CITY OF DULUTH
PURCHASING DIVISION
Room 120 City Hall
411 West First Street
Duluth, Minnesota 55802-1199
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Addendum 1
File # 18-0116E (18-10AA)
Project: Dead Ship Two – Temporary Relocation of the William A. Irvin

This addendum serves to notify all bidders of the following changes to the solicitation documents:

Attached please find a list of additional information as well as the final tow plans dated 7.16.18.

Please acknowledge receipt of this Addendum by initialing and dating Addendum #1 at the bottom of the below the bid form.

Posted: 7.16.18

AMI
Consulting Engineers P.A.

July 16, 2018

Re: William A. Irvin Dead Ship Tow Bid No. 18-0116E: Addendum #1
AMI Project # 181078

- The temporary guide wall structure may be left in place during the winter. The Contractor is responsible for coordinating navigational requirements with the USCG and reverifying the alignment of the guide structure prior to moving the Irvin back to MN Slip.

- The allowable deflection of the temporary guide wall will increase as the vessel moves further from the MN Slip Pedestrian Bridge. The maximum allowable deflection at the outer corner of the dock wall will be 6". The maximum allowable deflection will linearly increase to 2'-0" at 200 lineal feet from the corner of the dock wall.

- Five of the six deck winches will be fully operational by the time the vessel needs to be removed from the slip. Benson Electric Company out of Superior, WI will inspect & test the carbon brushes, brush holders and commutators, winch controls & brakes. The forward deck winch will not be operational.

- Three of the five operational deck winches have 200 feet of steel cable. One of the midship deck wenches has 300 feet of steel cable and one of the stern deck winches have 400 feet of cable. All the cables are less than one year old and have been certified. One of the cable certifications showing the results of the mill test & load tests has been included to this addendum. The Contractor is responsible for supplying additional steel cable if they determine it to be necessary.

- The decorative anchor on the stern and the third anchor attached to the bow anchor will need to be removed prior to moving the vessel. The anchors may be removed and left at the DECC. The Contractor will be responsible for removing the anchors, moving the anchors to the specified storage area at the DECC and reinstalling the anchors on the Irvin once it returns to MN Slip in the Spring of 2019.

- The vessel will be at Fraser Shipyards, Inc. (Fraser) from the Fall of 2018 to the Spring of 2019. The Contractor is responsible for towing the vessel to & from Fraser and properly securing the vessel at Fraser & MN Slip. Fraser personnel will be responsible for moving the vessel in & out of the dry dock. The exact location of the vessel at Fraser is undetermined and the Contractor is responsible for coordinating the vessels location prior to the tow.

- The docks & boats along the Canal Park (East) side of MN Slip will not be removed until October 1st, 2018. The Contractor is responsible for working around the docks and boats while there are in the marina. The City will notify that no boats shall enter or leave MN Slip while the Contractor is moving the vessel. The United States Coast Guard (USCG) will also provide a safety perimeter during the relocation of the vessel.

- All the doors on the vessel do lock but the forward doors are all constructed of wood.

91 MAIN STREET
SUPERIOR, WI 54880
PH: (715) 718-2193
FAX: (877) 761-7058

- The DECC will be responsible for securing any items in the vessel associated with the "Haunted Ship", the gift shop, concessions and museum tours. The Contractor shall coordination with the DECC on any items not properly secured by the time of the move.

- The Contractor shall be responsible for securing the bridge crane above the engine room and the deck crane which is utilized to remove the hatch covers.

- Additional water ballast can not be added to the vessel since the sea chests have been completely welded shut.

- Since the steel bridge members of the MN Slip Pedestrian Bridge overhang the face of the concrete abutment on the canal park side (east side), the City of Duluth will issue a separate contract to pull the steel members past the face of the concrete abutment. The steel bridge members on the DECC side (west side) will not be altered. It is the responsibility of the Contractor to coordinate with the DECC, City of Duluth & the Contractor performing the required bridge work. The bridge Contractor will also be required to provide a redundant system to hold the bridge members in position during the relocation process.

- The size of the tugs in the slip after the MN Slip cleanup project in the fall of 2018, will be restricted to "Tender Tugs" with a maximum draft depth of 7 feet. The maximum propeller horsepower of the tugs shall not exceed 400 HP. The size of the tug inside the slip prior to the cleanup project is not restricted but the Contractor shall review the existing bathymetry of the slip. The size of the tug outside of the slip is also not restricted.

- Power to the vessel is currently provide by shore. The emergency generator onboard does currently generate power but the operation of it is unknown. The Contractor shall determine how to transfer power from the emergency generator to the vessel or will be responsible for providing temporary power to the Irvin during the relocation process if required.

- The new dock wall, which is currently being constructed, will include eight new 65-ton staghorn bollards spaced at approximately 100-foot intervals. The plans have been updated to include the approximate location of the bollards.

- AMI Consulting Engineers performed an underwater inspection of the hull. The final report titled "SS William A Irvin Underwater Hull Inspection" dated June 26th, 2018 has been provided for information purposes. This document is referred to as Appendix B in the project specifications.

- The propeller and rubber of the vessel are ***not*** adequately locked out. This information was confirmed during the project walkthrough on June 27th, 2018 with potential Contractors.

- The Contractor is responsible for confirming the number & size of hull penetrations and if covers will be necessary.

- The Contractor is responsible for determine if the existing seals around the propeller shaft need to be repacked prior to the movement of the Irvin. If necessary, the Contractor shall repack the seals as necessary.

- Contractor is responsible for verify the amount of potential pollutants on the vessel prior to the relocation of the vessel.

- The Contractor is responsible for determining the air draft of the vessel and determining if any overhead obstructions may impact the movement/tow of the vessel.

- The damaged steel plates documented at the bow of the vessel will be the responsibility of the DECC.

- The drawing set has been updated to include additional information of the current condition of the Irvin, the condition of the new seawall at the time of the vessel movement, and other miscellaneous information.

If you have any questions or comments, please contact AMI at (715) 718-2193 extension 17.

Respectfully Submitted,

Chase Dewhirst
Marine Engineering Manager

Manho Rope & Wire Ltd.

Registered by

Manufacture
71, Noksanhwajeon-ro, Gangseo-gu,
BUSAN,KOREA
TEL : 82-51-831-5611~6
FAX : 82-51-831-5617

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AMERICAN BUREAU OF SHIPPING
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GERMANISCHER LLOYD
RINA.REGISTRO ITALIANO NAVALE
BUREAU VERITAS

Sheet No. 2016A-102-01

Date MAR.24.2016

LRB 00524879 ~ 00524881

PO # 57025101

MILL TEST CERTIFICATE

Customer : Messrs SOUTHWEST WIRE ROPE INC

Supplier : Messrs MANHO ROPE & WIRE LTD.

L/C No.	D/A	Order No.	7-57025101-SWR	
Commodity	UNGALVANIZED STEEL WIRE ROPE			
Construction	6XWS36 IWRC	Grade	EIPS	
Specification	API 9A	Lubrication	C	
Order Quantity	5,000.00 Feet	Reel No.	8-10	
Gross Weight		Net Weight	27,749.59	Lbs

TEST RESULT

Rope Dia	1 0/0	(Actual)	1.026 Inch	Preforming	GOOD	
Kind of Lay	R.H.R.L			Length of Lay	6.16	Inch
Specified Breaking Strength of Wire Rope					103,400.00	Lbs
Actual Breaking strength of Wire Rope					105,820.00	Lbs
Nominal Dia. of Wire					0.057	Inch
Tensile Strength of Wires	Min	194	Max		196	Kg / ㎟
Number of Torsion of Wires	Min	32	Max		36	Times
Weight of Zinc Coating						

CHEMICAL ANALYSIS OF WIRE ROD

%

Heat No.	C	Si	Mn	P	S
SF66057	0.7311	0.204	0.652	0.0116	0.0038

REMARKS TORSION TEST LENGTH : 100D

Quality Control Dept

AMI
Consulting Engineers P.A.

June 26, 2018

Erik Birkland
City of Duluth
1532 West Michigan Street
Duluth, MN 55806

Re: SS William A Irvin Underwater Hull Inspection
AMI Project # 171295

Mr. Birkland:

This letter is written in regards to the underwater visual inspection AMI Consulting Engineers, PA (AMI) performed on the steel hull of the Vessel SS William A. Irvin (Irvin). The Irvin is located in Minnesota Slip (MN Slip) adjacent to the Duluth Entertainment Convention Center (DECC) in Duluth, MN. The purpose of the inspection was to visually inspection the hull below the waterline for damage or deterioration and assess the corrosion of the hull.

Background Information
Based on the historical construction drawings, the Irvin was a Great Lakes bulk carrier originally constructed in 1937. The vessel was in the fleet until 1978 when it was retired. The Irvin sat dormant until it was purchased by the DECC in 1986. Based on American Bureau of Shipping (ABS) records, the vessel was last in dry-dock in 1981 when the hull was repainted and the sea chests were sealed shut with ⅜" thick plate. The vessel was then moved to MN Slip where it is currently located. The steel plating below the waterline consists of ½", ⅝" & ¾" thick steel plating. The steel plating was primarily riveting together but some welding was documented on areas of the hull.

Procedures for Inspection
The AMI Engineering inspection team consisted of one professional engineer diver and two divers/tenders. Surface supplied diving techniques were utilized during all phases of the underwater inspection process to meet OSHA, US Coast Guard, and Association of Diving Contractors International (ADCI) standards to ensure proper safety at all times. The divers used an underwater helmet mounded video camera to document the existing condition of the dock wall for future review by the City, DECC & AMI personnel.

The divers performed a Level I underwater inspection of the steel hull below the waterline where access was available. A level I inspection consists of documenting any areas of damage, major deterioration, or irregularities that can be observed visually or tactilely below the waterline without removing any marine grown/ life. At three different locations, the steel hull was cleaned and a corrosion assessment was performed. This assessment was completed with an ultrasonic thickness (UT) gage and a pipe pit gage to determine the average remaining thickness of the hull plating. The UT gage requires a relatively flat surface to accurately measure the remaining steel thickness. When a flat surface was not present, pit measurements were performed with the pipe pit gage to measure the penetration of the pit into the hull. Corrosion documentation is important to determine effects of microbiologically induced corrosion (MIC) which is a known cause of accelerated steel loss in the Duluth – Superior Harbor.

To describe the marine growth on the hull, the divers used terminology standardized in the United States Navy (US Navy). The US Navy uses the term "Fouling Rating Scale" & "Fouling Percentages" to

describe the amount of unwanted material that has accumulated on the surface. Fouling Rate Scale (FR) is based on a rating number that increase from 0 to 100 on 10-point increments. Each FR designation represents different types of marine growth with the lowest severity of marine growth with a FR 0 to the highest severity of marine growth with FR 100. The standard table of the different FR is presented in Table 1 & picture examples of each FR is also provided in Attachment C.

Type	Fouling Rating (FR)	Description
Soft	0	A clean, foul-free surface; red and/or black AF paint or a bare metal surface.
Soft	10	Light shades of red and green (incipient slime). Bare metal and painted surfaces are visible beneath the fouling.
Soft	20	Slime as dark green patches with yellow or brown colored areas (advanced slime). Bare metal and painted surfaces may by obscured by the fouling.
Soft	30	Grass as filaments up to 3 inches (76 mm) in length, projections up to 1/4 inch (6.4 mm) in height; or a flat network of filaments, green, yellow, or brown in color; or soft non calcareous fouling such as sea cucumbers, sea grapes, or sea squirts projecting up to 1/4 inch (6.4 mm) in height. The fouling can not be easily wiped off by hand.
Hard	40	Calcareous fouling in the form of tubeworms less than ¼ inch in diameter or height.
Hard	50	Calcareous fouling in the form of barnacles less than ¼ inch in diameter or height.
Hard	60	Combination of tubeworms and barnacles, less than ¼ inch (6.4 mm) in diameter or height.
Hard	70	Combination of tubeworms and barnacles, greater than ¼ inch in diameter or height.
Hard	80	Tubeworms closely packed together and growing upright away from surface. Barnacles growing one on top of another, ¼ inch or less in height. Calcareous shells appear clean or white in color.
Hard	90	Dense growth of tubeworms with barnacles, ¼ inch or greater in height; Calcareous shells brown in color (oysters and mussels); or with slime or grass overlay.
Composite	100	All forms of fouling present, Soft and Hard, particularly soft sedentary animals without calcareous covering (tunicates) growing over various forms of hard growth.

Table 1: Fouling Ratings (FR) in Order of Increasing Severity

Existing Conditions

AMI mobilized to the project site on June 3rd, 2018 to begin its underwater inspection of the hull. The divers stationed the entire length of vessel and utilized the diver's umbilical to determine the location along the hull of the Irvin. The stern of the vessel was selected as STA 0+00. All defects documented during the inspection can be reviewed in Appendix A & B. The following is a summary of our inspection and should be used in conjunction with the appendices.

The marine growth and corrosion documented on the hull of the vessel was typical of other facilities around the Duluth-Superior Harbor. A light marine growth or algae was documented over the entire surface area of the hull which would be described as a FR 10 to 30 with 100% coverage. Below the light layer of algae, rust tubercles were documented from the waterline to 6'-0" below the waterline. The rust tubercles have a harder surface with a FR rating of 60 with 70% to 80% coverage from the waterline to 4'-0" below the waterline. The concentration of the rust tubercles significantly dropped off at 4'-0" to 6'-0" below the water and no rust tubercles were documented below 8'-0". The bottom of the vessel is approximately 10'-0" below the waterline and only the light marine growth or algae was documented.

Below the rust tubercles, steel corrosion of the hull was documented in the form of overlapping pits. The highest concentration of pitting was documented from the waterline to 4'-0" below the waterline with a coverage of 70% to 80%. The concentration of the pits dropped off below 4'-0" and no pits were documented below the 8'-0" as described with the rust tubercles above.

The penetration of the pits documented between the waterline and 4'-0" below the waterline ranged from approximately 3/16" to 9/32". The size or diameter of the pits also ranged from 5/16" to 1" along the

same water depth range. The corrosion transitioned to a light etching below 4'-0" and no corrosion was documented below 8'-0". The average pit penetration of all the corrosion assessments was approximately 0.222". A typical condition of the corrosion on the hull can be seen in Picture 1.

Picture 1: Typical Condition of the Corrosion

During the inspection, AMI also documented the condition of the coating that was applied in 1981. However, due to the low visibility of the water at the time of the inspection, AMI was unable to verify the condition of the coating and document any deterioration. But due to the amount of pitting documented, it is likely that the coating near the waterline is severely deteriorated and is no longer protecting the steel hull from corrosion.

Conclusions

Based on other scientific studies that AMI has been involved with over the past twelve years, the average corrosion rate in the Duluth-Superior Harbor is approximately 0.0107 inches per year on standard uncoated ASTM A36 steel.

The highest concentration of the corrosion was documented between the waterline and 4'-0" below the waterline with an average pit depth of 0.222". Base on the historical construction drawings of the Irvin, the hull plating near the waterline was constructed of ¾" or ⅝" thick steel plates. However, at the overlaps or seams in the hull, the hull plating tapers down to approximately ½". The sea chests were also sealed up with approximately ⅜" thick steel plate. The effects of the corrosion and the different estimated times to perforations in steel plating are summarized in Table 1 for the different steel thicknesses below the waterline.

Nominal Thickness	Actual Thickness [in]	Min Steel Thickness at Base of Pit [in]	% Steel Loss	Estimated Time to Perforations
⅜"	0.375	0.153	59%	15 to 20 Years
½"	0.465	0.243	48%	20 to 25 Years
⅝"	0.637	0.415	35%	40 to 45 Years
¾"	0.759	0.537	29%	50 to 55 Years

Table 2: Results of Corrosion Assessment & Estimated Time to Perforations

Perforations of the ⅜" steel plates are likely to occur in 15 to 20 years. But the locations of the ⅜" steel plates are isolated to the sea chests, so the condition of these plates will have little impact on the overall structural integrity of the hull. Perforations of the hull at the overlaps where ½" steel is located, are likely to occur in 20 to 25 years. The amount of corrosion documented resulted in an approximate steel loss of

48% in these areas. Based on this information, the overlaps in the steel plating are the most susceptible to damage if the hull is not protected from further corrosion.

Lower corrosion rates have been documented closer to the Duluth Entry, so the corrosion rate is likely not as severe as 0.0107 inches per year. On previous projects, a corrosion rate could be estimated from the data collected and the known historical information. But there are several variables in particular to this project that make it difficult to determine a corrosion rate. One difficulty is determining when the corrosion on the hull started. Based on scientific studies, it is believed that the type of corrosion in the Duluth- Superior Harbor (MIC) did not occur until approximately 1972 when the Clean Water Act was enacted. The hull of the vessel was also coated in 1981 and would prevent any future corrosion until the coating became deteriorated. It is also likely that some corrosion did occur on the steel hull prior to being coating in 1981, but the extend of that deterioration is unknown. Due to these unknowns, AMI utilized the know corrosion rate of 0.0107 inches per year.

Recommendations

After reviewing all of the data and assessing the existing site conditions, AMI Consulting Engineers, makes the following recommendations. Due to the condition of the hull and AMI's knowledge of the Duluth-Superior Harbor, AMI's recommends that the hull of the vessel be coated with a corrosion resistant epoxy coating. AMI based its recommendation of the following items:

- The vessel is required to be moved from its current location in MN Slip due to the remediation of the contaminated sediments in MN Slip. The vessel will already be relocated to Fraser Shipyards where the hull could be recoated and other repairs could be performed.
- While the vessel in is dry-dock, the hull could be inspected more thoroughly to document & potentially remediate any deteriorated sections of the hull.
- The vessel will be at greater risk of major structural damage if the vessel is moved out of MN Slip in the future. The corrosion will continue to deteriorate the steel hull causing steel members to become thinner. The risk of severe structural damage will increase as the steel members become thinner.
- The cost to remove the vessel from MN Slip will only become more expensive in the future.
- Coating the vessel in the wet could be completed but the longevity of the coating once applied is much less than when it is applied in a dry controlled environment.
- Mobile cofferdams have also been utilized to coat & repair vessels below the waterline but the cost of equipment, labor & difficult access to the vessel would make this option not viable.

If you have any questions or comments, please contact AMI at (715) 718-2193 extension 17.

Respectfully Submitted,

Chase Dewhirst, PE
Marine Engineering Manager

Reviewed by,
Chad W. Scott, PE
Principal

Enclosed:

- Appendix A - Underwater Inspection Notes
- Appendix B - Corrosion Assessment Results
- Appendix C - Picture Examples of Typical Fouling Ratings (Provided by Nordic Group "Underwater Ship Husbandry Manual" Revision 1, Dated July 28th, 2017)
- Appendix D - Historical William A. Irvin Construction Drawings "Midship Section"

APPENDIX A – UNDERWATER INSPECITON NOTES

Team Leader: Chase Dewhirst
Inspection Date: 6/3/2018
Inspection Time: 1000-1400
Inspection Type: Level I/II
Water Elevation: 601.92 ft to 602.45 ft

Station	Video Tape Time Ref.	Depth (ft)	Buckling Present	Corrosion				Cracking Present	Holes		Marine Growth			Protective Coat'g Present	Stl Separation Present	Impact Damage Present	NDT Thickness Gauge Value (in.)	Debris		Addn'l Note Sheet No.	Comments
				Present	Type	Fouling Rate (FR)	Degree		Present	Size	Present	Fouling Rate (FR)	Degree					Present	Type		
Dive Number 1 - 6/03/18																					
0+00	-	0	-	X	Pitting	60	100%	-	-	-	X	70 - 80	100%	-	-	-	-	-	-	-	- Pits = 1/2" Long x 3/16" Pen with Zebra Mussels
0+50	-	0	-	X	Pitting	60	100%	-	-	-	X	50-70	65% to 100%	-	-	-	-	-	-	-	- Some light marine growoth over heavy pitting (Marine Growth; FR = 20-30)
-	0:12:00	-	-	-	-	-	-	-	-	-	X	10-20	100%	No	-	-	-	-	-	-	- Unable to determine if coating is intact due to trapped air & poor visibility. No
																					pitting or major corrosion documented
1+20	-	10	-	-	-	-	-	-	-	-	X	10-20	60%	No	-	-	-	-	-	-	- Unable to determine if coating is intact due to trapped air & poor visibility.
2+20	0:28:00	10	-	-	-	-	-	-	-	-	X	30	100%	No	-	-	-	-	-	-	- Unable to determine if coating is intact due to trapped air & poor visibility.
2+20	-	-	-	X	Pitting	60	15% to 20%	-	-	-	X	20-30	100%	-	-	-	-	-	-	-	- Pitting (FR 60) starts at approx. 9'-0" below the waterline and extends to surface.
																					Pits = 2" Long x 1" Wide x 3/16" Pen
1+90	-	16	-	X	Pitting	-	See Ad'l Sheets	-	-	-	-	-	-	-	-	-	-	-	-	-	- From WL to -4'-0" pits are exposed // From -4'-0" to bottom of hull Pits are filled
																					with hard marine growth (FR = 60)
Dive Number 2 - 6/03/18																					
6+11	-	-	-	X	Pitting	-	See Comments	-	-	-	X	10	15%	-	-	-	-	-	-	-	- From WL to -2'-0" // Pitting = 70 to 80% // Pit #1 = 1/4" Pen x 3/4" DIA // Pit #2 =
																					1/4" Pen x 5/8" Wide x 1/2" Long // Pit #3 = 7/32" Pen x 1/2" DIA
-	-	4		X	Pitting	-	See Comments	-	-	-	X	10	80%	-	-	-	-	-	-	-	- Pitting reduces significantly @ 4'-0" below the WL // Pitting is heavier on keel
																					==> 70% Coverage on Keel vs 10% Coverage on Hull (Approx. Same Pen & DIA)
-	-	6	-	-	-	-	-	-	-	-	X	10	100%	-	-	-	-	-	-	-	- Pitting stops at 6'-0" below the WL and no pits were documented on the bottom
4+11	-	10	-	-	-	-	-	-	-	-	X	20	100%	-	-	-	-	-	-	-	- No Pitting on Bottom
-	-	11.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	Timber	-	- Timber debirs documented below vessel at approx. 165' from inner dock wall //
																					Debris is approximately 1'-6" from bottom of hull (Approx 6'-6" from ML to Hull) //
																					Approx. located in line with the south corner of the fourth recreation dock on East
																					side of MN Slip.
3+96	-	-	-	X	Pitting	-	See Ad'l Sheets	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6+11	-	-	-	X	Pitting	-	See Comments	-	-	-	X	10	100%	-	-	-	-	-	-	-	- 0' to 2'-0" below WL = 50% Pitting Coverage // Below 4'-0" pitting drops off // Pitting
																					appears to be less on port Side than starboard side
5+61	-	-	-	X	Pitting	-	See Ad'l Sheets	-	-	-	-	-	-	-	-	-	-	-	-	-	- Unable to determine if coating is intact due to trapped air & poor visibility.

AMI Consulitng Engineers, PA
91 Main Street
Superior, WI 54880

APPENDIX B – CORROSION ASSESSMENT RESULTS

Corrosion Inspection

Station: 1+90 Inspection Date: 6/3/2018

Total Water Depth: 16 Feet Vessel Side Starboard

Pitting Inspection						
Depth Below WL	**Item / Location**	**1**	**2**	**3**	**Average**	**% Coverage/ Comments**
WL (0')	Pit Penetration	0.25	0.1875	0.219	0.219	70 to 80%
	Pit Diameter	0.5	1	0.75	0.750	
2'	Pit Penetration	0.2188	0.21875	0.188	0.208	80%
	Pit Diameter	0.5	0.75	1.25	0.833	
4'	Pit Penetration	0.1875	0.28125	0.219	0.229	80 to 90%
	Pit Diameter	0.3125	0.5	0.75	0.521	
6'	Pit Penetration	-	-	-	-	20% Uniform Etching (Beginning of Curve Plate)
	Pit Diameter	-	-	-	-	
8'	Pit Penetration	-	-	-	-	15% Uniform Etching (FR = 60) // 100% Marine Growth (FR = 10) // Bottom of Curve Plate
	Pit Diameter	-	-	-	-	
10'	Pit Penetration				-	100% Coverage of Marine Growth (FR = 10) // Bottom of Vessel
	Pit Diameter				-	

Note: Pit Measurements are in inches

Ultrasonic Thickness Inspection

Depth Below WL	1	2	3	Avg	Comments
WL (0')	0.750	-	-	0.750	-
7'	0.725	0.725	0.720	0.723	Start of Curve Plate
9'/10'	0.760	0.765	0.765	0.763	Bottom of Curve Plate

Note: UT Measurements are in inches

Corrosion Inspection

Station: 3+96 Inspection Date: 6/3/2018

Total Water Depth: - Feet Vessel Side Starboard

Pitting Inspection						
Depth Below WL	**Item / Location**	**1**	**2**	**3**	**Average**	**% Coverage/ Comments**
0' to 2'	Pit Penetration	0.21875	0.1875	0.25	0.219	Pitting = 70% Coverage // Maring Growth = 100% Coverage (FR = 20)
	Pit Diameter	0.75	0.5	0.5	0.583	
2' to 4'	Pit Penetration	0.1875	0.21875	0.188	0.198	Pitting = 15% Coverage @ 4'-0" // Maring Growth = 100% Coverage (FR = 20)
	Pit Diameter	0.5	0.75	0.5	0.583	
4' to Bottom of Hull	Pit Penetration	-	-	-	-	No Pitting // Marine Growth = 100% (FR = 20)
	Pit Diameter	-	-	-	-	

Note: Pit Measurements are in inches

Ultrasonic Thickness Inspection

Depth	1	2	3	Avg	Comments
WL (0')	0.745	0.745	0.750	0.747	-
2'	0.745	0.755	0.750	0.750	-
4'	0.695	0.745	0.720	0.720	Above Curve Plate
6'	0.720	0.715	0.700	0.712	Below Curve Plate

Note: UT Measurements are in inches

Corrosion Inspection

Station: 5+61 Inspection Date: 6/3/2018

Total Water Depth: - Feet Vessel Side Starboard

Pitting Inspection						
Depth Below WL	**Item / Location**	**1**	**2**	**3**	**Average**	**% Coverage/ Comments**
0' to 2'	Pit Penetration	0.21875	0.21875	0.25	0.229	Pitting = 80% Coverage // Maring Growth = 100% Coverage (FR = 10)
	Pit Diameter	0.5	0.625	0.75	0.625	
2' to 4'	Pit Penetration	0.25	0.25	0.25	0.250	Pitting = 30% Coverage @ 4'-0" // Maring Growth = 100% Coverage (FR = 20)
	Pit Diameter	1	0.75	1	0.917	
4' to Bottom of Hull	Pit Penetration	-	-	-	-	Minor Etching & decreases further from WL // Marine Growth = 100% (FR = 20)
	Pit Diameter	-	-	-	-	

Note: Pit Measurements are in inches

Ultrasonic Thickness Inspection

Depth	1	2	3	Avg	Comments
0' to 2'	0.675	0.680	0.660	0.672	-
2' to 4'	0.670	0.675	0.665	0.670	-
4' to 6'	0.570	0.585	0.575	0.577	-

Note: UT Measurements are in inches

APPENDIX C – PICTURES OF TYPICAL FOULING RATINGS

Provided by Nordic Group "Underwater Ship Husbandry Manual" Revision 1, Dated July 28th, 2017

Figure 081–1–1. Typical Fouling Ratings (FR) in Order of Increasing Severity (22 Photos)

Figure 081-1-1 (SH1) FR-10, Over 30 Percent Of Area (Sheet 1 of 22).

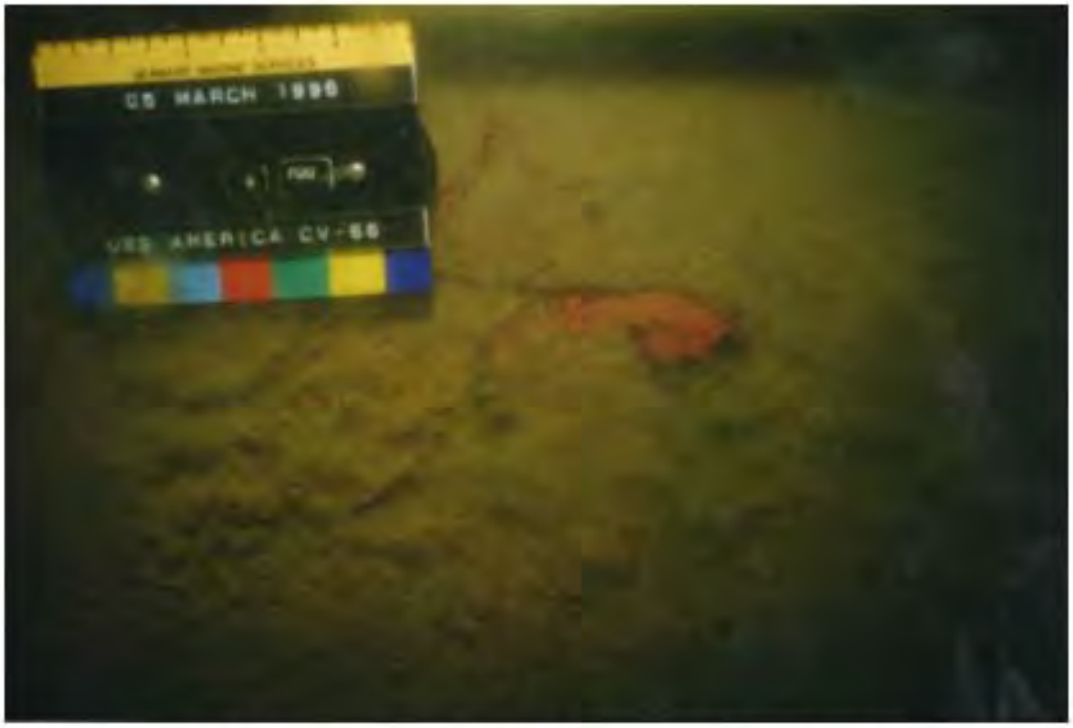

Figure 081-1-1 (SH2) FR-10, Over 100 Percent Of Area (Sheet 2 of 22).

Figure 081-1-1 (SH3) FR-20, Over 80 Percent Of Area (Sheet 3 of 22).

Figure 081-1-1 (SH4) FR-30, Over 40 Percent Of Area (Sheet 4 of 22).

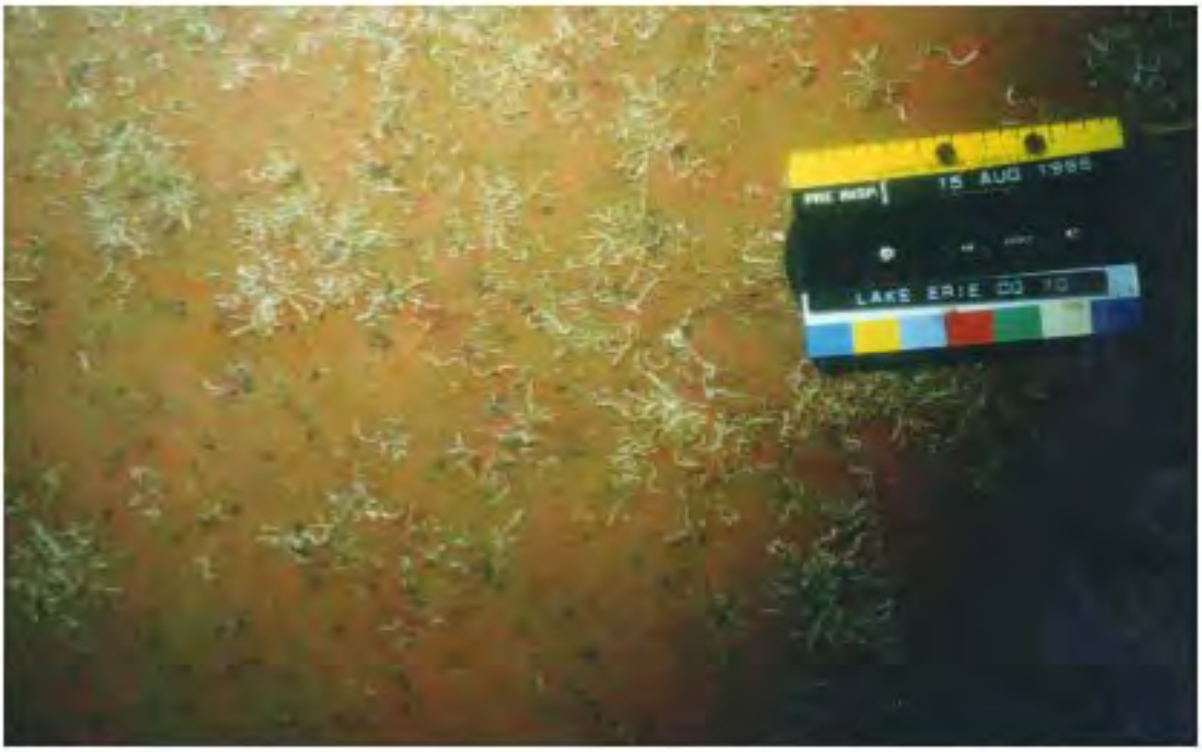

Figure 081-1-1 (SH5) FR-40, Over 20 Percent Of Area (Sheet 5 of 22).

Figure 081-1-1 (SH6) FR-40, Over 30 Percent Of Area (Sheet 6 of 22).

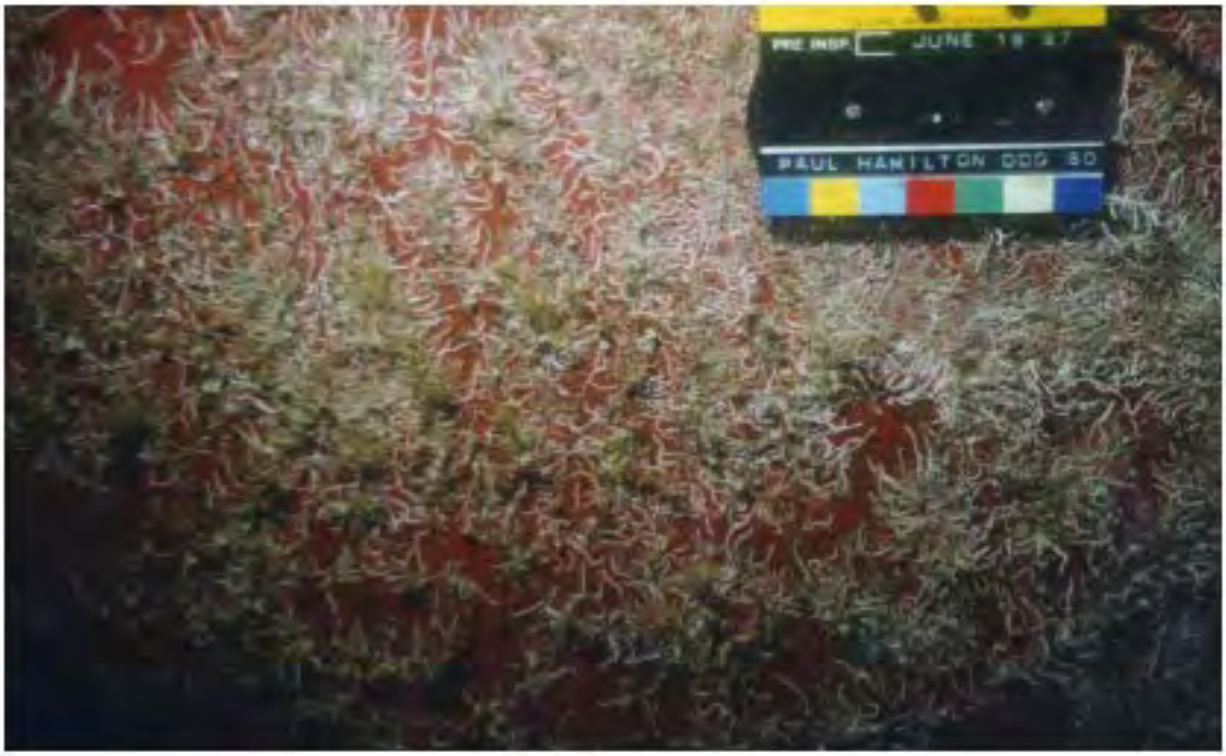

Figure 081-1-1 (SH7) FR-40, Over 90 Percent Of Area (Sheet 7 of 22).

Figure 081-1-1 (SH8) FR-50, Over 20 Percent Of Area (Sheet 8 of 22).

Figure 081-1-1 (SH9) FR-50, Over 40 Percent Of Area (Sheet 9 of 22).

Figure 081-1-1 (SH10) FR-50, Over 100 Percent Of Area (Sheet 10 of 22).

Figure 081-1-1 (SH11) FR-60, Over 15 Percent Of Area (Sheet 11 of 22).

Figure 081-1-1 (SH12) FR-60, Over 20 Percent Of Area (Sheet 12 of 22).

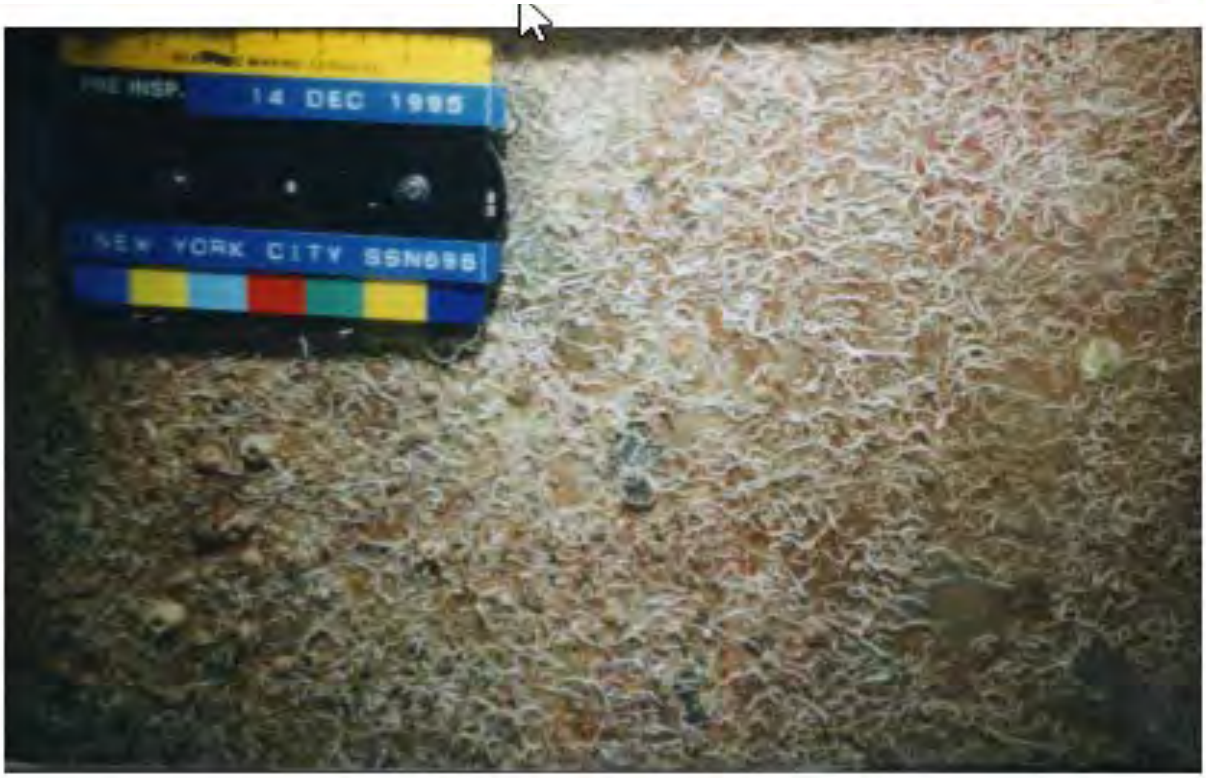

Figure 081-1-1 (SH13) FR-60, Over 90 Percent Of Area (Sheet 13 of 22).

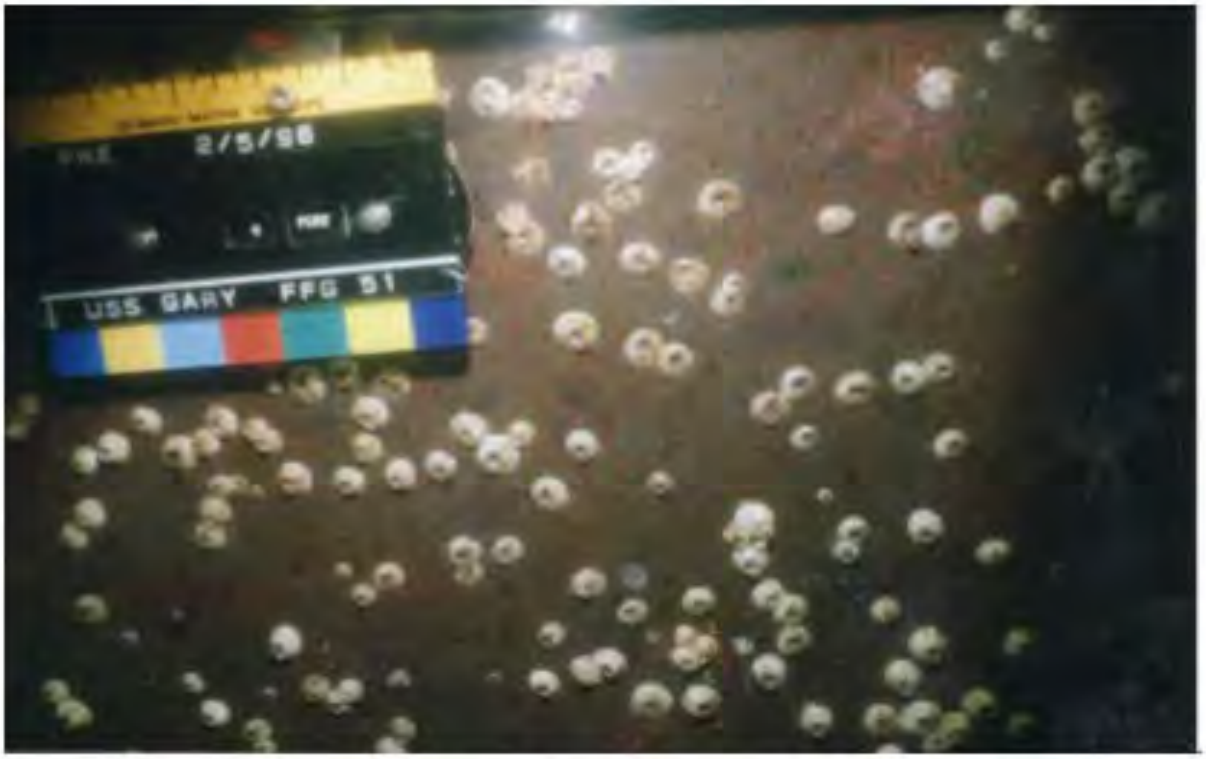

Figure 081-1-1 (SH14) FR-70, Over 20 Percent Of Area (Sheet 14 of 22).

Figure 081-1-1 (SH15) FR-70, Over 80 Percent Of Area (Sheet 15 of 22).

Figure 081-1-1 (SH16) FR-80, Over 60 Percent Of Area (Sheet 16 of 22).

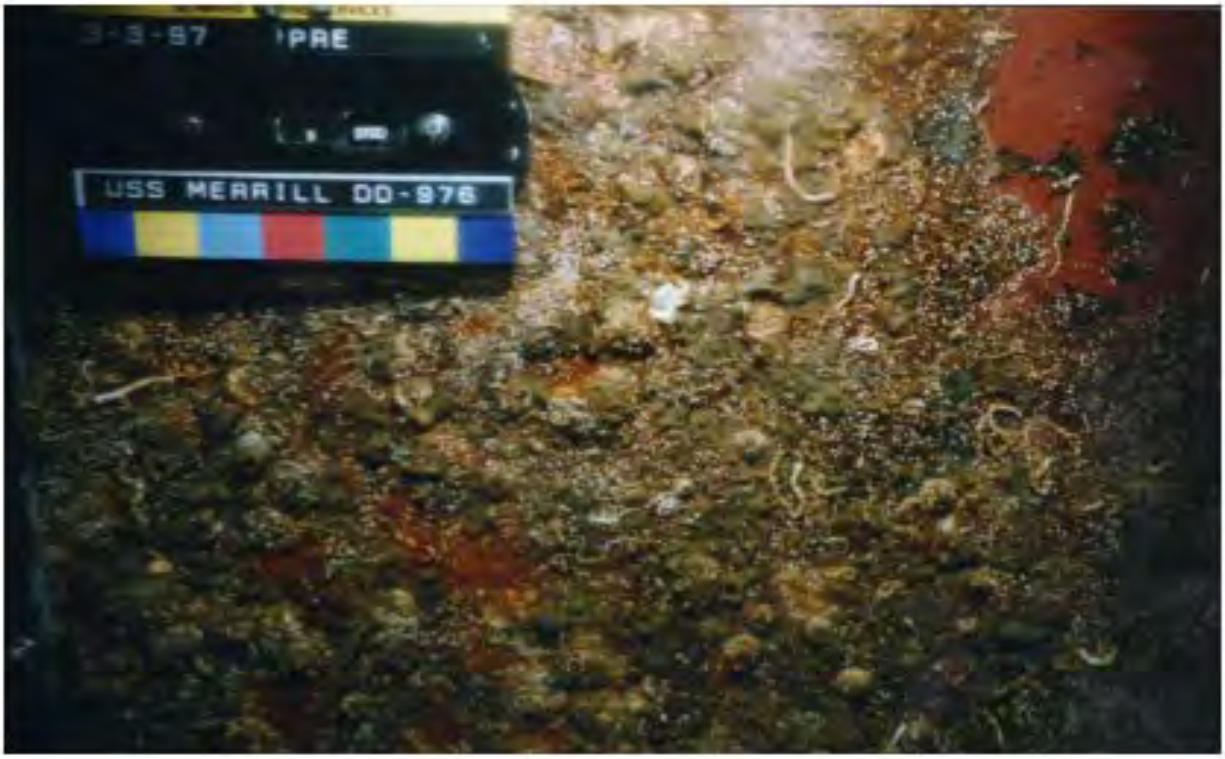

Figure 081-1-1. (SH17) FR-80, Over 80 Percent Of Area (Sheet 17 of 22).

Figure 081-1-1 (SH18) FR-80, Over 90 Percent Of Area (Sheet 18 of 22).

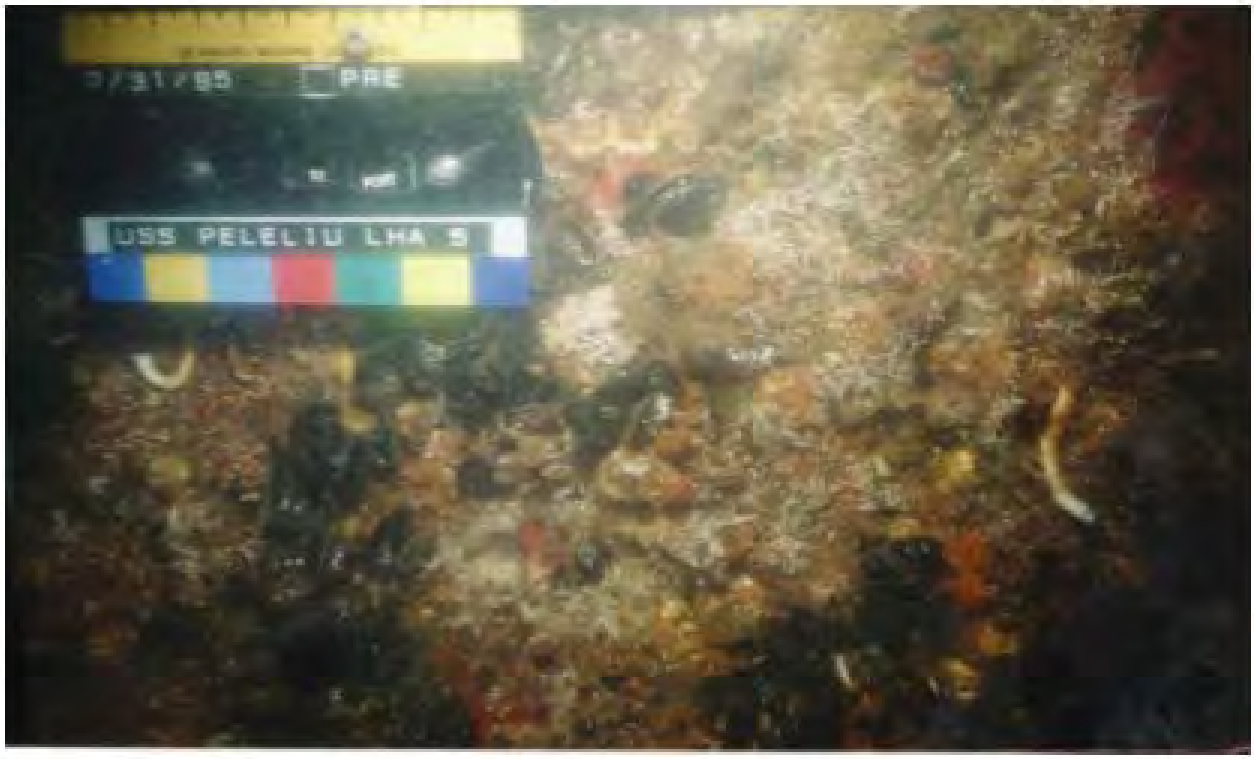

Figure 081-1-1 (SH19) FR-90, Over 90 Percent Of Area (Sheet 19 of 22).

Figure 081-1-1 (SH20) FR-90, Over 90 Percent Of Area (Sheet 20 of 22).

Figure 081-1-1 (SH21) FR-100, Over 50 Percent Of Area (Sheet 21 of 22).

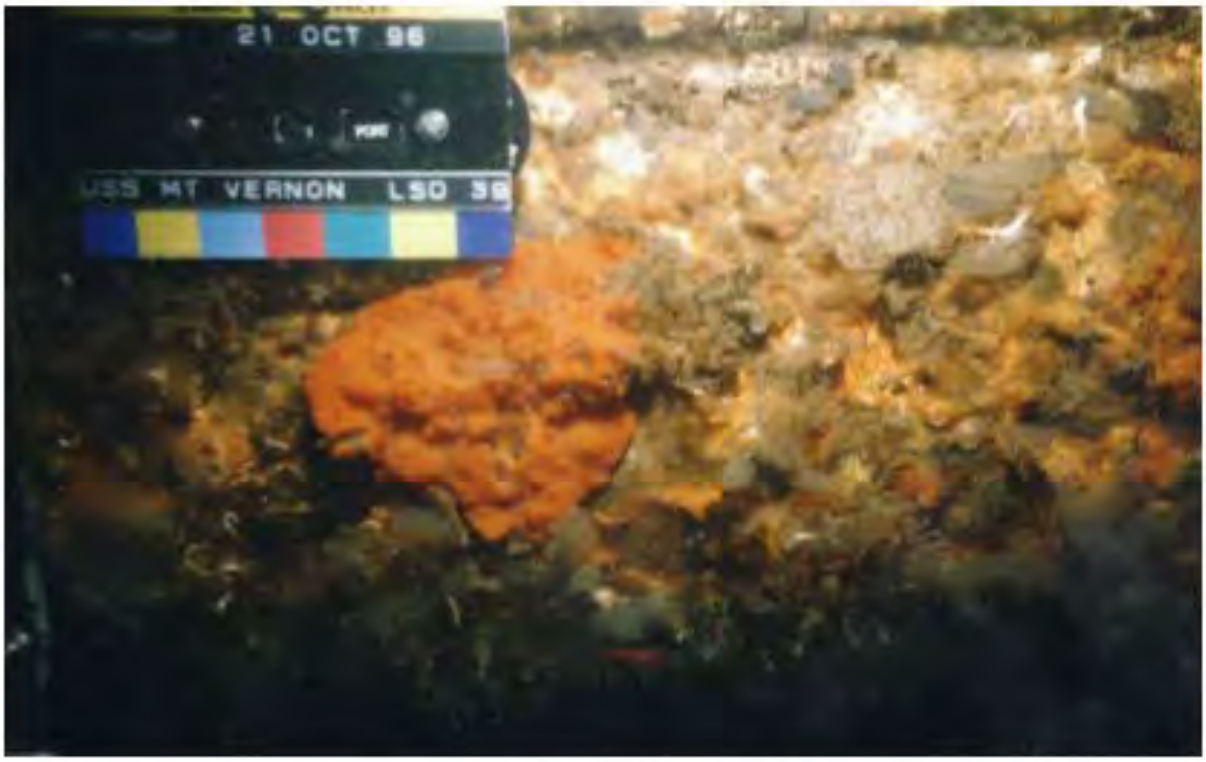

Figure 081-1-1 (SH22) FR-100, Over 100 Percent Of Area (Sheet 22 of 22).

APPENDIX D – HISTROICAL WILLIAM A. IRVIN CONSTRUCTION DRAWINGS “MIDSHIP SECTION”

NOTE: IN ALL PARTS OF STRUCTURE WHERE 1-1⅛ AND 1¼ RIVETS ARE SPECIFIED THE HOLES SHALL BE PUNCHED ⅛ LESS IN DIA. THAN THE RIVET AND REAMED TO SUIT THE RIVET AFTER THE MATERIAL IS IN PLACE.
SECTION OF SIDE KEELSON LOOKING OUTBOARD
SECTION AT HATCH COAMING
HATCH GIRDER BRACKET
SECTION AT LONGITUDINALS
INTERMEDIATE WEB BETWEEN ARCHES
15" CAMBER IN 38'-0"
24" x 20# HATCH GIRDER INCL. BETWN. ARCHES
MISC. SCANTLINGS
FORECASTLE FRAMES; 6" x 3½ x 15.3# CHL ON EACH FRAME AFT OF #11
SIDE PLATING 15#; BEAMS 6" x 3½" x 15.3# CHL
FORWD. OF PILOT HOUSE, DECK PLATING 11# ANG. TO SHELL 3" x 3" x 7.2#; DK PLATING FORD. OF PILOT HOUSE 13#.
SPAR DECK AT ENDS; BEAMS 12" x 25# CHLS ON ALTERNATE FRAMES, DECK PLATING 15#. ANG. 3½" x 3½" x 8.5# AND 6 x 6 x 28.7#
MAIN DK. AT ENDS; BEAMS 12" x 25# CHLS ON ALTERNATE FRS. DECK PLATING 15#. ANG. 3½ x 3½ x 8.5# STRINGER 15#.
FORE PEAK PANTING BEAMS 12" x 25# CHLS. STANCHS 10" I BEAMS ON ALTERNATE FRAMES.
PANTING STRINGER 24" x 15#, FACE ANGLE 5" x 3" x 9.8#, ANGLE TO SHELL 3" x 3" x 7.2#, BRKTS. 15# SPACED 6'-0".
AFT PEAK AND COLLISION BULKHEAD; FRAME 5" x 5" x 14.3# ANG. PLATING 15# TO MAIN DECK, 12.5# UP STIFFENERS; LOWER 7" x 3½" x 20.3# CHLS, BRACKETS 15#, 24" VERTICAL AND 4'-0" HORIZONTAL, UPPER VERTICAL 6" x 3½" x 11.7# ANG.
OTHER W.T. BULKHEADS, FRAMES 5 x 5 x 14.3# ANGLE, PLATING 15# FOR LOWER ½ TO 12.5#. STIFFENERS VERTICAL 10" x 3.45" x 21.9# CHLS SPACED 30". BKTS. 15#.
CARGO HOLD BHDS. PLATED WITH 15# PLATE STIFFENERS 10" x 3.45" x 21.9# CHL SPACED 24" 3½" x 3½" x 9.8# ANG. TO TANK TOP
STEM 11" x 4" TAPERED TO 9" x 3"
STERN FRAME, CAST STEEL, THREE SECTIONS
RUDDER STOCK 12" DIA. PINTLE 7" DIA.
FRAMES IN FORE PEAK 7" x 3.45" x 19.1# CHLS 18" APART
FRAMES IN MACHINERY SPACE 6" x 3½" x 15.3# CHLS 24" APART
FRAMES IN AFTER PEAK 6" x 3½" x 15.3# CHLS 24" APART
SIDE FRAMES 10" x 3½" x 23.6# CHLS 36" APART
WEBS IN MACHINERY SPACE 15# ANG. TO SHELL 3½" x 3½" x 9.8# SING. AND DBL. 3½" x 3½" x 8.5# FACE ANGLES. W.T. FLOORS AND BHDS. IN SIDE TANKS 17.5#
ARCH BRACKETS
ARCH STIFFENERS
WELDING DETAIL FOR DECK BETWEEN HATCHES
INTERMEDIATE BRKT. ON C.V. KEELSON
DETAIL AT INTERMEDIATE LONG'L CLIP
DETAIL W.J. 8
DETAIL W.J. 6
TANK TOP PLATING 24# TO 20# OUTSIDE OF CARGO HOLD. TANK TOP LONGLS 7" x 2.29" x 14.75# CHS WELDED TO PLATE
WEBS SPACED 12'-0"
15 FLOORS SPACED 6'-0"
BOTTOM LONGLS 10" x 3.45" x 26.6# ⅞ RIV. TO SHELL 5¼ PITCH
SECTION AT SIDE TANK (STBD. SIDE) LOOKING OUTBOARD
CENTER VERTICAL KEELSON
SECTION OF SIDE STRINGER
ALTERATIONS
1 WELDING
2 C.V.K. BKT. FR 160 TO 178
3 ANGLE REVERSED
4 CONT. WELD: FILL WITH HYDROLENE
5 WIRE LINE RAIL ON INBOARD SIDE OF WALK
6 WELDING CHANGED
L
72" x 47.5# FOR 4/5 L ⌀ TO 19# AT ENDS QUINTUPLE RIV. BUTTLAPS 22½ WIDE 1¼ RIV. 5" PITCH PLATES TO BE SCARPHED IN WAY OF BUTTLAPS
K
72" x 40# FOR ⅔ L ⌀ TO 19# AT ENDS QUINTUPLE RIV. BUTTLAPS 20 WIDE 1⅛ RIV. 4½ PITCH PLATES TO BE SCARPHED IN WAY OF BUTTLAPS
J
26" FOR ⅔ L ⌀ TO 19# AT ENDS QUAD. RIV. BUTTLAPS 12 WIDE ⅞ RIV. 3½" PITCH
H
26" FOR ⅔ L ⌀ TO 19# AT ENDS SINGLE BUTTSTRAPS 22" x 30" ⅞ RIV. 3½" PITCH QUAD. RIV.
G
31" FOR ⅔ L ⌀ TO 19# AT ENDS QUAD. RIV. BUTTLAPS 13½ WIDE 1" RIV. 4" PITCH
E
31 FOR ⅔ L ⌀ TO 19# AT ENDS QUAD. RIV. BUTTLAPS 13½ WIDE 1" RIV. 4" PITCH
D
C
B
STRAKES B-C-D 26" TO 19# AT ENDS TREBLE RIV. BUTTLAPS 8¾ WIDE ⅞ RIV. 3⅝ PITCH
A
48 x 40# PLATE DBLE. BUTTSTRIPS 1⅛ RIV. 4" PITCH INSIDE STRAP 28" x 25# QUAD. RIV. OUTSIDE STRAP 21½ x 28# TREBLE RIV.
PRINCIPAL DIMENSIONS
LENGTH OVERALL 610'-9"
LENGTH BETWEEN PERP. 593'-9¾" (STEM TO ℄ OF RUDDER STOCK)
BREADTH MOLDED 60'-0"
DEPTH MOLDED 32'-6"
EQUIPMENT
TWO BOWER ANCHORS 8000#
ONE STERN ANCHOR 6000#
350 FATHOMS WARPS 1" DIA. WIRE
180 FATHOMS CHAIN 2¼" DIA. CHAIN
70 FATHOMS 1¼" DIA. WIRE
STR. No [redacted]
MIDSHIP SECTION
PRINT [redacted]
ISSUED [redacted]
DRAWING No 3
DRAWN CHECKED APPROVED
SCALE ½" = 1 FOOT.
MARCH 20, 1937
TRACING No
AM.S.B.Co. 810-811

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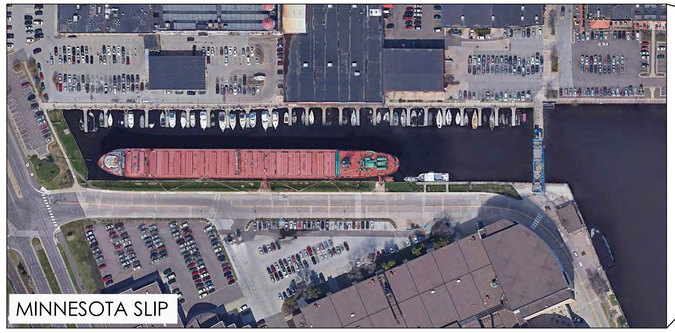

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GOVERNING SPECIFICATIONS

THE 2018 EDITION OF THE MINNESOTA DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR CONSTRUCTION AND THE 2017 VERSION OF THE DULUTH STANDARD CONSTRUCTION SPECIFICATIONS SHALL GOVERN.

811 Know what's below. Call before you dig.

THE LOCATIONS OF UNDERGROUND UTILITIES HAVE BEEN PROVIDED BY THE UTILITY OWNER, ARE SHOWN IN AN APPROXIMATE WAY ONLY AND HAVE NOT BEEN INDEPENDENTLY VERIFIED. THE CONTRACTOR SHALL FIELD VERIFY EXACT LOCATION OF ALL UTILITIES BEFORE COMMENCING CONSTRUCTION PER STATE LAW.

SURVEY/LAYOUT INFORMATION:

COORDINATE SYSTEM: MN COUNTY COORDINATE SYSTEM

DATUM: ST. LOUIS TRANSVERSE MERCATOR 96

GEOID: G12B

BENCHMARK HELD: AA9913

GENERAL PROJECT NOTES:

1. BIDDER WILL VISIT THE SITE TO UNDERSTAND THE SCOPE OF WORK. NO ADDITIONAL COMPENSATION WILL BE ALLOWED FOR ITEMS THAT COULD HAVE BEEN IDENTIFIED BY A SITE VISIT, STUDYING THE TOPOGRAPHIC & BATHYMETRIC SURVEYS, THOROUGHLY REVIEWING ALL PLANS AND REPORTS, AND ADDITIONAL INFORMATION REQUESTED FOR CLARIFICATION PRIOR TO BIDDING.
2. THE CONTRACTOR IS RESPONSIBLE FOR OBTAINING ALL REQUIRED PERMITS PRIOR TO STARTING WORK.
3. EXISTING SHIP MEASUREMENT & TOPOGRAPHIC INFORMATION TAKEN FROM SURVEYS DATED 4/23/18 AND 5/7/18 RESPECTIVELY. BATHYMETRIC SURVEYS PRODUCED BY THE USACE. SUPPLEMENTAL INFORMATION GATHERED FROM SITE VISITS, RECORD DRAWINGS AND PLANS OBTAINED FROM CLIENT, ARE SHOWN AS APPROXIMATE LOCATIONS ONLY AND SHALL BE FIELD VERIFIED PRIOR TO OR DURING CONSTRUCTION. CONTACT ENGINEER IMMEDIATELY IF ANY DISCREPANCIES ARE DISCOVERED.
4. THE LOCATIONS OF ALL EXISTING UTILITIES SHOWN ON THIS PLAN HAVE BEEN DETERMINED FROM THE BEST INFORMATION AVAILABLE AND ARE GIVEN FOR THE CONVENIENCE OF THE CONTRACTOR. THE ENGINEER ASSUMES NO RESPONSIBILITY FOR THEIR ACCURACY. PRIOR TO THE START OF ANY DEMOLITION ACTIVITY, THE CONTRACTOR SHALL NOTIFY THE UTILITY COMPANIES FOR ONSITE LOCATIONS OF EXISTING UTILITIES. THE CONTRACTOR IS REQUIRED TO TAKE DUE PRECAUTIONARY MEASURES TO PROTECT ANY EXISTING UTILITIES OR STRUCTURES LOCATED AT THE WORK SITE.
5. PROVIDE AND MAINTAIN TRAFFIC CONTROL DEVICES WHERE NECESSARY (INCIDENTAL). PLACEMENT OF THESE DEVICES SHALL BE APPROVED BY THE CITY AND ENGINEER PRIOR TO PLACEMENT. TRAFFIC CONTROL DEVICES SHALL MEET THE REQUIREMENTS OF THE MMUTCD, CURRENT ADDITION.
6. CONTRACTOR SHALL MAINTAIN FULL ACCESS TO ADJACENT PROPERTIES DURING CONSTRUCTION AND TAKE ALL PRECAUTIONS NECESSARY TO AVOID PROPERTY DAMAGE TO ADJACENT PROPERTIES.
7. ALL CONSTRUCTION WORK SHALL BE COMPLETED WITHIN CITY APPROVED WORKING HOURS.
8. INSTALL CONTROL FENCING AND BARRICADING AS NECESSARY TO PROTECT THE PUBLIC.

SHEET INDEX

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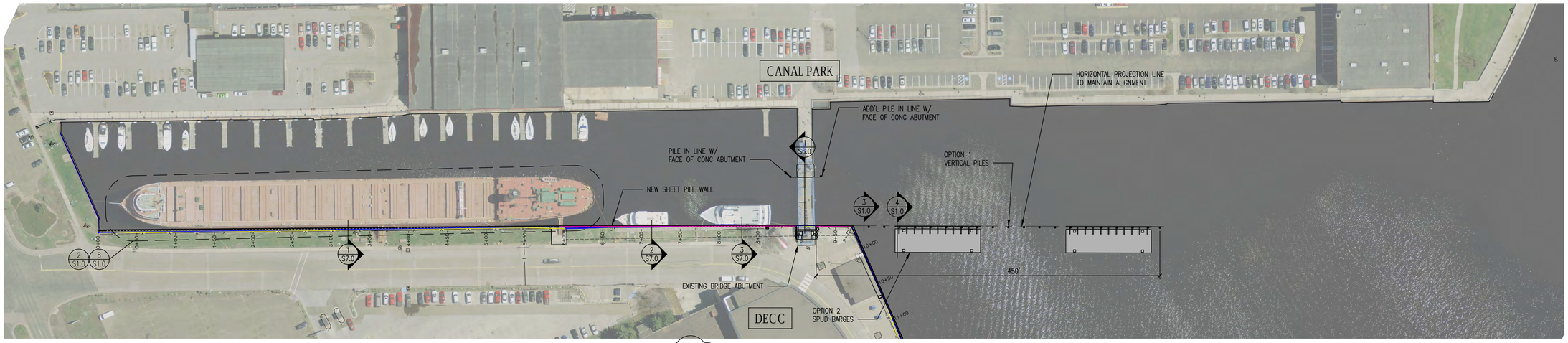
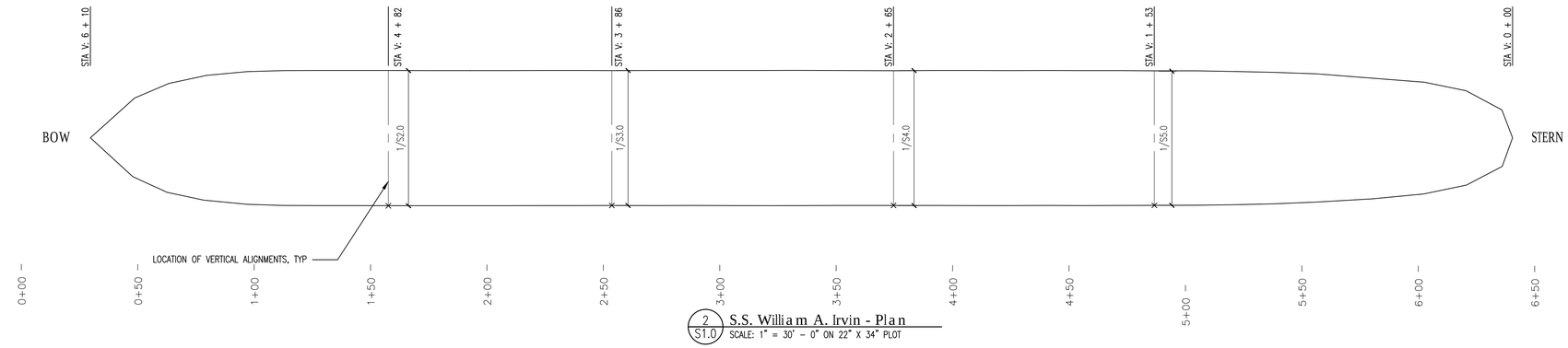


TRUE NORTH

PLAN NORTH

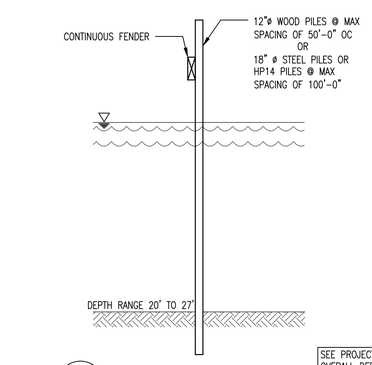
1 S1.0 **Minnesota Slip - Plan**
SCALE: 1" = 70' - 0" ON 22" X 34" PLOT
1. REFER TO MN SLIP PEDESTRIAN BRIDGE HISTORICAL DRAWINGS FOR DETAILS ON BRIDGE FOUNDATION BETWEEN STA 9+00 & 9+25

TEMPORARY GUIDE WALL MAY BE LEFT IN PLACE DURING THE WINTER. CONTRACTOR IS RESPONSIBLE FOR COORDINATING NAVIGATION REQUIREMENTS WITH USCG & RE-VERIFICATION OF ALIGNMENT PRIOR TO THE IRVIN MOVE IN THE SPRING OF 2019.



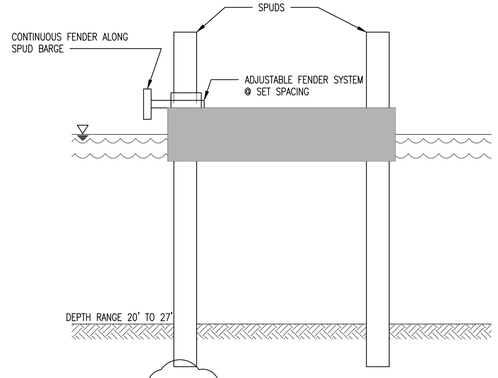
2 S1.0 **S.S. William A. Irvin - Plan**
SCALE: 1" = 30' - 0" ON 22" X 34" PLOT

MAX VELOCITY OF VESSEL
DURING MOVEMENT = 1FT PER EVERY 4 SECONDS
MAX SUSTAINED WIND SPEED = 5 MPH
MAX WIND GUST SPEED = 10 MPH
MAX WAVE HEIGHT = 6 INCHES
MAX CURRENT = 0.5 FT / SEC



SEE PROJECT SPECIFICATIONS FOR MAX OVERALL DEFLECTION OF STRUCTURAL COMPONENTS OF GUIDE WALL

3 S1.0 **Option 1 - Wood Piles**
SCALE: 1" = 10' - 0" ON 22" X 34" PLOT



SEE PROJECT SPECIFICATIONS FOR MAX OVERALL DEFLECTION OF STRUCTURAL COMPONENTS OF GUIDE WALL

4 S1.0 **Option 2 - Spud Barges**
SCALE: 1" = 10' - 0" ON 22" X 34" PLOT

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Plans and Sections

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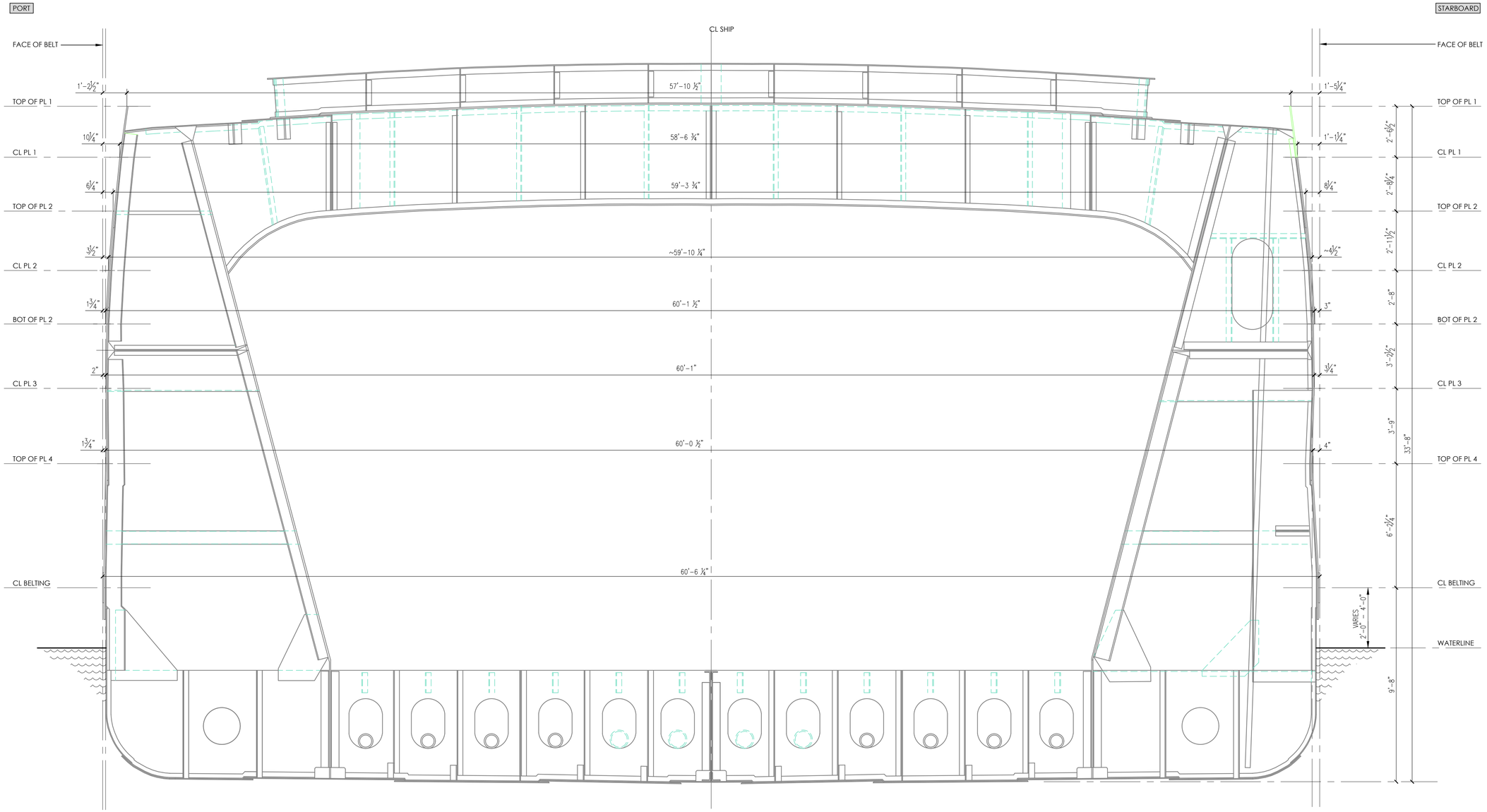

1 S2.0 IRVIN SECTION AT STA V: 1 + 53

3/8" = 1'-0" (24 X 36 PLOT)

NOTES:
1. STATIONING BEGINS AT THE STERN OF THE IRVIN AT THE EXTREME MEASUREMENT OF TOP OF PLATE 1. SEE 2/S1.0.
2. ALL MEASUREMENTS HAVE AN ACCURACY OF 1"±.

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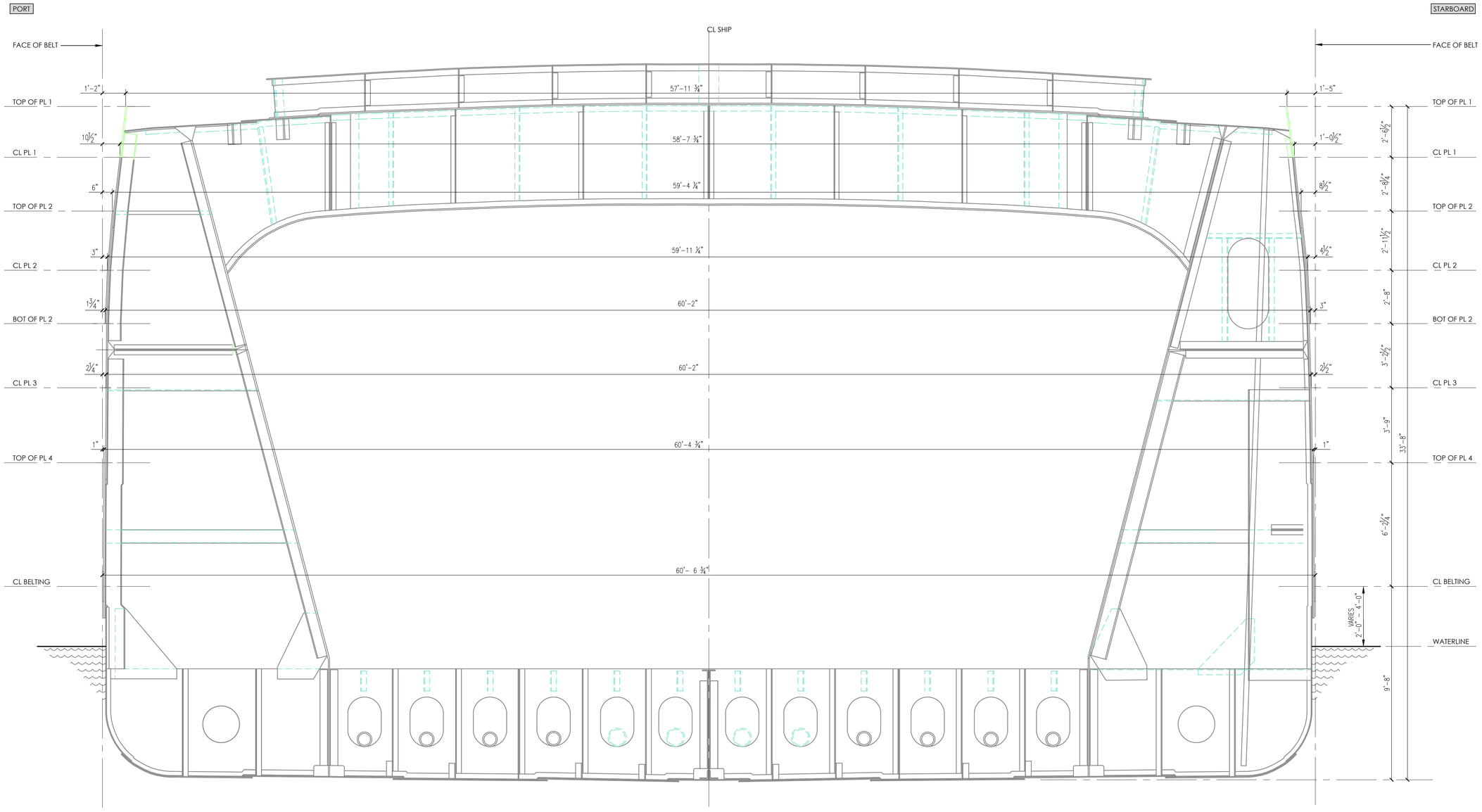

1 S3.0 IRVIN SECTION AT STA V: 2 + 65

3/8" = 1'-0" (24 X 36 PLOT)

NOTES:
1. STATIONING BEGINS AT THE STERN OF THE IRVIN AT THE EXTREME MEASUREMENT OF TOP OF PLATE 1. SEE 2/S1.0.
2. ALL MEASUREMENTS HAVE AN ACCURACY OF 1"±.

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Irvin Section at Sta 2 + 65
Section 2

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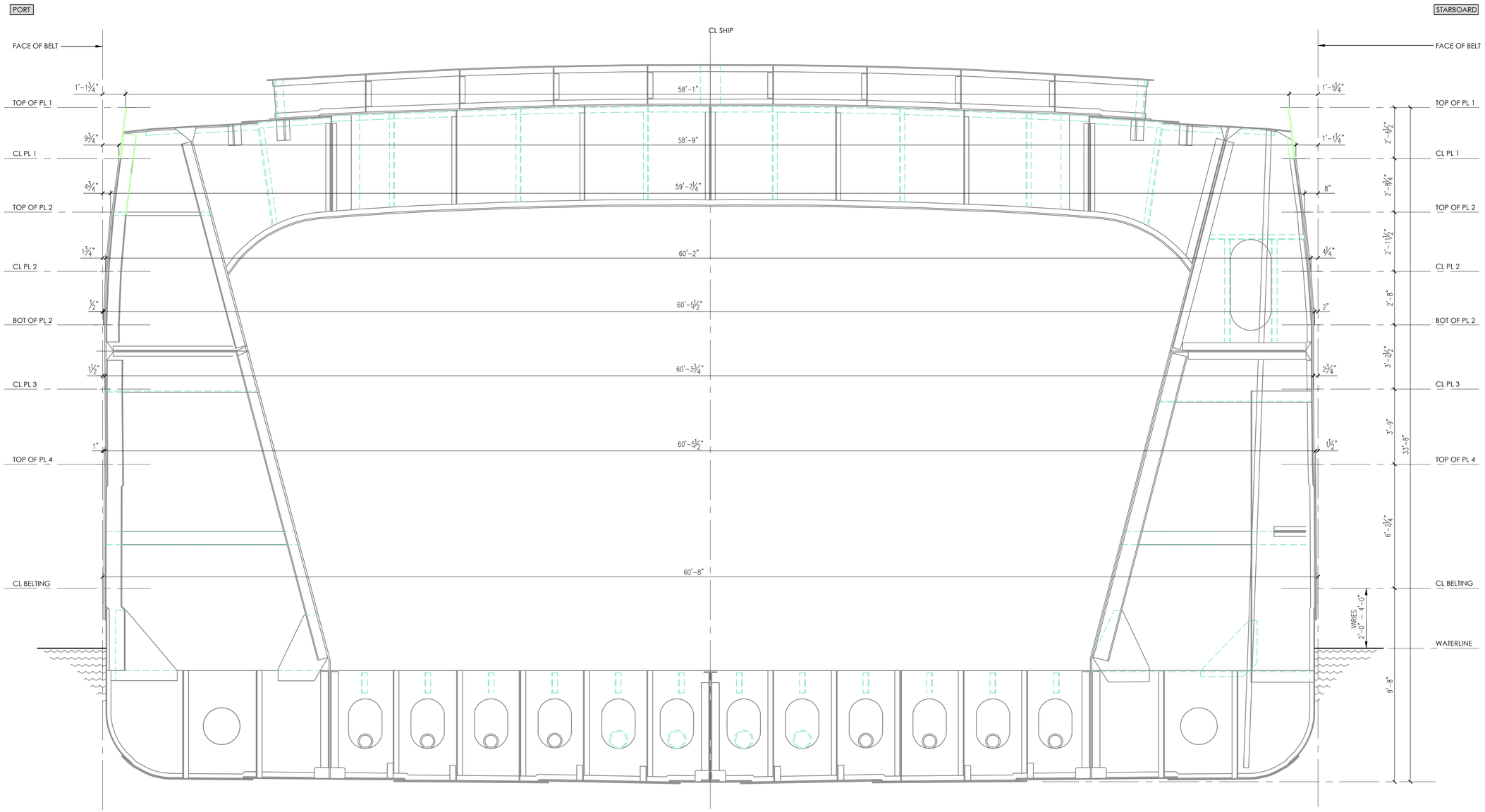

1 S4.0 IRVIN SECTION AT STA V: 3 + 86

3/8" = 1'-0" (24 X 36 PLOT)

NOTES:
1. STATIONING BEGINS AT THE STERN OF THE IRVIN AT THE EXTREME MEASUREMENT OF TOP OF PLATE 1. SEE 2/S1.0.
2. ALL MEASUREMENTS HAVE AN ACCURACY OF 1"±.

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Section 3

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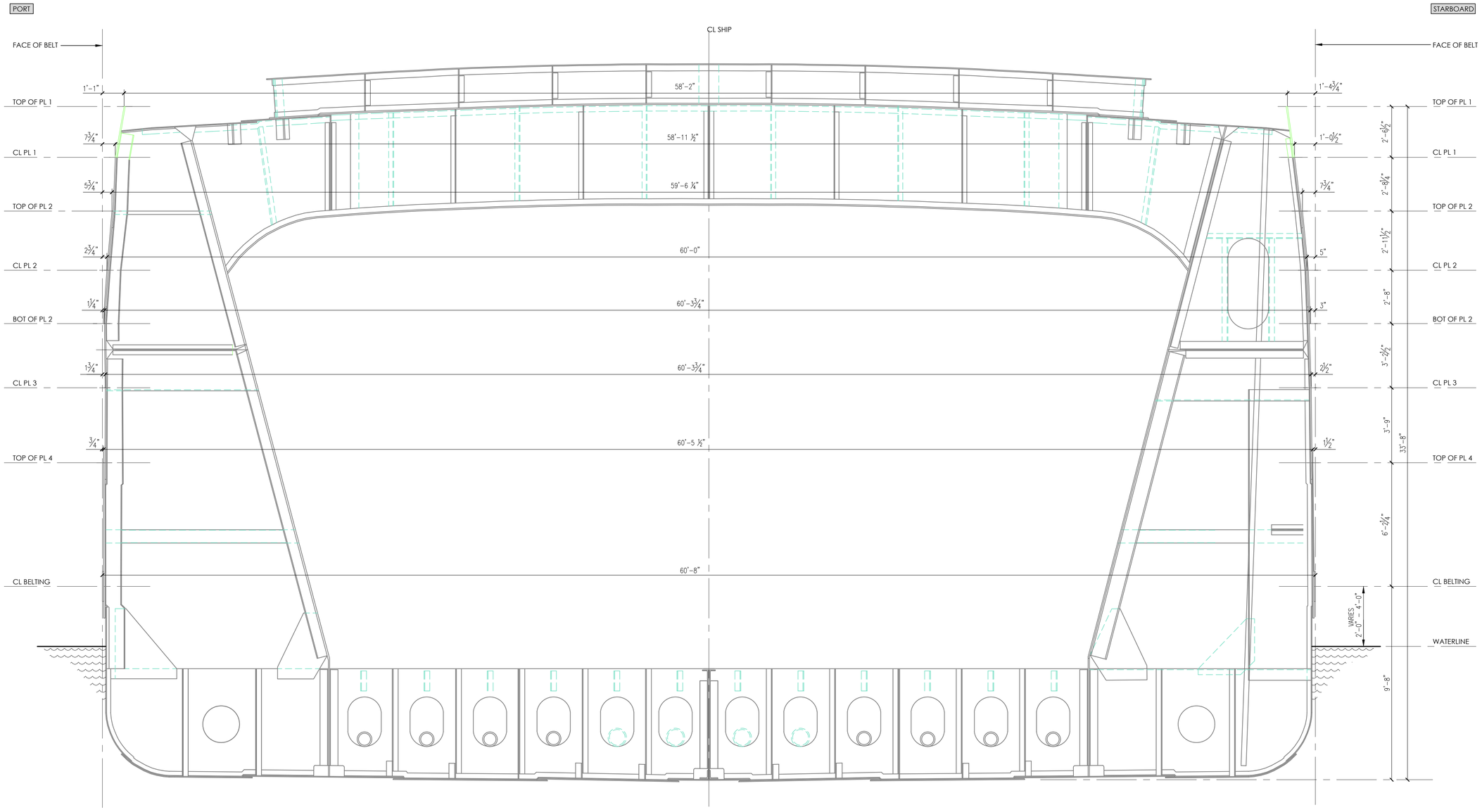

1 S5.0 IRVIN SECTION AT STA V: 4 + 85
3/8" = 1'-0" (24 X 36 PLOT)

NOTES:
1. STATIONING BEGINS AT THE STERN OF THE IRVIN AT THE EXTREME MEASUREMENT OF TOP OF PLATE 1. SEE 2/S1.0.
2. ALL MEASUREMENTS HAVE AN ACCURACY OF 1"±.

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Irvin Section at Sta 4 + 82
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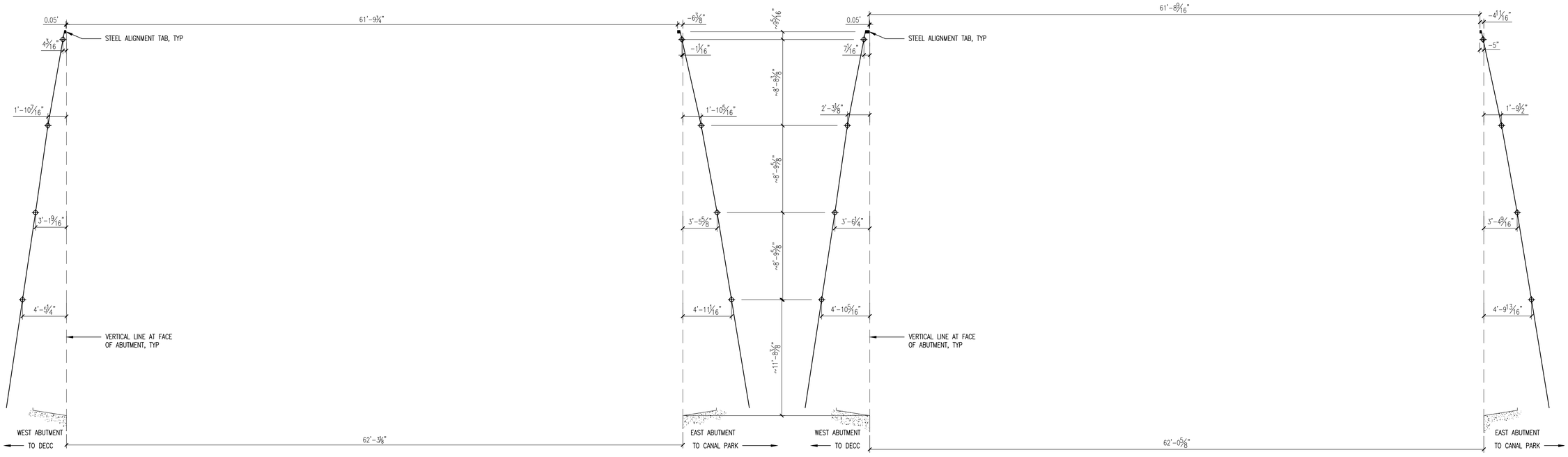

HARBOR SIDE OF BRIDGE (SOUTH SIDE)

SLIP SIDE OF BRIDGE (NORTH SIDE)

1 / S6.0 MINNESOTA SLIP REDESTRIAN BRIDGE
SCALE: 3/16" = 1'-0" ON 22" x 34" PLOT

THE CITY OF DULUTH WILL PARTIALLY DISASSEMBLE THE BRIDGE ON THE CANAL PARK (EAST) SIDE SO THAT ALL COMPONENTS ARE BEHIND OR INLINE WITH THE FACE OF THE CONCRETE ABUTMENT. CONTRACTOR IS RESPONSIBLE FOR VERIFYING THIS CONDITION PRIOR TO IRVIN MOVE.

NOTES:
- NEGATIVE DIMENSIONS INDICATE SECTIONS OF BRIDGE WHICH OVERHANG THE CONCRETE ABUTMENT WHEN LIFTED
- LIGHTING AND CONDUIT NOT SHOWN FOR CLARITY
- ⊕ INDICATES LOCATION OF MAIN BRIDGE MEMBER
- CARDINAL DIRECTIONS ARE BASED ON PLAN NORTH, NOT TRUE NORTH

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TWIN CITIES - IRON RANGE

REV:	DATE:	DESCRIPTION	REV. BY:

Irvin Relocation Design
City of Duluth
350 Harbor Drive
Duluth, Minnesota

Cross Sections
Pedestrian Bridge

JOB No: 181078
DATE: 07.10.18
DRAWN BY: PJB
DESIGNED BY: ZLM

SHEET: S6.0

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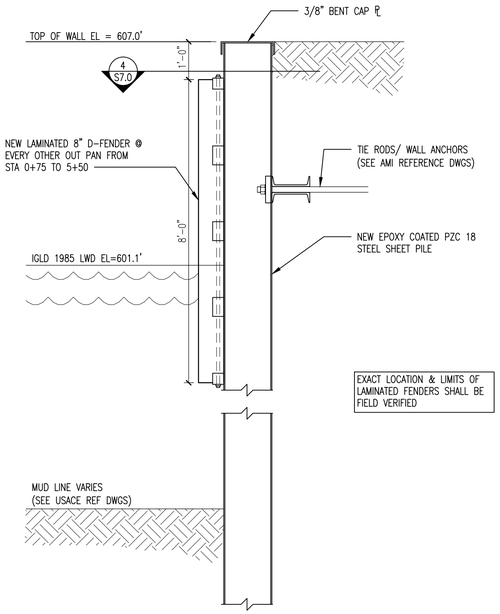
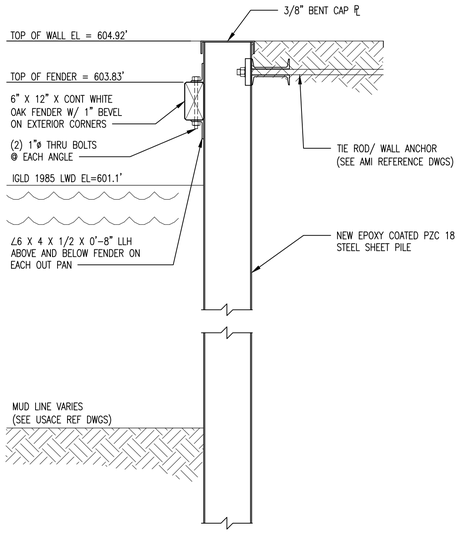
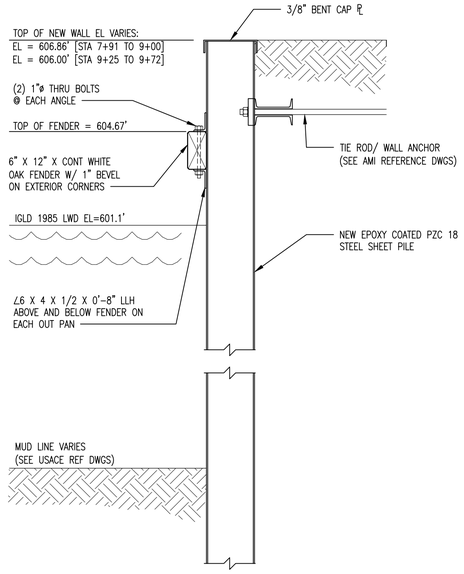


1 S7.0 Typical Dock Wall - STA 0 + 00 TO 6 + 65
SCALE: 1/2" = 1' - 0"

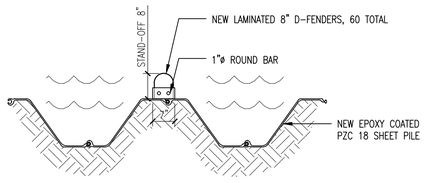


2 S7.0 Typical Dock Wall - STA 6 + 65 TO 7 + 91
SCALE: 1/2" = 1' - 0"



3 S7.0 Typical Dock Wall - STA 7 + 91 TO 9 + 00 & 9 + 25 TO 9 + 72
SCALE: 1/2" = 1' - 0"

1. REFER TO MN SLIP PEDESTRIAN BRIDGE HISTORICAL DRAWINGS FOR DETAILS ON BRIDGE FOUNDATION BETWEEN STATION 9+00 AND 9+25



4 S7.0 Typical Dock Wall Plan - STA 0 + 00 TO 6 + 65
SCALE: 1/2" = 1' - 0"

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Irvin Relocation Design
City of Duluth
350 Harbor Drive
Duluth, Minnesota

Dock Wall Details

JOB No: 181078
DATE: 07.10.18
DRAWN BY: SAJ
DESIGNED BY: CAD

SHEET:
S7.0

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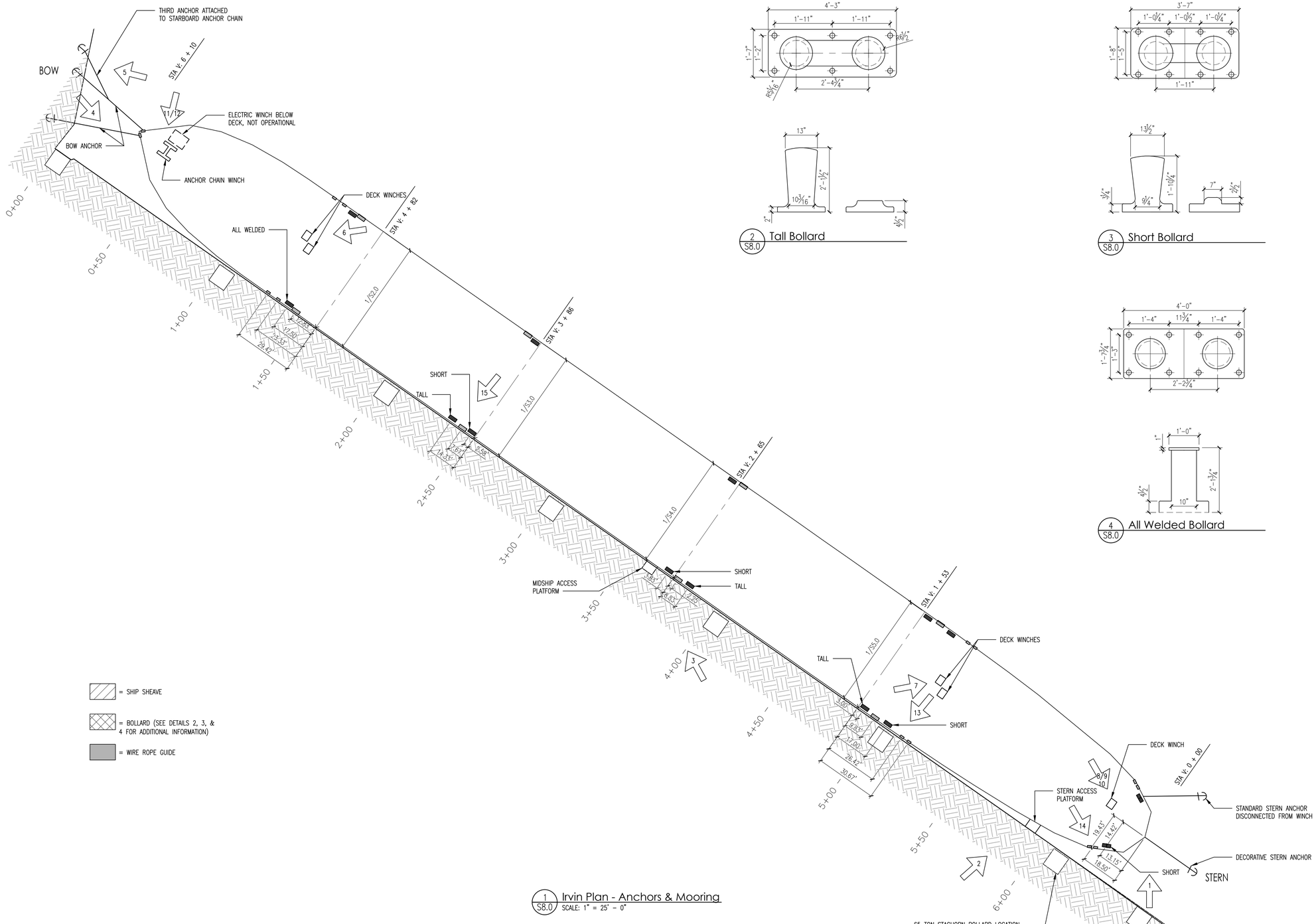

1 S8.0 Irvin Plan - Anchors & Mooring
SCALE: 1" = 25' - 0"

2 S8.0 Tall Bollard

3 S8.0 Short Bollard

4 S8.0 All Welded Bollard

REV. BY:	
DESCRIPTION	
REV:	
DATE:	

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Irvin Relocation Design
City of Duluth
350 Harbor Drive
Duluth, Minnesota

Irvin Plan - Anchors & Mooring

JOB No: 181078
DATE: 07.10.18
DRAWN BY: SAJ
DESIGNED BY: CWS

SHEET:
S8.0

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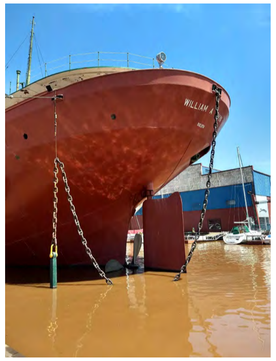
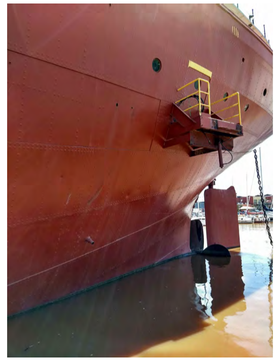


PHOTO 1



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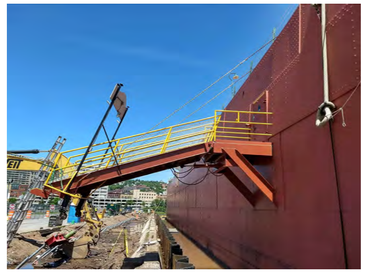

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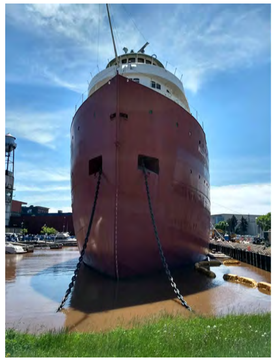

PHOTO 4

PHOTO 5

PHOTO 6

PHOTO 7

PHOTO 8

PHOTO 9

PHOTO 10

PHOTO 11

PHOTO 12

PHOTO 13

PHOTO 14

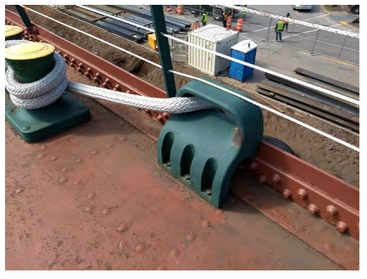

PHOTO 15

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Irvin Relocation Design
City of Duluth
350 Harbor Drive
Duluth, Minnesota

Irvin Anchors & Mooring Photos

JOB No: 181078
DATE: 07.10.18
DRAWN BY: SAJ
DESIGNED BY: CWS

SHEET:
S8.1

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