-B		MD	CHEM DET	MN RND	Mid-ML	Multiple			
PIER 2	98-C		MD	CHEM DET	MN RND	TZ-ML	C1/2			
PIER 2	98-D	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H ND, MID=S V-CRK UP TO 1/8"W MULT CORN MN RND, ML=H ND	16
PIER 2	98-E		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	98-E.8	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=F ND, MID=S V-CRK UP TO 1/8'W MULT CORN MN RND, ML=F ND	13
PIER 2	98-F		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	98-G		ND							
PIER 2	98-H		ND							
PIER 2	98.2-G.5 BAT		ND							
PIER 2	98.5-G		ND						EXT TOP TO WL	
PIER 2	98.5-H		ND						EXT TOP TO WL	20
PIER 2	98.8-B BAT		ND					Yes	ENCASED FROM 1' BELOW CAP ABOT 5' LONG	
PIER 2	99-A		MD	CHEM DET	MN RND	Mid-ML	C1/2		V-CRK C1/2 1/16"	
PIER 2	99-B		ND							
PIER 2	99-C	2	MJ	CHEM DET	MN RND	TZ-Mid	C2/3		WL=H ND, MID= VOID 14"X5"X2.5" DEEP F4 , ML=H ND VIDEO @ 2:41 PM	20
PIER 2	99-D		MD	V-CRK	≤1/8	Mid-water	Multiple			
PIER 2	99-E		MD	CHEM DET	MN RND	Tidal Zone	Multiple			
PIER 2	99-E.8	2	MD	CHEM DET	MN RND	TZ-Mid	Multiple		WL=S V-CRK UP TO 1/8"W MULT CORN MN RND, MID=MS V-CRK UP TO 1/8"W MULT CORN MN RND, ML=F ND	13
PIER 2	99-F		MD	CHEM DET	MN RND	TZ-ML	C2/3			

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
PIER 2	99-H		ND							
PIER 2	99.2-G.5 BAT		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	99.5-G		ND						EXT TO -5 @ 2:16 PM	
PIER 2	99.5-H		ND						EXT TO -5 @ 2:12 PM	
PIER 2	99.7-G		ND						EXT TO -5 @ 2:16 PM	
PIER 2	99.8-B BAT		MD	V-CRK	≤1/16	Mudline	C2/3			
PIER 2	100-A		MD	CHEM DET	MN RND	Mid-water	C2/3		V-CRK C2/3 1/8"	26
PIER 2	100-B	2	MD	CHEM DET	MN RND	TZ-ML	Multiple		WL=H ND, MID=MS V-CRK UP TO 1/8"W MULT CORN MN RND, ML=H ND	24
PIER 2	100-C	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H ND, MID=MS V-CRK UP TO 1/16"W, ML=F ND	19
PIER 2	100-D		MD	CHEM DET	MN RND	Mid-ML	Multiple			15
PIER 2	100-D.8	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=F ND, MID=MS V-CRK UP TO 1/8"W MULT CORN MN RND, ML=H ND	13
PIER 2	100-E.2		MD	CHEM DET	MN RND	Mid-ML	Multiple			12
PIER 2	100-E.8		MD	CHEM DET	MN RND	Mid-ML	Multiple			14
PIER 2	100-H		MD	CHEM DET	MN RND	TZ-Mid	Multiple		V-CRK 1/16" C2/3	24
PIER 2	100.2-G.5 BAT		MD	CHEM DET	MN RND	Tidal Zone	C4/1			
PIER 2	100.5-G		ND						EXT TO -5 @2:01 PM	
PIER 2	100.5-H		ND						EXT TO -5 @2:03 PM	
PIER 2	100.7-G		ND						EXT TO -5 @ 2:01 PM	
PIER 2	100.8-B BAT		MD	V-CRK	≤1/8	TZ-ML	Multiple			
PIER 2	101-A		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK C2/3 UP TO 1/16"	
PIER 2	101-B		MD	CHEM DET	MN RND	Mudline	C2/3			
PIER 2	101-B.2		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	101-C.5		MD	CHEM DET	MN RND	TZ-Mid	Multiple			
PIER 2	101-D.4		MD	V-CRK	≤1/16	Mudline	C2/3			
PIER 2	101-D.7		MD	CHEM DET	MN RND	TZ-ML	Multiple			
PIER 2	101-E		MD	CHEM DET	MN RND	TZ-Mid	Multiple		V-CRK MULTIPLE CORNERS UT TO 1/16"	
PIER 2	101-F	2	MJ	CHEM DET	MJ RND	TZ-Mid	C2/3		WL=H MN HC ON C3/4, MID=S, ML=F CHEM DET STOPS AT -15'	15
PIER 2	101-H	2	MD	CHEM DET	MN RND	Mid-water	C2/3		WL=H ND, MID=MS V-CRK 1/32" CORNER 3/4, ML=MS POCKET ON FACE 3 3"X4"X1 1/2" DEEP	24
PIER 2	101.2-G.5 BAT		ND							
PIER 2	101.5-G		ND						EXT TO -4 @ 1:32 PM	
PIER 2	101.5-H		ND						EXT TO -5 @ 1:29 PM	
PIER 2	101.7-G		ND						EXT TO -4 @ 1:32 PM	
PIER 2	102-A		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK C/23 UP TO 1/8"	26
PIER 2	102-B		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK C2/3 UP TO 1/8"	
PIER 2	102-B.2		MD	CHEM DET	MN RND	TZ-ML	Multiple		V-CRK MULTIPLE CORNERS UP TO 1/8"	
PIER 2	102-C.5		MD	CHEM DET	MN RND	TZ-ML	C2/3		V-CRK C2/3 1/8"	
PIER 2	102-D	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H ND, MID=MS V-CRK 1/16" MULTIPLE CORNERS , ML=F ND	13
PIER 2	102-D.7	2	MD	CHEM DET	MN RND	Mid-water	Multiple		WL=H ND, MID=MS , ML=F ND	13
PIER 2	102-F		ND							
PIER 2	102-H	2	MD	CHEM DET	MN RND	Mid-water	C2/3		WL=H ND, MID=MS V-CRK 1/16" C2/3, ML=F ND	23
DOLPHIN	1-A BAT	2	ND						ML=H, MID=H, WL=H	30
DOLPHIN	1-B BAT		ND							
DOLPHIN	1-C BAT		ND							
DOLPHIN	1-E BAT		ND							
DOLPHIN	1-G BAT		MD	V-CRK	≤1/32	Mid-ML	3		@ -23' TO -27' & AT ML @ 13:18, & V-CRK @F1 @-25'	
DOLPHIN	1-I BAT		ND							
DOLPHIN	1-J BAT		MN	OCS			3		corr spall above water 3" dia. X 1/4" deep	
DOLPHIN	1-L BAT		MN	MECH SP			1		1.5"Wx.5"Hx.5"D	28
DOLPHIN	2-A BAT		ND							
DOLPHIN	2-B BAT		ND							

STRUCTURE	PILE	INSP. LEVEL	RATING	DEFECT TYPE	DESCRIPTION	ELEV (FT)	PILE FACE	ENCASED	COMMENTS	MUDLINE DEPTH (MLLW) (FT)
DOLPHIN	2-E BAT		ND							
DOLPHIN	2-I BAT		MD	V-CRK	≤1/32	Tidal Zone	3		1' ABOVE WL X 24" H W/ CORR STAINING	
DOLPHIN	2-L BAT		ND							
DOLPHIN	2-M BAT		ND							
DOLPHIN	3-D		ND							
DOLPHIN	3-G		ND							
DOLPHIN	3-J		ND							
DOLPHIN	4-A BAT		MD	V-CRK	≤1/32	Tidal Zone	2		48"H	
DOLPHIN	4-M BAT		ND							
DOLPHIN	5-D	2	ND						ML=H, MID=H, WL=H	29
DOLPHIN	5-G		ND							
DOLPHIN	5-J		ND							
DOLPHIN	6-A BAT		ND							
DOLPHIN	6-C BAT		ND							
DOLPHIN	6-F BAT		ND							
DOLPHIN	6-H BAT		ND							
DOLPHIN	6-K BAT		ND							
DOLPHIN	6-M BAT	2	ND						ML=H, MID=H, WL=F	29
DOLPHIN	7-A BAT		MD	V-CRK	≤1/32	Mid-ML	4		-16' TO ML	29
DOLPHIN	7-C BAT		ND							
DOLPHIN	7-D BAT	2	ND						ML=H, MID=H, WL=H	29
DOLPHIN	7-F BAT		ND							
DOLPHIN	7-G BAT		ND							
DOLPHIN	7-H BAT		ND							
DOLPHIN	7-J BAT		ND							
DOLPHIN	7-K BAT		ND							
DOLPHIN	7-M BAT		ND							

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

Alameda Point Pier Inspections
Concrete Core Samples

Pier	Pile	Water Column Location	Location (MLLW)	Location (uncorrected)	Tidal Height	Date	Time
2	21-A	Waterline	1.5	-3	4.5	10/15/2016	915
2	21-A	Mid-Pile	-18.5	-23	4.5	10/15/2016	915
2	21-A	3' ↓ Mudline	-29.5	-34	4.5	10/15/2016	915
2	31.2-Bbat	Waterline	2.0	-3	5.0	12/2/2016	1027
2	31.2-Bbat	Mid-Pile	-8.0	-13	5.0	12/2/2016	1028
2	31.2-Bbat	3' ↓ Mudline	-20.0	-25	5.0	12/2/2016	1029
2	36-D	Waterline	3.9	-2	5.9	10/12/2016	1017
2	36-D	Mid-Pile	-6.9	-12	5.1	10/12/2016	1150
2	36-D	3' ↓ Mudline	-19.3	-23	3.7	10/12/2016	1305
2	46-E	Waterline	3.1	-2	5.1	12/3/2016	1127
2	46-E	Mid-Pile	-3.9	-9	5.1	12/3/2016	1127
2	46-E	3' ↓ Mudline	-16.9	-22	5.1	12/3/2016	1127
2	51-H	Waterline	4.2	-1	5.2	10/15/2016	1401
2	51-H	Mid-Pile	-7.8	-13	5.2	10/15/2016	1404
2	52-H	3' ↓ Mudline	-27.8	-33	5.2	10/15/2016	1359
2	55-F	Waterline	2.9	-3	5.9	12/3/2016	1436
2	55-F	Mid-Pile	-9.1	-15	5.9	12/3/2016	1436
2	55-F	3' ↓ Mudline	-19.1	-25	5.9	12/3/2016	1436
2	61-A	Waterline	0.6	-3	3.6	12/4/2016	1022
2	61-A	Mid-Pile	-12.4	-16	3.6	12/4/2016	1022
2	61-A	3' ↓ Mudline	-28.4	-32	3.6	12/4/2016	1022
2	62-C	Waterline	0.8	-5	5.8	12/4/2016	1443
2	62-C	Mid-Pile	-8.2	-14	5.8	12/4/2016	1443
2	62-C	3' ↓ Mudline	-21.2	-27	5.8	12/4/2016	1443
2	86-G	Waterline	2.1	-3	5.1	12/5/2016	1356
2	86-G	Mid-Pile	-13.9	-19	5.1	12/5/2016	1356
2	86-G	3' ↓ Mudline	-25.9	-31	5.1	12/5/2016	1356
2	88-F	Waterline	1.8	-3	4.8	12/7/2016	1700
2	88-F	Mid-Pile	-8.2	-13	4.8	12/7/2016	1700
2	88-F	3' ↓ Mudline	-20.2	-25	4.8	12/7/2016	1700
2	99-H	Waterline	2.7	-2	4.7	10/16/2016	1457
2	99-H	Mid-Pile	-8.3	-13	4.7	10/16/2016	1456
2	99-H	3' ↓ Mudline	-24.3	-29	4.7	10/16/2016	1454
3	30-A	Waterline	3.5	-2	5.5	10/10/2016	1436
3	30-A	Mid-Pile	-6.5	-12	5.5	10/10/2016	1436
3	30-A	3' ↓ Mudline	-22.5	-28	5.5	10/10/2016	1436

Appendix D

Deficiency Rating Criteria and Definitions

DRAFT

Rating Criteria

The general condition assessment ratings for the inspected structure are based on a six point assessment scale developed by the American Society of Civil Engineers (ASCE). The six point condition ratings are:

- 6 – Good: No problems or only minor problems noted. Structural elements may show some very minor deterioration, but no overstressing observed.
- 5 – Satisfactory: Minor to moderate defects and deterioration observed, but no overstressing observed.
- 4 – Fair: All primary structural elements are sound; but minor to moderate defects and deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the load bearing capacity of the structure.
- 3 – Poor: Advanced deterioration or overstressing observed on widespread portions of the structure, but does not significantly reduce the load carrying capacity of the structure.
- 2 – Serious: Advanced deterioration, overstressing, or breakage may have significantly affected the load bearing capacity of primary structural elements. Local failures are possible and loading restrictions may be necessary.
- 1 – Critical: Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural elements. More widespread failures are possible or likely to occur and load restrictions should be implemented as necessary.

Corrosion levels are defined as follows:

- Minor (or Light) – A light surface corrosion with no apparent loss of section.
- Moderate – Corrosion that is loose and flaking with some pitting. The scaling or exfoliation can be removed with some effort by use of a scraper or chipping hammer. The element exhibits measurable but not significant loss of section.
- Severe – Heavy, stratified corrosion or corrosion scales with extensive pitting. Removal requires exerted effort and may require mechanical means. Significant loss of section.

Deficiency Rating and Definitions are based on the California State Lands Commission Marine Facilities Division's Marine Oil Terminal Engineering and Maintenance Audit Manual (May 2004).

TABLE D - 1
CONDITION ASSESSMENT RATINGS FOR STEEL ELEMENTS

Condition Rating	Existing Damage	Defects Indicating Higher Damage Grade(s)
Not Inspected	Not inspected, inaccessible or passed by	
No Damage	Protective coating intact Light surface rust	
Minor	Less than 50 percent of perimeter or circumference affected by corrosion at any elevation or cross section Loss of thickness up to 15 percent 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)
Moderate	Over 50 percent of perimeter or circumference affected by corrosion at any elevation or cross section Loss of thickness 15 to 30 percent of nominal at any location	Moderate damage not appropriate if: Changes in straight line configuration or local buckling Loss of thickness exceeding 30 percent of nominal at any location
Major	Partial loss of flange edges or visible reduction of wall thickness on pipe piles Loss of nominal thickness 30 to 50 percent at any location	Major damage not appropriate if: Changes in straight line configuration or local buckling Perforations or loss of wall thickness exceeding 50 percent of nominal
Severe	Structural bends or buckling, breakage and displacement at supports, loose or lost connections Loss of wall thickness exceeding 50 percent of nominal at any location	

FIGURE D - 1
CONDITION ASSESSMENT RATINGS FOR STEEL ELEMENTS

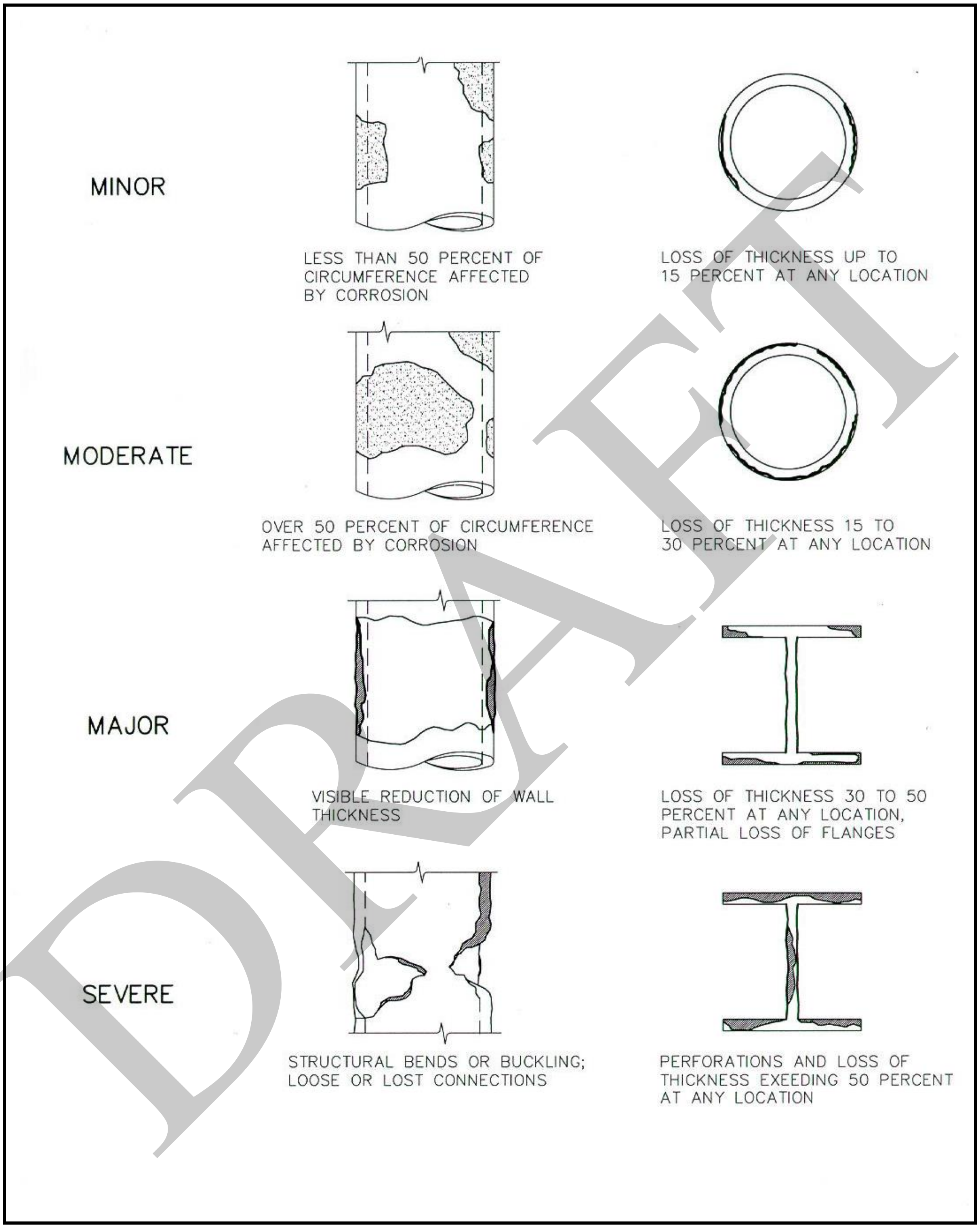
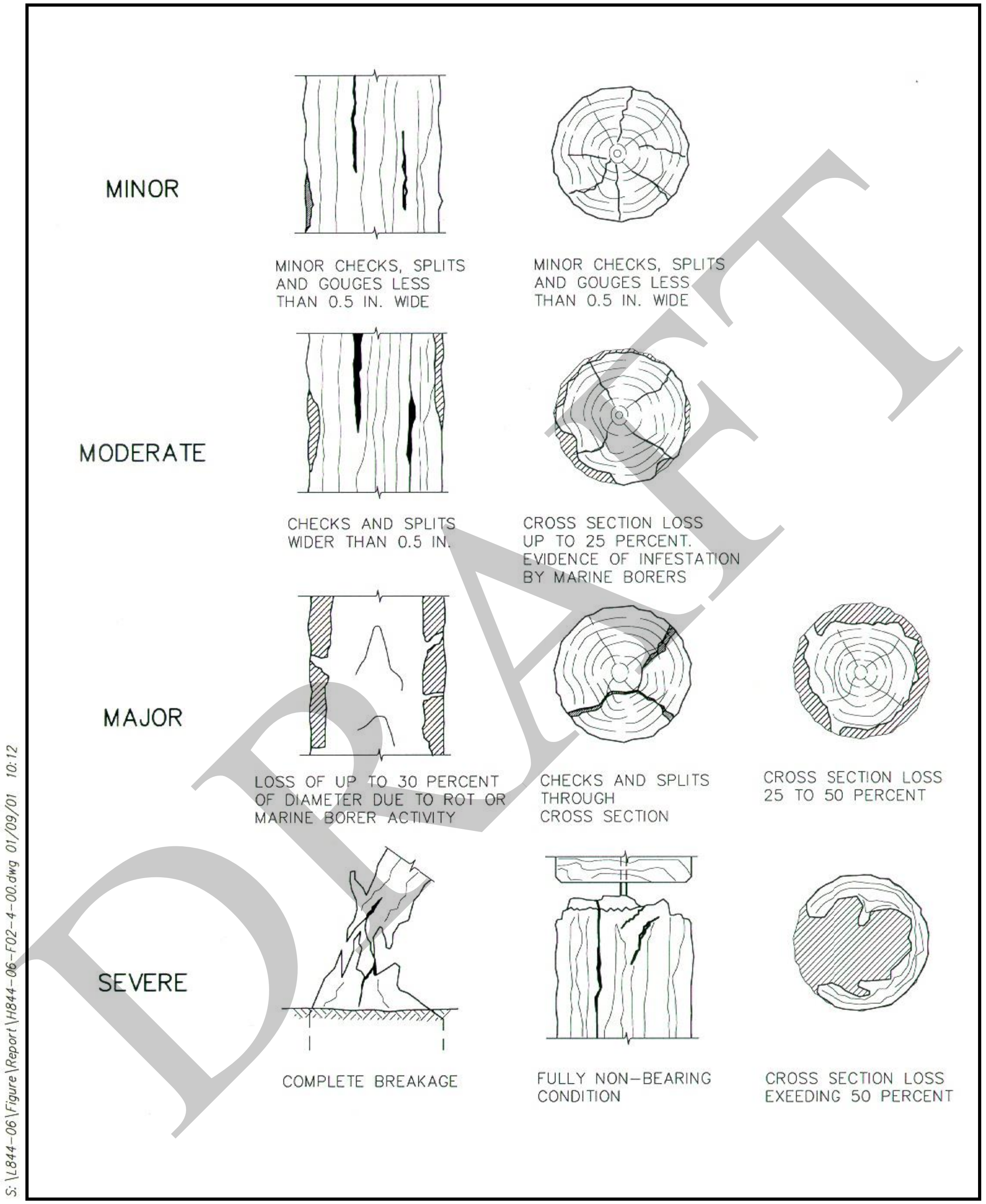


TABLE D-2
CONDITION ASSESSMENT RATINGS OF TIMBER ELEMENTS

Condition Rating	Existing Damage	Defects Indicating Higher Damage Grade(s)
Not Inspected	Not inspected, inaccessible or passed by	
No Damage	Sound surface material	
Minor	Checks, splits and gouges less than 0.5 in. wide	Minor damage not appropriate if: Loss of cross section Marine borers infestation Displacements, loss of bearing or connections
Moderate	Checks and splits wider than 0.5 in. Remaining diameter loss up to 15 percent Cross-section area loss up to 25 percent. Corroded hardware Evidence of infestation by marine borers	Moderate damage not appropriate if: Displacements, loss of bearing or connections
Major	Checks and splits through full depth of cross section Remaining diameter loss 15 to 30 percent Cross-section area loss 25 to 50 percent. Heavily corroded hardware. Displacement and misalignments at connections	Major deterioration not appropriate if: Partial or complete breakage
Severe	Remaining diameter reduced by more than 30 percent Cross-section area loss more than 50 percent Loss of connection and/or fully non-bearing condition Partial or complete breakage	

FIGURE D-2
CONDITION ASSESSMENT RATINGS FOR TIMBER ELEMENTS



SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

TABLE D-3
CONDITION ASSESSMENT RATINGS FOR REINFORCED CONCRETE ELEMENTS

Condition Rating	Existing Damage	Defects Indicating Higher Damage Grade(s)
Not Inspected	Not inspected, inaccessible or passed by	
No Damage	Good original surface, hard material, sound	
Minor	Mechanical abrasion or impact dents up to 1 in. in depth General cracks up to 1/16 in. in width Occasional corrosion stains or small pop-out corrosion spalls	Minor damage not appropriate if: Structural damage Corrosion cracks Chemical deterioration[1]
Moderate	Structural cracks up to 1/16 in. in width Corrosion cracks up to 1/4 in. in width Chemical deterioration(1): Random cracks up to 1/16 in. in width; “Soft” concrete and rounding of corners up to 1 in. deep	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”
Major	Structural cracks 1/16 in. to 1/4 in. in width and partial breakages (structural spalls) Corrosion cracks wider than 1/4 in. and open spalls (excluding pop-outs) Multiple cracking and disintegration of surface layer due to chemical deterioration	Major damage not appropriate if: Loss of cross section exceeding 30 percent due to any cause
Severe	Structural cracks wider than 1/4 in. or complete breakage. Loss of bearing and displacement at connections Complete loss of concrete cover due to corrosion of reinforcing steel with over 30 percent of diameter loss for any main reinforcing bar Loss of concrete cover (exposed steel) due to chemical deterioration Loss of over 30 percent of cross section due to any causes described above	

1. Chemical Deterioration: Sulfate attack, alkali-silica reaction, or ettringite distress.

FIGURE D-3
CONDITION ASSESSMENT RATINGS FOR REINFORCED CONCRETE ELEMENTS

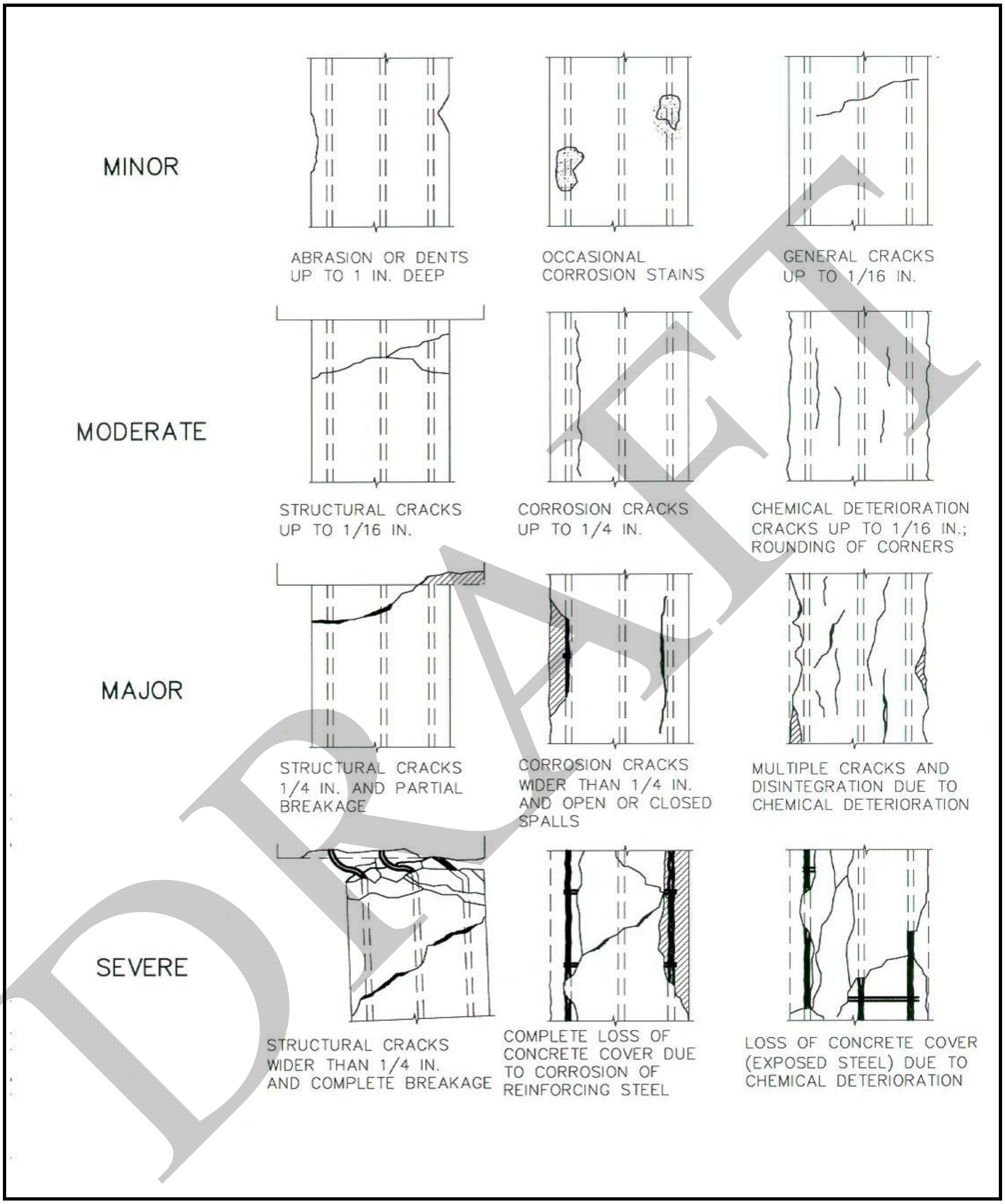


TABLE D-4
CONDITION ASSESSMENT RATINGS FOR PRESTRESSED CONCRETE ELEMENTS

Condition Rating	Existing Damage	Defects Indicating Higher Damage Grade(s)
Not Inspected	Not inspected, inaccessible or passed by	
No Damage	Good original surface, hard material, sound	
Minor	Minor mechanical or impact spalls up to 0.5 in. deep	Minor damage not appropriate if: Structural damage Corrosion damage Chemical deterioration[1] Cracks of any type or size
Moderate	Structural cracks up to 1/32 in. in width Chemical deterioration: random cracks up to 1/32 in. in width	Moderate damage not appropriate if: Structural breakage and/ or spalls Corrosion cracks Loss of cross section in any form “Softening” of concrete
Major	Structural cracks 1/32 in. to 1/8 in. in width Any corrosion cracks generated by strands or cables Chemical deterioration: cracks wider than 1/16 in. “Softening” or concrete up to 1 in. deep	Major deterioration not appropriate if: Exposed prestressing steel
Severe	Structural cracks wider than 1/8 in. and at least partial breakage or loss of bearing Corrosion spalls over any prestressing steel Partial spalling and loss of cross section due to chemical deterioration	

1. Chemical Deterioration: Sulfate attack, alkali-silica reaction or ettringite distress.

FIGURE D- 4
CONDITION ASSESSMENT RATINGS FOR PRESTRESSED CONCRETE ELEMENTS

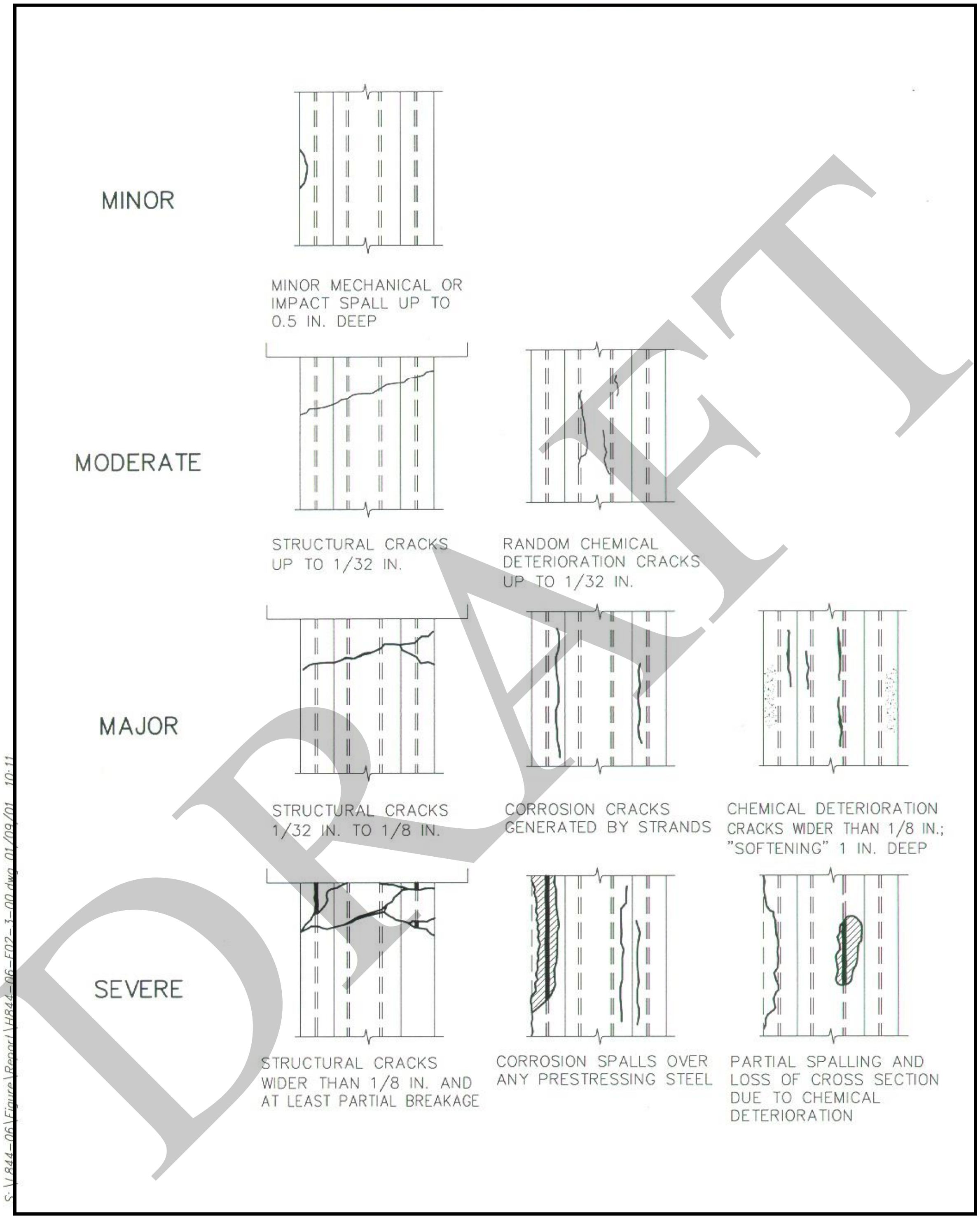
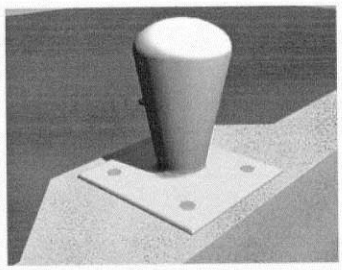
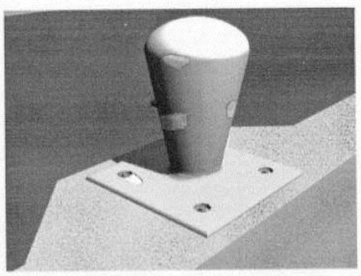


FIGURE D-5
CONDITION ASSESSMENT RATINGS FOR MOORING HARDWARE FIXTURES

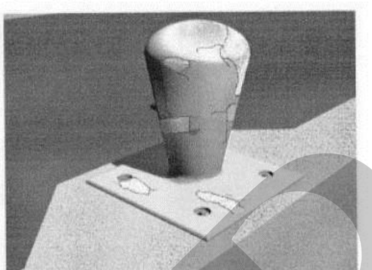
Example of Condition	Mooring Hardware Condition Rating



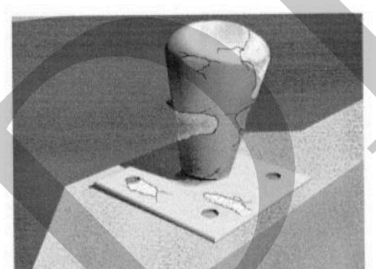
#1 No Defects
- New coating (minor blemishes and corrosion on less than 10% of surface area)
- No wear marks
- No visible corrosion of fasteners
- Bolt countersinks sealed



#2 Minor Defects
- Minor surface corrosion (10% to 25% of surface area)
- Minor wear marks on fitting surface less than 3.125 mm (.0125 inches) deep
- Minor corrosion of fasteners



#3 Moderate Defects
- Heavy corrosion with loose scale (greater than 25%)
- Noticeable corrosion of fasteners
- Significant surface wear marks up to 7.8125 mm (0.3125 inches) deep

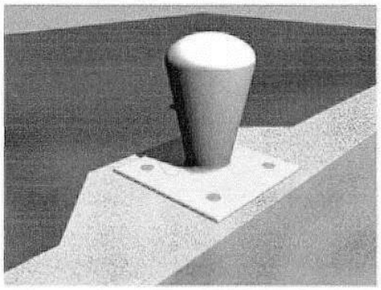


#4 Sever Defects
- Severe corrosion, heavy scale, noticeable surface pitting and 25% or greater loss of area at critical section
- Displaced or rotates fitting
- Broken or cracked fitting components
- Noticeable corrosion and section loss of fasteners
- Loose fasteners

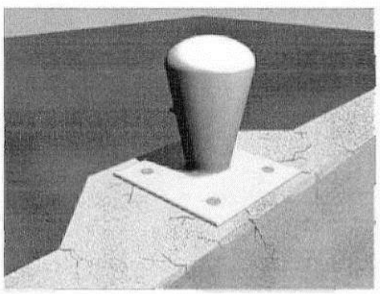
FIGURE D-6
CONDITION ASSESSMENT RATINGS FOR
MOORING HARDWARE BASE STRUCTURES

Example of Condition

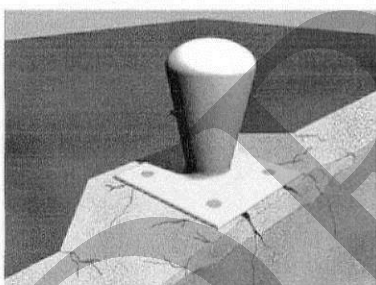
Mooring Support Structure Condition Rating



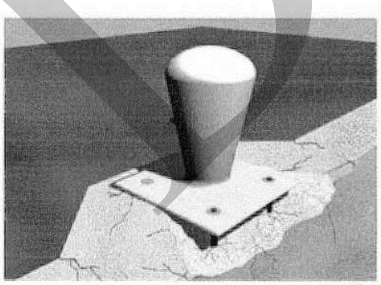
#1 No Defects
- Surface clean and smooth
- No cracking
- No noticeable deterioration



#2 minor Defects
- Weathering of concrete and wood
- Minor corrosion of steel (no significant section loss)
- Hairline cracking of concrete due to thermal expansion and/or age



#3 Moderate Defects
- Noticeable cracking of concrete due to age
- Corrosion of steel with section loss
- Timber cracked and checked, weathered, susceptible to dry rot



#4 Severe Defects
- Cracking or spalling as a result of overload under hardware base
- Dry rot on timber members
- Significant corrosion of steel members
- Displacement or yielding of any supporting members
- Loss of full bearing under hardware

TABLE D-5
ASCE RECOMMENDED INSPECTION INTERVALS

**ASCE STANDARD PRACTICE MANUAL FOR UNDERWATER INVESTIGATIONS
TABLE 2-2
RECOMMENDED MAXIMUM INTERVAL BETWEEN
UNDERWATER ROUTINE INSPECTIONS (YEARS)[1]**

Condition Rating From Previous Inspection	CONSTRUCTION MATERIAL: Unwrapped Wood or Unprotected Steel (no coating or cathodic protection)[4]		CONSTRUCTION MATERIAL: Concrete, Wrapped Wood, Protected Steel or Composite Materials (FRP, plastic, etc.)[4]		Channel Bottom or Mudline – Scour[4, 5] (Soundings[6] / Direct Observation)	
	Benign[2] Environment	Aggressive[3] Environment	Benign[2] Environment	Aggressive[3] Environment	Benign[2] Environment	Aggressive[3] Environment
6 (Good)	6	4	6	5	6 / 6	2 / 5
5 (Satisfactory)	6	4	6	5	6 / 6	2 / 5
4 (Fair)	5	3	5	4	6 / 6	2 / 5
3 (Poor)	4	3	5	4	6 / 6	2 / 5
2 (Serious)	2	1	2	2	2 / 2	2 / 2
1 (Critical)	0.5	0.5	0.5	0.5	1 / 1	0.5 / 1

1. The recommended maximum interval between Routine Inspections should be reduced as appropriate based on the extent of deterioration observed on a structure, the rate of further anticipated deterioration, the importance of the structure, or other factors. The intervals may likewise be increased as appropriate for non-typical cases such as alternative deterioration-resistance construction materials (i.e., special hardwoods), or other factors. Regulatory jurisdictions may also dictate the maximum inspection interval.
2. Benign environments include fresh water with low to moderate currents (maximum current always < .75 kts)
3. Aggressive environments include brackish or salt water, polluted water, or waters with moderate to swift currents (maximum current ≥ .75 kts)
4. The intervals indicate requirements for soundings and direct observation, respectively.
5. For most structures, two maximum intervals will be shown in this table, one for the assessment of construction material (wood, concrete, steel, etc) and one for scour (last 2 columns). The shorter interval of the two should dictate the maximum interval used.
6. Soundings may be performed at the time of the above water inspection.

SHORELINE ENGINEERING, INC.
STRUCTURAL / CIVIL / FORENSIC / ENGINEER-DIVERS

Appendix E – References

References

1. California Code of Regulations, Title 24, Chapter 31F, "Marine Oil Terminals Engineering and Maintenance Standards", California Building Standards Commission, 2013.
2. Marine Oil Terminal Engineering and Maintenance Audit Manual, California State Lands Commission – Marine Facilities Division, May 2004
3. ASCE Manuals and Reports on Engineering Practice No. 101, Underwater Investigations-Standard Practice Manual, 2001
4. Condition Assessment Report for Pier 1, Pier 2, & Pier 3, Moffatt & Nichol, March 2008.

APPENDIX B

AME Concrete Test Report

APPLIED MATERIALS & ENGINEERING, INC.
980 41st Street
Oakland, CA 94608
Tel: (510) 420-8190
FAX: (510) 420-8186
e-mail: info@appmateng.com

January 26, 2017

Project Number: 1160610C

Dr. Sam X. Yao, Ph.D., P.E.
SIMPSON GUMPERTZ & HEGER
500 12th Street, Suite 270
Oakland, CA 94607

Email: sxyao@sgh.com

Subject: Petrographic Examination and Testing of Concrete Cores
Alameda Piers 1, 2 & 3, Alameda, California

Dear Dr. Yao:

As requested, Applied Materials & Engineering, Inc. (AME) has examined and tested concrete core samples removed by others from the above-captioned project. The objectives of the examination were to determine the physical and compositional properties of the samples, and if any deleterious reactions were present. In addition, the chloride ion contents of the pile core samples were determined at incremental depths starting from the exterior exposed surfaces.

SAMPLE IDENTIFICATION

A total of forty-two (42) concrete cores were delivered to our laboratory in two sets. The first set, consisting of fifteen (15) cores, was delivered on October 17, 2016. The second set, consisting of 27 cores, was delivered on December 12, 2016. All samples were delivered in the wet condition, individual wrapped in plastic-wrap and protected with bubble-wrap. The sample description and sampling locations are listed in Table I (Set 1) and Table II (Set 2). Pile Cores 1 through 36 were used for petrographic examinations, compressive strength and chloride content profiles. Deck Cores 37 through 42 were tested for compressive strength only.

TEST METHOD & RESULTS

1) ASTM C 856, "*Standard Practice for Petrographic Examination of Hardened Concrete.*"

2) ASTM C 42, "*Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.*"

3) Chloride Ion Content: The chloride content tests were performed in accordance with the procedures described by the Germann Instruments Rapid Chloride Test (RCT). The precision of the RCT compares favorably with AASHTO T 260 and ASTM C 114 potentiometric titration for total acid-soluble chloride ion content of hardened concrete (Germann Instruments published product literature).

The following information was obtained:

1) Petrographic Examination of Pile Concrete

a) The concrete was composed of portland cement paste and normal-weight siliceous aggregate. The concrete was well proportioned and properly consolidated. No unusual placement features were observed.

b) The aggregate consisted of 1″ maximum size subangular to subround coarse aggregate composed of andesite/basalt, graywacke sandstone, chert, ultramafic volcanic rock fragments, felsite and less amounts of the granitic rock types. The fine aggregate consisted of rock fragments and minerals typical of the coarse aggregate.

c) Seawater attack caused cracking and microcracking in the out portion of the piles. The seawater attack softened the cement paste to depths typically less than 0.35″, but cracking and microcracking that was generally parallel the exterior surfaces extended to depths of 4½″ to 5″. The microcracks were typically completely filled with ettringite (calcium sulfoaluminate hydrate), carbonate minerals, and carbonated alkali-silica gel. Brucite (magnesium hydroxide) was occasionally detected, but positive identification of brucite was difficult due to the size of the crystals. It appeared that most of the areas were brucite was likely present it had converted to magnesium carbonate (the mineral magnesite) due to carbonation.

d) Observed reactions between the graywacke sandstone, and some volcanic rock types with the cement paste (reaction rims in the aggregate and calcium hydroxide depletion within the interstitial transition zone) was most likely due to alkali-silica reactivity (ASR), although ASR gel was usually absent or had carbonated. Alkali-silica reactivity was considered to be a consequence of the seawater attack, as decomposition of the cement paste reaction products (calcium silicate hydrates, abbreviated C-S-H), released silica which reacted with alkalis in the seawater. Expansion and cracking caused by ASR appeared to be minor.

e) The sulfate attack, in the form of ettringite formation in cracks and voids, was also a consequence of the seawater attack on the concrete, and appeared to be a contributing factor to cracking.

f) Deterioration was most prominent in the mid-water cores; less, but still significant, in the water-line cores; and diminished, but still present, in the mud-line cores. Figure 1 is a graph showing the DRI values for all the core samples. Note the increase in the damage rating at mid-water. Figure 2 shows the normal distribution of the DRI for the cores taken from the water-line, mid-water and mud-line locations. The DRI is typically applied to alkali-silica reactivity, but was found to be useful in rating the degree of seawater attack.

g) On average, the concrete was composed of approximately 28% cement paste and 71% aggregate, by volume. No fly ash or other supplementary cementitious materials were detected. The air content averaged approximately 1% and ranged from 0.1% to 2.5%. The concrete was not air-entrained. The average volumetric coarse-to-fine aggregate ratio (CA/FA) was approximately 1.3:1.

h) The bulk cement paste was medium gray to light gray and hard (difficult to scratch with steel probe), with a Mohs Hardness ranging from 3 to 4½. The aggregate-to-paste bond was good. In cores that had surface deterioration and paste softening, the Mohs Hardness was less than 2½.

i) The amount of unhydrated portland cement (UPC) clinker in the cement paste ranged between 3% and 7%. The paste was well hydrated and moderate to low capillary void porosity (relatively moderately dense paste).

j) The surface carbonation depth was typically less than 0.38″. Carbonation along crack margins rarely exceeded 1.5″.

k) The average water-cement ratio (w/c), estimated from the optical examination, was approximately 0.50 ± 0.05. Based on the estimated w/c (0.50) and the volumetric proportion of paste (28%), the calculated cement content was approximately 6 sacks/yd^3.

Tables III through XIV summarize the results of the petrographic examinations and damage ratings for the pile cores. Details of the individual core petrographic examinations are given in Appendix A.

2) Compressive Strength of Concrete Cores

The average compressive strength of the pile cores (Cores 1 through 36) was 7924 psi. The compressive strengths ranged from 2240 psi (Core 4) to 11350 psi (Core 24). It should be noted that the L/D ratio for Core 4 was less than 1.00, which makes the low compressive strength of the test sample questionable. All other core samples had compressive strengths greater than 5990 psi.

The average compressive strength of the deck cores (Cores 37 through 42) was 4992 psi. The compressive strengths ranged from 3870 psi (Core 41) to 6260 psi (Core 39).

Results of the compressive strength tests are given in Table XV (Set 1, Pile Cores 1 through 16), Table XVI (Set 2, Pile Cores 16 through 30), Table XVII (Set 2, Pile Cores 31 through 36) and Table XVIII (Set 2, Deck Cores 37 through 42). The individual test results are also included in the petrographic examination summary tables.

3) Chloride Ion Contents of Pile Concrete Cores

The chloride ion contents of the concrete were determined at incremental depths of 1″ starting at ½″ from the outer exposed surface. The results of the chloride ion profile testing are given in Tables XIX through XXI. The chloride ion contents are shown graphically in Figures 3 through 7. The individual test results are also included in the petrographic examination summary tables.

According to American Concrete Institute's ACI 222R-13, Manual of Concrete Practice, the theoretical maximum acid-soluble chloride content for reinforced concrete (to minimize chloride-induced corrosion) is 0.20% by weight of cement. Using the average cement content of 564 lb/yd^3, and an estimated concrete mixture weighing 4000 lb/yd^3, the maximum acid-soluble chloride content (theoretical threshold level) would be 0.028%, by weight of concrete, or the equivalent of 1.2 lb of chlorides per cubic yard of concrete.

According to Caltrans Guidelines for Chloride Concrete in Reinforced Concrete, 0.0 to 1.2 lb/yd^3 of chloride ions in concrete is considered passive (non-corroding), 1.2 to 3.0 lb/yd^3 indicate corrosion initiation, and greater than 3.0 lb/yd^3 indicates there is active corrosion.

All locations tested, except one, had chloride ion contents that exceeded the theoretical threshold level for chloride induced corrosion of reinforcing steel in concrete. The general trend was higher chloride contents at the surface and decreasing at depth. Sample 4-5, which was taken at approximately 8″ depth, was the only sample where the chloride ion content was less than 0.05%.

CONCLUSIONS

1) The pile concrete represented by Cores 1 through 36 was composed of portland cement paste and subangular to subround siliceous aggregate. The concrete was well consolidated. The aggregate distributions were good. No unusual placement features were observed.

2) Deterioration due to sea-water attack was significant in all pile cores. The depth of deterioration was observed to depths of 4.5" to 5". The damage caused by the sea-water attack consisted primarily of cracks and microcracks filled with ettringite, carbonate minerals and carbonated alkali-silica gel. Brucite was occasionally observable. Alkali-silica reactivity was a consequence of the sea-water attack, but not a major contributing factor to the formation of cracking. Sulfate attack appeared to be a secondary contributing factor to the microcracking.

3) The average pile concrete compressive strength was 7924 psi. The average deck concrete compressive strength was 4992 psi.

4) The chloride ion contents to 4.5″ depth, as measured from the exposed surface, were higher than the theoretical threshold value for chloride-induced corrosion of steel reinforcement embedded in concrete.

Please call if any questions arise.

Sincerely,

APPLIED MATERIALS & ENGINEERING, INC.

Jon Asselanis
Materials Scientist/Senior Petrographer

Reviewed by:

Armen Tajirian, Ph.D., PE
Principal

Samples will be held for 30 days after submittal of final report and then discarded unless notified in writing. Storage of held samples will be billed monthly. There is a $100 per month storage fee. Return shipment charges are the responsibility of the client.

TABLE I

CONCRETE CORES SAMPLE IDENTIFICATIONS AND SAMPLING LOCATIONS

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Set 1 – Received October 17, 2016						
Count	Date Received	Date Cored	Pier	Pile	Face	Location
1	10/17/16	10/14/16	2	21-A	2	Water-line
2	10/17/16	10/14/16	2	21-A	2	Mid-water
3	10/17/16	10/15/16	2	21-A	2	Mud-line
4	10/17/16	10/12/16	2	36-D	2	Water-line
5	10/17/16	10/12/16	2	36-D	2	Mid-water
6	10/17/16	10/12/16	2	36-D	2	Mud-line
7	10/17/16	10/15/16	2	51-H	4	Water-line
8	10/17/16	10/15/16	2	51-H	1	Mid-water
9	10/17/16	10/13/16	2	52-H	4	Mud-line
10	10/17/16	10/16/16	2	99-H	4	Water-line
11	10/17/16	10/16/16	2	99-H	4	Mid-water
12	10/17/16	10/16/16	2	99-H	4	Mud-line
13	10/17/16	10/11/16	3	30-A	2	Water-line
14	10/17/16	10/10/16	3	30-A	2	Mid-water
15	10/17/16	10/11/16	3	30-A	2	Mud-line

TABLE II

CONCRETE CORES SAMPLE IDENTIFICATIONS AND SAMPLING LOCATIONS

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Set 2 – Received December 7, 2016						
Count	Date Received	Date Cored	Pier	Pile	Face	Location
16	12/7/16	12/2/16	2	31.2-B	3	Water-line
17	12/7/16	12/2/16	2	31.2-B	3	Mid-water
18	12/7/16	12/2/16	2	31.2-B	3	Mud-line
19	12/7/16	12/3/16	2	46-E	4	Water-line
20	12/7/16	12/3/16	2	46-E	4	Mid-water
21	12/7/16	12/3/16	2	46-E	4	Mud-line
22	12/7/16	12/3/16	2	55-F	4	Water-line
23	12/7/16	12/3/16	2	55-F	4	Mid-water
24	12/7/16	12/3/16	2	55-F	4	Mud-line
25	12/7/16	12/4/16	2	61-A	2	Water-line
26	12/7/16	12/4/16	2	61-A	2	Mid-water
27	12/7/16	12/4/16	2	61-A	2	Mud-line
28	12/7/16	12/4/16	2	62-C	2	Water-line
29	12/7/16	12/4/16	2	62-C	2	Mid-water
30	12/7/16	12/4/16	2	62-C	2	Mud-line
31	12/7/16	12/5/16	2	86-G	4	Water-line
32	12/7/16	12/5/16	2	86-G	4	Mid-water
33	12/8/16	12/7/16	2	86-G	4	Mud-line
34	12/8/16	12/7/16	2	88-F	1	Water-line
35	12/8/16	12/7/16	2	88-F	4	Mid-water
36	12/8/16	12/7/16	2	88-F	4	Mud-line
37	12/7/16	12/6/16	1	---	---	Deck - West End
38	12/7/16	12/6/16	1	---	---	Deck - East End
39	12/7/16	12/6/16	2	37-38	---	North Side
40	12/7/16	12/6/16	2	91-92	---	South Side
41	12/7/16	12/6/16	3	---	---	1
42	12/7/16	12/6/16	3	---	---	South Side

TABLE III

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 21-A				
Core Location (within Pile) and Number	Water-line (Core 1)	Mid-water (Core 2)	Mud-line (Core 3)	Average
Concrete Characteristics:				
Paste Content, %	30.5	27.9	26.9	28.4
Coarse Aggregate Content, %	39.6	47.3	42.6	43.2
Fine Aggregate Content, %	29.5	24.1	29.4	27.7
Coarse-to-fine aggregate ratio (CA/FA)	1.3:1	2.0:1	1.4:1	1.6:1
Total Air Content, %	0.4	0.7	1.1	0.7
Total Aggregate Content, %	69.0	71.4	72.0	70.8
Cement Content, sacks/yd^3	6.6	6.1	6.1	6.3
Estimated water-to-cement ratio (w/c)	0.48	0.48	0.48	0.48
Damage Index Rating (DRI)	1057	5017	3934	3336.1
Compressive Strength, psi	6320	5990	6740	6350
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.236	0.948	0.714	0.633
1.5 from exterior surface, in.	0.195	0.952	0.575	0.574
2.5 from exterior surface, in.	0.174	0.967	0.444	0.529
3.5 from exterior surface, in.	0.115	0.650	0.324	0.363
4.5 from exterior surface, in.	0.066	0.611	0.137	0.271

TABLE IV

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 36-D				
Core Location (within Pile) and Number	Water-line (Core 4)	Mid-water (Core 5)	Mud-line (Core 6)	Average
Concrete Characteristics:				
Paste Content, %	27.1	24.6	28.2	26.6
Coarse Aggregate Content, %	31.8	36.3	30.6	32.9
Fine Aggregate Content, %	40.8	37.7	40.2	39.6
Coarse-to-fine aggregate ratio (CA/FA)	0.8:1	1.0:1	0.8:1	0.8:1
Total Air Content, %	0.3	1.4	1.0	0.9
Total Aggregate Content, %	72.6	73.9	70.8	72.5
Cement Content, sacks/yd^3	6.0	5.6	6.2	5.9
Estimated water-to-cement ratio (w/c)	0.48	0.48	0.48	0.48
Damage Index Rating (DRI)	912	5208	1697	2606
Compressive Strength, psi	2240	7590	8190	6010
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.127	0.917	0.572	0.539
1.5 from exterior surface, in.	0.173	0.650	0.195	0.339
2.5 from exterior surface, in.	0.067	0.700	0.200	0.322
3.5 from exterior surface, in.	0.072	0.545	0.090	0.236
4.5 from exterior surface, in.	0.009	0.311	0.416	0.245

TABLE V

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 51-H and 52-H				
Core Location (within Pile) and Number	Water-line (Core 7)	Mid-water (Core 8)	Mud-line (Core 9)	Average
Concrete Characteristics:				
Paste Content, %	25.7	31.9	27.2	28.3
Coarse Aggregate Content, %	35.6	33.6	38.2	35.8
Fine Aggregate Content, %	38.2	34.3	34.3	35.6
Coarse-to-fine aggregate ratio (CA/FA)	0.9:1	1.0:1	1.1:1	1.0:1
Total Air Content, %	0.5	0.1	0.3	0.3
Total Aggregate Content, %	73.8	67.9	72.5	71.4
Cement Content, sacks/yd³	5.6	6.9	5.9	6.1
Estimated water-to-cement ratio (w/c)	0.50	0.48	0.50	0.49
Damage Index Rating (DRI)	2591	5019	1446	3019
Compressive Strength, psi	7200	6040	7540	6930
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.859	1.037	0.814	0.904
1.5 from exterior surface, in.	0.708	0.500	0.694	0.634
2.5 from exterior surface, in.	0.262	0.910	0.575	0.582
3.5 from exterior surface, in.	0.257	0.538	0.932	0.576
4.5 from exterior surface, in.	0.234	0.717	0.750	0.567

TABLE VI

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 99-H				
Core Location (within Pile) and Number	Water-line (Core 10)	Mid-water (Core 11)	Mud-line (Core 12)	Average
Concrete Characteristics:				
Paste Content, %	28.6	20.7	30.2	26.5
Coarse Aggregate Content, %	37.5	53.0	39.4	43.3
Fine Aggregate Content, %	33.3	25.4	29.8	29.5
Coarse-to-fine aggregate ratio (CA/FA)	1.1:1	2.1:1	1.3:1	1.5:1
Total Air Content, %	0.5	1.0	0.6	0.7
Total Aggregate Content, %	70.8	78.3	69.2	72.8
Cement Content, sacks/yd^3	6.2	4.7	6.5	5.8
Estimated water-to-cement ratio (w/c)	0.50	0.50	0.50	0.50
Damage Index Rating (DRI)	1474	3285	392	1717
Compressive Strength, psi	8810	7860	7730	8130
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.449	0.385	0.772	0.535
1.5 from exterior surface, in.	0.541	0.680	0.621	0.614
2.5 from exterior surface, in.	0.449	0.451	0.559	0.486
3.5 from exterior surface, in.	0.421	0.431	0.218	0.357
4.5 from exterior surface, in.	0.248	0.245	0.226	0.240

TABLE VII

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 3, Pile 30-A				
Core Location (within Pile) and Number	Water-line (Core 13)	Mid-water (Core 14)	Mud-line (Core 15)	Average
Concrete Characteristics:				
Paste Content, %	28.0	30.2	29.1	29.1
Coarse Aggregate Content, %	42.3	34.6	37.1	38.0
Fine Aggregate Content, %	28.8	33.7	32.1	31.5
Coarse-to-fine aggregate ratio (CA/FA)	1.5:1	1.0:1	1.2:1	1.2:1
Total Air Content, %	1.0	1.5	1.7	1.4
Total Aggregate Content, %	71.1	68.3	69.2	69.5
Cement Content, sacks/yd^3	6.3	6.7	6.5	6.5
Estimated water-to-cement ratio (w/c)	0.45	0.45	0.45	0.45
Damage Index Rating (DRI)	1194	684	1545	1141
Compressive Strength, psi	10480	8530	8480	9160
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	1.140	0.979	0.711	0.944
1.5 from exterior surface, in.	0.512	0.804	0.653	0.657
2.5 from exterior surface, in.	0.547	0.532	0.523	0.534
3.5 from exterior surface, in.	0.391	0.677	0.372	0.480
4.5 from exterior surface, in.	0.391	0.446	0.339	0.392

TABLE VIII

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 31.2-B				
Core Location (within Pile) and Number	Water-line (Core 16)	Mid-water (Core 17)	Mud-line (Core 18)	Average
Concrete Characteristics:				
Paste Content, %	29.9	29.9	27.5	29.1
Coarse Aggregate Content, %	32.1	38.6	41.0	37.3
Fine Aggregate Content, %	37.2	30.7	30.7	32.9
Coarse-to-fine aggregate ratio (CA/FA)	0.9:1	1.3:1	1.3:1	1.2:1
Total Air Content, %	0.8	0.8	0.7	0.8
Total Aggregate Content, %	69.3	69.3	71.8	70.1
Cement Content, sacks/yd³	6.2	6.4	5.7	6.1
Estimated water-to-cement ratio (w/c)	0.53	0.50	0.55	0.53
Damage Index Rating (DRI)	1124	2401	2283	1936
Compressive Strength, psi	9620	8980	8750	9120
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.494	0.671	0.302	0.489
1.5 from exterior surface, in.	0.712	0.619	0.357	0.563
2.5 from exterior surface, in.	0.706	0.649	0.323	0.559
3.5 from exterior surface, in.	0.572	0.421	0.315	0.436
4.5 from exterior surface, in.	0.521	0.100	0.298	0.307

TABLE IX

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 46-E				
Core Location (within Pile) and Number	Water-line (Core 19)	Mid-water (Core 20)	Mud-line (Core 21)	Average
Concrete Characteristics:				
Paste Content, %	27.0	31.0	28.6	28.9
Coarse Aggregate Content, %	50.5	38.6	46.4	45.2
Fine Aggregate Content, %	21.9	30.0	24.7	25.5
Coarse-to-fine aggregate ratio (CA/FA)	2.3:1	1.3:1	1.9:1	1.8:1
Total Air Content, %	0.6	0.4	0.4	0.4
Total Aggregate Content, %	72.4	68.6	71.0	70.7
Cement Content, sacks/yd^3	5.9	6.6	5.9	6.1
Estimated water-to-cement ratio (w/c)	0.50	0.50	0.55	0.52
Damage Index Rating (DRI)	4541	5425	3585	4517
Compressive Strength, psi	7350	6390	7580	7110
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.641	0.496	0.824	0.654
1.5 from exterior surface, in.	0.654	0.943	0.807	0.801
2.5 from exterior surface, in.	0.688	0.871	0.724	0.761
3.5 from exterior surface, in.	0.565	0.897	1.423	0.961
4.5 from exterior surface, in.	0.528	0.975	0.405	0.636

TABLE X

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 55-F				
Core Location (within Pile) and Number	Water-line (Core 22)	Mid-water (Core 23)	Mud-line (Core 24)	Average
Concrete Characteristics:				
Paste Content, %	27.0	27.2	30.4	28.2
Coarse Aggregate Content, %	46.9	47.2	44.2	46.1
Fine Aggregate Content, %	25.1	25.0	24.5	24.9
Coarse-to-fine aggregate ratio (CA/FA)	1.9:1	1.9:1	1.8:1	1.9:1
Total Air Content, %	1.0	0.6	0.9	0.8
Total Aggregate Content, %	72.0	72.2	68.7	71.0
Cement Content, sacks/yd^3	5.6	5.7	6.3	5.9
Estimated water-to-cement ratio (w/c)	0.55	0.53	0.53	0.54
Damage Index Rating (DRI)	1121	1342	453	972
Compressive Strength, psi	8550	8450	11350	9450
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.761	0.715	0.423	0.633
1.5 from exterior surface, in.	0.660	0.893	0.272	0.608
2.5 from exterior surface, in.	0.471	0.777	0.195	0.481
3.5 from exterior surface, in.	0.482	0.260	0.112	0.284
4.5 from exterior surface, in.	0.460	0.379	0.052	0.297

TABLE XI

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 61-A				
Core Location (within Pile) and Number	Water-line (Core 25)	Mid-water (Core 26)	Mud-line (Core 27)	Average
Concrete Characteristics:				
Paste Content, %	29.6	33.6	30.2	31.1
Coarse Aggregate Content, %	37.9	29.0	41.1	36.0
Fine Aggregate Content, %	32.0	37.2	27.9	32.4
Coarse-to-fine aggregate ratio (CA/FA)	1.2:1	0.8:1	1.5:1	1.1:1
Total Air Content, %	0.4	0.2	0.8	0.5
Total Aggregate Content, %	69.9	66.2	69.0	68.4
Cement Content, sacks/yd^3	6.4	7.1	6.6	6.7
Estimated water-to-cement ratio (w/c)	0.50	0.50	0.48	0.49
Damage Index Rating (DRI)	4918	7444	1350	4571
Compressive Strength, psi	8910	8430	7160	8170
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.764	0.912	0.562	0.746
1.5 from exterior surface, in.	0.694	0.758	0.475	0.642
2.5 from exterior surface, in.	0.641	0.767	0.204	0.538
3.5 from exterior surface, in.	0.334	0.745	0.115	0.398
4.5 from exterior surface, in.	0.273	0.665	0.058	0.332

TABLE XII

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 62-C				
Core Location (within Pile) and Number	Water-line (Core 28)	Mid-water (Core 29)	Mud-line (Core 30)	Average
Concrete Characteristics:				
Paste Content, %	31.4	28.7	29.5	29.9
Coarse Aggregate Content, %	37.0	39.6	33.2	36.6
Fine Aggregate Content, %	29.1	30.9	35.0	31.6
Coarse-to-fine aggregate ratio (CA/FA)	1.3:1	1.3:1	0.9:1	1.2:1
Total Air Content, %	2.5	0.8	2.4	1.9
Total Aggregate Content, %	66.1	70.5	68.1	68.2
Cement Content, sacks/yd^3	6.4	5.9	6.2	6.2
Estimated water-to-cement ratio (w/c)	0.55	0.55	0.53	0.54
Damage Index Rating (DRI)	2482	3646	629	2252
Compressive Strength, psi	9070	7590	6350	7670
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	1.153	0.824	0.517	0.832
1.5 from exterior surface, in.	0.761	1.008	0.311	0.694
2.5 from exterior surface, in.	0.421	0.794	0.151	0.455
3.5 from exterior surface, in.	0.515	0.724	0.145	0.461
4.5 from exterior surface, in.	0.421	0.638	0.065	0.375

TABLE XIII

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 86-G				
Core Location (within Pile) and Number	Water-line (Core 31)	Mid-water (Core 32)	Mud-line (Core 33)	Average
Concrete Characteristics:				
Paste Content, %	27.3	25.4	27.0	26.6
Coarse Aggregate Content, %	43.1	43.8	40.0	42.3
Fine Aggregate Content, %	28.1	30.1	32.0	30.1
Coarse-to-fine aggregate ratio (CA/FA)	1.5:1	1.5:1	1.2:1	1.4:1
Total Air Content, %	1.5	0.7	1.1	1.1
Total Aggregate Content, %	71.2	73.9	72.0	72.4
Cement Content, sacks/yd^3	5.7	5.1	5.6	5.4
Estimated water-to-cement ratio (w/c)	0.55	0.58	0.55	0.56
Damage Index Rating (DRI)	5537	3482	1516	3512
Compressive Strength, psi	8590	7870	8460	8310
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.530	0.597	0.838	0.655
1.5 from exterior surface, in.	0.983	0.777	0.528	0.763
2.5 from exterior surface, in.	0.671	0.811	0.439	0.640
3.5 from exterior surface, in.	0.625	0.267	0.243	0.378
4.5 from exterior surface, in.	0.479	0.582	0.137	0.399

TABLE XIV

SUMMARY OF THE PETROGRAPHIC EXAMINATIONS AND DAMAGE RATING INDEX OF PILE CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Pier 2, Pile 88-F				
Core Location (within Pile) and Number	Water-line (Core 34)	Mid-water (Core 35)	Mud-line (Core 36)	Average
Concrete Characteristics:				
Paste Content, %	27.3	30.4	27.3	28.4
Coarse Aggregate Content, %	43.6	40.3	40.6	41.5
Fine Aggregate Content, %	27.8	28.5	31.0	29.1
Coarse-to-fine aggregate ratio (CA/FA)	1.6:1	1.4:1	1.3:1	1.4:1
Total Air Content, %	1.3	0.7	1.0	1.0
Total Aggregate Content, %	71.4	68.8	71.6	70.6
Cement Content, sacks/yd^3	6.0	6.6	6.0	6.2
Estimated water-to-cement ratio (w/c)	0.48	0.48	0.48	0.48
Damage Index Rating (DRI)	1275	3936	998	2070
Compressive Strength, psi	8330	9550	8210	8700
Chloride Ion Content, % by wt. of concrete:				
0.5 from exterior surface, in.	0.614	0.646	0.253	0.505
1.5 from exterior surface, in.	0.612	0.607	0.238	0.485
2.5 from exterior surface, in.	0.665	0.544	0.177	0.462
3.5 from exterior surface, in.	1.106	0.542	0.114	0.587
4.5 from exterior surface, in.	0.196	0.475	0.075	0.249

TABLE XV

COMPRESSIVE STRENGTH OF CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Set 1 – Pile Cores 1 through 15									
Sample ID	As Received Height (in.)	Trimmed Height (in.)	Diameter (in.)	Capped Height (in.)	Area (in.^{2})	L/D Ratio	Correction Factor	Ultimate Load (lb)	Ultimate Strength (psi)
1	11.08	4.50	4.21	4.31	13.91	1.02	0.875	100,490	6320
2	11.41	4.67	4.21	4.94	13.91	1.17	0.911	91,410	5990
3	8.49	5.24	4.21	5.48	13.91	1.30	0.936	100,230	6740
4	9.44	3.76	4.21	4.19*	13.91	0.99	0.870*	35,860	2240*
5	10.35	4.92	4.21	5.12	13.91	1.22	0.923	114,480	7590
6	10.47	4.43	4.21	4.72	13.91	1.12	0.899	126,720	8190
7	9.68	4.27	4.21	4.47	13.91	1.06	0.884	113,360	7200
8	15.81	4.09	4.21	4.30	13.91	1.02	0.875	96,010	6040
9	10.90	4.58	4.21	4.71	13.91	1.12	0.899	116,620	7540
10	11.97	5.16	4.21	5.43	13.91	1.29	0.934	131,250	8810
11	11.54	5.41	4.21	5.58	13.91	1.33	0.939	116,480	7860
12	11.39	4.78	4.21	4.97	13.91	1.18	0.913	117,730	7730
13	10.98	4.98	4.21	5.13	13.91	1.22	0.923	158,030	10480
14	10.57	4.86	4.21	5.04	13.91	1.20	0.918	129,260	8530
15	10.59	4.74	4.21	4.98	13.91	1.18	0.913	129,160	8480
Average (Set 1)									7316
Standard Deviation (Set 1)									1769
Coefficient of Variation (Set 1)									24.2%
*Test data is questionable due to L/D ratio less than 1:1 (trimmed height was less than diameter). 0.870 correction factor used for calculation									

TABLE XVI

COMPRESSIVE STRENGTH OF CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Set 2 – Pile Cores 16 through 30									
Sample ID	As Received Height (in.)	Trimmed Height (in.)	Diameter (in.)	Capped Height (in.)	Area (in.^{2})	L/D Ratio	Correction Factor	Ultimate Load (lb)	Ultimate Strength (psi)
16		5.51	4.18	5.70	13.72	1.36	0.943	139,910	9620
17		..	4.18	4.30	13.72	1.03	0.877	140,420	8980
18		..	4.18	4.31	13.72	1.03	0.877	136,830	8750
19		..	4.18	3.98*	13.72	0.95	0.870*	115,810	7346
20		4.64	4.18	4.80	13.72	1.15	0.905	96,780	6390
21		5.49	4.18	5.73	13.72	1.37	0.944	110,190	7580
22		5.09	4.18	4.02*	13.72	0.96	0.870*	134,840	8553
23		4.69	4.18	5.06	13.72	1.21	0.920	125,970	8450
24		5.06	4.18	5.32	13.72	1.27	0.932	167,070	11350
25		4.65	4.18	4.97	13.72	1.19	0.916	133,400	8910
26		5.02	4.18	5.26	13.72	1.26	0.931	124,130	8430
27		4.18	4.18	4.43	13.72	1.06	0.884	111,140	7160
28		4.69	4.18	4.98	13.72	1.19	0.916	135,850	9070
29		4.00	4.18	4.24	13.72	1.01	0.872	119,410	7590
30		5.07	4.18	5.34	13.72	1.28	0.933	93,410	6350

*Test data is questionable due to L/D ratio less than 1:1 (trimmed height was less than diameter). 0.870 correction factor used for calculation

TABLE XVII

COMPRESSIVE STRENGTH OF CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Set 2 – Pile Cores 31 through 36									
Sample ID	As Received Height (in.)	Trimmed Height (in.)	Diameter (in.)	Capped Height (in.)	Area (in.^{2})	L/D Ratio	Correction Factor	Ultimate Load (lb)	Ultimate Strength (psi)
31		5.28	4.18	5.51	13.72	1.32	0.938	125,650	8590
32		5.25	4.18	5.51	13.72	1.32	0.938	115,050	7870
33		4.49	4.18	4.73	13.72	1.13	0.901	128,830	8460
34		5.67	4.18	5.90	13.72	1.41	0.949	120,430	8330
35		4.83	4.18	5.06	13.72	1.21	0.920	142,400	9550
36		5.04	4.18	5.28	13.72	1.26	0.931	120,980	8210
Average (Set 2)									8359
Standard Deviation (Set 2)									1097
Coefficient of Variation (Set 2)									13.1%
Average (All Pile Cores)									7924
Standard Deviation (All Pile Cores)									1506
Coefficient of Variation (All Pile Cores)									19.0%

TABLE XVIII

COMPRESSIVE STRENGTH OF CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Set 2 – Deck Cores 37 through 42									
Sample ID	As Received Height (in.)	Trimmed Height (in.)	Diameter (in.)	Capped Height (in.)	Area (in.^{2})	L/D Ratio	Correction Factor	Ultimate Load (lb)	Ultimate Strength (psi)
37	8.61	8.24	4.18	8.52	13.72	2.04	1.000	65,990	4810
38	8.72	8.02	4.18	8.38	13.72	2.00	1.000	75,290	5490
39	8.15	..	4.18	8.33	13.72	1.99	1.000	85,850	6260
40	8.73	8.12	4.18	8.31	13.72	1.99	1.000	66,950	4880
41	10.83	8.43	4.18	8.61	13.72	2.06	1.000	53,140	3870
42	10.48	8.36	4.18	8.63	13.72	2.06	1.000	63,680	4640
								Average	4992
								Standard Deviation	740
								Coefficient of Variation	14.8%

TABLE XIX

CHLORIDE ION CONTENTS OF CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Sample ID	Depth from Exposed Surface (in.)	Meter Reading (mV)	Chlorides by Weight of Concrete (%)	Chlorides by Weight of Concrete (lb/yd^3)[1]	Above Threshold Level
1-1	0.5	11.4	0.236	9.44	Yes
1-2	1.5	16.1	0.195	7.79	Yes
1-3	2.5	18.8	0.174	6.97	Yes
1-4	3.5	28.9	0.115	4.61	Yes
1-5	4.5	42.6	0.066	2.63	Yes
2-1	0.5	-22.5	0.948	37.91	Yes
2-2	1.5	-22.6	0.952	38.07	Yes
2-3	2.5	-23	0.967	38.70	Yes
2-4	3.5	-13.3	0.650	26.00	Yes
2-5	4.5	-11.8	0.611	24.45	Yes
3-1	0.5	-15.6	0.714	28.57	Yes
3-2	1.5	-10.3	0.575	22.99	Yes
3-3	2.5	-4.0	0.444	17.76	Yes
3-4	3.5	3.7	0.324	12.95	Yes
3-5	4.5	24.6	0.137	5.50	Yes
4-1	0.5	26.5	0.127	5.09	Yes
4-2	1.5	19.0	0.173	6.92	Yes
4-3	2.5	42.2	0.067	2.67	Yes
4-4	3.5	40.2	0.072	2.90	Yes
4-5	~8	90.9	0.009	0.36	No
5-1	0.5	-21.7	0.917	36.69	Yes
5-2	1.5	-13.3	0.650	26.00	Yes
5-3	2.5	-15.1	0.700	27.99	Yes
5-4	3.5	-9.0	0.545	21.80	Yes
5-5	4.5	4.7	0.311	12.43	Yes
6-1	0.5	-10.2	0.572	22.90	Yes
6-2	1.5	16.1	0.195	7.79	Yes
6-3	2.5	15.5	0.200	7.98	Yes
6-4	3.5	34.9	0.090	3.60	Yes
6-5	4.5	-2.4	0.416	16.63	Yes
7-1	0.5	-20.1	0.859	34.36	Yes
7-2	1.5	-15.4	0.708	28.34	Yes
7-3	2.5	8.9	0.262	10.46	Yes
7-4	3.5	9.3	0.257	10.29	Yes
7-5	4.5	11.6	0.234	9.37	Yes
8-1	0.5	-24.7	1.037	41.49	Yes
8-2	1.5	-6.9	0.500	20.00	Yes
8-3	2.5	-21.5	0.910	36.39	Yes
8-4	3.5	-8.7	0.538	21.53	Yes
8-5	4.5	-15.7	0.717	28.69	Yes

[1] Cement content based on average derived from the petrographic examination data, concrete unit weight assumed to be 4000 lb/yd^3

TABLE XX

CHLORIDE ION CONTENTS OF CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Sample ID	Depth from Exposed Surface (in.)	Meter Reading (mV)	Chlorides by Weight of Concrete (%)	Chlorides by Weight of Concrete (lb/yd^3)[1]	Above Threshold Level
9-1	0.5	-18.8	0.814	32.58	Yes
9-2	1.5	-14.9	0.694	27.76	Yes
9-3	2.5	-10.3	0.575	22.99	Yes
9-4	3.5	-22.1	0.932	37.30	Yes
9-5	4.5	-16.8	0.750	30.01	Yes
10-1	0.5	-4.3	0.449	17.98	Yes
10-2	1.5	-8.8	0.541	21.62	Yes
10-3	2.5	-4.3	0.449	17.98	Yes
10-4	3.5	-2.7	0.421	16.84	Yes
10-5	4.5	10.2	0.248	9.92	Yes
11-1	0.5	-0.5	0.385	15.38	Yes
11-2	1.5	-14.4	0.680	27.20	Yes
11-3	2.5	-4.4	0.451	18.05	Yes
11-4	3.5	-3.3	0.431	17.26	Yes
11-5	4.5	10.5	0.245	9.80	Yes
12-1	0.5	-17.5	0.772	30.89	Yes
12-2	1.5	-12.2	0.621	24.85	Yes
12-3	2.5	-9.6	0.559	22.34	Yes
12-4	3.5	13.4	0.218	8.70	Yes
12-5	4.5	12.5	0.226	9.03	Yes
13-1	0.5	-27	1.140	45.60	Yes
13-2	1.5	-7.5	0.512	20.50	Yes
13-3	2.5	-9.1	0.547	21.89	Yes
13-4	3.5	-0.9	0.391	15.64	Yes
13-5	4.5	-0.9	0.391	15.64	Yes
14-1	0.5	-23.3	0.979	39.18	Yes
14-2	1.5	-18.5	0.804	32.18	Yes
14-3	2.5	-8.4	0.532	21.27	Yes
14-4	3.5	-14.3	0.677	27.09	Yes
14-5	4.5	-4.1	0.446	17.83	Yes
15-1	0.5	-15.5	0.711	28.46	Yes
15-2	1.5	-13.4	0.653	26.11	Yes
15-3	2.5	-8	0.523	20.92	Yes
15-4	3.5	0.3	0.372	14.89	Yes
15-5	4.5	2.6	0.339	13.55	Yes

[1] Cement content based on average derived from the petrographic examination data, concrete unit weight assumed to be 4000 lb/yd^3

TABLE XXI

CHLORIDE ION CONTENTS OF CONCRETE CORES

Alameda Piers 1, 2 & 3, Alameda, California

AME Project No. 1160610C

Sample ID	Depth from Exposed Surface (in.)	Meter Reading (mV)	Chlorides by Weight of Concrete (%)	Chlorides by Weight of Concrete (lb/yd³)[1]	Above Threshold Level
1-1	0.5	11.4	0.236	9.44	Yes
1-2	1.5	16.1	0.195	7.79	Yes
1-3	2.5	18.8	0.174	6.97	Yes
1-4	3.5	28.9	0.115	4.61	Yes
1-5	4.5	42.6	0.066	2.63	Yes
2-1	0.5	-22.5	0.948	37.91	Yes
2-2	1.5	-22.6	0.952	38.07	Yes
2-3	2.5	-23	0.967	38.70	Yes
2-4	3.5	-13.3	0.650	26.00	Yes
2-5	4.5	-11.8	0.611	24.45	Yes
3-1	0.5	-15.6	0.714	28.57	Yes
3-2	1.5	-10.3	0.575	22.99	Yes
3-3	2.5	-4.0	0.444	17.76	Yes
3-4	3.5	3.7	0.324	12.95	Yes
3-5	4.5	24.6	0.137	5.50	Yes
4-1	0.5	26.5	0.127	5.09	Yes
4-2	1.5	19.0	0.173	6.92	Yes
4-3	2.5	42.2	0.067	2.67	Yes
4-4	3.5	40.2	0.072	2.90	Yes
4-5	~8	90.9	0.009	0.36	No
5-1	0.5	-21.7	0.917	36.69	Yes
5-2	1.5	-13.3	0.650	26.00	Yes
5-3	2.5	-15.1	0.700	27.99	Yes
5-4	3.5	-9.0	0.545	21.80	Yes
5-5	4.5	4.7	0.311	12.43	Yes
6-1	0.5	-10.2	0.572	22.90	Yes
6-2	1.5	16.1	0.195	7.79	Yes
6-3	2.5	15.5	0.200	7.98	Yes
6-4	3.5	34.9	0.090	3.60	Yes
6-5	4.5	-2.4	0.416	16.63	Yes
7-1	0.5	-20.1	0.859	34.36	Yes
7-2	1.5	-15.4	0.708	28.34	Yes
7-3	2.5	8.9	0.262	10.46	Yes
7-4	3.5	9.3	0.257	10.29	Yes
7-5	4.5	11.6	0.234	9.37	Yes
8-1	0.5	-24.7	1.037	41.49	Yes
8-2	1.5	-6.9	0.500	20.00	Yes
8-3	2.5	-21.5	0.910	36.39	Yes
8-4	3.5	-8.7	0.538	21.53	Yes
8-5	4.5	-15.7	0.717	28.69	Yes

[1] Cement content based on average derived from the petrographic examination data, concrete unit weight assumed to be 4000 lb/yd³

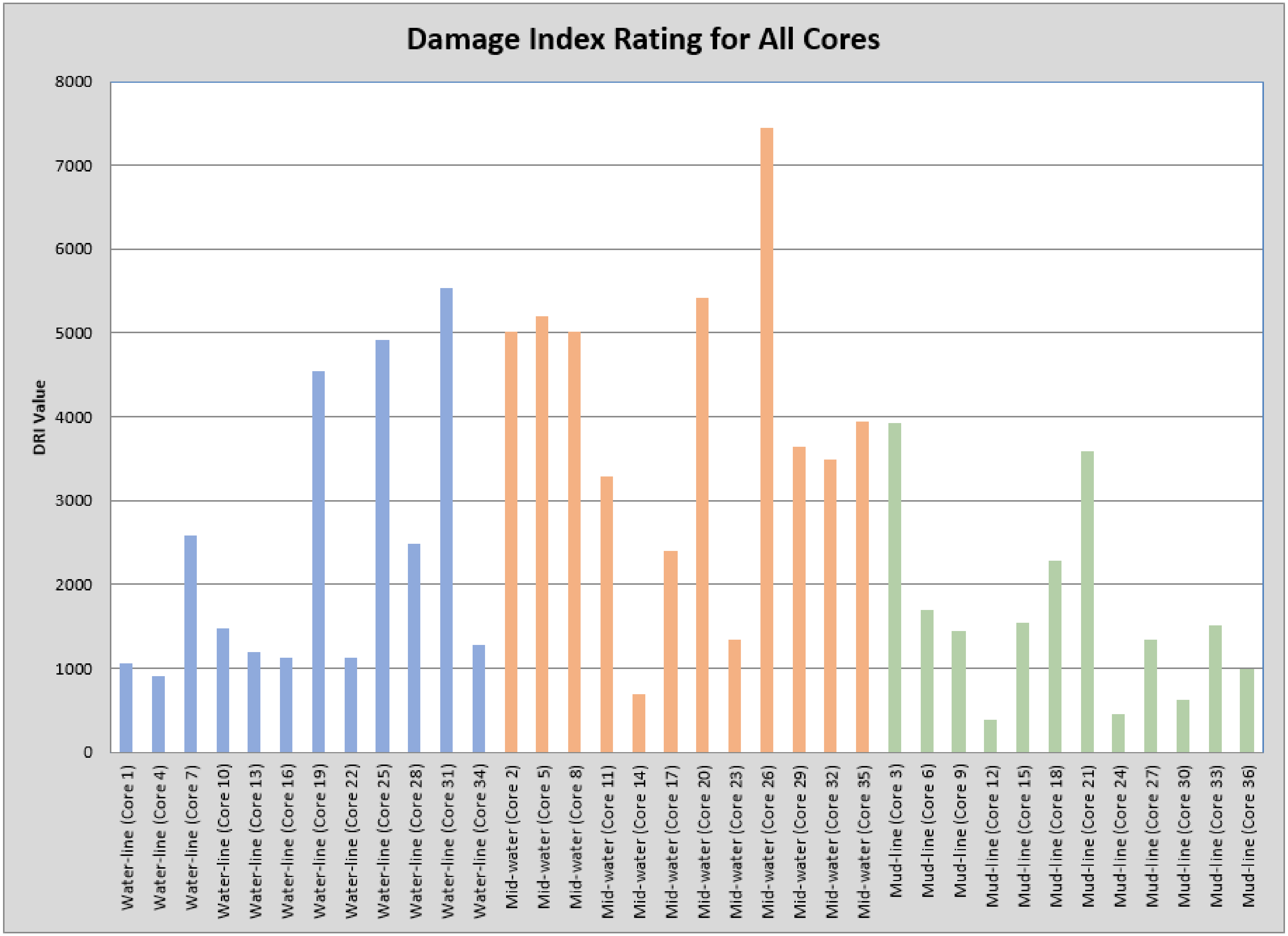


Figure 1. Damage Rating Index (DRI) for all the pile cores

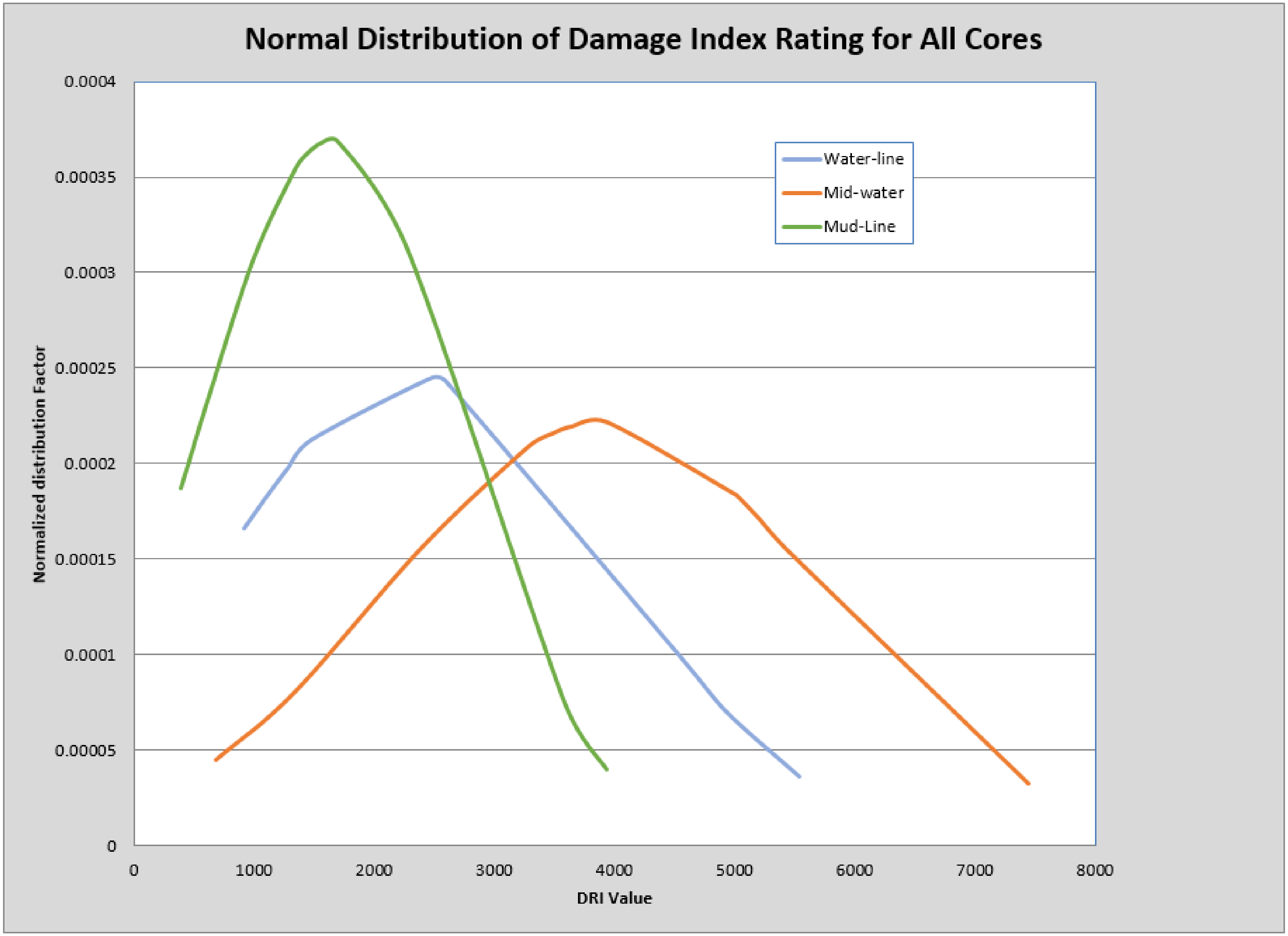


Figure 2. Normal distribution of Damage Rating Index values for the pile core samples. The frequency of DRI occurred with the mid-water core samples.

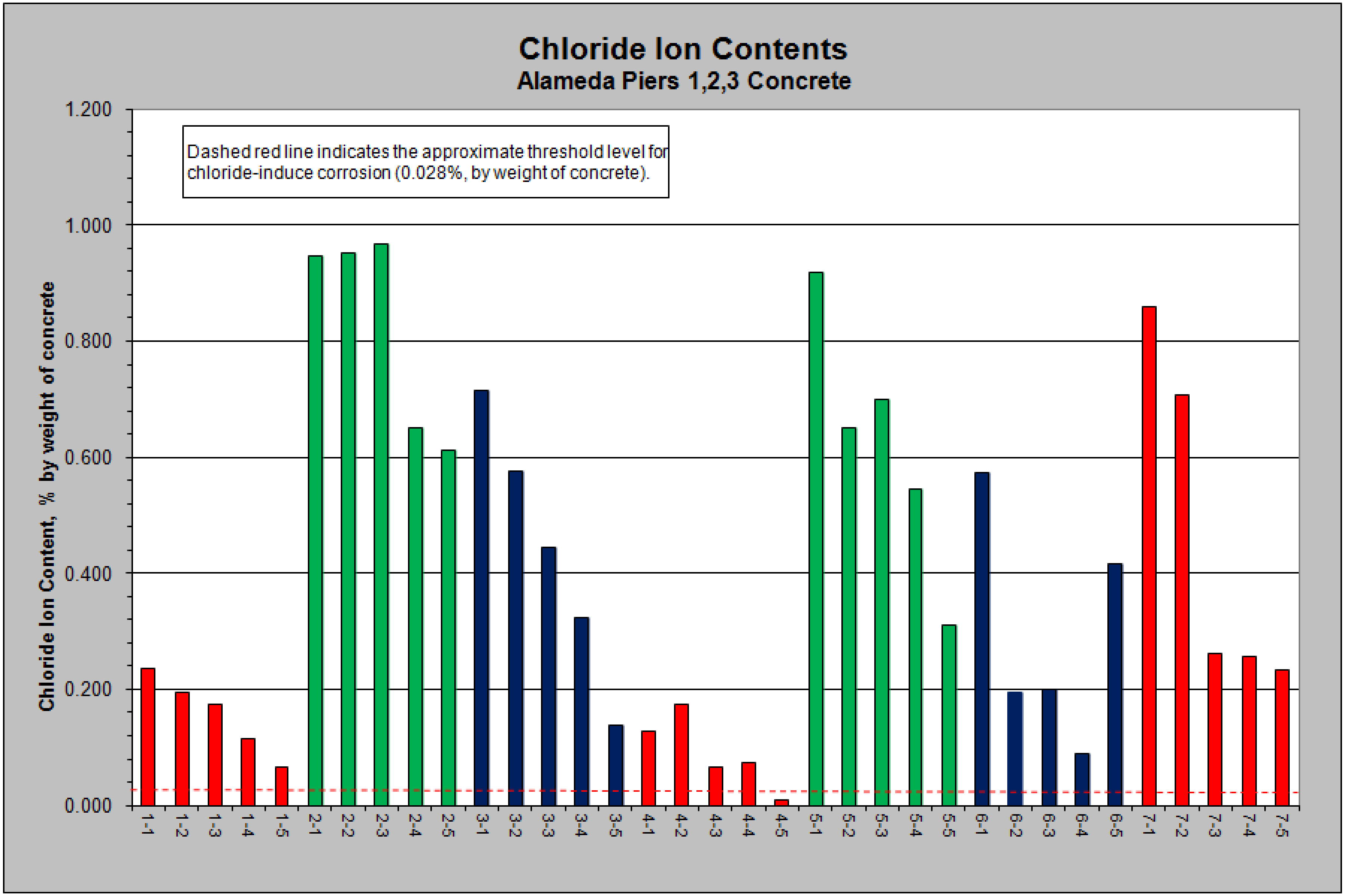


Figure 3. Chloride Contents for Set 1, Cores 1 through 7

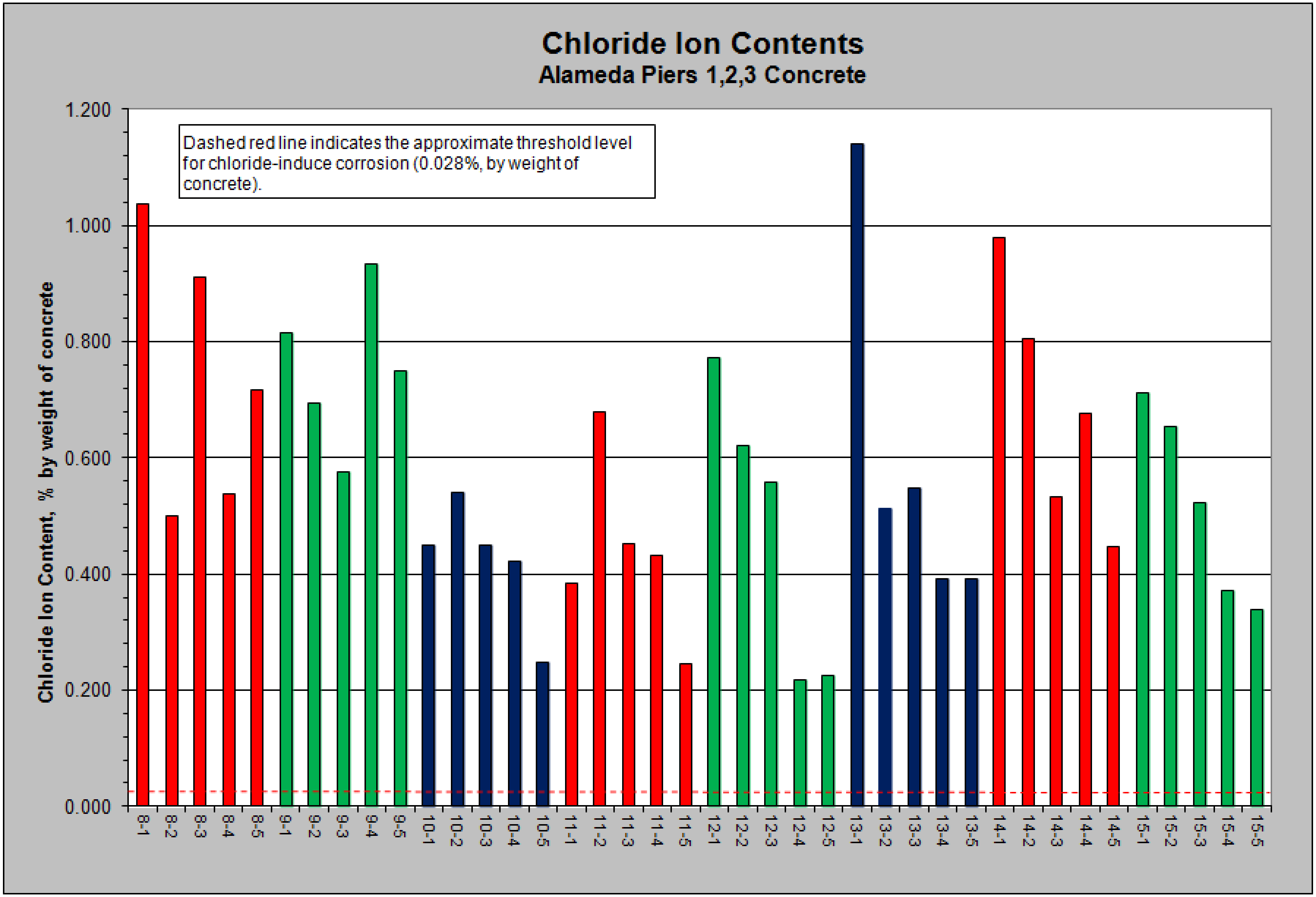


Figure 4. Chloride Contents for Set 1, Cores 8 through 15

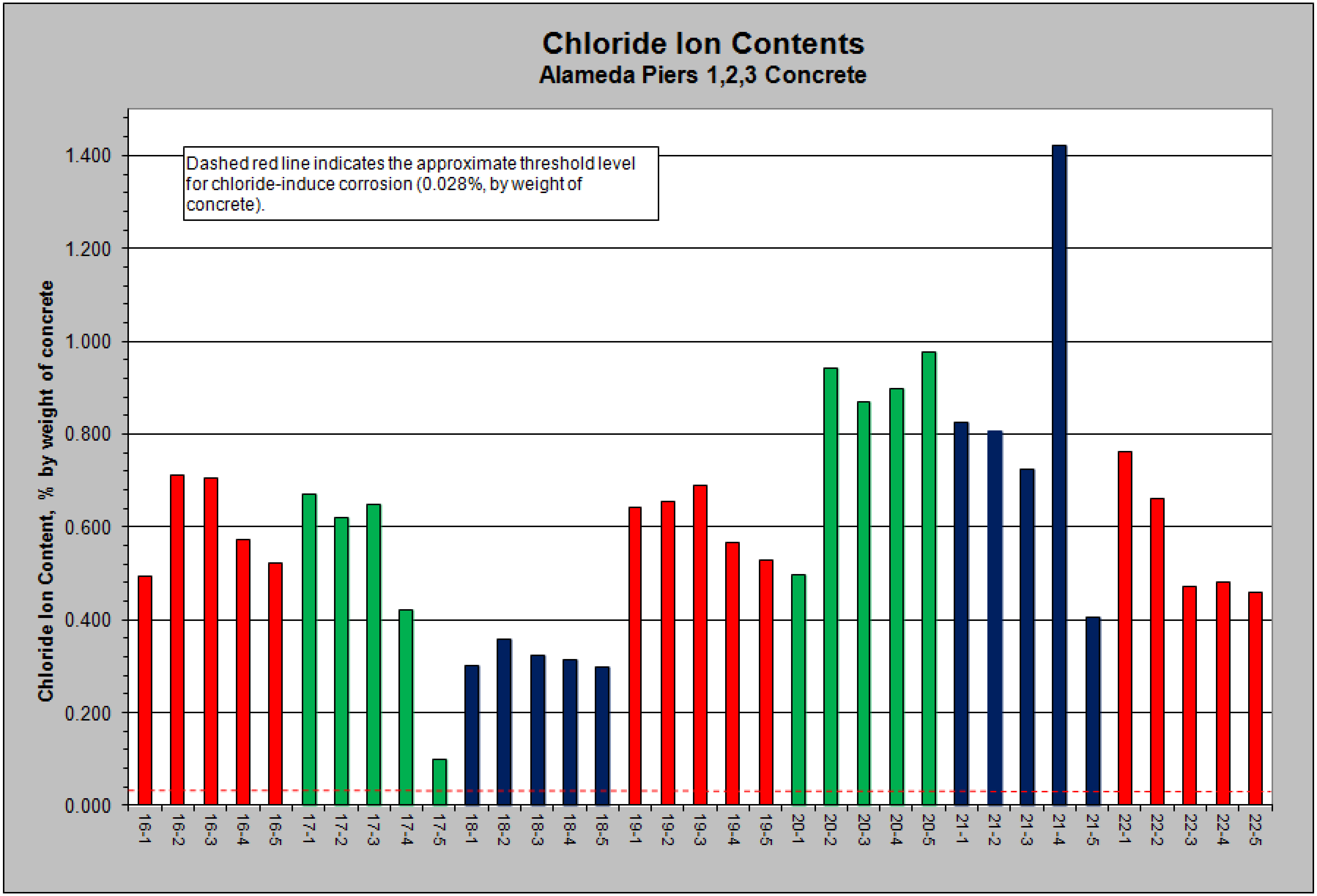


Figure 5. Chloride Contents for Set 2, Cores 16 through 22

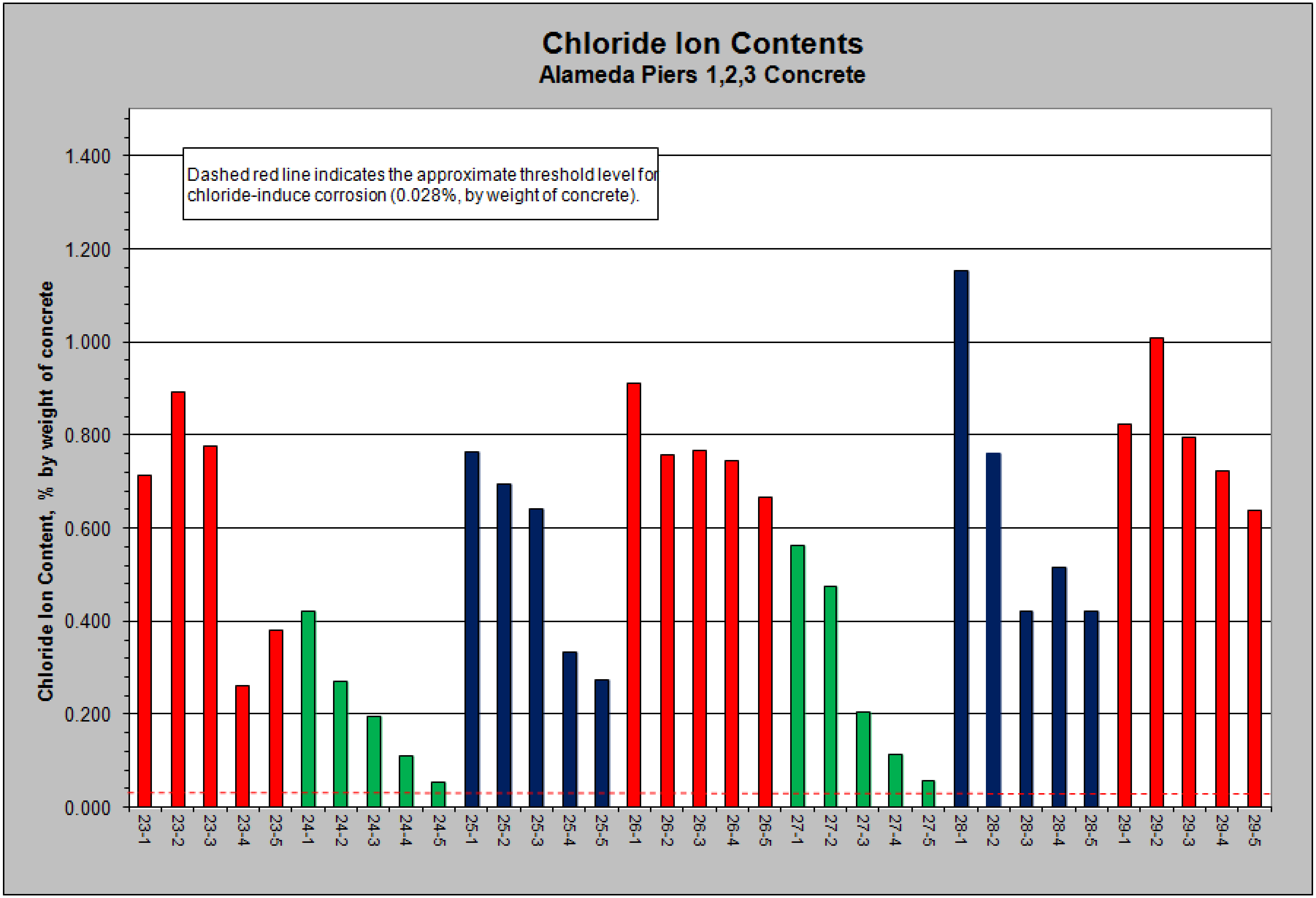


Figure 6. Chloride Contents for Set 2, Cores 23 through 29

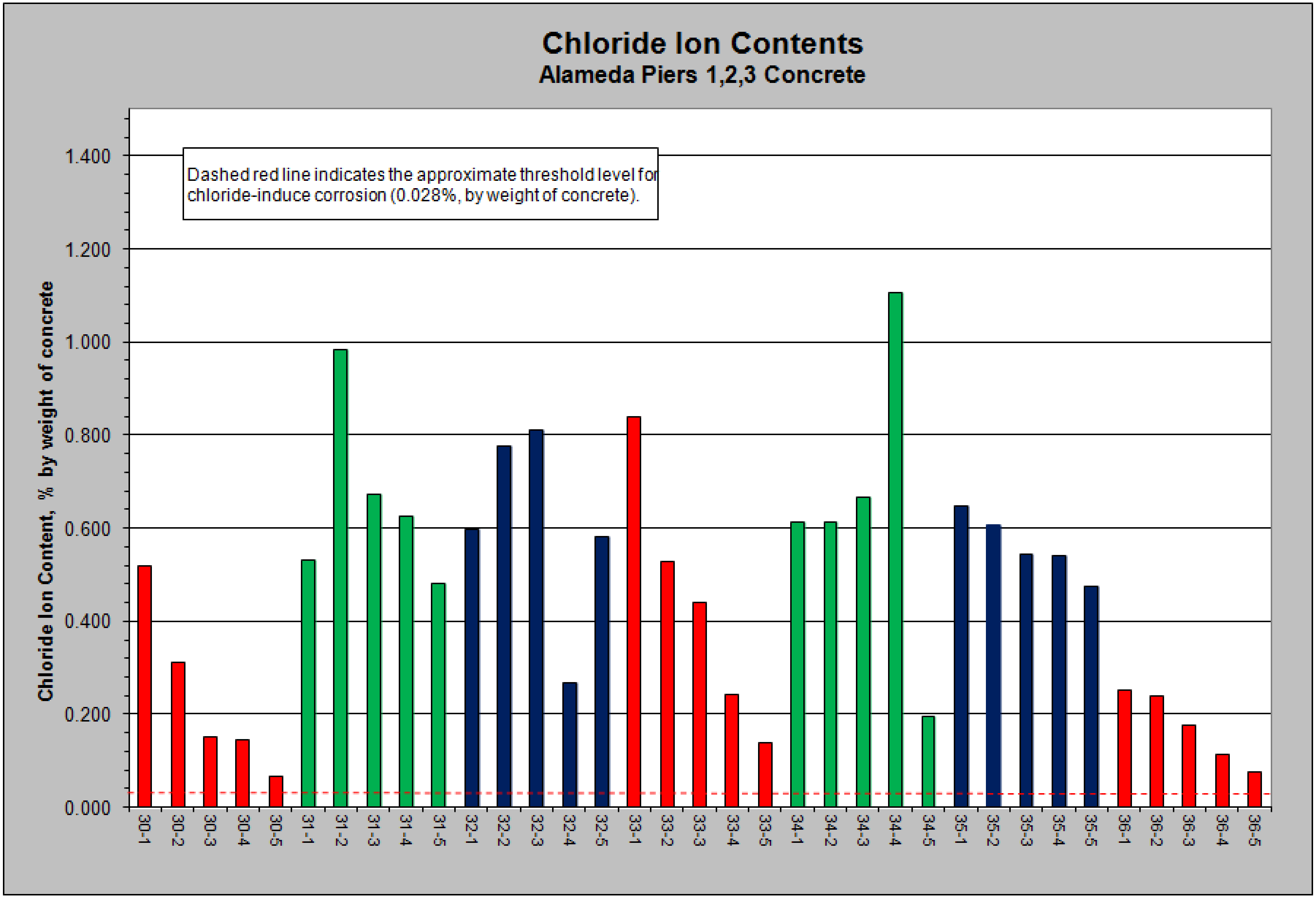


Figure 7. Chloride Contents for Set 2, Cores 30 through 36

APPENDIX A

PETROGRAPHIC EXAMINATION DATA SHEETS

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 11/7/2016

Sample ID: Pier 2, Pile 21-A

	Water-line (Core 1)		Mid-water (Core 2)		Mud-line (Core 3)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	570	30.5	478	27.9	432	26.9
Coarse Aggregate (CA) Content	739	39.6	812	47.3	683	42.6
Fine Aggregate (FA) Content	550	29.5	414	24.1	472	29.4
Entrained Air (spherical voids with diameters < 1 mm)	5	0.3	4	0.2	3	0.2
Entrapped Air (irregular shaped voids or diameters > 1 mm)	3	0.2	8	0.5	14	0.9
Total	1867	100.0	1716	100.0	1604	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.34		1.96		1.45
Total Air Content		0.4		0.7		1.1
Total Aggregate Content		69.0		71.4		72.0

	Water-line (Core 1)	Mid-water (Core 2)	Mud-line (Core 3)
Estimated cementitious materials content (sacks/yd³):	6.6	6.1	6.1
GENERAL AGGREGATE PROPERTIES:			
Maximum Size Aggregate (MSA), in.:	¾	1	1
Volumetric Proportions (% Aggregate):	69	71	72
Distribution:	Good	Good	Good
Segregation:	None	None	None
Consolidation:	Good	Good	Good
Flat & Elongated Particles:	Low	Low	Low
CA/FA:	1.34:1	1.96:1	1.45:1
Gap Graded:	Slightly gapped at #4	Slightly gapped at #4	Slightly gapped at #4
One Size:	No	No	No
Coarse Aggregate Rock Types:	Normal Weight	Normal Weight	Normal Weight
Major:	Graywacke sandstone, chert, mafic volcanic	Graywacke sandstone, chert, mafic volcanic	Graywacke sandstone, chert, mafic volcanic
Minor:	Granitic rock types, fine-grain gabbro	Granitic rock types, fine-grain gabbro	Granitic rock types, fine-grain gabbro
Trace:	Vein quartz, serpentinite	Vein quartz, serpentinite	Vein quartz, serpentinite
Shape and Texture:	Subangular	Subangular	Subangular
Fine Aggregate Mineral Species and Rock Types:	Normal Weight	Normal Weight	Normal Weight
Major:	Graywacke rock fragments, chert, quartz, feldspar	Graywacke rock fragments, chert, quartz, feldspar	Graywacke rock fragments, chert, quartz, feldspar
Minor:	Mafic volcanic rock fragments	Mafic volcanic rock fragments	Mafic volcanic rock fragments
Trace:	Pyroxene, chlorite, opaques	Pyroxene, chlorite, opaques	Pyroxene, chlorite, opaques
Shape and Texture:	Angular to subangular	Angular to subangular	Angular to subangular
Reinforcement:	#8 rebar at 4.81", ⅜" diameter smooth bar at 3.84" depth	#8 rebar at 3.45", corroded	#8 rebar at 3.45", corroded, ⅜" dimeter wire at same depth
Cement Paste:			
Color:	Light gray to tan	Light gray to tan	Light gray to tan
Scratch Hardness (Mohs Hardness):	4½	3 to 3½	4½
Surface Carbonation Depth, in. (Determined by pH):	Nil	Nil	Nil
Cracking and Other Features:	Reaction rims, secondary mineralization in cracks and voids, fractured aggregate	Secondary mineralization in TZ common. Reaction rims, secondary mineralization in cracks and voids, fractured aggregate	Secondary mineralization in cracks, voids and TZ common. Reaction rims, fractured aggregate
Diameter (in.)	4.3	4.2	4.2
Nominal Length (in.)	11.1	11.4	8.5
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface (barnacles)	Marine growth on surface (mullusca)	Marine growth on surface (mullusca)

Petrographic Examination
Macroscopic Analysis

Client:	SGH
Project:	Alameda Piers 1, 2 & 3
AME Project Number:	1160610C
Date:	11/7/2016

Sample ID:	Pier 2, Pile 21-A		
	Water-line (Core 1)	Mid-water (Core 2)	Mud-line (Core 3)
Thin-section (TS) Number(s):	3826	3827	3828
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Light to medium at surface	Light at surface	Typically light, medium along crack margins
Calcium Hydroxide Content (CH)*:	15 to 18%	20%	15%
Size:	Small to medium	Small to medium	Very small to small
Distribution:	Fairly even	Even	Even (depletion common)
Transition Zone (TZ) Development:	Nil	Thin	Nil
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Moderately low
Unhydrated Portland Cement Particles (UPC's), %*:	5 to 6%	5 to 6%	6 to 7%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters up to 150 μm across	Clusters up to 120 μm across common	Clusters up to 145 μm across
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.48	0.48	0.45
Secondary Deposits:	ASR reaction product (carbonated gel) in cracks and lining to filling voids, ettringite lining and filling voids and cracks	ASR reaction product (carbonated gel) in cracks and lining to filling voids, ettringite lining and filling voids and cracks	ASR reaction product (carbonated gel) in cracks and lining to filling voids, ettringite lining and filling voids and cracks, possible brucite lining some large cracks
Deleterious Reactions:	Sea water attack: CH depletion, ASR and minor sulfate attack	Sea water attack: CH depletion, ASR and minor sulfate attack, numerous parallel cracking at approximately 2" depth	Sea water attack: CH depletion, ASR and minor sulfate attack, numerous parallel cracking at approximately 2" depth
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	Moderate	High	High
Transverse:	Moderate	High	High
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor paste alteration, still hard and strong	Minor paste alteration, still hard and strong	Minor paste alteration, still hard and strong

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 11/7/2016

Sample ID: Pier 2, Pile 36-D

	Water-line (Core 4)		Mid-water (Core 5)		Mud-line (Core 6)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	408	27.1	377	24.6	429	28.2
Coarse Aggregate (CA) Content	479	31.8	555	36.3	466	30.6
Fine Aggregate (FA) Content	615	40.8	577	37.7	612	40.2
Entrained Air (spherical voids with diameters < 1 mm)	3	0.2	9	0.6	13	0.9
Entrapped Air (irregular shaped voids or diameters > 1 mm)	1	0.1	13	0.8	2	0.1
Total	1506	100.0	1531	100.0	1522	100.0
Coarse-to-fine aggregate ratio (CA/FA)		0.78		0.96		0.76
Total Air Content		0.3		1.4		1.0
Total Aggregate Content		72.6		73.9		70.8
Estimated cementitious materials content (sacks/yd³):	6.0		5.6		6.2	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	¾		1		¾	
Volumetric Proportions (% Aggregate):	73		74		71	
Distribution:	Good		Good		Good	
Segregation:	None		None		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	0.78:1		0.96:1		0.76:1	
Gap Graded:	Gapped at #4		Gapped at #4		Gapped at #4	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic	
Minor:	Granitic rock types, fine-grain gabbro		Granitic rock types, fine-grain gabbro		Granitic rock types, fine-grain gabbro	
Trace:	Vein quartz, serpentinite		Vein quartz, serpentinite		Vein quartz, serpentinite	
Shape and Texture:	Subangular		Subangular		Subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments		Mafic volcanic rock fragments	
Trace:	Pyroxene, chlorite, opaques, opal		Pyroxene, chlorite, opaques		Pyroxene, chlorite, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	#8 rebar at 4.21", ⅜" diameter smooth bar cast at 3.44" depth		Smooth bar at 3.34" depth (very corroded), small rebar cast at 4.13" depth		#8 rebar at 6.43", corroded, ⅛" diameter wire at 3.44 depth	
Cement Paste:						
Color:	Light gray to tan		Light gray to tan		Light gray to tan	
Scratch Hardness (Mohs Hardness):	3½		4½		3½	
Surface Carbonation Depth, in. (Determined by pH):	Nil		Nil		Nil	
Cracking and Other Features:	Reaction rims, traces of secondary mineralization in cracks and voids		Some secondary mineralization in TZ common. Reaction rims, secondary mineralization in cracks and voids, fractured aggregate		Extensive subparallel cracking in outer 1"	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	9.4		10.4		10.5	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface (barnacles)		Fractured exterior surface, appears deteriorated		Marine growth on surface	

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 11/7/2016

Sample ID: Pier 2, Pile 36-D

	Water-line (Core 4)	Mid-water (Core 5)	Mud-line (Core 6)
Thin-section (TS) Number(s):	3829	3830	3831
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Light to medium at surface	Light at surface	Light to medium
Calcium Hydroxide Content (CH)*:	20%	20%	15%
Size:	Small to medium	Small to medium	Very small to small
Distribution:	Fairly even	Fairly uneven	Fairly even (depletion fairly common)
Transition Zone (TZ) Development:	Nil	Thin	Nil
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Moderately low
Unhydrated Portland Cement Particles (UPC's), %*:	5%	5 to 6%	6 to 7%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters to 130 μm across common, up to 170 μm	Clusters up to 150 μm across common	Clusters up to 145 μm across
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.48	0.48	0.48
Secondary Deposits:	Secondary CH and calcite in small voids	ASR reaction product (carbonated gel) in cracks and lining to filling voids, ettringite lining and filling voids and cracks	Ettringite lining and filling voids and cracks
Deleterious Reactions:	Minor sea water attack: minor amount of CH depletion	Sea water attack: CH depletion, ASR and minor sulfate attack, numerous cracks in TZ	Sea water attack: CH depletion, minor ASR and minor sulfate attack
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	Moderately low	High	Moderately low
Transverse:	Low	High	Moderate
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor paste alteration	Minor paste alteration, paste still hard	Minor paste alteration, still hard and strong

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 11/8/2016

Sample ID: Pier 2, Pile 51-H and 52-H

POINT COUNT: **Volumetric Proportions (% by volume)**	Water-line (Core 7)		Mid-water (Core 8)		Mud-line (Core 9)	
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	397	25.7	523	31.9	418	27.2
Coarse Aggregate (CA) Content	550	35.6	551	33.6	586	38.2
Fine Aggregate (FA) Content	590	38.2	562	34.3	527	34.3
Entrained Air (spherical voids with diameters < 1 mm)	8	0.5	2	0.1	2	0.1
Entrapped Air (irregular shaped voids or diameters > 1 mm)	0	0.0	0	0.0	3	0.2
Total	1545	100.0	1638	100.0	1536	100.0
Coarse-to-fine aggregate ratio (CA/FA)		0.93		0.98		1.11
Total Air Content		0.5		0.1		0.3
Total Aggregate Content		73.8		67.9		72.5

	Water-line (Core 7)	Mid-water (Core 8)	Mud-line (Core 9)
Estimated cementitious materials content (sacks/yd^3):	5.6	6.9	5.9
GENERAL AGGREGATE PROPERTIES:			
Maximum Size Aggregate (MSA), in.:	1	1	¾
Volumetric Proportions (% Aggregate):	74	68	72
Distribution:	Good	Poor	Good
Segregation:	None	Slight	None
Consolidation:	Good	Good	Good
Flat & Elongated Particles:	Low	Low	Low
CA/FA:	0.93:1	0.98:1	1.11:1
Gap Graded:	None	Not gapped, but poor distribution	None
One Size:	No	No	No
Coarse Aggregate Rock Types:	Normal Weight	Normal Weight	Normal Weight
Major:	Graywacke sandstone, chert, mafic volcanic	Graywacke sandstone, chert, mafic volcanic	Graywacke sandstone, chert, mafic volcanic
Minor:	Granitic rock types, felsites, fine-grain gabbro	Granitic rock types, felsites, fine-grain gabbro	Granitic rock types, felsites, fine-grain gabbro
Trace:	Vein quartz, serpentinite	Vein quartz, serpentinite	Vein quartz, serpentinite
Shape and Texture:	Subangular	Subangular	Subangular
Fine Aggregate Mineral Species and Rock Types:	Normal Weight	Normal Weight	Normal Weight
Major:	Graywacke rock fragments, chert, quartz, feldspar	Graywacke rock fragments, chert, quartz, feldspar	Graywacke rock fragments, chert, quartz, feldspar
Minor:	Mafic volcanic rock fragments	Mafic volcanic rock fragments	Mafic volcanic rock fragments
Trace:	Pyroxene, chlorite, opaques, opal	Pyroxene, chlorite, opaques, opal	Pyroxene, chlorite, opaques
Shape and Texture:	Angular to subangular	Angular to subangular	Angular to subangular
Reinforcement:	None	None	smooth ⅜" diameter bar at 3.57" depth
Cement Paste:			
Color:	Light gray	Light gray	Light gray
Scratch Hardness (Mohs Hardness):	4½	4	4½
Surface Carbonation Depth, in. (Determined by pH):	Nil	0.06	Nil
Cracking and Other Features:	One crack normal to surface to depth of approximately 1", parallel cracking at 1" depth	Numerous subparallel cracks to 2" depth and random cracking at depth	Extensive subparallel cracking to 4" depth
Diameter (in.)	4.2	4.2	4.2
Nominal Length (in.)	9.7	15.2	10.9
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface	Marine growth on surface	Minor marine growth on surface

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 11/8/2016

Sample ID: Pier 2, Pile 51-H and 52-H

	Water-line (Core 7)	Mid-water (Core 8)	Mud-line (Core 9)
Thin-section (TS) Number(s):	3832	3833	3834
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	None is TS	Light to medium at surface	Very light at surface
Calcium Hydroxide Content (CH)*:	20%	20%	15 to 20%
Size:	Small to occasionally medium	Small	Small
Distribution:	Even	Even	Even
Transition Zone (TZ) Development:	Nil	Thin	Nil
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Moderately low
Unhydrated Portland Cement Particles (UPC's), %*:	4%	4-5%	4-5%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters to 160 μm across	Clusters up to 125 μm across common	Clusters to 165 μm across
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.50	0.48	0.50
Secondary Deposits:	Ettringite in voids and cracks	ASR reaction product (carbonated gel) in cracks and lining to filling voids, ettringite lining and filling voids and cracks	Ettringite in voids and cracks
Deleterious Reactions:	Sea water attack: CH depletion, ASR and sulfate attack, numerous parallel cracking at approximately 2" depth	Sea water attack: CH depletion, ASR and sulfate attack, numerous parallel cracking at approximately 5" depth	Sea water attack: CH depletion, ASR and sulfate attack, numerous parallel cracking at approximately 3½" depth
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	High	High	Moderately high
Transverse:	Moderately high	High	Moderately high
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor paste alteration	Minor paste alteration, still hard and strong	Minor paste alteration

Petrographic Examination
Macroscopic Analysis

Client:	SGH
Project:	Alameda Piers 1, 2 & 3
AME Project Number:	1160610C
Date:	11/8/2016

Sample ID: Pier 2, Pile 99-H

	Water-line (Core 10)		Mid-water (Core 11)		Mud-line (Core 12)	
POINT COUNT:						
Volumetric Proportions (% by volume)	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	489	28.6	353	20.7	559	30.2
Coarse Aggregate (CA) Content	640	37.5	905	53.0	730	39.4
Fine Aggregate (FA) Content	569	33.3	434	25.4	551	29.8
Entrained Air (spherical voids with diameters < 1 mm)	6	0.4	7	0.4	7	0.4
Entrapped Air (irregular shaped voids or diameters > 1 mm)	3	0.2	10	0.6	4	0.2
Total	1707	100.0	1709	100.0	1851	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.12		2.09		1.32
Total Air Content		0.5		1.0		0.6
Total Aggregate Content		70.8		78.3		69.2

	Water-line (Core 10)	Mid-water (Core 11)	Mud-line (Core 12)
Estimated cementitious materials content (sacks/yd³):	6.2	4.7	6.5
GENERAL AGGREGATE PROPERTIES:			
Maximum Size Aggregate (MSA), in.:	1	1	1
Volumetric Proportions (% Aggregate):	71	78	69
Distribution:	Moderately poor	Good	Poor
Segregation:	None	None	Slight
Consolidation:	Good	Good	Good
Flat & Elongated Particles:	Low	Low	Low
CA/FA:	1.12:1	2.09:1	1.32:1
Gap Graded:	None	None	Appears gapped at #4
One Size:	No	No	No
Coarse Aggregate Rock Types:	Normal Weight	Normal Weight	Normal Weight
Major:	Graywacke sandstone, chert, mafic volcanic	Graywacke sandstone, chert, mafic volcanic	Graywacke sandstone, chert, mafic volcanic
Minor:	Granitic rock types, felsites, fine-grain gabbro	Granitic rock types, felsites, fine-grain gabbro	Granitic rock types, felsites, fine-grain gabbro
Trace:	Vein quartz, serpentinite	Vein quartz, serpentinite	Vein quartz, serpentinite
Shape and Texture:	Subangular	Subangular	Subangular
Fine Aggregate Mineral Species and Rock Types:	Normal Weight	Normal Weight	Normal Weight
Major:	Graywacke rock fragments, chert, quartz, feldspar	Graywacke rock fragments, chert, quartz, feldspar	Graywacke rock fragments, chert, quartz, feldspar
Minor:	Mafic volcanic rock fragments	Mafic volcanic rock fragments	Mafic volcanic rock fragments
Trace:	Pyroxene, chlorite, opaques, opal	Pyroxene, chlorite, opaques, opal	Pyroxene, chlorite, opaques
Shape and Texture:	Angular to subangular	Angular to subangular	Angular to subangular
Reinforcement:	None	smooth ⅜" diameter bar at 2.11" depth	#8 rebar at 2.66", corroded
Cement Paste:			
Color:	Light gray	Light gray	Light gray
Scratch Hardness (Mohs Hardness):	4½	3½	4 to 4½
Surface Carbonation Depth, in. (Determined by pH):	Nil	Nil	Nil
Cracking and Other Features:	Minor brown discoloration near surface	Secondary mineralization in TZ common	Mortar rich, secondary mineralization in TZ fairly common
Diameter (in.)	4.2	4.2	4.2
Nominal Length (in.)	11.0	11.5	11.4
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface	Brown staining on surface	Brown staining on surface

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 11/8/2016

Sample ID: Pier 2, Pile 99-H

	Water-line (Core 10)	Mid-water (Core 11)	Mud-line (Core 12)
Thin-section (TS) Number(s):	3835	3836	3837
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Very light	Light, typical. Medium along crack margins	Light to medium
Calcium Hydroxide Content (CH)*:	15 to 20%	20%	>20%
Size:	Small	Small	Small
Distribution:	Even	Even	Even
Transition Zone (TZ) Development:	Thin to nil	Thin	Thin to nil
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Moderately low
Unhydrated Portland Cement Particles (UPC's), %*:	4-5%	4%	4%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters to 115 μm across common	Clusters up to 140 μm across common	Clusters to 100 μm across typical. Up to 190 μm
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.50	0.50	0.50
Secondary Deposits:	Minor amounts of Ettringite in voids and cracks	ASR reaction product (carbonated gel) in cracks and lining to filling voids, ettringite lining and filling voids and cracks, possible brucite lining some large cracks	Ettringite in voids and some cracks, seconary CH throughout
Deleterious Reactions:	Sea water attack: CH depletion, minor ettringite formation	Sea water attack: CH depletion, ASR and sulfate attack, heavy microcracking	Sea water attack: minor amount of CH depletion, ettringite formation in voids
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	Moderately low	High	Low
Transverse:	Moderately low	High	Moderately low
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor paste alteration	Paste alteration, but still hard and strong	Minor paste alteration

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 11/9/2016

Sample ID: Pier 3, Pile 30-A

	Water-line (Core 13)		Mid-water (Core 14)		Mud-line (Core 15)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	497	28.0	534	30.2	441	29.1
Coarse Aggregate (CA) Content	751	42.3	613	34.6	562	37.1
Fine Aggregate (FA) Content	512	28.8	596	33.7	487	32.1
Entrained Air (spherical voids with diameters < 1 mm)	9	0.5	16	0.9	20	1.3
Entrapped Air (irregular shaped voids or diameters > 1 mm)	8	0.5	11	0.6	5	0.3
Total	1777	100.0	1770	100.0	1515	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.47		1.03		1.15
Total Air Content		1.0		1.5		1.7
Total Aggregate Content		71.1		68.3		69.2
Estimated cementitious materials content (sacks/yd³):	6.3		6.7		6.5	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	¾		¾		1	
Volumetric Proportions (% Aggregate):	71		68		69	
Distribution:	Good		Good		Good	
Segregation:	None		None		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	1.47:1		1.03:1		1.15:1	
Gap Graded:	None		None		Slightly gapped at #4	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic	
Minor:	Felsites, gabbro		Felsites, gabbro		Felsites, gabbro	
Trace:	Vein quartz		Vein quartz		Vein quartz	
Shape and Texture:	Subround to subangular		Subround to subangular		Subround to subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments		Mafic volcanic rock fragments	
Trace:	Granitic rock fragments, chlorite. Serpentine, opaques		Granitic rock fragments, chlorite. Serpentine, opaques		Granitic rock fragments, chlorite. Serpentine, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	⅜" diameter smooth bar at 2.21" depth, 0.63" diameter wire at 3.46" depth		None		⅜" diameter smooth bar at 1.96" depth, #8 rebar at 2.81" depth	
Cement Paste:						
Color:	Medium dark gray		Medium dark gray		Medium dark gray	
Scratch Hardness (Mohs Hardness):	4½ in bulk, 3 in carbonated layer		4½ in bulk, 3 to 3½ in carbonated paste		3½ to 4	
Surface Carbonation Depth, in. (Determined by pH):	0.18		0.16		0.05	
Cracking and Other Features:	Heavy microcracking at surface		Heavy microcracking at surface		Surface eroded except where there is marine growth	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	11.0		10.6		10.6	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface		Brown staining and marine growth on surface		Marine growth on surface, eroded	

Petrographic Examination
Macroscopic Analysis

Client:	SGH
Project:	Alameda Piers 1, 2 & 3
AME Project Number:	1160610C
Date:	11/9/2016

Sample ID:	Pier 3, Pile 30-A		
	Water-line (Core 13)	Mid-water (Core 14)	Mud-line (Core 15)
Thin-section (TS) Number(s):	3838	3839	3840
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Spoardic medium to light	Spoardic medium to light	Light to medium
Calcium Hydroxide Content (CH)*:	< 15%	< 15%	15 to 18%
Size:	Small	Small	Small
Distribution:	Uneven	Uneven	Uneven
Transition Zone (TZ) Development:	Thin to nil	Thin to nil	Thin to nil
Capillary Void Porosity (CVP):	Low	Low	Low
Unhydrated Portland Cement Particles (UPC's), %*:	6 to 7%	6 to 7%	6 to 7%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite, alite	Belite clusters, belite, some alite	Belite clusters, belite, alite
Size:	Clusters typically < 80 µm	Clusters typically < 115 µm	Clusters to 80 µm across typical. Up to 180 µm
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.45	0.45	0.45
Secondary Deposits:	Ettringite filling voids and cracks	Ettringite filling voids and cracks	Some ettringite in voids and some cracks
Deleterious Reactions:	Sea water attack: CH depletion, ettringite formation, heavy microcarcking	Sea water attack: CH depletion, ASR and sulfate attack, heavy microcracking	Sea water attack: minor amount of CH depletion, ettringite formation in voids
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	High	High	High
Transverse:	High	High	Moderately high
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor paste alteration	Paste alteration, but still hard and strong	Paste alteration

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/18/2017

Sample ID: Pier 2, Pile 31.2-B

	Water-line (Core 16)		Mid-water (Core 17)		Mud-line (Core 18)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	519	29.9	615	29.9	553	27.5
Coarse Aggregate (CA) Content	558	32.1	793	38.6	825	41.0
Fine Aggregate (FA) Content	645	37.2	631	30.7	618	30.7
Entrained Air (spherical voids with diameters < 1 mm)	9	0.5	10	0.5	6	0.3
Entrapped Air (irregular shaped voids or diameters > 1 mm)	5	0.3	6	0.3	8	0.4
Total	1736	100.0	2055	100.0	2010	100.0
Coarse-to-fine aggregate ratio (CA/FA)		0.87		1.26		1.33
Total Air Content		0.8		0.8		0.7
Total Aggregate Content		69.3		69.3		71.8
Estimated cementitious materials content (sacks/yd³):	6.2		6.4		5.7	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	¾		¾		1	
Volumetric Proportions (% Aggregate):	69		69		72	
Distribution:	Good		Good		Good	
Segregation:	None		None		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	0.87:1		1.26:1		1.33:1	
Gap Graded:	None		Slightly gapped at #4		Gapped at #4	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Mafic volcanic. graywacke sandstone, chert		Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic	
Minor:	Vein quartz, fine-grain gabbro		Granitic rock types, fine-grain gabbro		Granitic rock types, fine-grain gabbro	
Trace:	Ultramafic		Vein quartz, serpentinite		Vein quartz, serpentinite	
Shape and Texture:	Subangular to subround		Subangular		Subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments, serpentine		Mafic volcanic rock fragments	
Trace:	Pyroxene, chlorite, opaques		Pyroxene, chlorite, opaques		Pyroxene, chlorite, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	None		#8 rebar cast at 3.58", ⅜" dimeter wire at same depth		0.07" diameter wire at 3.32" and 4.53"	
Cement Paste:						
Color:	Light gray to tan		Light gray to tan		Light gray to tan	
Scratch Hardness (Mohs Hardness):	3½		3 to 3½		4	
Surface Carbonation Depth, in. (Determined by pH):	Unevenly to a depth of 0.21		Unevenly to a depth of 0.16		Unevenly to a depth of 0.15	
Cracking and Other Features:	Reaction rims, secondary mineralization in cracks and voids		Reaction rims, secondary mineralization in cracks and voids		Secondary mineralization in cracks, voids and TZ common. Reaction rims, fractured aggregate	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	11.9		11.8		10.7	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface (barnacles)		Marine growth on surface (Mollusca)		Marine growth on surface (Mollusca)	

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/18/2017

Sample ID: Pier 2, Pile 31.2-B

	Water-line (Core 16)	Mid-water (Core 17)	Mud-line (Core 18)
Thin-section (TS) Number(s):	3869	3870	3871
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Light to medium at surface	Medium to slightly heavy at surface	Typically light, medium along crack margins
Calcium Hydroxide Content (CH)*:	20 to 25%	20%	15 to 20%
Size:	Small to medium	Small to medium	Very small to small
Distribution:	Fairly even	Even	Common in TZ
Transition Zone (TZ) Development:	Thin	Very thin	Thin
Capillary Void Porosity (CVP):	Moderate	Moderately low	Moderate
Unhydrated Portland Cement Particles (UPC's), %*:	3 to 5%	4 to 6%	4 to 5%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite, trace alite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters up to 150 μm across	Clusters up to 175 μm across	Clusters up to 200 μm across, typ. < 150 μm
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.53	0.50	0.55
Secondary Deposits:	Ettringite lining and filling voids and cracks	Ettringite lining and filling voids and cracks	Ettringite lining and filling voids and cracks
Deleterious Reactions:	Sea water attack: CH depletion, minor ASR and minor sulfate attack	Sea water attack: CH depletion, minor ASR and minor sulfate attack	Sea water attack: CH depletion, ASR and minor sulfate attack
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	High	Moderate	Low
Transverse:	Moderate to high	Moderate	Low
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor paste alteration, still hard and strong	Minor paste alteration, still hard and strong	Minor paste alteration, still hard and strong

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/18/2017

Sample ID: Pier 2, Pile 46-E

	Water-line (Core 19)		Mid-water (Core 20)		Mud-line (Core 21)	
POINT COUNT:						
Volumetric Proportions (% by volume)	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	478	27.0	524	31.0	503	28.6
Coarse Aggregate (CA) Content	894	50.5	653	38.6	816	46.4
Fine Aggregate (FA) Content	388	21.9	507	30.0	434	24.7
Entrained Air (spherical voids with diameters < 1 mm)	4	0.2	3	0.2	7	0.4
Entrapped Air (irregular shaped voids or diameters > 1 mm)	6	0.3	3	0.2	0	0.0
Total	1770	100.0	1690	100.0	1760	100.0
Coarse-to-fine aggregate ratio (CA/FA)		2.30		1.29		1.88
Total Air Content		0.6		0.4		0.4
Total Aggregate Content		72.4		68.6		71.0
Estimated cementitious materials content (sacks/yd³):	5.9		6.6		5.9	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	1		1		¾ to 1	
Volumetric Proportions (% Aggregate):	72		69		71	
Distribution:	Good		Good		Good	
Segregation:	None		None		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	2.3:1		1.29:1		1.88:1	
Gap Graded:	Slightly gapped at #4		Slightly gapped at #4		Slight gap at #4	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	mafic volcanic, graywacke sandstone, chert		Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic	
Minor:	Vein quartz, fine-grain gabbro		Granitic rock types, fine-grain gabbro		Vein quartz, serpentinite	
Trace:	----		Vein quartz, serpentinite		Granitic rock types	
Shape and Texture:	Subangular		Subangular		Subround to subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Quartz, chert, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments, graywacke rock fragments		Mafic volcanic rock fragments	
Trace:	Pyroxene, lizardite, chlorite, opaques		Pyroxene, chlorite, opal, opaques		Pyroxene, chlorite, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	#8 rebar at 3" and 9.68" depth, 0.3" diameter smooth bar 2.28" and 3.89" depth, plus tie-wire		Rebar cast at base		#8 rebar at 3.64", corroded, 0.3" diameter smooth bar at 2.81 depth	
Cement Paste:						
Color:	Light gray		Light gray		Light gray to tan	
Scratch Hardness (Mohs Hardness):	3½		3 to 3½		4	
Surface Carbonation Depth, in. (Determined by pH):	Less than 0.02"		to 1.20" following cracks		Nil	
Cracking and Other Features:	Reaction rims, secondary mineralization in TZ, cracks and voids, Extensive subparallel cracking in outer 2"		Secondary mineralization in TZ fairly common. Reaction rims, secondary mineralization in cracks and voids, fractured aggregate. Extensive cracking in outer 2"		Secondary mineralization in TZ common. Reaction rims, secondary mineralization in cracks and voids, fractured aggregate. Extensive cracking in outer 2½"	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	11.5		9.4		13.1	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface (barnacles)		Fractured exterior surface		Marine growth on surface	

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/18/2017

Sample ID: Pier 2, Pile 46-E

	Water-line (Core 19)	Mid-water (Core 20)	Mud-line (Core 21)
Thin-section (TS) Number(s):	3872	3873	3874
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	None in TS	Heavy at surface	Light
Calcium Hydroxide Content (CH)*:	18 to 22%	Obscured by carbonation	20%
Size:	Small	----	Very small to small
Distribution:	Fairly even	----	Even
Transition Zone (TZ) Development:	Nil	Thin	Thin
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Moderate
Unhydrated Portland Cement Particles (UPC's), %*:	5%	4 to 6%	4%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters as large as 360 μm across	Clusters up to 130 μm across	Clusters up to 110 μm across
Grain Relief:	Low	Very low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.50	0.50	0.55
Secondary Deposits:	Ettringite and possible carbonated ASR gel filling voids and cracks	Ettringite and possible brucite lining and filling voids and cracks	Ettringite and possible carbonated ASR gel filling voids and cracks
Deleterious Reactions:	Minor sea water attack: minor ASR, minor amount of CH depletion, ettringite in TZ	Sea water attack: CH depletion, minor ASR and minor sulfate attack, numerous cracks in TZ	Sea water attack: CH depletion, minor ASR and minor sulfate attack
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	Moderate	High	Moderately high
Transverse:	Moderately low	High	Moderate
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor paste alteration	Minor paste alteration, paste still hard	Minor paste alteration, still hard and strong

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/19/2017

Sample ID: Pier 2, Pile 55-F

	Water-line (Core 22)		Mid-water (Core 23)		Mud-line (Core 24)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	502	27.0	503	27.2	588	30.4
Coarse Aggregate (CA) Content	872	46.9	873	47.2	853	44.2
Fine Aggregate (FA) Content	467	25.1	463	25.0	474	24.5
Entrained Air (spherical voids with diameters < 1 mm)	5	0.3	7	0.4	12	0.6
Entrapped Air (irregular shaped voids or diameters > 1 mm)	14	0.8	4	0.2	5	0.3
Total	1860	100.0	1850	100.0	1932	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.87		1.89		1.80
Total Air Content		1.0		0.6		0.9
Total Aggregate Content		72.0		72.2		68.7
Estimated cementitious materials content (sacks/yd³):	5.6		5.7		6.3	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	¾		¾		1	
Volumetric Proportions (% Aggregate):	72		72		69	
Distribution:	Good		Good		Good	
Segregation:	None		None		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	1.87:1		1.89:1		1.8:1	
Gap Graded:	No		No		None	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic	
Minor:	Granitic rock types, felsites, fine-grain gabbro		Granitic rock types, felsites, fine-grain gabbro		Granitic rock types, felsites, fine-grain gabbro	
Trace:	Vein quartz, serpentinite		Vein quartz, serpentinite		Vein quartz, serpentinite	
Shape and Texture:	Subround to subangular		Subround to subangular		Subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments		Mafic volcanic rock fragments	
Trace:	Pyroxene, chlorite, opaques, opal		Pyroxene, chlorite, opaques, serpentine		Pyroxene, chlorite, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	None		None		Smooth 0.3" diameter bar on top of #8 rebar at 2.85" depth with tie wire	
Cement Paste:						
Color:	Medium gray		Medium gray		Medium gray	
Scratch Hardness (Mohs Hardness):	4½		3-3½		4	
Surface Carbonation Depth, in. (Determined by pH):	Nil		0.17" maximum		Nil	
Cracking and Other Features:	Reaction rims on coarse aggregate particles, white mineralization lining voids		Reaction rims on coarse aggregate particles, white mineralization lining voids		Reaction rims on coarse aggregate particles, minor white mineralization lining voids	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	10.8		11.0		11.1	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth and mud on surface		Marine growth and mud on surface		Minor marine growth on surface	

Petrographic Examination
Macroscopic Analysis

Client:	SGH
Project:	Alameda Piers 1, 2 & 3
AME Project Number:	1160610C
Date:	1/19/2017

Sample ID:	Pier 2, Pile 55-F		
	Water-line (Core 22)	Mid-water (Core 23)	Mud-line (Core 24)
Thin-section (TS) Number(s):	3875	3876	3877
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Medium to occasionally heavy around voids	Medium to heavy	Light
Calcium Hydroxide Content (CH)*:	20%	20%	15 to 20%
Size:	Small and medium to occasionally large in TZ	Small to medium	Small to medium
Distribution:	Uneven	Uneven	Uneven
Transition Zone (TZ) Development:	Moderate	Thin to moderate	Thin to moderate
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Moderately low
Unhydrated Portland Cement Particles (UPC's), %*:	4%	4-5%	4-5%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters typically < 110 μm	Clusters up to 175 μm across, typ. < 100 μm	Clusters to 145 μm across, typ. Less
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.55	0.53	0.53
Secondary Deposits:	Ettringite lining and partially filling voids	Possible brucite in TZ cracks, ettringite filling fine cracks	Minor amounts of carbonated ettringite lining voids
Deleterious Reactions:	Minor sea water attack: minor CH depletion	Sea water attack: CH depletion in fine crack zones, possible ASR and sulfate attack, numerous parallel cracking at approximately ½" depth	Minor sea water attack: minor CH depletion
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	Low	High	Low
Transverse:	Low	High	Very low
MISCELLANEOUS CEMENT PASTE INFORMATION:	Very minor paste alteration	Paste alteration, still hard and strong	Very minor paste alteration

Petrographic Examination
Macroscopic Analysis

Client:	SGH
Project:	Alameda Piers 1, 2 & 3
AME Project Number:	1160610C
Date:	1/19/2017

Sample ID: Pier 2, Pile 61-A

	Water-line (Core 25)		Mid-water (Core 26)		Mud-line (Core 27)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	543	29.6	636	33.6	540	30.2
Coarse Aggregate (CA) Content	695	37.9	549	29.0	735	41.1
Fine Aggregate (FA) Content	587	32.0	704	37.2	498	27.9
Entrained Air (spherical voids with diameters < 1 mm)	6	0.3	2	0.1	7	0.4
Entrapped Air (irregular shaped voids or diameters > 1 mm)	2	0.1	2	0.1	7	0.4
Total	1833	100.0	1893	100.0	1787	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.18		0.78		1.48
Total Air Content		0.4		0.2		0.8
Total Aggregate Content		69.9		66.2		69.0
Estimated cementitious materials content (sacks/yd³):	6.4		7.1 (high content due to low CA content)		6.6	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	1		1		¾	
Volumetric Proportions (% Aggregate):	70		66		69	
Distribution:	Moderately good		Poor		Moderately good	
Segregation:	None		Moderate		Slight	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	1.18:1		0.78:1		1.48:1	
Gap Graded:	Slight gap at #4		Gapped at sizes > than ½"		No	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic		Graywacke sandstone, chert, mafic volcanic	
Minor:	Vein quartz, fine-grain gabbro		Vein quartz, fine-grain gabbro		Granitic rock types, felsites, fine-grain gabbro	
Trace:	Felsites		Felsites		Vein quartz, serpentinite	
Shape and Texture:	Subround to subangular		Subround to subangular		Subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments		Mafic volcanic rock fragments	
Trace:	Pyroxene, chlorite, opaques		Pyroxene, chlorite, opaques, lizardite		Pyroxene, chlorite, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	0.3" diameter smooth bar at 3.54" depth, #8 rebar at 3.68" depth, with tie wire		Smooth 0.29" diameter bar at 3.4" depth, #8 rebar at 4.09" depth		Smooth 0.29" diameter bar at 3.27" depth, #8 rebar at 4.12" depth	
Cement Paste:						
Color:	Medium light gray		Light gray		Light gray	
Scratch Hardness (Mohs Hardness):	4		3-3½		3½	
Surface Carbonation Depth, in. (Determined by pH):	Nil, carbonation in voids and crack margins common		0.22" with carbonation in voids and crack margins common		< 0.03"	
Cracking and Other Features:	Subparallel cracks to surface with secondary white mineralization to approximately 1" depth		Crack normal to exterior face to approximately 3.4". Subparallel cracks to surface with secondary white mineralization to approximately 5.2" depth		Some reaction rims on CA	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	10.0		11.0		10.3	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface		Marine growth on surface		Marine growth and mud on surface	

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/19/2017

Sample ID: Pier 2, Pile 61-A

	Water-line (Core 25)	Mid-water (Core 26)	Mud-line (Core 27)
Thin-section (TS) Number(s):	3878	3879	3880
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	medium to heavy in and around voids	Light, typical. Medium to heavy in around voids and crack margins	Light, occasionally medium around voids
Calcium Hydroxide Content (CH)*:	15 to 20%	20%	>20%
Size:	Small	Small	Small
Distribution:	Fairly	Even	Even
Transition Zone (TZ) Development:	Appears thin	Appears thin to nil	Thin to nil
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Moderately low
Unhydrated Portland Cement Particles (UPC's), %*:	4-5%	4-6%	5-6%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters to 185 μm across, typ. < 90 μm	Clusters up to 130 μm across	Clusters to 110 μm across common
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.50	0.50	0.48
Secondary Deposits:	Possible brucite filling crack ins in CA TZ. Ettringite in voids and cracks, cracks with carbonated ASR in CA and paste	ASR reaction product (carbonated gel) in cracks and lining to filling voids, ettringite lining and filling voids and cracks, possible brucite lining some large cracks	Ettringite lining and filling small voids, minor CH depletion
Deleterious Reactions:	Sea water attack: CH depletion, ASR and sulfate attack, heavy microcracking	Sea water attack: CH depletion, ASR and sulfate attack, heavy microcracking	Sea water attack: minor amount of CH depletion, ettringite formation in voids
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	High	High	Low
Transverse:	High	High	Very low
MISCELLANEOUS CEMENT PASTE INFORMATION:	Moderate paste alteration	Paste alteration, but still fairly hard	Minor paste alteration

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/23/2017

Sample ID: Pier 2, Pile 62-C

	Water-line (Core 28)		Mid-water (Core 29)		Mud-line (Core 30)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	539	31.4	485	28.7	492	29.5
Coarse Aggregate (CA) Content	635	37.0	668	39.6	553	33.2
Fine Aggregate (FA) Content	498	29.1	521	30.9	583	35.0
Entrained Air (spherical voids with diameters < 1 mm)	14	0.8	6	0.4	15	0.9
Entrapped Air (irregular shaped voids or diameters > 1 mm)	28	1.6	7	0.4	25	1.5
Total	1714	100.0	1687	100.0	1668	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.28		1.28		0.95
Total Air Content		2.5		0.8		2.4
Total Aggregate Content		66.1		70.5		68.1
Estimated cementitious materials content (sacks/yd³):	6.4		5.9		6.2	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	¾ to 1		¾		¾ to 1	
Volumetric Proportions (% Aggregate):	66		70		68	
Distribution:	Good		Good		Good	
Segregation:	None		None		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	1.28:1		1.28:1		0.95:1	
Gap Graded:	No		No		No	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic	
Minor:	Vein Quartz		Vein Quartz		Vein Quartz	
Trace:	Felsite, granitic rock types		Felsite, granitic rock types		Felsite, granitic rock types	
Shape and Texture:	Subround to subangular		Subround to subangular		Subround to subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments		Mafic volcanic rock fragments	
Trace:	Granitic rock fragments, chlorite. Serpentine, opaques		Granitic rock fragments, chlorite. Serpentine, opaques		Granitic rock fragments, chlorite. Serpentine, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	#8 rebar at 4.47" depth		#8 rebar at 4.04" depth		0.29" diameter smooth bar at 3.28" depth, #8 rebar at 4.07" depth	
Cement Paste:						
Color:	Medium light gray		Medium light gray		Medium light gray	
Scratch Hardness (Mohs Hardness):	3		4½ in bulk, < 2 in carbonated paste		3½ to 4	
Surface Carbonation Depth, in. (Determined by pH):	< 0.04"		0.30		0.16	
Cracking and Other Features:	Minor amount of CA with reaction rims		Heavy microcracking at surface to 3" depth, outer 0.30" weak and decomposed		Minor amount of CA with reaction rims, white secondary mineral deposits in crack at bottom (purposely fractured for core extraction)	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	10.3		9.7		10.3	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface		Marine growth on surface		Marine growth on surface	

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/23/2017

Sample ID: Pier 2, Pile 62-C

	Water-line (Core 28)	Mid-water (Core 29)	Mud-line (Core 30)
Thin-section (TS) Number(s):	3890	3891	3892
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Medium to heavy (heavy along crack margins)	Medium to heavy (heavy along crack margins)	Medium to heavy (heavy along crack margins)
Calcium Hydroxide Content (CH)*:	20%	< 15%	20%
Size:	Small	Small	Small
Distribution:	Even	Uneven (due to depletion)	Fairly uneven
Transition Zone (TZ) Development:	Thin	Thin	Thin to nil
Capillary Void Porosity (CVP):	Moderately low	Moderately low	Low
Unhydrated Portland Cement Particles (UPC's), %*:	3 to 5%	4%	4 to 6%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters typically < 150 μm	Clusters typically < 140 μm	Clusters to 145 μm across . Typ. < 80 μm
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.55	0.55	0.53
Secondary Deposits:	Ettringite filling voids and cracks, possible brucite in some cracks	Ettringite filling voids and cracks	Ettringite in most cracks
Deleterious Reactions:	Sea water attack: CH depletion, possible ASR	Sea water attack: CH depletion, ASR and sulfate attack, heavy microcracking	Sea water attack: CH depletion, probable ASR and sulfate attack
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	Moderate	High	Moderate
Transverse:	Moderately high	High	Moderately high
MISCELLANEOUS CEMENT PASTE INFORMATION:	Minor to moderate paste alteration	Paste alteration, but still hard and strong	Paste alteration common

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/24/2017

Sample ID: Pier 2, Pile 86-G

	Water-line (Core 31)		Mid-water (Core 32)		Mud-line (Core 33)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	507	27.3	461	25.4	462	27.0
Coarse Aggregate (CA) Content	800	43.1	794	43.8	684	40.0
Fine Aggregate (FA) Content	522	28.1	546	30.1	548	32.0
Entrained Air (spherical voids with diameters < 1 mm)	15	0.8	12	0.7	13	0.8
Entrapped Air (irregular shaped voids or diameters > 1 mm)	12	0.6	0	0.0	5	0.3
Total	1856	100.0	1813	100.0	1712	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.53		1.45		1.25
Total Air Content		1.5		0.7		1.1
Total Aggregate Content		71.2		73.9		72.0
Estimated cementitious materials content (sacks/yd³):	5.7		5.1		5.6	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	1		¾		¾	
Volumetric Proportions (% Aggregate):	71		74		72	
Distribution:	Good		Good		Good	
Segregation:	None		None		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	1.53:1		1.45:1		1.25:1	
Gap Graded:	No		No		No	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic	
Minor:	Felsites, gabbro		Vein quartz		Felsites, gabbro	
Trace:	Vein quartz		Felsites, gabbro		Vein quartz	
Shape and Texture:	Subangular		Subangular		Subround to subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments		Mafic volcanic rock fragments	
Trace:	Granitic rock fragments, chlorite. Serpentine, opaques		Granitic rock fragments, chlorite. Serpentine, opaques		Granitic rock fragments, chlorite. Serpentine, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	None		None		None	
Cement Paste:						
Color:	Medium gray		Medium gray		Medium gray	
Scratch Hardness (Mohs Hardness):	3½ in bulk, 2½ in carbonated layer		3½ in bulk, 2½ in carbonated paste		3 to 3½	
Surface Carbonation Depth, in. (Determined by pH):	0.38" nominal, to 1.86" along cracks from surface		0.33" (max)		< 0.05"	
Cracking and Other Features:	Hairline cracks to 3.41" depth, partially filled with white secondary minerals, Minor amount of reaction rims on CA		Microcracks to 1.75", Reaction rims on CA common		Minor amount of reaction rims on CA	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	11.2		11.2		9.9	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface		Marine growth on surface		Marine growth on surface	

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/24/2017

Sample ID: Pier 2, Pile 86-G

	Water-line (Core 31)	Mid-water (Core 32)	Mud-line (Core 33)
Thin-section (TS) Number(s):	3893	3894	3895
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Medium to heavy, mainly along cracks and voids	Medium to heavy	Medium, occasionally heavy
Calcium Hydroxide Content (CH)*:	15 to 20%	20 to 22%	20%
Size:	Small	Small	Small
Distribution:	Even	Even	Uneven
Transition Zone (TZ) Development:	Thin to nil	Thin to nil	Thin to nil
Capillary Void Porosity (CVP):	Moderate	Moderate	Moderate to moderate low
Unhydrated Portland Cement Particles (UPC's), %*:	3 to 5%	3 to 4%	4 to 5%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters to to 200 μm, typically < 80 μm	Clusters to to 180 μm, typically < 100 μm	Clusters to 150 μm across common. Up to 205 μm
Grain Relief:	Very low	Very low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.55	0.58	0.55
Secondary Deposits:	Ettringite filling voids and cracks, possible carbonated ASR gel and brucite	Ettringite lining/filling voids and filling cracks	Carbonation at depth, possible brucite
Deleterious Reactions:	Sea water attack: CH depletion, ettringite formation, ASR	Sea water attack: CH depletion, Sulfate attack, possible ASR	Sea water attack: CH depletion, carbonation of paste matrix
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	High	Moderate	Low
Transverse:	High	High (mainly in outer 1")	Low
MISCELLANEOUS CEMENT PASTE INFORMATION:	Paste alteration	Paste alteration	High degree of paste alteration, but little cracking

Petrographic Examination
Macroscopic Analysis

Client:	SGH
Project:	Alameda Piers 1, 2 & 3
AME Project Number:	1160610C
Date:	1/19/2017

Sample ID: Pier 2, Pile 88-F

	Water-line (Core 34)		Mid-water (Core 35)		Mud-line (Core 36)	
POINT COUNT:						
Volumetric Proportions (% by volume)						
	Count (0.10" increments)	%	Count (0.10" increments)	%	Count (0.10" increments)	%
Paste Content	496	27.3	499	30.4	475	27.3
Coarse Aggregate (CA) Content	793	43.6	661	40.3	706	40.6
Fine Aggregate (FA) Content	505	27.8	468	28.5	538	31.0
Entrained Air (spherical voids with diameters < 1 mm)	5	0.3	11	0.7	13	0.7
Entrapped Air (irregular shaped voids or diameters > 1 mm)	18	1.0	1	0.1	5	0.3
Total	1817	100.0	1640	100.0	1737	100.0
Coarse-to-fine aggregate ratio (CA/FA)		1.57		1.41		1.31
Total Air Content		1.3		0.7		1.0
Total Aggregate Content		71.4		68.8		71.6
Estimated cementitious materials content (sacks/yd³):	6.0		6.6		6.0	
GENERAL AGGREGATE PROPERTIES:						
Maximum Size Aggregate (MSA), in.:	1		¾		¾	
Volumetric Proportions (% Aggregate):	71		69		72	
Distribution:	Good		Moderately good		Good	
Segregation:	None		Moderate		None	
Consolidation:	Good		Good		Good	
Flat & Elongated Particles:	Low		Low		Low	
CA/FA:	1.57:1		1.41:1		1.31:1	
Gap Graded:	No		Gapped at #4		No	
One Size:	No		No		No	
Coarse Aggregate Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic		Graywacke and arkose sandstone, chert, mafic volcanic	
Minor:	Felsites, gabbro/diabase		Felsites, gabbro		Felsites, gabbro	
Trace:	Vein quartz		Vein quartz		Vein quartz	
Shape and Texture:	Subround to subangular		Subround to subangular		Subround to subangular	
Fine Aggregate Mineral Species and Rock Types:	Normal Weight		Normal Weight		Normal Weight	
Major:	Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar		Graywacke rock fragments, chert, quartz, feldspar	
Minor:	Mafic volcanic rock fragments		Mafic volcanic rock fragments		Mafic volcanic rock fragments	
Trace:	Granitic rock fragments, opaques		Granitic rock fragments, chlorite, pyroxene, opaques		Granitic/gabbroic rock fragments, opaques	
Shape and Texture:	Angular to subangular		Angular to subangular		Angular to subangular	
Reinforcement:	0.28" diameter smooth bar at 3.00" depth, #8 rebar 3.73" depth		None		#8 rebar at 3.33" depth	
Cement Paste:						
Color:	Medium gray		Medium gray		Medium gray	
Scratch Hardness (Mohs Hardness):	4 to 4½ in bulk, 2 in carbonated layer		3 to 3½ in bulk, 2 to 2½ in carbonated paste		3½ to 4	
Surface Carbonation Depth, in. (Determined by pH):	0.31		0.23" max		Nil	
Cracking and Other Features:	Reaction rims on CA common		Minor amount of reaction rims on CA		Reaction rims on CA common	
Diameter (in.)	4.2		4.2		4.2	
Nominal Length (in.)	11.8		9.9		10.3	
MISCELLANEOUS SAMPLE INFORMATION:	Marine growth on surface		Marine growth on surface		Marine growth on surface	

Petrographic Examination
Macroscopic Analysis

Client: SGH
Project: Alameda Piers 1, 2 & 3
AME Project Number: 1160610C
Date: 1/19/2017

Sample ID: Pier 2, Pile 88-F

	Water-line (Core 34)	Mid-water (Core 35)	Mud-line (Core 36)
Thin-section (TS) Number(s):	3904	3905	3906
CEMENT PASTE PROPERTIES:			
Carbonation: Determined by thin-section:			
Carbonation Intensity	Medium to heavy, mainly along cracks and voids	Medium to heavy, mainly along cracks and voids	Medium to heavy, mainly along cracks and voids
Calcium Hydroxide Content (CH)*:	15 to 18%	15 to 18%	15%
Size:	Small	Small	Small
Distribution:	Uneven	Uneven	Fairly even
Transition Zone (TZ) Development:	Thin to nil	Thin to nil	Thin to nil
Capillary Void Porosity (CVP):	Low	Low	Low
Unhydrated Portland Cement Particles (UPC's), %*:	6%	5 to 6%	5 to 6%
Shape:	Subround to subangular	Subround to subangular	Subround to subangular
Type:	Belite clusters, belite, trace alite	Belite clusters, belite	Belite clusters, belite
Size:	Clusters typically < 130 μm	Clusters typically < 135 μm	Clusters up to 170 μm
Grain Relief:	Low	Low	Low
Pozzolans*, Additives and Pigments: *percent of cement paste volume	None	None	None
Estimated water-binder ratio (w/b), ±0.05: (Binder = cement + pozzolan)	0.48	0.48	0.48
Secondary Deposits:	Ettringite filling voids and cracks	Ettringite filling cracks	Carbonation at depth
Deleterious Reactions:	Sea water attack: CH depletion, sulfate attack	Sea water attack: CH depletion, sulfate attack	Sea water attack: CH depletion, carbonation of paste matrix
Fiber Reinforcement (type and amount**): **percent of sample volume	None	None	None
Microcracking:			
Radial:	High	High	Low
Transverse:	High	High	Low
MISCELLANEOUS CEMENT PASTE INFORMATION:	Paste alteration	Paste alteration, still hard and strong	Paste alteration

APPENDIX B

DAMAGE RATING INDEX (DRI) DATA SHEETS

APPLIED MATERIALS & ENGINEERING, INC.
980 41st Street
Oakland, CA 94608
Tel: (510) 420-8190
FAX: (510) 420-8186
e-mail: info@appmateng.com

Criteria for Damage Rating Index (DRI) for Determining the Alkali-Silica Reactivity (ASR) in Concrete Cores

The following criteria are used for the *Damage Rating Index* (DRI) determination of potential Alkali-Silica Reactivity (ASR) for core samples removed from concrete structures:

Each core sample is sawn-cut with a continuous-rim, water-cooled diamond-bonded saw blade in the longitudinal direction. The longitudinal cross-section is lapped on diamond bond metal discs until all saw-cut marks are removed and a smooth nearly-polished surface is obtained. The cross-sections are then examined by naked-eye and a variable zoom stereomicroscope with magnifications up to 56x. The *Damage Rating Index* (DRI) is determined by counting petrographic features that indicate the presence or potential presence of ASR. The DRI is described by Grattan-Bellew (1992) and Dunbar and Grattan-Bellew (1995), among others. The petrographic features used to determine the DRI are given in Table I. Each feature is given a weighing factor based on their relative significance in the overall deterioration process. The DRI in this study focused on coarse aggregate particles, or aggregate greater than the No. 4 U.S. standard sieve size.

As noted by others, there is currently no rating system for the DRI values that correspond to the severity of concrete affected by ASR. However, based on our experience, we have adopted the following general guideline for the degree of ASR, based on the visual examination determination of the DRI:

1) If the DRI is 0 then no ASR is present,
2) If the DRI is between 0 and 500 then ASR is very unlikely,
3) If the DRI is between 500 and 1000 then ASR is unlikely,
4) If the DRI is between 1000 and 2000 then ASR is possible, and
5) If the DRI is greater than 2000 than ASR is probable.

Based on these DRI values, a cut-off at 1500 was used in this study for selection of concrete core samples to evaluate further by microscopic thin-section analysis and other petrographic techniques.

The DRI value of approximately 1500 equates to one (1) of each petrographic feature on a 3" by 4" cross-sectional slice, or 12 in.^{2} of concrete.

SELECTED REFERENCES

1) FHWA-HIF-09-004. Fournier, Benoit, Berube, Marc-Andre, Folliard, Kevin J., Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures, Federal Highway Administration (FHWA), January 2010.

2) FHWA-HIF-09-001. Thomas, Michael, D.A., Fournier, Benoit, Folliard, Kevin J., Report on Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction, Federal Highway Administration (FHWA), April 2008.

3) FHWA-RD-01-164. Van Dam, T.J., Sutter, L.L., Smith, K.D., Wade, M.J., Peterson, K.R., Guidelines for Detection, Analysis, and Treatment of Materials-Related Distress in Concrete Pavements – Volume 2: Appendix B: Laboratory Methods, Federal Highway Administration (FHWA), August 2002.

4) Dunbar. P.A. and Grattan-Bellew, P.E. 1995. Results of damage rating evaluation of condition of concrete from a number of structures affected by AAR. *In* Proceedings of CANMET/ACI International Workshop on AAR in Concrete, Dartmouth, Nova Scotia, CANMET, Department of Natural Resources Canada, pp. 257-265.

5) Grattan-Bellew, P.E. 1992. Comparison of laboratory and field evaluation of alkali-silica reaction in large dams. *In* Proceedings of the First International Conference on Concrete Alkali-Aggregate Reactions in Hydroelectric Plants and Dams, September-October 1992, Fredericton, NB, Canada, 23p.

6) Grattan-Bellew, P.E. and Mitchell, L.D. 2006. Quantitative petrographic analysis of concrete–the damage rating index (DRI) method, a review. Proceedings of *Marc-André Bérubé Symposium on Alkali-Aggregate Reaction (AAR) in Concrete*, Montréal (Canada), May 2006, edited by B. Fournier, CANMET-MTL, 45-70.

TABLE I

PETROGRPAHIC FEATURES AND WEIGHING FACTORS FOR THE DAMAGE RATING INDEX TO DETERMINE POTENTIAL ALKALI-SILICA REACTIVITY IN CONCRETE

Petrographic Feature	Weighing Factor
Cementitious Paste with Cracks and Gel	x 4.00
De-bonded Coarse Aggregate	x 3.00
Coarse Aggregate with Cracks and Gel	x 2.00
Cementitious Paste with Cracks	x 2.00
Air Voids Lined or Filled with Gel	x 0.50
Reaction Rims around Aggregate	x 0.50
Coarse Aggregate with Cracks	x 0.25

TABLE II

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 21-A Face 2					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 1		Sample 2		Sample 3	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	0	0	0	0	1	0.25
Coarse aggregate with cracks and gel	2.00	0	0	0	0	0	0
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	5	2.5	0	0	8	4
Cement paste with cracks	2.00	0	0	4	8	3	6
Cement paste with cracks and gel	4.00	0	0	0	0	0	0
Air voids lined or filled with gel	0.50	0	0	0	0	0	0
Sum		5	2.5	4	8	12	10.25
Area (cm^2)		139.5		120.6		123.3	
Normalized Area (cm^2)		1.40		1.21		1.23	
Damage Rating Index (DRI)		**179**		**663**		**831**	

Area Calculations

Length (in.)	5.15	4.45	4.55
Width (in.)	4.2	4.2	4.2
Area ($in.^2$)	21.63	18.69	19.11
Area (cm^2)	139.5	120.6	123.3

TABLE II.1 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 36-D Face 2					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 4		Sample 5		Sample 6	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	0	0	0	0	1	0.25
Coarse aggregate with cracks and gel	2.00	0	0	1	2	0	0
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	2	1	2	1	5	2.5
Cement paste with cracks	2.00	0	0	3	6	2	4
Cement paste with cracks and gel	4.00	0	0	1	4	0	0
Air voids lined or filled with gel	0.50	0	0	0	0	0	0
Sum		2	1	7	13	8	6.75
Area (cm²)		98.6		117.6		107.6	
Normalized Area (cm²)		0.99		1.18		1.08	
Damage Rating Index (DRI)		**101**		**1105**		**627**	

Area Calculations

Length (in.)	3.64	4.34	3.97
Width (in.)	4.2	4.2	4.2
Area (in.²)	15.288	18.228	16.674
Area (cm²)	98.6	117.6	107.6

TABLE II.2 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 51-H Face 4		Pier 2 Pile 51-H Face 1		Pier 2 Pile 52-H Face 4	
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 7		Sample 8		Sample 9	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	1	0.25	11	2.75	2	0.5
Coarse aggregate with cracks and gel	2.00	0	0	0	0	2	4
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	3	1.5	5	2.5	5	2.5
Cement paste with cracks	2.00	5	10	7	14	4	8
Cement paste with cracks and gel	4.00	0	0	0	0	2	8
Air voids lined or filled with gel	0.50	1	0.5	1	0.5	0	0
Sum		10	12.25	24	19.75	15	23
Area (cm²)		103.2		190.8		108.9	
Normalized Area (cm²)		1.03		1.91		1.09	
Damage Rating Index (DRI)		**1187**		**1035**		**2111**	

Area Calculations

Length (in.)	3.81	7.04	4.02
Width (in.)	4.2	4.2	4.2
Area (in.²)	16.002	29.568	16.884
Area (cm²)	103.2	190.8	108.9

TABLE II.3 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 99-H Face 4					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 10		Sample 11		Sample 12	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	0	0	2	0.5	0	0
Coarse aggregate with cracks and gel	2.00	0	0	0	0	0	0
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	0	0	1	0.5	3	1.5
Cement paste with cracks	2.00	2	4	2	4	0	0
Cement paste with cracks and gel	4.00	0	0	0	0	0	0
Air voids lined or filled with gel	0.50	0	0	0	0	0	0
Sum		2	4	5	5	3	1.5
Area (cm²)		130.6		143.1		133.9	
Normalized Area (cm²)		1.31		1.43		1.34	
Damage Rating Index (DRI)		**306**		**349**		**112**	

Area Calculations

Length (in.)	4.82	5.28	4.94
Width (in.)	4.2	4.2	4.2
Area (in.²)	20.244	22.176	20.748
Area (cm²)	130.6	143.1	133.9

TABLE II.4 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 3 Pile 30-A Face 2					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 13		Sample 14		Sample 15	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	0	0	0	0	1	0.25
Coarse aggregate with cracks and gel	2.00	0	0	0	0	0	0
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	2	1	1	0.5	2	1
Cement paste with cracks	2.00	2	4	0	0	3	6
Cement paste with cracks and gel	4.00	0	0	0	0	0	0
Air voids lined or filled with gel	0.50	0	0	0	0	0	0
Sum		4	5	1	0.5	6	7.25
Area (cm^2)		144.4		127.9		118.1	
Normalized Area (cm^2)		1.44		1.28		1.18	
Damage Rating Index (DRI)		**346**		**39**		**614**	

Area Calculations

Length (in.)	5.33	4.72	4.36
Width (in.)	4.2	4.2	4.2
Area ($in.^2$)	22.386	19.824	18.312
Area (cm^2)	144.4	127.9	118.1

TABLE II.5 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 31.2-B Face 3					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 16		Sample 17		Sample 18	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	0	0	0	0	1	0.25
Coarse aggregate with cracks and gel	2.00	0	0	0	0	3	6
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	3	1.5	4	2	5	2.5
Cement paste with cracks	2.00	0	0	0	0	0	0
Cement paste with cracks and gel	4.00	2	8	7	28	4	16
Air voids lined or filled with gel	0.50	10	5	13	6.5	16	8
Sum		15	14.5	24	36.5	29	32.75
Area (cm^2)		129.0		152.0		143.5	
Normalized Area (cm^2)		1.29		1.52		1.43	
Damage Rating Index (DRI)		**1124**		**2401**		**2283**	

Area Calculations

	Water-line (Sample 16)	Mid-Water (Sample 17)	Mud-Line (Sample 18)
Length (in.)	4.76	5.61	5.32
Width (in.)	4.20	4.20	4.18
Area ($in.^2$)	19.99	23.56	22.24
Area (cm^2)	129.0	152.0	143.5

TABLE II.6 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 46-E Face 4					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 19		Sample 20		Sample 21	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	2	0.5	7	1.75	0	0
Coarse aggregate with cracks and gel	2.00	2	4	6	12	3	6
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	2	1	3	1.5	12	6
Cement paste with cracks	2.00	0	0	3	6	0	0
Cement paste with cracks and gel	4.00	11	44	9	36	11	44
Air voids lined or filled with gel	0.50	8	4	11	5.5	12	6
Sum		25	53.5	39	62.75	38	62
Area (cm^2)		117.8		115.7		173.0	
Normalized Area (cm^2)		1.18		1.16		1.73	
Damage Rating Index (DRI)		**4541**		**5425**		**3585**	

Area Calculations

Length (in.)	4.39	4.31	6.46
Width (in.)	4.16	4.16	4.15
Area ($in.^2$)	18.26	17.93	26.81
Area (cm^2)	117.8	115.7	173.0

TABLE II.7 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 55-F Face 4					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 22		Sample 23		Sample 24	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	2	0.5	3	0.75	3	0.75
Coarse aggregate with cracks and gel	2.00	1	2	1	2	0	0
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	3	1.5	7	3.5	6	3
Cement paste with cracks	2.00	0	0	2	4	0	0
Cement paste with cracks and gel	4.00	2	8	1	4	0	0
Air voids lined or filled with gel	0.50	7	3.5	10	5	5	2.5
Sum		15	15.5	24	19.25	14	6.25
Area (cm²)		138.3		143.4		138.0	
Normalized Area (cm²)		1.38		1.43		1.38	
Damage Rating Index (DRI)		**1121**		**1342**		**453**	

Area Calculations

Length (in.)	5.14	5.33	5.13
Width (in.)	4.17	4.17	4.17
Area (in.²)	21.43	22.23	21.39
Area (cm²)	138.3	143.4	138.0

TABLE II.8 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 61-A Face 2					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 25		Sample 26		Sample 27	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	2	0.5	3	0.75	2	0.5
Coarse aggregate with cracks and gel	2.00	4	8	7	14	1	2
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	4	2	6	3	3	1.5
Cement paste with cracks	2.00	5	10	2	4	2	4
Cement paste with cracks and gel	4.00	10	40	20	80	2	8
Air voids lined or filled with gel	0.50	10	5	12	6	2	1
Sum		35	65.5	50	107.75	12	17
Area (cm^2)		133.2		144.7		125.9	
Normalized Area (cm^2)		1.33		1.45		1.26	
Damage Rating Index (DRI)		**4918**		**7444**		**1350**	

Area Calculations

Length (in.)	5.38	4.68	5.38
Width (in.)	4.17	4.17	4.17
Area ($in.^2$)	22.43	19.52	22.43
Area (cm^2)	144.7	125.9	144.7

TABLE II.9 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 62-C Face 2					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 28		Sample 29		Sample 30	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	5	1.25	2	0.5	2	0.5
Coarse aggregate with cracks and gel	2.00	4	8	4	8	0	0
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	4	2	3	1.5	4	2
Cement paste with cracks	2.00	1	2	2	4	0	0
Cement paste with cracks and gel	4.00	3	12	7	28	1	4
Air voids lined or filled with gel	0.50	12	6	9	4.5	3	1.5
Sum		29	31.25	27	46.5	10	8
Area (cm²)		125.9		127.5		127.3	
Normalized Area (cm²)		1.26		1.28		1.27	
Damage Rating Index (DRI)		**2482**		**3646**		**629**	

Area Calculations

Length (in.)	4.68	4.74	4.73
Width (in.)	4.17	4.17	4.17
Area (in.²)	19.52	19.77	19.72
Area (cm²)	125.9	127.5	127.3

TABLE II.10 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 86-G Face 4					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 31		Sample 32		Sample 33	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	6	1.5	3	0.75	2	0.5
Coarse aggregate with cracks and gel	2.00	5	10	2	4	3	6
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	4	2	8	4	4	2
Cement paste with cracks	2.00	4	8	1	2	1	2
Cement paste with cracks and gel	4.00	12	48	8	32	1	4
Air voids lined or filled with gel	0.50	18	9	11	5.5	9	4.5
Sum		49	78.5	33	48.25	20	19
Area (cm²)		141.8		138.6		125.4	
Normalized Area (cm²)		1.42		1.39		1.25	
Damage Rating Index (DRI)		**5537**		**3482**		**1516**	

Area Calculations

Length (in.)	5.27	5.15	4.66
Width (in.)	4.17	4.17	4.17
Area (in.²)	21.98	21.48	19.43
Area (cm²)	141.8	138.6	125.4

TABLE II.11 (Cont.)

DAMAGE RATING INDEX RESULTS

Alameda Piers 1, 2, and 3

AME Project 1160610C

		Pier 2 Pile 88-F Faces 1 and 4					
		Water-line		Mid-Water		Mud-Line	
Sample Identification		Sample 34		Sample 35		Sample 36	
Petrographic Feature	Weighing Factor	Feature	Weighed	Feature	Weighed	Feature	Weighed
Coarse aggregate with cracks	0.25	1	0.25	4	1	1	0.25
Coarse aggregate with cracks and gel	2.00	1	2	3	6	1	2
Coarse aggregate debonded	3.00	0	0	0	0	0	0
Reaction rims around aggregate	0.50	5	2.5	2	1	10	5
Cement paste with cracks	2.00	4	8	1	2	0	0
Cement paste with cracks and gel	4.00	1	4	8	32	1	4
Air voids lined or filled with gel	0.50	5	2.5	13	6.5	3	1.5
Sum		17	19.25	31	48.5	16	12.75
Area (cm²)		150.9		123.2		127.8	
Normalized Area (cm²)		1.51		1.23		1.28	
Damage Rating Index (DRI)		**1275**		**3936**		**998**	

Area Calculations

Length (in.)	5.61	4.58	4.75
Width (in.)	4.17	4.17	4.17
Area (in.²)	23.39	19.10	19.81
Area (cm²)	150.9	123.2	127.8

APPENDIX C

ENGEO Pile Input Parameters Memorandum

TECHNICAL MEMORANDUM

To: Mr. Rune Iversen

Date: November 29, 2016

Project No.: 13206.000.000

Project Name: Alameda Point – Pier 2 and 3 Assessment

Subject: **PILE INPUT PARAMETERS**

Total Pages 8

The attached tables and figure provide a summary of generalized ultimate axial capacities, lateral p-y springs, and axial T-Z springs, as well as the approximate limits along the length of the pier that they should be utilized, for use in analysis of the existing Pier 2 and Pier 3 at Alameda Point in Alameda, California. Our idealized subsurface profile and soil-structure interaction springs are based on existing data.

The p-y springs represent incremental soil resistance at the defined pile depths. To develop springs at intermediate depths, linear interpolation can be used to modify the values of the resisting load. We provide an upper and lower bound based on p-multipliers of 0.5 and 2, respectively. This relatively wide range between upper bound and lower bound is based on the limited amount of strength information.

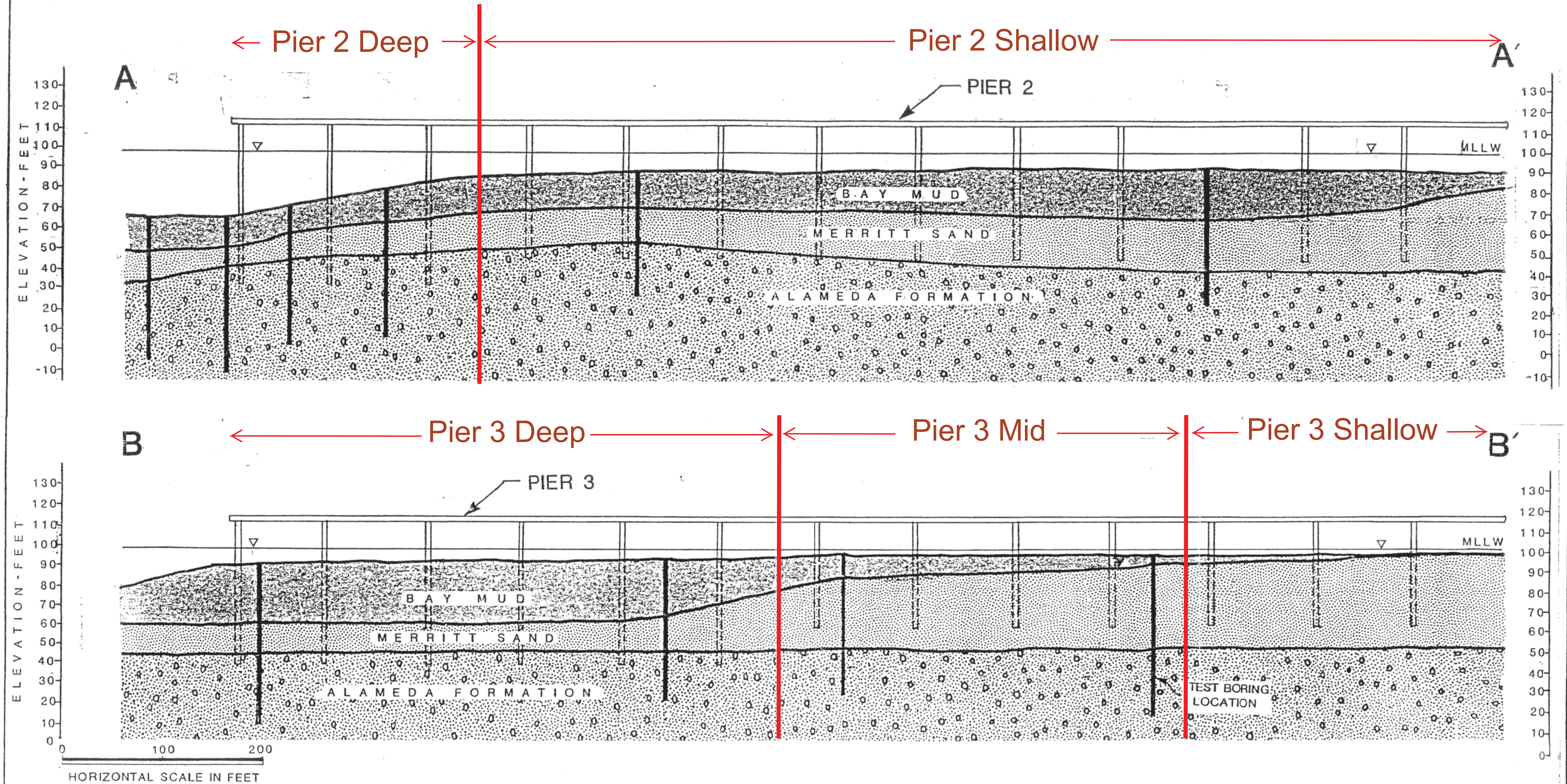
The T-Z springs estimate the axial load-displacement behavior of the piles; these pile springs represent our “best estimate” of pile axial behavior. The behavior provided presents pile tip deflection with varying load applied at the pile top. We also provide our estimate of ultimate axial geotechnical capacity.

Please contact us if you have any questions.

Attachment: Figure 1: Approximate Limits of Generalized Pier Sections
Table I: Pier 2 Lateral p-y Springs
Table II: Pier 3 Lateral p-y Springs
Table III: Axial T-Z Springs
Table IV: Ultimate Axial Capacities

Prepared By: Mr. James Yang

Reviewed By: Mr. Jeff Fippin



NOTES:

1) ELEVATIONS ARE BASED ON ALAMEDA NAVAL AIR STATION DATUM

2) SOIL BOUNDARIES ARE INTERPOLATIONS BETWEEN BORINGS. ACTUAL BOUNDARIES MAY VARY FROM THOSE SHOWN.

3) THE BOTTOM PROFILE IS BASED ON TEST BORING INFORMATION, AND A HYDROGRAPHIC SURVEY PERFORMED BY M&M CONSULTANTS, NOV.1982.

Harding Lawson Associates
Engineers, Geologists
& Geophysicists

Cross Sections A-A' and B-B'
Pier and Wharf Assessment
Alameda Naval Air Station
Alameda, California

PLATE **3-2**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
RICE	13134,001.0		12/13/82		

Table I: Pier 2 Lateral p-y Springs

Section	Pier 2 Shallow							
Upper Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	77.5	51.0	0.46	93.5	2.84	127.5	7.20
YBM	7.4	70.1	120.8	0.46	221.4	2.84	301.9	7.20
Merritt	6.5	71.0	2238.4	0.17	3130.4	0.35	3394.4	0.65
Merritt	32.5	45.0	15652.6	0.28	21890.7	0.56	23736.5	1.05

Section	Pier 2 Deep							
Upper Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	60.0	59.5	0.73	93.5	2.84	127.5	7.20
YBM	8.9	51.1	157.4	0.73	247.3	2.84	337.2	7.20
Merritt	9.0	51.0	2686.0	0.17	3863.6	0.39	4073.2	0.65
Merritt	18.9	41.1	7998.1	0.25	11504.4	0.55	12128.7	0.92
Alameda	19.0	41.0	11147.0	0.26	16033.9	0.58	16903.9	0.96
Alameda	25.0	35.0	21821.8	0.30	31388.5	0.67	33091.8	1.12

Table I: Pier 2 Lateral p-y Springs

Section	Pier 2 Shallow							
Lower Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	77.5	12.8	0.46	23.4	2.84	31.9	7.20
YBM	7.4	70.1	30.2	0.46	55.3	2.84	75.5	7.20
Merritt	6.5	71.0	559.6	0.17	782.6	0.35	848.6	0.65
Merritt	32.5	45.0	3913.1	0.28	5472.7	0.56	5934.1	1.05

Section	Pier 2 Deep							
Lower Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	60.0	14.9	0.73	23.4	2.84	31.9	7.20
YBM	8.9	51.1	39.3	0.73	61.8	2.84	84.3	7.20
Merritt	9.0	51.0	671.5	0.17	965.9	0.39	1018.3	0.65
Merritt	18.9	41.1	1999.5	0.25	2876.1	0.55	3032.2	0.92
Alameda	19.0	41.0	2786.7	0.26	4008.5	0.58	4226.0	0.96
Alameda	25.0	35.0	5455.4	0.30	7847.1	0.67	8272.9	1.12

Table II: Pier 3 Lateral p-y Springs

Section	Pier 3 Shallow							
Upper Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
Merritt	0.0	80.0	0.0	0.35	0.0	0.70	0.0	0.80
Merritt	29.9	50.1	7001.4	0.15	16482.2	0.52	18632.8	1.12

Section	Pier 3 Mid							
Upper Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	90.0	66.1	0.81	103.9	3.15	141.7	8.00
YBM	4.9	85.1	122.4	0.81	192.3	3.15	262.3	8.00
Merritt	5.0	85.0	1658.0	0.19	2384.9	0.43	2514.3	0.72
Merritt	38.9	51.1	21868.8	0.33	31456.2	0.74	33163.2	1.23
Alameda	39.0	51.0	30358.3	0.34	43667.4	0.77	46037.0	1.28
Alameda	44.0	46.0	48226.5	0.37	69369.0	0.84	73133.4	1.40

Section	Pier 3 Deep							
Upper Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	81.5	47.2	0.30	85.0	1.73	141.7	8.00
YBM	13.4	68.1	141.7	0.30	283.3	2.37	425.0	8.00
Merritt	13.5	68.0	4476.7	0.19	6260.8	0.39	6800.9	0.77
Merritt	31.4	50.1	15148.5	0.28	21185.7	0.56	23013.3	1.12
Alameda	31.5	50.0	21054.5	0.29	29445.4	0.59	31985.6	1.17
Alameda	40.5	41.0	39832.4	0.34	55707.1	0.67	60512.8	1.34

Table II: Pier 3 Lateral p-y Springs

Section	Pier 3 Shallow							
Lower Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
Merritt	0.0	80.0	0.00	0.35	0.00	0.70	0.00	0.80
Merritt	29.9	50.1	1750.35	0.15	4120.55	0.52	4658.20	1.12

Section	Pier 3 Mid							
Lower Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	90.0	16.53	0.81	25.97	3.15	35.42	8.00
YBM	4.9	85.1	30.60	0.81	48.08	3.15	65.57	8.00
Merritt	5.0	85.0	414.51	0.19	596.23	0.43	628.59	0.72
Merritt	38.9	51.1	5467.21	0.33	7864.04	0.74	8290.79	1.23
Alameda	39.0	51.0	7589.57	0.34	10916.85	0.77	11509.25	1.28
Alameda	44.0	46.0	12056.61	0.37	17342.26	0.84	18283.34	1.40

Section	Pier 3 Deep							
Lower Bound								
Material	Depth Below Mudline (ft.)	Elevation (MLLW ft.)	P1 (lbs/in)	Y1 (in)	P2 (lbs/in)	Y2 (in)	P3 (lbs/in)	Y3 (in)
YBM	0.0	81.5	11.81	0.30	21.25	1.73	35.42	8.00
YBM	13.4	68.1	35.42	0.30	70.83	2.37	106.25	8.00
Merritt	13.5	68.0	1119.18	0.19	1565.21	0.39	1700.24	0.77
Merritt	31.4	50.1	3787.12	0.28	5296.43	0.56	5753.33	1.12
Alameda	31.5	50.0	7060.77	0.51	7960.84	1.02	7996.40	1.17
Alameda	40.5	41.0	9958.10	0.34	13926.78	0.67	15128.19	1.34

Table III: Axial T-Z Springs

Section	Pier 2 Shallow
Top Load (kips)	Tip Movement (inches)
0.2	0.00
2.3	0.00
11.7	0.01
23.5	0.01
116.3	0.05
174.4	0.10
229.8	0.50
263.3	1.00
301.7	2.00

Section	Pier 2 Deep
Top Load (kips)	Tip Movement (inches)
0.2	0.00
2.5	0.00
12.5	0.01
25.1	0.01
117.0	0.05
166.3	0.10
236.9	0.50
281.8	1.00
326.0	2.00

Section	Pier 3 Shallow
Top Load (kips)	Tip Movement (inches)
0.2	0.00
1.9	0.00
9.4	0.01
18.7	0.01
93.7	0.05
134.5	0.10
194.9	0.50
233.8	1.00
278.3	2.00

Section	Pier 3 Mid
Top Load (kips)	Tip Movement (inches)
4.0	0.00
19.8	0.01
39.8	0.01
197.2	0.05
267.5	0.10
354.6	0.50
410.3	1.00
474.1	2.00

Section	Pier 3 Deep
Top Load (kips)	Tip Movement (inches)
0.3	0.00
2.9	0.00
14.6	0.01
29.2	0.01
144.2	0.05
204.8	0.10
286.2	0.50
336.5	1.00
394.3	2.00

Table IV: Ultimate Axial Capacities

Case	Pile Diameter and Type	Generalized Length	Ultimate Capacity
		feet	kips
Pier 2 Shallow	20-inch square precast	71	312
Pier 2 Deep	18-inch square precast, prestressed	81	326
Pier 3 Shallow	20-inch square precast	59	353
Pier 3 Mid	20-inch square precast	70	495
Pier 3 Deep	20-inch square precast	72	416

Pile Ultimate Tension Capacities		
Location	Soil Level	Capacity (kips)
Pier 2	Shallow	114
Pier 2	Deep	80
Pier 3	Shallow	124
Pier 3	Mid	167
Pier 3	Deep	119

- Capacities provided by ENGEO

APPENDIX D

Preliminary Analysis: Mooring Calculation Package

1.0 Summary of Calculations

1.1 Mooring Analysis

The following mooring analysis is done for the Alameda Piers 1, 2, and 3 to investigate a safe mooring during a 100 year return period storm event. The analysis was conducted for nine vessels with standard mooring arrangments as seen on the project site. The vessels include the Algol, Capella, Cape Orlando, Admiral William H. Callaghan, Gem State, Keystone State, Grandcanyon State, Cape Herny, and Cape Mohican.

The vessel is modeled with actual fairlead positions and mooring line capacities as provided by vessel diagrams, general arrangement drawings, and line certificates. The analysis shows that these vessels require additional mooring lines during extreme storm conditions located at many bollard locations to distribute load over the extent of the pier.

Vessel	Number of Lines	Mooring Line MBL (kips)
Cape Orlando	16	120-221
Algol[1]	24	101-249
Capella[1]	-	-
Admiral William H. Callaghan	15	217
Gem State[2]	16	156-225
Keystone State[2]	-	-
Grand Canyon State[2]	-	-
Cape Henry	25	-
Cape Mohican[3]	37	123-470

Note: 1) Nested Together 2) Nested Together 3) Analysis is done when nested with Cape Henry

2.0 Optimoor Input

2.1.1 Berth Data for Alameda Pier 1 Berth 3-4

Berth Data for Berth 3-4 Pier 1

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Orlando\Berth 3-4 Pier 1.bth)

Units in ft & kips

Left to Right of Screen Site Plan Points:	90°
Width of Channel (for Current):	1000
Pier Height (Fixed) above Datum:	13.7
Dredged Depth below Datum:	32.0
Permissible Surge Excursion Fwd/Aft:	± 6.56
Permissible Sway Excursion Port/Stbd:	± 3.28
Dist of Berth Target to Right of Origin:	-16.4
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	mean

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
C	-239.6	45.4	0.0	70
D	-139.0	8.0	0.0	70
E	-103.0	8.0	0.0	70
F	180.8	8.0	0.0	70
G	207.6	8.0	0.0	40
H	340.9	8.0	0.0	70
I	372.5	8.0	0.0	70

Buoy/ Anchor	X-Dist Origin	Y-Dist Origin	Ht above Dredged	Top Chain Length	Top Chain Diam	2nd Chain Length	2nd Chain Diam	3rd Chain Length	3rd Chain Diam	4th Chain Length	4th Chain Diam
A	-536.6	230.8	9.8	114.0	2.0						
B	-371.8	230.4	9.8	90.0	2.0						

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-32.0	10.0	12.0	93.6
bb	66.0	10.0	12.0	93.6
cc	151.0	10.0	20.0	171.6

Fender Load-Compression Data

aa 186 kips
3.60 ft

bb 186 kips
3.60 ft

cc 344 kips
3.60 ft

2.0 Optimoor Input

2.1.2 Berth Data for Alameda Pier 2 Berth 7-8

Berth Data for Berth 7-8 Pier 2

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Capella & Algol\Berth 7-8 Pier 2.bth)
Units in ft & kips

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	1000
Pier Height (Fixed) above Datum:	16.0
Dredged Depth below Datum:	32.0
Permissible Surge Excursion Fwd/Aft:	± 6.56
Permissible Sway Excursion Port/Stbd:	± 3.28
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	mean

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-564.0	-84.0	0.0	40
B	-528.0	-60.0	0.0	40
C	-510.0	14.0	0.0	70
D	-492.0	-36.0	0.0	70
E	-396.0	3.0	0.0	40
F	-360.0	3.0	0.0	40
G	-222.0	3.0	0.0	70
H	-186.0	3.0	0.0	40
I	-150.0	3.0	0.0	40
J	30.0	3.0	0.0	40
K	318.0	3.0	0.0	70
L	354.0	3.0	0.0	70
M	498.0	3.0	0.0	40
N	534.0	3.0	0.0	70
O	606.0	3.0	0.0	70
P	630.0	3.0	0.0	40
Q	654.0	3.0	0.0	70

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	210.0	16.0	11.0	19.6
bb	0.0	10.0	11.0	19.6
cc	-114.0	10.0	11.0	19.6

Fender Load-Compression Data

aa 152 kips
3.00 ft

bb 152 kips
3.00 ft

cc 152 kips
3.00 ft

2.0 Optimoor Input

2.1.3 Berth Data for Alameda Pier 2 Berth 9

Berth Data for Berth 9 Pier 2

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Callaghan\Berth 9 Pier 2.bth)
Units in ft & kips

Left to Right of Screen Site Plan Points:	90°
Width of Channel (for Current):	1000
Pier Height (Fixed) above Datum:	16.0
Dredged Depth below Datum:	32.0
Permissible Surge Excursion Fwd/Aft:	± 6.56
Permissible Sway Excursion Port/Stbd:	± 3.28
Dist of Berth Target to Right of Origin:	-16.4
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	mean

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-432.0	12.0	0.0	70
B	-432.0	68.0	0.0	70
C	-162.0	5.0	0.0	70
D	174.0	5.0	0.0	70
E	210.0	5.0	0.0	40
F	360.0	5.0	0.0	70
G	426.0	5.0	0.0	40

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-214.0	2.5	11.0	71.5
bb	-138.0	3.5	7.0	38.5
cc	-90.0	2.5	11.0	71.5
dd	-41.3	2.5	11.0	71.5
ee	-18.0	2.5	11.0	71.5
ff	30.0	3.5	7.0	38.5
gg	66.0	2.5	11.0	71.5

Fender Load-Compression Data

```
  aa   151 kips
      3.00 ft

  bb      0     30 kips
      1.00   2.40 ft

  cc   151 kips
      3.00 ft

  dd   151 kips
      3.00 ft

  ee   151 kips
      3.00 ft

  ff      0     30 kips
      1.00   2.40 ft

  gg   151 kips
      3.00 ft
```

2.0 Optimoor Input

2.1.4 Berth Data for Alameda Pier 2 Berth 10

Berth Data for Berth 10 Pier 2

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Keystone\Berth 10 Pier 2.bth)

Units in ft & kips

Left to Right of Screen Site Plan Points:	90°
Width of Channel (for Current):	1000
Pier Height (Fixed) above Datum:	16.0
Dredged Depth below Datum:	32.0
Permissible Surge Excursion Fwd/Aft:	± 6.56
Permissible Sway Excursion Port/Stbd:	± 3.28
Dist of Berth Target to Right of Origin:	-16.4
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	mean

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-438.0	3.0	0.0	70
B	-330.0	3.0	0.0	70
C	-294.0	3.0	0.0	40
D	-222.0	3.0	0.0	70
E	-120.0	3.0	0.0	70
F	66.0	3.0	0.0	40
G	168.0	3.0	0.0	40
H	210.0	3.0	0.0	70
I	240.0	3.0	0.0	40
J	312.0	3.0	0.0	70
K	369.0	3.0	0.0	70

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-100.0	16.0	10.0	30.0
bb	-50.0	16.0	10.0	30.0
cc	0.0	16.0	10.0	30.0
dd	50.0	16.0	10.0	30.0
ee	100.0	16.0	10.0	30.0

Fender Load-Compression Data

aa 50 kips
0.08 ft

bb 50 kips
0.08 ft

cc 50 kips
0.08 ft

dd 50 kips
0.08 ft

ee 50 kips
0.08 ft

2.0 Optimoor Input

2.1.5 Berth Data for Alameda Pier 3 Berth 16

Berth Data for Pier 3 Berth 16
(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Henry & Mohican\Pier 3 Berth 16.bth)
Units in ft & kips

Left to Right of Screen Site Plan Points:	90°
Width of Channel (for Current):	1000
Pier Height (Fixed) above Datum:	16.0
Dredged Depth below Datum:	32.0
Permissible Surge Excursion Fwd/Aft:	± 6.56
Permissible Sway Excursion Port/Stbd:	± 3.28
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	mean

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-456.0	5.0	0.0	70
B	-420.0	5.0	0.0	40
C	-384.0	5.0	0.0	40
D	-348.0	5.0	0.0	70
E	-240.0	5.0	0.0	70
F	-204.0	5.0	0.0	40
G	-132.0	5.0	0.0	70
H	120.0	5.0	0.0	40
I	192.0	5.0	0.0	70
J	228.0	5.0	0.0	40
K	408.0	5.0	0.0	70
L	528.0	5.0	0.0	70
M	-564.0	5.0	0.0	70
N	-528.0	5.0	0.0	40
O	-492.0	5.0	0.0	40
P	552.0	5.0	0.0	40
Q	588.0	5.0	0.0	40

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-96.0	3.5	7.0	38.5
bb	-60.0	3.5	7.0	38.5
cc	-24.0	3.5	7.0	38.5
dd	12.0	3.5	7.0	38.5
ee	48.0	3.5	7.0	38.5
ff	156.0	3.5	7.0	38.5
gg	192.0	3.5	7.0	38.5

Fender Load-Compression Data

Fender	Load / Compression
aa	50 kips 1.00 ft
bb	50 kips 1.00 ft
cc	50 kips 1.00 ft
dd	50 kips 1.00 ft
ee	50 kips 1.00 ft
ff	50 kips 1.00 ft
gg	50 kips 1.00 ft

2.2.1 Vessel Data for Cape Orlando

Vessel Data for Cape Orlando

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Orlando\Cape Orlando.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

```
                                   LBP: 593.0
                               Breadth:  92.0
                                 Depth:  61.8
                                Target:   0.0 fwd from midship and 0.0 above deck at side
          End-on projected windage area:  5242 above deck level
            Side projected windage area: 18988 above deck level
                Fendering possible from: 0.384 LBP aft of midship
                                     to: 0.395 LBP fwd of midship
             Current drag data based on:  OPTIMOOR (Generic Data)
                Wind drag data based on:  OCIMF Tanker (U-shaped Bow)
              Wave motion data based on:  User specified circular motion
  Radius of maximum wave-induced motion: 0.30 significant wave height
 Radius of maximum swell-induced motion: 0.50 significant swell height
```

Flatside Contour

X-dist	-227.5	-187.3	133.8	187.3	234.2
Depth	33.1	48.1	48.1	40.3	18.0

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL		Tail Segment-1 Lgth-Size-Type-BL		
1	304.0	-25.5	0.0	0.0		0.0	9.0JET	211	50.0	4.7pla	221
2	316.0	0.0	0.0	0.0		0.0	9.0Dan	181	50.0	4.7pla	221
3	304.0	25.5	0.0	13.8		0.0	9.0JET	211	50.0	4.7pla	221
4	304.0	25.5	0.0	13.8		0.0	9.0Dan	181	50.0	3.7pla	221
5	304.0	25.5	0.0	32.3		0.0	9.0Dan	181			
6	304.0	25.5	0.0	32.3		0.0	9.0JET	211			
7	254.3	46.0	0.0	10.3		0.0	9.0JET	211			
8	254.3	46.0	0.0	58.8		0.0	9.0Dan	181			
9	-275.2	46.0	0.0	11.3		0.0	7.1JET	120			
10	-275.2	46.0	0.0	62.5		0.0	7.1JET	120			
11	-281.6	46.0	0.0	62.5		0.0	7.1JET	120			
12	-288.6	46.0	0.0	27.5		0.0	9.0JET	211			
13	-293.6	46.0	0.0	27.5		0.0	7.1JET	120			
14	-316.7	-42.8	0.0	35.3		0.0	9.0JET	211			
15	-316.7	-42.8	0.0	47.4		0.0	4.7pla	221			
16	-316.7	-42.8	0.0	47.4		0.0	4.7pla	221			

Codes for Types of Line:
pla: Plasma 12 Strand
JET: 6-Strand Jetcore
Dan: Superdan Plaited

2.2.2 Vessel Data for Algol and Capella

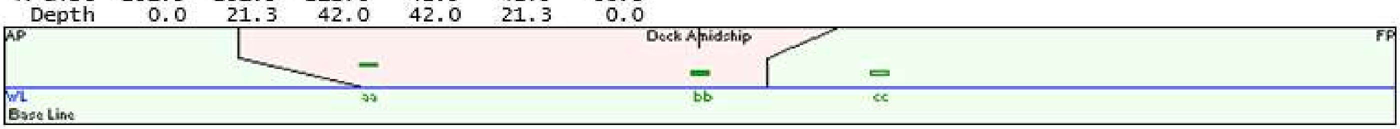
Vessel Data for Capella - Algol

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Capella & Algol\Capella - Algol.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

```
                              LBP: 880.5
                          Breadth: 211.0
                            Depth:  68.4
                           Target:   0.0 fwd from midship and 0.0 above deck at side
       End-on projected windage area: 12816 above deck level
         Side projected windage area: 18641 above deck level
             Fendering possible from: 0.331 LBP aft of midship
                                  to: 0.100 LBP fwd of midship
          Current drag data based on:  OPTIMOOR (Generic Data)
             Wind drag data based on:  Vessels Nesting (2)
           Wave motion data based on:  User specified circular motion
 Radius of maximum wave-induced motion: 0.30 significant wave height
Radius of maximum swell-induced motion: 0.50 significant swell height
```

Flatside Contour

X-dist	-291.5	-291.5	-212.0	42.5	42.5	88.3
Depth	0.0	21.3	42.0	42.0	21.3	0.0



Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	460.0	-52.8	0.0	30.0		0.0	9.012D 249	
2	460.0	-52.8	0.0	30.0		0.0	3.5 SF 101	50.0 9.012D 249
3	438.0	-41.8	0.0	7.5		0.0	8.012D 195	
4	459.8	52.8	0.0	30.0		0.0	9.012D 247	
5	459.8	52.8	0.0	30.0		0.0	8.012D 195	
6	438.0	63.8	0.0	7.5		0.0	7.1 ns 103	
7	438.0	63.8	0.0	7.5		0.0	7.1 ns 103	
8	385.0	74.8	0.0	10.0		0.0	8.012D 195	
9	346.9	82.3	0.0	10.0		0.0	8.0 db 218	
10	347.0	82.3	0.0	10.0		0.0	9.012D 247	
11	186.0	104.0	0.0	10.0		0.0	8.0 db 218	
12	0.0	104.0	0.0	10.0		0.0	9.012D 247	
13	-402.0	93.8	0.0	0.0		0.0	9.012D 247	
14	-440.0	83.8	0.0	12.0		0.0	9.012D 247	
15	-440.0	83.8	-12.0	12.0		0.0	7.1 NS 103	
16	-477.0	76.8	0.0	15.0		0.0	9.012D 247	
17	-474.0	77.3	0.0	28.0		0.0	9.012D 247	
18	-485.0	66.8	0.0	16.5		0.0	9.012D 247	
19	-485.0	52.8	0.0	11.0		0.0	9.012D 247	
20	-485.0	38.8	0.0	16.5		0.0	9.012D 247	
21	-440.0	-21.8	-12.0	12.0		0.0	3.5 SF 101	50.0 9.012D 249
22	-485.0	-38.8	0.0	16.5		0.0	9.012D 247	
23	-485.0	-52.8	0.0	11.0		0.0	9.012D 247	
24	-485.0	-66.8	0.0	16.5		0.0	9.012D 247	

Codes for Types of Line:
SF: Steel wire (Fibre core)
NS: Nylon 3 or 8-Strand (new)
ns: nylon 3 or 8-strand (broken-in)
db: DOUBLEBRAID polyester
12D: 12 Strand Dacron Polyester

2.2.3 Vessel Data for Adm. W. M. Callaghan

Vessel Data for Admiral Callaghan

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Callaghan\Admiral Callaghan.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

```
                              LBP: 626.5
                          Breadth:  92.0
                            Depth:  60.1
                           Target:   0.0 fwd from midship and 0.0 above deck at side
      End-on projected windage area:  5670 above deck level
        Side projected windage area:  7026 above deck level
            Fendering possible from: 0.363 LBP aft of midship
                                to: 0.374 LBP fwd of midship
         Current drag data based on:  OPTIMOOR (Generic Data)
            Wind drag data based on:  OCIMF Tanker (V-shaped Bow)
          Wave motion data based on:  User specified circular motion
  Radius of maximum wave-induced motion: 0.30 significant wave height
 Radius of maximum swell-induced motion: 0.50 significant swell height
```

Flatside Contour

X-dist	-227.5	-96.7	215.0	234.2
Depth	33.1	48.1	48.1	18.0

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	-349.0	-34.0	0.0	32.3		0.0	9.0 pp 217	
2	-349.0	-33.0	0.0	20.3		0.0	9.0 pp 217	
3	-349.0	-32.0	0.0	10.3		0.0	9.0 pp 217	
4	-339.0	42.7	0.0	16.9		0.0	9.0 pp 217	
5	-338.0	42.7	0.0	29.8		0.0	9.0 pp 217	
6	-310.0	44.5	0.0	16.7		0.0	3.0 pp 217	
7	-310.0	44.5	0.0	16.7		0.0	3.0 pp 217	
8	-274.0	45.1	0.0	16.4		0.0	9.0 pp 217	
9	-274.0	45.1	0.0	16.4		0.0	9.0 pp 217	
10	254.3	29.1	0.0	11.9		0.0	9.0 pp 217	
11	286.0	21.6	0.0	8.8		0.0	9.0 pp 217	
12	286.0	21.6	0.0	8.8		0.0	9.0 pp 217	
13	326.0	10.5	0.0	7.7		0.0	9.0 pp 217	
14	329.7	0.0	0.0	22.9		0.0	9.0 pp 217	
15	329.7	0.0	0.0	10.2		0.0	3.0 pp 217	

Codes for Types of Line:
pp: polypropylene dry (broken-in)

2.2.4 Vessel Data for Gem State, Grand Canyon State, and Keystone State

Vessel Data for All State Classes

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Keystone\All State Classes.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

LBP:	633.0
Breadth:	230.4
Depth:	45.5
Target:	0.0 fwd from midship and 0.0 above deck at side
End-on projected windage area:	9675 above deck level
Side projected windage area:	17048 above deck level
Fendering possible from:	0.352 LBP aft of midship
to:	0.190 LBP fwd of midship
Current drag data based on:	OCIMF (Conventional Bow)
Wind drag data based on:	Vessels Nesting (3)
Wave motion data based on:	User specified circular motion
Radius of maximum wave-induced motion:	0.30 significant wave height
Radius of maximum swell-induced motion:	0.50 significant swell height

Flatside Contour

X-dist	-222.5	-177.5	75.0	120.0
Depth	0.0	45.0	45.0	0.0

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	-306.0	76.3	0.0	15.0			10.0 ns 225	
2	-306.0	76.3	0.0	15.0			10.0 ns 225	
3	-302.0	85.8	0.0	10.8			10.0 ns 225	
4	-300.0	86.8	0.0	11.9			10.0 ns 225	
5	-272.0	102.3	0.0	6.6			10.0 ns 225	
6	-270.0	103.3	0.0	16.3			10.0 ns 225	
7	-157.0	107.5	0.0	10.0			10.0 ns 225	
8	-153.0	107.5	0.0	10.0			4.9 P8 156	
9	164.0	107.5	0.0	10.0			4.9 P8 156	
10	166.0	107.5	0.0	10.0			10.0 ns 225	
11	275.9	107.5	0.0	12.7			10.0 ns 225	
12	275.9	107.5	0.0	12.7			10.0 ns 225	
13	312.1	99.0	0.0	9.2			10.0 ns 225	
14	318.8	98.3	0.0	8.8			10.0 ns 225	
15	353.7	84.5	0.0	21.9			10.0 ns 225	
16	358.8	76.8	0.0	15.7			10.0 ns 225	

Codes for Types of Line:
ns: nylon 3 or 8-strand (broken-in)
P8: P8 Proton 8 Strand HMPE

2.2.5 Vessel Data for Cape Henry

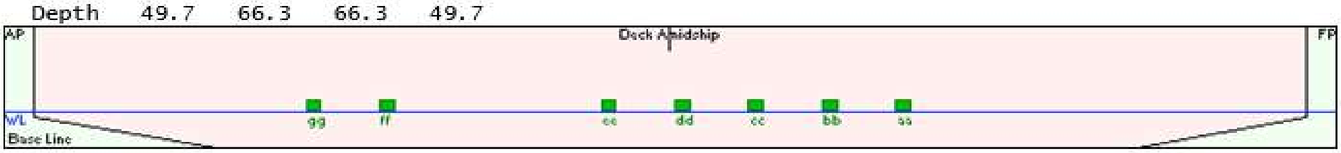
Vessel Data for Cape Henry

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Henry\Cape Henry.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

```
                                LBP: 650.0
                            Breadth: 105.8
                              Depth:  66.3
                             Target:   0.0 fwd from midship and 0.0 above deck at side
        End-on projected windage area: 11071 above deck level
          Side projected windage area: 12335 above deck level
              Fendering possible from: 0.478 LBP aft of midship
                                  to: 0.478 LBP fwd of midship
           Current drag data based on:  OCIMF (Conventional Bow)
              Wind drag data based on:  OCIMF Tanker (U-shaped Bow)
            Wave motion data based on:  User specified circular motion
  Radius of maximum wave-induced motion: 0.30 significant wave height
 Radius of maximum swell-induced motion: 0.50 significant swell height
```

Flatside Contour

X-dist	-310.6	-221.0	227.5	310.6
Depth	49.7	66.3	66.3	49.7



Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	398.0	0.0	0.0	24.0			8.0 pp 123	
2	398.0	0.0	0.0	53.0			9.0 pp 156	
3	398.0	0.0	0.0	53.0			9.0 pp 156	
4	398.0	0.0	0.0	24.0			9.0 pp 156	
5	395.0	7.7	0.0	22.5			9.0 pp 156	
6	380.0	25.0	0.0	36.0			9.0 pp 156	
7	380.0	25.0	0.0	21.0			9.0 pp 156	
8	380.0	25.0	0.0	21.0			9.0 pp 156	
9	353.0	40.0	0.0	21.0			9.0 pp 156	
10	353.0	40.0	0.0	21.0			9.0 pp 156	
11	315.0	51.7	0.0	61.0			9.0 pp 156	
12	315.0	51.7	0.0	24.0			9.0 pp 156	
13	68.3	52.9	0.0	29.0			9.0 pp 156	
14	-50.0	52.9	0.0	23.5			9.0 pp 156	
15	-354.0	52.8	0.0	66.0			8.0 pp 123	
16	-355.0	52.8	0.0	64.0			8.0 pp 123	
17	-356.0	52.8	0.0	46.0			8.0 pp 123	
18	-356.0	52.8	0.0	46.0			8.0 pp 123	
19	-357.0	52.8	0.0	64.0			8.0 pp 123	
20	-358.0	52.8	0.0	33.0			8.0 pp 123	
21	-358.0	52.8	0.0	33.0			8.0 pp 123	
22	-402.0	-45.5	0.0	65.0		0.0	9.0 pp 156	
23	-402.0	-46.0	0.0	36.0		0.0	9.0 pp 156	
24	-402.0	-46.5	0.0	20.0		0.0	9.0 pp 156	
25	-402.0	-46.5	0.0	20.0		0.0	9.0 pp 156	

Codes for Types of Line:
pp: polypropylene dry (broken-in)

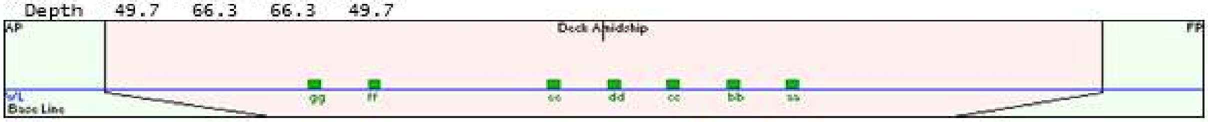
2.2.6 Vessel Data for Cape Henry

Vessel Data for Henry - Mohican

(file I:\OAK\Projects\2016\167543.00-ALPR\CALCULATIONS\Optimoor\MLA\Henry & Mohican\Henry - Mohican.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

LBP: 721.5
Breadth: 212.0
Depth: 66.3
Target: 0.0 fwd from midship and 0.0 above deck at side
End-on projected windage area: 22142 above deck level
Side projected windage area: 12335 above deck level
Fendering possible from: 0.416 LBP aft of midship
to: 0.416 LBP fwd of midship
Current drag data based on: OCIMF (Conventional Bow)
Wind drag data based on: Vessels Nesting (2)
Wave motion data based on: User specified circular motion
Radius of maximum wave-induced motion: 0.30 significant wave height
Radius of maximum swell-induced motion: 0.50 significant swell height

Flatside Contour				
X-dist	-300.0	-200.0	210.0	300.0
Depth	49.7	66.3	66.3	49.7



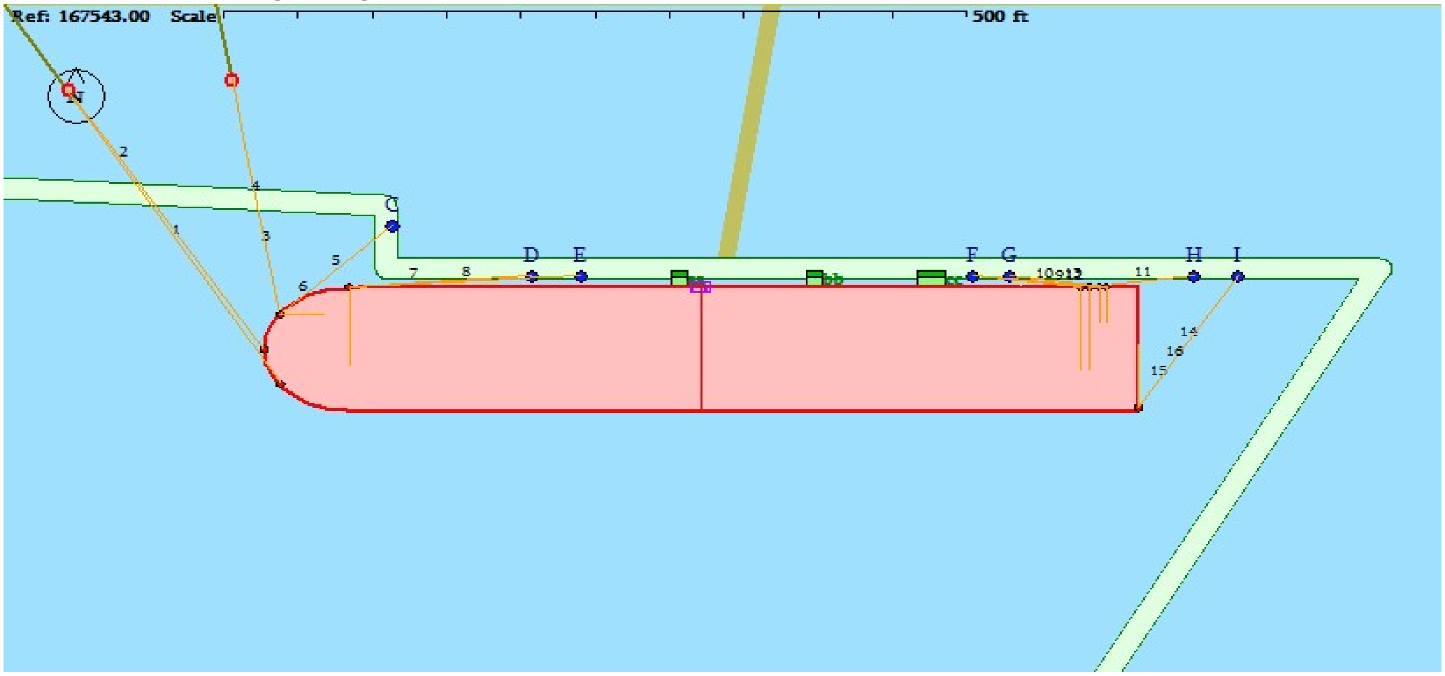
Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	398.0	53.0	0.0	24.0		0.0	8.0 pp 123	
2	398.0	53.0	0.0	53.0		0.0	9.0 pp 156	
3	398.0	53.0	0.0	53.0		0.0	9.0 pp 156	
4	398.0	53.0	0.0	24.0		0.0	9.0 pp 156	
5	395.0	60.7	0.0	22.5		0.0	9.0 pp 156	
6	380.0	78.0	0.0	36.0		0.0	9.0 pp 156	
7	380.0	78.0	0.0	21.0		0.0	9.0 pp 156	
8	380.0	78.0	0.0	21.0		0.0	9.0 pp 156	
9	353.0	93.0	0.0	21.0		0.0	9.0 pp 156	
10	353.0	93.0	0.0	21.0		0.0	9.0 pp 156	
11	315.0	104.7	0.0	61.0		0.0	9.0 pp 156	
12	315.0	104.7	0.0	24.0		0.0	9.0 pp 156	
13	68.3	105.9	0.0	29.0		0.0	9.0 pp 156	
14	-50.0	105.9	0.0	23.5		0.0	9.0 pp 156	
15	-354.0	105.8	0.0	66.0		0.0	8.0 pp 123	
16	-355.0	105.8	0.0	64.0		0.0	8.0 pp 123	
17	-356.0	105.8	0.0	46.0		0.0	8.0 pp 123	
18	-356.0	105.8	0.0	46.0		0.0	8.0 pp 123	
19	-357.0	105.8	0.0	64.0		0.0	8.0 pp 123	
20	-358.0	105.8	0.0	33.0		0.0	8.0 pp 123	
21	-358.0	105.8	0.0	33.0		0.0	8.0 pp 123	
22	-402.0	7.5	0.0	65.0		0.0	9.0 pp 156	
23	-402.0	7.0	0.0	36.0		0.0	9.0 pp 156	
24	-402.0	6.5	0.0	20.0		0.0	9.0 pp 156	
25	-402.0	6.5	0.0	20.0		0.0	9.0 pp 156	
26	495.0	-53.0	0.0	25.8		0.0	10.0 db 343	
27	495.0	-53.0	0.0	25.8		0.0	10.0 db 343	
28	495.0	-53.0	0.0	25.8		0.0	10.0 db 343	
29	495.0	-53.0	0.0	25.8		0.0	10.0 db 343	
30	463.0	-33.0	0.0	57.9		0.0	10.0 db 343	
31	463.0	-33.0	0.0	48.5		0.0	10.0 db 343	
32	444.0	-26.4	0.0	16.5		0.0	10.0 db 343	
33	423.0	-17.3	0.0	12.0		0.0	10.0 db 343	
34	-380.0	-101.6	0.0	8.0		0.0	10.0 db 343	
35	-380.0	-101.6	0.0	23.2		0.0	12.0 db 470	
36	-380.0	-4.4	0.0	8.0		0.0	10.0 db 343	
37	-380.0	-4.4	0.0	23.2		0.0	12.0 db 470	

Codes for Types of Line:
pp: polypropylene dry (broken-in)
db: DOUBLEBRAID polyester

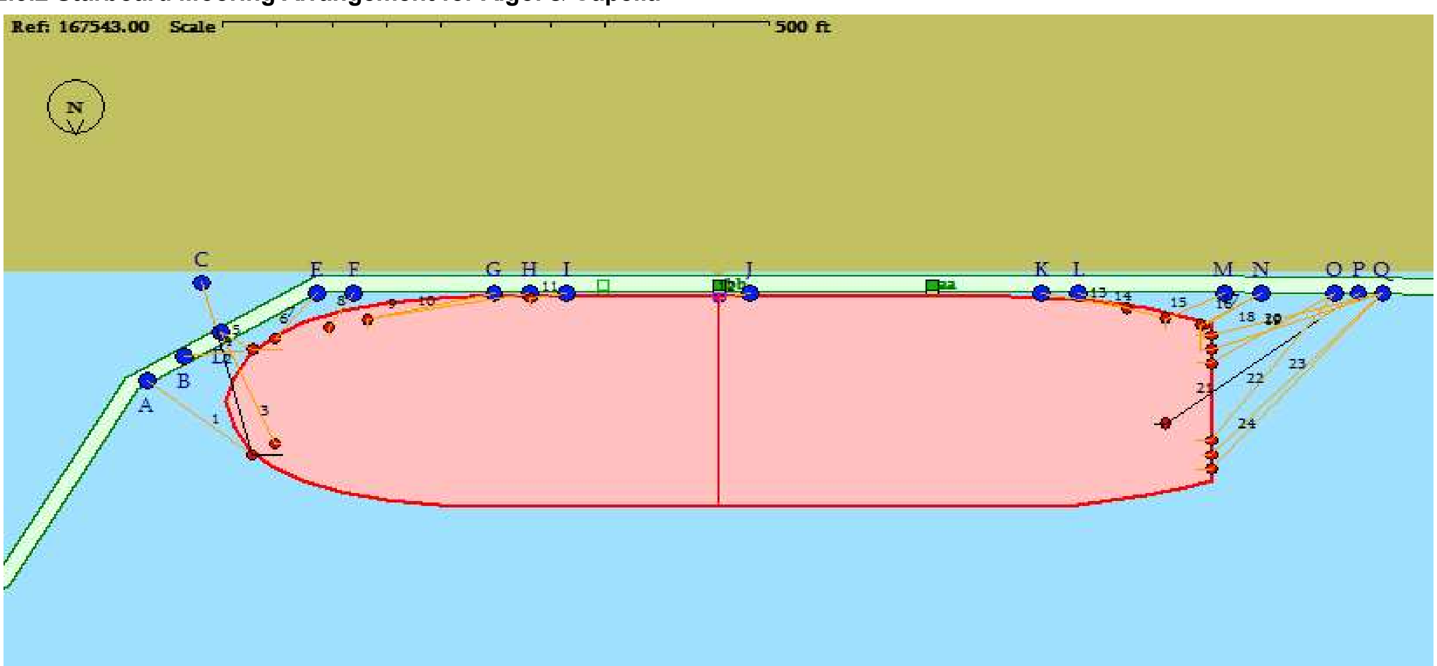
CLIENT	City of Alameda	SHEET NO.	13
SUBJECT	Alameda Piers mooring calculations	PROJECT NO.	167543.00
	Mooring Arrangements	DATE	22 Mar 2017
		BY	MLA
		CHECKED BY	RI

2.3 Mooring Arrangement

2.3.1 Starboard Mooring Arrangement for Cape Orlando



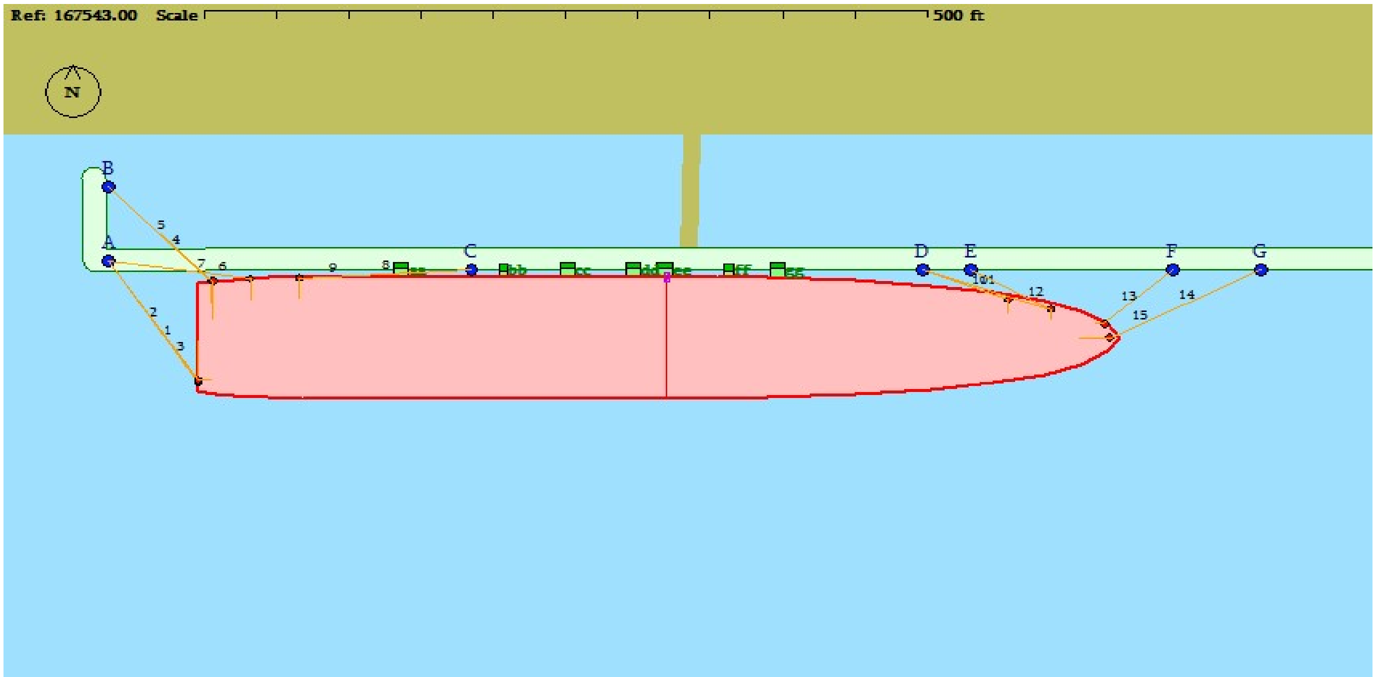
2.3.2 Starboard Mooring Arrangement for Algol & Capella



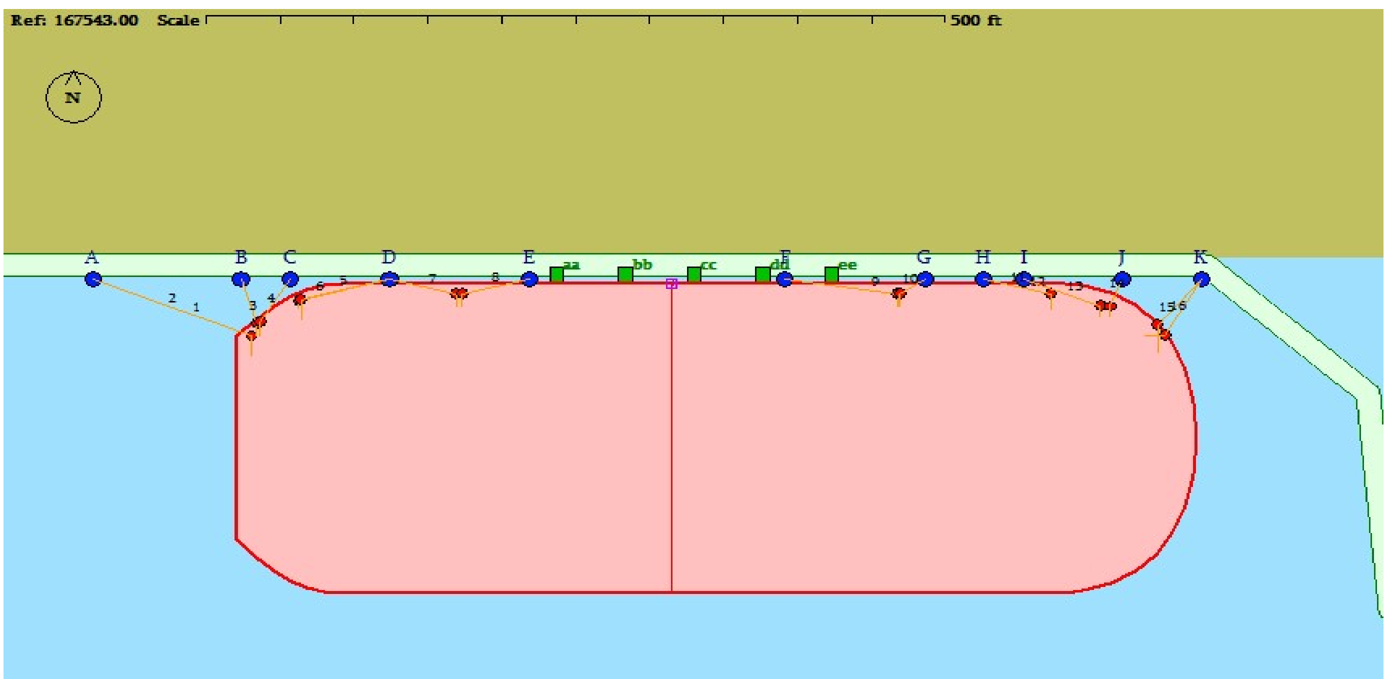
SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

CLIENT	City of Alameda	SHEET NO.	14
SUBJECT	Alameda Piers mooring calculations	PROJECT NO.	167543.00
	Mooring Arrangements	DATE	22 Mar 2017
		BY	MLA
		CHECKED BY	RI

2.3.3 Port Mooring Arrangement for Adm. W. M. Callaghan



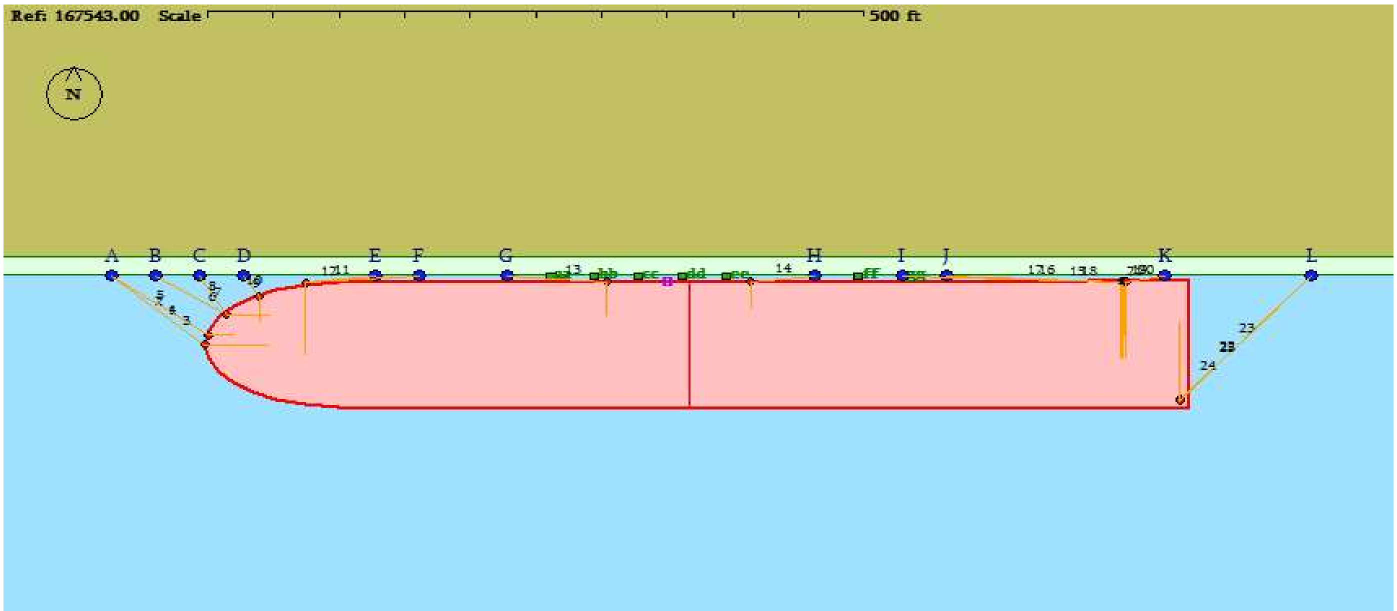
2.3.4 Port Mooring Arrangement for Gem State, Grand Canyon State, and Keystone State



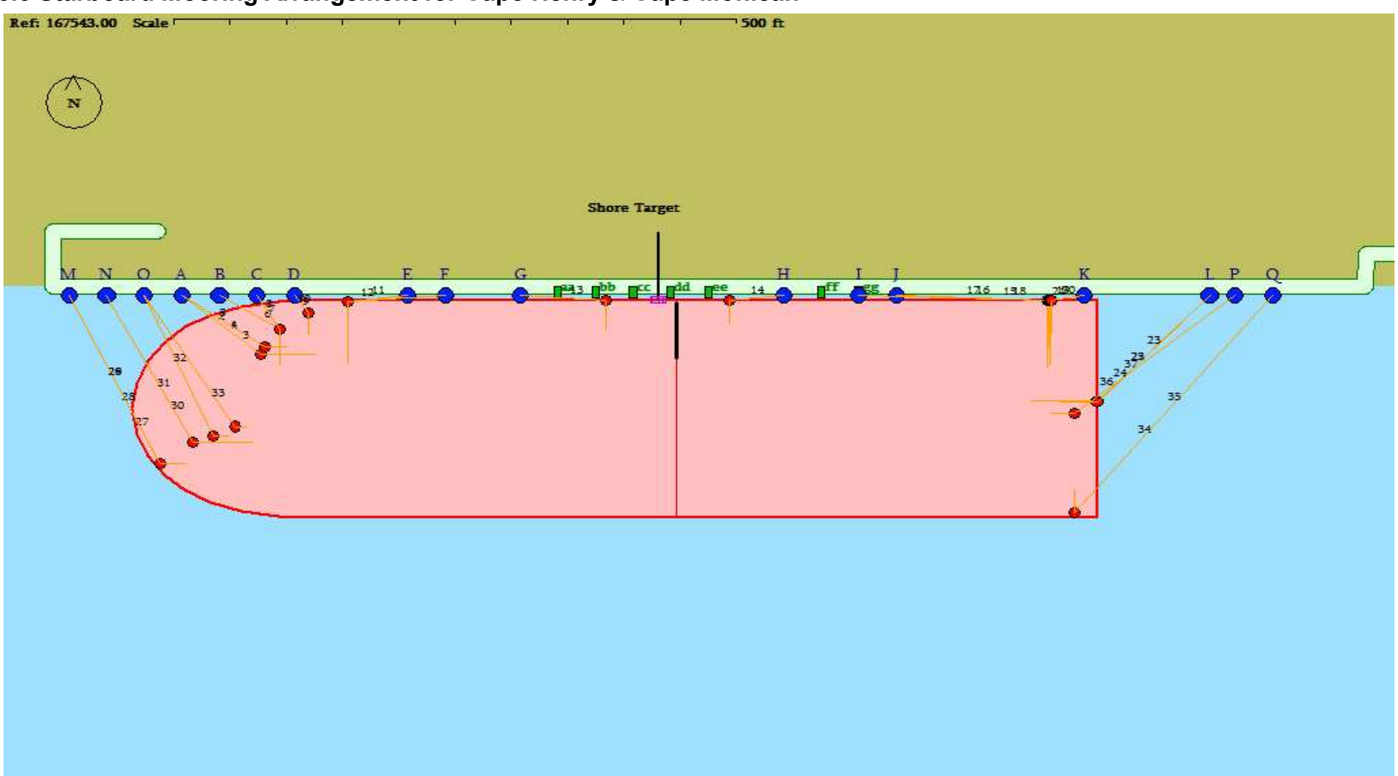
SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

		SHEET NO.	15
		PROJECT NO.	167543.00
CLIENT	City of Alameda	DATE	22 Mar 2017
SUBJECT	Alameda Piers mooring calculations	BY	MLA
	Mooring Arrangements	CHECKED BY	RI

2.3.5 Starboard Mooring Arrangement for Cape Henry



2.3.6 Starboard Mooring Arrangement for Cape Henry & Cape Mohican



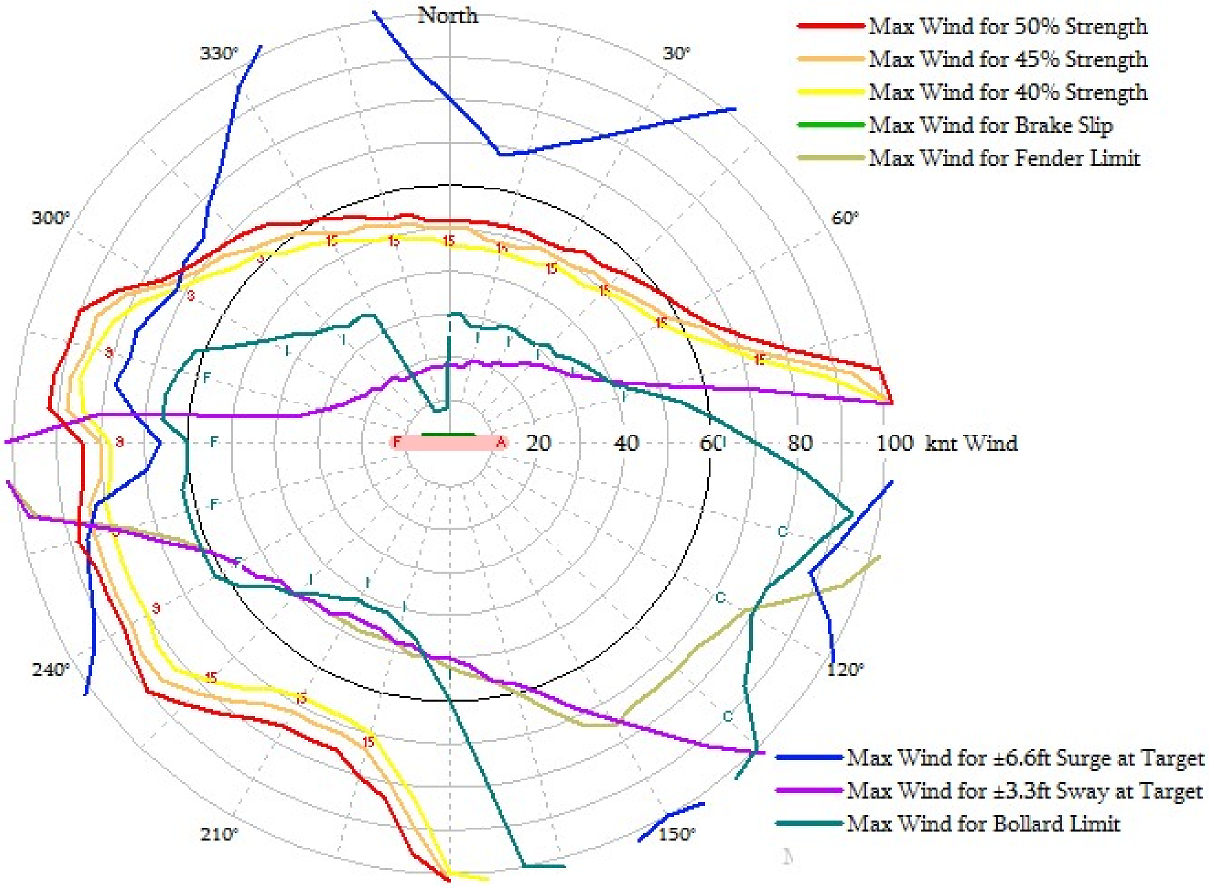
3.0 Mooring Results

The following table contains the results from the mooring analysis for both dynamic and static mooring analyses. The angles herein were determined for further analysis after initially conducting a wind sweep at 5 degree intervals to determine the critical wind induced loads on the berths.

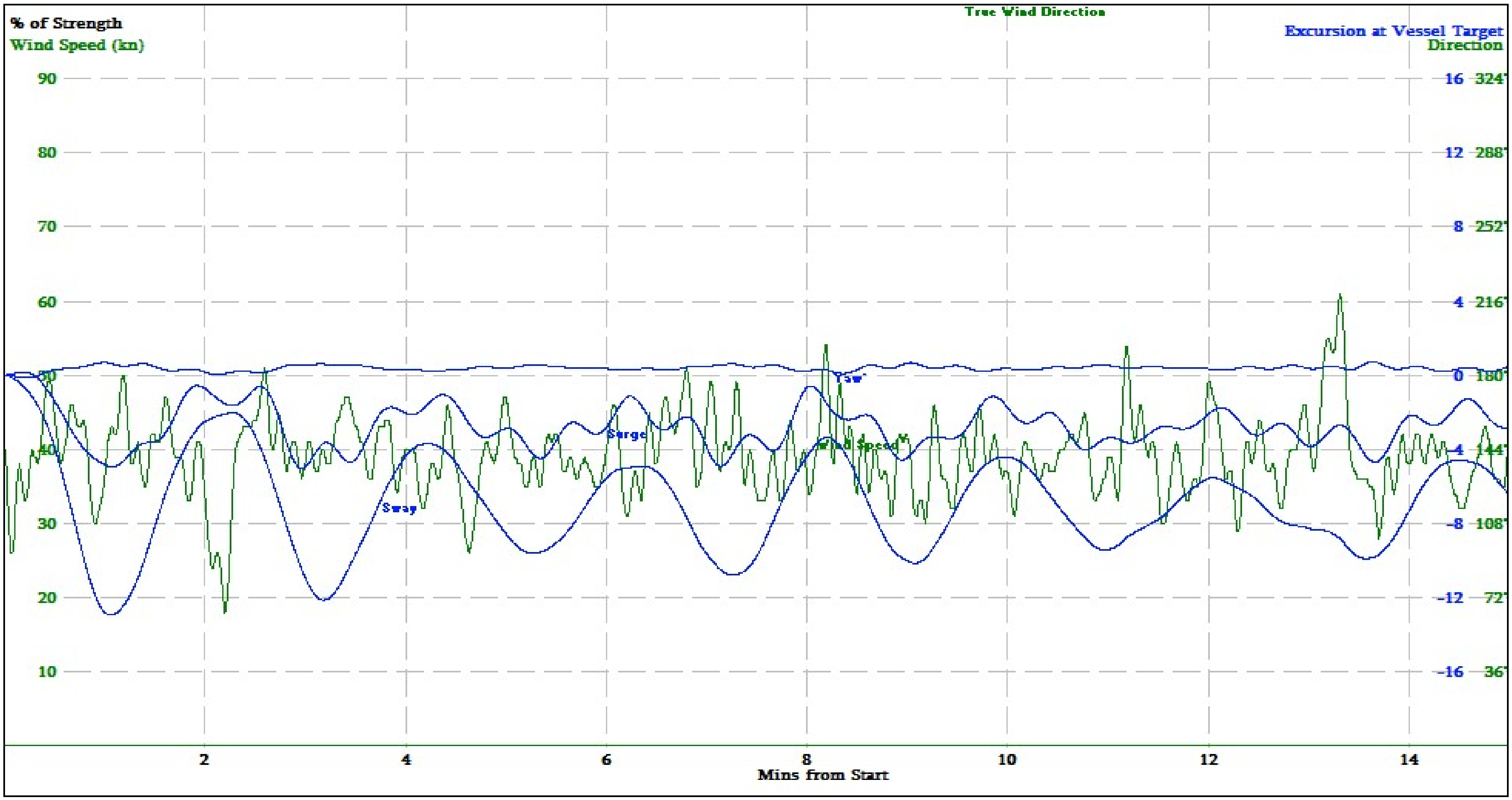
	Governing Case	Dynamic Analysis: Corresponding Force X Force (kips)	Y Force (kips)	Moment/ LBP	Max Mooring Point Load (kips)	Static Analysis: Corresponding Force X Force (kips)	Y Force (kips)	Moment/ LBP
Orlando -15	Max X Force	-17.4	-	-	403.5	-13	404.4	-49.8
	Max Y Y Force	-	528.6	-				
	Max Moment	-	-	-66.3				
Orlando -345	Max X Force	-59.5	-	1.6	432	-45	424.3	1.8
	Max Y Y Force	-	554.9	-				
	Max Moment	-21.7	186	3.5				
Algol & Capella 135	Max X Force	148.4	-	-	245.3	113.2	707.6	18.6
	Max Y Y Force	-	935.7	-				
	Max Moment	-	-	24.5				
Algol & Capella 180	Max X Force	-43.9	-	-	166	-32.3	553.1	-18.2
	Max Y Y Force	-	728.3	-				
	Max Moment	-	-	-24.6				
Algol & Capella 225	Max X Force	-18.7	84.7	-9.1	222.6	-161.9	714	-77.2
	Max Y Y Force	-214.2	940.7	-101.9				
	Max Moment	-18.7	84.7	-9.1				
Callahan -15	Max X Force	6.8	-	-	140.1	5.2	-266.4	-1.7
	Max Y Y Force	-	-351.9	-				
	Max Moment	-	-	-2.2				
Callahan -345	Max X Force	-14.1	-	-	173.4	-10.8	-255.3	30.9
	Max Y Y Force	-	-337	-				
	Max Moment	-	-	40.5				
State Class -0	Max X Force	0.6	-278	12.6	156.2	0.4	-300.3	13.8
	Max Y Y Force	0.5	-396	18.2				
	Max Moment	-	-	-				
State Class 45	Max X Force	150.2	-	-	230.5	113.8	-481.9	-13.6
	Max Y Y Force	-	-635.6	-				
	Max Moment	-	-	-18				
State Class -300	Max X Force	-	-	-	-	-136	-400.6	375.8
	Max Y Y Force	-	-	-				
	Max Moment	-	-	-				
Henry -15	Max X Force	-28	-	-	448.5	-21.3	394.1	-46.5
	Max Y Y Force	-	517.3	-				
	Max Moment	-	-	-61				
Henry & Mohican -60	Max X Force	-367	-	-	396.1	-277.7	462.2	-423
	Max Y Y Force	-	609.9	-				
	Max Moment	-	-	-561.3				
Henry & Mohican -330	Max X Force	133	-	-	206.8	101.1	601.9	9.8
	Max Y Y Force	-	794.2	-				
	Max Moment	-	-	13.1				

Wind Capability Rose for Cape Orlando at Berth 3-4 Pier 1

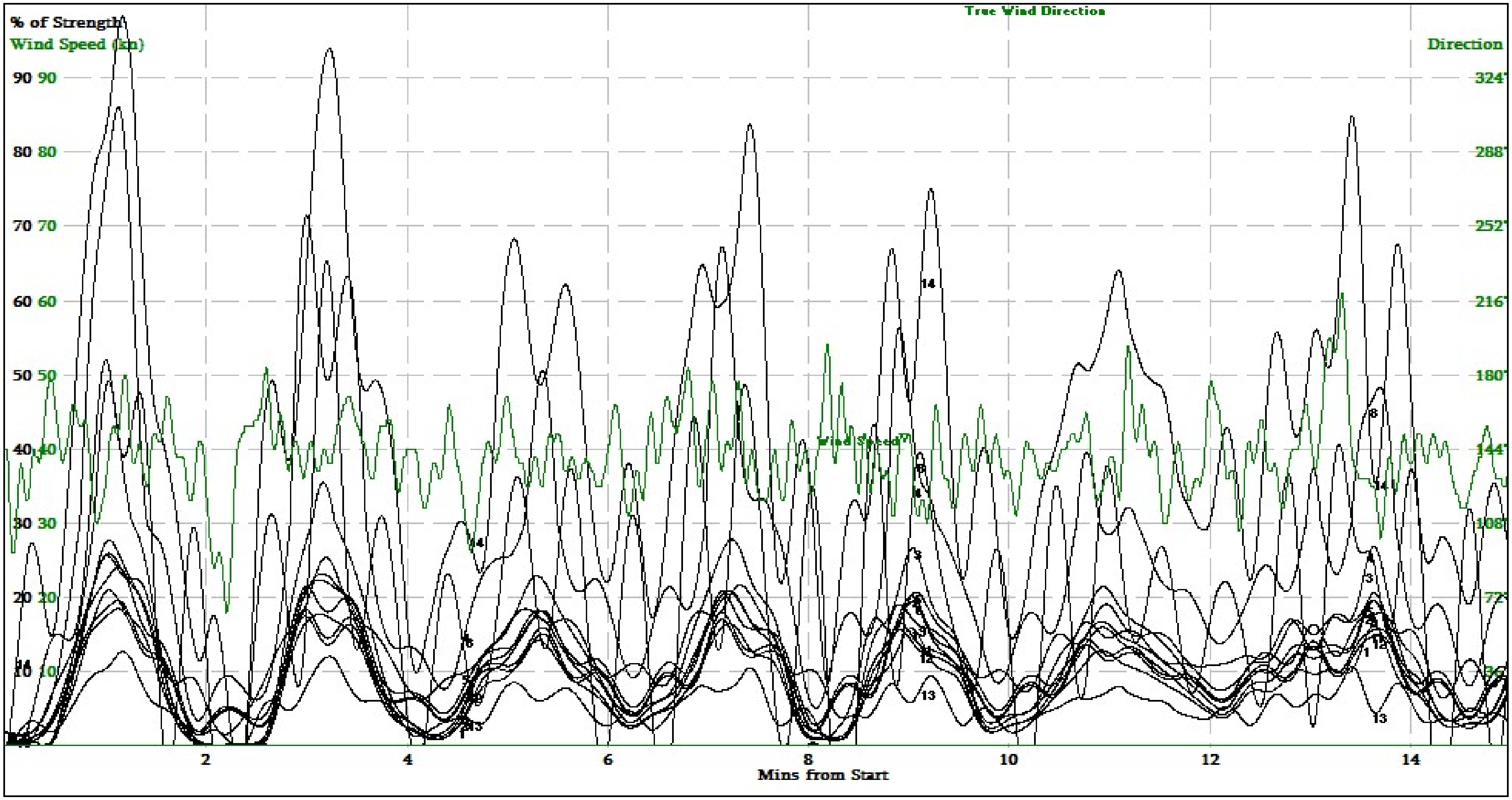
```
Analysis for Time: 1200 Feb 01 2017
              Ref: 167543.00
          Remarks: Alameda Point Naval Reserve
      Water Level:   0.00 above datum
            Draft:  19.4
             Trim:   0.0
```



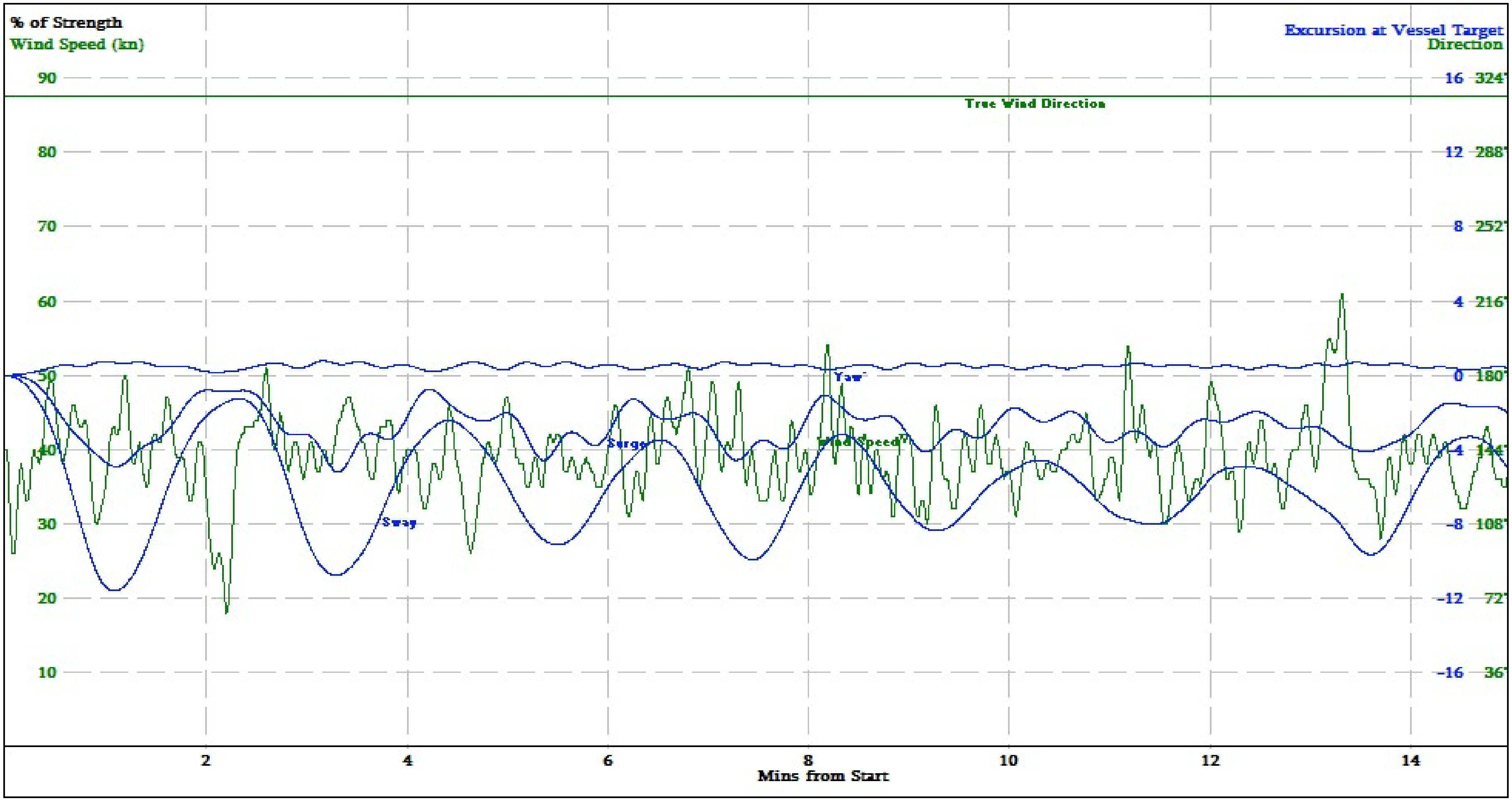
Cape Orlando 0°



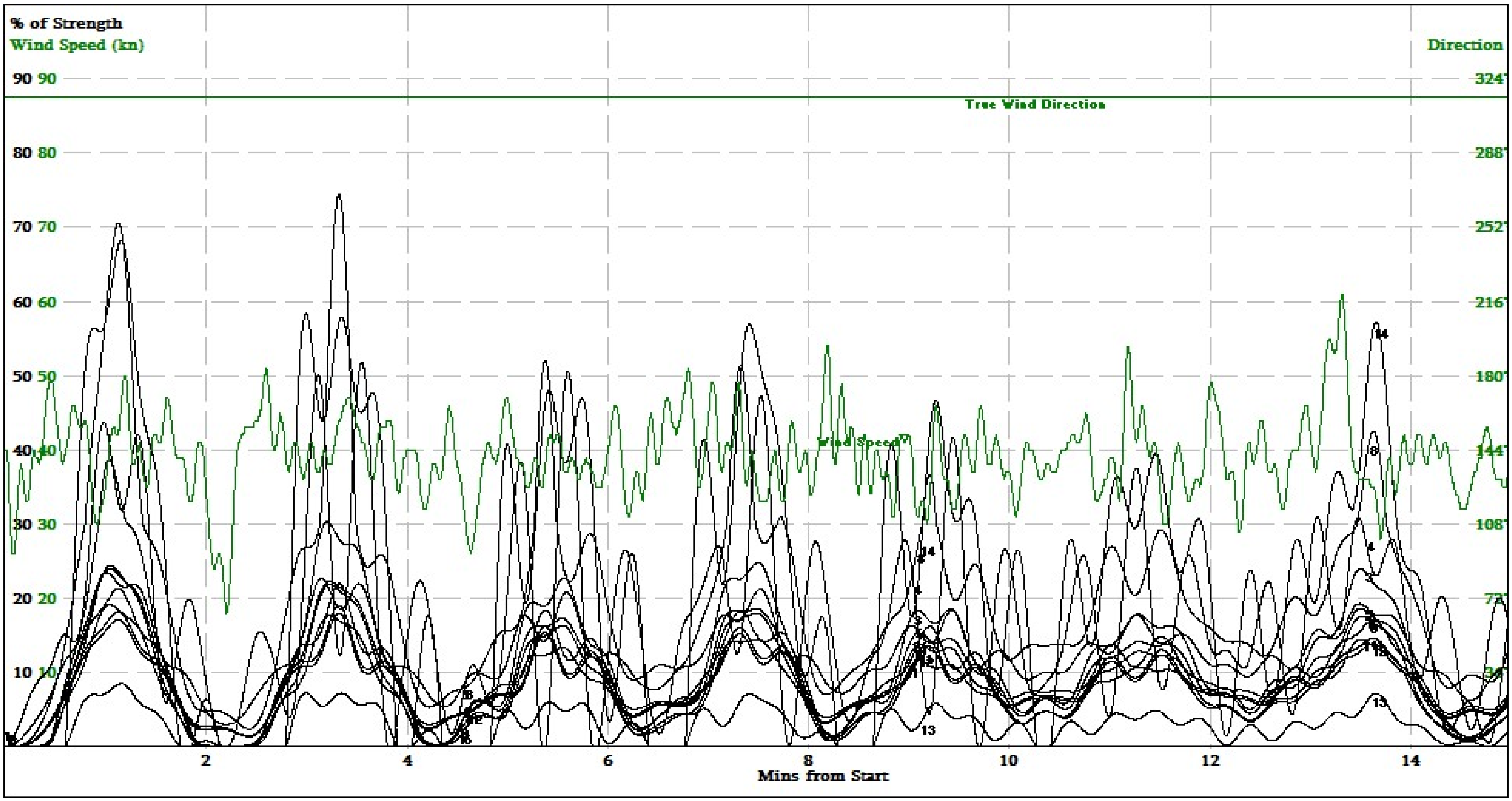
Cape Orlando 0°



Cape Orlando 315°

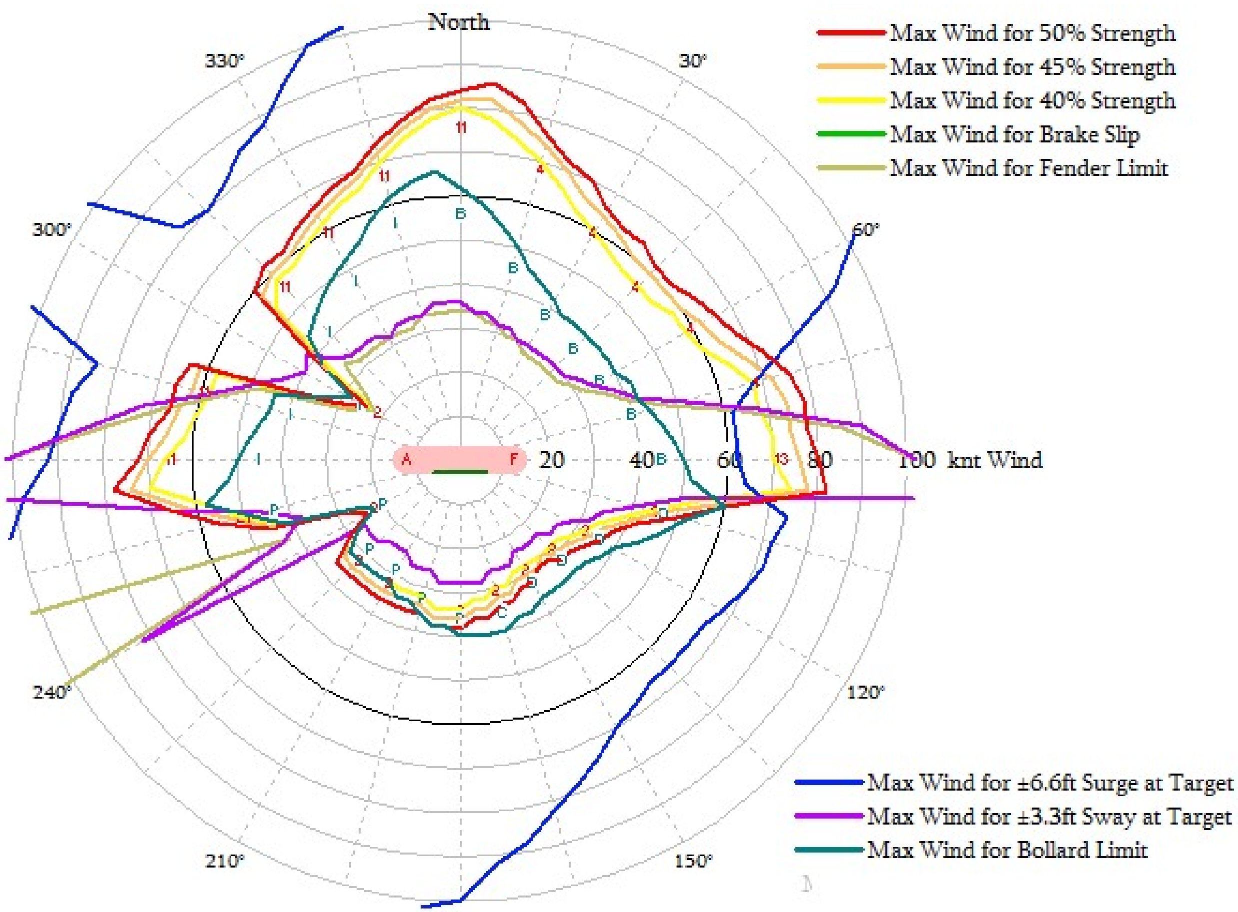


Cape Orlando 315°

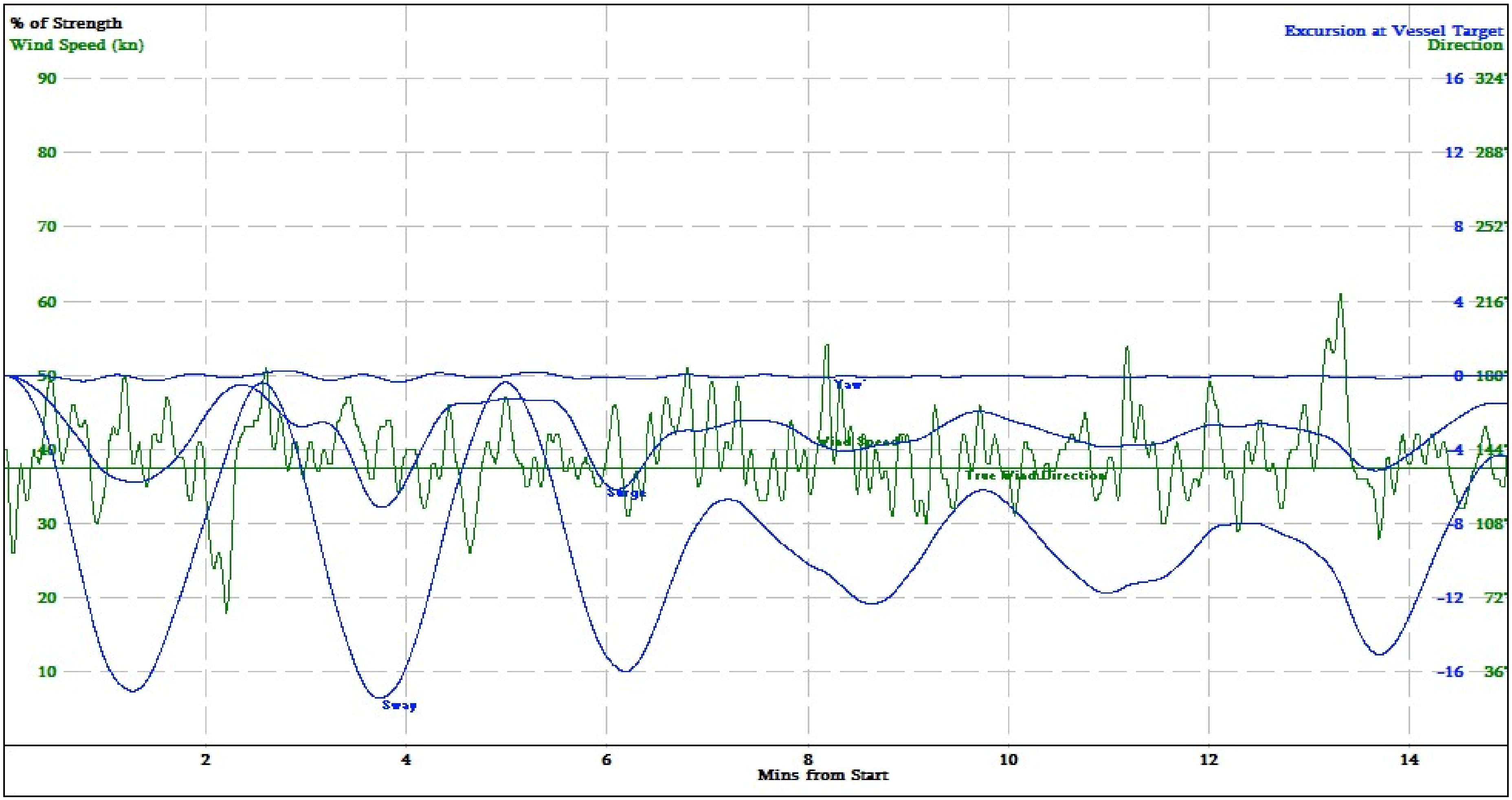


Wind Capability Rose for Capella - Algol at Berth 7-8 Pier 2

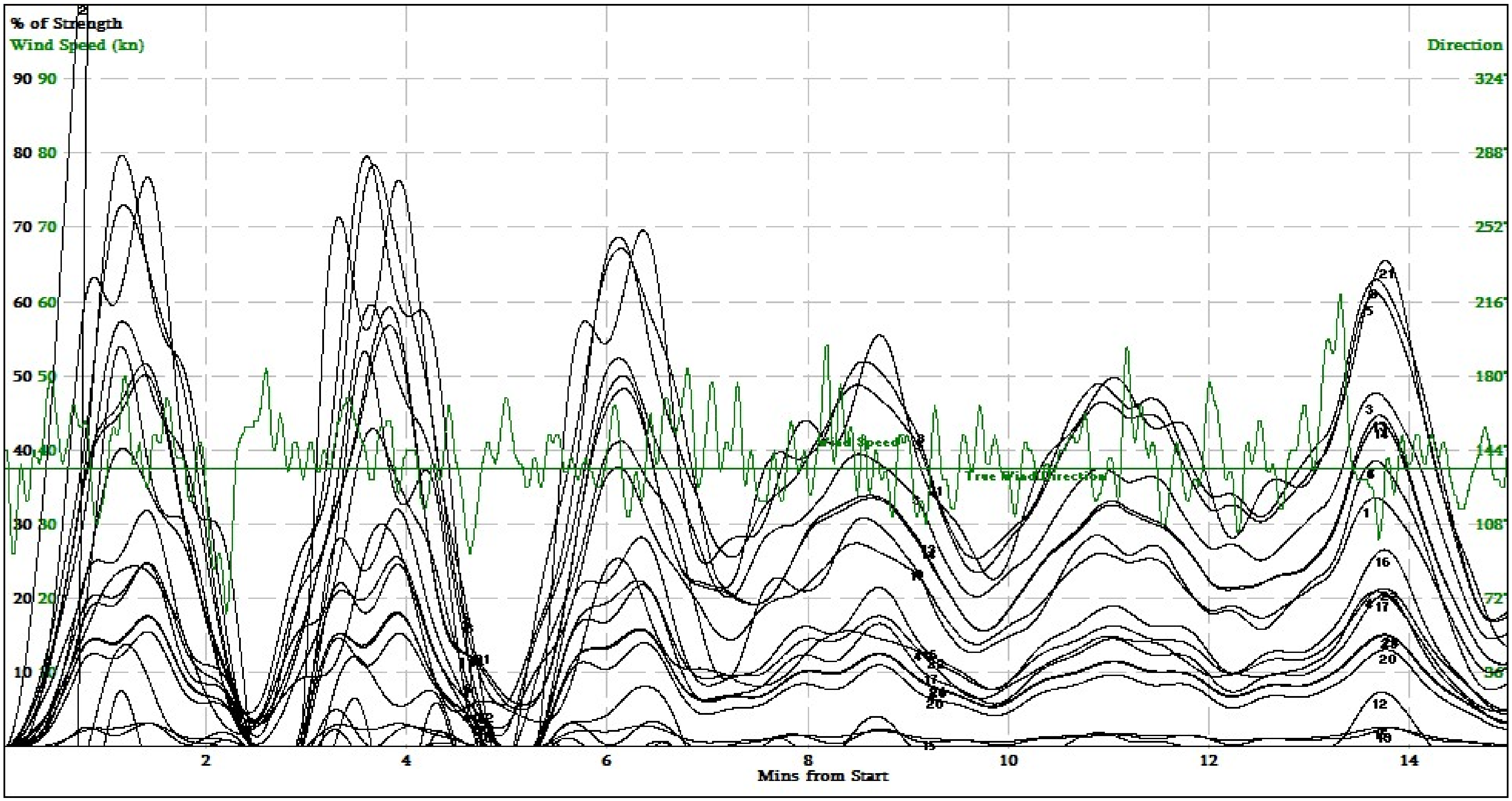
```
Analysis for Time: 1200 Apr 28 2016
              Ref: 167543.00
          Remarks: Alameda Point Naval Reserve
      Water Level:   0.00 above datum
            Draft:  26.5
             Trim:   0.0
```



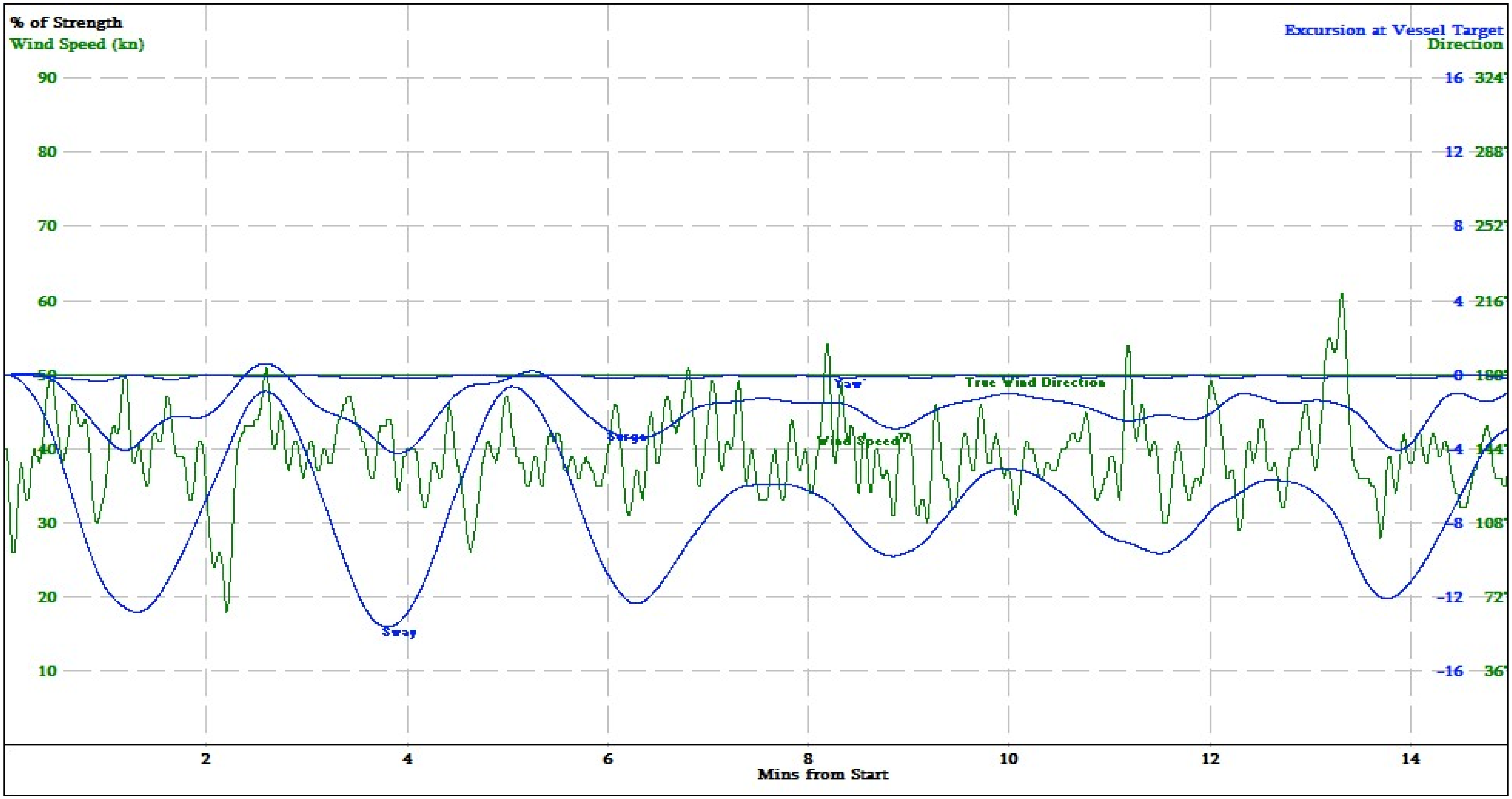
Algol & Capella 135°



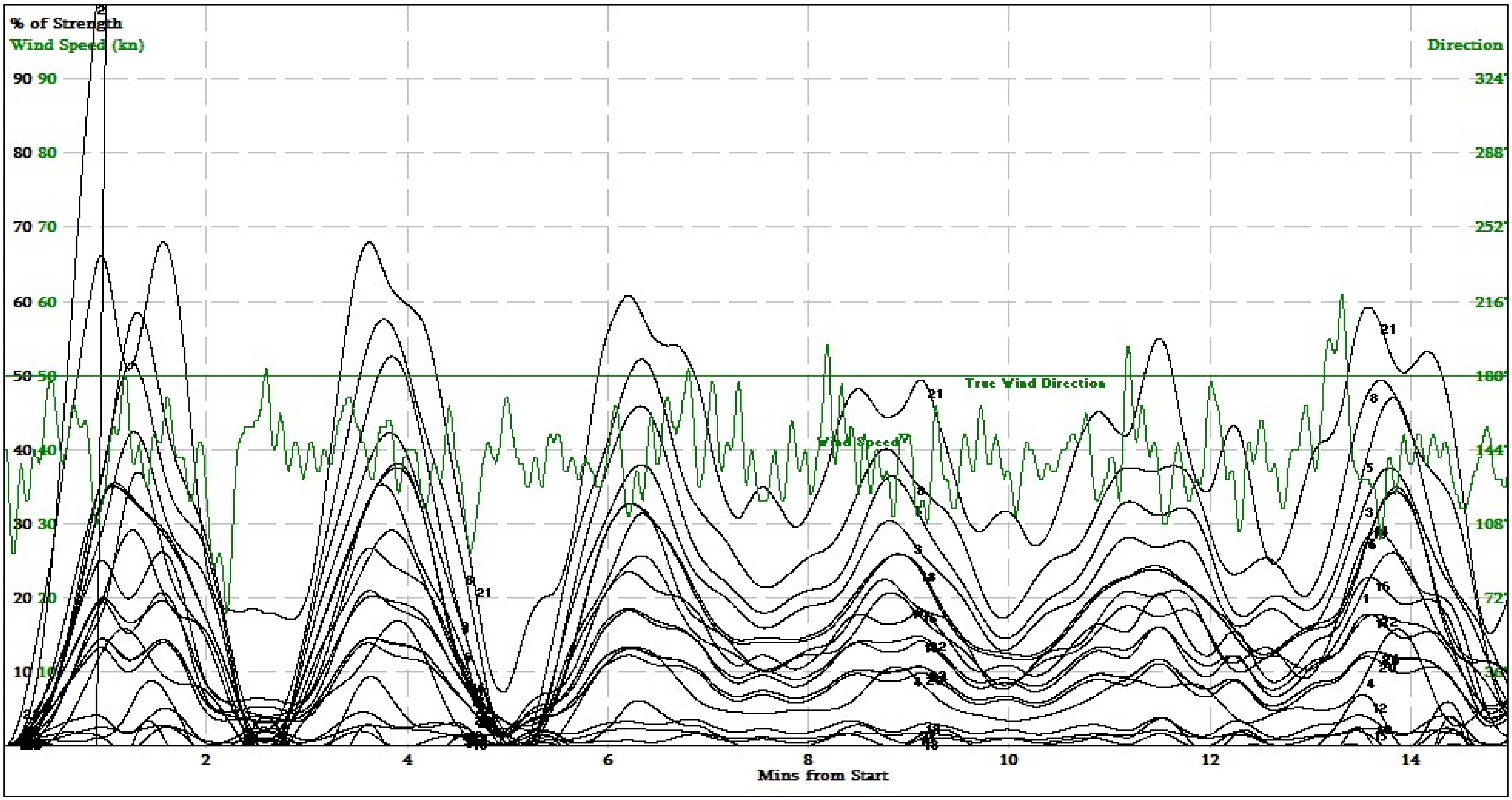
Algol & Capella 135°



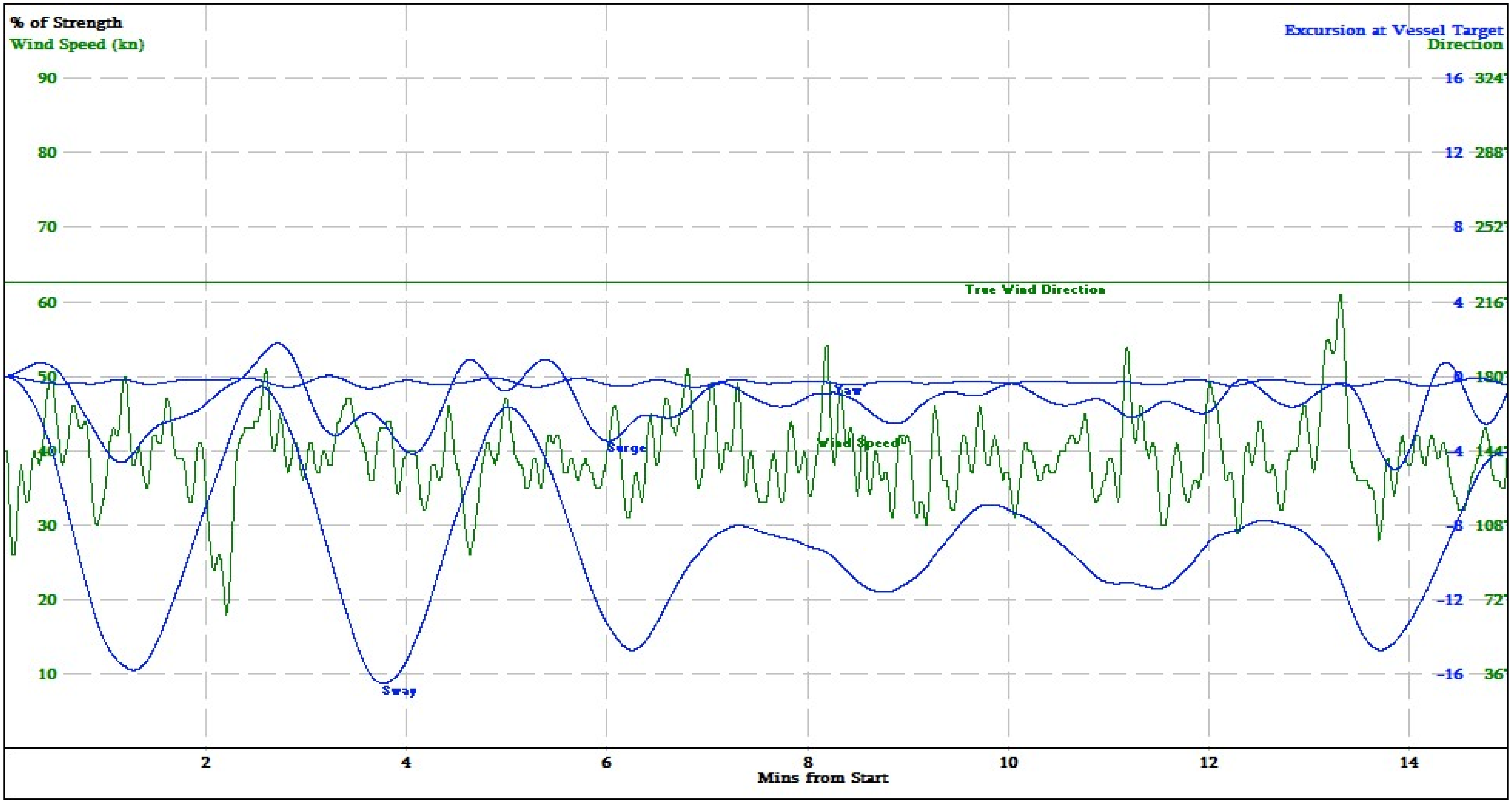
Algol & Capella 180°



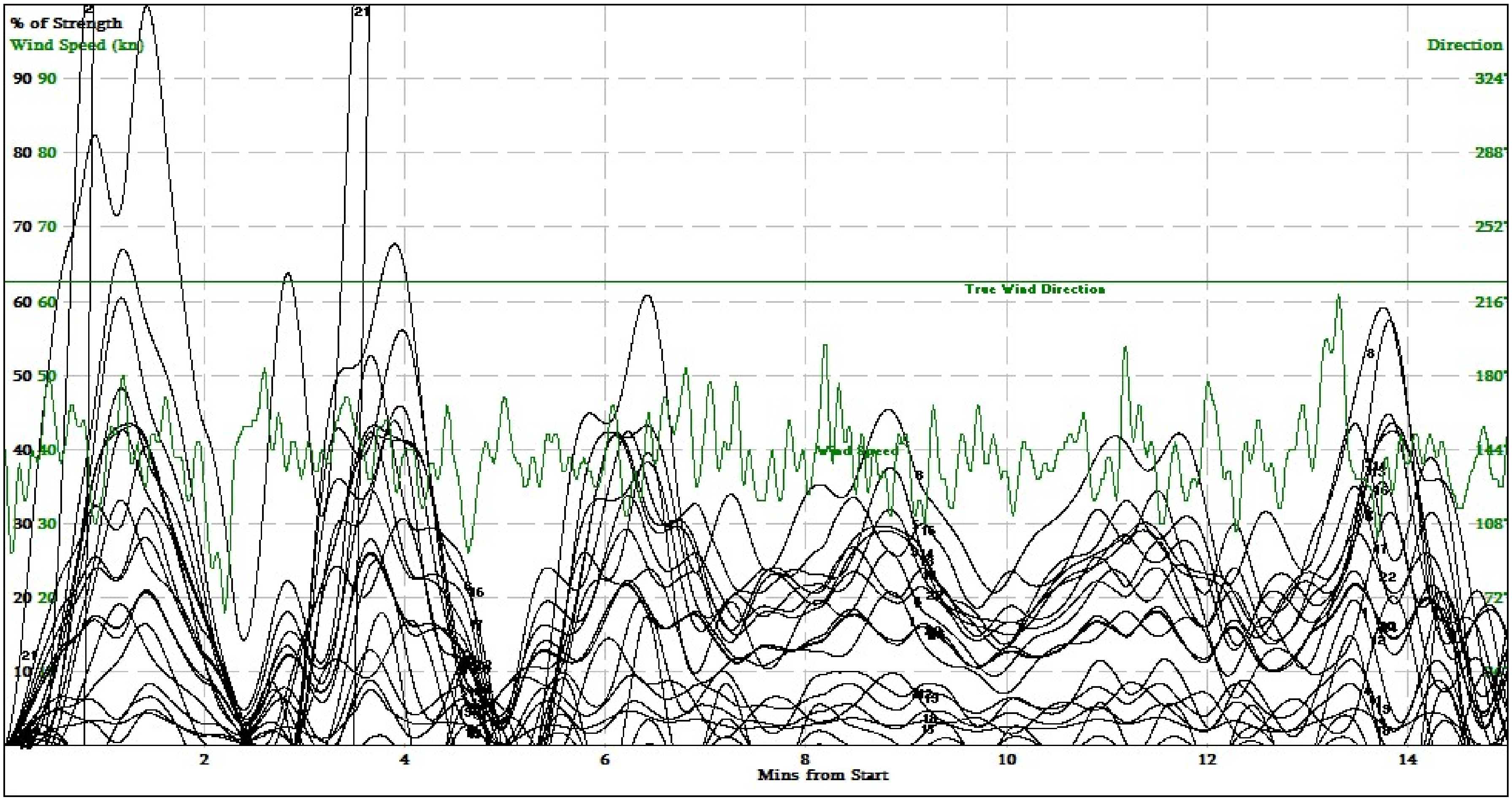
Algol & Capella 180°



Algol & Capella 235°

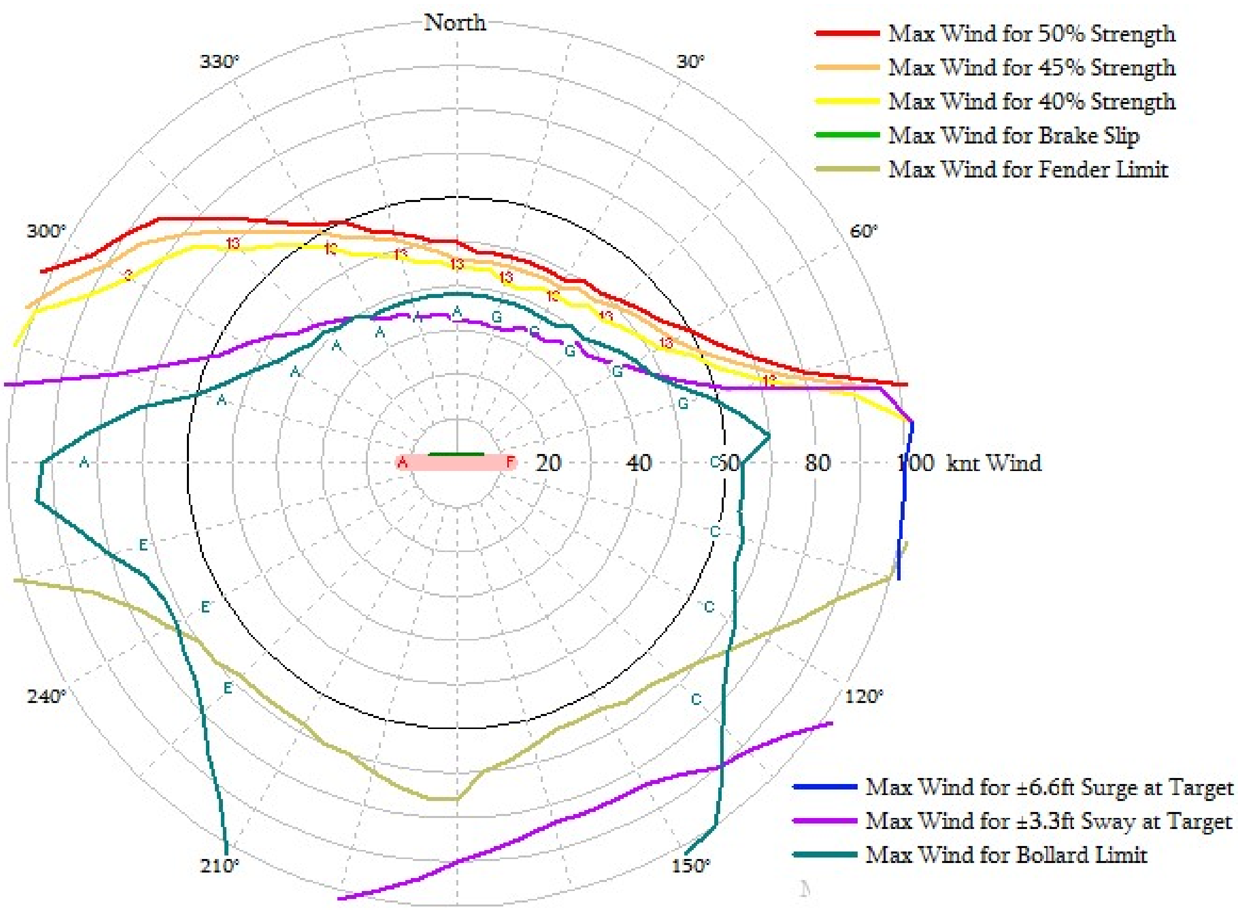


Algol & Capella 235°

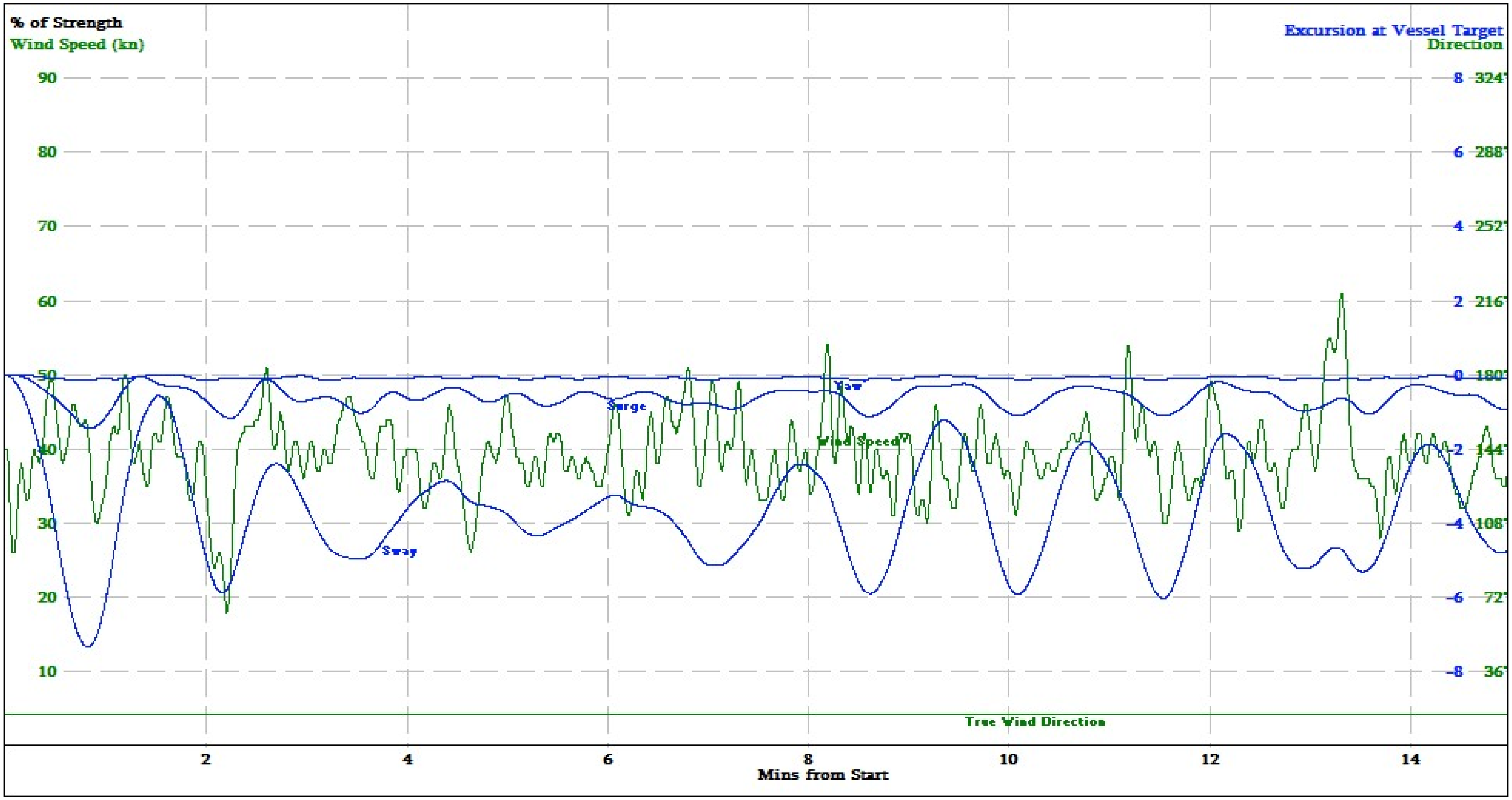


Wind Capability Rose for Admiral Callaghan at Berth 9 Pier 2

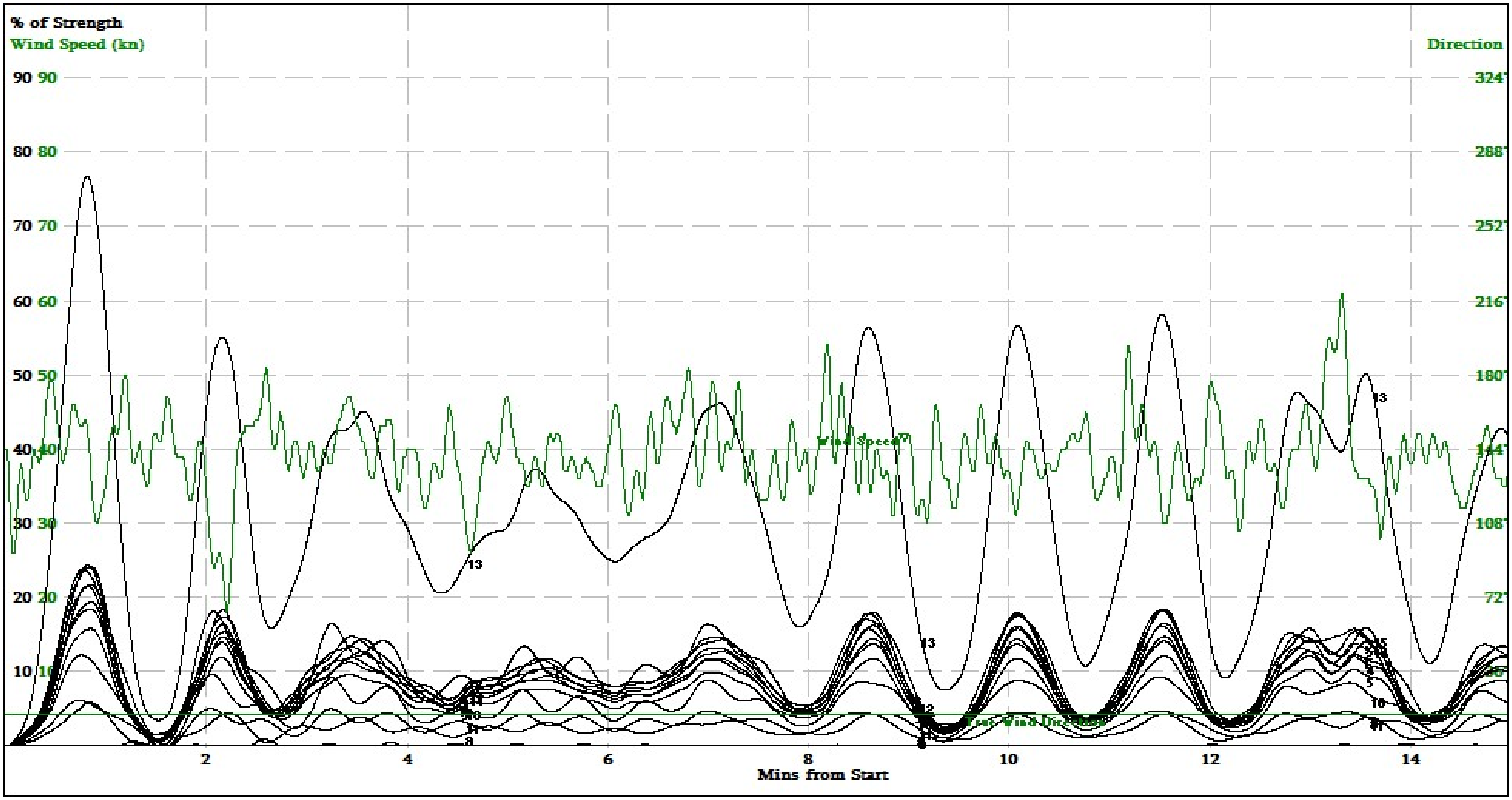
```
Analysis for Time: 1200 Apr 28 2016
              Ref: 167543.00
          Remarks: Alameda Point Naval Reserve
      Water Level:   0.00 above datum
            Draft:  20.5
             Trim:   0.0
```



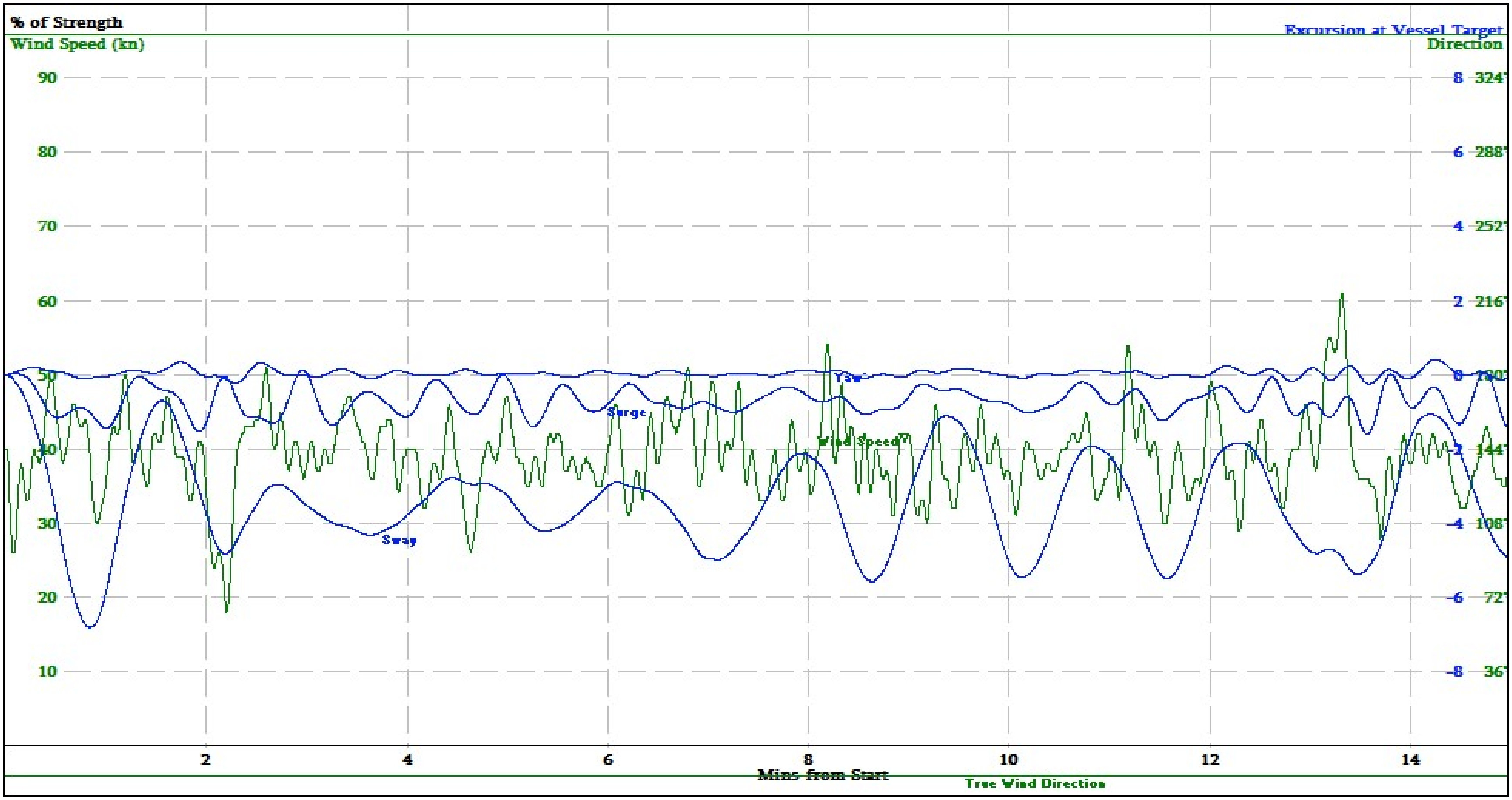
Admiral Callaghan 15°



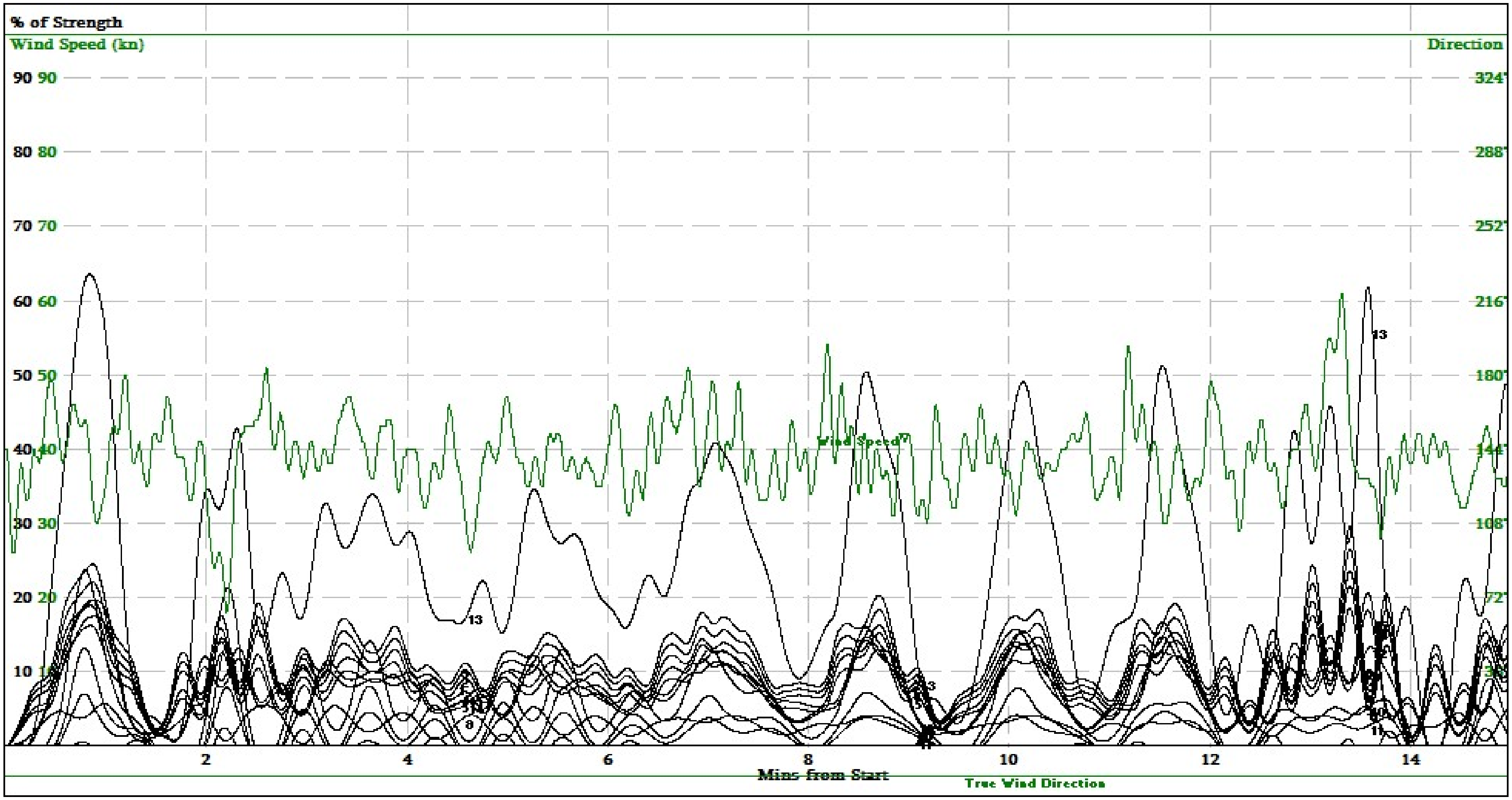
Admiral Callaghan 15°



Admiral Callaghan 345°

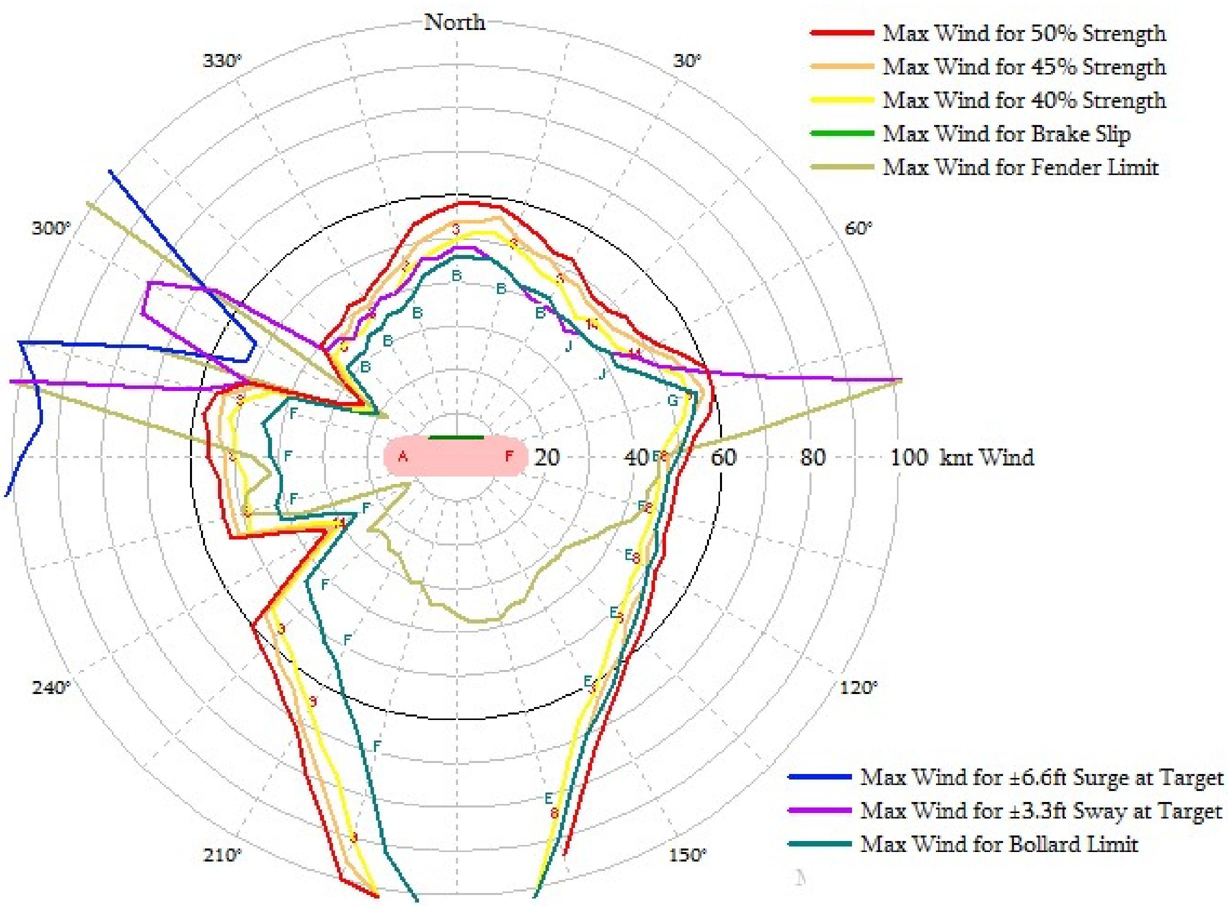


Admiral Callaghan 345°

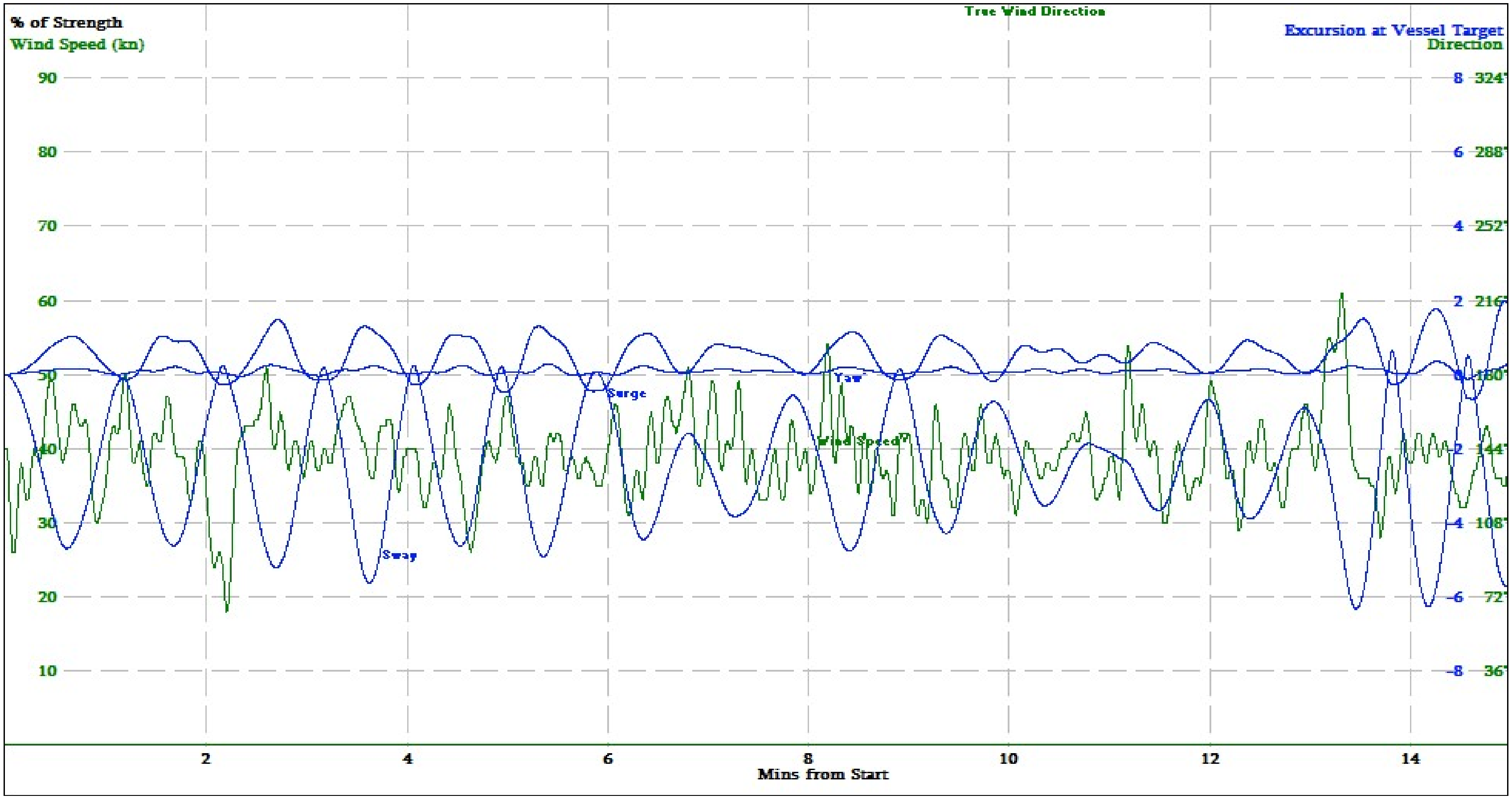


Wind Capability Rose for All State Classes at Berth 10 Pier 2

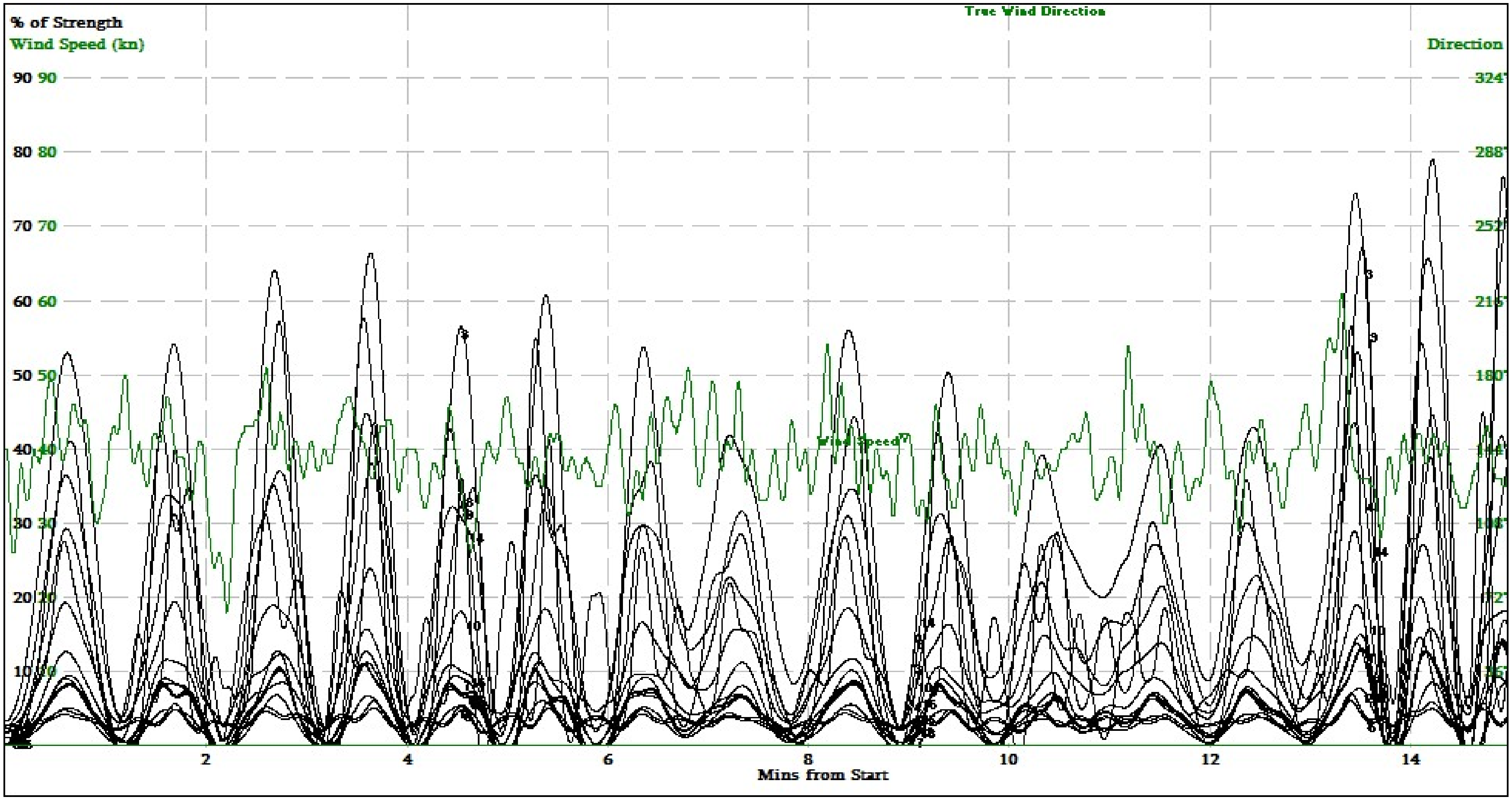
```
Analysis for Time: 1200 Apr 28 2016
              Ref: 167543.00
          Remarks: Alameda Point Naval Reserve
      Water Level:   0.00 above datum
            Draft:  18.0
             Trim:   0.0
```



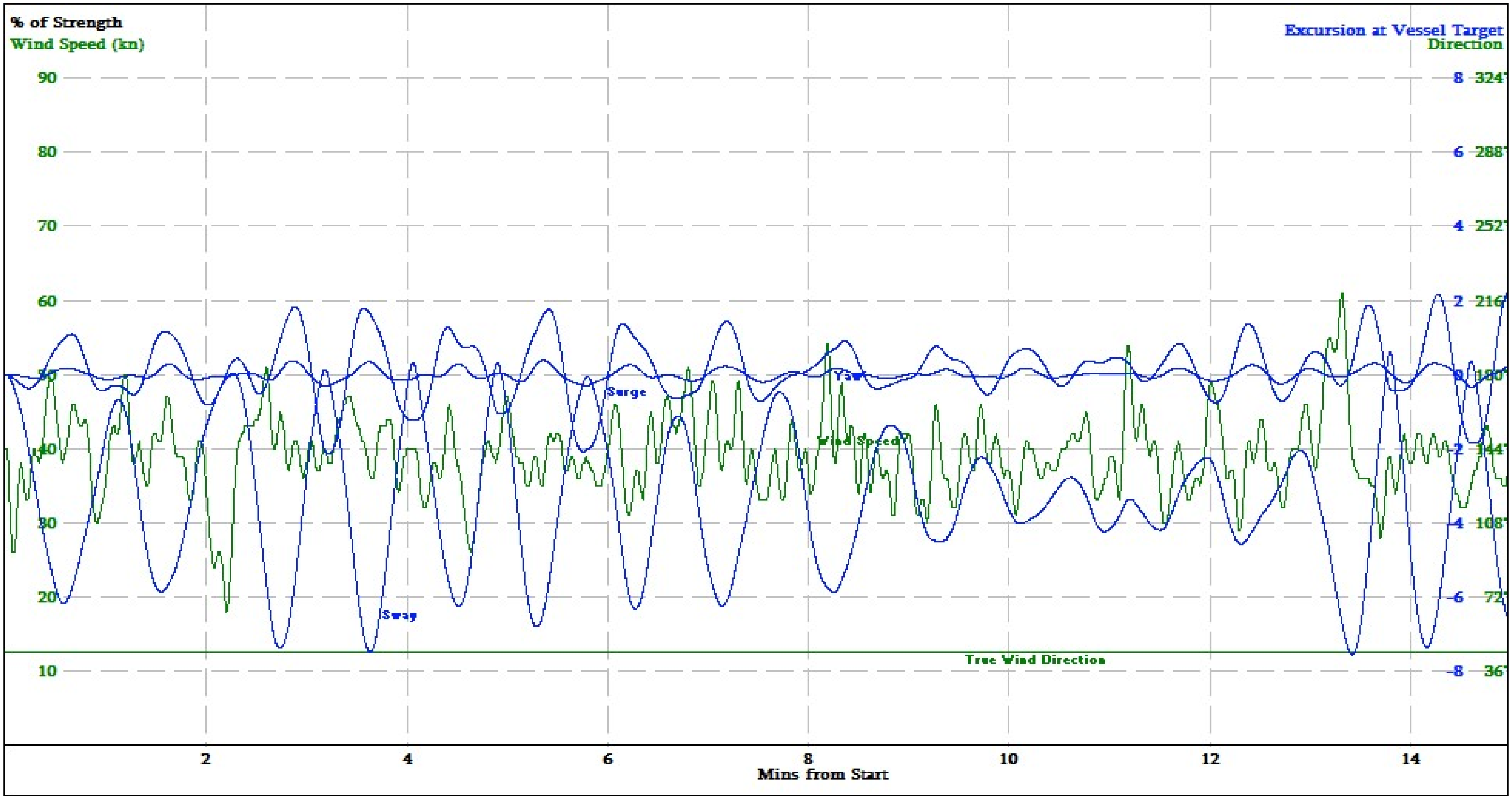
All State Classes 0°



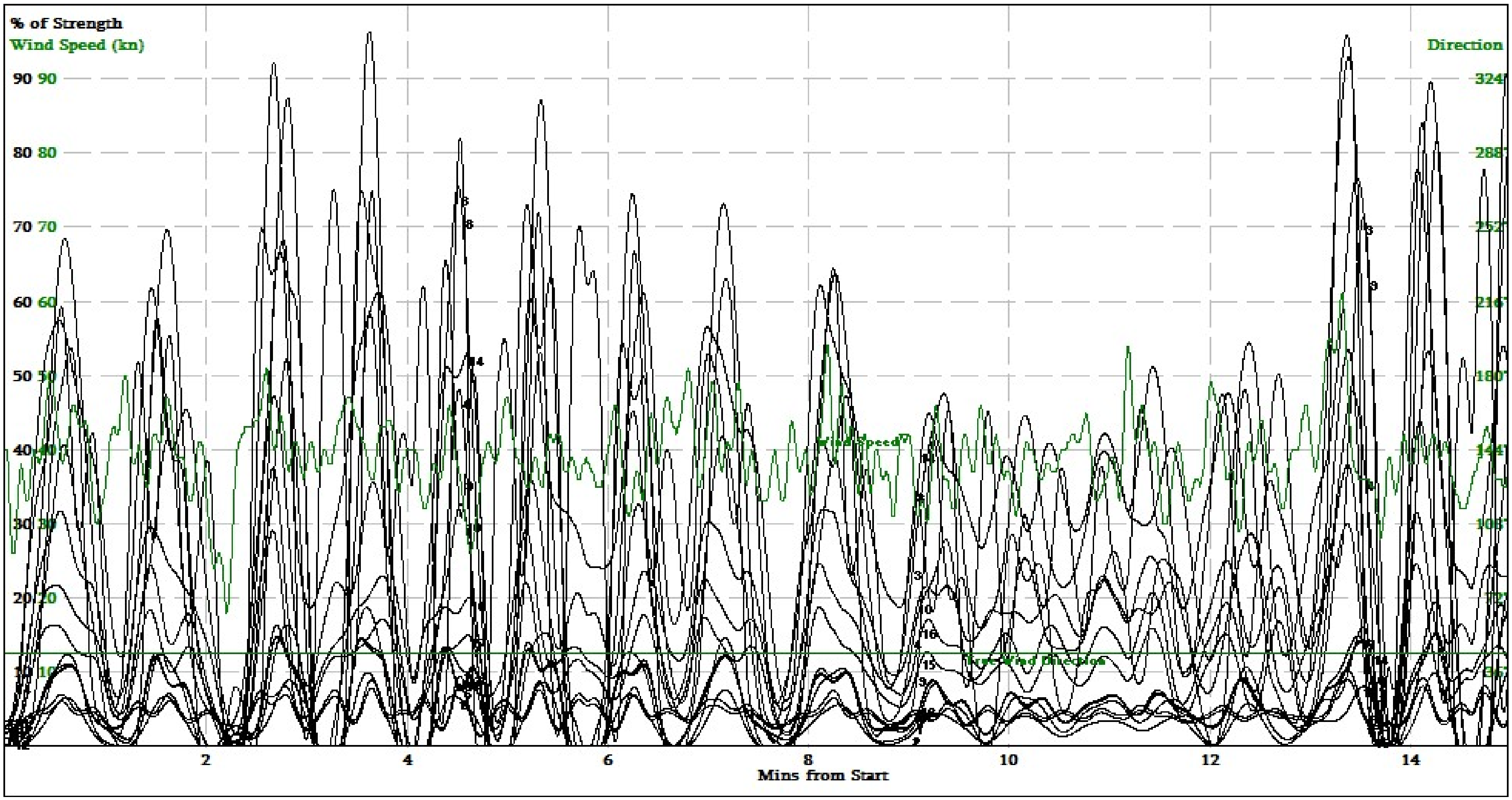
All State Classes 0°



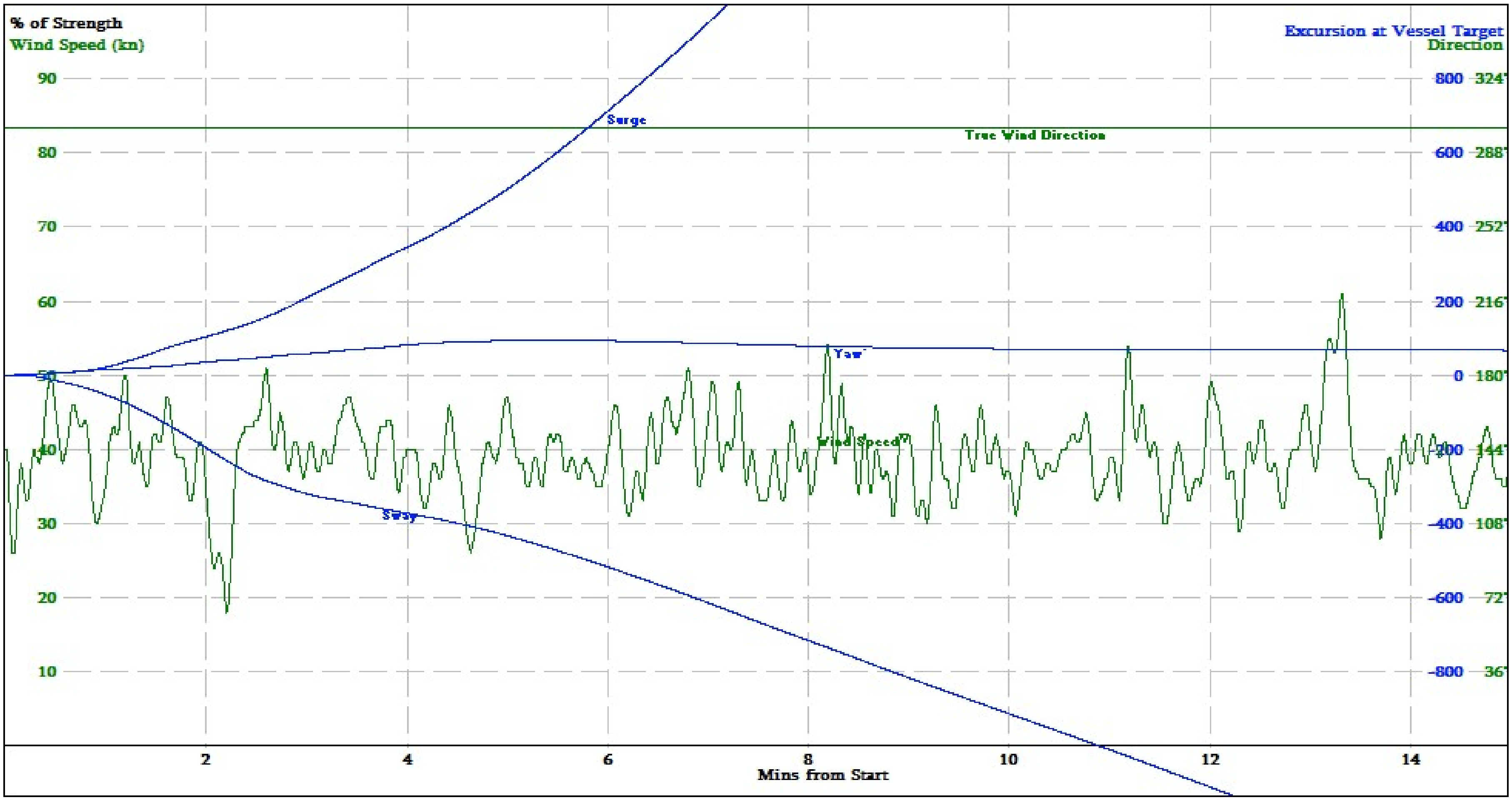
All State Classes 45°



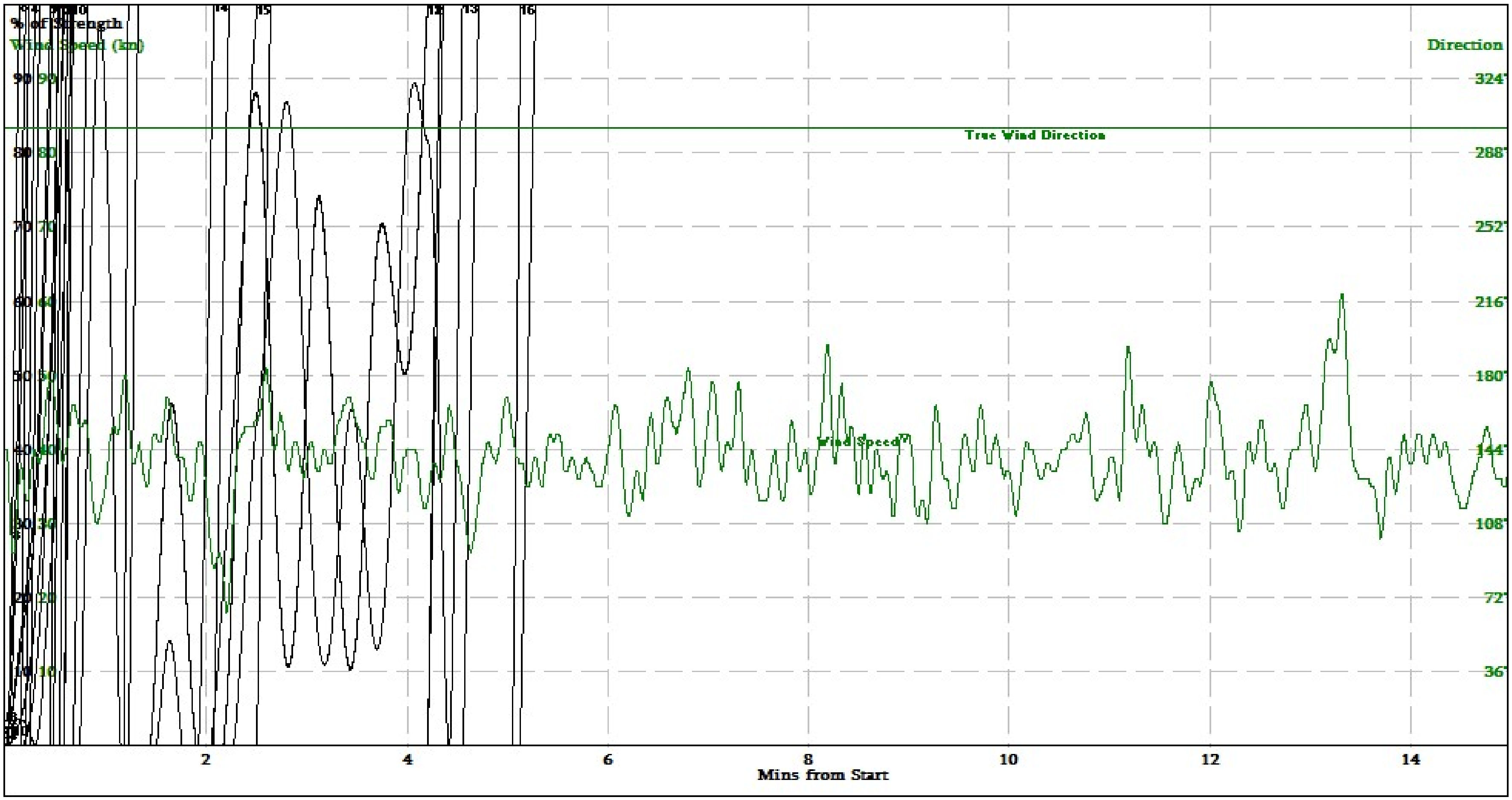
All State Classes 45°



All State Classes 300°

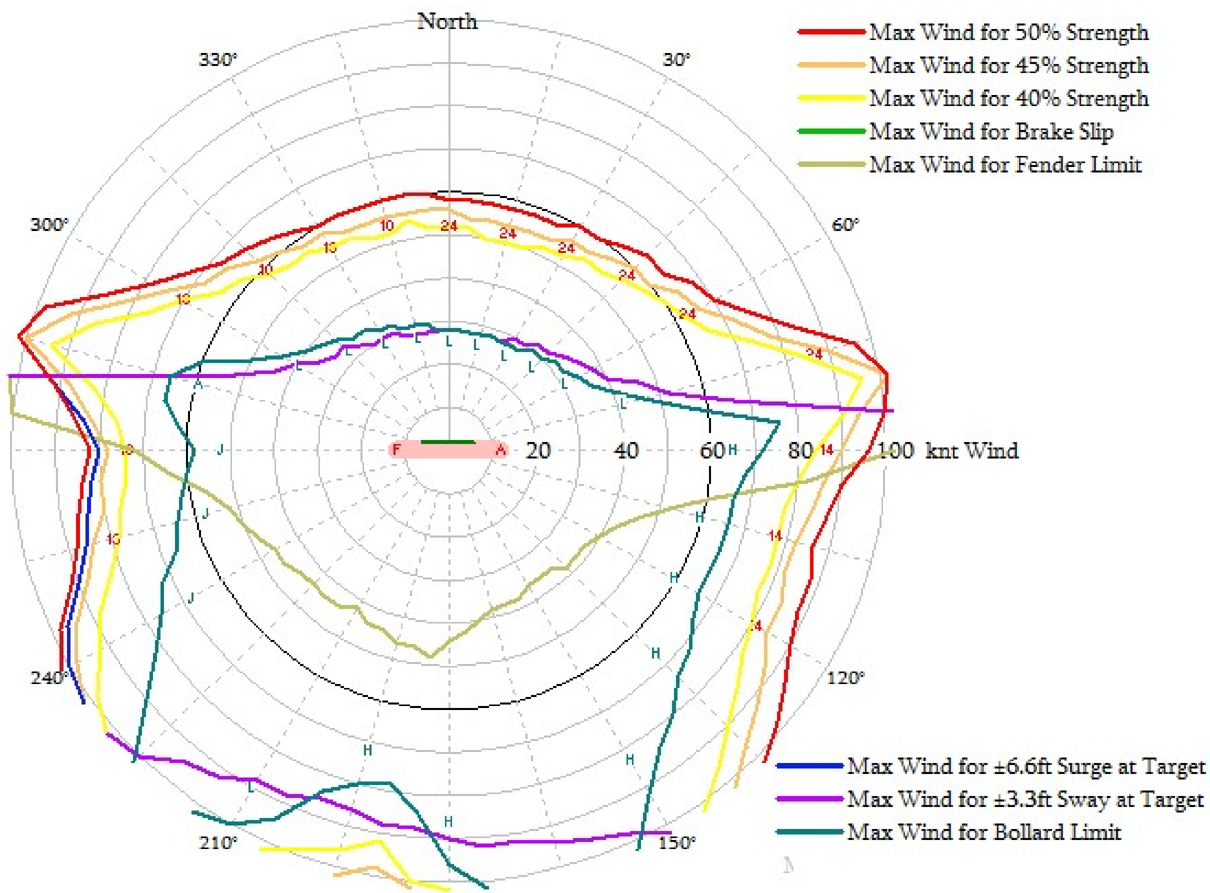


All State Classes 300°

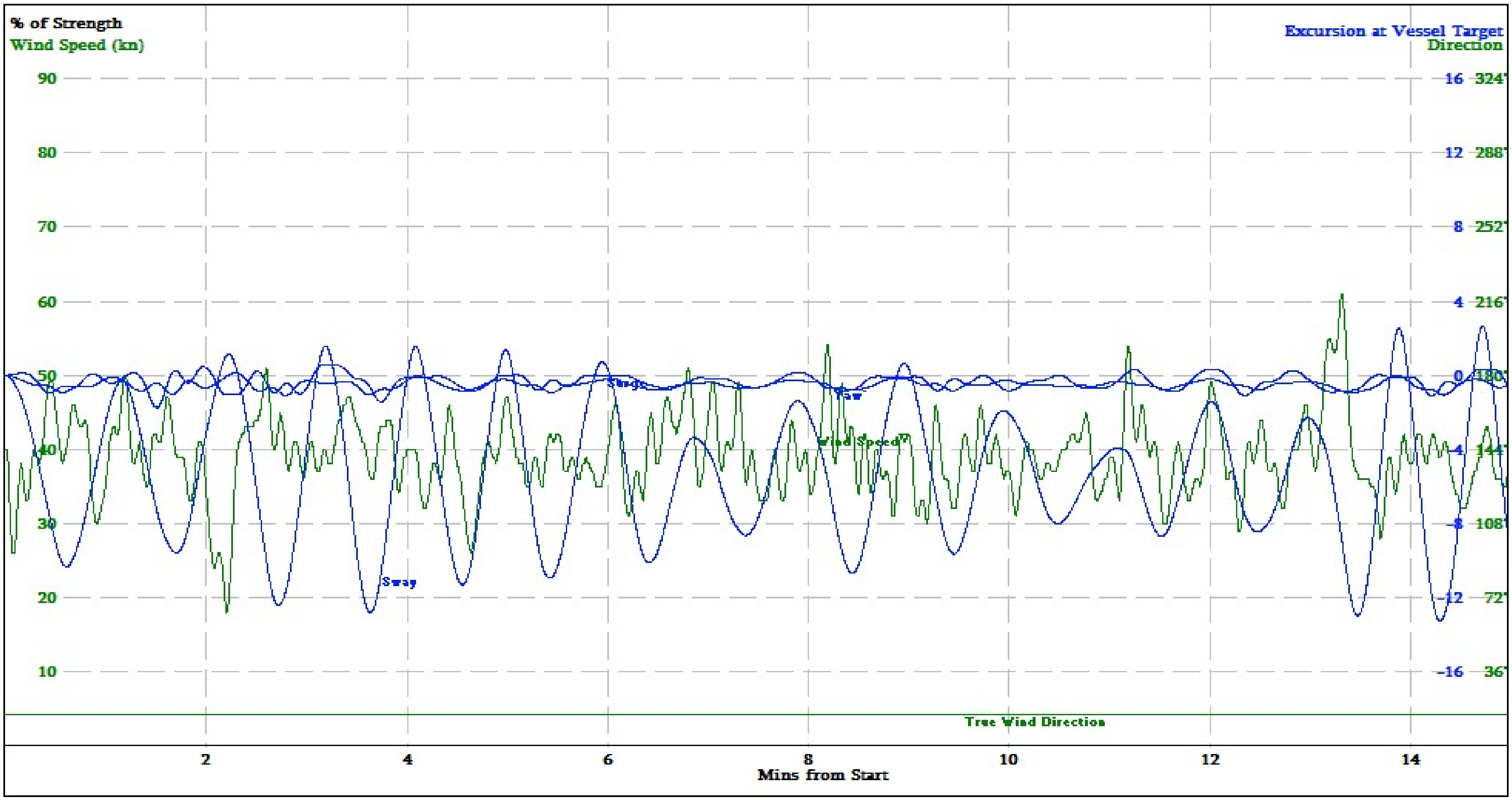


Wind Capability Rose for Cape Henry at Berth 16 Pier 3

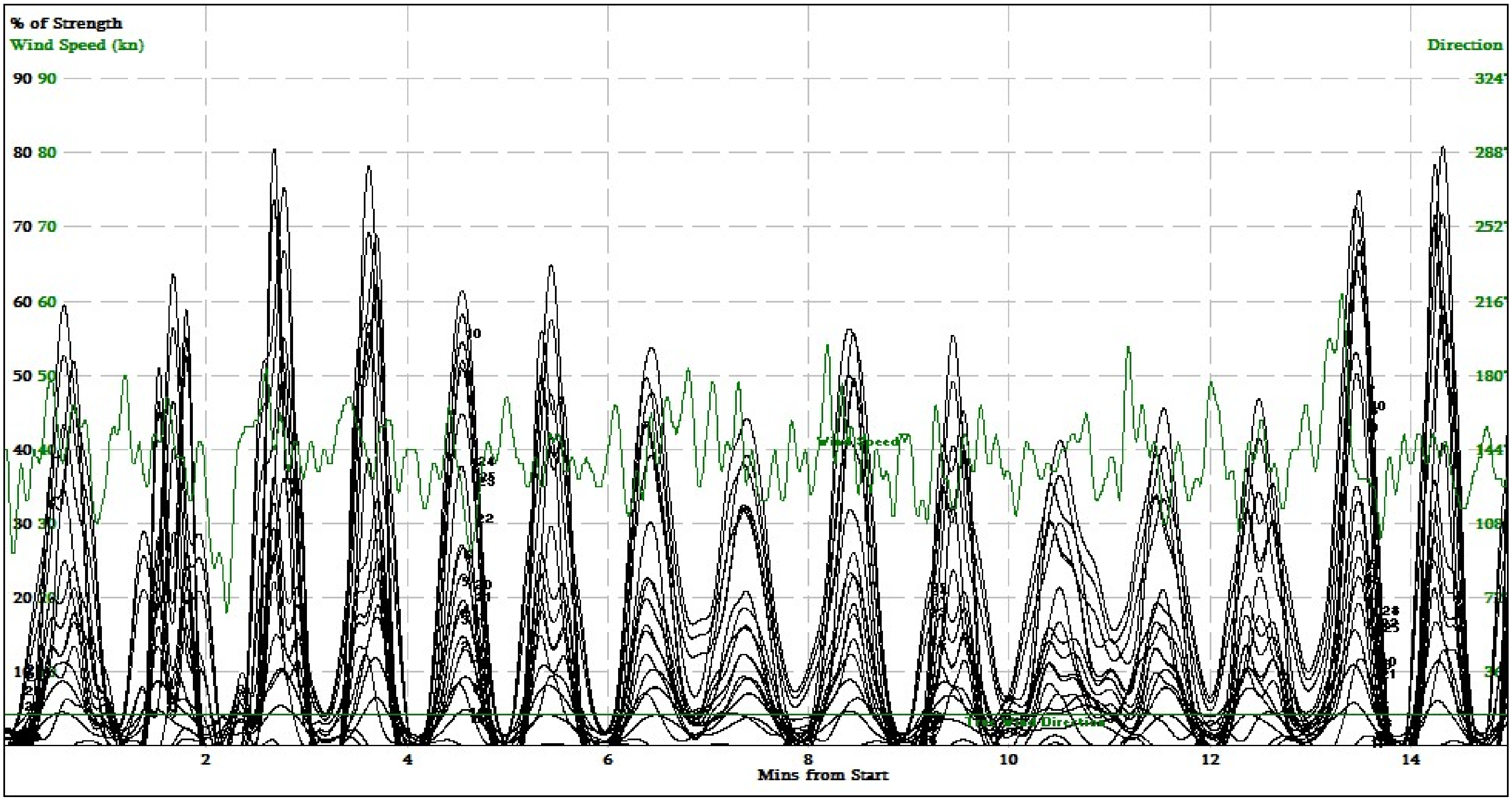
```
Analysis for Time: 1200 Apr 28 2016
              Ref: 167543.00
          Remarks: Alameda Point Naval Reserve
      Water Level:   0.00 above datum
            Draft:  19.7
             Trim:   0.0
```



Cape Henry 15°

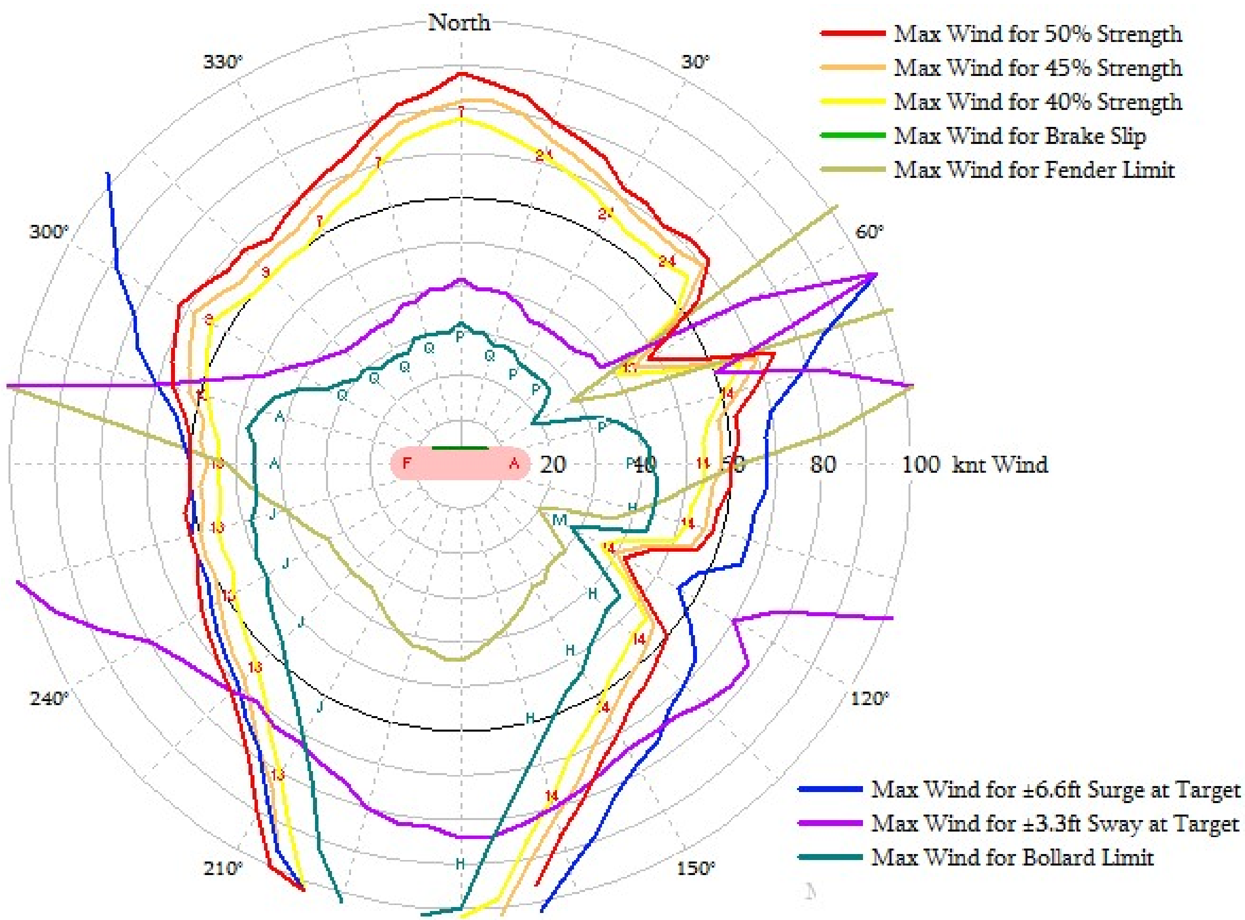


Cape Henry 15°

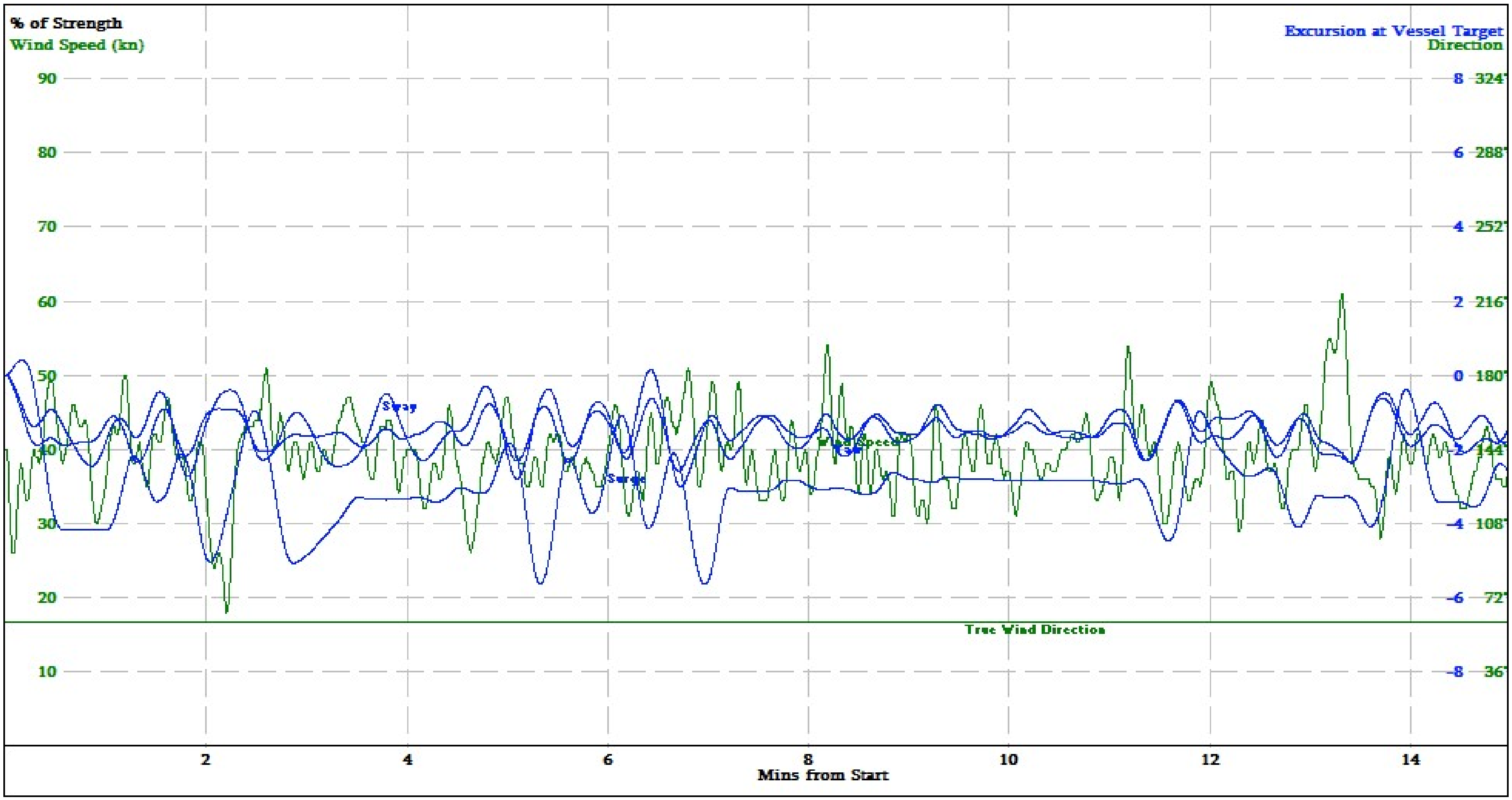


Wind Capability Rose for Henry - Mohican at Berth 16 Pier 3

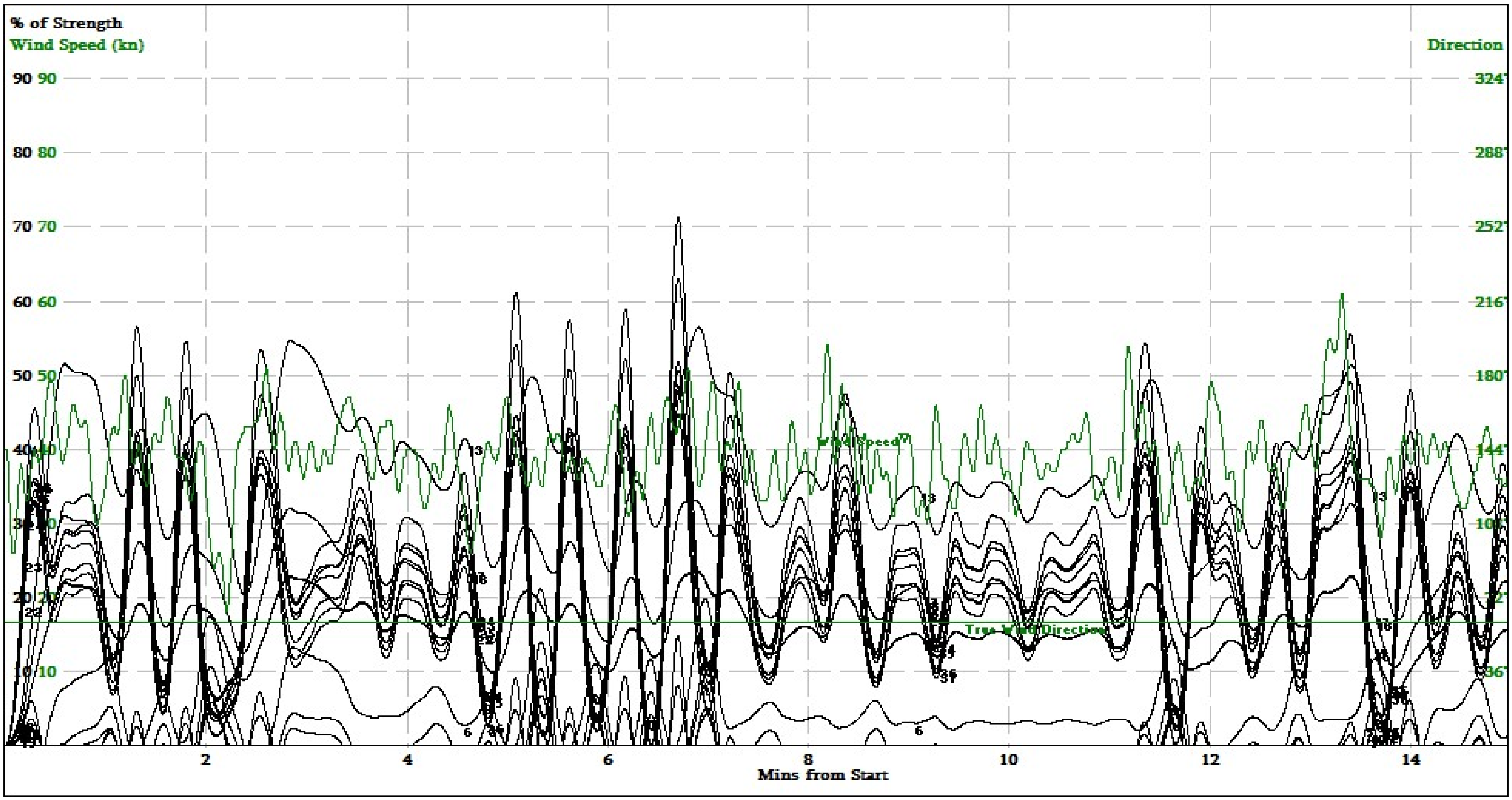
```
Analysis for Time: 1200 Apr 28 2016
              Ref: 167543.00
          Remarks: Alameda Point Naval Reserve
      Water Level:   0.00 above datum
            Draft:  19.7
             Trim:   0.0
```



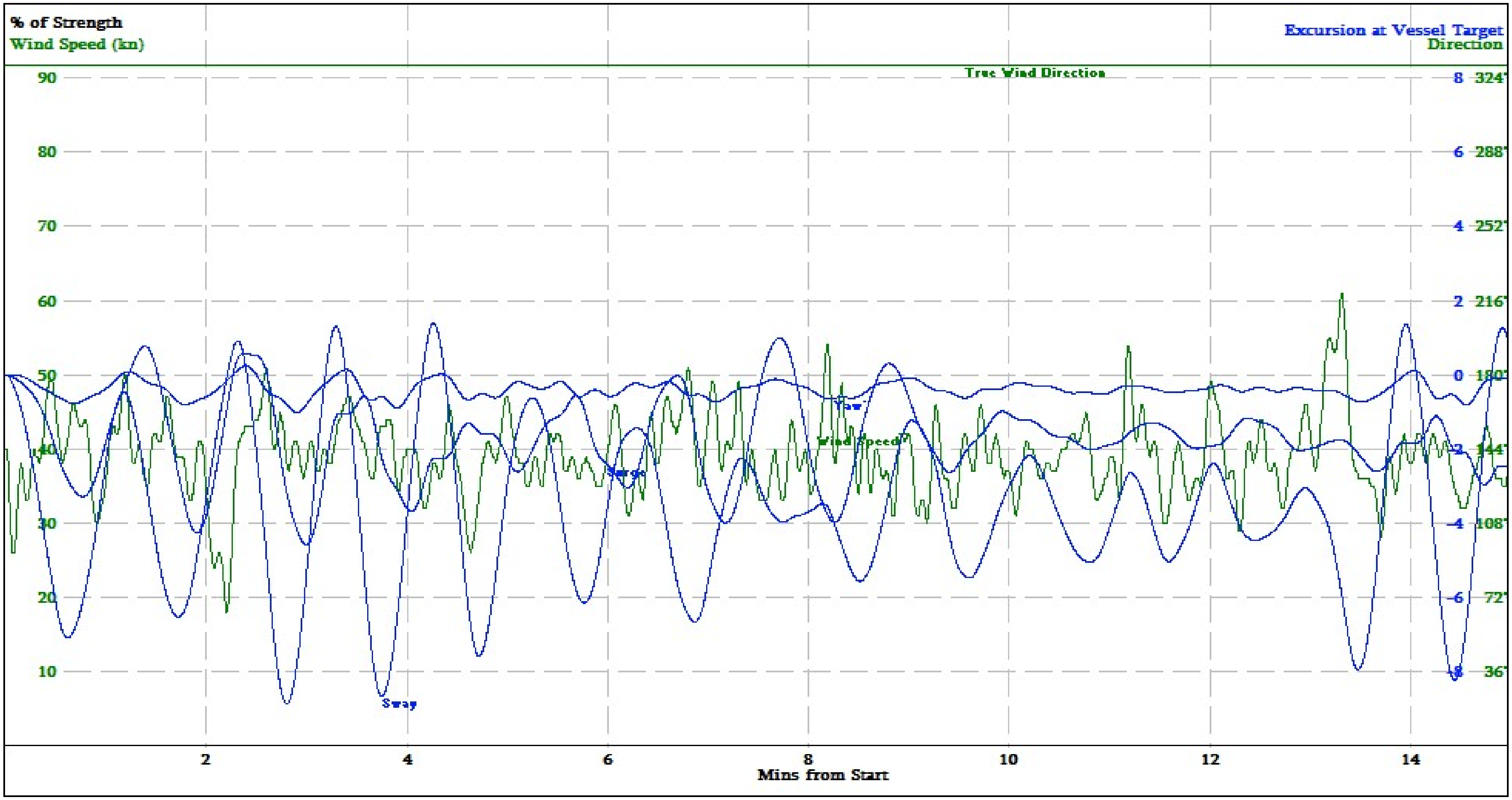
Cape Henry & Cape Mohican 60°



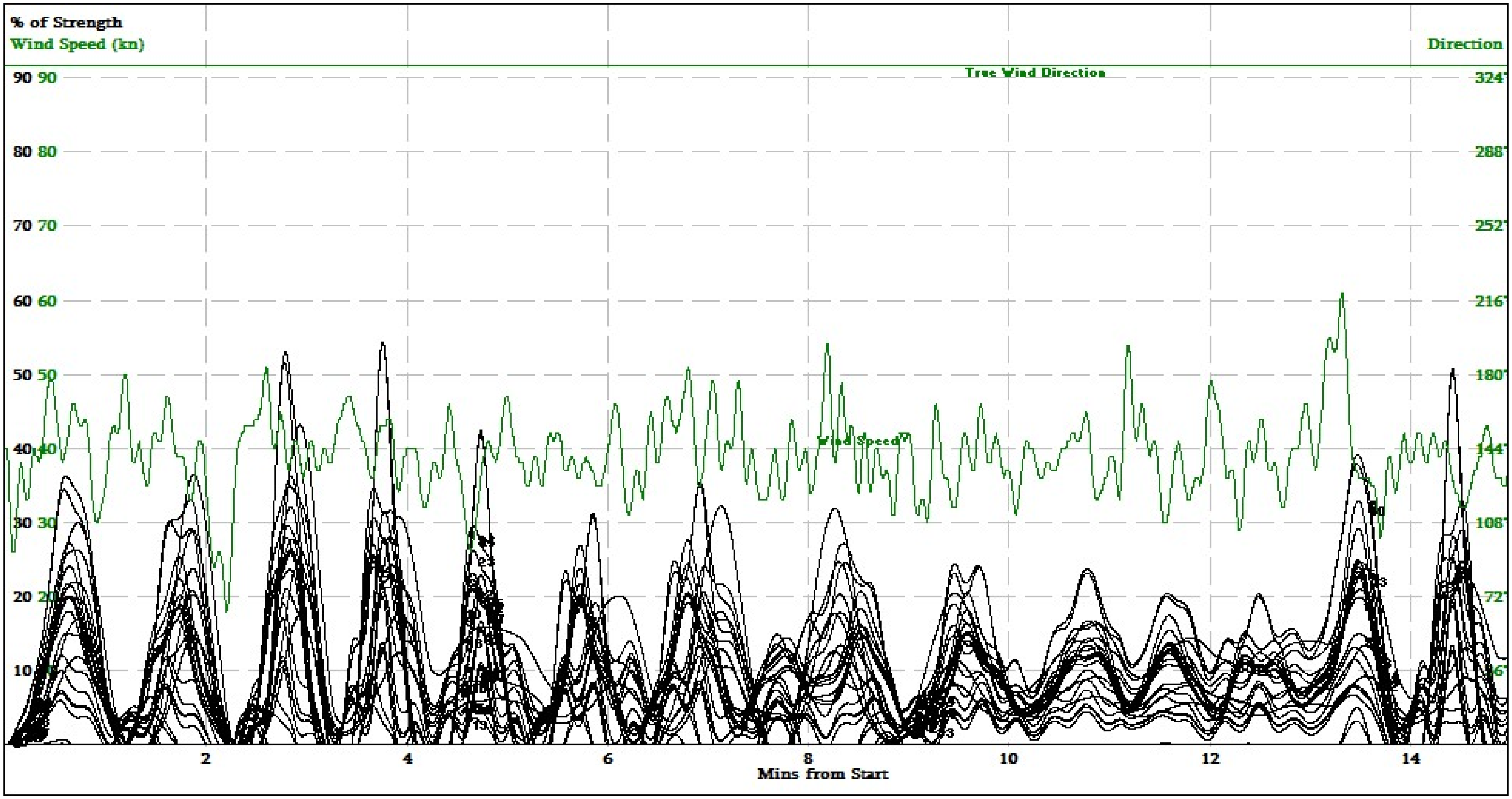
Cape Henry & Cape Mohican 60°



Cape Henry & Cape Mohican 330°



Cape Henry & Cape Mohican 330°



APPENDIX E

Preliminary Analysis: Structural Calculation Package of Piers 1, 2, and 3

Structural Calculations- Alameda Point Piers 1, 2, and 3

Alameda Point Piers
Alameda, CA
7 April 2017

SGH Project 167543

SIMPSON GUMPERTZ & HEGER

Engineering of Structures
and Building Enclosures

PREPARED FOR:

City of Alameda
950 West Mall Square
Alameda, California

PREPARED BY:

500 12th Street, Suite 270
Oakland, CA 94607
Tel: 510.457.4600
Fax: 510.457.4599

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

SHEET NO. ____

PROJECT NO. 167543.00 ALPR

DATE 04 April 2017

BY ERM

CHECKED BY RI

CLIENT City of Alameda

SUBJECT Alameda Piers Structural Calculations Package

INDEX TO CALCULATIONS:

LOADS

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

CLIENT City of Alameda

SUBJECT Pier Nominal Loads

SHEET NO. ______

PROJECT NO. 167543.00 ALPR

DATE 04 April 2017

BY ERM

CHECKED BY RI

PIER NOMINAL LOADS

INTRODUCTION

The following calculations are performed to determine the nominal, dead, live, and mooring loads on Pier No. 1. The MARAD Lease Requriements will be used as a guideline for determining minimum load requirements. However, other load considerations not outlined in the MARAD Requirements will be obtained from the United Facilities Criteria (UFC). The loads calculated below will be used to run various analyses on the pier.

REFERENCES

- *Maritime Administration (MARAD) Lease Requirements*
- *United Facilites Criteria - Design: Piers & Warves (UFC 4-152-03)*
- *United Facilites Criteria - Design: Moorings (UFC 4-159-03)*
- *AASHTO LRFD Bridge Design Specifications 2012 (AASHTO BDS)*

DEAD LOADS

Only the weight of the deck slab is calculated below as the self-weight of the pile cap and piles will automatically be calculated in the SAP2000 model of the pier. Since the three piers have varying thicknesses, loads for varying thicknesses are calculated below.

Deck Slab Thickness	t_{slab}	8	9	10	in
Deck Area Dead Load	p_{deck}	100.0	112.5	125.0	psf

LIVE LOADS

Minimum required live loads are obtained from UFC 4-152. Both a uniform area live load and concentrated truck loads are considered in this analysis in their appropriate load combinations.

Area Live Load p_L 425 psf MARAD Lease Requirements, pg. A-3

Truck Load (AASHTO BDS Figure 3.6.1.2.2-1)

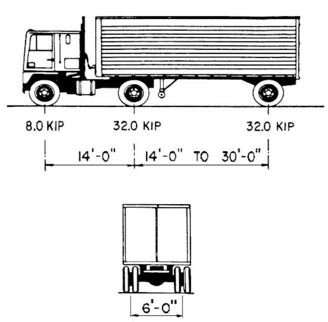


Figure 3.6.1.2.2-1—Characteristics of the Design Truck

Forklift Point Load P_{fork} 4 kip MARAD Lease Requirements, pg. A-3
Used for deck local analysis only. By inspection, this load will not control for global pier analysis.

MOORING LOADS

In lieu of carrier and ship information, the strength of the mooring hardware will be considered the lateral load applied to the pier since the mooring load will be limited by this strength. The strength of the mooring hardware was previously calculated in a 2008 study of the piers to determine the bollard ratings. Note that the load factors from UFC 4-152 will still be used.

Mooring Hardware Working Capacity P_{moor} 70 kip Applied horizontally and at 45 deg above horizontal

PIER NOMINAL LOADS (CONT'D)

LOAD COMBINATIONS

The following LRFD load combinations are taken from UFC 4-152 Table 3-6 and are considered in the analysis of the piers. Since typical mooring loads will be substituted by the load required to develop the strength of the morring hardware, the maximum load factor among Cs and Ws factors will be used. (Cs = Current loads on ship, Ws = Wind loads on ship)

Vacant Load Combinations

VLC1: 1.4D
VLC2: 1.2D + 1.6L

Mooring Load Combinations

All UFC 4-152 Mooring Load Combinations		Cs and Ws substituted by M	Governing Mooring LCs
MLC1:	1.4D + 0.0L + 1.4Cs + 0.0Ws	1.4D + 0.0L + 1.4M	1.4D + 0.0L + 1.4M
MLC2:	1.2D + 1.6L + 1.2Cs + 0.0Ws	1.2D + 1.6L + 1.2M	1.2D + 1.6L + 1.2M
MLC3:	1.2D + 1.0L + 1.2Cs + 0.0Ws	1.2D + 1.0L + 1.2M	*Superseded by MLC5*
MLC4:	1.2D + 0.0L + 1.2Cs + 0.8Ws	1.2D + 0.0L + 1.2M	*Superseded by MLC1*
MLC5:	1.2D + 1.0L + 1.2Cs + 1.6Ws	1.2D + 1.0L + 1.6M	*1.2D + 1.0L + 1.6M*
MLC6:	1.2D + 1.0L + 1.2Cs + 0.0Ws	1.2D + 1.0L + 1.2M	*Superseded by MLC5*
MLC7:	0.9D + 0.0L + 0.9Cs + 1.6Ws	0.9D + 0.0L + 1.6M	0.9D + 0.0L + 1.6M
MLC8:	0.9D + 0.0L + 0.9Cs + 0.0Ws	0.9D + 0.0L + 0.9M	*Superseded by MLC7*

where: M = General Mooring Load

Final Load Combinations

VLC1:	1.4D
VLC2:	1.2D + 1.6L
MLC1:	1.4D + 0.0L + 1.4M
MLC2:	1.2D + 1.6L + 1.2M
MLC5:	1.2D + 1.0L + 1.6M
MLC7:	0.9D + 0.0L + 1.6M

Pier 1 Capacity

Alameda Pier 1 Geotechnical Capacity Calculation

Reference: Foundation Analysis and Design, Fifth Edition - Bowles 1997

Introduction

Pier 1 structure is made of a segmental cofferdam. The top of the pier is at EL. +112'. The original design of the cells was made of steel sheet piles extending to EL. +62'-6" on the south side of the pier and to EL. 77'-6" on the north side. Pier 1 was repaired and retrofitted in 1988 with king piles on the perimeter with precast concrete panels in between and timber fender piles on the outside. The king piles are tied together using 3"ϕ tie rods having a working load of 125 ton. The tie rods are spaced @ 6'-8" at each king pile and are installed 5 ft below top of the pier at an average EL. +107'. The king piles on the south side of the pier are W36X260 extending to EL. +32' while on the north side of the pier the king piles are W14X109 extending to EL. +68'. Figure 1 shows a typical transverse section of Pier 1 and the cells planar dimensions.

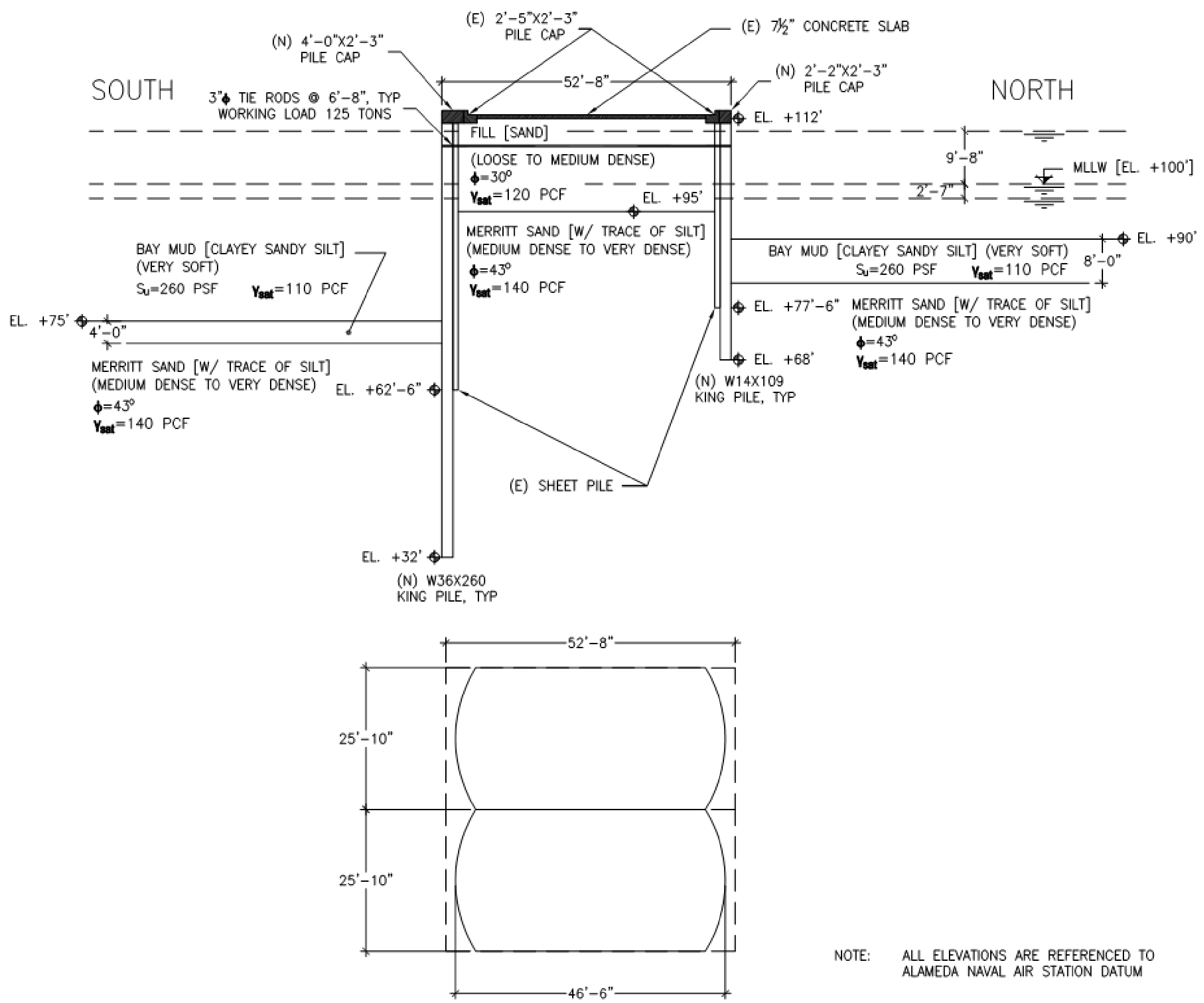


Figure 1: Typical Transverse Section of Pier 1 showing Elevations, Cells Dimensions and Soil Stratification.

Existing Geotechnical Conditions

The native soils at the site are in general characterized by very soft Bay Mud (Clayey Sandy Silt) underlain by medium dense to very dense Merritt Sand with trace of silt. On the south side of the pier the Bay Mud starts at EL. +75' and is 4' thick underlain by Merritt Sand, while on the north side the Bay Mud starts at EL. +90' and is 8' thick underlain by Merritt Sand. Inside the pier cells, Merritt Sand starts at EL. +95' and is overlain by loose to medium dense sand Fill to top of the pier at EL. +112'. The Mean Low Low Water Level (MLLW) is at EL. +100'. The maximum tidal range of record is (+) 9'-8" and the minimum tidal range of record is (-) 2'-7", both measured from the MLLW. Figure 1 shows a typical transverse section of Pier 1 and soil stratification inside and on both sides of the cells.

Soil Properties

The mechanical properties of the Fill, Bay Mud and Merritt Sand were interpreted from the general description of the soil layers on Sheet No. 6 (DWG. No. C-5) of the construction drawings of Pier 1 repair project dated 1988. Table 1 gives a summary of the unit weight and shear strength parameters of the three layers encountered.

Table 1: Mechanical Properties of the Fill, Bay Mud and Merritt Sand at Pier 1 Site.

			Shear Strength Properties	
Layer	**Description**	**Saturated Unit Weight [pcf]**	**Undrained Shear Strength [psf]**	**Angle of Internal Friction [degrees]**
Fill	Loose to Medium Dene Sand	120	------	30
Bay Mud	Very Soft Clayey Sandy Silt	110	260	------
Merritt Sand	Medium Dense to Very Dense Sand with trace of Silt	140	------	43

Pier 1 Segmental Cofferdam Geotechnical Capacity

The bearing and lateral capacity of the segmental cofferdam are calculated using TVA method for segmental cofferdam design (Bowles, 1997). The approach is based on evaluating the sliding and overturning stability of the segmental cofferdam for the external loading acting on the cells. The native soils inside the cells at its base are described as very dense sand. This soil would act as a plug at the base of the cells. The segmental cofferdam is thus assumed to behave as a rigid body and its global stability is evaluated accordingly.

The bearing levels of the sheet pile tips on the north and south sides are uneven with the north side 36' higher than the south side. Thus the cells resemble an inclined footing at 36 degrees with the horizontal. The pier is in a stable condition and the water level on both sides of the pier is always even at same elevation even during fluctuation. Therefore, it is judged that the lateral earth pressures on the north and south sides of the pier are in the at rest state.

The king piles at the perimeter are tied together using 3"ϕ tie rods across the pier. The tie rods have a working load of 125 ton. The tie rods are spaced @ 6'-8" at each king pile and are installed 5 ft below the top of the pier at an average EL. +107'. Fo the segmental cofferdam to behave as a rigid body the tie rods should withstand the induced tensile loads without excessive elongation or failure. Thus, the tensile loads in the tie rods should be less than the recommended working load of 125 ton.

A mooring load of 110 kip spaced at 80 ft is assumed to act on the pier at the bollard/cleat locations. The mooring load is assumed a horizontal static load acting in the North-South direction towards the south at the top of the pier (i.e. EL. +112'). Assuming that the mooring load and the cell internal soil pressure to the ground level on the south side are taken entirely by the tie rods, a maximum tensile load in the tie rods can be conservatively estimated as follows:

$$T_{max} := \left[\frac{110000\text{lb}}{80\text{ft}} + 0.5\cdot\left[\left(77.6\frac{\text{lb}}{\text{ft}^3}\,34.67\text{ft}\right) + \left(425\frac{\text{lb}}{\text{ft}^2} + 7.5\text{in}\cdot 150\frac{\text{lb}}{\text{ft}^3}\right)\right]\cdot(34.67\text{ft})\cdot 1.0\cdot\frac{1}{3}\right]\cdot 6.67\text{ft} = 66\cdot\text{ton}$$

less than 125 ton (OK)

For stability calculations, the water level is assumed even on both sides of the pier at an EL. +109'-8" corresponding to the MLLW plus the maximum tidal range of record (i.e. EL. +109'-8") with the mooring load acting simultaneously. This loading case corresponds to the adverse loading condition.

Two cases were considered for the live load at the top of the pier: 1) HS20-44 standard truck; 2) uniform live load of 425 psf. Figure 2 and Figure 3 show a free-body diagram of the cofferdam cell for the considered two live load cases.

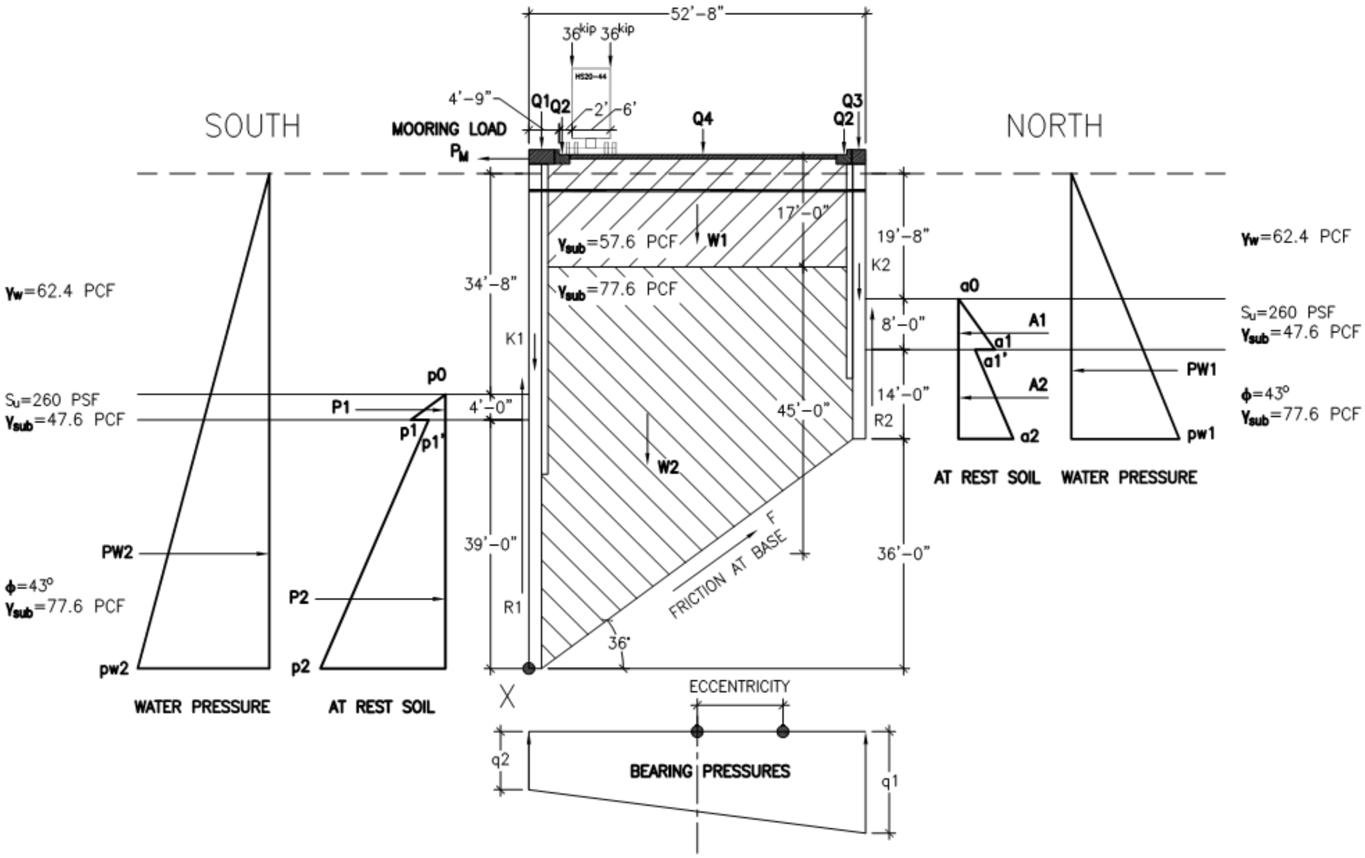


Figure 2: Pier 1 Segmental Cofferdam External Loads and Reactions with HS20-44 standard truck.

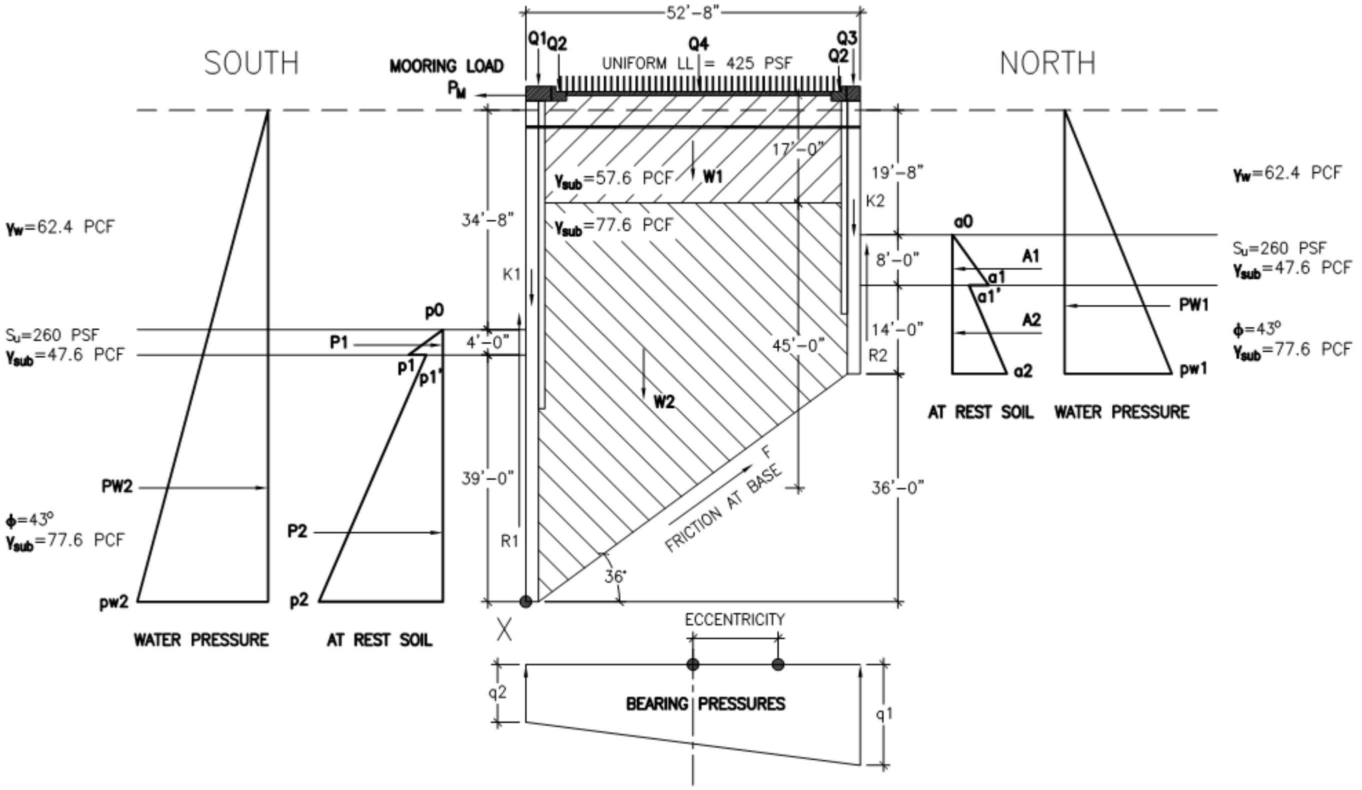


Figure 3: Pier 1 Segmental Cofferdam External Loads and Reactions with 425 psf Uniform Live Load.

External Loading

The external loads acting on Pier 1 are as follows (with reference to Figure 2 and Figure 3):

1. At rest lateral earth pressure on north side (A1 and A2).
2. Lateral water pressure on north side (PW1).
3. At rest lateral earth pressure on south side (P1 and P2).
4. Lateral water pressure on south side (PW2).
5. Friction at base of the equivalent inclined footing (F).
6. Weight of soil inside segmental cofferdam cells (W1 and W2).
7. Mooring load (P_M).
8. Weight of king piles on the north and south sides (K1 and K2)
9. Skin Friction along the king piles (R1 and R2)
10. Weight of pile caps tying the sheet piles and king piles (Q1, Q2_N, Q2_S, Q3)
11. Weight of concrete pavement (Q4)
12. Weight of HS20-44 standard truck (Figure 2) or uniform live load of 425 psf (Figure 3)
13. Bearing pressures at base.

Table 2 gives a summary of soil and water pressures and loads acting on the segmental cofferdam of Pier 1.

Table 2: Soil and Water Pressures and Loads acting on Pier 1 Structure.

Layer	Incremental Depth [ft]	Unit Weight [pcf]	Earth Pressure Coefficient	Undrained Shear Strength [psf]	Pressure	[psf]	Load	[lb/ft]
Bay Mud	0	47.6	1.00	260	a0	0	A1	1523
	8	47.6	1.00	260	a1	381	A2	4114
Merritt Sand	8	47.6	0.32	0	a1'	121	P1	-381
	14	77.6	0.32	0	a2	467	P2	-21128
Bay Mud	0	47.6	1.00	260	p0	0	PW1	54167
	4	47.6	1.00	260	p1	190	PW2	-188202
Merritt Sand	4	47.6	0.32	0	p1'	61	W1	-51571
	39	77.6	0.32	0	p2	1023	W2	-183912
Water	41.67	62.4	1.00	0	pw1	2600	F * cos(36)	-143725
Water	77.67	62.4	1.00	0	pw2	4846	P_M	1375
							K1	-51120
							K2	-20519
							R1	13135
							R2	2557
							Q1	1350
							Q2_S	816
							Q2_N	816
							Q3	731
							Q4	4938
							HS20-44_S	1286
							HS20-44_N	1286
							Uniform LL	18346
							Σ H [lb/ft]	-148532

Sliding and Overturning Stability

The sliding and overturning stability of Pier 1 are evaluated for the external loads calculated in Table 2 for a 1 ft tributary width of the segmental cofferdam. Table 3 gives a summary of the stabilizing and destabilizing forces and moments for the considered two live load cases with the calculated Factor of Safety (FOS) against sliding and overturning.

The critical FOS against sliding is 5.78 and against overturning is 3.77 for the assigned mooring loads of 110 kip at 80 ft spacing and HS20-44 truck load. Both values are acceptable.

Table 3: Stabilizing and Destabilizing External Loads and Moments acting on Pier 1 Structure for Sliding and Overturning Stability.

Pressure	[psf]	Load	[lb/ft]	Moment Arm @ X [ft]	Moment @ X [lb.ft/ft]
a0	0	A1	1523	52.67	80222
a1	381	A2	4114	41.63	171245
a1'	121	P1	-381	40.33	-15359
a2	467	P2	-21128	13.73	-290015
p0	0	PW1	54167	49.89	2702315
p1	190	PW2	-188202	25.89	-4872337
p1'	61	W1	-51571	26.33	-1358042
p2	1023	W2	-183912	22.82	-4197281
pw1	2600	F * cos(36)	-143725	0.00	0
pw2	4846	P_M	1375	80.00	110000
		K1	-51120	0.00	0
		K2	-20519	52.67	-1080688
		R1	13135	0.00	0
		R2	2557	52.67	134688
		Q1	1350	2.00	2700
		Q2_S	816	5.21	4248
		Q2_N	816	49.29	40204
		Q3	731	51.58	37720
		Q4	4938	26.33	130021
		HS20-44_S	1286	6.75	8679
		HS20-44_N	1286	12.75	16393
		Uniform LL	18346	26.33	483107
		Σ H [lb/ft]	-148532		
HS20-44 Case		Sliding FOS	5.78	Overturning FOS	3.77
Uniform LL Case		Sliding FOS	5.78	Overturning FOS	3.91
				Eccentricity [ft]	2.93
HS20-44 Case		Maximum Bearing Pressure		q1 [psf]	7661.74
		Minimum Bearing Pressure		q2 [psf]	3831.36
				Eccentricity [ft]	2.91
Uniform LL Case		Maximum Bearing Pressure		q1 [psf]	8053.50
		Minimum Bearing Pressure		q2 [psf]	4038.63

Bearing Capacity

Pier 1 segmental cofferdam cells resemble a spread footing inclined at 36 degrees with the horizontal. The ultimate bearing capacity of the cells is evaluated using Hansen bearing capacity equation for an effective width (B_{eff}) based on the base eccentricity from the external loads acting on the cofferdam cells (Bowles, 1997).

$e := 6.23\text{ft}$

$B := 52\text{ft} + 8\text{in} = 52.67\cdot\text{ft}$

$B_{eff} := B - 2e = 40.21\cdot\text{ft}$ $\quad D := 14\text{ft}$ $\quad \phi := 43°$ $\quad c := 0\frac{\text{lb}}{\text{ft}^2}$ $\quad \gamma := 77.6\frac{\text{lb}}{\text{ft}^3}$

Resultant horizontal load acting on footing (from Table 3), $H := 148532\frac{\text{lb}}{\text{ft}}$

Resultant vertical load acting on footing, $V := 51571\frac{\text{lb}}{\text{ft}} + 183912\frac{\text{lb}}{\text{ft}} = 2.355\times10^5\cdot\frac{\text{lb}}{\text{ft}}$

$$N_q := \exp(\pi\cdot\tan(\phi))\cdot\left(\tan\left(45° + \frac{\phi}{2}\right)\right)^2 = 99.01$$

$$N_c := \left(N_q - 1\right)\cot(\phi) = 105.11$$

$$N_\gamma := 1.5\cdot\left(N_q - 1\right)\tan(\phi) = 137.1$$

$$d_q := 1 + 2\tan(\phi)\,(1 - \sin(\phi))^2\,\text{atan}\left(\frac{D}{B_{eff}}\right) = 1.06$$

$$d_c := 1 + 0.4\,\text{atan}\left(\frac{D}{B_{eff}}\right) = 1.13$$

$$d_\gamma := 1$$

$s_q := 1$ $\quad s_c := 1$ $\quad s_\gamma := 1$ $\quad g_q := 1$ $\quad g_c := 1$ $\quad g_\gamma := 1$

$$i_q := \left(1 - \frac{0.5H}{V + B_{eff}\cdot 0\frac{\text{lb}}{\text{ft}^2}\cot(\phi)}\right)^3 = 0.32$$

$$i_c := i_q - \left(\frac{1 - i_q}{N_q - 1}\right) = 0.31$$

$$i_\gamma := \left[1 - \frac{\left(0.7 - \frac{36}{450}\right)\cdot H}{V + B_{eff}\cdot 0\frac{\text{lb}}{\text{ft}^2}\cot(\phi)}\right]^4 = 0.14$$

$$b_q := \exp\left(-2 \times 36 \cdot \frac{\pi}{180} \tan(\phi)\right) = 0.31$$

$$b_c := 1 - \frac{36}{147} = 0.76$$

$$b_\gamma := \exp\left(-2.7 \times 36 \cdot \frac{\pi}{180} \tan(\phi)\right) = 0.21$$

$$q_{ult} := c \cdot N_c \cdot s_c \cdot d_c \cdot i_c \cdot g_c \cdot b_c + \gamma \cdot D \cdot N_q \cdot s_q \cdot d_q \cdot i_q \cdot g_q \cdot b_q + 0.5 \cdot \gamma \cdot B_{eff} \cdot N_\gamma \cdot s_\gamma \cdot d_\gamma \cdot i_\gamma \cdot g_\gamma \cdot b_\gamma = 17414 \cdot \frac{lb}{ft^2}$$

Maximum bearing pressure under the cofferdam cell (from Table 3), $q1 := 8053.5 \frac{lb}{ft^2}$

$$FOS := \frac{q_{ult}}{q1} = 2.16$$

The critical FOS against bearing capacity failure is 2.16 for the assigned mooring loads of 110 kip at 80 ft spacing and 425 psf uniform live load. This value is acceptable.

DCR FOR BENT SCENARIOS

Pier 2 Vertical DCR

All lengths in feet

Original

Span1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7
6	10	12	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 4	**@ Batter Support 1 & 2**	**@ Support 4 & 5**
	VLC2-13: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	257.51	-222.7	86
DCR	0.65	0.56	0.76

Explanation: This configuration is the original layout for the piles.

Reconfiguration 1

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
6	22	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 2	**@ Batter Support 2**	**@ Suppot 3**
	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	456.82	-250.75	121.39
DCR	1.15	0.63	1.08

Explanation: This configuration assumes that the third pile is missing. *since removing the second pile would effect a 16' span, which is already assessed in the original layout, removing the third pile is the next worst case scenario*

Reconfiguration 2

Span1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7
6	10	10.5	19	10.5	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 4	**@ Batter Support 1 & 2**	**@ Support 4 & 5**
	VLC2-14: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	363.39	-225	102.7
DCR	0.92	0.57	0.91

Explanation: This scenario assumes the fourth and fifth piles are missing and replaced with piles effecting a 19' central span

Reconfiguration 3

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
16	12	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 3	**@ Batter Support 2**	**@ Support 3**
	VLC2-15: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	252.35	-252.55	88.6
DCR	0.64	0.64	0.79

Explanation: This scenario assumes the second pile is missing, to assess the variation of moment demand considering multiple 16' spans

Reconfiguration 4

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
8	20	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 2	**@ Batter Support 2**	**@ Support 3**
	VLC2-3: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	407.19	-245.14	110.9
DCR	1.03	0.62	0.98

Explanation: This scenario assumes the second and third piles are missing and one replacement is added 8' from the first pile

Reconfiguration 5

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
10	18	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 2	**@ Batter Support 2**	**@ Support 3**
	VLC2-6: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	334.77	-243.6	100.27
DCR	0.84	0.61	0.89

Explanation: This scenario assumes the second and third piles are missing and one replacement is added 10' from the first pile

Reconfiguration 6

Span1	Span 2	Span 3	Span 4
18	18	18	18

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 2	**@ Support 3**	**@ Support 3**
	VLC2-8: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	286.17	-241.57	101.42
DCR	0.72	0.61	0.90

Explanation: This scenario assumes a completely new configuration of five piles 18' oc

Pier 2 Vertical DCR

Reconfiguration 7

Span1	Span 2	Span 3
24	24	24

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 3	**@ Support 2 & 3**	**@ Support 2 & 3**
	VLC2-25: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	417.06	-375.19	129.34
DCR	1.05	0.94	1.15

This scenario assumes a completely new configuration of four piles 24' oc

Reconfiguration 8

Span1	Span 2	Span 3	Span 3	Span 3
14	14	16	14	14

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 3	**@ Support 3 & 4**	**@ Support 3 & 4**
	VLC2-13: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	241.42	-155.19	85.98
DCR	0.61	0.39	0.76

This scenario assumes a new configuration of 6 piles, with the largest span being 16' and the others 14'

Reconfiguration 9

Span1	Span 2	Span 3	Span 3	Span 3
10	20	16	20	10

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 4	**@ Support 3 & 4**	**@ Support 3 & 4**
	VLC2-24: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	374.15	-251.71	114.08
DCR	0.94	0.63	1.01

This scenario assumes the second, third, sixth and seventh piles are missing and two replacements are added 8' from the existing outer piles

Reconfiguration 10

Span1	Span 2	Span 3	Span 3	Span 3
9	18	18	18	9

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 4	**@ Support 3 & 4**	**@ Support 3 & 4**
	VLC2-22: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	347.15	-218.17	101.6
DCR	0.87	0.55	0.90

This scenario assumes a new configuration of 6 piles with the largest span being 18'

Reconfiguration 11

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
6	10	28	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 3	**@ Support 4**	**@ Support 4**
	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L	VLC2a: 1.2D + 1.6L
	704.42	-385.63	153.15
DCR	1.77	0.97	1.36

This scenario assumes a new configuration of 6 piles with the largest span being 18'

Load Case Key:

1. VLC2-##: 1.2D + 1.6L — With Truck Load
2. VLC2a: 1.2D + 1.6L — With MARAD 425psf Live Load
3. MLC.... — Mooring Loads

M0 as the last term is the 0d egree Mooring load

M45 as the last term is the 45d egree Mooring load

Pier 2 Vertical + Horizontal DCR

All lengths in feet

Original

Span1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7
6	10	12	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Batter Support 2	**@ Batter Support 1**	**@ Support 5**
	MLC7b: 0.9D + 1.6M.45	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
	285.87	-335.932	88.37
DCR	0.72	0.85	0.78

Explanation: This configuration is the original layout for the piles.

Reconfiguration 1

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
6	22	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 2	**@ Batter Support 1**	**@ Batter Support 1**
	VLC2a: 1.2D + 1.6L	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
	456.82	-352.37	119.88
DCR	1.15	0.89	1.06

This configuration assumes that the third pile is missing.
since removing the second pile would effect a 16' span, which is already assessed in the original layout, removing the third pile is the next worst case scenario

Reconfiguration 2

Span1	Span 2	Span 3	Span 4	Span 5	Span 6	Span 7
6	10	10.5	19	10.5	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 4	**@ Batter Support 1**	**@ Support 5**
	VLC2a: 1.2D + 1.6L	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
	350.6	-338.47	105.09
DCR	0.88	0.85	0.93

This scenario assumes the fourth and fifth piles are missing and replaced with piles effecting a 19' central span

Reconfiguration 3

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
16	12	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Batter Support 2	**@ Batter Support 2**	**@ Support 4**
	MLC7b: 0.9D + 1.6M.45	VLC2a: 1.2D + 1.6L	MLC2a: 1.2D + 1.6L + 1.2M.0
	287.58	-252.55	86.52
DCR	0.72	0.64	0.77

This scenario assumes the second pile is missing, to assess the variation of moment demand considering multiple 16' spans

Reconfiguration 4

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
8	20	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 2	**@ Batter Support 1**	**@ Support 3**
	VLC2a: 1.2D + 1.6L	MLC2a: 1.2D + 1.6L + 1.2M.0	VLC2a: 1.2D + 1.6L
	376.47	-328.73	110.9
DCR	0.95	0.83	0.98

This scenario assumes the second and third piles are missing and one replacement is added 8' from the first pile

Reconfiguration 5

Span1	Span 2	Span 3	Span 4	Span 5	Span 6
10	18	16	12	10	6

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Span 2	**@ Batter Support 1**	**@ Support 3**
	MLC2a: 1.2D + 1.6L +	MLC5a: 1.2D + 1.0L + 1.6M.0	VLC2a: 1.2D + 1.6L
	306.82	-301	100.27
DCR	0.77	0.76	0.89

This scenario assumes the second and third piles are missing and one replacement is added 10' from the first pile

Reconfiguration 6

Span1	Span 2	Span 3	Span 4
18	18	18	18

	Max +Mu	Max -Mu	Max Vu
	kip-ft	kip-ft	kip
	@ Batter Support 2	**@ Batter Support 1**	**@ Support 3**
	MLC7b: 0.9D + 1.6M.45	MLC5a: 1.2D + 1.0L + 1.6M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
	368.02	-316.72	104.23
DCR	0.93	0.80	0.93

This scenario assumes a completely new configuration of five piles 18' oc

Pier 2 Vertical + Horizontal DCR

Reconfiguration 7

Span1	Span 2	Span 3					
				Max +Mu	Max -Mu	Max Vu	
24	24	24		kip-ft	kip-ft	kip	This scenario assumes a completely new configuration of four piles 24' oc
				@ Span 3	@ Support 3	@ Support 3	
				MLC2b: 1.2D + 1.6L + 1.2M.45	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	
				459.49	-436.36	134.08	
			DCR	1.16	1.10	1.19	

Reconfiguration 8

Span1	Span 2	Span 3	Span 3	Span 3		Max +Mu	Max -Mu	Max Vu	
14	14	16	14	14		kip-ft	kip-ft	kip	This scenario assumes a new configuration of 6 piles, with the largest span being 16' and the others 14'
						@ Span 5	@ Batter Support 1	@ Support 4	
						MLC7b: 0.9D + 1.6M.45	MLC5a: 1.2D + 1.0L + 1.6M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	
						342.93	-307.33	89.49	
					DCR	0.86	0.77	0.79	

Reconfiguration 9

Span1	Span 2	Span 3	Span 3	Span 3		Max +Mu	Max -Mu	Max Vu	
10	20	16	20	10		kip-ft	kip-ft	kip	This scenario assumes the second, third, sixth and seventh piles are missing and two replacements are added 8' from the existing outer piles
						@ Span 4	@ Batter Support 1	@ Support 4	
						MLC2b: 1.2D + 1.6L + 1.2M.45	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2b: 1.2D + 1.6L + 1.2M.45	
						403.63	-357.95	121	
					DCR	1.02	0.90	1.07	

Reconfiguration 10

Span1	Span 2	Span 3	Span 3	Span 3		Max +Mu	Max -Mu	Max Vu	
9	20	16	20	10		kip-ft	kip-ft	kip	This scenario assumes a new configuration of 6 piles with the largest span being 18'
						@ Span 4	@ Batter Support 1	@ Support 4	
						MLC2b: 1.2D + 1.6L + 1.2M.45	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2b: 1.2D + 1.6L + 1.2M.45	
						324.29	-342.6	109.98	
					DCR	0.82	0.86	0.98	

Reconfiguration 11

Span1	Span 2	Span 3	Span 4	Span 5	Span 6		Max +Mu	Max -Mu	Max Vu	
6	10	28	12	10	6		kip-ft	kip-ft	kip	This scenario assumes a new configuration of 6 piles with the largest span being 18'
							@ Span 3	@ Batter Support 1	@ Support 4	
							MLC2a: 1.2D + 1.6L +	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	
							709.45	-459.95	154.84	
						DCR	1.79	1.16	1.37	

Reconfiguration 12

Span1	Span 2	Span 3	Span 4	Span 5	Span 6			Max +Mu	Max -Mu	Max Vu	
6	10	12	16	12	10	6		kip-ft	kip-ft	kip	This scenario assumes that the batter pile farthest from the lateral load is missing
								@ Batter Support 2	@ Support 5	@ Support 5	
								MLC7b: 0.9D + 1.6M.45	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	
								413	-171	88.61	
							DCR	1.04	0.43	0.79	

Reconfiguration 13

Span1	Span 2	Span 3	Span 4	Span 5	Span 6			Max +Mu	Max -Mu	Max Vu	
6	10	12	16	12	10	6		kip-ft	kip-ft	kip	This scenario assumes that the batter pile closest to the lateral load is missing
								@ Batter Support 4	@ Batter Support 1	@ Support 5	
								VLC2-13: 1.2D + 1.6L	MLC5a: 1.2D + 1.0L + 1.6M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	
								254.15	-360.8	88.06	
							DCR	0.64	0.91	0.78	

Load Case Key:

1. VLC2-##: 1.2D + 1.6L — With Truck Load
2. VLC2a: 1.2D + 1.6L — With MARAD 425psf Live Load
3. MLC.... — Mooring Loads

M0 as the last term is the 0d egree Mooring load
M45 as the last term is the 45d egree Mooring load

Pier 3 10 in. Slab DCR

All lengths in feet

Original			Max +Mu	Max -Mu	Max Vu
			kip-ft	kip-ft	kip
			@ 12' Span	**@ 12' Span**	**@ Mid Bent**
Maximum Span = 12'	Original pristine configuration		MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
			58.06	-56.44	-45
		DCR	0.91	0.88	-0.19

Explanation
This configuration is the original layout for the piles.

		Max +Mu	Max -Mu	Max Vu
		kip-ft	kip-ft	kip
		@ 12' Span	**@ 12' Span**	**@ Mid Bent**
if one bent is completely missing		MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
		68.3	-66.3	-58
	DCR	1.07	1.04	-0.24

		Max +Mu	Max -Mu	Max Vu
		kip-ft	kip-ft	kip
		@ 18' Span	**@ 18' Span**	**@ Mid Bent**
if one pile is missing so that the longest span is 18'		MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
		-61	61.9	-34
	DCR	-0.95	-0.97	-0.14

		Max +Mu	Max -Mu	Max Vu
		kip-ft	kip-ft	kip
if one pile is missing so that the longest span is 16'				
	DCR	0.00	0.00	0.00

Load Case Key:

1. VLC2-##: 1.2D + 1.6L — With Truck Load
2. VLC2a: 1.2D + 1.6L — With MARAD 425psf Live Load
3. MLC…. — Mooring Loads

M0 as the last term is the 0d egree Mooring load
M45 as the last term is the 45d egree Mooring load

Moment Capacity in 10" slab	64 kip-ft
Moment Capacity in 26" slab	318 kip-ft

Pier 3 26 in. Slab DCR

All lengths in feet

Original

			Max +Mu	Max -Mu	Max Vu	Explanation
			kip-ft	kip-ft	kip	This configuration is the original layout for the piles.
			@ Batter Support 3	**@ Batter Support 3**	**@ Support 5**	
Maximum Span = 12'	Original pristine configuration		MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	
			229.97	-265.33	66.33	
		DCR	0.72	0.83	0.06	

		Max +Mu	Max -Mu	Max Vu
		kip-ft	kip-ft	kip
		@ Batter Support 3	**@ Batter Support 3**	**@ Support 5**
If one bent is completely missing		MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
		278.9	-313	-88.93
	DCR	0.88	0.98	-0.08

		Max +Mu	Max -Mu	Max Vu
		kip-ft	kip-ft	kip
		@ Batter Support 3	**@ Batter Support 3**	**@ Support 5**
If one pile is missing so that the longest span is 18'		MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0	MLC2a: 1.2D + 1.6L + 1.2M.0
		228.48	-265.23	-66.78
	DCR	0.72	0.83	-0.06

Load Case Key:

1. VLC2-##: 1.2D + 1.6L — With Truck Load
2. VLC2a: 1.2D + 1.6L — With MARAD 425psf Live Load
3. MLC…. — Mooring Loads

M0 as the last term is the 0d egree Mooring load
M45 as the last term is the 45d egree Mooring load

Moment Capacity in 10" slab	64 kip-ft
Moment Capacity in 26" slab	318 kip-ft

P-M INTERACTION

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

SHEET NO.

PROJECT NO. 167543.00 ALPR

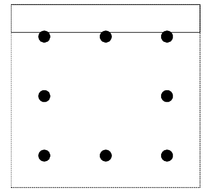
DATE 04 April 2017

BY ERM

CHECKED BY RI

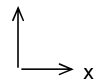
CLIENT

SUBJECT Concrete Beam-Column



Calculate P-M Interaction for a rectangular concrete section

	y		x	
Column Size:	20	x	20	in.

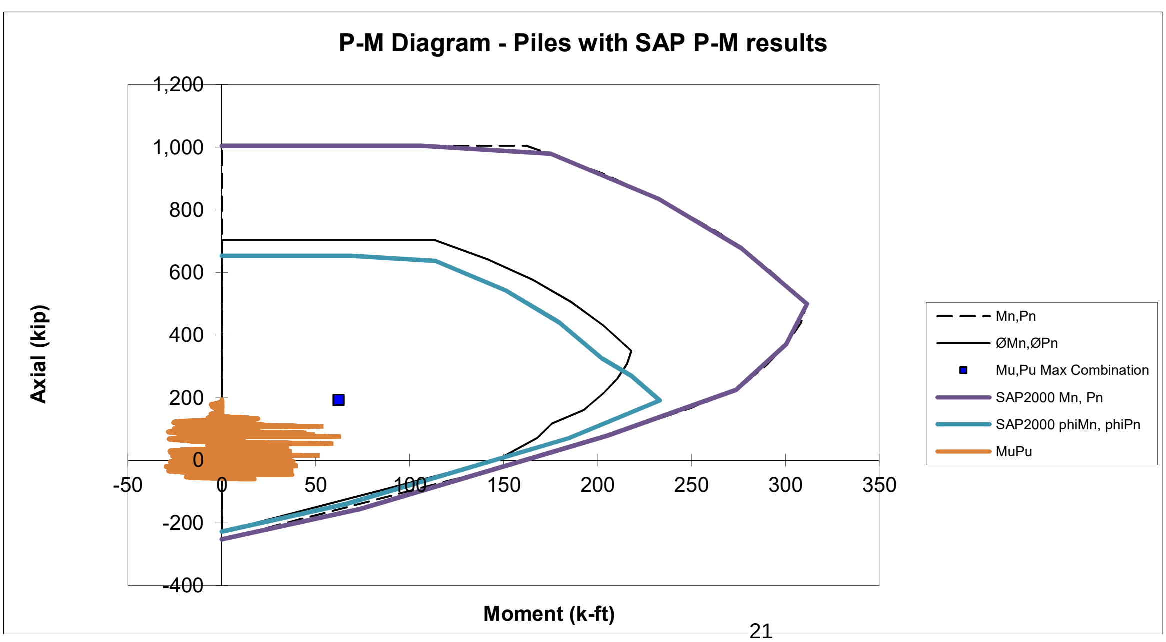


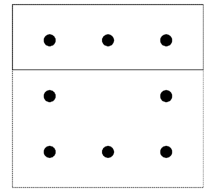
bar size:	#8		tie size:	#8				
cover:	3	in	D_{tie}=	1 in		Y=0 @ bottom of Section		
D_b=	1	in	A_{tie}=	0.79 in²		top of section in compression		
A_b=	0.79	in²	# vert tie bars:	0		Pno=0.80Po=	1,005	kip
			tie spacing:	0 in		c_b=	11.30	in
c:	3.562	in	d=	16.5 in		P_b=	499	kip
b_1=	0.85		F_y tie:	0	psi	f'$_c$:	3,000	psi
a=	3.0277	in	**0.85*V_n=**	**#DIV/0!**	**kip**	F_y:	40,000	psi
						A_s=	6.32	in²
effective concrete area=	60.554	in² centroid @ 18.49 in				$A_{s\ min}$=	1.65	in²
concrete force=.85*f'c*Aw=	154	kips (compression)				sum of moment about y=0 =	162	k-ft
T1=(sum bar force)=	154	kip (tension)				na @ y=	10	in
						sum of moment about na = M_n=	162	k-ft
						P_n=	(0)	kip (tension)
						Desired Pn=	216	kip (compression)
			ϕP_n=	**0.0**		**ϕM_n=**	**146.2**	**k-ft**
			ties or spirals:	ties		ϕ =	0.900	(for tied column)
			P_u:	194.1 kip		M_u:	62	k-ft

X (in)	Y (in)	strain (in/in)	f_s (ksi)	Maximum Bar Stress	A_b (in²)	Bar Force (kips)	M about y=0 (k-in)
6.5	16.5	-0.0001	-1.5	40.0	0.79	-1.2	-19.7
-6.5	16.5	-0.0001	-1.5	40.0	0.79	-1.2	-19.7
6.5	3.5	0.0109	40.0	40.0	0.79	31.6	110.6
-6.5	3.5	0.0109	40.0	40.0	0.79	31.6	110.6
0	16.5	-0.0001	-1.5	40.0	0.79	-1.2	-19.7
0	3.5	0.0109	40.0	40.0	0.79	31.6	110.6
6.5	10	0.0054	40.0	40.0	0.79	31.6	316.0
-6.5	10	0.0054	40.0	40.0	0.79	31.6	316.0
		0.0138	40.0	40.0	0	0.0	0.0
		0.0138	40.0	40.0	0	0.0	0.0
		0.0138	40.0	40.0	0	0.0	0.0
		0.0138	40.0	40.0	0	0.0	0.0

M_n (k-ft)	P_n (kip)
0	1,005
162	1,005
202	918
237	823
266	723
290	615
312	500
308	439
301	374
290	305
275	230
249	167
211	90
162	0
0	-253

$ØM_n$ (k-ft)	$ØP_n$ (kip)
0	704
113	704
166	576
186	506
203	430
218	350
216	307
211	262
203	214
193	161
176	118
168	71
146	0
0	-228





Calculate P-M Interaction for a rectangular concrete section

	y		x	
Column Size:	18	x	18	in.

Y=0 @ bottom of Section
top of section in compression

bar size:	#8		tie size:	#2				
cover:	3	in	D_{tie}=	0.25 in				
D_b=	1	in	A_{tie}=	0.0491 in²				
A_b=	0.79	in²	# vert tie bars:	2		Pno=0.80Po=	850	kip
			tie spacing:	8 in		c_b=	9.93	in
c:	7.54	in	d=	14.5 in		P_b=	393	kip
b_1=	0.85		F_y tie:	40,000	psi	f'c:	3,000	psi
a=	6.409	in	**0.85*V_n=**	**30.4**	**kip**	F_y:	40,000	psi
						A_s=	6.32	in²

effective concrete area= 115.36 in² centroid @ 14.80 in
concrete force=.85*f'c*Aw= 294 kips (compression)
T1=(sum bar force)= 33 kip (tension)

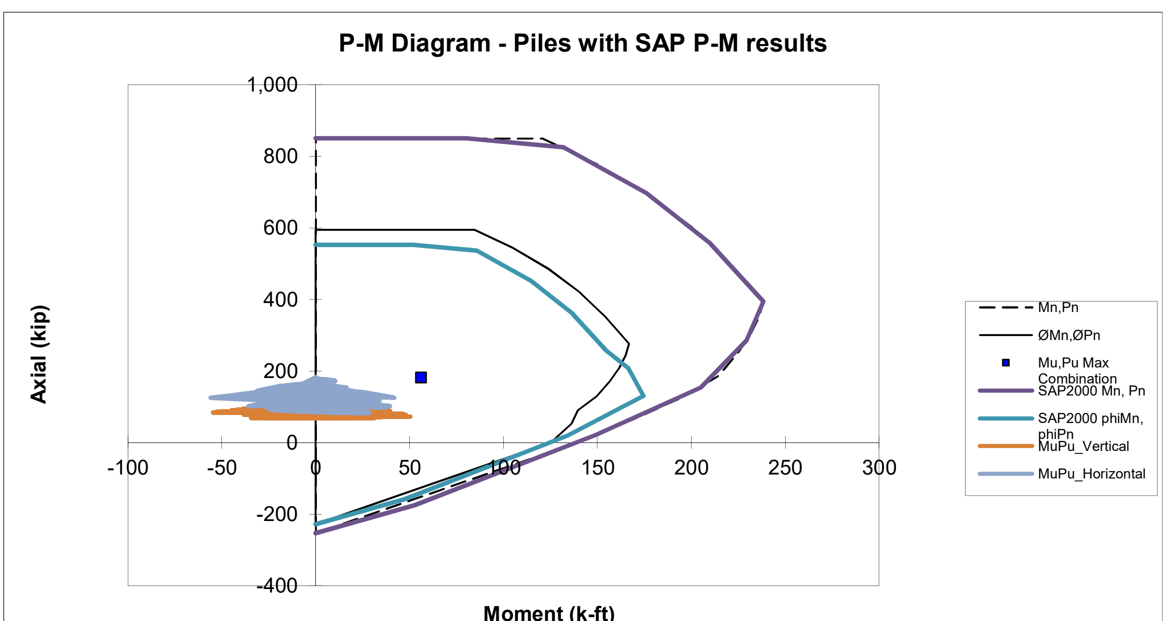
$A_{s\ min}$=	1.31	in²
sum of moment about y=0 =	422	k-ft
na @ y=	9	in
sum of moment about na = M_n=	226	k-ft
P_n=	262	kip (compression)
Desired Pn=	262	kip (compression)

ΦP_n=	**183.1**	**ΦM_n=**	**158.3**	**k-ft**
ties or spirals:	ties	Φ =	0.700	(for tied column)
P_u:	183.1 kip	M_u:	56	k-ft

X (in)	Y (in)	strain (in/in)	f_s (ksi)	Maximum Bar Stress	A_b (in²)	Bar Force (kips)	M about y=0 (k-in)
5.5	14.5	-0.0016	-37.5	40.0	0.79	-29.6	-429.0
-5.5	14.5	-0.0016	-37.5	40.0	0.79	-29.6	-429.0
5.5	3.5	0.0028	40.0	40.0	0.79	31.6	110.6
-5.5	3.5	0.0028	40.0	40.0	0.79	31.6	110.6
0	14.5	-0.0016	-37.5	40.0	0.79	-29.6	-429.0
0	3.5	0.0028	40.0	40.0	0.79	31.6	110.6
5.5	9	0.0006	16.8	40.0	0.79	13.3	119.8
-5.5	9	0.0006	16.8	40.0	0.79	13.3	119.8
		0.0042	40.0	40.0	0	0.0	0.0
		0.0042	40.0	40.0	0	0.0	0.0
		0.0042	40.0	40.0	0	0.0	0.0
		0.0042	40.0	40.0	0	0.0	0.0

M_n (k-ft)	P_n (kip)
0	850
121	850
150	779
177	694
200	603
220	503
238	394
236	348
231	298
224	245
214	185
194	126
169	66
139	0
0	-253

ØM_n (k-ft)	ØP_n (kip)
0	595
85	595
124	486
140	422
154	352
167	276
165	243
162	209
157	172
150	130
140	90
136	53
125	0
0	-228



CAPACITY

A1.0 DESIGN BASIS - One Way Slab

The following information is extracted from the structural drawings.

A1.1.1 Section Properties

Depth of slab section in roof floor $B_D := 8\,in$

Width of slab section in roof floor $B_W := 12\,in$

Centerline span adjacent supports $Span_c := 12\,ft$

Left support width $Sup_{1w} := 18\,in$

Right support width $Sup_{2w} := 18\,in$

A1.1.2 Material Properties

Strength of concrete $f'_c := 3\,ksi$

Strength of reinforcing steel $f_y := 40\,ksi$

Modulus of elasticity of steel $E_s := 29000\,ksi$

Allowable strain at strength for concrete $\varepsilon_c := 0.003\,\frac{in}{in}$

Yield strain of steel $\varepsilon_s := \frac{f_y}{E_s} = 0.00138 \cdot \frac{in}{in}$

A1.1.3 Design Parameters

Concrete clear cover over steel $c_c := 1.5\,in$

Strength reduction factor for flexure
(ACI 318-14 Table 21.2.2 - tension controlled) $\phi_f := 0.9$

Strength reduction factor for shear
(ACI 318-14 Table 21.2.1) $\phi_s := 0.75$

A2.0 DESIGN CALCULATIONS

A2.0.1 Slab Reinforcement

Reinforcement Bar Diameters

Reinforcement bar diameter for 1st layer of top bar $\phi_{t1} := 0.625\mathbf{in}$

Reinforcement bar diameter for 2nd layer of top bar $\phi_{t2} := 0\mathbf{in}$

Reinforcement bar diameter for 1st layer of bottom bar $\phi_{b1} := 0.625\mathbf{in}$

Reinforcement bar diameter for 2nd layer of bottom bar $\phi_{b2} := 0\mathbf{in}$

Reinforcement bar diameter for stirrups $\phi_{st} := 0\mathbf{in}$

Bar Reinforcement Areas

Reinforcement area for 1st layer of top bar $A_{t1} := \pi \cdot \frac{\phi_{t1}^2}{4} = 0.31\,\mathbf{in}^2$

Reinforcement area for 2nd layer of top bar $A_{t2} := \pi \cdot \frac{\phi_{t2}^2}{4} = 0$

Reinforcement area for 1st layer of bottom bar $A_{b1} := \pi \cdot \frac{\phi_{b1}^2}{4} = 0.31\,\mathbf{in}^2$

Reinforcement area for 2nd layer of bottom bar $A_{b2} := \pi \cdot \frac{\phi_{b2}^2}{4} = 0$

Reinforcement area for a single leg of stirrups $A_{st} := \pi \cdot \frac{\phi_{st}^2}{4} = 0$

Number of bars in first top layer LE $No_{lt1} := 2.1818$

Number of bars in second top layer LE $No_{lt2} := 0$

Total area of bars in first top layer LE $\quad A_{t1\_t} := A_{t1} \cdot No_{lt1} = 0.7\,in^2$

Total area of bars in second top layer LE $\quad A_{t2\_t} := A_{t2} \cdot No_{lt2} = 0$

Total reinforcing area top LE $\quad A_{t\_t} := A_{t1\_t} + A_{t2\_t} = 0.7\,in^2$

Number of bars in first bottom layer $\quad No_{b1} := 1.091$

Number of bars in second bottom layer $\quad No_{b2} := 0$

Total area of bars in first bottom layer $\quad A_{b1\_t} := A_{b1} \cdot No_{b1} = 0.3\,in^2$

Total area of bars in second bottom layer $\quad A_{b2\_t} := A_{b2} \cdot No_{b2} = 0$

Total reinforcing area bottom layer $\quad A_{bt} := A_{b1\_t} + A_{b2\_t} = 0.3\,in^2$

Height from Compression Face to Tension Reinforcement

'd' dimension for 1st layer of bottom bars

$$d_1 := B_D - c_c - \phi_{st} - \frac{\phi_{b1}}{2} = 6.19\,in$$

'd' dimension for 2nd layer of bottom bars (assume the spacing between layers is governed by ACI 318-14 Section 25.2.2)

$$d_2 := \begin{cases} 0in & \text{if } \phi_{b2} < 0.1in \\ \left(d_1 - \phi_{st} - 1in - \frac{\phi_{b2}}{2}\right) & \text{otherwise} \end{cases}$$

$$d_2 = 0\,in$$

'd' dimension for 1st layer of top bars

$$d'_1 := c_c + \phi_{st} + \frac{\phi_{t1}}{2} = 1.812\,in$$

'd' dimension for 2nd layer of top bars (assume the spacing between layers is governed by ACI 318-14 Section 25.2.2)

$$d'_2 := \begin{cases} 0in & \text{if } \phi_{t2} < 0.1in \\ \left(d'_1 + 1in + \phi_{t2}\right) & \text{otherwise} \end{cases}$$

$$d'_2 = 0\,in$$

A2.1 POSITIVE MOMENT CAPACITY OF SLAB

Allowable effective width
(ACI 318-14 Table 6.3.2.1)

$$b_{eff} := B_W = 12\,\mathbf{in}$$

Slab Characteristics - Depth of Compression Block

Finding the depth of the compression block and the compression steel stress for a doubly reinforced concrete section is an iterative process. Equilibrium between the tension and compression forces needs to be achieved. Below is the general process:

1) Estimate the depth of the compression block
2) Calculate the distance to the neutral axis
3) Determine the stress in the tension and compression steel
4) Sum the moments to find equilibrium
    a) If the moments do not sum to zero, start at step 1) and re-estimate the depth of the compression block

Estimate the depth of the compression block

$$\mathbf{a} := 1.1332761\,\mathbf{in}$$

Slab Characteristics - Depth to Neutral Axis

Reinforced concrete stress block modifier

$$\beta_1 := \min\left[0.85 - \frac{0.5\left(f'_c - 4000\mathbf{psi}\right)}{1000\mathbf{psi}}, 0.85\right] = 0.85$$

Distance from compression face to neutral axis

$$c_b := \frac{a}{\beta_1} = 1.33\,\mathbf{in}$$

Slab Characteristics - Determine Steel Stresses

Steel stress in 1st layer of bottom steel
(the maximum allowable steel stress is 60ksi)

$$f_{s1} := \min\left[f_y, \varepsilon_c \cdot E_s \cdot \frac{\left(d_1 - c_b\right)}{c_b}\right]$$

$$f_{s1} = 40 \cdot \mathbf{ksi}$$

Steel stress in 2nd layer of bottom steel
(the maximum allowable steel stress is 60ksi)

$$f_{s2} := \left| \begin{array}{ll} 0\mathbf{ksi} \;\; \text{if} \;\; \phi_{b2} < 0.1\mathbf{in} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \frac{\left(d_2 - c_b\right)}{c_b}\right] & \text{otherwise} \end{array} \right.$$

$$f_{s2} = 0 \cdot \mathbf{ksi}$$

Steel stress in 1st layer of top steel
(the maximum allowable steel stress is 60ksi)

$$f'_{s1} := \begin{vmatrix} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_1)}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_1)}{c_b} < 0\text{ksi} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_1)}{c_b}\right] & \text{otherwise} \end{vmatrix}$$

$$f'_{s1} = -31.272 \cdot \text{ksi}$$

Steel stress in 2nd layer of top steel
(the maximum allowable steel stress is 60ksi)

$$f'_{s2} := \begin{vmatrix} \text{if } \phi_{t2} > 0.1\text{in} \\ \quad \begin{vmatrix} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_2)}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_2)}{c_b} < 0\text{ksi} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_2)}{c_b}\right] & \text{otherwise} \end{vmatrix} \\ 0\text{ksi} \quad \text{otherwise} \end{vmatrix}$$

$$f'_{s2} = 0 \cdot \text{ksi}$$

Slab Characteristics - Equilibrium Between Compression and Tension Forces

Equilibrium is reached when the compression and tension forces in section are balanced.

The allowable tension force in the 1st layer of the bottom steel

$$F_1 := A_{b1\_t} \cdot f_{s1} = 13.389 \cdot \text{kip}$$

The allowable tension force in the 2nd layer of the bottom steel

$$F_2 := A_{b2\_t} \cdot f_{s2} = 0 \cdot \text{kip}$$

The allowable compression force in the 1st layer of the top steel

$$F'_1 := A_{t1\_t} \cdot f'_{s1} = -20.932 \cdot \text{kip}$$

The allowable compression force in the 2nd layer of the top steel

$$F'_2 := A_{t2\_t} \cdot f'_{s2} = 0 \cdot \text{kip}$$

The allowable compression force in the concrete

$$F_c := 0.85 \cdot f'_c \cdot a \cdot b_{eff} = 34.678 \cdot \mathbf{kip}$$

$$F_c = 34.678 \cdot \mathbf{kip}$$

The sum of the forces shall equal 0 for equilibrium

$$Eq := F_1 + F_2 - F'_1 - F'_2 - F_c = -0.36 \cdot \mathbf{kip}$$

$$\mathbf{if}(-0.5\mathbf{kip} < Eq < 0.5\mathbf{kip}, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Slab Characteristics - Moment Capacity

Since the tension and compression forces result in equilibrium, the assumed compression block depth is accurate. The moment capacity is therefore the sum of the moments about the 1st bottom layer of steel.

Moment of concrete compression force

$$M_c := \left[0.85 \cdot f'_c \cdot a \cdot b_{eff} \cdot \left(d_1 - \frac{a}{2}\right)\right] = 194.922 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Moment of steel 1st layer - top of section

$$M_{t1} := A_{t1\_t} \cdot f'_{s1} \cdot (d_1 - d'_1) = -91.58 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Moment of steel 2nd layer - top of section

$$M_{t2} := A_{t2\_t} \cdot f'_{s2} \cdot (d_1 - d'_2) = 0 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Moment of steel 2nd layer - bottom of section

$$M_{b2} := A_{b2\_t} \cdot f_{s2} \cdot (d_1 - d_2) = 0 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Positive moment capacity of section

$$M_{np} := M_c + M_{t1} + M_{t2} + M_{b2}$$

$$M_{np} = 8.61 \cdot \mathbf{kip} \cdot \mathbf{ft}$$

Slab Characteristics - Strength Reduction Factor

The strength reduction factor is checked to determine whether the section is tension controlled, compression controlled or in the transition zone.

Strength reduction factor (ACI 318-14 Chapter 21)

$$\phi_f := \begin{cases} 0.65 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} \le \dfrac{f_y}{E_s} \\ 0.9 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} > 0.005 \\ \left[0.65 + \dfrac{\left[0.25 \cdot \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} - \dfrac{f_y}{E_s} \right]}{0.005 - \dfrac{f_y}{E_s}} \right] & \text{otherwise} \end{cases}$$

$$\phi_f = 0.9$$

Nominal postitive moment capacity of section

$$\mathbf{phiM_{np\_LE}} := \phi_f \cdot M_{np} = 7.75 \cdot \mathbf{kip} \cdot \mathbf{ft}$$

A2.2 NEGATIVE MOMENT CAPACITY OF SLAB

Slab Characteristics - Depth of Compression Block

Finding the depth of the compression block and the compression steel stress for a doubly reinforced concrete section is an iterative process. Equilibrium between the tension and compression forces needs to be achieved. Below is the general process:

1) Estimate the depth of the compression block
2) Calculate the distance to the neutral axis
3) Determine the stress in the tension and compression steel
4) Sum the moments to find equilibrium
    a) If the moments do not sum to zero, start at step 1) and re-estimate the depth of the compression block

Estimate the depth of the compression block

$$\mathbf{a} := 1.179023\mathbf{in}$$

Slab Characteristics - Depth to Neutral Axis

Reinforced concrete stress block modifier

$$\beta_1 := \mathbf{min}\left[0.85 - \frac{0.5(f'_c - 4000\mathbf{psi})}{1000\mathbf{psi}}, 0.85 \right] = 0.85$$

Distance from compression face to neutral axis

$$c_b := \frac{a}{\beta_1} = 1.39\,\mathbf{in}$$

Slab Characteristics - Determine Steel Stresses

Steel stress in 1st layer of bottom steel (the maximum allowable steel stress is 60ksi)

$$f_{s1} := \begin{cases} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \dfrac{\left[c_b - \left(B_D - d_1\right)\right]}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \dfrac{\left[c_b - \left(B_D - d_1\right)\right]}{c_b} < 0\text{ksi} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{\left[c_b - \left(B_D - d_1\right)\right]}{c_b}\right] & \text{otherwise} \end{cases}$$

$$f_{s1} = -26.683 \cdot \text{ksi}$$

Steel stress in 2nd layer of bottom steel (the maximum allowable steel stress is 60ksi)

$$f_{s2} := \begin{cases} \text{if } \phi_{b2} > 0.1\text{in} \\ \quad \begin{cases} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \dfrac{\left[c_b - \left(B_D - d_2\right)\right]}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \dfrac{\left[c_b - \left(B_D - d_2\right)\right]}{c_b} < 0\text{ksi} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{\left[c_b - \left(B_D - d_2\right)\right]}{c_b}\right] & \text{otherwise} \end{cases} \\ 0\text{ksi} \quad \text{otherwise} \end{cases}$$

$$f_{s2} = 0 \cdot \text{ksi}$$

Steel stress in 1st layer of top steel (the maximum allowable steel stress is 60ksi)

$$f'_{s1} := \begin{cases} 0\text{ksi} & \text{if } \phi_{t1} < 0.1\text{in} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{\left[\left(B_D - d'_1\right) - c_b\right]}{c_b}\right] & \text{otherwise} \end{cases}$$

$$f'_{s1} = 40 \cdot \text{ksi}$$

Steel stress in 2nd layer of top steel (the maximum allowable steel stress is 60ksi)

$$f'_{s2} := \begin{cases} 0\text{ksi} & \text{if } \phi_{t2} < 0.1\text{in} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{\left[\left(B_D - d'_2\right) - c_b\right]}{c_b}\right] & \text{otherwise} \end{cases}$$

$$f'_{s2} = 0 \cdot \text{ksi}$$

Slab Characteristics - Equilibrium Between Compression and Tension Forces

Equilibrium is reached when the compression and tension forces in the girder section are balanced.

The allowable tension force in the 1st layer of the bottom steel

$$\mathbf{F_1} := \mathbf{A_{b1\_t}} \cdot \mathbf{f_{s1}} = -8.931 \cdot \mathbf{kip}$$

The allowable tension force in the 2nd layer of the bottom steel

$$\mathbf{F_2} := \mathbf{A_{b2\_t}} \cdot \mathbf{f_{s2}} = 0 \cdot \mathbf{kip}$$

The allowable compression force in the 1st layer of the top steel

$$\mathbf{F'_1} := \mathbf{A_{t1\_t}} \cdot \mathbf{f'_{s1}} = 26.775 \cdot \mathbf{kip}$$

The allowable compression force in the 2nd layer of the top steel

$$\mathbf{F'_2} := \mathbf{A_{t2\_t}} \cdot \mathbf{f'_{s2}} = 0 \cdot \mathbf{kip}$$

The allowable compression force in the concrete

$$\mathbf{F_c} := 0.85 \cdot \mathbf{f'_c} \cdot \left(\mathbf{B_W} \cdot \mathbf{a}\right) = 36.078 \cdot \mathbf{kip}$$

The sum of the forces shall equal 0 for equilibrium

$$\mathbf{Eq} := \mathbf{F'_1} + \mathbf{F'_2} - \mathbf{F_1} - \mathbf{F_2} - \mathbf{F_c} = -0.37 \cdot \mathbf{kip}$$

$$\mathbf{if}\left(-0.5\mathbf{kip} < \mathbf{Eq} < 0.5\mathbf{kip}, \text{"OK"}, \text{"NG"}\right) = \text{"OK"}$$

Slab Characteristics - Moment Capacity

Since the tension and compression forces result in equilibrium, the assumed compression block depth is accurate. The moment capacity is therefore the sum of the moments about the 1st top layer of steel.

Moment of concrete compression force

$$\mathbf{M_{cn}} := \left[0.85 \cdot \mathbf{f'_c} \cdot \mathbf{a} \cdot \mathbf{B_W} \cdot \left[\left(\mathbf{B_D} - \mathbf{d'_1}\right) - \frac{\mathbf{a}}{2}\right]\right]$$

$$\mathbf{M_{cn}} = 201.96 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Moment of steel 1st layer - bottom of girder

$$\mathbf{M_{b1n}} := \mathbf{A_{b1\_t}} \cdot \mathbf{f_{s1}} \cdot \left(\mathbf{d_1} - \mathbf{d'_1}\right) = -39.07 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Moment of steel 2nd layer - bottom of girder

$$\mathbf{M_{b2n}} := \mathbf{A_{b2\_t}} \cdot \mathbf{f_{s2}} \cdot \left(\mathbf{d_1} - \mathbf{d_2}\right) = 0 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Moment of steel 2nd layer - top of girder

$$\mathbf{M_{t2n}} := \mathbf{A_{t2\_t}} \cdot \mathbf{f'_{s2}} \cdot \left(\mathbf{d_1} - \mathbf{d'_2}\right) = 0 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Negative moment capacity of girder

$$M_{nn} := M_{cn} + M_{b1n} + M_{b2n} + M_{t2n}$$

$$M_{nn} = 13.57 \cdot kip \cdot ft$$

Slab Characteristics - Strength Reduction Factor

The strength reduction factor is checked to determine whether the section is tension controlled, compression controlled or in the transition zone.

Strength reduction factor (ACI 318-14 Chapter 21)

$$\phi_f := \begin{cases} 0.65 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} \le \dfrac{f_y}{E_s} \\ 0.9 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} > 0.005 \\ \left[0.65 + \dfrac{\left[0.25 \cdot \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} - \dfrac{f_y}{E_s} \right]}{0.005 - \dfrac{f_y}{E_s}} \right] & \text{otherwise} \end{cases}$$

$$\phi_f = 0.9$$

Nominal negative moment capacity of section

$$phiM_{nn\_LE} := \phi_f \cdot M_{nn} = 12.22 \cdot kip \cdot ft$$

A3.0 SHEAR CAPACITY OF THE SLAB

The shear capacity of the slab is governed by the concrete section.

Modification factor for lightweight concrete (ACI 318-14 Table 19.2.4.2)

$$\lambda := 1.0$$

Shear capacity of concrete (ACI 318-14 equations 22.5.5.1)

$$V_c := 2 \cdot \lambda \cdot \sqrt{f'_c \cdot psi} \cdot B_W \cdot d_1 = 8.13 \cdot kip$$

$$phiV_c := \phi_s \cdot V_c = 6.1 \cdot kip$$

Total shear strength of reinforced concrete section at left end

$$phiV_n := phiV_c = 6.1 \cdot kip$$

A4.0 DEMAND TO CAPACITY RATIO

The demands are taken from the accompanying SAP2000 model, in which traffic, live and dead loads are considered to evaluate the moment and shears induced in the system based on MARAD specifications.

Maximum positive moment demand on pier bent - original layout $M_{up\_orig} := 237.56\,kip \cdot ft$

Maximum positive moment demand on pier bent - modified layout $M_{up\_mod} := 435.63\,kip \cdot ft$

Maximum negative moment demand on pier bent - original layout $M_{un\_orig} := -140.83\,kip \cdot ft$

Maximum negative moment demand on pier bent - modified layout $M_{un\_mod} := -304.71\,kip \cdot ft$

Maximum shear demand on pier bent - original layout $V_{u\_orig} := 86.16\,kip$

Maximum shear demand on pier bent - modified layout $V_{u\_mod} := 126.32\,kip$

Slab Characteristics - Strength Reduction Factor

DCR positive moment - original layout $DCR_1 := \dfrac{M_{up\_orig}}{phiM_{np\_LE}} = 30.65$

DCR positive moment - modified layout $DCR_2 := \dfrac{M_{up\_mod}}{phiM_{np\_LE}} = 56.2$

DCR negative moment - original layout $DCR_2 := \dfrac{M_{un\_orig}}{phiM_{nn\_LE}} = -11.53$

DCR negative moment - modified layout $DCR_4 := \dfrac{M_{un\_mod}}{phiM_{nn\_LE}} = -24.94$

DCR shear - original layout $DCR_5 := \dfrac{V_{u\_orig}}{phiV_n} = 14.12$

DCR shear - modified layout $DCR_6 := \dfrac{V_{u\_mod}}{phiV_n} = 20.71$

A1.0 DESIGN BASIS - BEAM

The following information is extracted from the structural drawings.

A1.1.1 Section Properties

Depth of beam section in roof floor	$B_D := 60\mathbf{in}$
Width of beam section in roof floor	$B_W := 18\mathbf{in}$
Thinkness of flange (slab section) in roof floor	$Flg_{thk} := 0\mathbf{in}$
Centerline span adjacent columns	$Span_c := 12\mathbf{ft}$
Clear span between adjacent beams left	$Span_{bl} := 12\mathbf{ft} - 18\mathbf{in} = 10.5 \cdot \mathbf{ft}$
Clear span between adjacent beams on right	$Span_{br} := 12\mathbf{ft} - 18\mathbf{in} = 10.5 \cdot \mathbf{ft}$
Left column support width	$Col_{1w} := 20\mathbf{in}$
Right column support width	$Col_{2w} := 20\mathbf{in}$

A1.1.2 Material Properties

Strength of concrete	$f'_c := 3\mathbf{ksi}$
Strength of reinforcing steel	$f_y := 40\mathbf{ksi}$
Modulus of elasticity of steel	$E_s := 29000\mathbf{ksi}$
Allowable strain at strength for concrete	$\varepsilon_c := 0.003 \frac{\mathbf{in}}{\mathbf{in}}$
Yield strain of steel	$\varepsilon_s := \frac{f_y}{E_s} = 0.00138 \cdot \frac{\mathbf{in}}{\mathbf{in}}$

A1.1.3 Design Parameters

Concrete clear cover over steel	$c_c := 1.5\mathbf{in}$
Strength reduction factor for flexure (ACI 318-14 Table 21.2.2 - tension controlled)	$\phi_f := 0.9$

Strength reduction factor for shear (ACI 318-14 Table 21.2.1) $\phi_s := 0.75$

A2.0 DESIGN CALCULATIONS

A2.0.1 Beam Reinforcement @ LE

Reinforcement Bar Diameters

Reinforcement bar diameter for 1st layer of top bar $\phi_{t1} := 1.128\mathbf{in}$

Reinforcement bar diameter for 2nd layer of top bar $\phi_{t2} := 0\mathbf{in}$

Reinforcement bar diameter for 1st layer of bottom bar $\phi_{b1} := 1.128\mathbf{in}$

Reinforcement bar diameter for 2nd layer of bottom bar $\phi_{b2} := 0\mathbf{in}$

Reinforcement bar diameter for stirrups $\phi_{st} := 0.5\mathbf{in}$

Note: Bottom rebar values obtained from drawing "Pier 2 Improvements, Pier 2 Demolition and Miscellaneous Sections and Details" (drawing No. 6,131,609)
Top rebar values assumed to be same size.

Bar Reinforcement Areas

Reinforcement area for 1st layer of top bar $A_{t1} := \pi \cdot \frac{\phi_{t1}^2}{4} = 1\,\mathbf{in}^2$

Reinforcement area for 2nd layer of top bar $A_{t2} := \pi \cdot \frac{\phi_{t2}^2}{4} = 0$

Reinforcement area for 1st layer of bottom bar $A_{b1} := \pi \cdot \frac{\phi_{b1}^2}{4} = 1\,\mathbf{in}^2$

Reinforcement area for 2nd layer of bottom bar $A_{b2} := \pi \cdot \frac{\phi_{b2}^2}{4} = 0$

Reinforcement area for a single leg of stirrups $A_{st} := \pi \cdot \frac{\phi_{st}^2}{4} = 0.2\,\mathbf{in}^2$

Number of bars in first top layer LE $No_{lt1} := 3$

Number of bars in second top layer LE $\mathbf{No_{lt2}} := 0$

Total area of bars in first top layer LE $\mathbf{A_{t1\_t}} := \mathbf{A_{t1}} \cdot \mathbf{No_{lt1}} = 3\,\mathbf{in}^2$

Total area of bars in second top layer LE $\mathbf{A_{t2\_t}} := \mathbf{A_{t2}} \cdot \mathbf{No_{lt2}} = 0$

Total reinforcing area top LE $\mathbf{A_{t\_t}} := \mathbf{A_{t1\_t}} + \mathbf{A_{t2\_t}} = 3\,\mathbf{in}^2$

Number of bars in first bottom layer $\mathbf{No_{b1}} := 3$

Number of bars in second bottom layer $\mathbf{No_{b2}} := 0$

Total area of bars in first bottom layer $\mathbf{A_{b1\_t}} := \mathbf{A_{b1}} \cdot \mathbf{No_{b1}} = 3\,\mathbf{in}^2$

Total area of bars in second bottom layer $\mathbf{A_{b2\_t}} := \mathbf{A_{b2}} \cdot \mathbf{No_{b2}} = 0$

Total reinforcing area bottom layer $\mathbf{A_{bt}} := \mathbf{A_{b1\_t}} + \mathbf{A_{b2\_t}} = 3\,\mathbf{in}^2$

Height from Compression Face to Tension Reinforcement

'd' dimension for 1st layer of bottom bars

$$\mathbf{d_1} := B_D - \mathbf{c_c} - \phi_{\mathbf{st}} - \frac{\phi_{\mathbf{b1}}}{2} = 57.44\,\mathbf{in}$$

'd' dimension for 2nd layer of bottom bars (assume the spacing between layers is governed by ACI 318-14 Section 25.2.2)

$$\mathbf{d_2} := \begin{cases} 0\,\mathbf{in} & \text{if } \phi_{\mathbf{b2}} < 0.1\,\mathbf{in} \\ \left(\mathbf{d_1} - \phi_{\mathbf{st}} - 1\,\mathbf{in} - \frac{\phi_{\mathbf{b2}}}{2}\right) & \textbf{otherwise} \end{cases}$$

$$\mathbf{d_2} = 0\,\mathbf{in}$$

'd' dimension for 1st layer of top bars

$$\mathbf{d'_1} := \mathbf{c_c} + \phi_{\mathbf{st}} + \frac{\phi_{\mathbf{t1}}}{2} = 2.564\,\mathbf{in}$$

'd' dimension for 2nd layer of top bars (assume the spacing between layers is governed by ACI 318-14 Section 25.2.2)

$$\mathbf{d'_2} := \begin{array}{|l} 0\mathbf{in} \ \ \mathbf{if} \ \ \phi_{\mathbf{t2}} < 0.1\mathbf{in} \\ \left(\mathbf{d'_1} + 1\mathbf{in} + \phi_{\mathbf{t2}}\right) \ \ \mathbf{otherwise} \end{array}$$

$$\mathbf{d'_2} = 0\mathbf{in}$$

A2.1 POSITIVE MOMENT CAPACITY OF BEAM AT LEFT END

Since the top slab is integral with the beam in the roof, a portion on either side of the beam can act as a t-beam flange. ACI 318 allows us to consider a portion of the adjacent slab area on either side of the face of a member. These criteria are listed in ACI 318-14 Table 6.3.2.1. The magnitude of benefit depends on whether the slab overhangs on both sides of the beam or just one side. Below is a check for the effective beam thickness we will take advantage of in the subsequent moment calculations.

Beam Characteristics - Effective Width Calculation

Designation of whether the slab overhangs (S.O.) on one or two sides of the t-beam

$$\mathbf{SO} := 0$$

$$\mathbf{SO_{ref}} := \begin{bmatrix} 6\cdot\mathbf{Flg_{thk}} & \dfrac{\left(\mathbf{Span_{br}}\right)}{2} & \dfrac{\mathbf{Span_c} - \dfrac{\mathbf{Col_{1w}}}{2} - \dfrac{\mathbf{Col_{2w}}}{2}}{12} \\ 8\cdot\mathbf{Flg_{thk}} & \dfrac{\left(\mathbf{Span_{br}}\right)}{2} & \dfrac{\mathbf{Span_c} - \dfrac{\mathbf{Col_{1w}}}{2} - \dfrac{\mathbf{Col_{2w}}}{2}}{8} \end{bmatrix} = \begin{pmatrix} 0 & 63 & 10 \\ 0 & 63 & 16 \end{pmatrix}\mathbf{in}$$

$$\mathbf{b_{eff1}} := \mathbf{min}\left[\left(\mathbf{SO_{ref}}^{\mathbf{T}}\right)^{\langle 0\rangle}\right] = 0\mathbf{in} \qquad \mathbf{b_{eff2}} := \mathbf{min}\left[\left(\mathbf{SO_{ref}}^{\mathbf{T}}\right)^{\langle 1\rangle}\right] = 0\mathbf{in}$$

$$\mathbf{b_{eff}} := \mathbf{if}\left(\mathbf{SO} < 2, \mathbf{b_{eff1}} + \mathbf{B_W}, \mathbf{b_{eff2}}\cdot 2 + \mathbf{B_W}\right)$$

Allowable effective width (ACI 318-14 Table 6.3.2.1)

$$\mathbf{b_{eff}} := 18\mathbf{in}$$

Beam Characteristics - Depth of Compression Block

Finding the depth of the compression block and the compression steel stress for a doubly reinforced concrete section is an iterative process. Equilibrium between the tension and compression forces needs to be achieved. Below is the general process:

1) Estimate the depth of the compression block
2) Calculate the distance to the neutral axis
   a) If the distance is less than the flange thickness then a single rectangular section comprises the compression block
   b) If the distance is greater than the flange thickness then the web of the T-beam contributes to the compression block
3) Determine the stress in the tension and compression steel
4) Sum the moments to find equilibrium
   a) If the moments do not sum to zero, start at step 1) and re-estimate the depth of the compression block

Estimate the depth of the compression block

$$\mathbf{a} := 2.3048597\mathbf{in}$$

Beam Characteristics - Depth to Neutral Axis

Reinforced concrete stress block modifier

$$\beta_1 := \mathbf{min}\left[0.85 - \frac{0.5(\mathbf{f'_c} - 4000\mathbf{psi})}{1000\mathbf{psi}}, 0.85\right] = 0.85$$

Distance from compression face to neutral axis

$$\mathbf{c_b} := \frac{\mathbf{a}}{\beta_1} = 2.71\,\mathbf{in}$$

Beam Characteristics - Determine Steel Stresses

Steel stress in 1st layer of bottom steel
(the maximum allowable steel stress is 60ksi)

$$\mathbf{f_{s1}} := \mathbf{min}\left[\mathbf{f_y}, \varepsilon_c \cdot \mathbf{E_s} \cdot \frac{(\mathbf{d_1} - \mathbf{c_b})}{\mathbf{c_b}}\right]$$

$$\mathbf{f_{s1}} = 40 \cdot \mathbf{ksi}$$

Steel stress in 2nd layer of bottom steel
(the maximum allowable steel stress is 60ksi)

$$\mathbf{f_{s2}} := \begin{cases} 0\mathbf{ksi} & \mathbf{if}\ \phi_{b2} < 0.1\mathbf{in} \\ \mathbf{min}\left[\mathbf{f_y}, \varepsilon_c \cdot \mathbf{E_s} \cdot \frac{(\mathbf{d_2} - \mathbf{c_b})}{\mathbf{c_b}}\right] & \mathbf{otherwise} \end{cases}$$

$$\mathbf{f_{s2}} = 0 \cdot \mathbf{ksi}$$

Steel stress in 1st layer of top steel
(the maximum allowable steel stress is 60ksi)

$$f'_{s1} := \begin{cases} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_1)}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_1)}{c_b} < 0\text{ksi} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_1)}{c_b}\right] & \text{otherwise} \end{cases}$$

$$f'_{s1} = 4.736 \cdot \text{ksi}$$

Steel stress in 2nd layer of top steel
(the maximum allowable steel stress is 60ksi)

$$f'_{s2} := \begin{cases} \text{if } \phi_{t2} > 0.1\text{in} \\ \quad \begin{cases} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_2)}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_2)}{c_b} < 0\text{ksi} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \dfrac{(c_b - d'_2)}{c_b}\right] & \text{otherwise} \end{cases} \\ 0\text{ksi} \quad \text{otherwise} \end{cases}$$

$$f'_{s2} = 0 \cdot \text{ksi}$$

Beam Characteristics - Equilibrium Between Compression and Tension Forces

Equilibrium is reached when the compression and tension forces in the beam section are balanced.

The allowable tension force in the 1st layer of the bottom steel

$$F_1 := A_{b1\_t} \cdot f_{s1} = 119.919 \cdot \text{kip}$$

The allowable tension force in the 2nd layer of the bottom steel

$$F_2 := A_{b2\_t} \cdot f_{s2} = 0 \cdot \text{kip}$$

The allowable compression force in the 1st layer of the top steel

$$F'_1 := A_{t1\_t} \cdot f'_{s1} = 14.197 \cdot \text{kip}$$

The allowable compression force in the 2nd layer of the top steel

$$F'_2 := A_{t2\_t} \cdot f'_{s2} = 0 \cdot \text{kip}$$

The allowable compression force in the concrete

$$F_c := \begin{cases} 0.85 \cdot f'_c \cdot a \cdot b_{eff} & \text{if } \left| \begin{array}{l} a < Flg_{thk} \\ Flg_{thk} < 0.1in \end{array} \right. \\ \left[0.85 \cdot f'_c \cdot \left[b_{eff} \cdot Flg_{thk} + B_W \cdot \left(a - b_{eff} \right) \right] \right] & \text{otherwise} \end{cases}$$

$$F_c = 105.793 \cdot kip$$

The sum of the forces shall equal 0 for equilibrium

$$Eq := F_1 + F_2 - F'_1 - F'_2 - F_c = -0.07 \cdot kip$$

$$\text{if}(-0.5kip < Eq < 0.5kip, \text{"OK"}, \text{"NG"}) = \text{"OK"}$$

Beam Characteristics - Moment Capacity

Since the tension and compression forces result in equilibrium, the assumed compression block depth is accurate. The moment capacity is therefore the sum of the moments about the 1st bottom layer of steel.

Moment of concrete compression force

$$M_c := \begin{cases} \left[0.85 \cdot f'_c \cdot a \cdot b_{eff} \cdot \left(d_1 - \frac{a}{2} \right) \right] & \text{if } \left| \begin{array}{l} a < Flg_{thk} \\ Flg_{thk} < 0.1in \end{array} \right. \\ \left[0.85 \cdot f'_c \cdot \left[Flg_{thk} \cdot b_{eff} \cdot \left(d_1 - \frac{Flg_{thk}}{2} \right) + \left(a - Flg_{thk} \right) \cdot B_W \cdot \left(d_1 - Flg_{thk} - \frac{a - Flg_{thk}}{2} \right) \right] \right] & \text{otherwise} \end{cases}$$

$$M_c = 5954.41 \cdot kip \cdot in$$

Moment of steel 1st layer - top of beam

$$M_{t1} := A_{t1\_t} \cdot f'_{s1} \cdot \left(d_1 - d'_1 \right) = 779.04 \cdot kip \cdot in$$

Moment of steel 2nd layer - top of beam

$$M_{t2} := A_{t2\_t} \cdot f'_{s2} \cdot \left(d_1 - d'_2 \right) = 0 \cdot kip \cdot in$$

Moment of steel 2nd layer - bottom of beam

$$M_{b2} := A_{b2\_t} \cdot f_{s2} \cdot \left(d_1 - d_2 \right) = 0 \cdot kip \cdot in$$

Positive moment capacity of beam

$$M_{np} := M_c + M_{t1} + M_{t2} + M_{b2}$$

$$M_{np} = 561.12 \cdot kip \cdot ft$$

Beam Characteristics - Strength Reduction Factor

The strength reduction factor is checked to determine whether the beam is tension controlled, compression controlled or in the transition zone.

Strength reduction factor (ACI 318-14 Chapter 21)

$$\phi_f := \begin{cases} 0.65 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} \le \dfrac{f_y}{E_s} \\ 0.9 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} > 0.005 \\ \left[0.65 + \dfrac{\left[0.25 \cdot \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} - \dfrac{f_y}{E_s} \right]}{0.005 - \dfrac{f_y}{E_s}} \right] & \text{otherwise} \end{cases}$$

$$\phi_f = 0.9$$

Nominal postitive moment capacity of beam

$$\mathbf{phiM_{np\_LE}} := \phi_f \cdot M_{np} = 505.01 \cdot \mathbf{kip \cdot ft}$$

A2.2 NEGATIVE MOMENT CAPACITY OF BEAM AT LEFT END

In the positive moment capacity calculation, the effective width of the T-beam section was considered since the flange significantly contributed to the compressive capacity of the concrete section. For the negative moment capacity, the flange resides in the tensile region and therefore does not contribute. Iterating to find the depth of the compression block is still necessary, the steps to find the negative moment capacity are shown below. We look at the end condition of the representative beam.

Beam Characteristics - Depth of Compression Block

Finding the depth of the compression block and the compression steel stress for a doubly reinforced concrete section is an iterative process. Equilibrium between the tension and compression forces needs to be achieved. Below is the general process:

1) Estimate the depth of the compression block
2) Calculate the distance to the neutral axis
3) Determine the stress in the tension and compression steel
4) Sum the moments to find equilibrium
    a) If the moments do not sum to zero, start at step 1) and re-estimate the depth of the compression block

Estimate the depth of the compression block

$$\mathbf{a} := 2.304859\mathbf{in}$$

Beam Characteristics - Depth to Neutral Axis

Reinforced concrete stress block modifier

$$\beta_1 := \min\left[0.85 - \frac{0.5(f'_c - 4000psi)}{1000psi}, 0.85\right] = 0.85$$

Distance from compression face to neutral axis

$$c_b := \frac{a}{\beta_1} = 2.71\,in$$

Beam Characteristics - Determine Steel Stresses

Steel stress in 1st layer of bottom steel (the maximum allowable steel stress is 60ksi)

$$f_{s1} := \begin{cases} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \frac{\left[c_b - (B_D - d_1)\right]}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \frac{\left[c_b - (B_D - d_1)\right]}{c_b} < 0ksi \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \frac{\left[c_b - (B_D - d_1)\right]}{c_b}\right] & \text{otherwise} \end{cases}$$

$$f_{s1} = 4.736 \cdot ksi$$

Steel stress in 2nd layer of bottom steel (the maximum allowable steel stress is 60ksi)

$$f_{s2} := \begin{cases} \text{if } \phi_{b2} > 0.1in \\ \quad \begin{cases} \max\left[-f_y, \varepsilon_c \cdot E_s \cdot \frac{\left[c_b - (B_D - d_2)\right]}{c_b}\right] & \text{if } \varepsilon_c \cdot E_s \cdot \frac{\left[c_b - (B_D - d_2)\right]}{c_b} < 0ksi \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \frac{\left[c_b - (B_D - d_2)\right]}{c_b}\right] & \text{otherwise} \end{cases} \\ 0ksi \quad \text{otherwise} \end{cases}$$

$$f_{s2} = 0 \cdot ksi$$

Steel stress in 1st layer of top steel (the maximum allowable steel stress is 60ksi)

$$f'_{s1} := \begin{cases} 0ksi & \text{if } \phi_{t1} < 0.1in \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \frac{\left[(B_D - d'_1) - c_b\right]}{c_b}\right] & \text{otherwise} \end{cases}$$

$$f'_{s1} = 40 \cdot ksi$$

Steel stress in 2nd layer of top steel (the maximum allowable steel stress is 60ksi)

$$f'_{s2} := \begin{cases} 0\,\mathbf{ksi} & \text{if } \phi_{t2} < 0.1\,\mathbf{in} \\ \min\left[f_y, \varepsilon_c \cdot E_s \cdot \frac{\left[\left(B_D - d'_2\right) - c_b\right]}{c_b}\right] & \text{otherwise} \end{cases}$$

$$f'_{s2} = 0 \cdot \mathbf{ksi}$$

Beam Characteristics - Equilibrium Between Compression and Tension Forces

Equilibrium is reached when the compression and tension forces in the girder section are balanced.

The allowable tension force in the 1st layer of the bottom steel

$$F_1 := A_{b1\_t} \cdot f_{s1} = 14.197 \cdot \mathbf{kip}$$

The allowable tension force in the 2nd layer of the bottom steel

$$F_2 := A_{b2\_t} \cdot f_{s2} = 0 \cdot \mathbf{kip}$$

The allowable compression force in the 1st layer of the top steel

$$F'_1 := A_{t1\_t} \cdot f'_{s1} = 119.919 \cdot \mathbf{kip}$$

The allowable compression force in the 2nd layer of the top steel

$$F'_2 := A_{t2\_t} \cdot f'_{s2} = 0 \cdot \mathbf{kip}$$

The allowable compression force in the concrete

$$F_c := 0.85 \cdot f'_c \cdot \left(B_W \cdot a\right) = 105.793 \cdot \mathbf{kip}$$

The sum of the forces shall equal 0 for equilibrium

$$Eq := F'_1 + F'_2 - F_1 - F_2 - F_c = -0.07 \cdot \mathbf{kip}$$

$$\text{if}\left(-0.5\,\mathbf{kip} < Eq < 0.5\,\mathbf{kip}, \text{"OK"}, \text{"NG"}\right) = \text{"OK"}$$

Beam Characteristics - Moment Capacity

Since the tension and compression forces result in equilibrium, the assumed compression block depth is accurate. The moment capacity is therefore the sum of the moments about the 1st top layer of steel.

Moment of concrete compression force

$$M_{cn} := \left[0.85 \cdot f'_c \cdot a \cdot B_W \cdot \left[\left(B_D - d'_1\right) - \frac{a}{2}\right]\right]$$

$$M_{cn} = 5954.41 \cdot \mathbf{kip} \cdot \mathbf{in}$$

Moment of steel 1st layer - bottom of girder $M_{b1n} := A_{b1\_t} \cdot f_{s1} \cdot (d_1 - d'_1) = 779.03 \cdot kip \cdot in$

Moment of steel 2nd layer - bottom of girder $M_{b2n} := A_{b2\_t} \cdot f_{s2} \cdot (d_1 - d_2) = 0 \cdot kip \cdot in$

Moment of steel 2nd layer - top of girder $M_{t2n} := A_{t2\_t} \cdot f'_{s2} \cdot (d_1 - d'_2) = 0 \cdot kip \cdot in$

Negative moment capacity of girder $M_{nn} := M_{cn} + M_{b1n} + M_{b2n} + M_{t2n}$

$M_{nn} = 561.12 \cdot kip \cdot ft$

Beam Characteristics - Strength Reduction Factor

The strength reduction factor is checked to determine whether the beam is tension controlled, compression controlled or in the transition zone.

Strength reduction factor (ACI 318-14 Chapter 21)

$$\phi_f := \begin{cases} 0.65 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} \le \dfrac{f_y}{E_s} \\ 0.9 & \text{if } \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} > 0.005 \\ \left[0.65 + \dfrac{\left[0.25 \cdot \varepsilon_c \cdot \dfrac{(d_1 - c_b)}{c_b} - \dfrac{f_y}{E_s} \right]}{0.005 - \dfrac{f_y}{E_s}} \right] & \text{otherwise} \end{cases}$$

$\phi_f = 0.9$

Nominal negative moment capacity of beam $phiM_{nn\_LE} := \phi_f \cdot M_{nn} = 505.01 \cdot kip \cdot ft$

A3.0 SHEAR CAPACITY OF THE BEAM AT THE LEFT END

The shear capacity of the beam is governed by the concrete section and supplied shear reinforcing. Two stirrup reinforcing configurations are given for the RB-35 Beam, the smaller stirrup spacing being at the right end of the beam closest to the interior column.

Stirrup type (A = 2 legs, B & C = 4 legs) $\mathbf{Leg_{num}} := A = 2$

Total stirrup area per line of stirrup $\mathbf{A_{st\_t}} := \mathbf{A_{st}} \cdot \mathbf{Leg_{num}} = 0.39\,\mathbf{in}^2$

Spacing of stirrup reinforcing in shear region of beam
(Spacing along full length of beam) $\mathbf{spcg_{st}} := 12\mathbf{in}$

Shear capacity of stirrups (ASCI 318-14 equation 22.5.10.5.3) $\mathbf{V_s} := \dfrac{\mathbf{A_{st\_t}} \cdot \mathbf{f_y} \cdot \mathbf{d_1}}{\mathbf{spcg_{st}}} = 75.18 \cdot \mathbf{kip}$

$\mathbf{phiV_s} := \phi_s \cdot \mathbf{V_s} = 56.39 \cdot \mathbf{kip}$

Modification factor for lightweight
concrete (ACI 318-14 Table 19.2.4.2) $\lambda := 1.0$

Shear capacity of concrete (ACI 318-14 equations 22.5.5.1) $\mathbf{V_c} := 2 \cdot \lambda \cdot \sqrt{\mathbf{f'_c} \cdot \mathbf{psi}} \cdot \mathbf{B_W} \cdot \mathbf{d_1} = 113.25 \cdot \mathbf{kip}$

$\mathbf{phiV_c} := \phi_s \cdot \mathbf{V_c} = 84.94 \cdot \mathbf{kip}$

Total shear strength of reinforced concrete section at left end $\mathbf{phiV_n} := \mathbf{phiV_s} + \mathbf{phiV_c} = 141.33 \cdot \mathbf{kip}$

A4.0 DEMAND TO CAPACITY RATIO

The demands are taken from the accompanying SAP2000 model, in which traffic, live and dead loads are considered to evaluate the moment and shears induced in the system based on MARAD specifications.

Maximum positive moment demand on pier bent - original layout $M_{up\_orig} := 237.56\,\mathbf{kip\cdot ft}$

Maximum positive moment demand on pier bent - modified layout $M_{up\_mod} := 435.63\,\mathbf{kip\cdot ft}$

Maximum negative moment demand on pier bent - original layout $M_{un\_orig} := -140.83\,\mathbf{kip\cdot ft}$

Maximum negative moment demand on pier bent - modified layout $M_{un\_mod} := -304.71\,\mathbf{kip\cdot ft}$

Maximum shear demand on pier bent - original layout $V_{u\_orig} := 86.16\,\mathbf{kip}$

Maximum shear demand on pier bent - modified layout $V_{u\_mod} := 126.32\,\mathbf{kip}$

Beam Characteristics - Strength Reduction Factor

DCR positive moment - original layout $DCR_1 := \frac{M_{up\_orig}}{phiM_{np\_LE}} = 0.47$

DCR positive moment - modified layout $DCR_2 := \frac{M_{up\_mod}}{phiM_{np\_LE}} = 0.86$

DCR negative moment - original layout $DCR_2 := \frac{M_{un\_orig}}{phiM_{nn\_LE}} = -0.28$

DCR negative moment - modified layout $DCR_4 := \frac{M_{un\_mod}}{phiM_{nn\_LE}} = -0.6$

DCR shear - original layout $DCR_5 := \frac{V_{u\_orig}}{phiV_n} = 0.61$

DCR shear - modified layout $DCR_6 := \frac{V_{u\_mod}}{phiV_n} = 0.89$

Check minimum steel reinforcing

$$A_{vmin} := \max\left(\frac{3\sqrt{f'_c \cdot psi}}{f_y} \cdot B_W \cdot d_1, \frac{200 \cdot psi \cdot B_W \cdot d_1}{f_y}\right) = 5.169\, in^2$$

$$\text{if}\left(A_{vmin} < A_{bt}, \text{"OK"}, \text{"NG"}\right) = \text{"NG"}$$

Check minimum steel reinforcing

$$A_{vmin} := \max\left(\frac{3\sqrt{f'_c \cdot psi}}{f_y} \cdot B_W \cdot d'_1, \frac{200 \cdot psi \cdot B_W \cdot d'_1}{f_y}\right) = 0.231\, in^2$$

$$\text{if}\left(A_{vmin} < A_{bt}, \text{"OK"}, \text{"NG"}\right) = \text{"OK"}$$

Check minimum steel reinforcing

$$A_{vmin} := \max\left(\frac{3\sqrt{f'_c \cdot psi}}{f_y} \cdot B_W \cdot d_2, \frac{200 \cdot psi \cdot B_W \cdot d_2}{f_y}\right) = 0\, in^2$$

$$\text{if}\left(A_{vmin} < A_{bt}, \text{"OK"}, \text{"NG"}\right) = \text{"OK"}$$

Check minimum steel reinforcing

$$A_{vmin} := \max\left(\frac{3\sqrt{f'_c \cdot psi}}{f_y} \cdot B_W \cdot d'_2, \frac{200 \cdot psi \cdot B_W \cdot d'_2}{f_y}\right) = 0\, in^2$$

$$\text{if}\left(A_{vmin} < A_{bt}, \text{"OK"}, \text{"NG"}\right) = \text{"OK"}$$

DEMAND AND CAPACITY

SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

CLIENT Alameda Pier #2 & #3
SUBJECT Beam and Slab Capacity Calculations

SHEET NO.
PROJECT NO. 167543.00 ALPR
DATE 04 April 2017
BY ERM
CHECKED BY RI

Material Properties:

Concrete			Reinforcing Steel		
Compressive Strength (f_c'):	3,000	psi	Yield Strength (f_y):	40	ksi
Elastic Modulus (E_c):	3,122,019	psi	Elastic Modulus (E_s):	29,000	ksi
Stress Block Factor (β_1):	0.85		Clear Cover:	2	in.

SGH Member ID	Member Type	Length L (ft)	Clear Span l_n (ft)	Web Clear Span Left s_{wl} (ft)	Web Clear Span Right s_{wr} (ft)	Web Depth d_w (in.)	Web Width b_w (in.)	Flange Thickness h_f (in.)	Flange Width Left b_{fl} (in.)	Flange Width Right b_{fr} (in.)
Bent Cap #6 Top bars	-	16.0	80.00	10.50	10.50	48.0	18.0	0.0	0.00	0.00
Slab	-	12.0	10.50	39.50	39.50	48.0	12.0	0.0	0.00	0.00
Bent Cap #7 Top bars	-	16.0	80.00	10.50	10.50	48.0	18.0	0.0	0.00	0.00
Bent Cap #8 Top bars	-	16.0	80.00	10.50	10.50	48.0	18.0	0.0	0.00	0.00
Bent Cap #9 Top bars	-	16.0	14.33	10.50	10.50	48.0	18.0	0.0	0.00	0.00
Pier 3 Slab	-	12.0	12.00	23.17	23.17	26.0	80.0	0.0	0.00	0.00
Pier 3 Slab	-	12.0	12.00	23.17	23.17	10.0	48.0	0.0	0.00	0.00

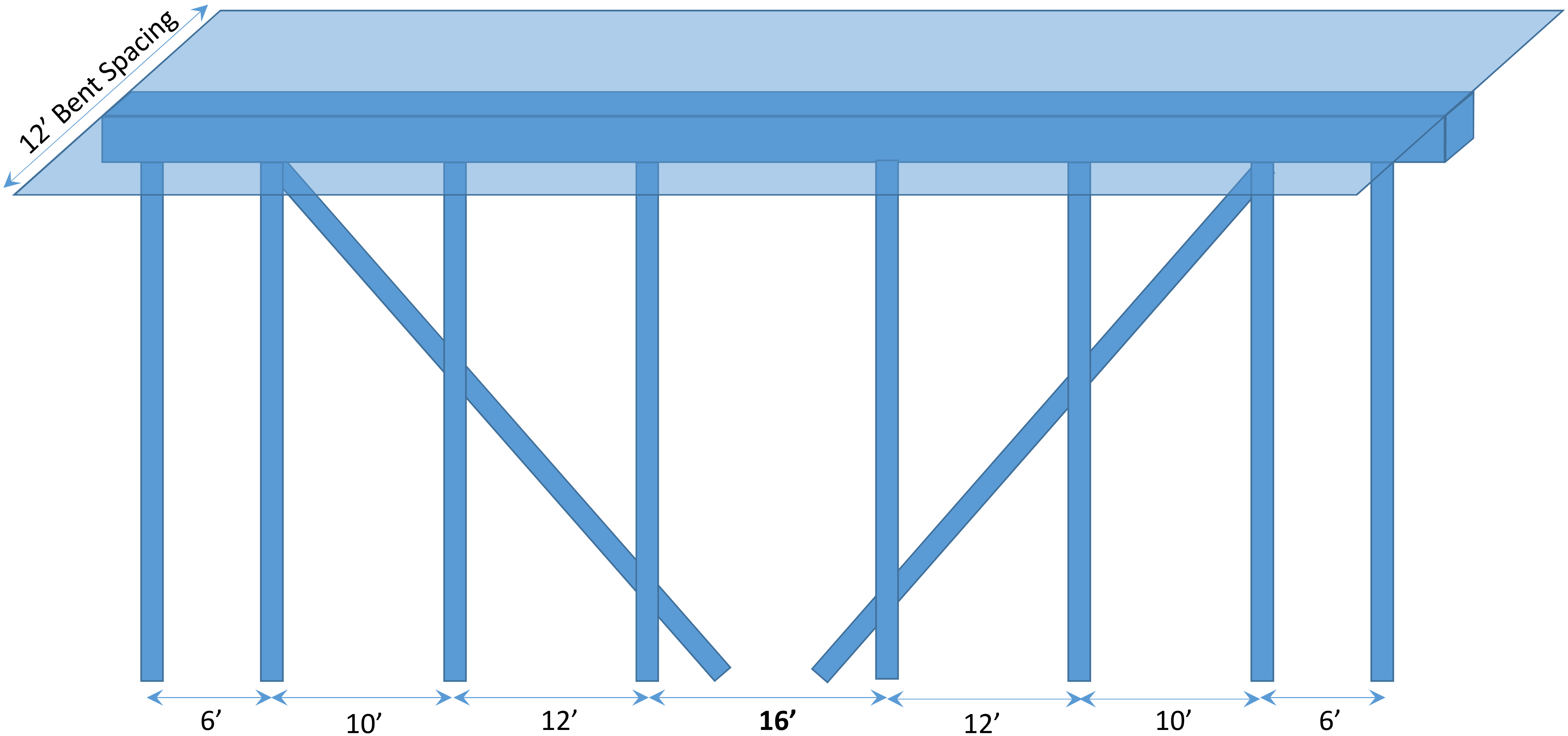
Bending in Positive Direction

SGH Member ID	Begining Station (ft)	End Station (ft)	A_{s1} (in.^{2})	d_1 (in.)	A_{s2} (in.^{2})	d_2 (in.)	A_{s1}' (in.^{2})	d_1' (in.)	A_{s2}' (in.^{2})	d_2' (in.)	Nuetral Axis Depth c (in.)	Equivalent Stress Block Depth a (in.)	f_{s1} (ksi)	f_{s2} (ksi)	f_{s1}' (ksi)	f_{s2}' (ksi)	Equilibrium	M_n (k-in.)	ϕ	ϕM_n (k-in.)
Bent Cap #6 Top bars	0.0	20.0	3.00	44.94			1.32	2.88			2.98	2.5295313	40.00	0.00	2.95	0.00	0.00	5234.27	0.90	4710.85
	20.0	-4.0	3.00	44.94			1.32	2.88			2.98	2.5295313	40.00	0.00	2.95	0.00	0.00	5234.45	0.90	4711.01
	-4.0	16.0	3.00	44.94			1.32	2.88			2.98	2.5295313	40.00	0.00	2.95	0.00	0.00	5234.27	0.90	4710.85
Slab	0.0	2.6	0.34	45.69			0.68	2.31			1.56	1.3262032	40.00	0.00	-40.00	0.00	0.00	653.68	0.90	588.31
	2.6	9.4	0.34	45.69			0.68	2.31			1.56	1.3262032	40.00	0.00	-40.00	0.00	0.00	653.68	0.90	588.31
	9.4	12.0	0.34	45.69			0.68	2.31			1.56	1.3262032	40.00	0.00	-40.00	0.00	0.00	653.68	0.90	588.31
Bent Cap #7 Top bars	0.0	20.0	3.00	44.94			1.80	2.94			3.00	2.5470992	40.00	0.00	1.72	0.00	0.00	5234.34	0.90	4710.91
	20.0	-4.0	3.00	44.94			1.80	2.94			3.00	2.5470992	40.00	0.00	1.72	0.00	0.00	5234.52	0.90	4711.07
	-4.0	16.0	3.00	44.94			1.80	2.94			3.00	2.5470992	40.00	0.00	1.72	0.00	0.00	5234.34	0.90	4710.91
Bent Cap #8 Top bars	0.0	20.0	3.00	44.94			2.37	3.00			3.03	2.5734483	40.00	0.00	0.79	0.00	0.00	5234.69	0.90	4711.22
	20.0	-4.0	3.00	44.94			2.37	3.00			3.03	2.5734483	40.00	0.00	0.79	0.00	0.00	5234.87	0.90	4711.39
	-4.0	16.0	3.00	44.94			2.37	3.00			3.03	2.5734483	40.00	0.00	0.79	0.00	0.00	5234.69	0.90	4711.22
Bent Cap #9 Top bars	0.0	3.6	3.00	44.94			3.00	3.06			3.07	2.6075373	40.00	0.00	0.10	0.00	0.00	5235.31	0.90	4711.78
	3.6	12.4	3.00	44.94			3.00	3.06			3.07	2.6075373	40.00	0.00	0.10	0.00	0.00	5235.49	0.90	4711.95
	12.4	16.0	3.00	44.94			3.00	3.06			3.07	2.6075373	40.00	0.00	0.10	0.00	0.00	5235.31	0.90	4711.78
Pier 3 Slab	0.0	3.0	4.40	23.63			4.40	2.38			1.77	1.5043657	40.00	0.00	-29.75	0.00	0.00	4238.04	0.90	3814.24
	13.0	9.0	4.40	23.63			4.40	2.38			1.77	1.5043658	40.00	0.00	-29.75	0.00	0.00	4238.04	0.90	3814.24
	26.0	12.0	4.40	23.63			4.40	2.38			1.77	1.5043657	40.00	0.00	-29.75	0.00	0.00	4238.04	0.90	3814.24
Pier 3 Slab	0.0	3.0	2.64	7.63			2.64	2.38			1.77	1.5043617	40.00	0.00	-29.75	0.00	0.00	853.21	0.90	767.89
	12.0	9.0	2.64	7.63			2.64	2.38			1.77	1.5043617	40.00	0.00	-29.75	0.00	0.00	853.21	0.90	767.89
	24.0	12.0	2.64	7.63			2.64	2.38			1.77	1.5043617	40.00	0.00	-29.75	0.00	0.00	853.21	0.90	767.89
																				317.85
																				317.85
																				63.99
																				49.03
																				392.65

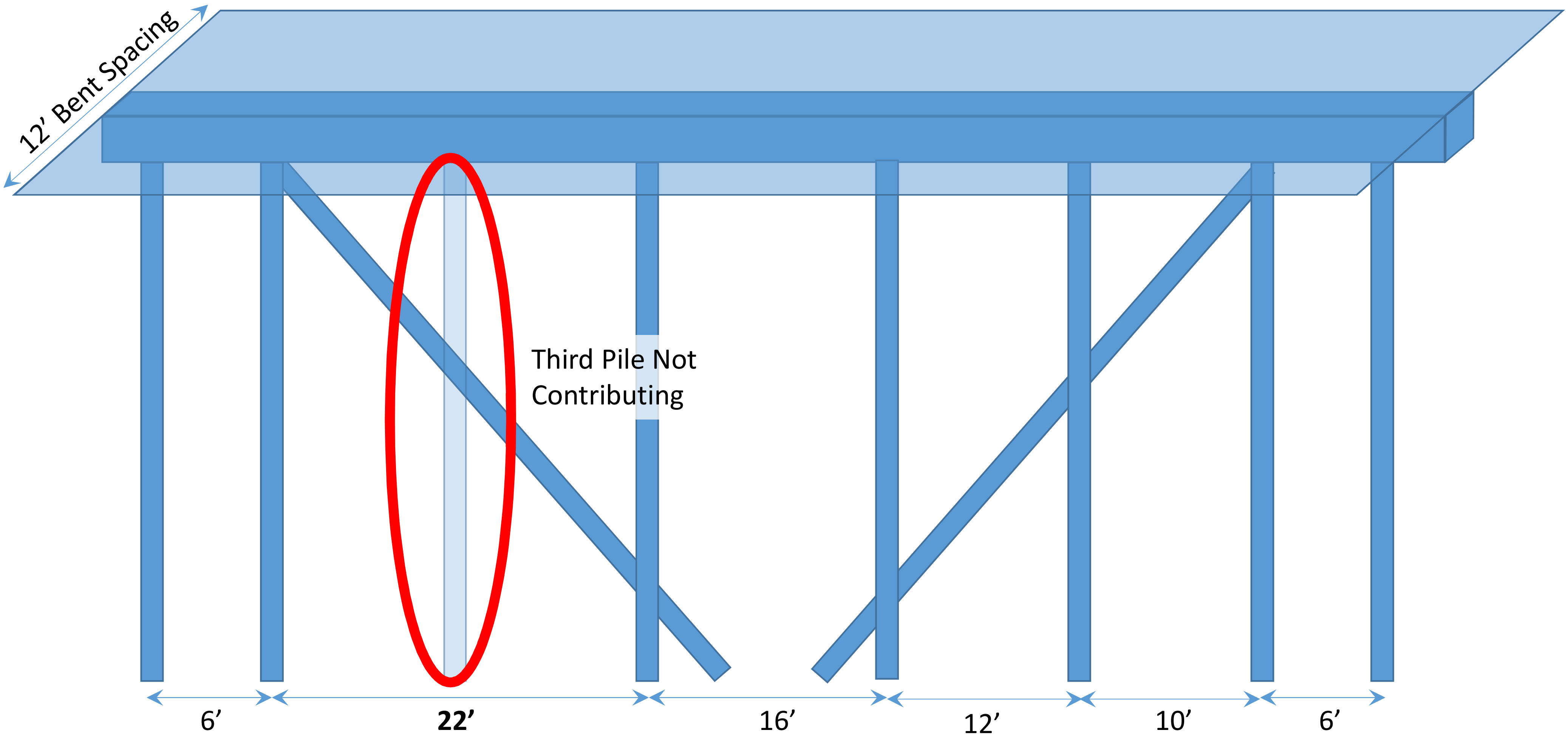
Bending in Negative Direction

SGH Member ID	Nuetral Axis Depth c (in.)	Equivalent Stress Block Depth a (in.)	f_{s1} (ksi)	f_{s2} (ksi)	f_{s1}' (ksi)	f_{s2}' (ksi)	Equilibrium	M_n (k-in.)	ϕ	ϕM_n (k-in.)
Bent Cap #6 Top bars	2.59	2.198908	-16.04	0.00	40.00	0.00	0.00	2419.10	0.90	2177.19
	2.59	2.198097	-16.03	0.00	40.00	0.00	0.00	2419.00	0.90	2177.10
	2.59	2.198908	-16.04	0.00	40.00	0.00	0.00	2419.10	0.90	2177.19
Slab	1.56	1.326203	-40.00	0.00	40.00	0.00	0.00	1240.43	0.90	1116.38
	1.56	1.326203	-40.00	0.00	40.00	0.00	0.00	1240.43	0.90	1116.38
	1.56	1.326203	-40.00	0.00	40.00	0.00	0.00	1240.43	0.90	1116.38
Bent Cap #7 Top bars	2.71	2.305588	-11.28	0.00	40.00	0.00	0.00	3226.15	0.90	2903.53
	2.71	2.304757	-11.26	0.00	40.00	0.00	0.00	3226.07	0.90	2903.46
	2.71	2.305588	-11.28	0.00	40.00	0.00	0.00	3226.15	0.90	2903.53
Bent Cap #8 Top bars	2.87	2.442434	-5.77	0.00	40.00	0.00	0.00	4182.12	0.90	3763.91
	2.87	2.441582	-5.76	0.00	40.00	0.00	0.00	4182.07	0.90	3763.86
	2.87	2.442434	-5.77	0.00	40.00	0.00	0.00	4182.12	0.90	3763.91
Bent Cap #9 Top bars	3.07	2.607537	0.10	0.00	40.00	0.00	0.00	5235.31	0.90	4711.78
	3.07	2.606662	0.12	0.00	40.00	0.00	0.00	5235.30	0.90	4711.77
	3.07	2.607537	0.10	0.00	40.00	0.00	0.00	5235.31	0.90	4711.78
Pier 3 Slab	1.77	1.504366	-29.75	0.00	40.00	0.00	0.00	4238.04	0.90	3814.24
	1.77	1.504366	-29.75	0.00	40.00	0.00	0.00	4238.04	0.90	3814.24
	1.77	1.504366	-29.75	0.00	40.00	0.00	0.00	4238.04	0.90	3814.24
Pier 3 Slab	1.77	1.504362	-29.75	0.00	40.00	0.00	0.00	853.21	0.90	767.89
	1.77	1.504362	-29.75	0.00	40.00	0.00	0.00	853.21	0.90	767.89
	1.77	1.504362	-29.75	0.00	40.00	0.00	0.00	853.21	0.90	767.89
										317.85
	kip-ft									317.85
	kip-ft									63.99
	kip-ft									93.03
										392.65

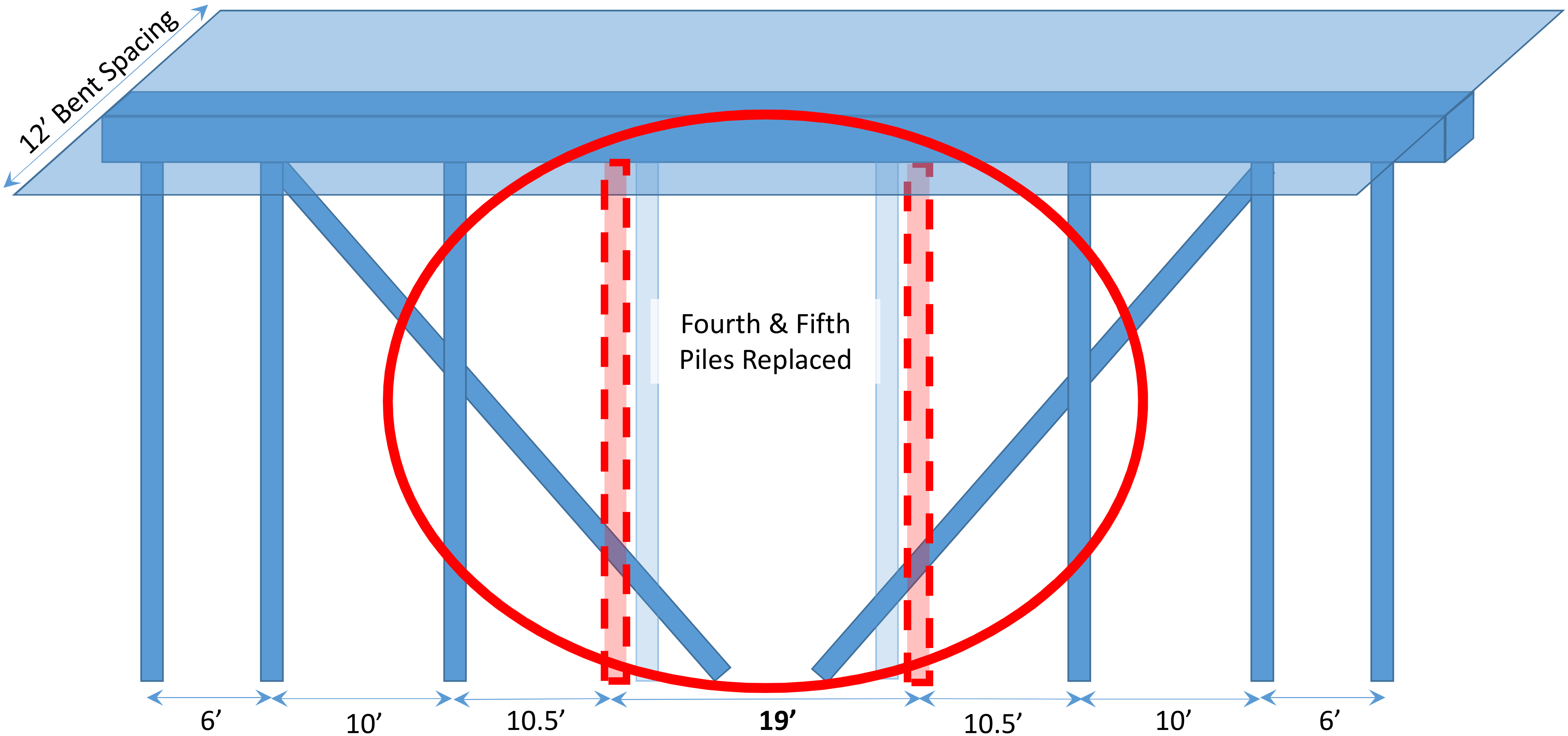
Structural Calculation Reconfiguration Scenarios



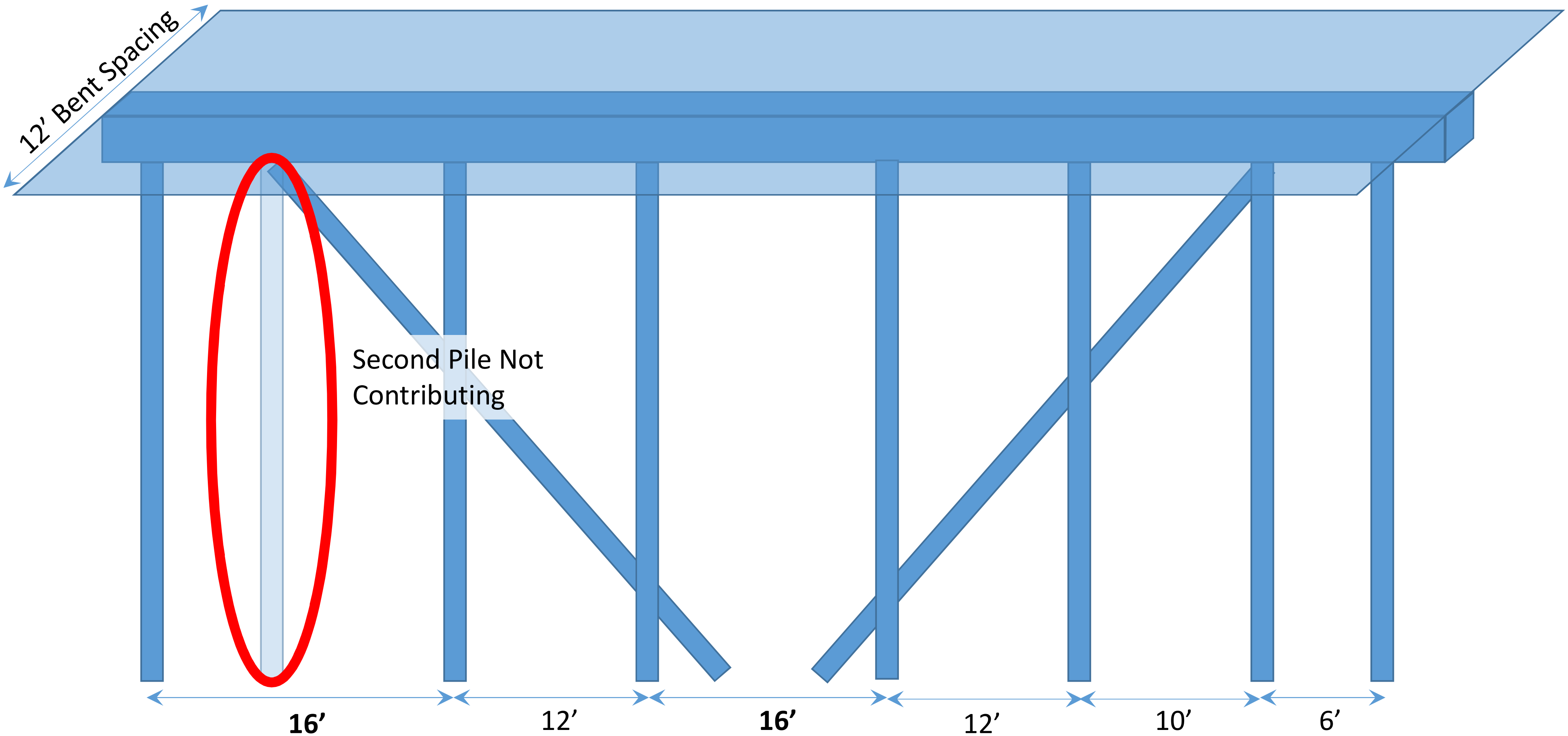
Original Design Configuration



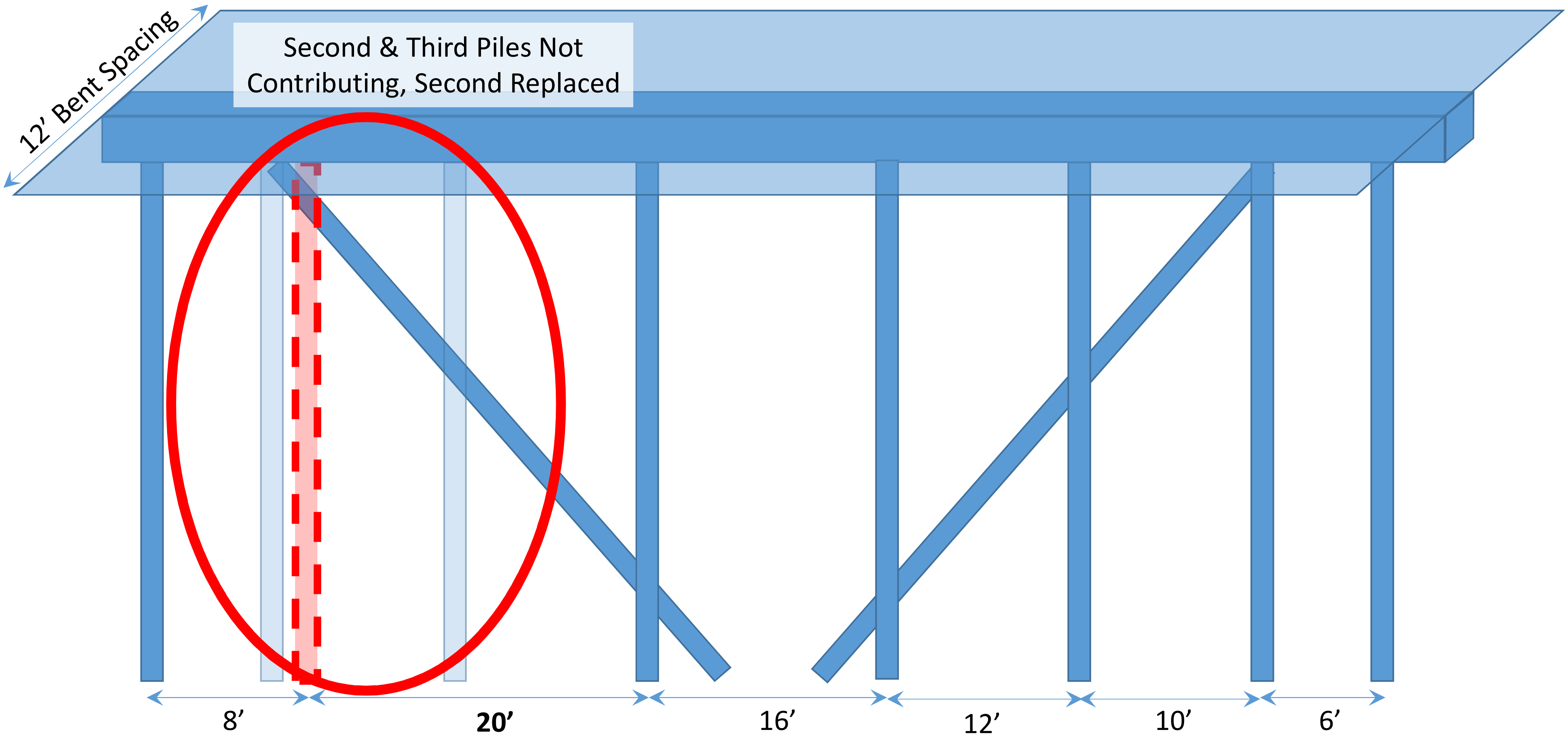
Re-configuration #1



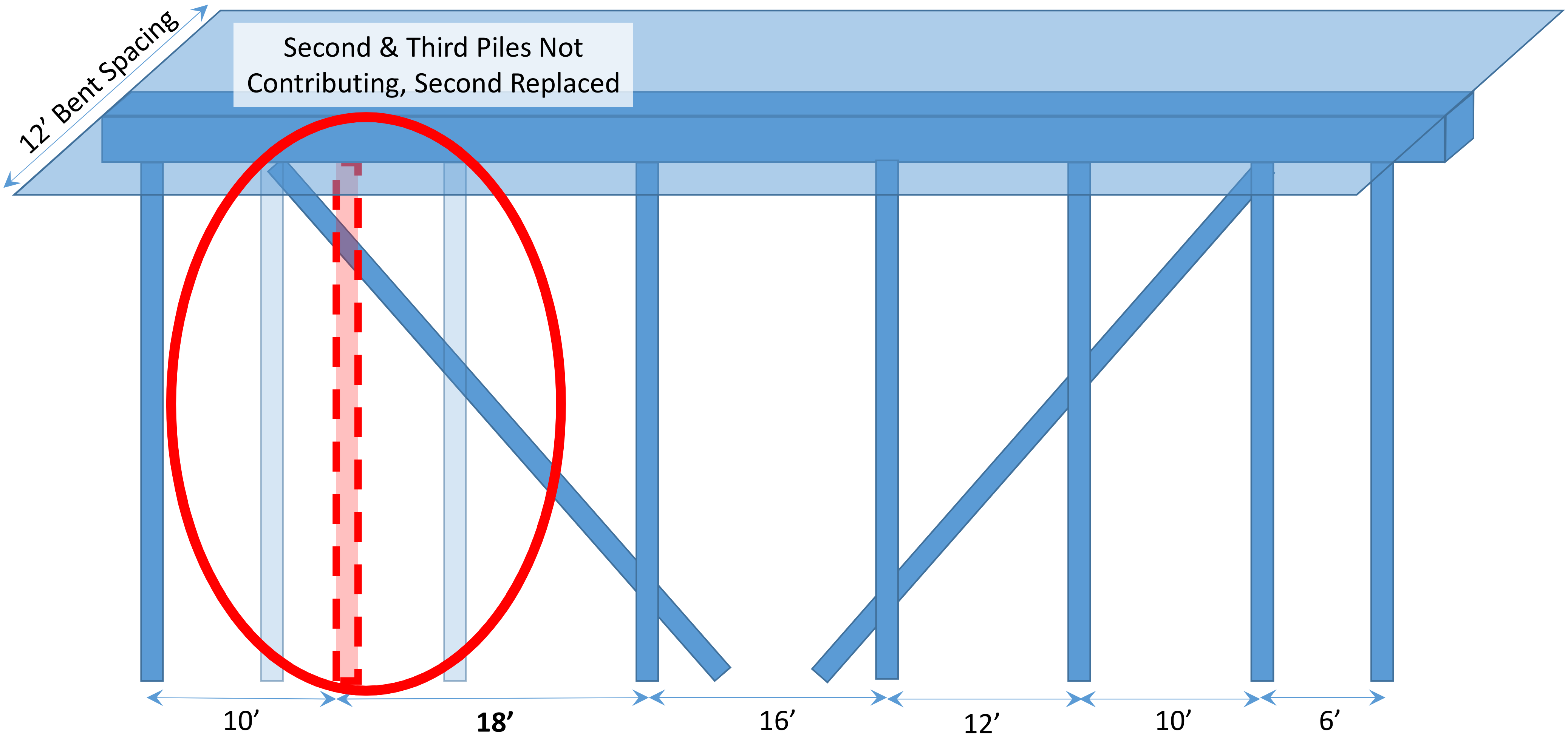
Re-configuration #2



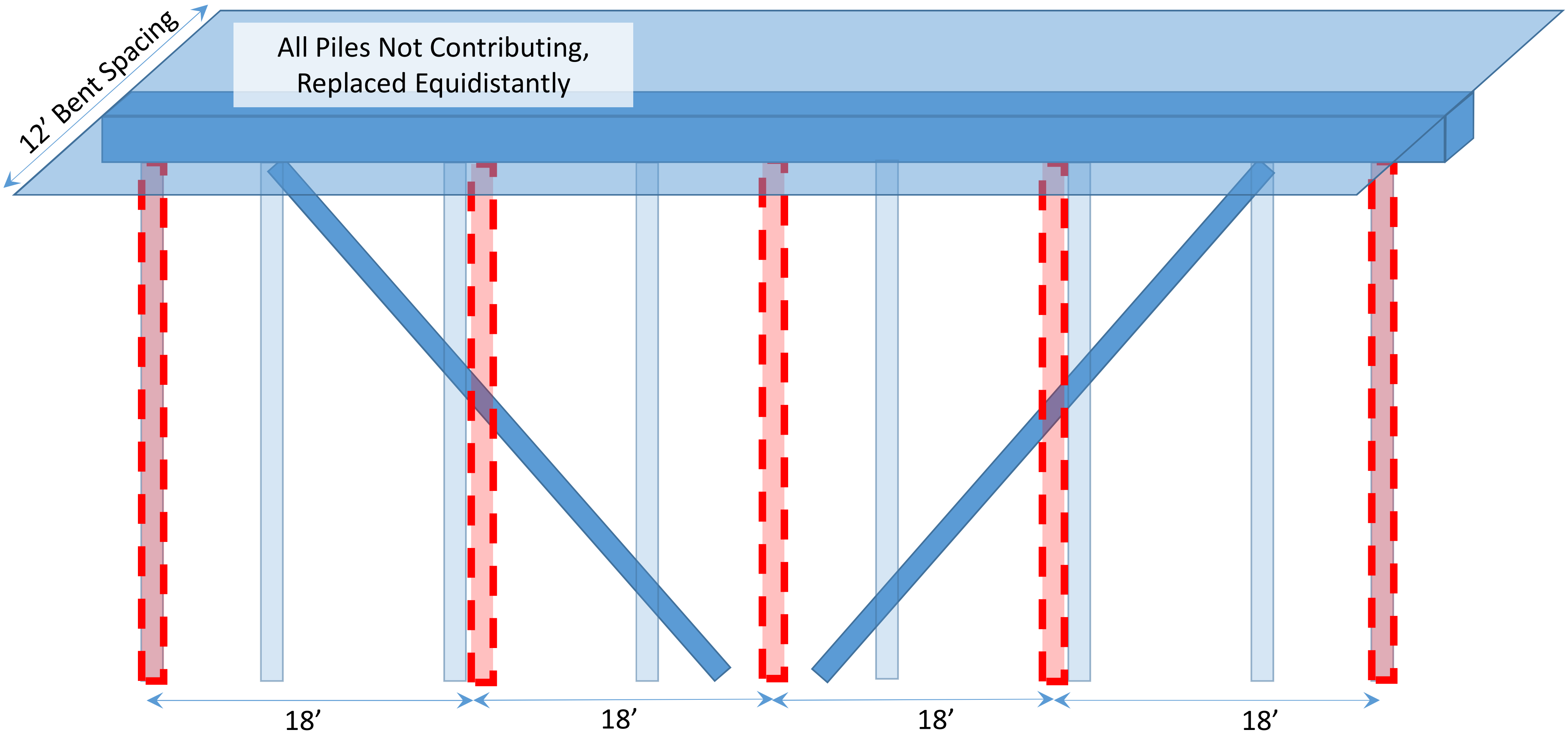
Re-configuration #3



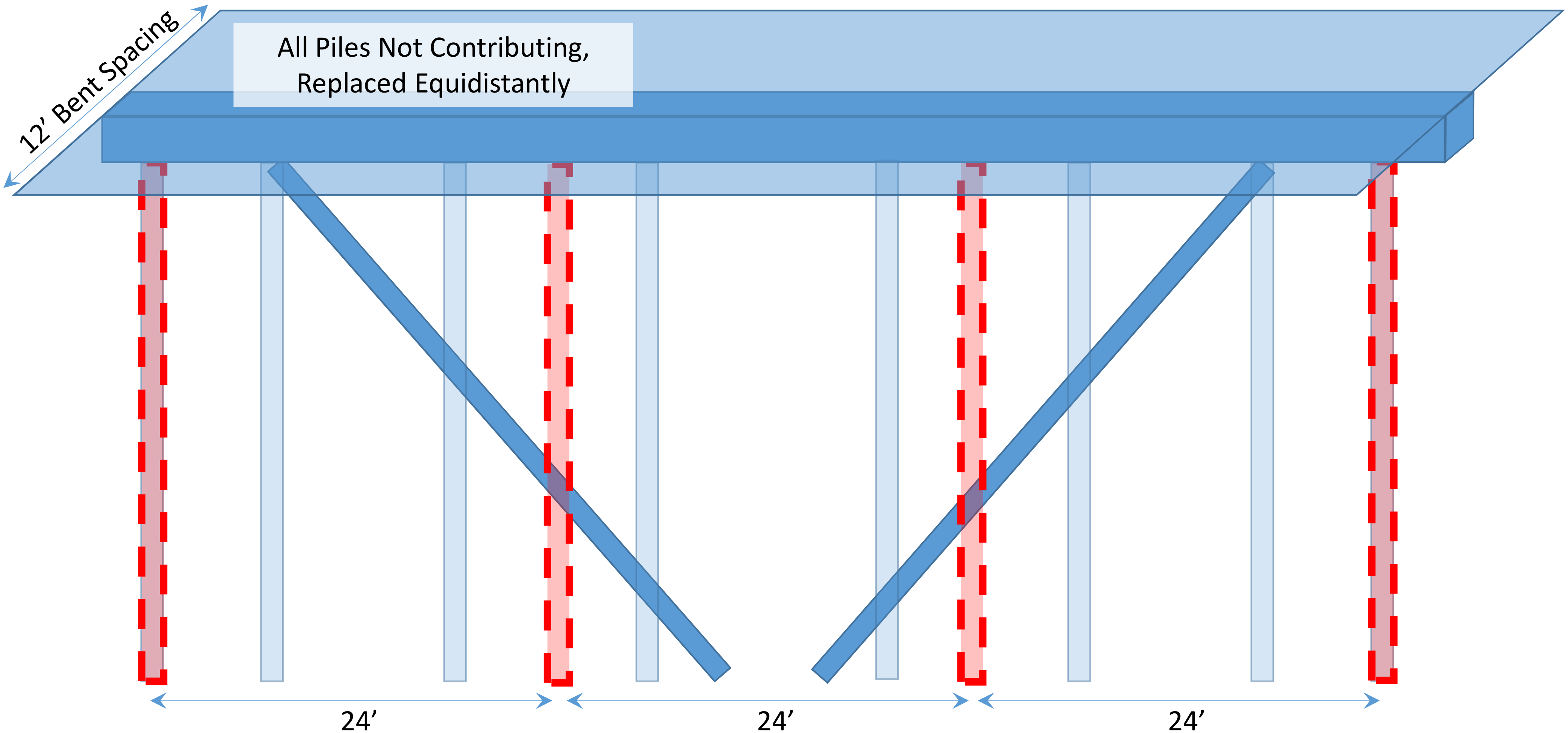
Re-configuration #4



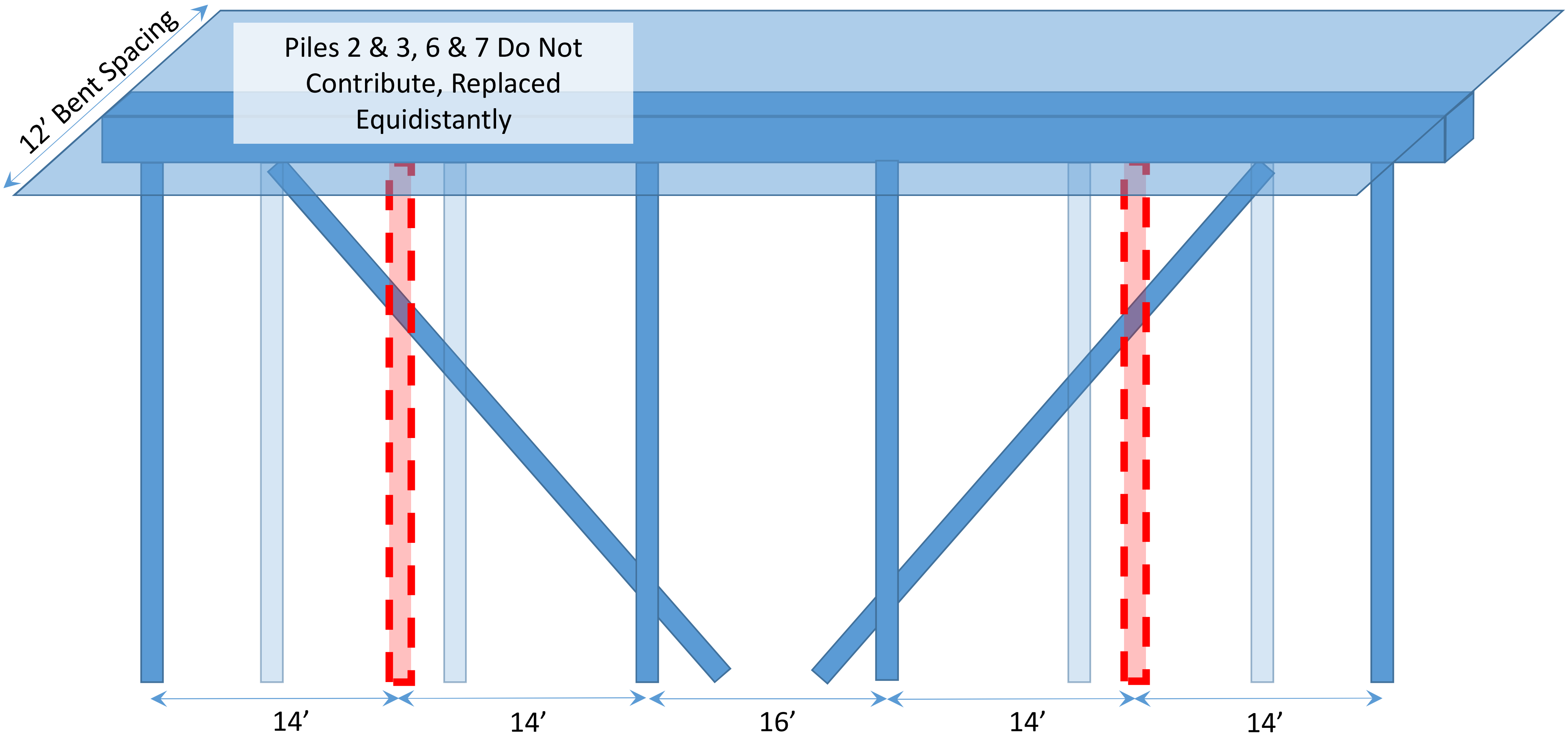
Re-configuration #5



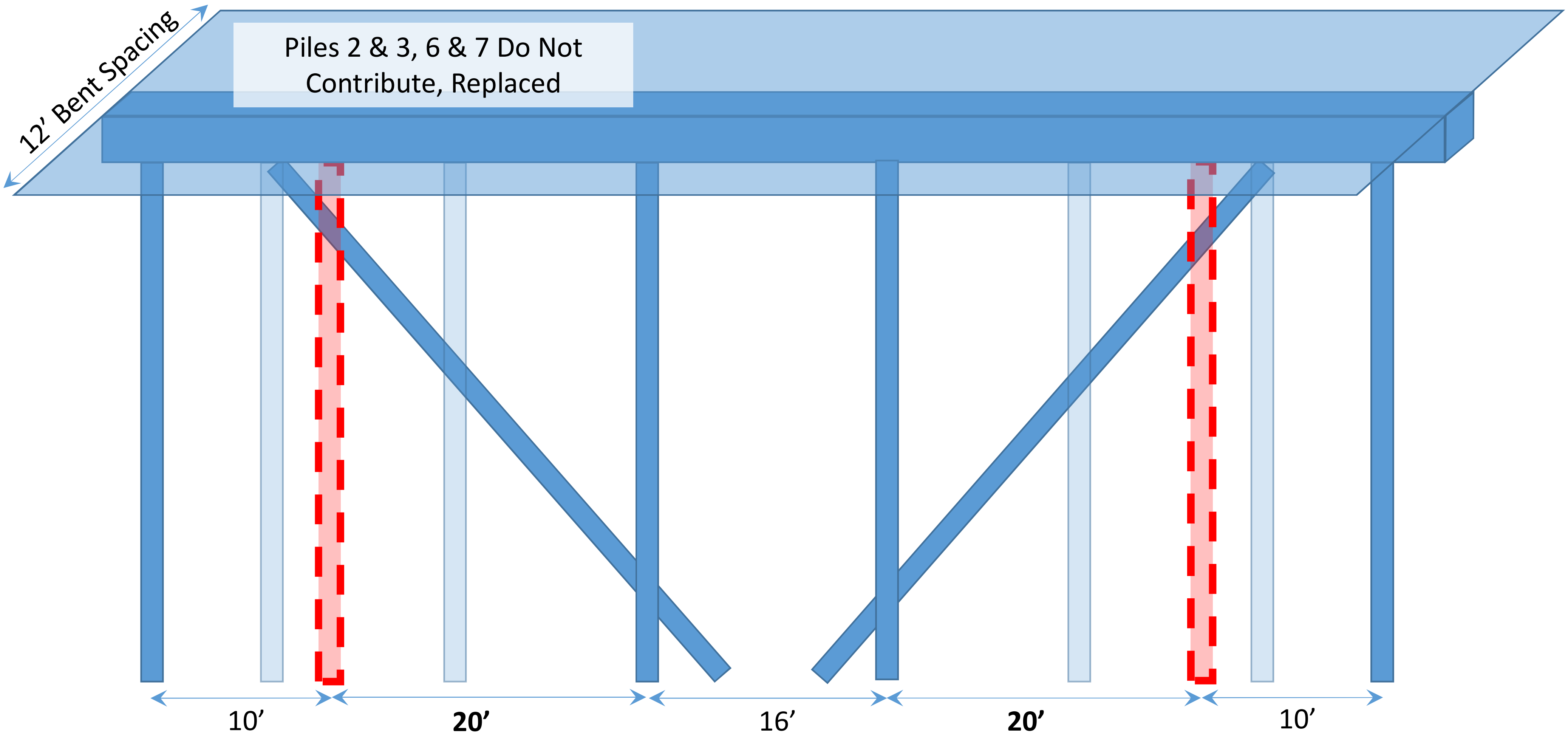
Re-configuration #6



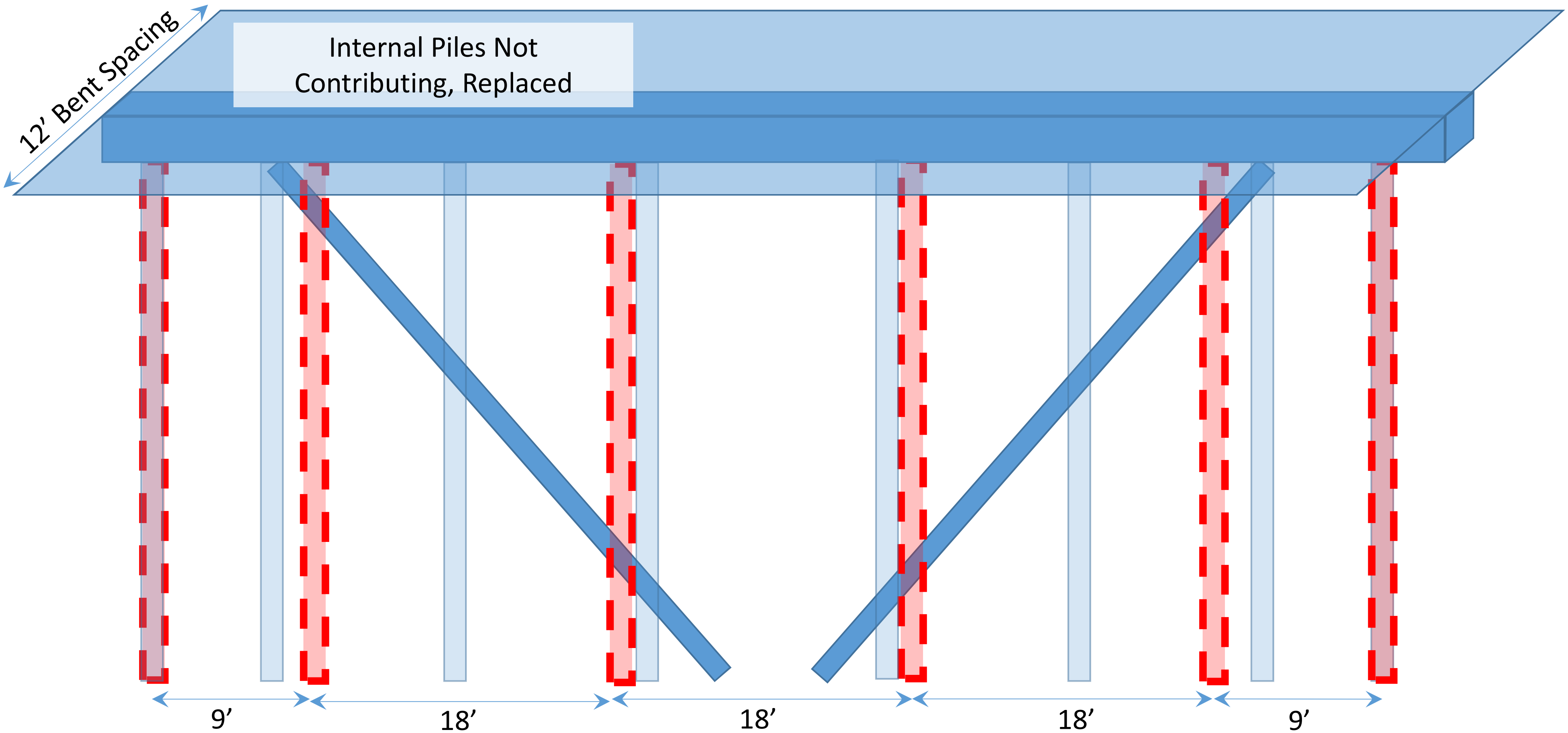
Re-configuration #7



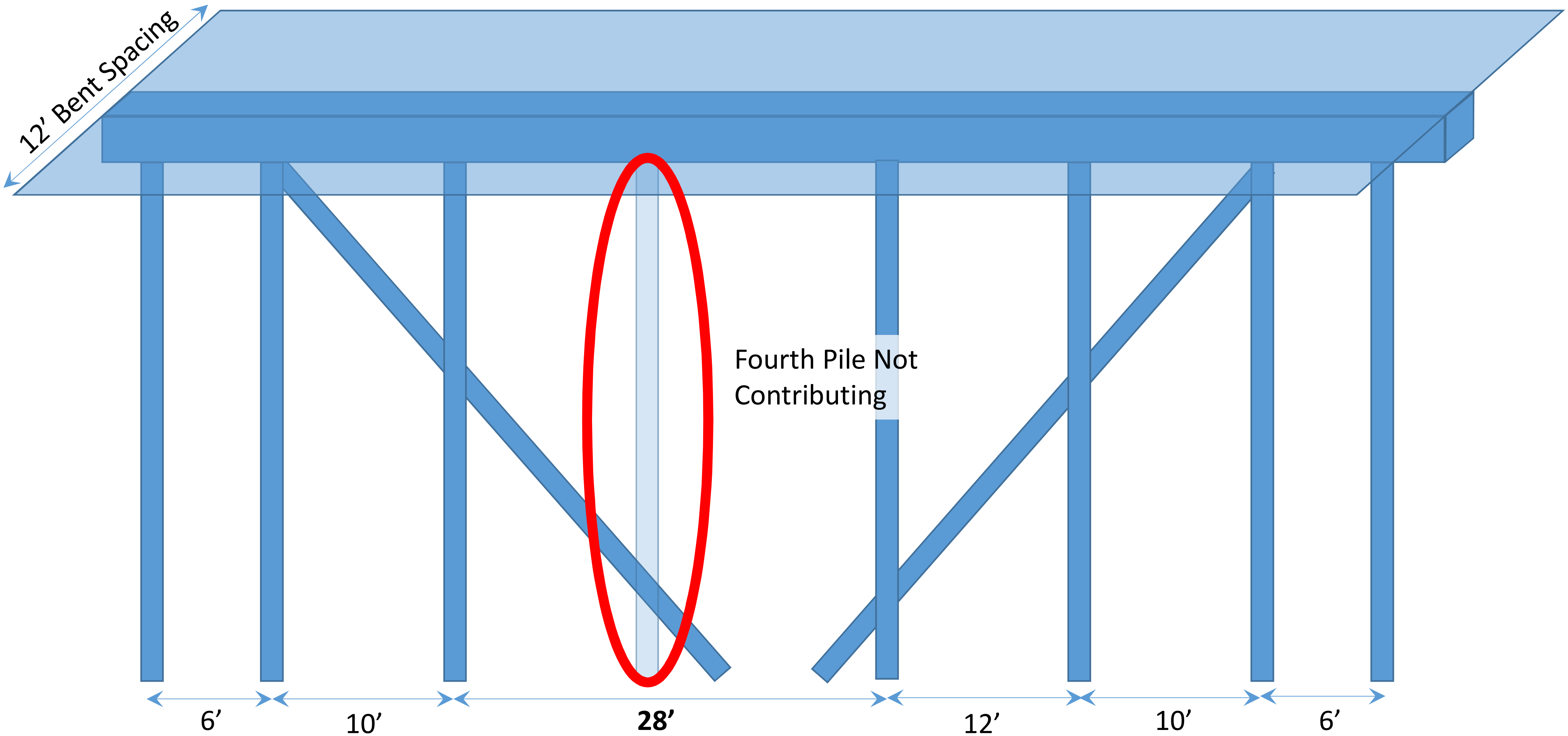
Re-configuration #8



Re-configuration #9



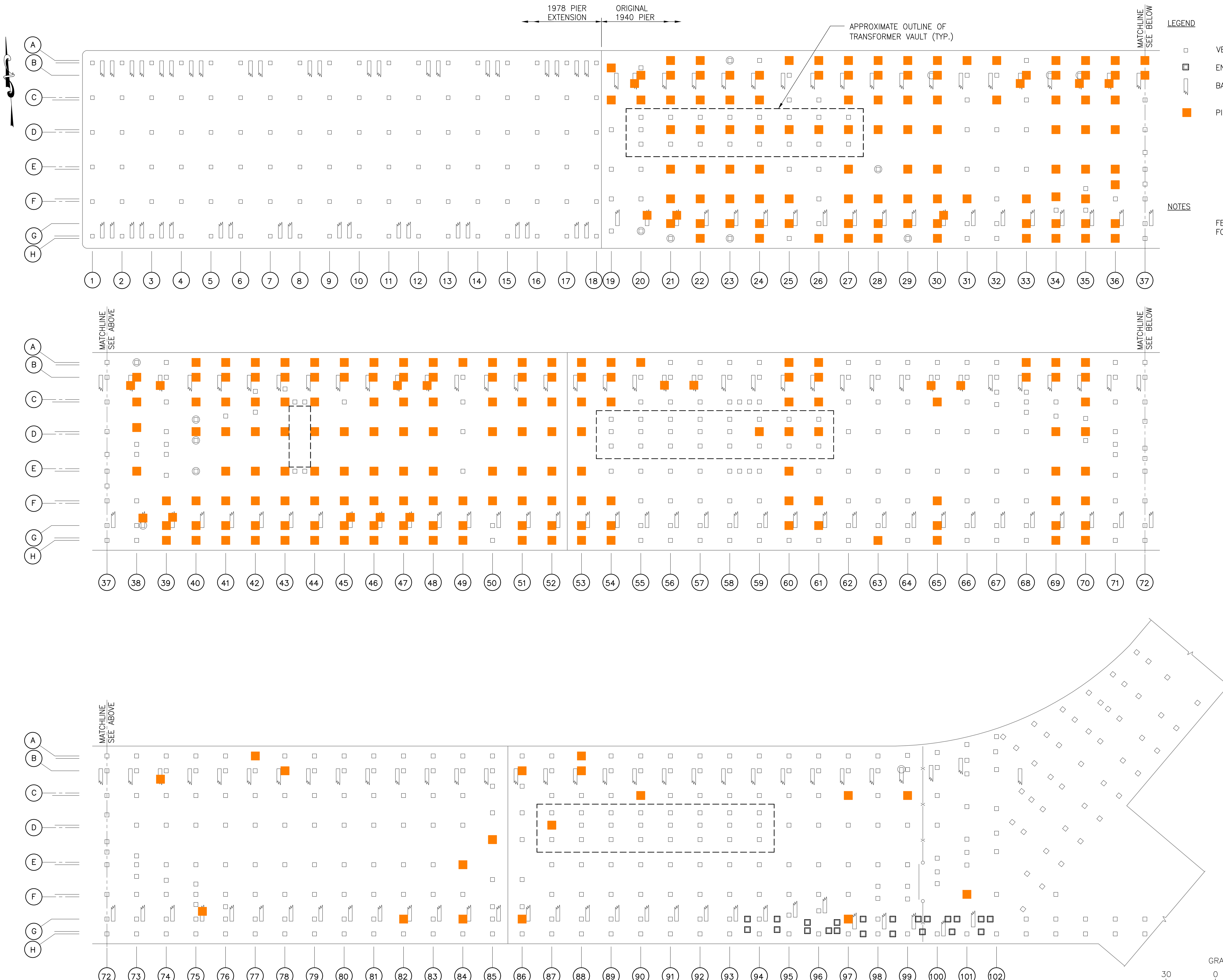
Re-configuration #10



Re-configuration #11

APPENDIX F

Repair and Replacement Option Plans and Elevations



LEGEND

- VERTICAL PILE
- ENCASED PILE
- BATTER PILE
- PILE TO BE REPAIRED

NOTES

FENDER PILES NOT SHOWN FOR CLARITY

GRAPHIC SCALE

30 0 30 60

1" = 30'

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

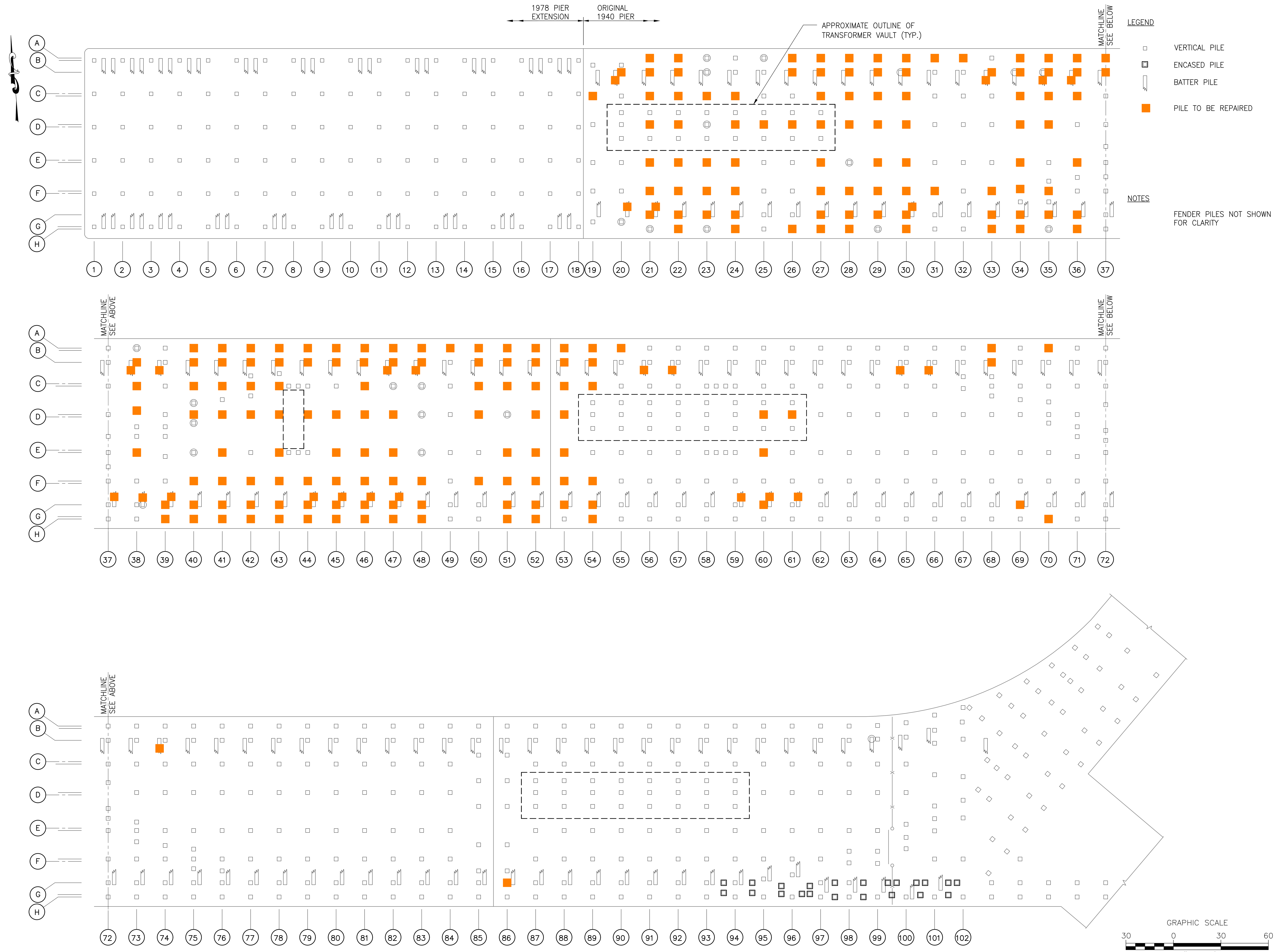
PIER 2 OPTION 1 PILE REPAIR PLAN

Drawing Title

Project No.	Checked	Date
167543.00	RI	
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

Seal



SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

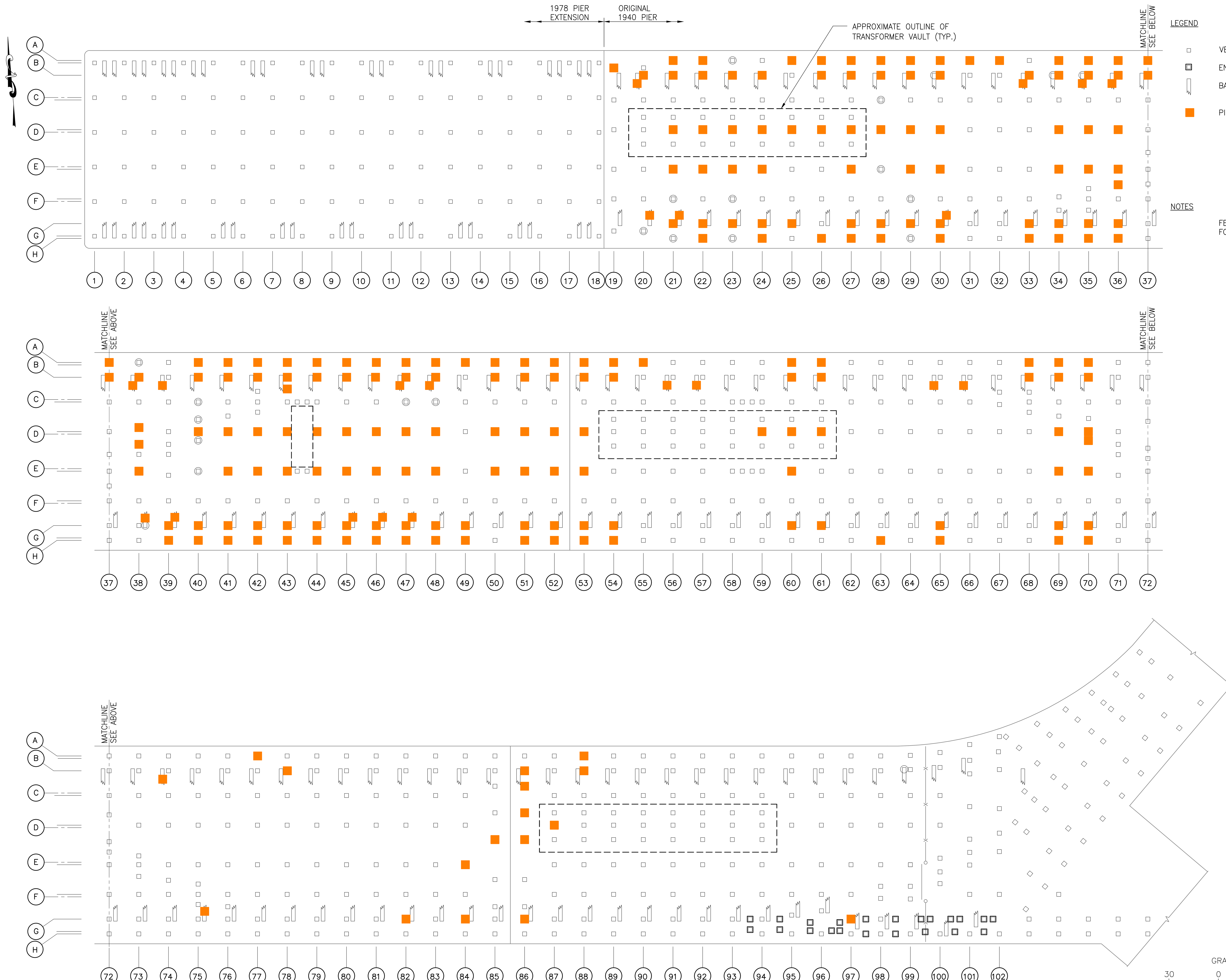
PIER 2 OPTION 2 PILE REPAIR PLAN

Drawing Title

Project No.	Checked	Date
167543.00	RI	
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

Seal



LEGEND

VERTICAL PILE

ENCASED PILE

BATTER PILE

PILE TO BE REPAIRED

NOTES

FENDER PILES NOT SHOWN FOR CLARITY

GRAPHIC SCALE

30 0 30 60

1" = 30'

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

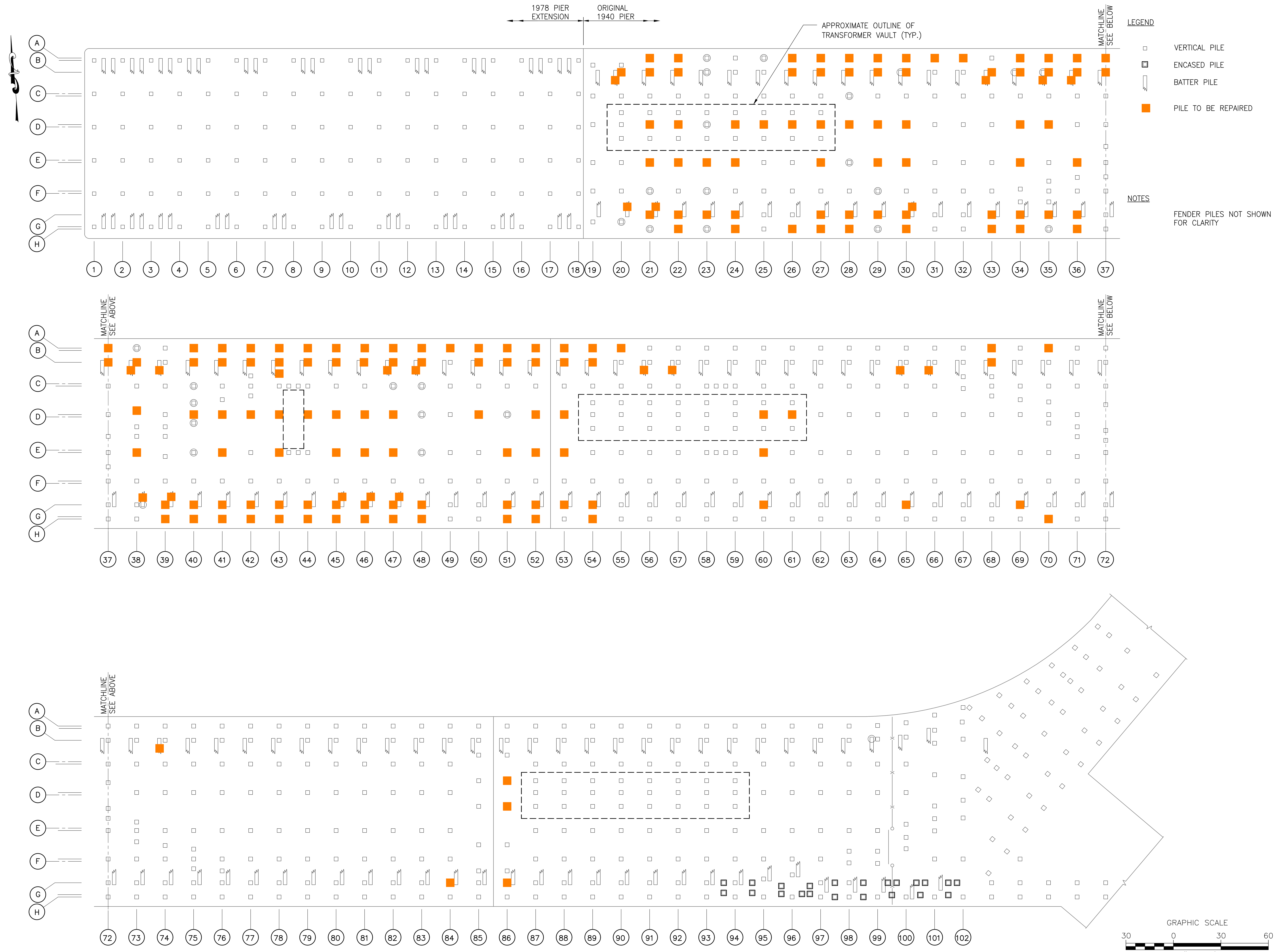
PIER 2 OPTION 3 PILE REPAIR PLAN

Drawing Title

Project No.	Checked	Date
167543.00	RI	
Drawn	Approved	Scale
JRT	WMB	AS NOTED

Drawing No.

Seal



SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS
ALAMEDA, CA

Project

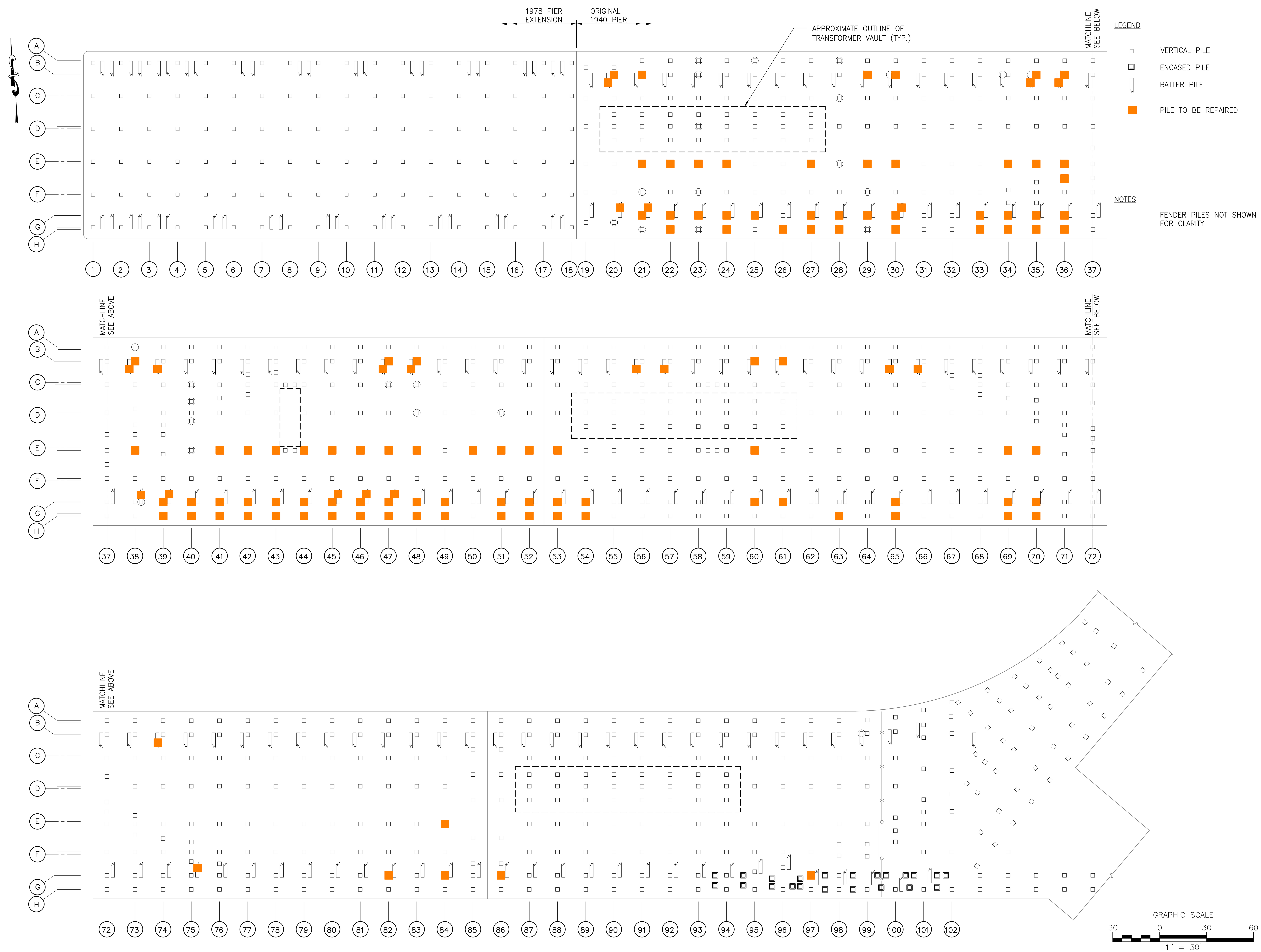
PIER 2 OPTION 4 PILE REPAIR PLAN

Drawing Title

Project No. 167543.00	Checked RI	Date
Drawn JRT	Approved WMB	Scale AS NOTED

Drawing No.

Seal



SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com
Boston Chicago Houston Los Angeles New York San Francisco Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS
ALAMEDA, CA

Project

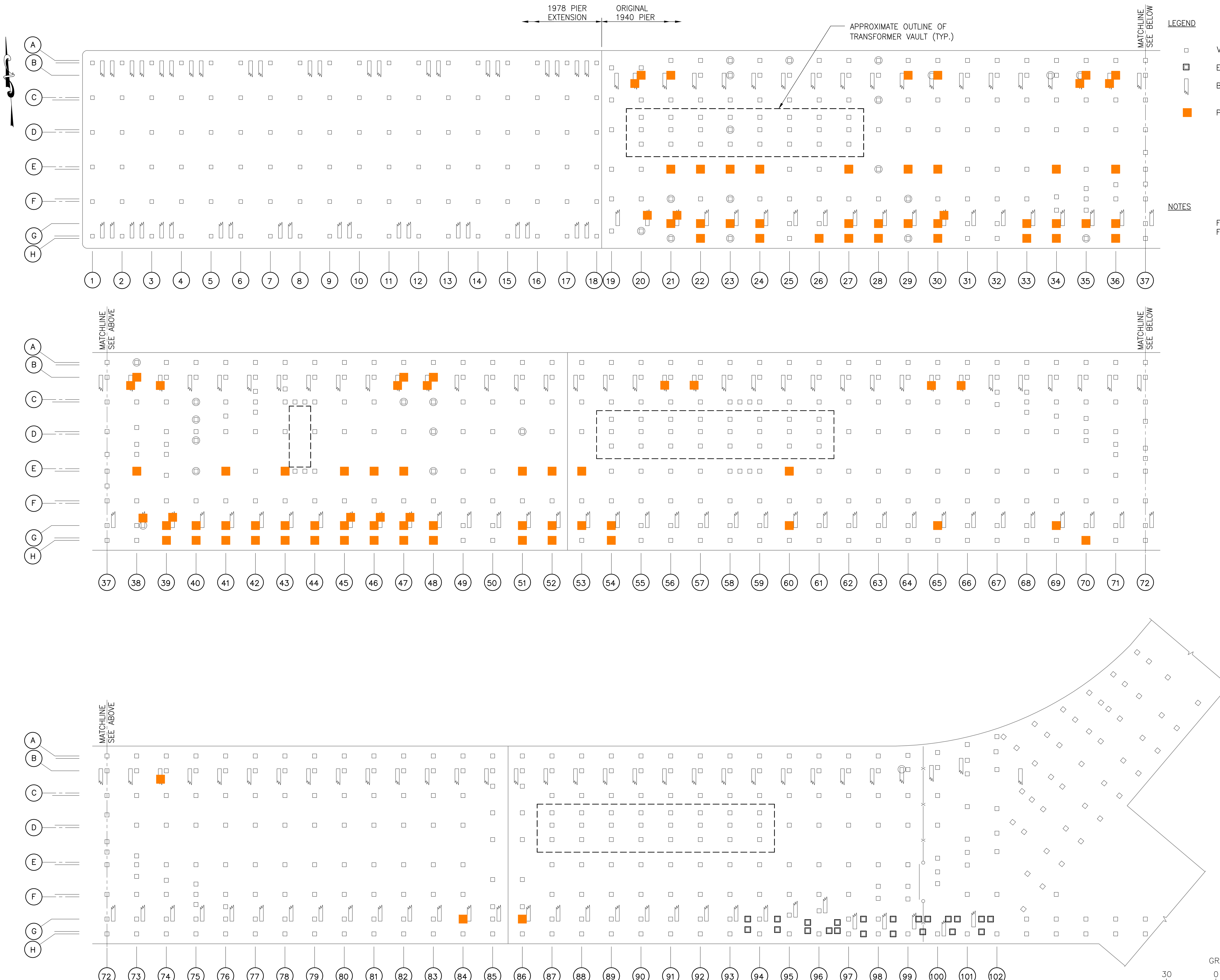
PIER 2 OPTION 5 PILE REPAIR PLAN

Drawing Title

Project No. 167543.00	Checked RI	Date
Drawn JRT	Approved WMB	Scale AS NOTED

Drawing No.

Seal



LEGEND

VERTICAL PILE

ENCASED PILE

BATTER PILE

PILE TO BE REPAIRED

NOTES

FENDER PILES NOT SHOWN FOR CLARITY

GRAPHIC SCALE

30 0 30 60

1" = 30'

SIMPSON GUMPERTZ & HEGER

Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS

ALAMEDA, CA

Project

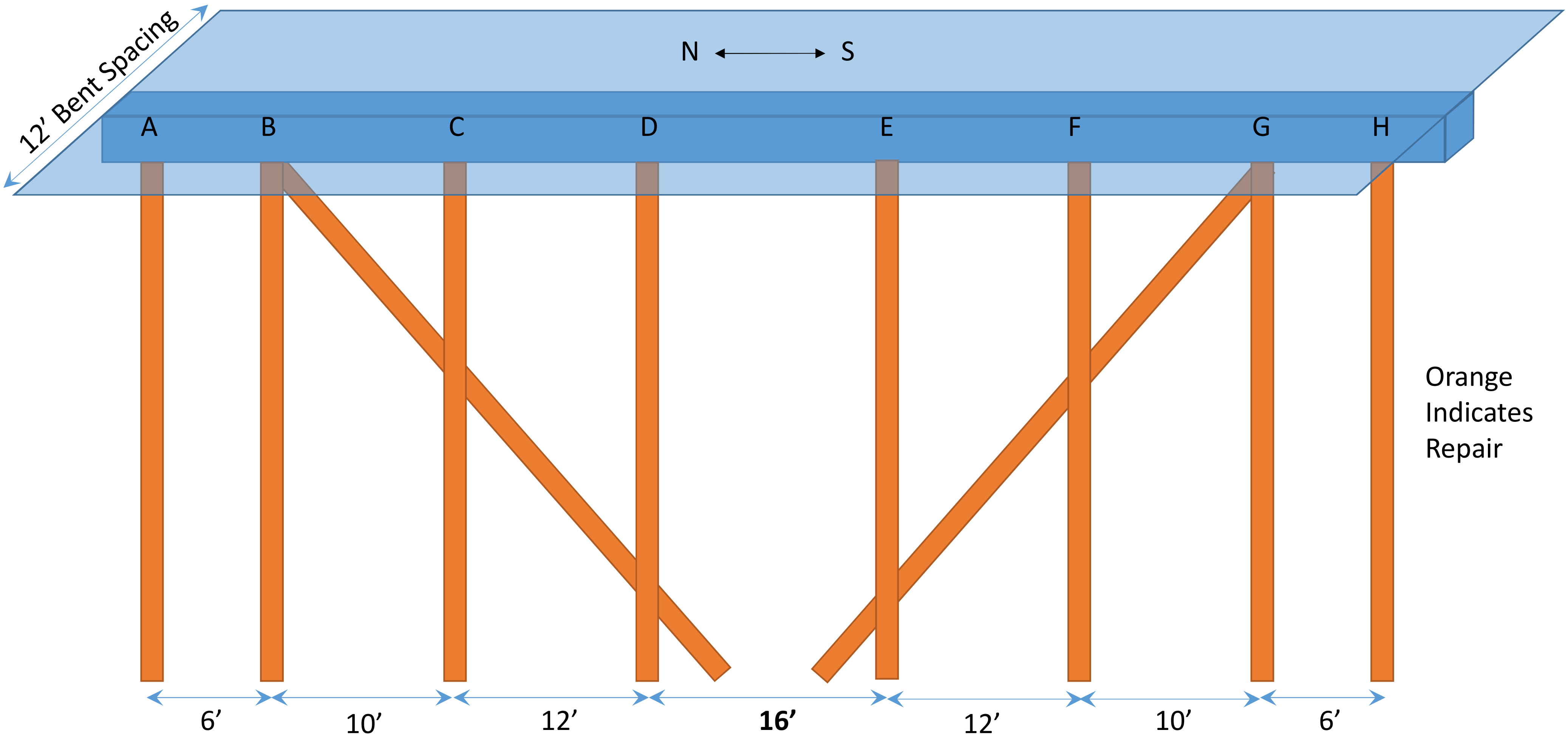
PIER 2 OPTION 6 PILE REPAIR PLAN

Drawing Title

Project No.	Checked	Date
167543.00	RI	
Drawn	Approved	Scale
JRT	WMB	AS NOTED

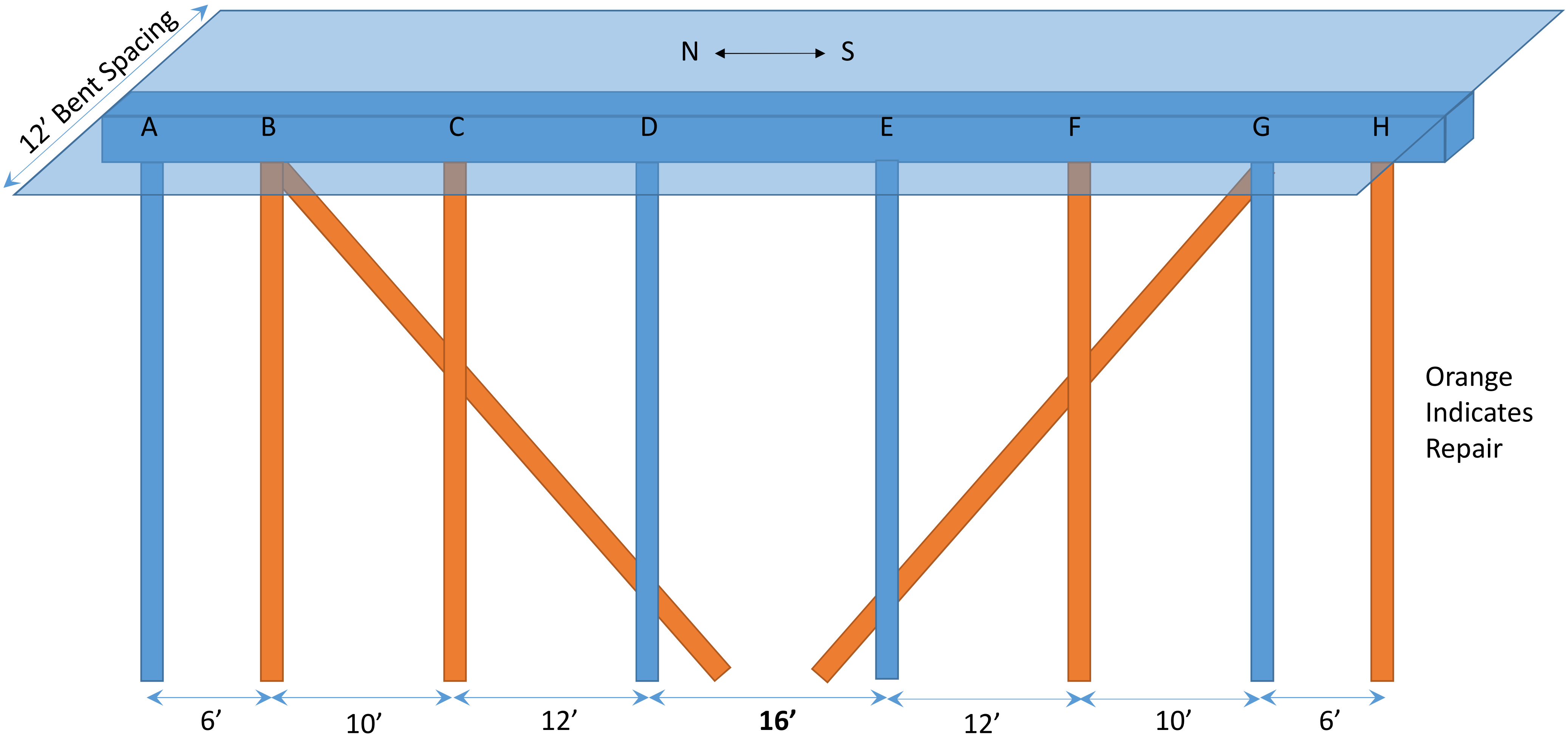
Drawing No.

Seal



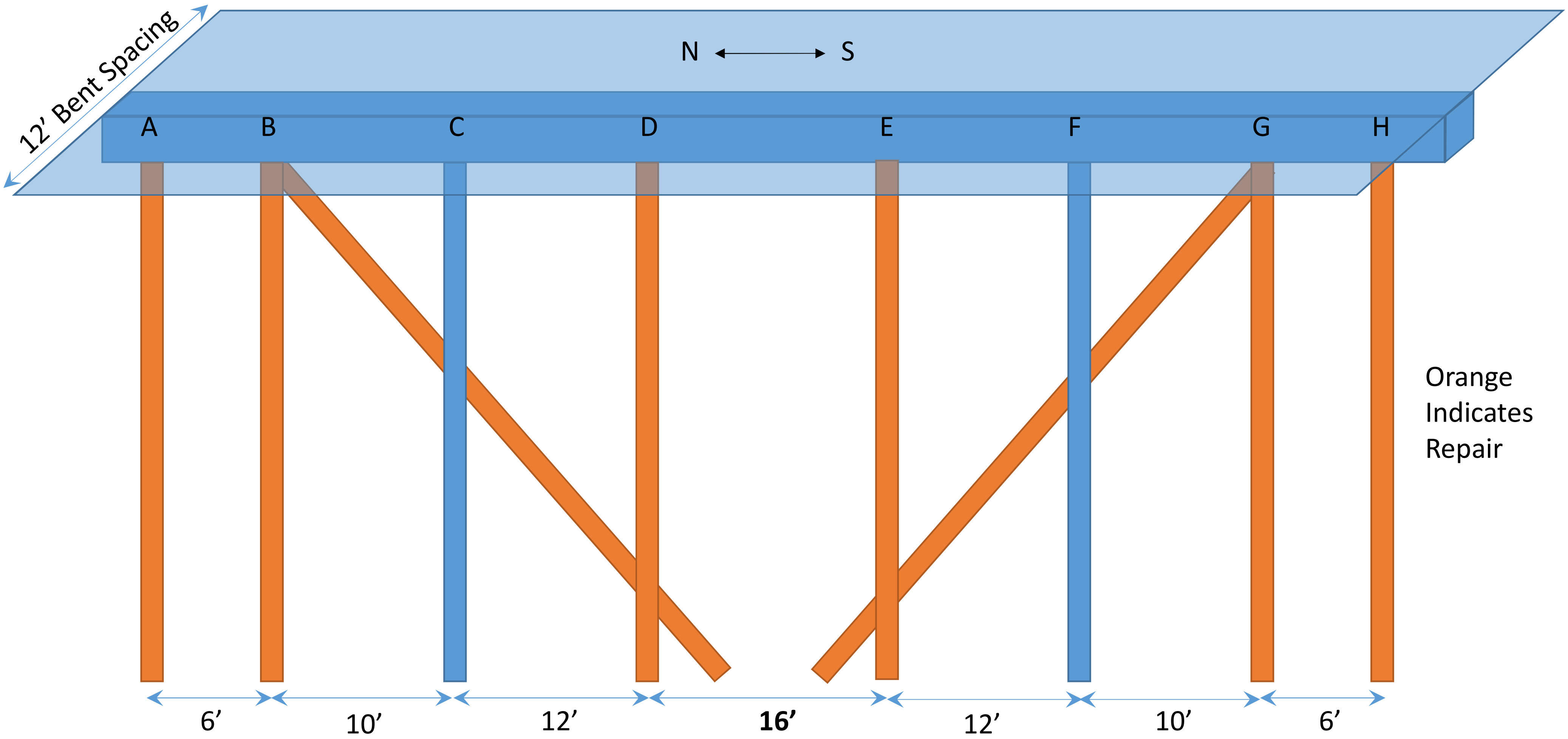
Example all Piles need Repair

Option 1



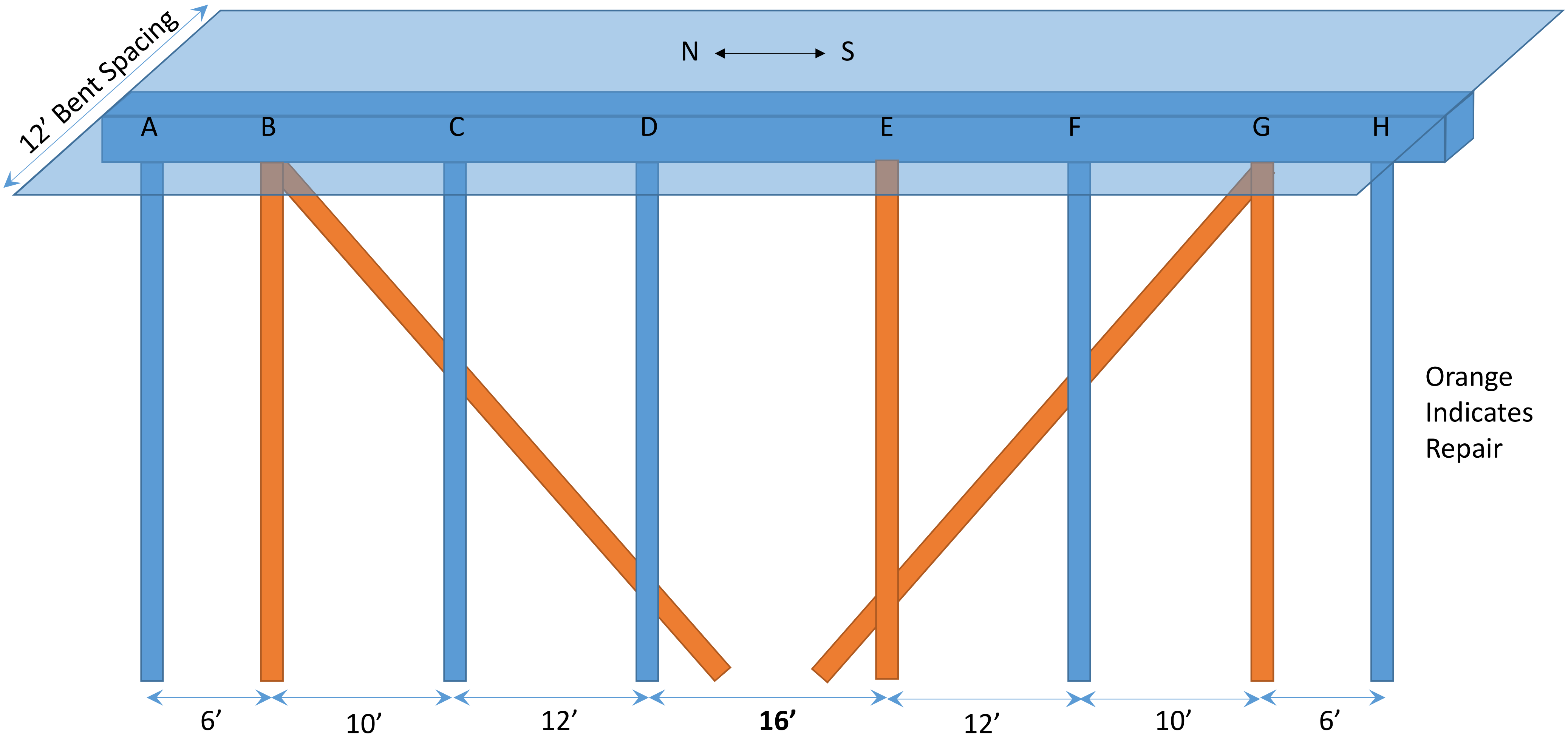
Option 2

Example Major and Severe pile layout



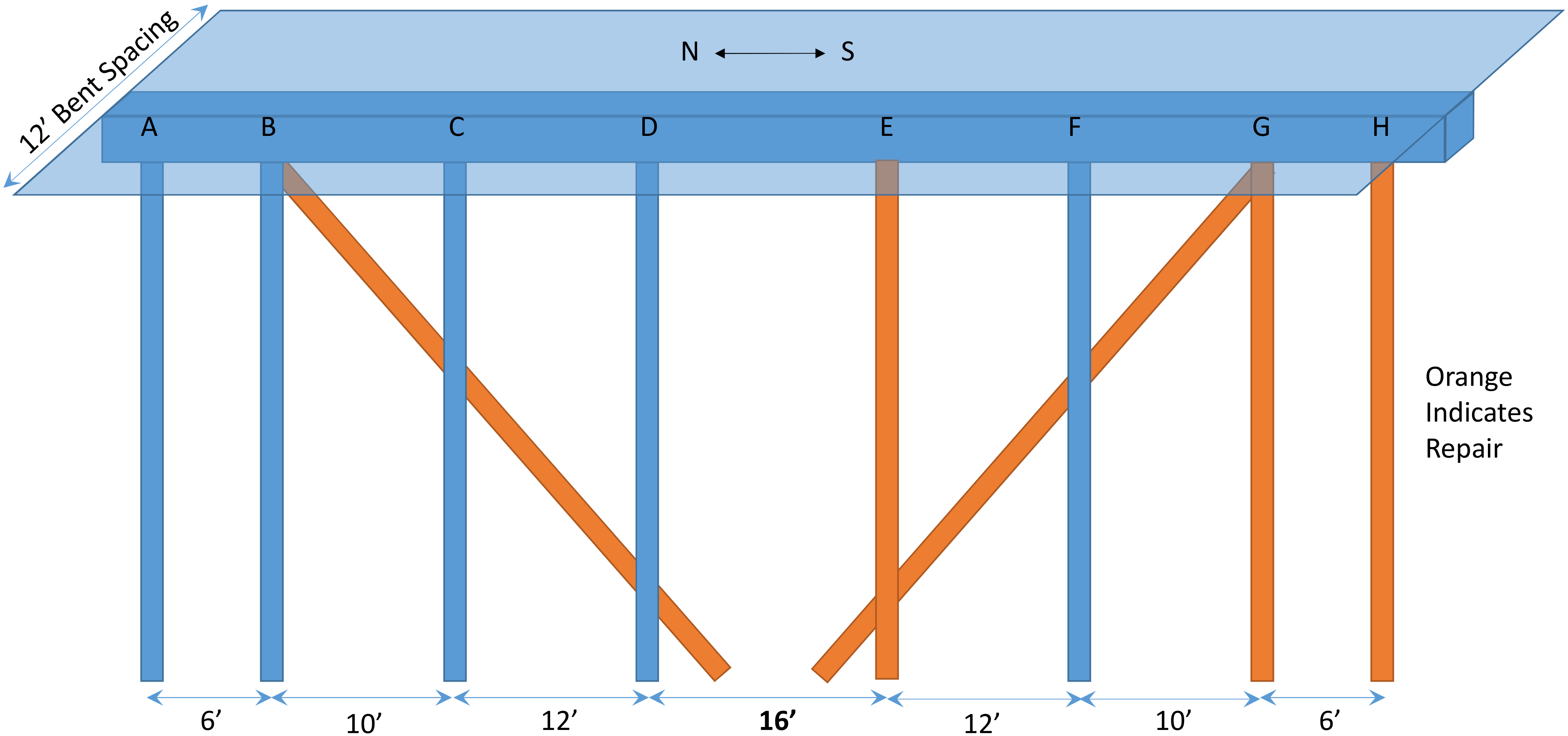
<u>Option 3</u>

Example Major and Severe pile repair (excluding C and F)



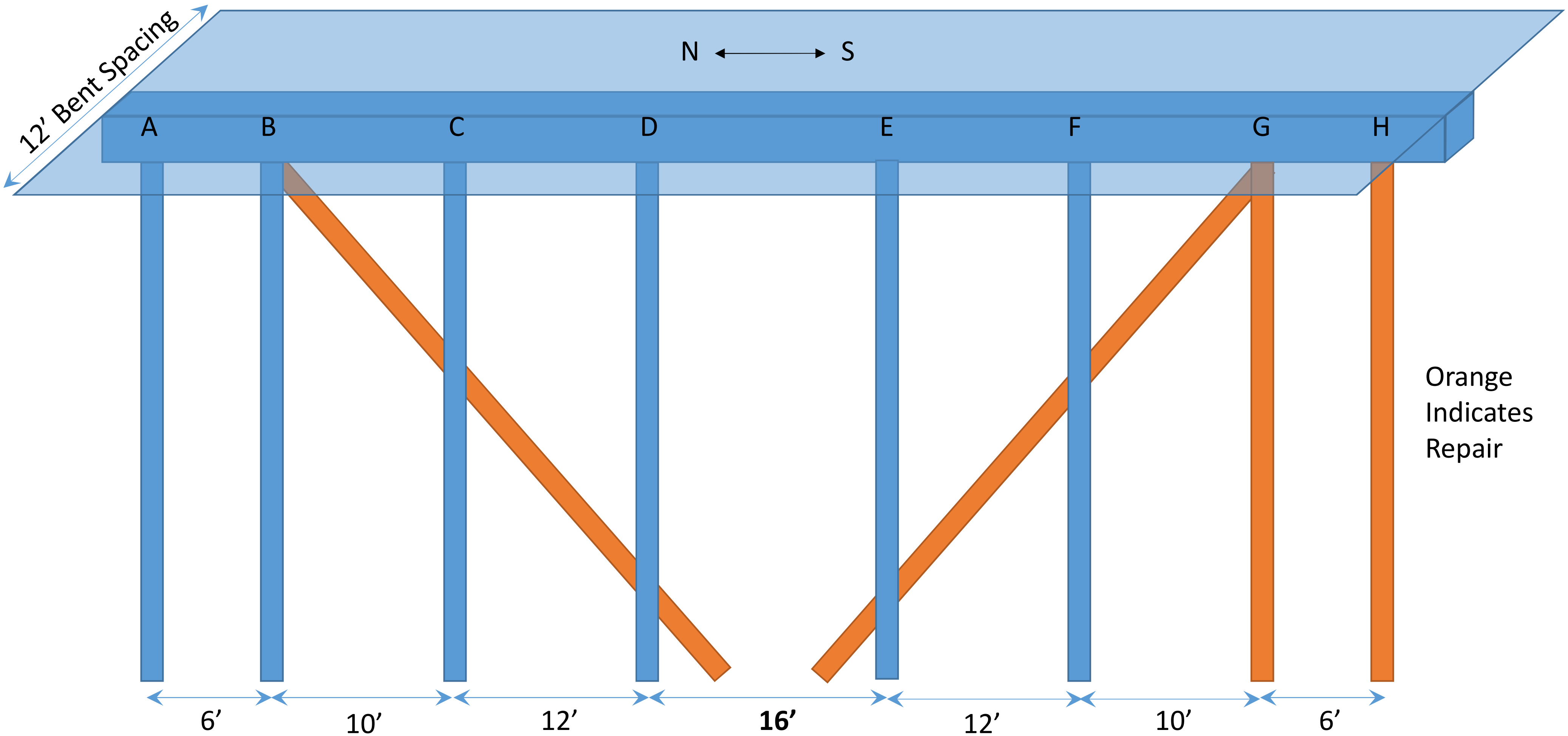
Option 4

Example Severe pile repair (excluding C and F)



Option 5

Example all Southern Pile repair (excluding F)



Option 6

Example all Severe Southern Pile repair (excluding F)

										Nonstandard Piles			
Row	A	B	B-Bat	C	D	E	F	G-Bat	G	H	B.5	C.5	D.5	F.5
Severe Totals	31	28	22	23	25	19	26	30	29	23	2	3	2	2
Major Totals	7	10	10	12	8	8	9	6	8	5	1	2	1	0
Average Depths	25.7	22.9	19.3	17.8	13.6	14.0	18.1	18.2	22.4	24.5	20.3	15.7	13.8	20.3
Length of Repair (ft)	33.7	30.9	29.2	25.8	21.6	22.0	26.1	28.0	30.4	32.5	28.3	23.7	21.8	28.3

Cost Evaluation	
Cost per LF	$950

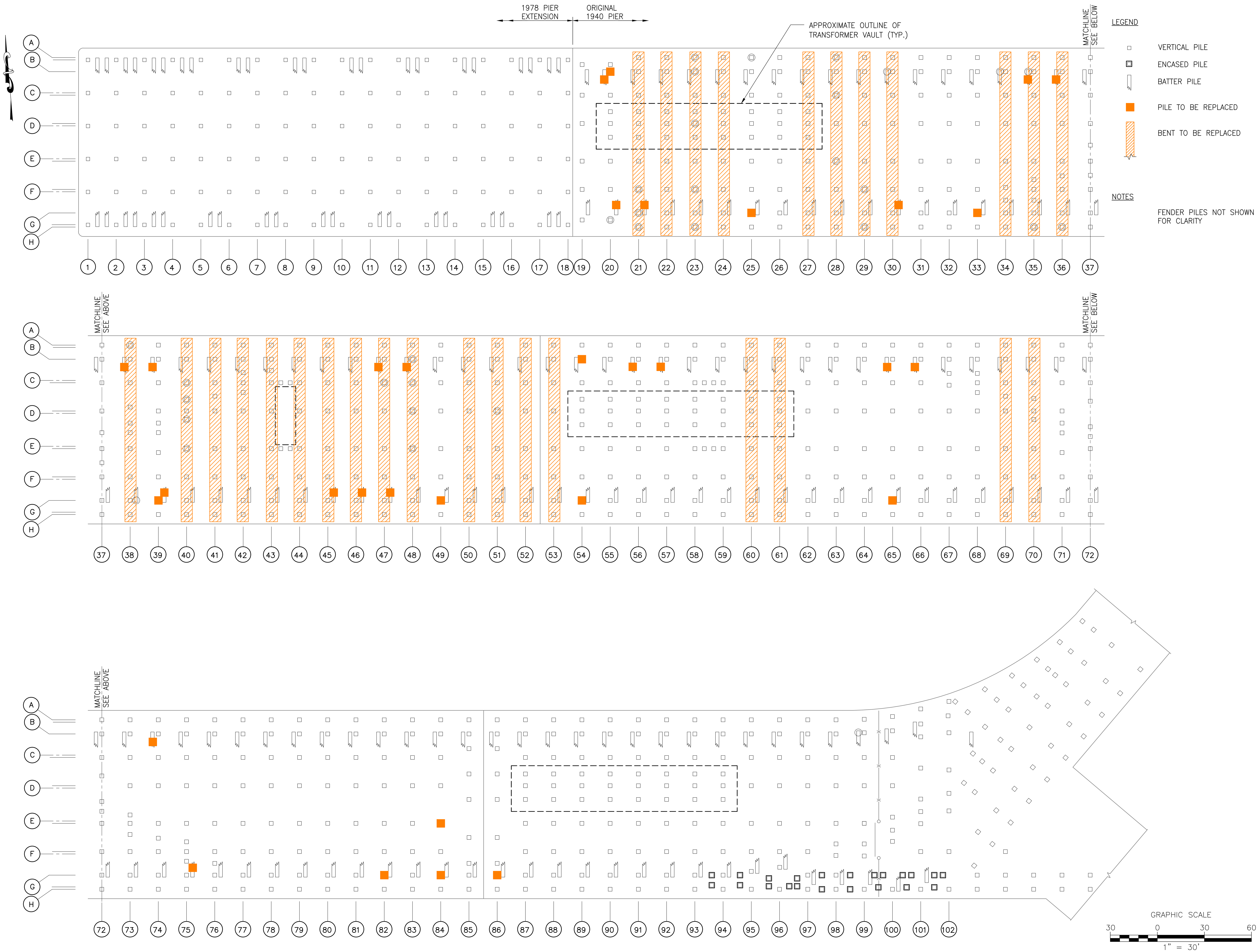
Length of B-Bat (ft)	21.2
Length of G-Bat (ft)	20

	Piles
B-Bat near bollards	13
B Next to Bat	10
G-Bat near Bollards	8
G Next to Bat	10

Contingency	45%

Mobilization	$75,000

Possible Plumb Pile Repair Schemes		Cost
Option 1	Repair To Original Capacity	$13,235,186.19
Option 2	Repair Only Severe to Original Capcity	$10,062,382.69
Option 3	Repair All Piles Except C & F	$6,568,505.18
Option 4	Repair All Severe Piles Exept C & F	$5,539,239.27
Option 5	Repair All Southern Piles Except F	$2,873,581.56
Option 6	Repair All Severe Southern Piles Except F	$2,407,479.06



SIMPSON GUMPERTZ & HEGER
Engineering of Structures and Building Enclosures

Simpson Gumpertz & Heger Inc.
500 12th Street, Suite 270
Oakland, California 94607
main: 510.457.4600 fax: 510.457.4599
www.sgh.com

Boston
Chicago
Houston
Los Angeles
New York
San Francisco
Washington, DC

Consultant

No.	Date	Description	By

ALAMEDA POINT PIERS 1, 2, & 3 INSPECTIONS
ALAMEDA, CA

Project

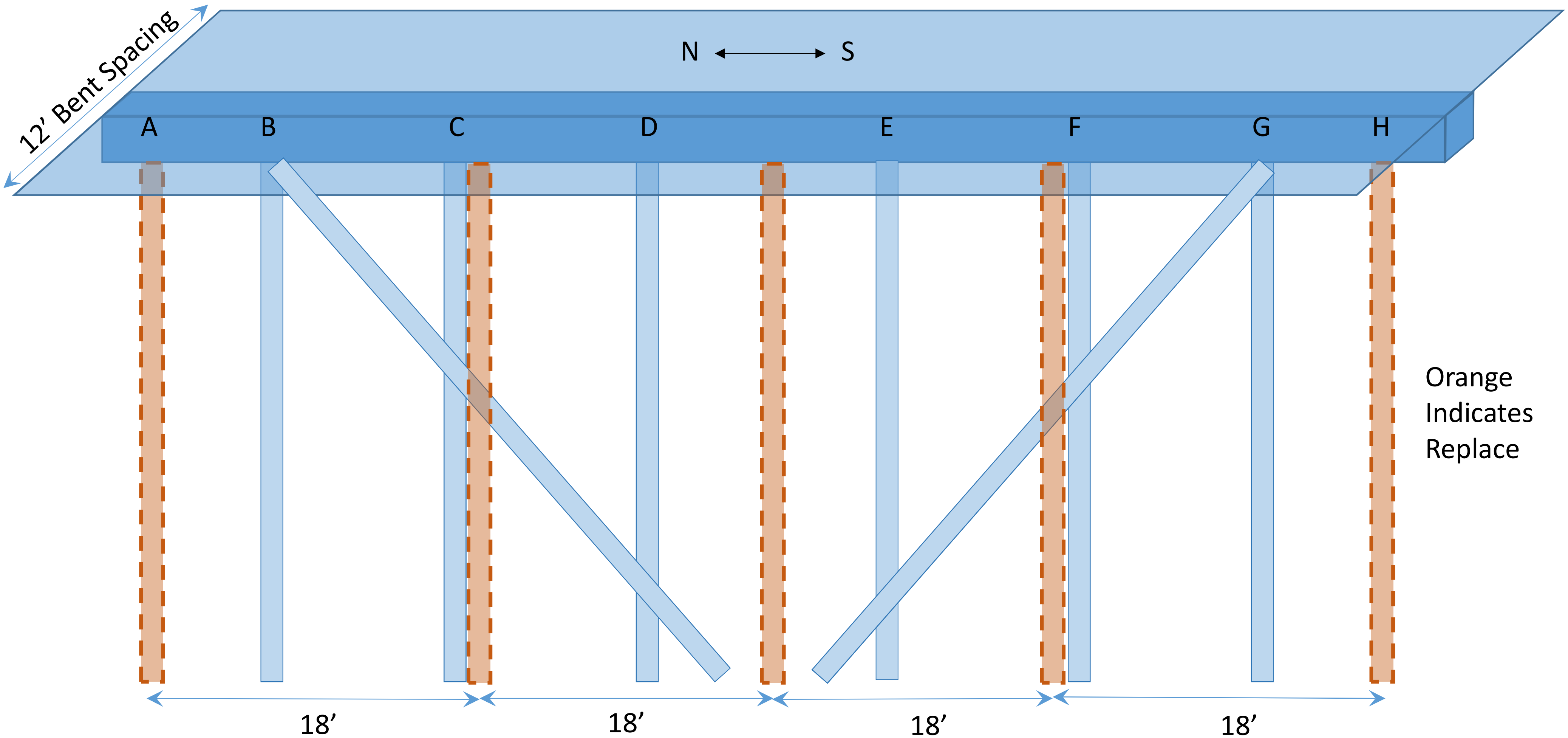
PIER 2 OPTION 1 PILE REPLACEMENT PLAN

Drawing Title

Project No.	Checked	Date
167543.00	RI	09/29/16
Drawn	**Approved**	**Scale**
JRT	WMB	AS NOTED

Seal

Drawing No.
-


12’ Bent Spacing
N
S
A
B
C
D
E
F
G
H
Orange
Indicates
Replace
18’
18’
18’
18’

CLIENT Alameda Piers
SUBJECT Pile Replacement Costs

Mobilization/ Demobilization	$ 200,000.00	
Environmental/ Regulatory Support	$ 140,000.00	
Install 24" Octognal Pile	$ 28,250.00	*each
Demolish deck/ RPS New Pile Cap	$ 8,250.00	*per pile location

Fully Replace Bent	29
Additional Piles	32

Contingency	45%

Total Cost	$ 9,860,725.00

APPENDIX G

Interzone 954 Specifications

Interzone® 954

International®

Modified Epoxy

PRODUCT DESCRIPTION

A two component, low VOC, high solids, modified epoxy barrier coat designed to give long term protection in a single coat application. Will continue to cure when immersed in water and has excellent cathodic disbondment resistance.

INTENDED USES

Primarily designed for use in offshore splashzone maintenance, where its continued cure under immersed conditions makes it ideal for coping with tidal movements and surges. May be applied to reoxidised and slightly damp surfaces. Interzone 954 has also found extensive use in a number of other corrosive environments including pulp and paper plants, chemical plants, jetties and sluice gates.

As part of a non-slip deck system in conjunction with appropriate aggregate.

PRACTICAL INFORMATION FOR INTERZONE 954

Colour Range available via the Chromascan system

Gloss Level Gloss

Volume Solids 85% ± 3% (depends on colour)

Typical Thickness 250-500 microns (10-20 mils) dry equivalent to 294-588 microns (11.8-23.5 mils) wet

Theoretical Coverage 1.70 m²/litre at 500 microns d.f.t and stated volume solids
68 sq.ft/US gallon at 20 mils d.f.t and stated volume solids

Practical Coverage Allow appropriate loss factors

Method of Application Airless Spray, Air Spray, Brush, Roller

Drying Time

Temperature	Touch Dry	Hard Dry	Overcoating Interval with recommended topcoats *Minimum*	*Maximum*
10°C (50°F)	14 hours	24 hours	24 hours	14 days[1]
15°C (59°F)	10 hours	18 hours	18 hours	10 days[1]
25°C (77°F)	4 hours	8 hours	8 hours	7 days[1]
40°C (104°F)	90 minutes	3 hours	3 hours	5 days[1]

[1] Maximum overcoating intervals are shorter when using polysiloxane topcoats. Consult International Protective Coatings for further details.

REGULATORY DATA

Flash Point (Typical) Part A 30°C (86°F); Part B 44°C (111°F); Mixed 33°C (91°F)

Product Weight 1.62 kg/l (13.5 lb/gal)

VOC	1.87 lb/gal (225 g/lt)	EPA Method 24
	151 g/kg	EU Solvent Emissions Directive (Council Directive 1999/13/EC)
	133 g/lt	Chinese National Standard GB23985

See Product Characteristics section for further details

SURFACE PREPARATION

The performance of this product will depend upon the degree of surface preparation. The surface to be coated must be clean and free from contamination. Prior to paint application all surfaces should be assessed and treated in accordance with ISO 8504:2000.

Accumulated dirt and soluble salts must be removed. Dry bristle brushing will normally be adequate for accumulated dirt. Soluble salts should be removed by fresh water washing.

Oil or grease should be removed in accordance with SSPC-SP1 solvent cleaning.

Abrasive Blast Cleaning

Abrasive blast clean to Sa2½ (ISO 8501-1:2007) or SSPC-SP6. If oxidation has occurred between blasting and application of Interzone 954, the surface should be reblasted to the specified visual standard.

Surface defects revealed by the blast cleaning process should be ground, filled, or treated in the appropriate manner.

A surface profile of 50-75 microns (2-3 mils) is recommended.

Hand or Power Tool Preparation

Hand or power tool clean to a minimum St3 (ISO 8501-1:2007) or SSPC-SP3 for atmospheric use only.

Note, all scale must be removed and areas which cannot be prepared adequately by chipping or needle gun should be spot blasted to a minimum standard of Sa2 (ISO 8501-1:2007) or SSPC-SP6. Typically this would apply to C or D grade rusting in this standard.

Ultra High Pressure Hydroblasting / Abrasive Wet Blasting

May be applied to surfaces prepared to Sa2 (ISO 8501-1:2007) or SSPC-SP6 which have flash rusted to no worse than Grade HB2M (refer to International Hydroblasting Standards). It is also possible to apply to damp surfaces in some circumstances. Further information is available from International Protective Coatings.

Aged Coatings

Interzone 954 is suitable for overcoating some sound intact aged coatings. To ensure compatibility, application and evaluation of a test patch is required.

APPLICATION

Mixing

Material is supplied in two containers as a unit. Always mix a complete unit in the proportions supplied. Once the unit has been mixed it must be used within the working pot life specified.

(1) Agitate Base (Part A) with a power agitator.

(2) Combine entire contents of Curing Agent (Part B) with Base (Part A) and mix thoroughly with power agitator.

Mix Ratio

4 part(s) : 1 part(s) by volume

Working Pot Life

10°C (50°F)	15°C (59°F)	25°C (77°F)	40°C (104°F)
3 hours	2 hours	90 minutes	45 minutes

Note: Pot life will be reduced if alternative curing agent EAA984 is used. See Product Characteristics for further details.

Airless Spray	Recommended	Tip Range 0.53-0.66 mm (21-26 thou) Total output fluid pressure at spray tip not less than 176 kg/cm² (2503 p.s.i.)
Air Spray (Pressure Pot)	Recommended	Gun DeVilbiss MBC or JGA Air Cap 62 Fluid Tip AC
Brush	Suitable	Typically 100-150 microns (4.0-6.0 mils) can be achieved
Roller	Suitable	Typically 75-125 microns (3.0-5.0 mils) can be achieved
Thinner	International GTA220 (or International GTA415)	Thinning is not normally required. Consult the local representative for advice during application in extreme conditions. Do not thin more than allowed by local environmental legislation.

Cleaner

International GTA822 or International GTA415

Work Stoppages

Do not allow material to remain in hoses, gun or spray equipment. Thoroughly flush all equipment with International GTA822. Once units of paint have been mixed they should not be resealed and it is advised that after prolonged stoppages work recommences with freshly mixed units.

Clean Up

Clean all equipment immediately after use with International GTA822. It is good working practice to periodically flush out spray equipment during the course of the working day. Frequency of cleaning will depend upon amount sprayed, temperature and elapsed time, including any delays.

All surplus materials and empty containers should be disposed of in accordance with appropriate regional regulations/legislation.

PRODUCT CHARACTERISTICS

Maximum film build in one coat is best attained by airless spray. When applying by methods other than airless spray, the required film build is unlikely to be achieved. Application by air spray may require a multiple cross spray pattern to attain maximum film build. Low or high temperatures may require specific application techniques to achieve maximum film build.

When applying Interzone 954 by brush or roller, it may be necessary to apply multiple coats to achieve the total specified system dry film thickness.

Surface temperature must always be a minimum of 3°C (5°F) above dew point.

Do not apply at steel temperatures below 4°C (39°F).

When applying Interzone 954 in confined spaces ensure adequate ventilation.

In special cases where overcoating is required and curing has been at low temperatures and high relative humidities, ensure no amine bloom is present prior to application of subsequent topcoats.

Condensation occurring during or immediately after application may result in a matt finish and an inferior film.

Premature exposure to ponding water will cause a colour change, especially in dark colours.

In common with all epoxies Interzone 954 will chalk and discolour on exterior exposure. However, these phenomena are not detrimental to anti-corrosive performance.

Where a durable cosmetic finish with good gloss and colour retention is required overcoat with recommended topcoats.

When applied between tides on jetties, piling etc., Interzone 954 can be immersed within 30 minutes. This will lead to whitening of dark colours but will not affect ultimate anti-corrosive performance.

For use in atmospheric service a minimum dry film thickness of 350 microns (14 mils) is required in one coat when applied direct to steel, for water immersion a minimum of 450 microns (18 mils) dry film thickness is recommended. In each case protection can be achieved in a single coat application by airless spray. Interzone 954 is suitable for steelwork exposed under buried conditions (IM3 according to ISO 12944-2)

Interzone 954 may be applied to suitably sealed or primed concrete; contact International Protective Coatings for further advice on specification and primers.

Interzone 954 can be used as a non-skid deck system by modification with addition of GMA132 (crushed flint) aggregate. Application should then be to a suitably primed surface. Typical thicknesses will be between 500-1,000 microns (20-40 mils). Preferred application is by a suitable large tip hopper gun (e.g. Sagola 429 or Air texture gun fitted with a 5-10 mm nozzle). Trowel or roller can be used for small areas. Alternatively, a broadcast method of application can be used. Consult International Protective Coatings for further details.

Interzone 954 is compatible with sacrificial and impressed current cathodic protection systems.

Alternative Curing Agent (EAA984)
Drying and overcoating information is as on page 1. Pot life times are as follows:

Working Pot Life	10°C (50°F)	15°C (59°F)	25°C (77°F)	40°C (104°F)
	2 hours	1 hour	45 minutes	20 minutes

Note: VOC values are typical and are provided for guidance purpose only. These may be subject to variation depending on factors such as differences in colour and normal manufacturing tolerances.

Low molecular weight reactive additives, which will form part of the film during normal ambient cure conditions, will also affect VOC values determined using EPA Method 24.

SYSTEMS COMPATIBILITY

Interzone 954 will generally be applied to bare steel prepared by dry abrasive blasting, wet abrasive blasting or ultra high pressure hydroblasting.

The following primers are recommended for Interzone 954:

Intercure 200
Intercure 200HS
Intergard 251
Interzinc 315
Interzinc 52
Interzone 1000
Intergard 269 (for underwater use)
Interline 982 (for underwater use)

The following topcoats are recommended for Interzone 954:

Interfine 629HS
Interfine 878
Interfine 979
Intergard 740
Intersleek 167
Interthane 870
Interthane 990
Interzone 954

For other suitable primers/topcoats, consult International Protective Coatings.

ADDITIONAL INFORMATION

Further information regarding industry standards, terms and abbreviations used in this data sheet can be found in the following documents available at www.international-pc.com:

- Definitions & Abbreviations
- Surface Preparation
- Paint Application
- Theoretical & Practical Coverage

Individual copies of these information sections are available upon request.

SAFETY PRECAUTIONS

This product is intended for use only by professional applicators in industrial situations in accordance with the advice given on this sheet, the Material Safety Data Sheet and the container(s), and should not be used without reference to the Material Safety Data Sheet (MSDS) which International Protective Coatings has provided to its customers.

All work involving the application and use of this product should be performed in compliance with all relevant national, Health, Safety & Environmental standards and regulations.

In the event welding or flame cutting is performed on metal coated with this product, dust and fumes will be emitted which will require the use of appropriate personal protective equipment and adequate local exhaust ventilation.

If in doubt regarding the suitability of use of this product, consult International Protective Coatings for further advice.

PACK SIZE

Unit Size	Part A		Part B	
	Vol	Pack	Vol	Pack
20 litre	16 litre	20 litre	4 litre	5 litre
5 US gal	4 US gal	5 US gal	1 US gal	1 US gal

For availability of other pack sizes, contact International Protective Coatings.

SHIPPING WEIGHT (TYPICAL)

Unit Size	Part A	Part B
20 litre	30.4 kg	4.6 kg
5 US gal	56.4 lb	11.5 lb

STORAGE

Shelf Life — 12 months minimum at 25°C (77°F). Subject to re-inspection thereafter. Store in dry, shaded conditions away from sources of heat and ignition.

Important Note

The information in this data sheet is not intended to be exhaustive; any person using the product for any purpose other than that specifically recommended in this data sheet without first obtaining written confirmation from us as to the suitability of the product for the intended purpose does so at their own risk. All advice given or statements made about the product (whether in this data sheet or otherwise) is correct to the best of our knowledge but we have no control over the quality or the condition of the substrate or the many factors affecting the use and application of the product. Therefore, unless we specifically agree in writing to do so, we do not accept any liability at all for the performance of the product or for (subject to the maximum extent permitted by law) any loss or damage arising out of the use of the product. We hereby disclaim any warranties or representations, express or implied, by operation of law or otherwise, including, without limitation, any implied warranty of merchantability or fitness for a particular purpose. All products supplied and technical advice given are subject to our Conditions of Sale. You should request a copy of this document and review it carefully. The information contained in this data sheet is liable to modification from time to time in the light of experience and our policy of continuous development. It is the user's responsibility to check with their local representative that this data sheet is current prior to using the product.

This Technical Data Sheet is available on our website at www.international-marine.com or www.international-pc.com, and should be the same as this document. Should there be any discrepancies between this document and the version of the Technical Data Sheet that appears on the website, then the version on the website will take precedence.

Issue date: 22/03/2016

International

Proven Coatings Performance for Wave and Tidal Assets

AkzoNobel

Preventing corrosion, maintaining efficiency, supporting industry growth

AkzoNobel and high potential wave and tidal locations

Located to best support the growth of the industry

Complete coating solutions

A product range developed with our customers in mind

- Product range for any wave or tidal asset
- Single source – increasing cost effectiveness
- Simplified specification process
- Tested to the highest standard including to Norsok M-501
- Helps you maintain your asset efficiency

Total customer support

The benefits of working as partners

- World-class technical support structure
- Global locations and ISO certified manufacture
- Local support and advice
- NACE and FROSIO qualified technical sales
- From specification writing to maintenance and repair

Peace of mind

Global competency, local support

- Among the leaders in corrosion protection
- Global product range
- Environmental leadership
- Over 40 years track record in the offshore industry
- Experts in offshore asset protection

Offshore protection

We have a long history in offshore asset protection, moving from the birth of the offshore oil and gas industry, through the rapid growth of the North Sea oil and gas fields from the late 1960s, to the expansion of offshore wind in the 21st century. This experience could be invaluable to you when considering protection for wave and tidal assets and this can give you the advantage.

Forty years offshore

With over 40 years track record coating offshore and submerged structures, we have an enviable record of protecting assets in some of the harshest environments on earth.

Our long history in the offshore oil and gas industry gives us the knowledge and experience to understand the marine environment, develop suitable products and systems and to help advise our customers on specifications, device coating lifetimes and future maintenance requirements.

Having been involved in the offshore industry from its outset, many of our coatings systems have been rigorously tested to ISO and NORSOK standards. Indeed members of our technical team have been involved in the development of these standards and we continue to have input on new standards today.

Our NORSOK-approved systems include products from our Interzone® and Intershield® ranges and were designed for long term corrosion protection in offshore environments.

Testing for offshore and submerged structures

As with structures in all environments it is important to be confident that the coatings provided will give the necessary protection for the lifetime of the asset.

The offshore industry uses accelerated testing to qualify suitable systems. The baseline for standards in offshore environments should be ISO 20340, which includes cyclic testing of salt spray, condensation and UV exposure, attempting to mimic real life conditions. The high regard for the ISO 20340 standard has led to its adoption as a fundamental part of the internationally recognized NORSOK M501 standard. NORSOK M501 uses the ISO 20340 standard to offer what is currently the most encompassing view on requirements for corrosion protection of offshore assets.

These standards should be used as a guide to the most appropriate specification for your asset. However, nothing can compare to real life track record and experience.

Offshore renewables

In the 21st century; AkzoNobel has been able to use extensive knowledge of the protection of offshore structures in a new industry – offshore wind.

In offshore wind we are using our experience to protect submerged assets and those in the splash zone, typically foundations and transition pieces. This has helped us to generate a greater wealth of knowledge and expertise in marine and subsea environments.

We are now transferring this knowledge to wave and tidal devices. Our long track record has helped us to be the coating supplier of choice for a range of devices which have either already undergone significant in-water testing, are currently in production, or are planned next-generation devices. Our experience in this area includes tidal turbines, floating oscillating water column (OWC) devices, wave energy convertors, hinged flap assets and devices which pump water onshore for pumped hydro power generation.

Case study: Pelamis P2 protected by AkzoNobel

"Pelamis Wave Power uses International® Protective Coatings from AkzoNobel on our Pelamis machines, offshore wave energy converters that harness the movement of ocean waves to generate electricity.

Interzone® , a reliable and robust offshore coating. For its specific use on the Pelamis WEC, AkzoNobel produced a specific painting specification for application for our sub-contractors in order to produce a reliable coatings system.

® is applied to the insides of the power modules to keep them bright and clean for ongoing O&M work. ® was used on some subsea systems that require to be free of marine fouling for reliable operation.

We chose AkzoNobel as they are a worldwide company with an extensive product range that is widely used and specified in the offshore industry. Our experience using their International® products on previous machines was good, with the coatings available being both robust and easily repairable.

Previous coatings systems considered by Pelamis required specialist application systems and locations depending on the paint type used. We required a non-site specific paint system that could be readily applied in both our facilities and those of a sub-contractor, and one that would also allow in-service repairs to damaged zones.

We specify our coatings system to meet a design life of 20 years, and by consulting AkzoNobel we were provided with a suitable coatings system to meet our design needs. We also appreciate that in the offshore environment there may be a requirement for repair of any coating system, and this was also an important influencing factor in our selection of paint system." - Pelamis Wave Power

What's important to you?

Asset protection

The Interzone® series from AkzoNobel's International® range of protective coatings have been protecting steel offshore for over 30 years and should be the coating range of choice for long term protection of your assets. From the high build epoxies of Interzone® 485 and 954 to the glass flake epoxy of Interzone® 1000, these low volatile organic compound (VOC) coatings provide excellent corrosion, abrasion and chemical resistance.

® 1000 contains a high proportion of chemically-resistant glass flake in the dry film, giving it outstanding performance in the protection of subsea structures; an ideal coating for turbine nacelles, foundations and static underwater assets. Interzone® 1000 has been extensively tested to NORSOK M-501 and when combined with its outstanding long term track record, should make your coating choice an easy decision.

Interzone® 1000 after almost 30 years in an offshore environment

Lower section utilizing cathodic protection

Asset efficiency

The Interzone® range can give fantastic corrosion protection, however when considering coatings for moving parts such as tidal turbine blades or water intake channels on OWC devices, then our Intersleek® range can provide a value-added solution.

Why a different coating for the moving parts?

is the key

Dependent upon the device type and the type of biofouling present, we estimate a 2-5 percent increase in drag, which can lead to as much as a 20 percent reduction in torque. In fact, even biofilms can lead to a 10 percent increase in drag, with a resultant effect upon torque and more importantly an adverse effect upon the financial performance of your asset.

® range has been designed with smoothness in mind, and in addition to its excellent foul-release performance, it is biocide-free; delivering best in class performance whilst considering the environment. Its exceptionally smooth, slippery, low friction surface prevents organisms attaching, saving you time and money in cleaning operations.

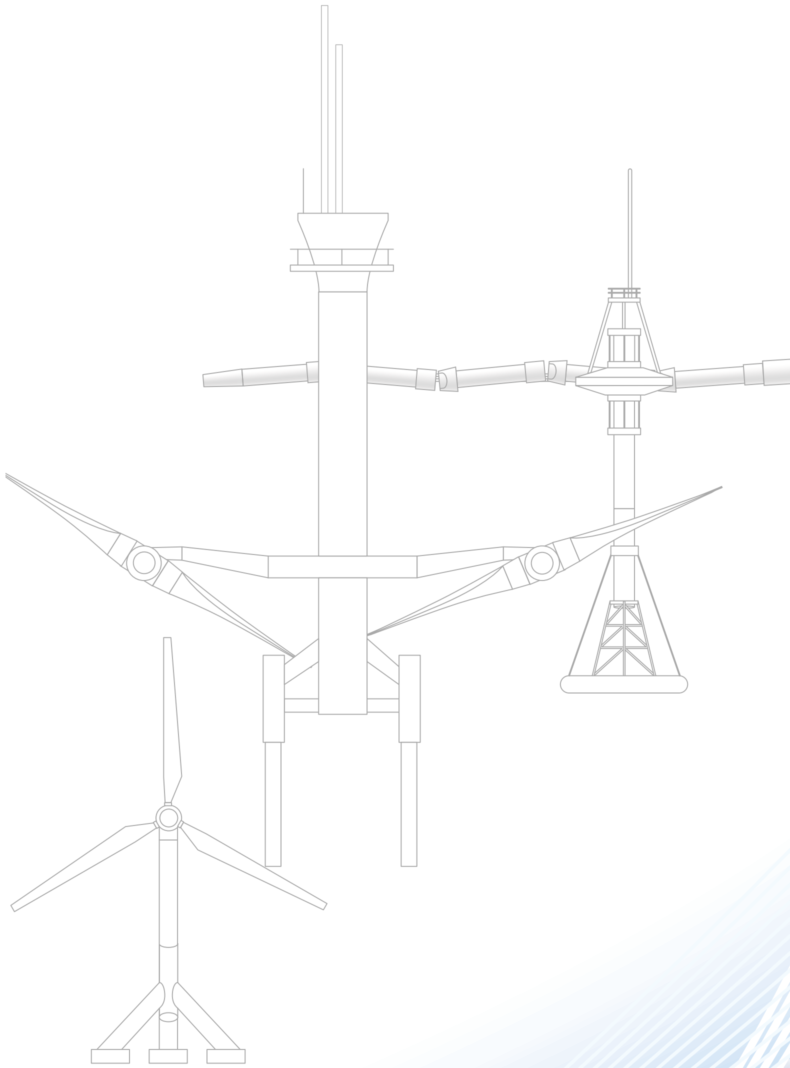
In addition to maintaining efficiency, Intersleek® can maintain buoyancy by minimizing weight gain from marine organism growth and can help with significant savings on maintenance costs by its easy clean characteristics.

Recommended systems

Our experience offshore has enabled us to develop a range of coatings systems suitable for most offshore and marine situations.

® range, ideal for mechanical and moving parts.

For help creating any specification tailored to your needs, please contact your local protective coatings representative.



System for topsides / ambient / non-immersed

Interzinc® 52 @ 50-75 µm (2-3 mils)
Intergard® 475HS @ 100-200 µm (4-8 mils)
Interthane® 990 @ 50-75 µm (2-3 mils)

Submerged static steel

Interzone® 954 @ 300-500 µm (12-20 mils)
Interzone® 954 @ 300-500 µm (12-20 mils)

System for submerged and splash zone areas for up to 30 years

Interzone® 1000 @ 500-750 µm (20-30 mils)
Interzone® 1000 @ 500-750 µm (20-30 mils)

Intersleek® systems for steel and composite up to 15 years anticorrosive performance

Intershield® 300 @ 150 µm (6 mils)
Intershield® 300 @ 150 µm (6 mils)
Intersleek® Tie Coat @ 100 µm (4 mils)
Intersleek® Foul Release @ 150 µm (6 mils)

15+ years anticorrosive performance

Interzone® 954 @ 200 µm (8 mils)
Interzone® 954 @ 200 µm (8 mils)
Intershield® 300 @ 125-150 µm (5-6 mils)
Intersleek® Tie Coat @ 100 µm (4 mils)
Intersleek® Foul Release @ 150 µm (6 mils)

Highlights of our track record

AR1000 | Atlantis Resources Corporation

Products: Interzone® 954

Aquamarine Power | Oyster 800

Products: Intergard® 269
Interzone® 954

Seagen
Twin Tidal Turbine
Marine Current Turbines

Products:
Interseal® 670HS
Intershield® 300
Interzone® 954
Intersleek® Tie Coat
Intersleek® Foul Release

HyTide | Voith Hydro

Products: Interzinc® 52, Interline® 975, Intershield® 300, Intersleek® Tie Coat, Intersleek® Foul Release

HS1000 | Andritz Hydro

Products: Interzone® 954, Intershield® 300, Intersleek® Tie Coat, Intersleek® Foul Release

www.international-pc.com
pc.communication@akzonobel.com

G8_WAVETIDAL_UK
11/14

APPENDIX H

MARAD Lease Requirements

1. INTRODUCTION AND BACKGROUND

The Maritime Administration (MARAD) requires real property for the exclusive long-term safe lay berthing for RRF vessels on the California Coast. Although the layberths are intended for the vessels identified in this sublease, the Sublessee may substitute vessels of a similar size or smaller. A Memorandum of Agreement (MOA) between the Department of the Defense (DOD) and the Department of Transportation (DOT) establishes that, in consideration of the National Defense and the American Merchant Marine, a mutual interest and responsibility exists for the joint establishment, maintenance and control of a Ready Reserve Force (RRF), which is an element of the National Defense Reserve Fleet (NDRF). The ships of the RRF are maintained by MARAD in various states of readiness to meet common user lift requirements of the armed services in a contingency. The RRF consists of 59 vessels as of October 1, 2004.

2. DEFINITIONS

Apron: An area adjacent to and extending the length of the berth used for vehicle passage, material staging, parking of vehicles engaged in maintenance, repair, delivery of parts, etc.

Berth: Any designated place where a vessel is secured including the dock and slip, usually indicated by a code or name.

Dock: The structure located within the layberth facility having the mooring hardware for vessels, synonymous with pier and wharf.

Layberth: A berth used by a vessel for an extended period of time.

Ramp: The primary vehicular access way onto a RO/RO vessel that is characterized by the location of entry (stern ramp/side-port ramp).

Slip: The water area of the layberth adjacent to the dock where the vessel is maneuvered during arrivals and departures.

Ship Manager/General Agent: The MARAD contractor for a designated group of RRF vessels that is responsible for ship operation, maintenance, and activation readiness.

Vertical live loads: These are items moving or being caused to move over the dock.

Water level: The height of water above or below the datum reference point as predicted by local tide tables and affected by seasonal flooding or drought.

Working Area: The area of a dock adjacent to vessel to be used for deliveries, staging gear, and vehicle access.

3. STATUS OF VESSELS

RRF vessels will normally be maintained in an idle status and will remain at the layberth site in all weather conditions, except to participate in a military exercise/operation, to conduct some repairs, or comply with periodic regulatory requirements. Ship activations and dock trials are expected to be conducted at the layberth.

RRF vessels may have a Reduced Operating Status (ROS) crew onboard.

The shipboard fire fighting system may be inoperable.

The cathodic protection systems may be energized.

Interior house and engineering spaces may be dehumidified with ship's equipment.

The mooring equipment will remain in operating condition. Mooring lines and wires will be provided by the Sublessee or the Sublessee's Ship Manager/General Agent for each vessel.

The vessels may be used for cargo handling training and for other training purposes.

4. BERTH REQUIREMENTS AND THE SUBLESSORS OBLIGATIONS

The layberth Sublessor shall bear all costs associated with obtaining and maintaining an acceptable safe layberth except as specifically identified. Some items are identified for emphasis only. An acceptable safe layberth shall meet the following minimum criteria and technical features:

Water depth shall be maintained at 32 feet for the NOAA chart datum. If the performance of normal maintenance to the layberth requires temporary movement of the vessel from the subject layberth, the Sublessor shall bear all expenses incurred in moving the vessel including but not limited to tugs, pilotage and temporary layberth costs. Any temporary layberth used shall meet all the requirements of this sublease. Should the Sublessor be unable to offer an acceptable substitute layberth during such a maintenance period, the Sublessee reserves the right to acquire and move the vessel to a temporary layberth of its choice at the Sublessor's expense or to terminate the sublease for default.

The proposed berthing facility shall be of sound structural design, construction and condition to support ship mooring.

The current configuration of mooring line fittings (bollards, bitts, cleats, etc.) shall be maintained to meet designed Safe Working Loads.

The Safe Working Load of all fittings on the layberth shall be identified on the required drawings that are submitted to the Sublessee.

The facility, including but not limited to the layberth and associated structures, shall be well preserved and maintained at all times to ensure the proper level of safety and security for the vessel and the facility, the safe movement of the vessel and vehicular traffic within the facility, and the cleanliness of the layberth (e.g., free from garbage and debris).

The Sublessor shall maintain all timber fenders.

Fenders between the dock and the vessel shall be provided to keep the vessel off non-wood portions (e.g., wood, metal, concrete) of the dock face at all times. No hull contact with non-wood surfaces is acceptable.

After the vessel(s) arrives at the berth, the Sublessee will inspect to ensure proper fendering.

The dock shall meet the following minimum criteria:

The deck shall have a paved concrete or asphalt surface in good condition.

The dock shall be of sufficient strength and dimensions to facilitate the movements of an HS 20-44 truck or the largest local fire fighting vehicle, whichever is greater, to and from the locations identified for the applicable vessel. The width of dock apron shall safely accommodate the two-way passing of two HS 20-44 trucks or fire fighting vehicles whichever is greater.

The dock shall safely support vertical live loads as follows:

The dock shall support a point-load characterized by a small tire warehouse forklift with 4,000-lb load.

Support uniform loading of 425 lbs. per square foot in all areas, including areas where the ramps will land.

The dock shall support truck loading to include the heaviest local fire fighting vehicle used in fire fighting efforts and American Association of State Highways and Transportation Officials (AASHTO) standard HS 20-44 truck. Standard HS 20-44 can be found in the Standard Specification for Highway Bridges and is available at the following address:

AASHTO
444 N. Capitol St., N.W.
Suite 225
Washington, D.C. 20001
(202) 624-5800

Present no obstruction, protrusion or obstacle that may prove hazardous to the ship and/or personnel.

The dock shall be located sufficiently distant from areas where sand, grit, dust, bird droppings or other airborne or waterborne substances could hazard the material readiness of the ship's equipment or crew safety. If foreign material is deposited on these vessels, the Sublessor shall be responsible for the cost of cleaning the vessel to the satisfaction of the Sublessee. Persistent deposits of foreign material are cause for termination of this sublease by default.

The Sublessor shall ensure that the layberth is protected by a well-maintained security fence that prevents access by unauthorized personnel. If the layberth is part of a larger facility, there shall be a security fence separating the layberth from the rest of the facility.

a). The Sublessor and the Sublessee shall jointly design a security fence of sufficient height and coverage that meets the Sublessee's security requirements and i) prevents unauthorized personnel from getting within 100 feet of the ship's hull, ii) prevents unauthorized access to mooring fittings, and iii) prevents access around the fence, all in a manner that aesthetically blends into the surrounding developed property."

b). The fence shall have a gate of sufficient size to allow access of the size vehicles discussed in 4.a.6). It shall have a lock with a card key/key code access system. Card keys/access codes will be provided to MARAD surveyors and appropriate crewmembers and contractors as determined by the ship manager.

c.) Fences and gates shall be properly maintained at all times. This includes, but is not limited to, ensuring that all fences, gates, and posts are free of rust, properly painted, vertically aligned and kept in a tear-free state (free from holes). Signs shall be placed on the fences advising that the area enclosed is Government property.

The Sublessor shall ensure personnel and contractor access to and security of the facility to meet the requirements set forth below:

Layberth and ship access shall be available at all times (including Sublessor provided access between nested vessels) to facilitate training, crew boarding, cargo handling, ship husbanding, activations, and repair services required by the Sublessee or its contractors.

The Sublessee/Ship Manager reserves the right to subcontract for ship repair and/or stevedore services of its own choosing for the purpose of performing work onboard, or associated with the vessel, at all times that the vessel is moored at the facility. Said contractors and subcontractors shall be provided with unencumbered access to the vessel (including support vehicles) including, but not limited to, access across any and all labor related picket lines. The ship's crew shall be permitted to load ship's stores and spare parts without the assessment of stevedore's fees.

The layberth and structures adjacent to the layberth shall not present a fire hazard to the vessel(s).

The Sublessor shall be responsible for, and bear all expenses associated with ensuring that there are properly paved and maintained access roads, (including bridges and tunnels if applicable) within the layberth facility. At all times during the term of this sublease, access roads (including bridges and tunnels) shall not present obstructions nor restrict the safe access to the dock by personnel and vehicular traffic including all local firefighting vehicles and AASHTO HS 20-44 trucks.

The access roads and bridges shall have sufficient load bearing capacity and dimensions for AASHTO standard HS 20-44 truck traffic and the largest and heaviest local firefighting vehicles.

There shall be an adequately sized turn around area to enable AASHTO standard HS 20-44 trucks to turn around. The turn-around area shall be in close proximity to the dock apron so that such vehicles can turn around and back up to the dock or turn around before leaving via the access road.

Provide paved, fenced and well maintained parking areas as delineated in the facility drawing attached at Exhibit D.

Road maintenance within the layberth facility shall be the responsibility of the Sublessor. All access roads, roadways, and layberth shall be kept clear from snow, ice, debris, potholes and vegetation at all times.

Provide lighting of at least 1.0 Foot-candles on the layberth for its entire length and width to include the apron and all mooring points to permit safe passage of personnel, line handlers, etc, as well as all parking areas.

Ensure that telephone communication with the facility operator and/or manager are available to the Sublessee on a 24-hour a day, seven-day a week basis. The Sublessor shall maintain telecopier capability (fax machine) in support of this requirement during normal working hours at the place of business.

Sublessor shall have a layberth security plan in compliance with U.S. Coast Guard Captain of the Port requirements, and have an Oil spill plan for their facility that is in accordance with the Clean Water Act.

The following equipment and services shall be provided and maintained by the Sublessor at the layberth:

Separate shore power outlets, connections and electric company metered services for each ship (including cables and attachment fittings approved by U.S. Coast Guard or American Bureau of Shipping) rated to meet at least 1200A per vessel 460V/3-phase/60hz electrical requirements to supply electric power for hotel services, lighting, machinery tests, dehumidification equipment and cathodic protection. Electric service shall provide circuit breakers equipped with short circuit and overload protection on all three phases, and when using single conductor cables, they must be of the same length, new or in good condition. Electric power service will be arranged between the Sublessee, General Service Administration and local utility. Electric power bills will be paid directly by the Sublessee to the utility.

Three telephone lines for each ship (including cables, attachment fittings, jack, and phones) shall be provided. Initial activation and ongoing service charges for the three lines shall be paid for by the Ship Manager/General Agent. Any additional lines requested by the Ship Manager/General Agent will be at their expense.

An industrial size dumpster (minimum size shall be 4.0 cubic yards), shall be located within 100 feet of the gangway base of each ship.

Layberth potable water service with demonstrated pressure maintained at minimum of 40 PSI via a minimum of a two and one-half inch (2½ inch) line capable of a minimum requirement of 200,000 gallons per day (gpd), as well as sewage.

Oil booms to support containment of oil spills. The existing oil booms are to be maintained and replaced as necessary to support RRF operations. Cleaning the oil booms is not required as part of maintaining the oil booms.

c. 1) Immediately following the execution of the Long-Term Sublease, the Sublessor and Sublessee shall jointly inspect the facilities and document the condition of the premises and their compliance with the requirements of the Sublease and these Technical Requirements. The Parties shall jointly prepare a list of items that must be addressed by Sublessor ("List of Deficiencies"). Sublessor shall, within four (4) months of the date of receiving a copy of the List of Deficiencies, correct such deficiencies or otherwise resolve each such deficiency in a manner satisfactory to the Sublessee.

2) In the event performance by Sublessor is impossible with respect to remedying the List of Deficiencies, Sublessee may undertake to remedy such deficiencies and offset costs incurred by Sublessee against the monthly lease amounts due and owing to Sublessor.

5. REIMBURSABLE SERVICES

Reimbursable services agreed to by the Sublessee shall be paid by the Sublessor and reimbursed by the Sublessee.

Water and sewage cost will be reimbursed by the Sublessee strictly based on the percentage of the metered water and sewage usage of the Sublessee as compared to the overall usage of water and sewage, multiplied by the invoiced cost to the Sublessor for the overall water and sewage usage.

Trash removal will be reimbursed by the Sublessee as arranged between the Sublessee and the layberth Sublessor.