

# Manley Brothers LLC

Marine Engineering, Appraisals & Surveying

200 Benton Street  
Phone: 636-225-9106

St. Louis, Missouri 63088  
Fax: 636-225-5303

## General Condition Survey

St. Louis Port Authority

## Municipal River Terminal

### “North Dock”

Located at Upper Mississippi River (UMR) Mile 181.76

Report No. W0312-1398

At the request of Mr. Otis Williams, and for the accounts of the St. Louis Port Authority and St. Louis Development Corporation, the undersigned marine surveyor and engineer have examined the “North Dock” facility at the Municipal River Terminal at the foot of North Market Street, St. Louis, Missouri.

The purpose of the survey was to determine the general condition of the North Dock facility. It was the further purpose to document those conditions both above and below the waterline which were of interest to the City of St. Louis as per the “North Dock RFP”.

#### Dates of Survey and task description:

March 27, 2012	Side Scan Sonar Survey	St. Louis River Stage: 20 ft.
April 9, 2012	Survey the Upper Bulkhead and Dock	
April 13&14, 2012	Underwater Dive Survey	St. Louis River Stage: 7 ft.
April 15, 2012	Alignment Survey of the Sheet Piling	



## General Description

The St. Louis Port Authority Municipal River Terminal dock consists of two barge dock facilities located at the foot of North Market Street. As of this report, dated April 27, 2012 the “Middle Dock” and the rehabilitation work on the South Dock are both on going.

The “North Dock” is the subject of this survey. The North Dock consists of a steel sheet pile bulkhead consisting of type PZ-35 sheet pile with a top elevation of approximately 423 ft.. The bulkhead extends from the right descending Mississippi River Bank outward as a ‘diagonal wing wall’ over a length of 30 pairs of visible “Z sheet piles”. The North Dock main barge berthing dock face then extends in a downstream or “south” in direction of an additional 176 pair of sheet piles. See the attached drawings for more detail.

The downstream end of the North Dock has now been connected to the “Middle Dock” bulkhead as per the facility rehabilitation contract by St. Louis Bridge Co. The south end area of the North Dock is to be reinforced, re-aligned and back filled as a portion of the current work being conducted by St. Louis Bridge Co.

This survey will offer specific details about the North Dock observed in a systematic manner and denote features and conditions about the North Dock which will be referenced by “pairs” of sheet piles. As properly detailed in the attached construction drawings by Booker and Assoc. dated 7-19-83 and 8-28-89 the bulkhead has type “A”

pairs of sheet piles which have a drilled diagonal “Rock Anchor” attachment. The wall also consists of an equal number of pile pairs as type “B”. These “B” pairs of piles were prefabricated with a vertical ‘soldier pile’ Wide Flange beam attached to the interior of the pile pairs. These three piece units were driven during the construction.

These pile pairs will be numbered from north to south or upstream to downstream. The No. 1 pair of Z piles is located at the shoreward extreme end of the upstream wing-wall. The wing-wall extends at a diagonal angle relative to the river channel and ends with sheet pile pair No. 30 at the upstream “corner”. It should be noted that the design drawings indicate that the upper diagonal wing wall extends at a 30 degree angle from the main wall. The shoreward pairs of z-piles were covered with rip rap and back fill and could not be examined. The main dock face then extends downstream over a length of an additional 176 pair of sheet piles. Therefore, the North Dock consists of 206 pairs of z-piles which were visible for examination.



Aerial View at the MRT “North Dock”

### **Report Format**

As per the RFP for this project, this report has been provided to the St. Louis Port Authority in both a written and digital format, and delivered on an external memory drive.

## **Survey Details and Methods**

The examination of the MRT North Dock was conducted with the following techniques and methods:

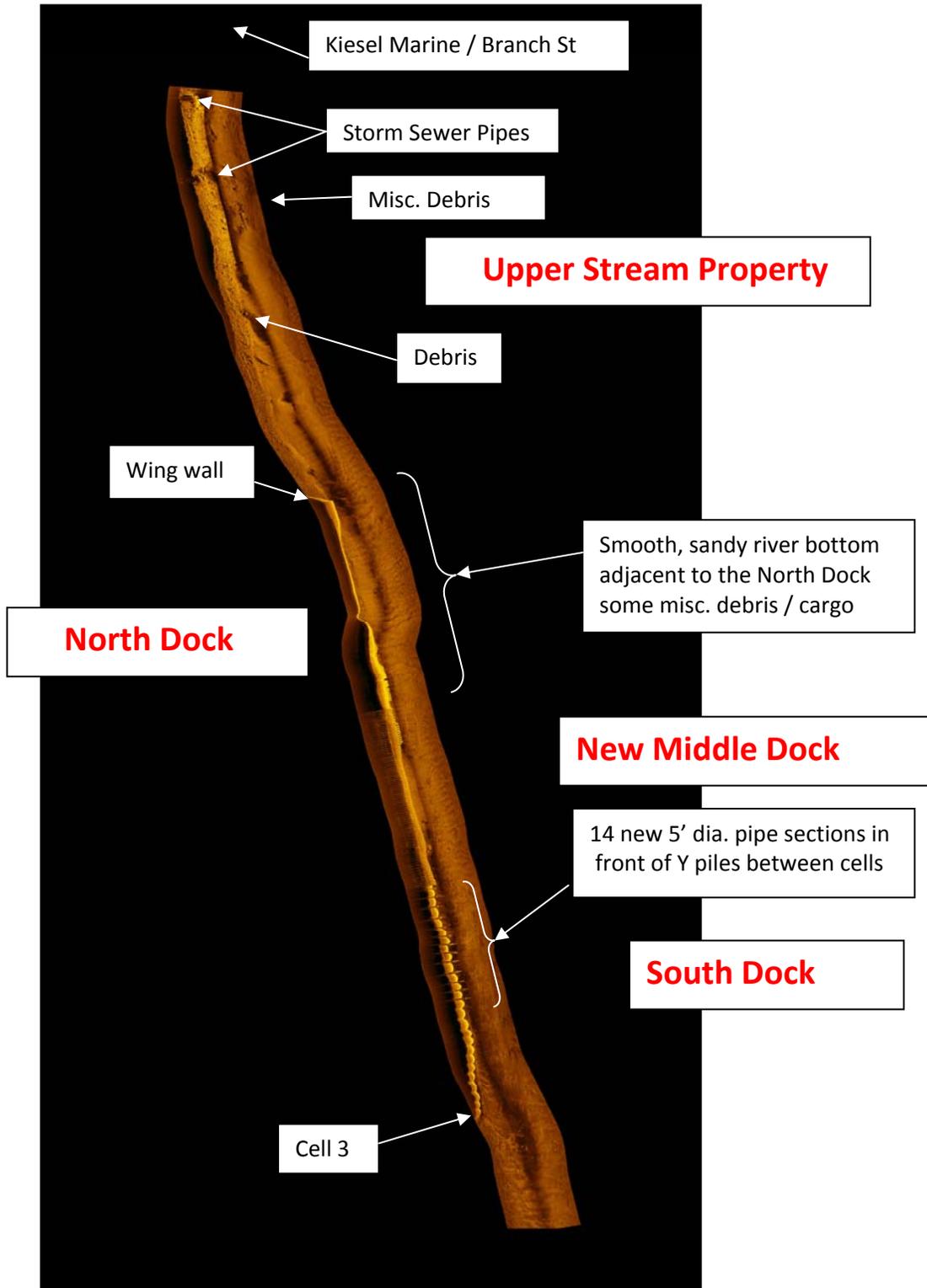
### **Side Scan Sonar**

On March 27, 2012, the facility and the adjacent river bottom were examined by River Diving and Savage with their Side Scan Sonar systems. The St. Louis River stage was approximately 20 ft. at the time of the survey. The survey was conducted with multiple passes in both the upstream and downstream directions. Both high and low frequency surveys were conducted at various target ranges. Both the 'high power' Kline and the more simple Lowerance side scan sonar systems were used to survey the river bottom and structure conditions. The side scan sonar surveys were very productive.

It should be noted that the river current and wind conditions made the examination less than ideal. Also various barges were located at the North Dock as well as along the South Dock during the survey. Please note that the attached image reflects the entire facility as surveyed. Not just the North Dock. The side scan sonar surveys revealed a great level of detail. The digital images clearly revealed a great level of detail about the dock structure as small as the sheet pile interlocks. The attached image is a mosaic of several of the Side Scan images. This large format image is best viewed digitally on screen to allow a level of magnification. This image, due to its size does not offer the significant detail in a print format. However, it does offer an overall view of the river conditions of the entire site.

The side scan sonar survey revealed that the upper portions of the site property river bank have been well stabilized with rip rap and construction debris. The river bank armament stone extend to a typical uniform 'toe'. Extending out from the stone rip rap, the river bottom is typically smooth sandy bottom. A few misc. areas of debris were noted which, if removed, would allow a safe barge fleet to operate in the area.

In general the area was found to be in very good order and generally free of debris. It should be noted that the area adjacent to the north dock had been recently dredged with mechanical dredge equipment, by Gateway Dredging, to return the area to sufficient water depths to accommodate loaded barges. It was reported that 30,000 tons of river sand and sediment had been removed. As a matter of record, it was also reported that Gateway Dredging and St. Louis Bridge Co. had removed a total of 800 tons of misc. spilled cargo and debris from along the south dock and along the 'middle dock' areas as part of the preparation work to drive sheet pile for the large rehabilitation work.



River Diving and Salvage Side Scan Sonar Image

### **Deck and Crane Pad Survey**

On April 9, and again on April 14, 2012, the undersigned surveyor and engineer examined the North Dock along the back filled areas of the sheet pile bulkhead.

### **Underwater Examination by Divers**

On April 13 and 14, 2012, the divers of River Diving and Salvage conducted an underwater examination of all of the sheet pile on the North Dock. The adjacent areas of river bottom were also examined for spilled cargo debris of noteworthy conductions. The dive survey was conducted with surface supplied, heavy dive gear. The divers utilized down lines and thoroughly examined 100 percent of all of the sheet piles of the North Dock. Each sheet pile was examined by the divers by feeling each interlock and the adjacent areas of web. The mild river conductions at the time of the survey allowed safe and reasonably comfortable survey. The attending surveyor was present during the entire inspection and directly interviewed the divers via top side communication regarding any noteworthy conditions. The survey was conducted in a systematic manner denoting each pair of sheet piles. The detailed results of the survey are included later in this report.

### **Ultrasonic Thickness Survey**

The sheet pile bulkhead materials were examined with non-destructive testing methods via ultrasonic thickness testing. (U/T) The pile surfaces were ground smooth with a cordless grinder at various locations above the water level. The U/T survey was conducted using a Krautkramer Branson meter which had been recently calibrated. The U/T survey was conducted from the dive boat at a river stage elevation of about 10-feet which was considered to be near the middle of the “Splash Zone”.

### **Alignment Survey**

The alignment of the sheet pile bulkhead was recorded as follows:

The top of the bulkhead sheet piling were visually examined by sighting along the length of the wall. See the attached photographs. The piles were also measured for lean ‘out of plumb’ with a 4-foot standard construction level. The vertical alignment examination was conducted both near the top of the bulkhead as well as toward the lower portions of the wall, just above the water line. It was noted that the sheet pile areas above the rock anchor penetrations had moved / rotated outward toward the river. Below the rock anchors the bulkhead was generally plumb. The details of this survey are attached.



**Alignment of the North Dock referenced from the new Middle Dock Beams**

### **Alignment Reporting**

The North Dock face was surveyed for alignment in comparison to the new Middle Dock face. A parallel line was established using the shore-side flange face of the Middle Dock W40 x 324 “King-Piles” as reference and transferred to the north along the length of the North Dock. Measurements were taken from the center sheet pile interlock of the river-side dock face to the reference line, with the recorded dimension subtracted from the design dimension of 40.76-inches. The final dimension determined the alignment in-line, shore-side or river-side of the Middle Dock face.

Please understand that this means of reference will need to be re-established in future surveys due to the fact that the Middle Dock was not backfilled or the tie-back and dead-men system was not in place on the day of survey and may likely move from that position when those activities take place. Also understand that the North Dock wall from Sheet Pile Pair # 194 thru Pair # 204 were not backfilled at the time of survey but are included in the South Dock Re-Construction scope to be reinforced, re-aligned, and backfilled.

An order-of-magnitude description of the results of the alignment survey is as follows. A complete reporting of the wall alignment is included as an attachment to this report:

**Manley Brothers LLC**

The top of the North Dock wall waves from the shore-side, into alignment, and to the river-side throughout its 664-foot length. For example, the up-stream limit of the dock wall (Corner # 30) is approximately 5.75-inches shore-side of the Middle Dock face; at numerous locations including Pair # 106 the wall is in-line with the Middle Dock wall, at Pairs # 129 thru #145 the wall is shore-side approximately 10.0-inches; and at Pairs # 173 to # 176 the wall goes to the opposite direction at 10.0 to 12.0-inches river-side. The extreme case is at the southern end of the North Dock where Pairs # 190 and 191 are 12.87-inches and 17.86-inches river-side respectively, but should be brought back into alignment during its re-construction.

The design drawings provided by ABS Consulting as SN-01 sheet 49 of 51 provides an accurate documentation of the general misalignment of the south ‘unfinished’ end of the North Dock.

### **Plumb Condition Reporting**

The lower portion of the sheet pile wall was measured for plumb using a standard construction level equaling 8-feet in length. The bottom of the level was positioned at the water line and the upper portion in contact with the sheet pile face. The level was held in a plumb position with a measurement taken of the distance between the level and the sheet piling.

Measurements were taken at each pair of sheets along the riverside face of the dock wall starting with Pair # 12 of the diagonal wall, continuing to Pair # 30 at the corner to the dock wall parallel to the river channel, and continuing along the face of the dock wall to Pair # 204.

Results of the lower wall, (near Elv. 390 ft. / 10 ft.) plumb readings are as follows:

#### **Up-Stream Diagonal Wall ( all Lean toward River):**

Plumb: 45.0%

Less than 0.50-Degree: 25.0%

Greater than 0.50 but less than 1.0-Degree: 20.0%

Greater than 1.0 but less than 1.5-Degree: 5.0%

#### **Dock Wall (all Lean toward River):**

Plumb: 6.54%

Less than 0.50-Degree: 31.78%

Greater than 0.50 but less than 1.0-Degree: 30.84%

Greater than 1.0 but less than 1.5-Degree: 17.76%

Greater than 1.5 but less than 3.0-Degree: 7.48%

Greater than 3.0 but less than 4.0-Degree: 2.80%

Greater than 4.0 but less than 5.5-Degree: 1.87%

The upper portion of the sheet pile wall (near Elv. 420 / 40 ft.) was measured for plumb using a 4-foot standard construction level. A 3-inch spacer was attached to the bottom of the level and held beyond the face of the dock wall. The level was held in a plumb position with a measurement taken of the distance between the level and the top of the sheet piling. The recorded measurement was subtracted from the 3-inch spacer dimension to determine the final distance from plumb.

Measurements were taken at each pair of sheets along the riverside face of the dock wall starting with Pair # 02 of the diagonal wall, continuing to Pair # 30 at the corner to the dock wall parallel to the river channel, and continuing along the face of the dock wall to Pair # 204.

Results of the upper wall (near Elv. 420 / 40 ft.) plumb readings are as follows:

Up-Stream Diagonal Wall (Lean toward River):

Plumb: 0.0%  
Less than 0.50-Degree: 13.33%  
Greater than 0.50 but less than 1.0-Degree: 46.67%  
Greater than 1.0 but less than 1.5-Degree: 33.33%  
Greater than 1.5 but less than 2.0-Degree: 6.67%

Dock Wall (Lean toward River):

Plumb: 0.0%  
Less than 0.50-Degree: 0.0%  
Greater than 0.50 but less than 1.0-Degree: 7.50%  
Greater than 1.0 but less than 1.5-Degree: 6.25%  
Greater than 1.5 but less than 3.0-Degree: 41.25%  
Greater than 3.0 but less than 4.0-Degree: 41.25%  
Greater than 4.0 but less than 5.5-Degree: 3.75%

**Specific Scope or Work items, as per the RFP, which were noted during the survey:**

**River bottom elevations along the dock face**

The March 27, 2012 side-scan sonar examination as well as the April 13 and 14 dive surveys revealed that the river bottom in the areas adjacent to the North Dock bulkhead were generally flat, smooth and stable. The water depths at the time of the dive survey were noted to be from 12 ft. to 16 ft. The typical river bottom stage elevations were noted to be from -5 ft. to -9 ft. or Elv. 375 ft. to Elv.371 ft.. The design documents reveal

an original, nominal bottom elevation of 368 ft. The middle portions of the North Dock near sheet pile pair No. 136 thru 150 were more shallow.

The attached hydrograph of the area was conducted by the US Army Corps of Engineers and generally reveals the contours of the river bottom in the area.

It should be noted that the river bottom depths adjacent to the upper portions of the North dock had experienced a level of siltation which negatively affected the utility of the dock. The area had been dredged just prior to our survey. The attached USACE survey was conducted prior to the dredging.

As a matter of record the following details should be considered. The USACE has installed a series of 3 stone ‘chevrons’ as river training structures in the middle areas of the river ending just upstream and out ward from the North Dock. These chevrons may be a source of siltation at the North Dock. This situation is subject to further study by the USACE which will not conclude by the date of this report.

It should also be noted that in 2010 and 2011 the Missouri River experienced extraordinary and massive flooding. The prolonged periods of high flow rates and elevated river depths may have created a level of siltation along the North Dock which may not be ordinary or typical.

In conclusion, the North Dock area remains a viable barge terminal facility during all by exceptional low water periods.

Further, long term review of the effects of the chevrons is required.

#### **Locate debris, spilled cargo from the face out 40’**

The nature of the river currents and working from a small dive boat tethered to the North Dock did not allow the divers to have a level of freedom to safely explore the entire river bottom from the bulkhead outward 40 ft. The divers were generally restricted with within 3 to 4 feet of the bulkhead to which they were secured. However, the side-scan sonar surveys were utilized to determine that the areas of river bottom from the bulkhead outward 40-feet were generally free of significant debris or dropped cargo. A few random pieces of debris such as logs were noted adjacent to the upper portions of the north dock. None of these appeared to be significant in size or location.

#### **Underwater examination notes and details**

The specific details noted by the divers were recorded as follows:

All of the sheet pile interlocks on the 206 sheet pile pairs on the North Dock were found to be intact and in good order. No sheet pile splice failures were noted by the divers. No areas of sheet pile failure was noted which created leaks of the back fill ballast sand.

The “underwater” portions of the sheet piles were in good order. The upper, visible portions of the bulkhead displayed more significant conditions.

As expected, the lowest portions of sheet pile which were always underwater displayed little to no corrosion, as per the divers feel. The sheet pile surface areas displayed rough areas of pitting and corrosion from a river level of about -2 feet and upward. The visible portions of the sheet pile, above the river levels displayed rough areas of corrosion pitting and general wear up through river levels of about +20 feet. The upper portions of the sheet pile generally did not display corrosion conditions.

However, a few random sections of sheet pile did display corrosion and de-lamination which extended from the top of the sheets downward, apparently due to cargo contamination. These details will be described in another area of this report.

The kevels and all fixtures underwater were found to be in good order.

#### **Sheet Pile Thickness and Corrosion**

As described above, the sheet pile thickness was examined at various locations. 1983 Archive design documents detail that the PZ-35 Sheet Piling had a flange thickness of 0.600-inches.

Random gage reading's taken along the length of the North Dock wall, each at or about the river elevation of +10-feet.

#### Up-stream Diagonal Wall (inches):

Pair # 12: 0.537”

Pair # 27: 0.519

Pair # 30: 0.544

#### Dock Face:

Pair # 31: 0.537

Pair # 128: 0.477

Pair # 35: 0.532

Pair # 132: 0.449

Pair # 47: 0.515

Pair # 142: 0.438

Pair # 69: 0.501

Pair # 184: 0.584

Pair # 78: 0.460

Pair # 204: 0.560

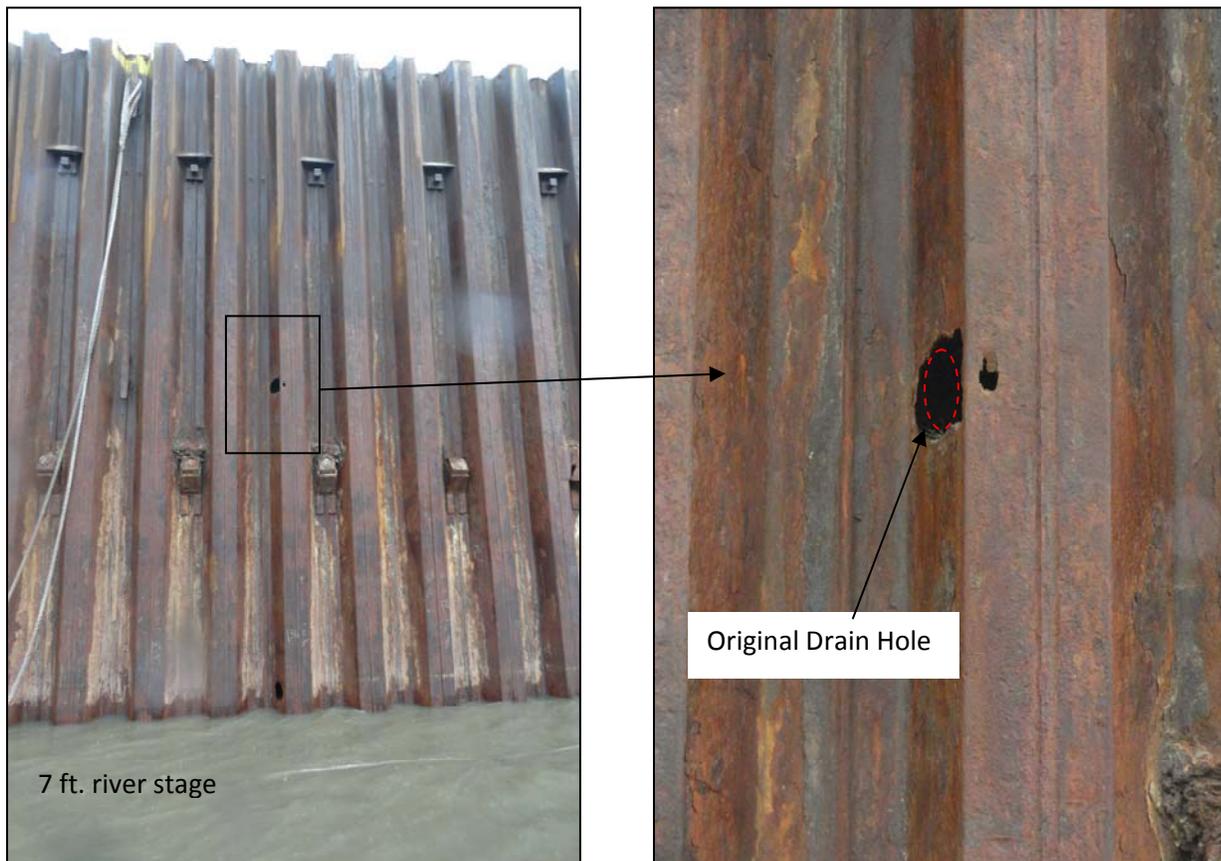
Pair # 116: 0.552

In general, the following conclusions were obtained:

When using 0.515-inches for an average remaining flange thickness, and 28-years of use, a corrosion rate of 0.003 per year is calculated. However, the most severe areas of corrosion revealed:  $.600''$  original -  $.438'' = .162''$  loss. This is a 27% loss of section and a corrosion rate of  $.0062''$  per year. (Assumed the new construction was 1986 = 26 yrs in service.)

The sheet pile adjacent to the hydraulic drain port on Sheet Pile Pair 130 was found to be corroded completely thru the  $.600''$  face of the pile. This corrosion rate would be approximately  $.023''$  per year. This condition will likely continue. The loss section modulus of the sheet pile pair will ultimately create a localized failure.

**This area of sheet pile should be closely monitored and considered for repair.**



**View at Sheet Pile pair No. 130 which displays extensive corrosion to the PZ-35 sheet pile. The corrosion has extended thru  $.600''$  of steel at the upper drain hole near Elv. 384**

### **Sheet pile top conditions**

The tops of the sheet piles have been distorted and rolled outward along the majority of the dock face. The sheet pile interlock has been forced apart as the sheet pile tops were deformed, presumably by contact with the crane tracks during cargo unloading operations.

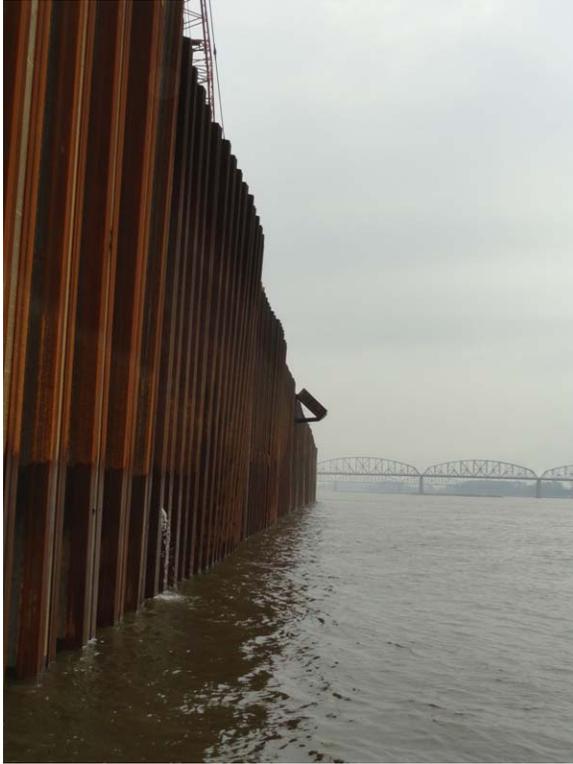
At this juncture the pile top deformations appear to be confined to the upper 4 to 6-inches of sheet pile. See the photographs for more detail. It would appear that the damage conditions have 'stabilized'. Further contact between the distorted sheet tops and the crane tracks is now not likely to cause further deformation to the lower portions of the sheeting.

If the sheet pile deformations were repaired by removing the upper portions of back fill and by burning off the deformed sections of sheet pile, there is a high likelihood that the freshly exposed, straight sections of sheet pile would be damaged in the same manor.

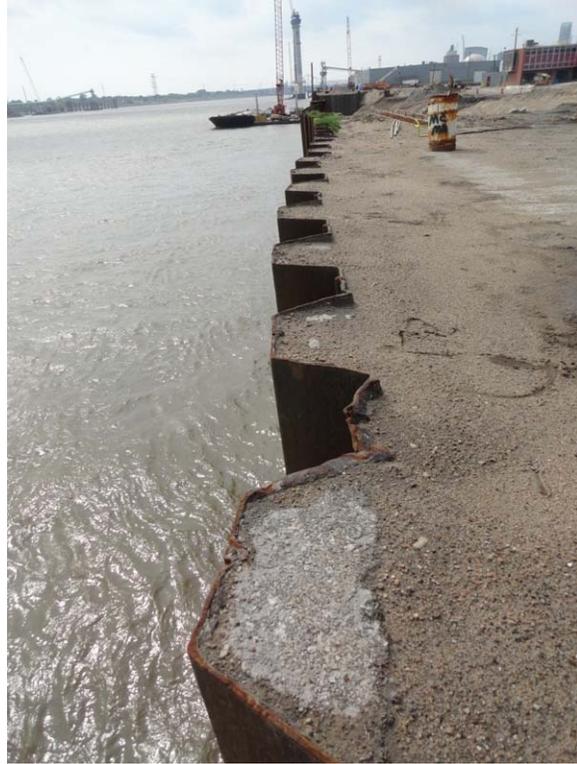
### **Photographs of the Dock**

This survey included photographic documentation of the north dock features from various vantage points including from the dock deck areas and from the survey boats. These photographs have been provided in electronic format via a jump drive.

Photographs which offer a representative sample of the North dock conditions are as follows:



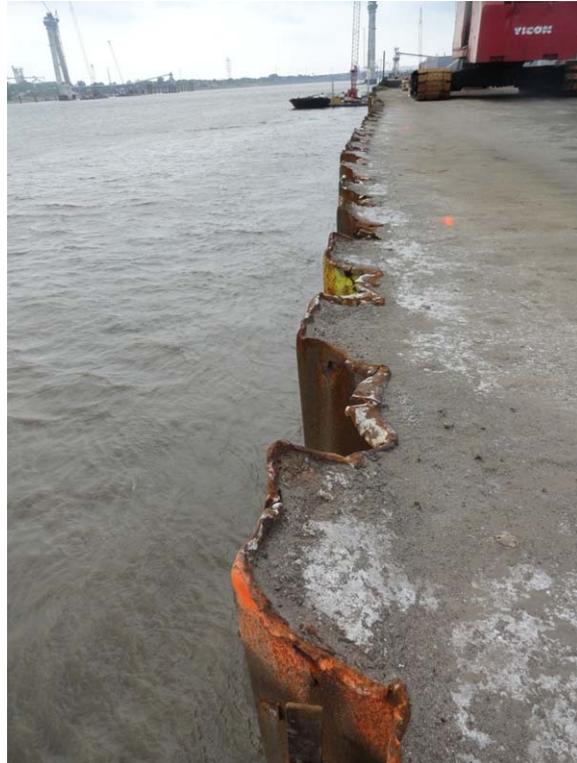
WALL ALIGNMENT (LOOKING UP-STREAM)



WALL ALIGNMENT (PAIR # 170)



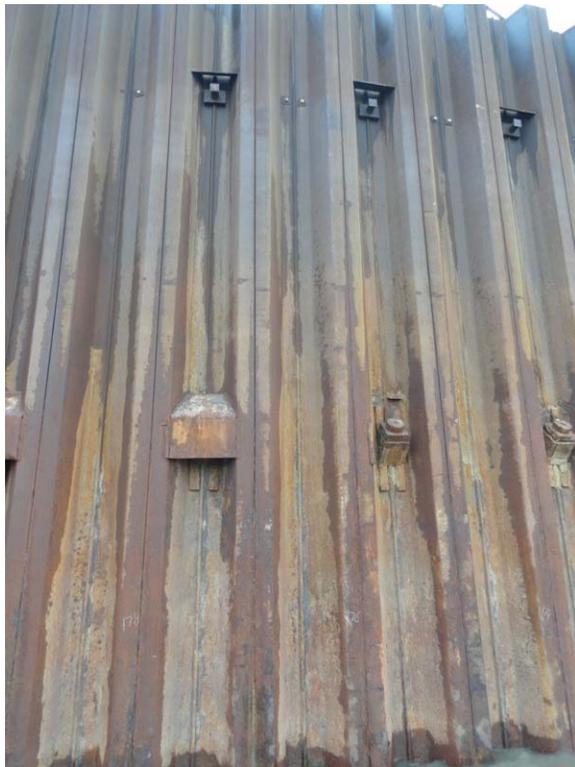
DRAIN CORROSION (PAIR # 130)



TOP OF SHEETING DAMAGE (PAIR # 59.5 THRU 99.5)



LADDER DAMAGE (PAIR # 110.5)



ROCK ANCHOR COVER PLATES - MISSING



TYPICAL ASPHALT ADAMAGE (PAIR # 59.5 THRU # 77.0)



ASPHALT DAMAGE (PAIR # 59.5 THRU # 77.0)

Additional photographs have been included in the digital format of this report.

**Proposed repair items for future consideration**

Sheet pile top deformations. This condition should be monitored.

Rock Anchor cover / protection plate repairs.

Sheet pile hydrostatic drain discharge areas repair and reinforcement

Ladder repair and reinforcement

Asphalt repair

Dock surface storm water run-off control

Address the random areas of corrosion.

**Suggested Long Term Maintenance Items**

Detailed examinations of the rock anchor tie head assemblies

Corrosion study of the rock anchor locations

Corrosion study of the damaged / scaly areas of sheet pile

“Preventative maintenance” approach required vs. “fix when broke” approach.

### **Bulkhead tie back conditions**

The upper dead-man tie back locations all appear to be in good order. This high elevation allows the tie back penetration to experience less wet - dry cycles and therefore less corrosion. It should be noted that the bulkhead is secured with lower diagonal “rock anchors” as a lower tie back system. After the initial installation a second level of tie back system was installed. The upper tie backs are secured to a concrete “dead man” wall.

The lower rock anchor tie backs appear to be in good order. Many of the “protection cover plates” have been damaged and / or torn off. This has been brought to the owner’s attention previously and no actions have been taken to reinstate the protection.

It was noted that the dock is currently being used as a general storage area for bulk sand, salt and coal. The large piles of bulk materials may be placing surcharge loadings on the dock which maybe in excess of the design intent. We suggest that the ‘dock operations’ be reviewed by an engineer to determine if the typical operating methods may lead to premature failure of the dock systems. Further, the heavy corrosion rates that some areas of sheet pile have sustained should be addressed.

### **Deck area Conditions adjacent to the Bulkhead**

The undersigned surveyor examined the dock surface areas adjacent to the bulkhead and found the areas to be in generally good order. No “potholes” were noted. The area did not display any subsidence or indication that the bulkhead was leaking back fill in any area.

The ‘crane platform’ areas appeared to be multiple courses of asphalt paving. Design documents indicated a thickness of 2-feet and a width of approximately 40-feet. An area of ‘wear course’ asphalt directly behind the dock wall has been damaged and is in need of repair. The extent of the damage is approximately 65-feet long at the dock wall, (Pairs 59.5 to 77.0) and continues at a diagonal direction toward the north, approximately 50-feet, and away from the dock face to a total width of approximately 30-feet. A minimum of 4-inches of thickness has been damaged and missing, and could be as much as 8-inches in some areas.

The remainder of the dock area was noted to be aggregate and in good order.

The dock surface topography was noted to be inconsistent. The majority of the North dock surface drained away from the sheet piles. Large shallow puddles of standing water were noted away from the bulkhead. The truck traffic atop of spilled or ‘run off’

cargo has solidified the aggregate surface to a level which restricts free drainage of the dock areas.

### **Kevels, Ladders, Fittings and guard rail conditions**

Mooring kevels were located at 3-elevations along the face of the dock wall. All were found to be in generally good order. The kevels were located at sheet pile Pairs # 32.5, 52.5, 72.5, 92.5, 112.5, 132.5, 146.5, 166.5, and 186.5.

The kevels were located at elevations 420, 402 and 384. Or at 3 ft. below the top of the wall. At approximately the 22 ft. river level. The lowest kevels were underwater at the time of the survey near the 5 ft. river stage. The Dive Survey noted them to be in good order.

It should be noted that the kevels were welded to the sheet pile pairs in the 'valley' of the Type B piles which have wide flange beams welded to the interior of the sheet pile pairs. The kevels were installed after portions of the interlocks were removed. All of the fittings were in good order. No areas of sheet pile damage or strain were noted adjacent to the fittings.

The ladders were found to be typically welded steel flat bar with rebar rungs. The ladders did not extend above the sheet pile tops, and did not appear to be OSHA complaint.

The ladders were located at Sheet Pile Pairs # 30.5, 70.5, 110.5, 144.5, and 184.5.

Specific ladder damages were notes as follows:

Pair # 30.5 –

- Bottom rail connection to sheet pile was loose.

Pair # 70.5 –

- Top rungs damaged.
- Bottom rail connection to sheet pile was loose.

Pair # 110.5 –

- Top and bottom rungs damaged.
- Bottom rail connection to sheet pile was loose.

Pair # 144.5 –

- Bottom rail connection to sheet pile was loose.

Pair # 184.5 –

- Rungs damaged at EL. 397.0.
- Bottom rail connection to sheet pile was loose.

### **Crane and Cargo damage to sheet pile**

As previously described above, the upper portions of the sheet pile were crushed and deformed from the top of the sheet pile pairs extending downward from 4 to 6-inches. The deformed sheet piles were rolled outward and flared. The sheet pile interlocks have been forced apart to conform to the deformations. These conditions were noted along a 150-foot length of the dock wall from Pair # 59.5 to Pair # 99.5.

### **Spilled Cargo and surface conditions**

The dock top deck surface and the sheet pile bulkhead were subject to routine contact with cargo spillage or dust in all areas.

The North Dock deck surface was generally kept 'bobcat clean' extending from the bulkhead landward over a width of at least 20 ft.

### **Conditions “beyond normal wear and tear”**

In way of the upstream diagonal wing wall section of the bulkhead, the sheet pile Pair # 27 was apparently impacted by a barge and set in from 0 to 4 inches over a height of 8-feet centered at the . The sheet pile interlock in the damaged area is in good order.

Ladders have been damaged, not worn/ corroded.

The areas of cargo contamination which have created large areas of sheet pile delaminating and corrosion should be addressed. If not corrected and / or stabilized these areas of localized corrosion will create a shortened working life of the overall dock facility.

The above survey report is submitted by the undersigned independent marine surveyor and engineer without prejudice to the rights of all parties concerned.

---

William J. Manley P.E.  
**Manley Brothers, LLC**

---

Neil Anderson  
**Manley Brothers, LLC**