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329502

April 23, 2014

Mr. Vivek Galav, P.E.
CITY OF WEST PALM BEACH
401 Clematis Street, 4th Floor
West Palm Beach, FL 33402

Via electronic mail: vgalav@wpb.org

RE: PIER INVESTIGATION AND ASSESSMENT RELATIVE TO THE CITY-WIDE PIER REPAIR AND MAINTENANCE PROJECT, CITY OF WEST PALM BEACH, PALM BEACH COUNTY, FLORIDA

Dear Mr. Galav:

The purpose of this letter report is to document the field investigation conducted by Coastal Systems International, Inc. (Coastal Systems) to evaluate the current condition and summarize engineering recommendations to repair or replace the piers as part of the City-Wide Pier Repair and Maintenance Project (Project). An above and below-water investigation was completed by a professional engineer on April 14, 2014. The findings of the field investigation are detailed below.

BACKGROUND

The Project consists of two piers along the Intracoastal Waterway. The first pier is located at the north end of Currie Park near the Northwood neighborhood. The second pier is located at the intersection of South Flagler Drive and Valencia Road in the El Cid neighborhood. Coastal Systems was authorized by the City of West Palm Beach (Client) to perform an engineering investigation of the existing piers to evaluate the current condition, remaining service life, and cost to repair or replace the substructure. The Client is currently proposing to replace the decking on both piers, per Invitation to Bid 13-14-02, and therefore this investigation included an assessment of the substructure only. This letter report summarizes the results of the field investigation, provides an assessment of the piers, and provides recommendations and cost estimates for potential rehabilitation and/or replacement of the substructure. The work was authorized by the Client in an agreement dated April XX, 2014.

Coastal Systems visited the above-referenced sites on April 14, 2014 to evaluate the condition of the piers at Currie Park and El Cid. An above and below-water (SCUBA) investigation of the existing piers was performed by a professional engineer in accordance with the American Society of Civil Engineers (ASCE) Underwater Investigations Standard Practice Manual (Manual). The definitions of levels of inspection and condition assessment ratings are attached in [Appendix A](#). Field measurements of existing structural components were collected while onsite,

as structural as-built information was not available prior to the investigation. For this investigation, each pier was identified based on its location as shown in [Figure 1](#).

Photographs documenting the site conditions at the time of the investigation were collected and are attached in [Appendix B](#).

CURRIE PARK PIER

OBSERVATIONS

The existing pier is a T-shaped configuration extending approximately 200 feet offshore from the existing concrete pile-panel bulkhead. The shore-perpendicular section of the pier is approximately 10 feet wide and 190 feet long. The shore-parallel “head” of the pier is 10 feet wide and 50 feet long. The substructure of the pier consists of 12”x12” precast concrete plumb piles. The pile layout, which shows typical spacing, is shown in [Figure 2](#). At the time of the investigation, the existing pier already had the decking removed by Bayshore Construction, Inc. (Contractor) as part of the initial rehabilitation of the Pier, but timber pile caps, stringers, and railing supports remained. Two concrete pile caps extended between bent 15 and 16 along row A and B. Each pile cap is 24” wide by 30” tall by 10 feet long (in the shore-perpendicular direction).

Level I evaluations were completed on each plumb pile. Level II evaluations were completed on every fourth plumb pile (approximately 10%). The ratings for each concrete pile are shown in [Figure 3](#). The exposed concrete on each pile was sounded with a masonry hammer at different elevations and appeared to be sound without any “hollow” areas observed. The concrete plumb piles were covered in heavy marine growth; therefore two 12” bands were cleaned using a masonry hammer just below the tidal zone and just above the mudline. Each pile was observed to have minor weathering and shrinkage cracking above the tidal zone. Occasional corrosion stains and spalling was observed at the hardware connection point at the top of the pile. No structural cracks below the tidal zone were observed. Minor, localized concrete patchwork was observed on some piles.

It was observed during the pre-construction meeting on April 1, 2014 with the Client and Contractor that the northeast corner of the pier was damaged and partially collapsed. The plumb pile at the northeastern end of the pier (16A) was observed to have a damaged area at the top of the pile on the north face approximately 12” in height which likely resulted from the vessel impact with the pier superstructure causing an approximate 2” loss of section and reduced bearing capacity.

Depth soundings were obtained along the pier using a folding ruler. The results are summarized in [Table 1](#) below. Depths were approximated using data published by National Oceanic and Atmospheric Administration (NOAA) Tide Station #8722607 (Palm Beach, FL).

Table 1: Depth Soundings along Pier

Pile ID	Depth [ft, MLLW]
4D	2.1
9D	4.0
13D	4.7
15E	4.1
16E	3.1
16A	3.2
13C	4.2

ASSESSMENT

The existing concrete piles appear to be approximately 20 years old based on the current condition of the concrete piles. A review of historic aerials for the site puts the construction of the pier sometime between February 1991 and January 1995. Pile 14D had “4-26-91” etched into the side. Assuming this is the date of manufacture or installation of the pile, this would be consistent with the pier being approximately 23 years old. The concrete piles all exhibited signs of minor deterioration with localized areas of moderate deterioration typical of concrete piles of this age. The size and orientation of the cracks in the top portions of the piles indicate localized overloading from the superstructure connections. The hardness of the concrete indicates minimal chemical deterioration of the piles. The damage caused by the vessel impact to the northeast corner of the pier does not appear to have caused any structural damage (cracking, buckling, displacement, etc.) to the piles in this area beyond the localized damage noted above. The concrete pile caps were observed to have sound concrete and square corners.

Based on the above noted field observations and criteria established in the ASCE Manual, the substructure (concrete piles and concrete pile caps) is given a rating of **Fair** as all primary structural elements are sound, but minor to moderate defects and/or deterioration was observed. Localized areas of moderate to advanced deterioration were present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.

The estimated remaining service life of the concrete piles is 10-15 years, based on existing site conditions and anticipated rates of deterioration; however, this remaining service life does not include potential impacts of a severe coastal storm event, overloading, or additional vessel impacts. Further, structural calculations for the original design or proposed improvements were not available for this evaluation. Also, Level III partially destructive testing (concrete coring) to assess remaining concrete capacity of the piles and pile caps was beyond the scope of this investigation.

RECOMMENDATIONS

Based on the above-referenced investigation performed by Coastal Systems and the proposed development plan (i.e. intended usage/loading), *repair/rehabilitation is the recommended action* for the Currie Park Pier and is summarized below.

Repair/Rehabilitation:

Only minor repairs are recommended at this time to address deteriorated areas. In addition to the small, damaged area on the pile at the northeast corner (16A), all exposed cracks and abraded areas on moderate piles (See [Figure 3](#)) should be repaired to restore the original square section and capacity and to prevent further chloride intrusion which would accelerate steel reinforcement corrosion and potential cracking. These crack repairs should be completed with a non-shrink grout for crack widths greater than $\frac{3}{4}$ " and with a marine-grade epoxy for crack widths less than $\frac{3}{4}$ ". Based on the current condition of the pier at the Project site, the above recommendation would restore the damaged pile at the northeastern corner to the pre-impact condition and provide protection from future corrosion cracking on the other deteriorated piles. This type of repair would likely extend the service life of the existing concrete piles by 5-10 years. These minor repairs could likely be completed by the Contractor as part of the existing repair and rehabilitation plan for approximately \$2,500 to \$3,500. Also, it would be advantageous for the Client to perform repairs at this time due to the available access allowed by the decking being currently removed. The cost of future repairs when the decking is installed would likely be greater.

The most economical option would be to leave the pier "as-is" and not perform any repair or replacement efforts at this time. However, this approach is not recommended based on the existing condition of the pier and the proposed repair and rehabilitation plan.

EL CID PIER

OBSERVATIONS

The existing pier is a T-shaped configuration extending approximately 55 feet offshore from the existing concrete pile-panel bulkhead. The shore-perpendicular section of the pier is approximately 8 feet wide and 37 feet long. The shore-parallel "head" of the pier is 17 feet wide and 37 feet long. The substructure of the pier consists of 10"x10" precast concrete plumb piles. The pile layout, which shows typical spacing, is shown in [Figure 4](#). The existing pier consists of timber joists, stringers, decking, and a dilapidated timber ladder at the southeast corner of the structure.

Level I evaluations were completed on each plumb pile. Level II evaluations were completed on every fifth plumb pile (approximately 20%). The ratings for each concrete pile are shown in [Figure 5](#). The exposed concrete on each pile was sounded with a masonry hammer at different

elevations and appeared to be sound without any “hollow” areas observed. The concrete plumb piles were covered in heavy marine growth; therefore two 12” bands were cleaned using a masonry hammer just below the tidal zone and just above the mudline. Each pile was observed to have moderate weathering and shrinkage cracking above the tidal zone. Multiple piles exhibited structural and corrosion cracking with widths between 1/8” to full section failures. Corrosion staining, shallow spalling, and localized areas of fascia loss was observed on multiple piles. No structural cracks below the tidal zone were observed.

Depth soundings were obtained along the pier using a folding ruler. The results are summarized in [Table 2](#) below. Depths were calculated using data published by National Oceanic and Atmospheric Administration (NOAA) Tide Station #8722607 (Palm Beach, FL).

Table 2: Depth Soundings along Pier

Pile ID	Depth [ft, MLLW]
2C	2.3
3C	4.9
4C	7.9
7C	11.8
6B	8.8
3B	3.9
1B	0.9

ASSESSMENT

The existing concrete piles appear to be approximately 30 years old based on the condition of the concrete piles. A review of historic aerials for the site indicates a pier located in the same footprint since at least 1958, but the pier has likely been repaired since then. The adjacent pile-panel bulkhead had “1-14-83” etched into one of the king piles. Assuming this is the date of manufacture or installation of the king pile, this would be consistent with the pier being approximately 31 years old. However, the date of construction of the current pier can only be estimated. The concrete piles all exhibited signs of moderate to advanced deterioration with localized areas of severe deterioration. The size and orientation of the cracks in the top portions of the piles indicate localized overloading from the superstructure connections and corrosion cracking. Multiple piles exhibited full plane failures through the entire pile and Pile 6A exhibited complete loss of concrete cover at the top of the pile with exposed, heavily corroded reinforcement. The hardness of the concrete and loss of fascia indicates moderate chemical deterioration of the piles.

Based on the above noted field observations and criteria established in the ASCE Manual, the substructure (concrete piles) is given a rating of **Poor** as advanced deterioration or overstressing was observed on widespread portions of the structure but does not appear to have significantly reduced the load-bearing capacity of the structure. This is mostly because the majority of existing hardware is through the full section of the pile. However, the existing hardware and timber decking may be preventing further failures and removal of the timber superstructure as

part of the pier repair and rehabilitation plan may exacerbate any deterioration and/or expose additional deteriorated areas. Repairs may need to be carried out with moderate urgency before public access to the pier is re-opened.

The existing concrete piles have likely exceeded their service life based on existing site conditions and anticipated rates of deterioration; however, this remaining service life does not include potential impacts of a severe coastal storm event, overloading, or additional vessel impacts. Structural calculations for the original design or proposed improvements were not available for this evaluation. Also, Level III partially destructive testing (concrete coring) to assess remaining concrete capacity of the piles was beyond the scope of this investigation.

RECOMMENDATIONS

Based on the above-referenced investigation performed by Coastal Systems, there are several options available for the existing waterfront structure, depending on the proposed pier repair and rehabilitation plan (i.e. intended usage/loading), allowable construction budget, and required service life. The available options are: 1) Complete Replacement, 2) Repair/Rehabilitation, or 3) Monitor/No-Action). These options are summarized below:

Pier Option #1 (Complete Replacement): As part of the overall pier repair and maintenance plan, the existing concrete piles could be abandoned and replaced with new concrete piles in the same footprint as the existing pier. The anticipated service life of a pier of this type is in excess of 30 years if properly designed and constructed according to industry standards. An estimated cost to replace the 20 existing concrete piles could range from approximately \$1,400-\$1,800 per pile.

Based on the proposed pier repair and maintenance plan, anticipated live loads, remaining service life, and current condition of the concrete piles, *complete replacement is the recommended approach* for the El Cid Pier. This option would provide a clean surface for the new IPE timber superstructure to be secured to the new piles and provide a properly engineered substructure. Environmental and building permits would be required for this option.

Pier Option #2 (Repair/Rehabilitation): In lieu of complete replacement, repair/rehabilitation may be a more economical option for the pier in the short term. All exposed cracks, abraded areas, and failed sections on moderate, advanced, and severe piles (See [Figure 6](#)) should be repaired. This option would require reforming of the deteriorated piles with a marine-grade concrete mortar to restore the original 10"x10" section, cleaning and coating of the corroded reinforcement, and removal of all damaged concrete. Further, all exposed cracks would have to be sealed with a non-shrink grout for crack widths greater than $\frac{3}{4}$ " and with a marine-grade epoxy for crack widths less than $\frac{3}{4}$ ". This type of repair would likely extend the service life of the existing concrete piles by 10-15 years. An estimated cost for repair/rehabilitation with this type of repair could range from approximately \$800-\$1000 per pile.

As an alternative, a pile splice could be installed on each damaged pile. A pile splice system would consist of saw cutting the existing piles just below the damaged sections and installing dowels into the existing pile with a marine-grade epoxy. Then a new pile would be spliced onto the top of the existing piles to the same elevation as the existing piles. This type of repair would likely extend the service life of the existing concrete piles by 10-15 years. Engineering design would be required for this repair option to select the reinforcement, epoxy, pile type and length or repair. An estimated cost for repair/rehabilitation with this type of system could range from approximately \$1000-\$1200 per pile.

Pier Option #3 (Monitor/No-Action): The most economical option would be to leave the pier “as-is” and not perform any repair or replacement efforts on the piles at this time. However, this approach would only be recommended if the pier remains closed to public use. Also, it is not recommended that the new timber superstructure and hardware be installed “below” the damaged areas as this will not prevent chloride ingress, deterioration, and further reduction in pile capacity.

As part of the Project, a regular inspection program should be instituted to continually monitor the condition of both the Currie Park and El Cid Piers. The ASCE Manual recommends that both piers be inspected every four (4) years based on the condition ratings presented herein and assuming recommended repairs are conducted at this time. Should repairs not be performed, follow-up inspections should be conducted every two (2) years to ensure deterioration rates are consistent that the structure can be left in service. The estimated cost for this option would be about \$2,500-\$5,000 per inspection, depending on scope, for a professional engineer to visually assess the piers. The assessment should also be expanded to include the timber superstructure and hardware components.

It should be noted that small surface or subsurface cracking may be present but was not observed due to the level of investigation undertaken and/or was visually obstructed during the field investigation due to low visibility or being located in a non-cleaned area of the piles. The Client will need to consider potential damage to the pier and safety issues associated with pier usage should there be instances of partial or complete failure of the pier either due to additional deterioration, overloading, or the effects of a severe coastal storm event

This letter report was prepared in accordance with generally accepted waterfront facility assessment engineering practice. The preliminary cost estimates are based on Coastal Systems’ experience in waterfront construction but should be confirmed by the Contractor. The assessment and recommendations submitted herein are based on the data obtained from the field observations. This report may not account for possible variations that may exist between the conditions observed due to limited underwater visibility and marine growth coverage. Coastal Systems appreciates the opportunity to provide professional engineering services relative to this project. Should you have any questions regarding this letter report or require additional information, please feel free to contact me directly at (561) 331-8849 or jpcheifet@coastalsystemsint.com.

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Mr. Vivek Galav, P.E.
April 23, 2014
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Sincerely,
COASTAL SYSTEMS INTERNATIONAL, INC.
Florida EB #7087

A handwritten signature in blue ink, appearing to read 'JPC', is positioned above the printed name of the signatory.

Jordon P. Cheifet, P.E., CFM
FL Reg. 72876
Senior Coastal Engineer

JPC:

Enclosures

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Appendix A

APPENDIX A

LEVELS OF UNDERWATER INSPECTION EVALUATION AND RATING SYSTEM

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

Level II Inspection: A detailed inspection that requires marine growth to be removed from portions of the structure. Cleaning is time-consuming, hence the need to base the inspection on a representative sampling of components. For piles, a 12-inch high band should be cleaned at designated locations, generally near the low waterline, at the mudline and midway between the low waterline and the mudline. On a rectangular pile, the marine growth removal should include at least three sides; on an octagonal pile, at least six sides; on a round pile, at least three-fourths of the perimeter. On large-diameter piles (3 ft or greater), 1-ft x 1-ft areas should be cleaned at four locations approximately equally spaced around the perimeter at each elevation. On large, solid-faced elements such as retaining structures, 1-ft x 1-ft areas should be cleaned at these three elevations. This inspection also should focus on typical areas of weakness such as attachment points and welds. It is intended to detect and identify damaged and deteriorated areas that may be hidden by surface biofouling. The thoroughness of cleaning should be governed by the tasks necessary to discern the condition of the underlying material. Removal of all biofouling staining is generally not required.

The Level II inspection is intended to detect and identify damaged and deteriorated areas, which may be hidden by surface biofouling. The thoroughness of cleaning should be governed by what is necessary to discern the condition of the underlying material. Removal of all biofouling staining is generally not needed.



APPENDIX A

Level III Inspection: A detailed inspection typically involving nondestructive or partially destructive testing, conducted to detect hidden or interior damage or to evaluate material homogeneity. Typical inspection and testing techniques include the use of ultrasonics, coring or boring, physical material sampling, and in situ hardness testing. This inspection is generally limited to key structural areas, areas that are suspect, and areas that may be representative of the underwater structure.

REFERENCE: Underwater Investigation Standard Practice Manual, American Society of Civil Engineers, Report No. 101, 2001.



APPENDIX A

ROUTINE CONDITION ASSESSMENT RATINGS

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

- Ratings should reflect only damage that was likely caused by the event. Long-term or pre-existing deterioration such as corrosion damage should be ignored unless the structural integrity of the structure is immediately threatened.
- Ratings are used to describe the existing in-place structure compared with the structure when new. The fact that the structure was designed for loads that are lower than the current standards for design should have no influence on the ratings.

REFERENCE: Underwater Investigation Standard Practice Manual, American Society of Civil Engineers, Report No. 101, 2001



Appendix B

Appendix B - Site Photographs



Photo 1: Typical Minor Pile (Pile 4B) - Looking North [Currie Park Pier]



Photo 2: Typical Moderate Pile (Pile 7A) - Looking South [Currie Park Pier]





Photo 3: Typical Advanced Pile (Pile 16") - Loss of Section from Vessel Impact - Looking Southwest [Currie Park Pier]



Photo 4: Typical Rounding at Top of Pile (Pile 4B) - Looking South [Currie Park Pier]



Photo 5: Concrete Pile Caps on T-Head - Looking Northeast
[Currie Park Pier]



Photo 6: Concrete Pile Caps on T-Head - Looking Northwest
[Currie Park Pier]





Photo 7: Typical Corrosion Staining on Moderate Pile (Pile 1A) - Looking South [Currie Park Pier]



Photo 8: Date of Manufacture or Construction "4-26-91" on Pile 15B - Looking Southeast [Currie Park Pier]





Photo 9: Typical Minor Pile (Pile 2B) - Looking North [El Cid Pier]



Photo 10: Typical Moderate Pile (Pile 3A) - Looking South [El Cid Pier]





Photo 11: Typical Advanced Pile (Pile 6B') - Looking North [El Cid Pier]



Photo 12: Typical Severe Pile (Pile 6A') - Looking South [El Cid Pier]





Photo 13: Complete Loss of Concrete Cover with Exposed and Corroded Reinforcement (Pile 6A') - Looking South [El Cid Pier]



Photo 14: Failure Crack at Top of Pile (Pile 5B) - Looking South [El Cid Pier]



Photo 15: Typical Heavy Marine Growth in Tidal Zone - Looking Northeast [El Cid Pier]



Photo 16: Date of Manufacture or Construction "1-14-83" on Adjacent Pile-Panel Bulkhead - Looking West [El Cid Pier]



Appendix C

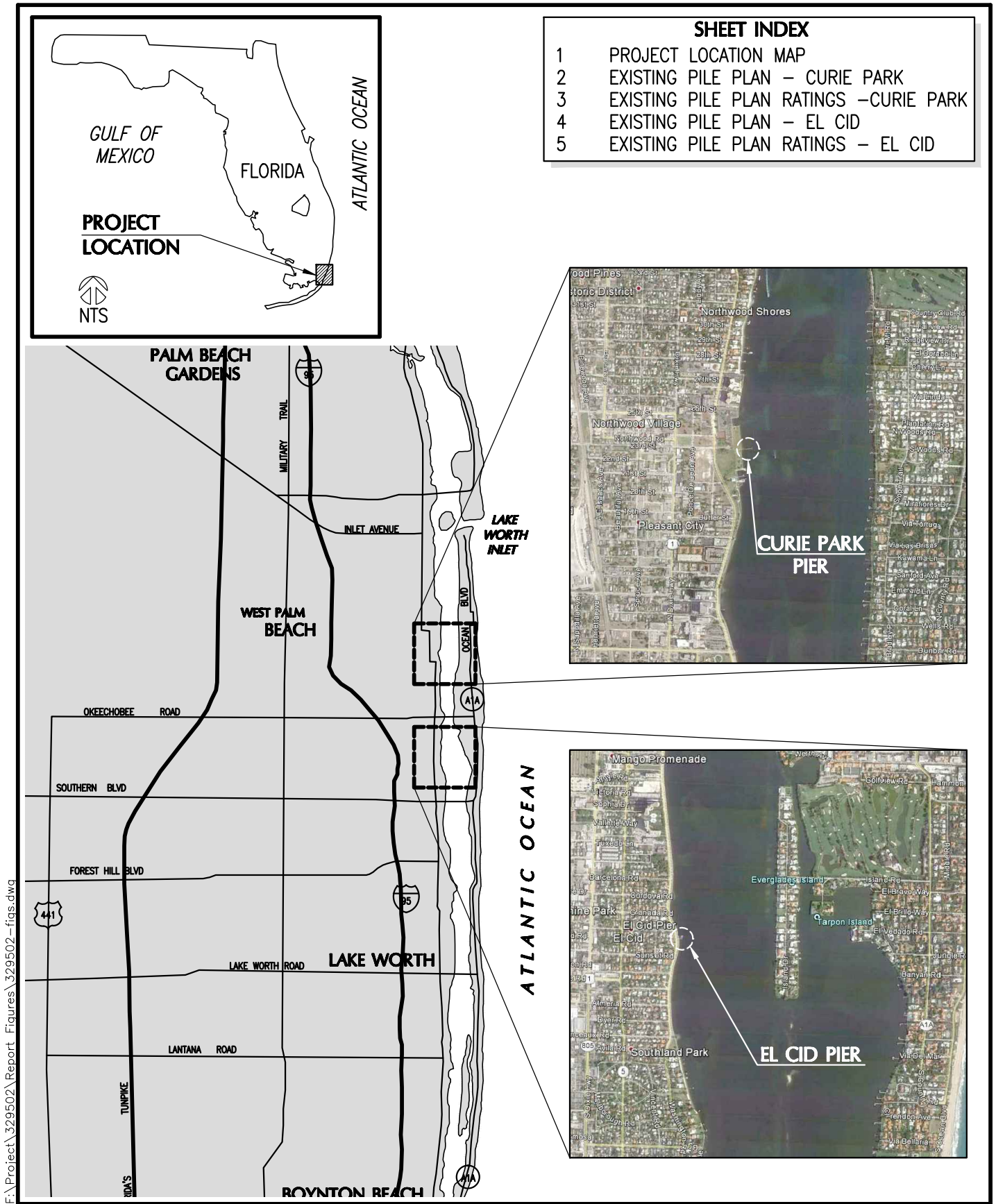


FIGURE 1
PROJECT LOCATION MAP

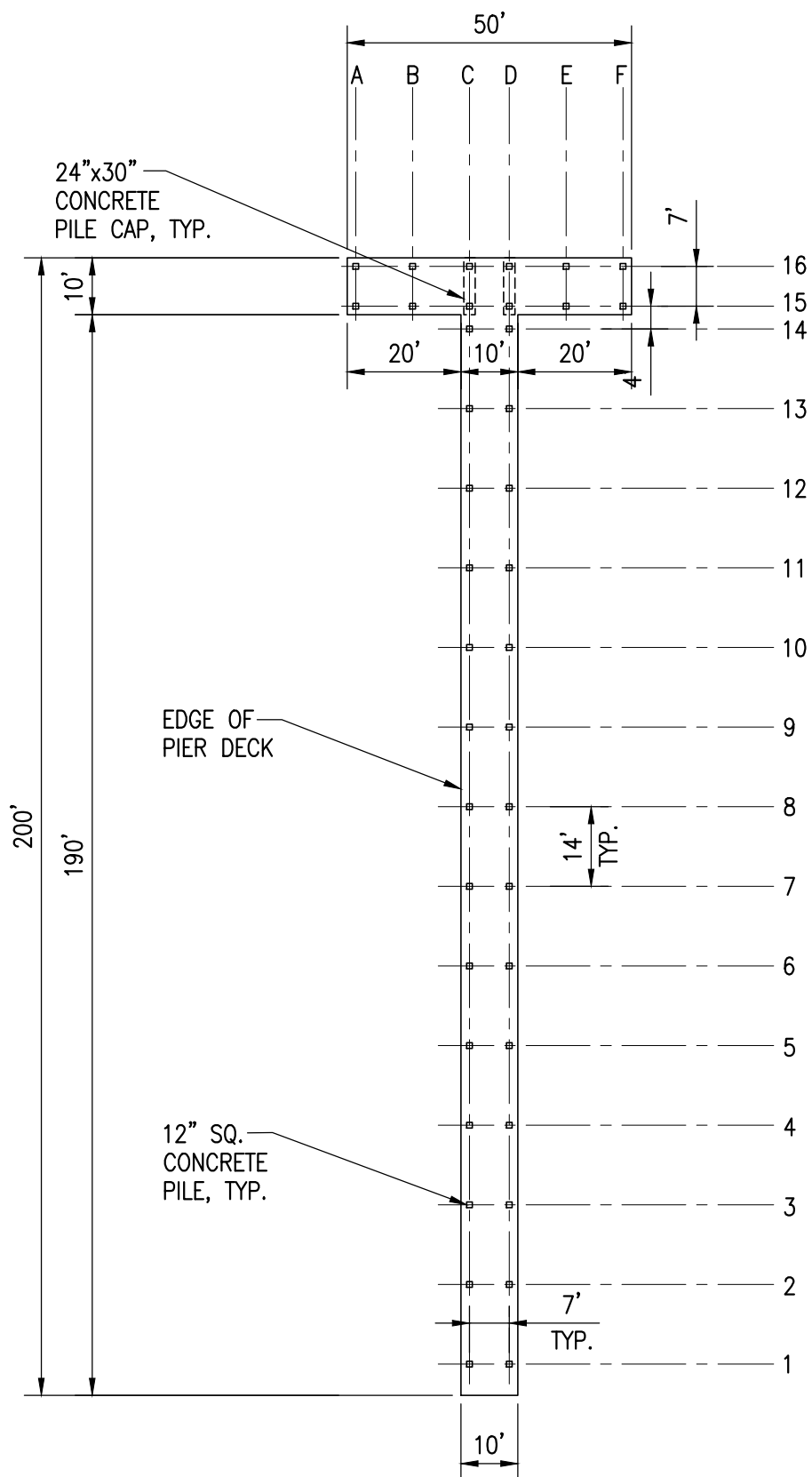
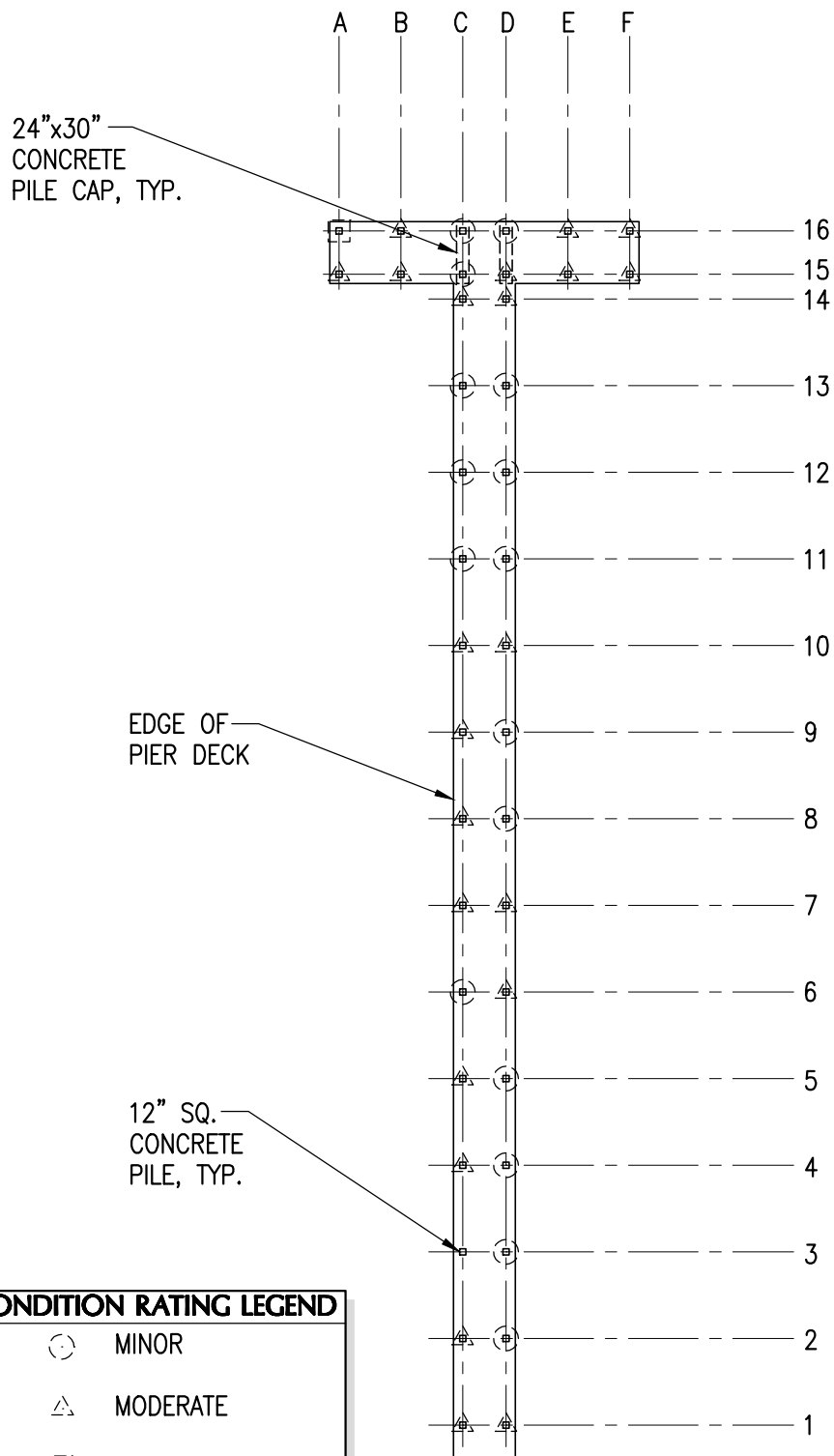


FIGURE 2
EXISTING PILE PLAN
CURIE PARK – NORTH PIER



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PILE CONDITION RATING LEGEND	
⊙	MINOR
△	MODERATE
□	ADVANCED
⊠	SEVERE

0 15 30
SCALE IN FEET
1" = 30'

FIGURE 3
EXISTING PILE CONDITION RATINGS
CURIE PARK – NORTH PIER

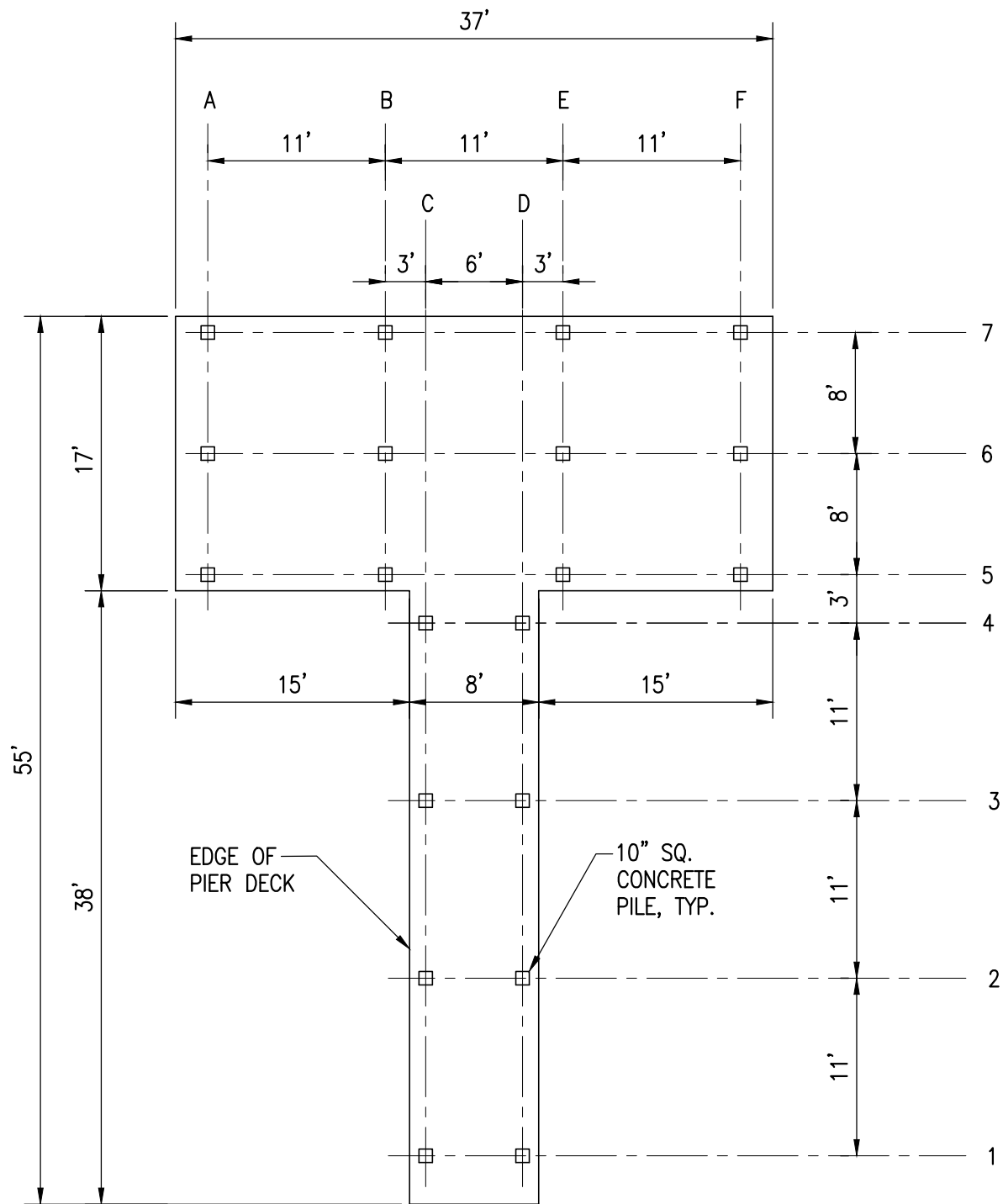


FIGURE 4
EXISTING PILE PLAN
EL CID PIER

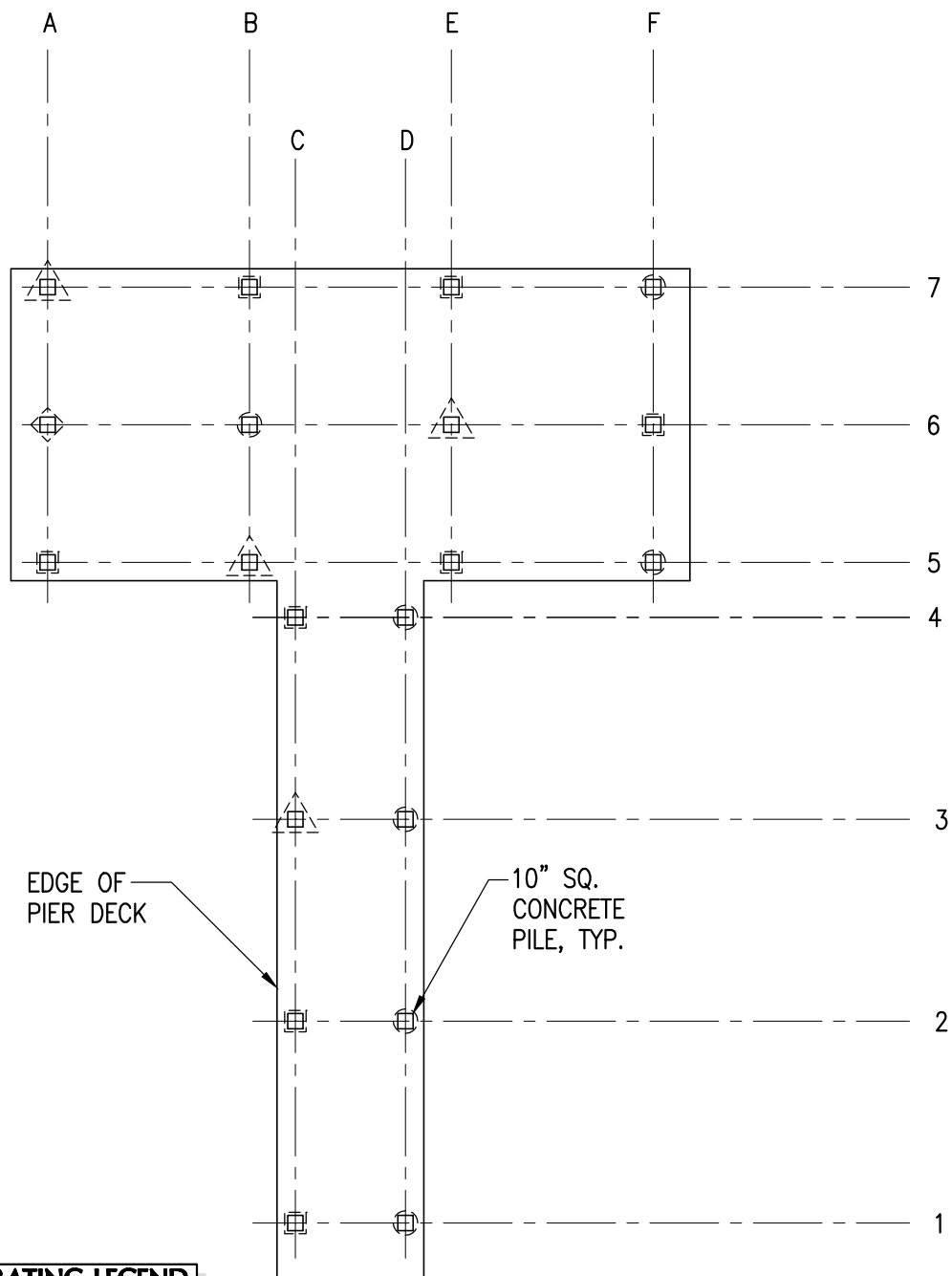


FIGURE 5
EXISTING PILE CONDITION RATINGS
EL CID PIER