3. INSPECTION FINDINGS

Pier 40 is in overall **Poor** condition with 22% of the H-piles rated Major and 35% of the H-piles rated Severe, primarily due to severe corrosion within the splash zone at the top of the H-piles.

The Pier Shed and Court Yard pile and underdeck conditions are presented in Appendix A, Figures A-1 through A-6 and Figures A-7 through A-12, respectively. The Finger Pier Extension pile and underdeck conditions are presented on Figure A-13. Photographs of observed conditions are presented in Appendix B, and the cost estimate breakdown is presented in Appendix C. Structural calculations are included in Appendix D.

3.1 STEEL H-PILES

The steel H-piles are in overall **Poor** condition with 35% of the H-piles rated Severe due to severe corrosion within the splash zone and at MLW on H-piles with no channel repairs. The edges of the H-pile flanges with severe corrosion are typically between 1/4 in. thick and knife-edged.

In general, the conditions of the steel H-piles at MLW, and below MLW, with the exception of H-piles without channel repairs, have little bearing on the overall pile ratings because they exhibit only minor to moderate deterioration, and appear to be adequately protected by the sacrificial anodes. Typically, the channel repairs and associated bolts exhibit minor pitting and the steel H-pile sections within these channel repair areas have adequate section remaining (Photo B-13).

A full visual inspection of the underlying steel H-piles was not possible at H-piles with epoxy coating or at H-piles with steel plate and epoxy coating repairs. However, the epoxy coating was broken off in small sections at H-piles that received a Level II/III inspection to reveal the underlying steel. At the epoxy coated H-piles strengthened by a welded steel plate, the underlying steel (original steel under the epoxy coating) exhibits moderate to severe deterioration beneath the epoxy coating. Based on the distribution of the observed deterioration, and the large percentage of the surface area of the H-pile that is hidden by epoxy coating, H-piles that contain a steel plate and epoxy coating with visible rust staining were conservatively graded as Major. It should be noted that the

top 1 in. to 3 in., approximately, of steel H-pile between the top of the welded steel plates and the pile cap remains unreinforced and exhibits rust staining and cracking of the epoxy coating at the pile flange edges. At Level II/III inspection areas on steel H-piles with only epoxy coating (without a steel plate repair), removal of the epoxy coating typically revealed a severe pile section. Therefore, all H-piles that exhibited rust staining through an epoxy coating repair (with no welded steel plate) were graded Severe during the inspection. The rust stains bleeding through the epoxy coating, as well as blistering of the coating, suggests that the underlying H-piles continue to corrode (Photo B-14 and 15).

The encasement repairs typically exhibit minor spalling and rust staining, therefore, steel H-piles with encasements were generally rated Minor during the inspection.

The pile condition rating plans are presented on Figures A-1 through A-6 for the Pier Shed and Court Yard and Figure A-13 for the Finger Pier Extension. A summary of the pile ratings are provided in Table 3-1.

Table 3-1 Summary of Pile Conditions

Location	No. of H-piles	Minor		Moderate		Major		Severe	
		No.	%	No.	%	No.	%	No.	%
Pier Shed	2,845	505	18%	669	24%	698	25%	973	34%
Court Yard	483	39	8%	255	53%	50	10%	139	29%
Finger Pier	135	8	6%	17	13%	25	19%	85	63%
Total	**3,463**	**552**	**16%**	**941**	**27%**	**773**	**22%**	**1,197**	**35%**

3.1.1 Pier shed

A total of 2,845 steel H-piles were inspected under the Pier Shed. Of these, 34% are rated Severe due to severe corrosion and section loss at the tops of the H-piles (Photo B-15 to B-21). The non-cluster H-piles exhibit the greatest deterioration because the tops of these H-piles are located within the splash zone, where the sacrificial anodes do not provide protection. In contrast, the pile caps at the cluster pile locations are typically 2 ft lower in elevation and the H-piles are fully submerged at MHW, thereby, receiving intermittent periods of cathodic protection from the sacrificial anodes.

This observation is substantiated by examining the conditions of cluster H-piles at Pile Rows 7 and 17, Bents Q and R. These H-piles are exposed within the splash zone, due to the upwards slope of the deck, and are generally the only cluster H-piles rated Major to Severe.

The cluster H-piles at the center of Bent A/B exhibit severe corrosion with knife-edging of the flanges and have channel repairs that extend to the tops of the H-piles. At Bent A/B, the H-piles at Cluster 18 are grouped together in an encasement that extends to the mudline.

At the third single pile north of Cluster Pile 4 in Bent P, there is one loose bolt at the top of its channel repair. At H-piles 12 and 14 in Bent U, the encasement repairs have full circumference spalls with all of the longitudinal reinforcing bars exposed.

Ultrasonic thickness readings indicate that the H-piles are mostly deteriorated at the pile tops, within the splash zone. It should be noted that the steel is typically heavily pitted above water, which makes it difficult to obtain accurate thickness readings. Above water readings could not be collected on some H-piles using standard inspection equipment. Use of special equipment, e.g. a hand-held grinder, would be required to remove the pitting for accurate readings on these H-piles. A summary of the obtained readings are provided in Table 3-2.

Table 3-2 Pier Shed - Average and Minimum Thickness Measurements on H-piles

Reading Location	Avg. Flange Thickness (Minimum Thickness)	Avg. Flange % Loss	Avg. Web Thickness (Minimum Thickness)	Avg. Web % Loss
Top of Pile	0.371 in. (hole)	40 (100)	0.509 in. (hole)	17 (100)
Mid-pile	0.481 in. (0.273 in.)	22 (56)	0.276 in. (hole)	55 (100)
Mudline	0.497 in. (0.245 in.)	19 (60)	0.473 in. (0.196 in.)	23 (68)

Notes: Section loss is based on the original flange and web thickness of 0.615 in.
The top value is the average of thickness reading, and the number in parenthesis is the minimum thickness reading recorded.

3.1.2 Court Yard

A total of 483 steel H-piles were inspected under the Court Yard. Of these, 29% are rated Severe primarily due to severe corrosion and section loss within the tidal zone at H-piles without channel repairs. There are 152 H-piles without channel repairs. Similar to the cluster H-piles under the Pier Shed, the H-piles under the Court Yard are fully submerged at MHW, thereby, receiving some level of protection from the sacrificial anodes (Photo B-22). There is only one encasement repair and only four steel plate and epoxy repairs on H-piles under the Court Yard.

Ultrasonic thickness readings indicate that the H-piles are the most deteriorated at mid-pile elevation. It should be noted that the steel is typically heavily pitted above water, which makes it difficult, and sometimes not possible, to obtain accurate thickness readings with standard inspection equipment. A summary of the obtained readings are provided in Table 3-3.

Table 3-3 Court Yard - Average and Minimum Thickness Measurements on H-piles

Reading Location	Avg. Flange Thickness (Minimum Thickness)	Avg. Flange % Loss	Avg. Web Thickness (Minimum Thickness)	Avg. Web % Loss
Top of Pile	0.463 in. (0.250 in.)	25 (59)	0.497 in. (0.227 in.)	19 (63)
Mid-pile	0.384 in. (0.162 in.)	38 (74)	0.379 in. (0.120 in.)	38 (81)
Mudline	0.526 in. (0.273 in.)	15 (56)	0.507 in. (0.258 in.)	18 (58)

Notes: Section loss is based on the original flange and web thickness of 0.615 in.
The top value is the average of thickness reading, and the number in parenthesis is the minimum thickness reading recorded.

3.1.3 Finger Pier

Of the 135 steel H-piles supporting the Finger Pier Extension, 63% are rated Severe due to severe corrosion and section loss with knife-edged flanges at the tops of the H-piles without encasement repair, and due to severely damaged encasements with the underlying steel H-piles exposed. The steel H-piles with severely damaged encasements are conservatively rated Severe because a full visual inspection was not possible during the inspection due to the presence of timber spacers located between the pile flanges and the remaining concrete comprising the encasements. Of the 32

encasements, 23 have severe damage which has exposed the steel H-piles and or steel cage reinforcement.

Ultrasonic thickness readings indicate that the H-piles are the most deteriorated at mid-pile elevation. It should be noted that the steel is typically heavily pitted above water, which makes it difficult, and sometimes not possible, to obtain accurate thickness readings with standard inspection equipment. A summary of the obtained readings is provided in Table 3-4.

Table 3-4 Finger Pier - Average and Minimum Thickness Measurements on H-piles

Reading Location	Avg. Flange Thickness (Minimum Thickness)	Avg. Flange % Loss	Avg. Web Thickness (Minimum Thickness)	Avg. Web % Loss
Top of Pile	0.359 in. (hole)	42 (100)	0.528 in. (0.253 in.)	14 (59)
Mid-pile	0.453 in. (0.368 in.)	26 (40)	0.396 in. (0.263 in.)	36 (57)
Mudline	0.443 in. (0.367 in.)	28 (40)	0.434 in. (0.245 in.)	30 (60)

Notes: Section loss is based on the original flange and web thickness of 0.615 in.
The top value is the average of thickness reading, and the number in parenthesis is the minimum thickness reading recorded.

3.2 CONCRETE PILE CAP

3.2.1 Pier Shed and Court Yard

The concrete pile caps under the Pier Shed and Court Yard are generally in **Fair** condition with corrosion cracks on the cap soffits that extend from the flange tips of the steel H-piles to the bottom corners of the pile caps. At a number of locations, these corrosion cracks have either extended along the vertical faces of the concrete pile caps at a 45 to 60 degree angle, or have resulted in spalls up to 2 ft high along the bottom corners of the caps (Photos B-14 and B-15). These deficiencies do not directly affect the load bearing capacity of the H-piles, however they could affect the integrity of the connections between the steel H-piles and the concrete caps. In the Court Yard, the pile caps typically have hairline map cracks on the vertical faces with efflorescence (Photo B-23).

At the pile caps along the edge beam of the Pier Shed, there are vertical cracks up to 1/2 in. wide and spalls due to severe corrosion of the bollard through-bolts at isolated locations. The vertical cracks and spalls on the pile caps due to corrosion of the bollard through-bolts are shown in Appendix A, Figures A-7 to A-12.

3.3 CONCRETE PILE CAP BEAM AND EDGE BEAM

3.3.1 Pier Shed and Court Yard

The concrete pile cap beams under the Pier Shed and Court Yard are in **Fair** condition with typical rust staining and opposing longitudinal corrosion cracks that have resulted in delaminations along the beam soffits (Photo B-24 and B-25). In isolated locations, the delaminations along the beam soffits have developed into spalls with exposed steel reinforcement for lengths ranging from 1 ft to nearly 15 ft across the entire width of the beams (Photo B-26 and B-27). Under the Court Yard, the pile cap beams typically have hairline map cracks on the vertical faces with efflorescence (Photo B-24).

There are typical vertical cracks up to 1/16 in. wide at the joints between the offshore pile cap beams and edge beams, and also at the mid-span locations at isolated pile cap beams. At the pile cap beam in Bent K, between Piles 14 and 14-bar, a 1/8 in. wide diagonal crack runs from a closed spall at the top of the beam and extends through the full depth of the beam. Between Piles 7-bar and 8 in Bent N, exposed reinforcing and foam is located in an area along the top edge of the beam where additional concrete was placed after the original casting of the pile cap beam. Additionally, steel reinforcement is protruding from the top surface of the pile cap at Pile Row 16.

A concrete closure wall extends around the south, west, and north perimeter of the Court Yard. The closure wall is located above the Court Yard pile cap beams along Pile Row 7-bar, on the south side, Pile Row 16-bar, on the north side, and along Pile Bent P-bar, on the west side, and typically exhibits cracking up to 1/16" and moderate spalling. At Bent P-bar, between Pile Rows 15-bar and 16, there are gaps at the joints between the concrete closure wall and a deck panel for the Pier Shed. Between Bent I and I-bar, along Pile Row 7-bar, a large crack up to 3/4 in. wide is located in the concrete closure wall where the wall is visibly deflected (Photo B-28 and B-29).

At Bent 18 there is a pile cap beam that runs east-west from Pile U to T. This beam exhibits cracking and delamination along the bottom edge, and there is a 2.5 in. gap between the top of the beam and the concrete deck slab above.

The concrete edge beams are in overall **Fair** condition with general areas of minor erosion up to 1 in. deep along the length of the beams. There are isolated delaminations and spalls with exposed reinforcing steel along the top and bottom edges of the edge beams ranging in length from 1 ft to 5 ft and up to 6 in. in depth. The largest area of erosion is located on the western edge beam between Bents 7 and 8-bar, where the full height of the beam is eroded away up to 1 in. deep with exposed reinforcing steel (Photo B-30).

The deficiencies on the pile cap beams and edge beams are shown in Figures A-7 through A-12.

3.3.2 Finger Pier Extension

The longitudinal concrete and transverse concrete beams at the Finger Pier Extension are in overall **Fair** condition. Similar to the beams under the Pier Shed and Court Yard, the beams exhibit rust staining and delaminations in the beam soffits (Photo B-31) with isolated spalls with exposed steel reinforcing.

The fascia of the concrete beams around the perimeter of the Finger Pier exhibit general areas of surface erosion up to 1/2 in. deep along the bottom and top edges. On the exterior face of the northern longitudinal beam at Bent V, there is a full height, 1/8 in. wide vertical crack due to corrosion of the cleat hardware. Also, along the exterior face of northern longitudinal beam, between W.4 and W.6, a 10 ft long by 1/8 in. wide horizontal crack is located at the longitudinal centerline of the beam.

The concrete beam deficiencies are included on Figure A-13.

3.4 CONCRETE UNDERDECK

3.4.1 Pier Shed and Court Yard

The concrete underdeck at Pier 40 is in overall **Fair** condition with minor hairline cracks (Photo B-3 and B-4). Isolated spalls up to 3 in. deep with exposed prestressing strands and reinforcing steel are located throughout the pier (Photo B-32 through B-34).

In general, these spalls are less than 2 sq ft in area with only one or two partially exposed steel reinforcing bars or prestressing strands.

At the deck panel south of Cluster Pile 11 in Bent E, multiple prestressing strands are exposed. In addition, at the deck panel east of Pile 9 East in Bent F, multiple prestressing strands are exposed and are broken (Photo B-35).

An approximately 30 sq ft spalled area with exposed steel reinforcing is located at a cast-in-place portion of the deck, west of the pile cap beam located south of Pile Cluster 7, in Bent F.

Between Bents 16 and 16-bar, several hangers are attached to the concrete underdeck and support a partially collapsed 48 in. diameter concrete outfall. At the offshore end of the pier, the outfall has completely collapsed and is supported by steel beams attached to the H-piles. Several pipe hangers remain attached to the underdeck and no longer support the outfall.

The locations of the deck panel spalls are included on the underdeck deficiency plans in Figures A-7 through A-12.

3.4.2 Finger Pier Extension

The Finger Pier Extension concrete underdeck is in overall **Fair** condition with areas of shallow cover and spalls with exposed steel reinforcing (Photo B-36 and B-37). The underdeck at the southwestern bay of the pier has an approximate 40 sq ft spall with two broken reinforcing bars and additional exposed steel reinforcing in both directions.

3.5 PIER APRON

The top of deck around the Pier Shed is generally in **Satisfactory** condition with cracks in the asphalt surface and typical deterioration of the expansion joints. There is a dislodged cleat at Bent 12 along the western edge of the pier, and a cleat with a broken horn near Bent J along the northern edge of the pier.

3.6 FENDER SYSTEM

The fender systems for the four Hornblower vessels, along the northern edge of the pier, are in overall **Good** condition. The timber fender system along the north side of the pier is approximately 300 ft long and exhibits minor deterioration and abrasion (Photo B-8 and B-38). To accommodate the Hornblower vessels that berth along the north side of the pier, steel pipe H-piles with tires and rubber fender blocks are attached to the concrete edge beam and serve as a fender system. These piles exhibit 100% coating loss and minor corrosion.

There is no functioning fender system along the southern and western edges of Pier 40. At the southern edge of the pier, portions of deteriorated timber chocks and rubber blocks remain attached to the fascia of the concrete edge beam.

The fender system on the Finger Pier Extension is also non-functional with only remnants of timber chocks attached to the fascia of the exterior longitudinal beams.

The timber fender cluster piles located at the western corners of the Finger Pier Extension and the northwest corner of Pier 40 are in **Poor** condition. All of the accessible timber piles are split or broken within the tidal zone (Photo B-39 and B-40).

3.7 CATHODIC PROTECTION SYSTEM

The cathodic protection system consists of sacrificial anodes attached to the north and/or south faces of each Pile with one to five sacrificial anodes per pile. At least two generations of sacrificial anodes exist at most pile locations under the Pier Shed and one generation of sacrificial anodes exists under the Court Yard. Based on field observations, it appears that both generations of anodes are of similar size. The anodes installed as part of the most recent cathodic protection efforts include a 144 lb anode located just below the mid-tide elevation, and a 115 lb anode located just above the mudline elevation. Details of the most recent anode installation efforts are provided in Appendix F. As outlined in the 2000 cathodic protection system plans, two sacrificial anodes were installed per pile with additional anodes installed as necessary. Additionally, 33 test stations were installed throughout the pier.

As part of this inspection, an estimated section loss of each anode was recorded and used in conjunction with electrical potential readings recorded at the 33 test stations to estimate the remaining functional life of the cathodic protection system. Table 3-5, below, presents the electrical potential readings collected in 2005, 2006, 2008, and 2014.

Pier 40 - Cathodic Protection Performance Evaluation

Pile (+) to Silver/Silver Chloride Reference (-) Potential - Volts												
Measurement Location	**13-Sep-05**			**13-Oct-06**			**21-Nov-08**			**27-Feb-14**		
	1' Below Water Line	**Half-Way to Mudline**	**At Mudline**	**1' Below Water Line**	**Half-Way to Mudline**	**At Mudline**	**1' Below Water Line**	**Half-Way to Mudline**	**At Mudline**	**At MLW**	**Half-Way to Mudline**	**At Mudline**
Test Location 1	-0.913	-0.916	-0.918	-0.900	-0.890	-0.900	-0.911	-0.904	-0.902	-0.844	-0.850	-0.856
Test Location 2	-0.980	-1.022	-1.050	-0.920	-0.925	-0.940	-0.918	-0.922	-0.905	-0.860	-0.913	-0.890
Test Location 3	-1.022	-1.045	-1.095	-0.963	-0.975	-0.970	-0.942	-0.955	-0.924	-0.920	-0.970	-0.928
Test Location 4	-1.031	-1.055	-1.070	-0.928	-0.930	-0.920	-0.913	-0.918	-0.911	-0.910	-0.926	-0.912
Test Location 5	-1.016	-1.050	-1.035	-0.885	-0.901	-0.903	-0.881	-0.893	-0.895	-0.874	-0.885	-0.864
Test Location 6	-1.055	-1.065	-1.058	-0.952	-0.940	-0.935	-0.937	-0.939	-0.934	-0.954	-0.938	-0.920
Test Location 7	-1.068	-1.070	-1.065	-0.948	-0.950	-0.943	-0.923	-0.932	-0.926	-0.973	-0.930	-0.848
Test Location 8	-1.080	-1.086	-1.058	-0.948	-0.920	-0.952	-0.935	-0.930	-0.924	-0.864	-0.919	-0.884
Test Location 9	-1.017	-1.020	-1.021	-0.870	-0.870	-0.850	-0.873	-0.864	-0.852	-0.925	-0.929	-0.896
Test Location 10	-1.100	-1.105	-1.109	-0.902	-0.910	-0.904	-0.895	-0.900	-0.887	-0.928	-0.929	-0.889
Test Location 11	-1.160	-1.190	-1.230	-0.860	-0.880	-0.860	-0.875	-0.873	-0.874	-0.877	-0.880	-0.860
Test Location 12	-1.058	-1.100	-1.130	-0.925	-0.930	-0.910	-0.912	-0.926	-0.924	-0.882	-0.880	-0.866
Test Location 13	-1.080	-1.108	-1.120	-0.925	-0.940	-0.890	-0.916	-0.924	-0.922	-0.970	-0.937	-0.905
Test Location 14	-1.054	-1.112	-1.115	-0.900	-0.930	-0.890	-0.887	-0.908	-0.903	-0.858	-0.888	-0.850
Test Location 15	-1.130	-1.140	-1.140	-0.880	-0.880	-0.860	-0.874	-0.894	-0.891	-0.866	-0.868	-0.864
Test Location 16	-1.072	-1.085	-1.110	-0.890	-0.880	-0.860	-0.895	-0.906	-0.890	-0.875	-0.889	-0.907
Test Location 17	-1.104	-1.110	-1.120	-0.890	-0.890	-0.880	-0.913	-0.926	-0.906	-0.836	-0.839	-0.803
Test Location 18	-1.056	-1.068	-1.065	-0.880	-0.890	-0.880	-0.883	-0.905	-0.902	-0.898	-0.836	-0.797
Test Location 19	-1.120	-1.150	-1.158	-0.910	-0.910	-0.900	-0.895	-0.898	-0.886	-0.815	-0.780	-0.746
Test Location 20	-2.150	-2.210	-2.200	-0.904	-0.915	-0.843	-0.904	-0.908	-0.904	-0.847	-0.858	-0.843
Test Location 21	-2.004	-2.140	-2.110	-0.890	-0.900	-0.880	-0.890	-0.897	-0.894	-0.795	-0.792	-0.778
Test Location 22	-1.860	-1.880	-1.880	-0.890	-0.910	-0.900	-0.887	-0.897	-0.888	-0.875	-0.870	-0.857
Test Location 23	-1.630	-1.650	-1.650	-0.912	-0.908	-0.900	-0.916	-0.905	-0.911	-0.820	-0.840	-0.811
Test Location 24	-1.084	-1.122	-1.108	-0.905	-0.920	-0.904	-0.892	-0.897	-0.893	-0.905	-0.910	-0.886
Test Location 25	-1.420	-1.460	-1.450	-0.880	-0.900	-0.890	-0.902	-0.914	-0.907	-0.900	-0.879	-0.863
Test Location 26	-1.220	-1.360	-1.340	-0.900	-0.910	-0.890	-0.894	-0.903	-0.902	-0.897	-0.896	-0.878
Test Location 27	-1.198	-1.208	-1.210	-0.930	-0.940	-0.890	-0.927	-0.933	-0.902	-0.953	-0.955	-0.917
Test Location 28	-1.088	-1.113	-1.124	-0.902	-0.924	-0.930	-0.898	-0.903	-0.891	-0.930	-0.913	-0.877
Test Location 29	-1.092	-1.108	-1.110	-0.920	-0.933	-0.925	-0.902	-0.908	-0.903	-0.947	-0.951	-0.940
Test Location 30	-1.087	-1.108	-1.134	-0.928	-0.925	-0.901	-0.914	-0.925	-0.915	-0.966	-0.980	-0.959
Test Location 31	-1.109	-1.120	-1.180	-0.911	-0.923	-0.917	-0.914	-0.915	-0.912	-0.954	-0.947	-0.919
Test Location 32	-1.034	-1.074	-1.100	-0.890	-0.910	-0.890	-0.883	-0.885	-0.902	-0.910	-0.919	-0.967
Test Location 33	-1.030	-1.065	-1.055	-0.904	-0.904	-0.903	-0.887	-0.897	-0.884	-0.890	-0.891	-0.874
Minimum Potential	**-0.913**			**-0.843**			**-0.852**			**-0.746**		
Maximum Potential	**-2.210**			**-0.975**			**-0.955**			**-0.980**		
Average Potential	**-1.208**			**-0.907**			**-0.905**			**-0.888**		

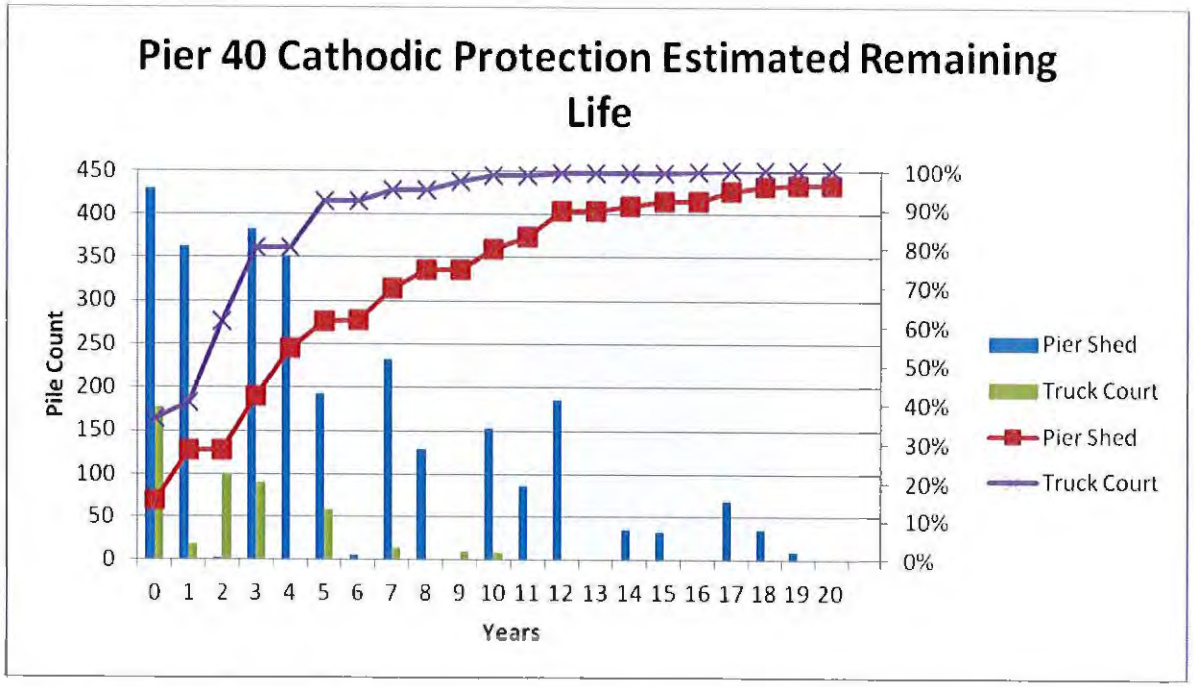
A comparison of these electrical potential readings shows that the current readings are slightly less negative than what were observed in earlier inspections. This slight, but notable decline in potential readings, combined with current observed section loss quantities on the anodes is a good indicator that the cathodic protection system is working to protect the underwater portions of the H-piles. It should be noted when reviewing these potential readings that the minimum threshold for cathodic protection, using a silver/silver-chloride reference cell in a 3.5m solution of KCl (Potassium Chloride), is -0.750V. As shown in Table 3-5, the average potential measured in 2014 is -0.888V, which is slightly less negative than the average measured in 2008, -0.905V. A reading of -0.746V was recorded at Test Location 19. Although this is below the minimum threshold of -0.750V, the difference is negligible and this pile can still be considered as protected. The anodes at this particular pile are likely close to the end of their functional life.

In addition to the remaining anode material, water depths (wetted surface areas of the H-piles) play a factor in the remaining functional life of the system. Average submerged pile depths of 15 ft and 20 ft were used for the Court Yard and the Pier Shed, respectively. The table below shows the estimated remaining life of the cathodic protection system.

Table **3-6** Pier 40 – Remaining Useful Life of Cathodic Protection System

Estimated Years Remaining	**Pier Shed**		**Court Yard**	
	Pile Count	Cumulative % of H-piles	Pile Count	Cumulative % of H-piles
0	430	15%	177	37%
1	363	28%	19	41%
2	3	28%	101	61%
3	383	42%	91	80%
4	352	55%	0	80%
5	193	61%	58	92%
6	6	62%	0	92%
7	233	70%	14	95%
8	129	75%	0	95%
9	1	75%	10	97%
10	153	80%	8	99%
11	87	83%	0	99%
12	186	90%	2	99%
13	1	90%	0	99%
14	36	91%	1	100%
15	33	92%	0	100%
16	0	92%	1	100%
17	68	95%	1	100%
18	35	96%	0	100%
19	10	96%	0	100%
20	1	96%	0	100%
More	12	100%	0	100%

The Court Yard H-piles are typically protected by two anodes per pile. The remaining useful life of these anodes ranges between 0 years and 17 years, with a median remaining useful life of 1 year. The Pier Shed H-piles are protected by two to five anodes per pile. The remaining useful life of these anodes ranges between 0 years and more than 20 years, with a median remaining useful life of 3.5 years. The graph below illustrates the information provided in the table above.



As illustrated in the graph above, a steep increase in the number of unprotected H-piles is expected over the next 3 years under the Court Yard. The Pier Shed is expected to experience a steady increase in unprotected H-piles over the next 10 years.

Overall, the electrical potential readings presented in Table 3-5 suggest that all H-piles are currently protected by the existing cathodic protection system; however, the estimated remaining life calculations suggest that the sacrificial anode system is nearing the end of its useful life, and is possibly no longer adequately protecting the H-piles in many areas. The following is a list of items that were considered when developing recommendations for the cathodic protection system.

- Potential readings were recorded at 33 locations throughout the pier, which represent only 1 percent of the total H-piles supporting the pier. A more extensive survey of electrical potentials would provide a more accurate analysis of the estimated remaining life of the system.
- The original pier cathodic protection system was an impressed current-type system and all H-piles are likely electrically bonded. This bonding allows H-piles with excess anode material to protect nearby H-piles with little or no anode material. The amount of protection offered, however, cannot be confirmed without a more extensive potential survey and therefore, was not included in this evaluation.
- The estimated remaining life calculations are reliant on visual observations and estimates of remaining anode sections.

While it is estimated that the majority of the pier is protected at the time of this report, most of the sacrificial cathodic protection system appears to be at the end of its useful life. Considering the items presented in the list above, and the degenerative effects of saltwater on an uncoated steel structure, it is recommended that action be taken to protect the steel H-piles supporting Pier 40.It is important to note that the data presented does not reflect the entire pier structure and that the items listed above introduce additional uncertainties regarding the overall protection of the pier.

In addition, the reference electrodes at the pier's potential test stations are no longer functioning and it is recommended that they be abandoned.