INTERSTATE 5 LIFT SPAN TRUNNION REPLACEMENT

3 MAIN TYPES OF MOVABLE BRIDGES

Most common is the bascule style

Typically used for shorter span lengths

Offers unlimited vertical clearance

3 MAIN TYPES OF MOVABLE BRIDGES

Vertical lift bridges are also quite common

This style is often used for longer span lengths

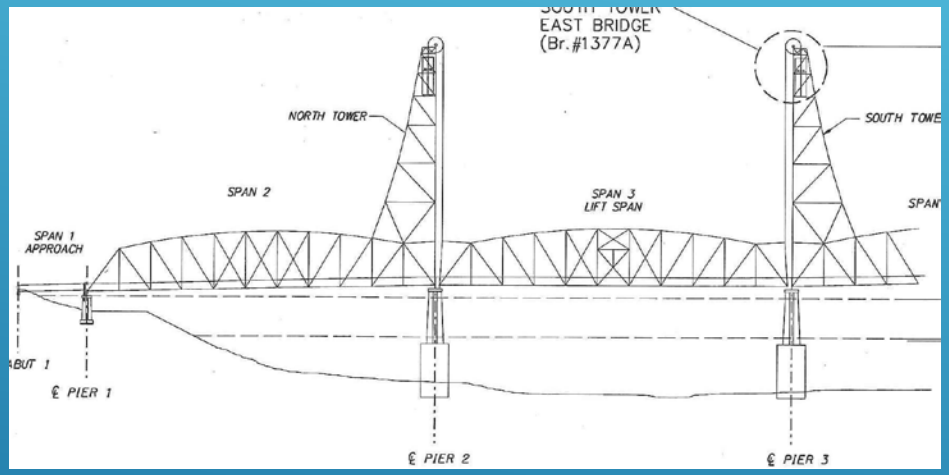
Have limited vertical clearance

3 MAIN TYPES OF MOVABLE BRIDGES

Swing spans are less common then bascules or lift spans

Often used for longer spans

LIFT SPAN OPERATION

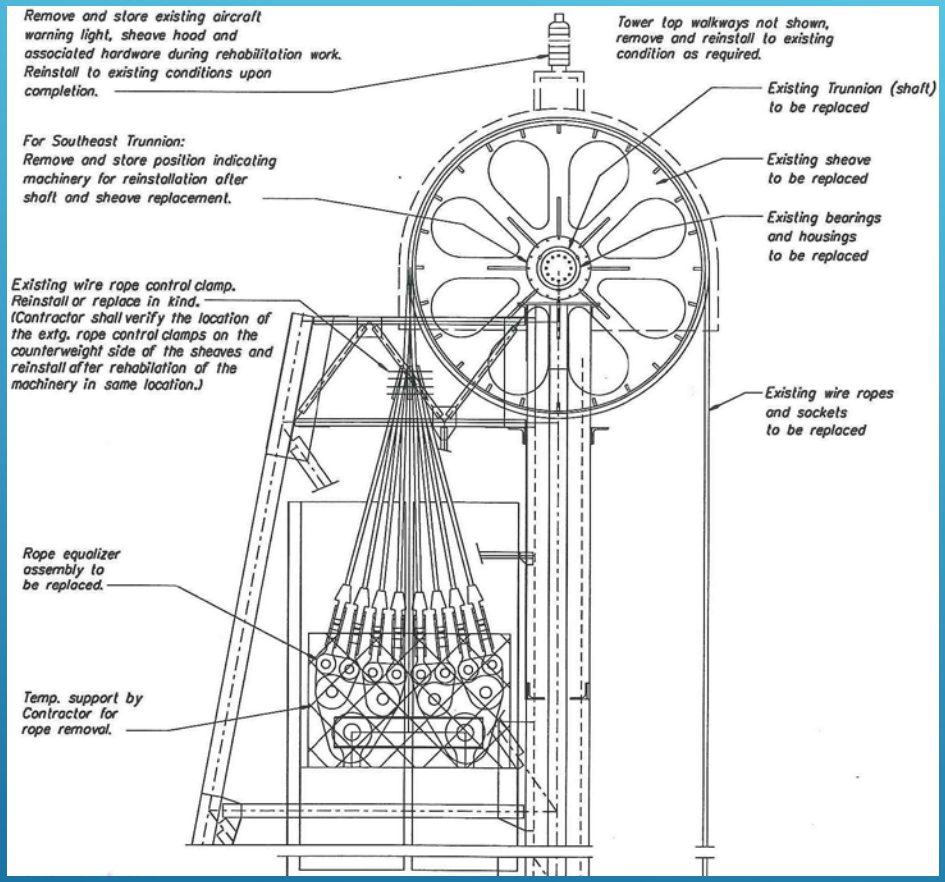


The lift span is balanced by the counterweights in each tower

The lift span is connected to the counterweights via large wire ropes

The wire ropes pass over the sheave/trunnion assemblies which allow low friction motion for raising and lowering the lift span

As the span goes up, the counterweights go down and vise versa



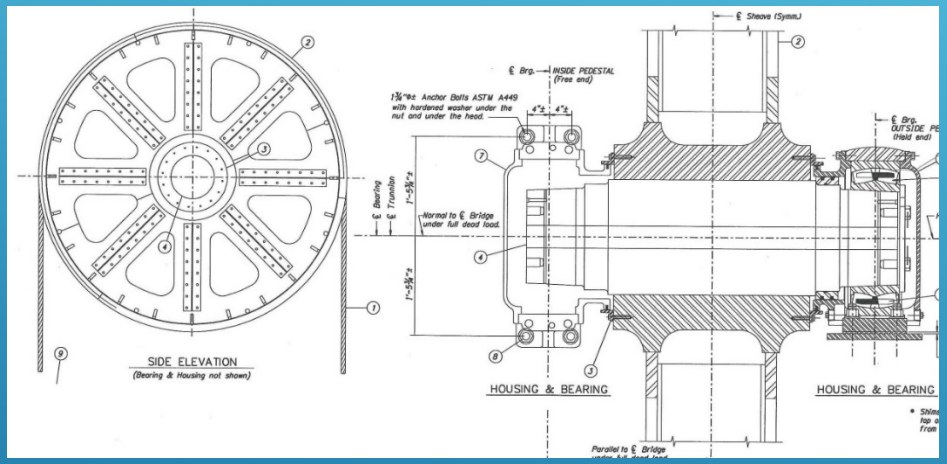
SHEAVE/TRUNNION

The sheave and trunnion assembly is much like a pulley

The heavily loaded wire ropes ride over the sheave as the sheave rotates

The trunnion supports the sheave in bearings on each of its ends to allow low friction rotation

TRUNNION IS SUPPORTED BY BEARINGS



The trunnion is fixed to and rotates with the sheave

At each end the trunnion is supported by bearings to allow low friction rotation

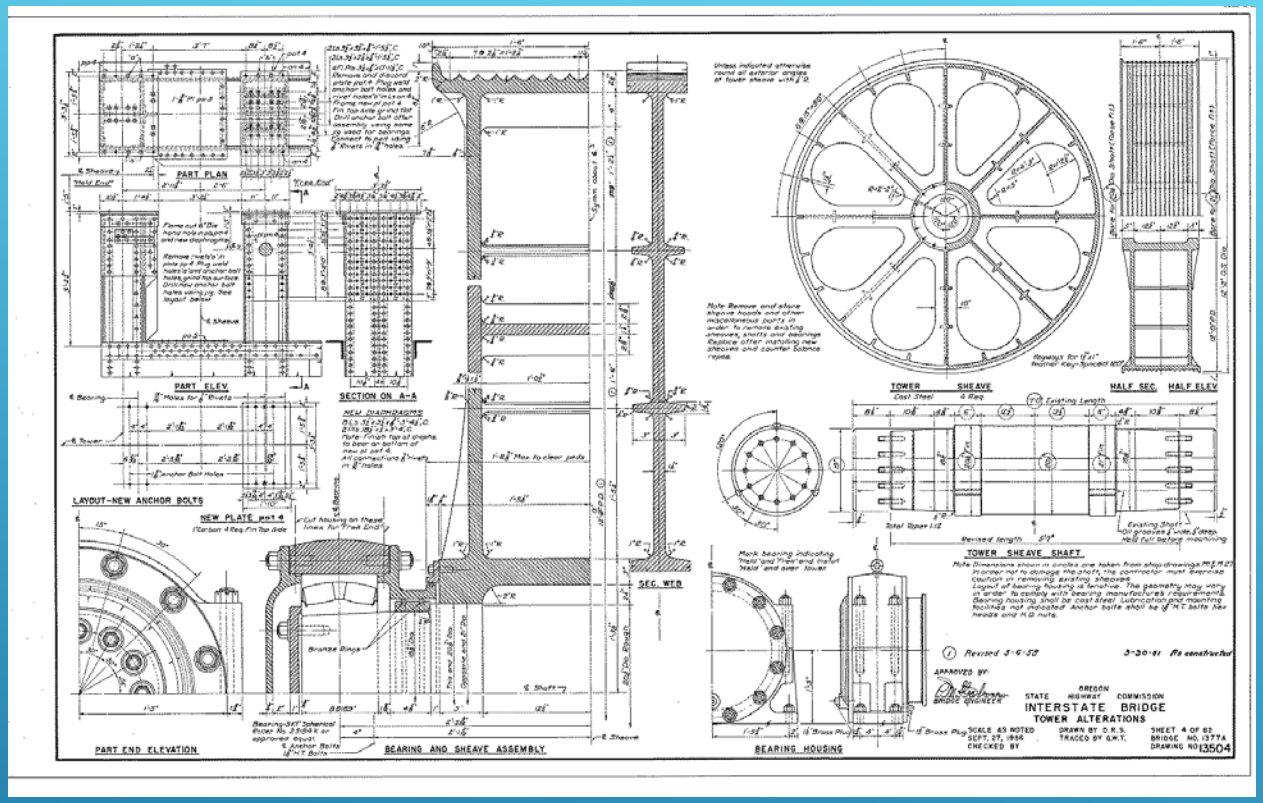
Shown here are modern rolling contact bearings

BEARING DESIGN HAS CHANGED OVER THE YEARS

The original bearings in the Interstate bridge (built in 1917) used a plain steel journal riding in a bronze bushing

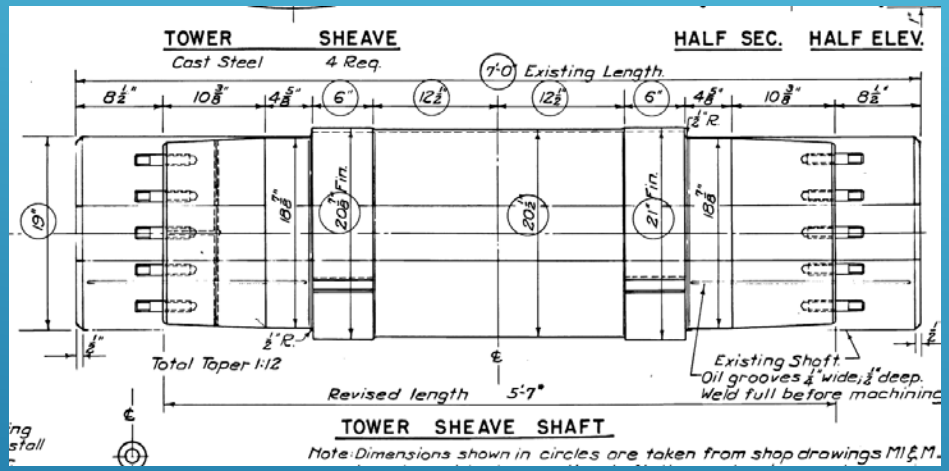
Grease between the journal and bushing provides for relatively low friction

Circa 1950's rolling contact bearings became more commonly used due to extremely low friction compared to the old plain journal / bushing style bearings



1958 CONVERSION TO ROLLING CONTACT BEARINGS

1958 REBUILD



New sheaves and bearing were installed in 1958.

The original trunnion shaft was welded and machined to accommodate the new rolling contact bearings.

Poor welds located in high stressed regions of the trunnion eventually lead to fatigue cracking of the trunnion.

The trunnions on the north tower cracked first which was discovered in 1994.

ULTRASOUND USED TO INSPECT FOR CRACKS

Fig 1.2 – 1997 UT examination of northeast trunnion (east face)

NORTH TRUNNION READY FOR FORENSIC ANALYSIS 1998

Fig. 3.4 – Trunnion after removal from sheave and prepared for NDE

IN SERVICE TRUNNIONS ARE INSPECTED WITH ULTRASONIC TESTING

WELDED GREASE GROVE DEVELOPS CRACK

b) Defect 1B. Note dissimilar metals defining the weld filled oilway

Fig. 3.5 – Defects at keyways detected by MT examination

18

SECTION OF ACTIVE CRACK

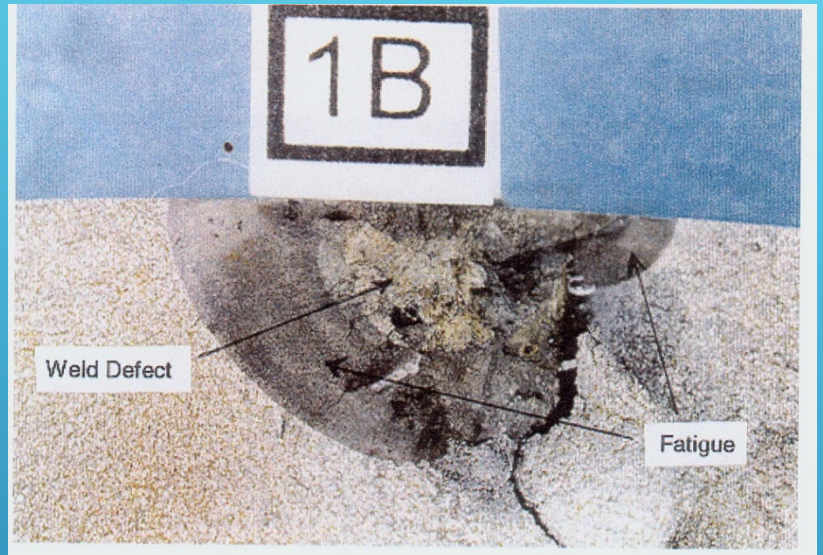


Fig. 4.2 – Initial defect at keyway 1B with fatigue crack extension after ultrasonic cleaning. (ATLSS)

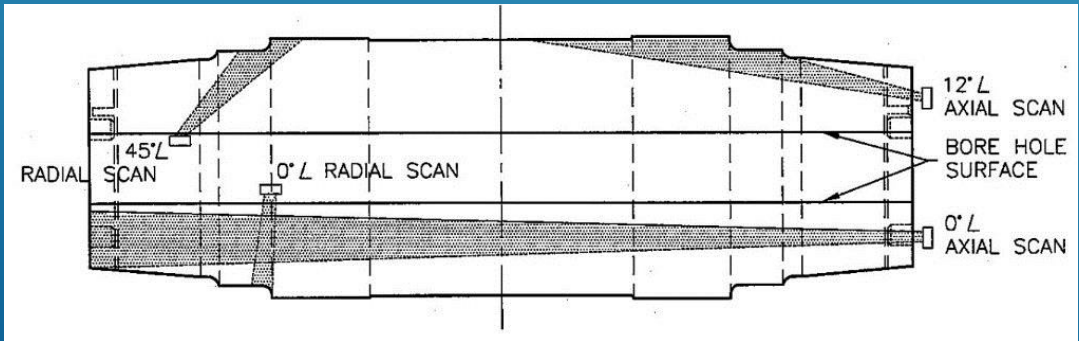
1998 FORENSIC ANALYSIS FINDS FATIGUE CRACKS IN TRUNNION

OLD TRUNNION PROVIDES NEW IMPROVED INSPECTION CAPABILITY

With knowledge gained from the 1998 forensic analysis of the cracked trunnion a much improved Ultrasonic Testing procedure was developed

This testing has allowed ODOT to monitor the two trunnion shafts on the south tower

Small cracks were first detected in 2011 and have been monitored since



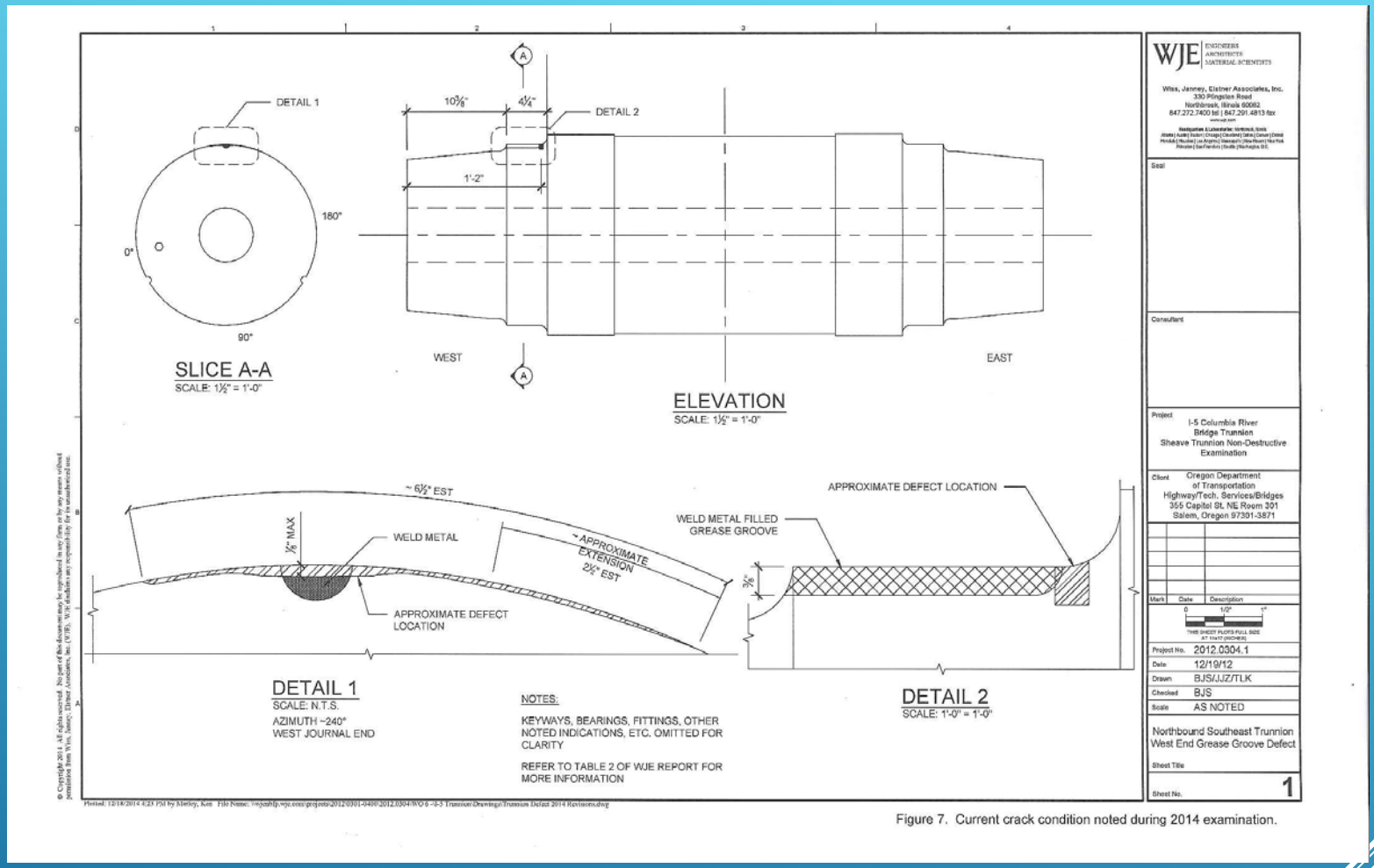


Figure 7. Current crack condition noted during 2014 examination.

2014 SHOWED SIGNIFICANT CRACK GROWTH

TIME TO PLAN FOR REPLACEMENT OF THE SOUTH TRUNNIONS

- 1996 replacement took 6 months with a 7 day shut down of the bridge
- The project was expedited due to lack of knowledge of the crack in the trunnion and concern it was not safe
- Knowledge of the cracking from the 1998 forensic analysis allows for a normal construction schedule this time

REPLACEMENT SEQUENCE

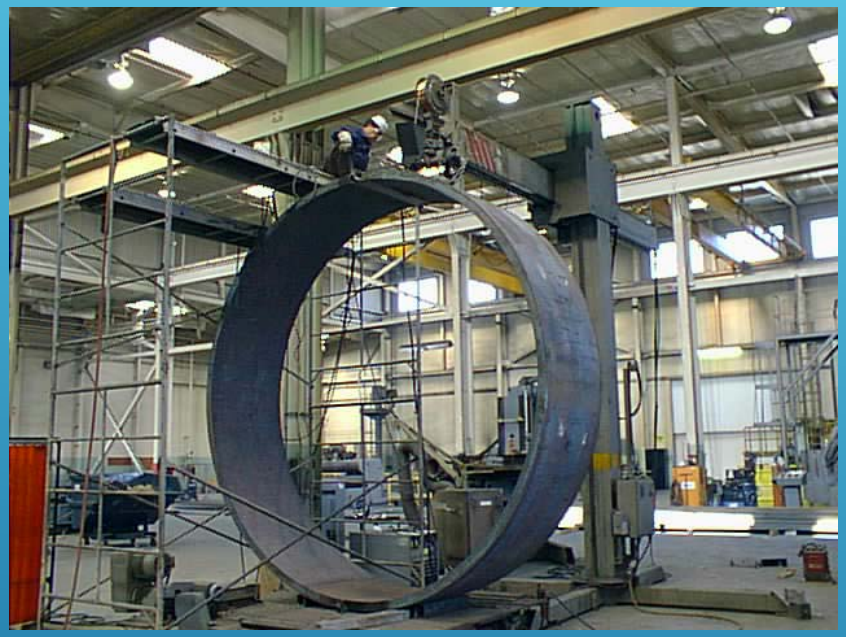
- Fabricate new sheaves, trunnions, bearings, wire ropes to replace existing on south tower
- Fabricate temporary counterweigh support structure
- Install support structure
- Shut bridge down and replace equipment on south tower
- Open bridge and remove temporary works

NEW TRUNNION BEING MACHINED

MACHINING SHEAVE HUB

FABRICATE NEW COMPONENTS

WELDING SHEAVE RIM



SHEAVE WEB

FABRICATE NEW COMPONENTS

ASSEMBLING SHEAVE

SHRINK FIT OF TRUNNION TO SHEAVE

FABRICATE NEW COMPONENTS

INSTALLING ROLLER BEARINGS

READY FOR PAINT

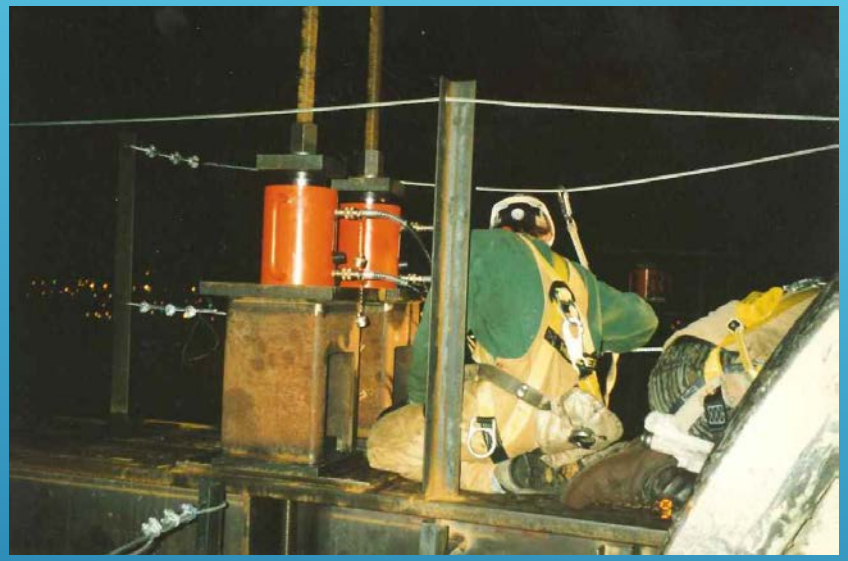
FABRICATE NEW COMPONENTS

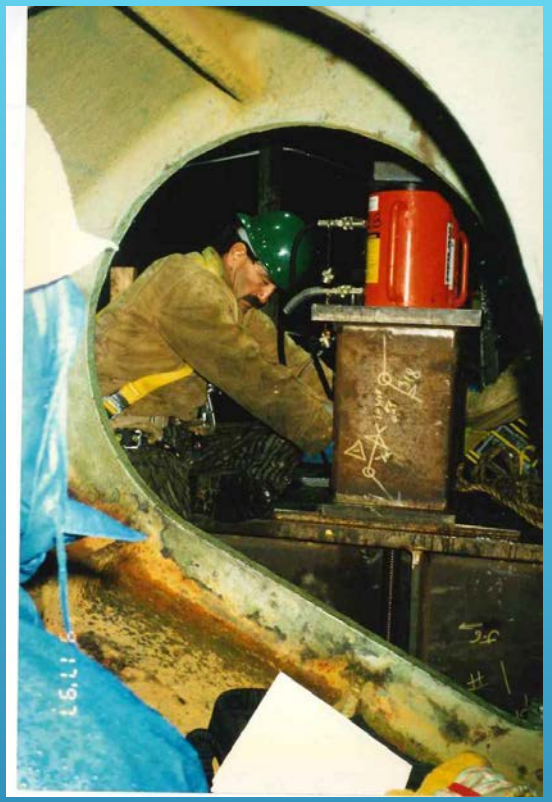
ERECT TOWER CRANE

ERECT TOWER CRANE

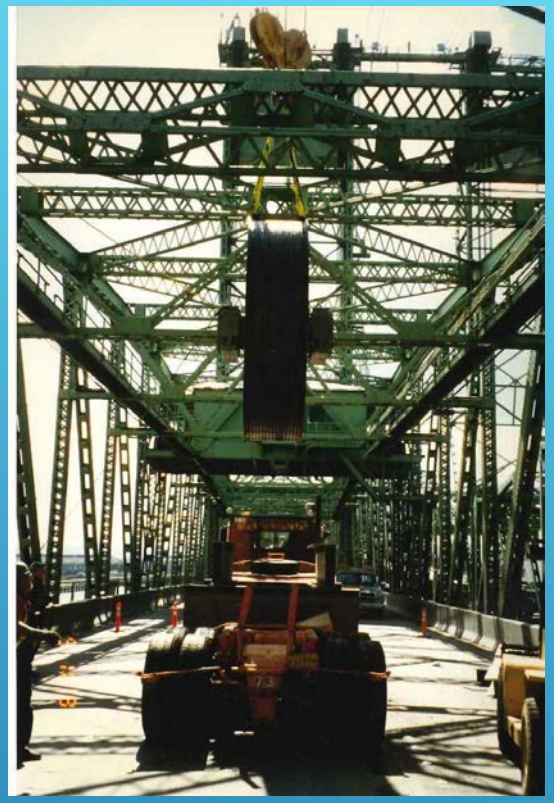
ERECT TOWER CRANE

ERECT COUNTERWEIGHT SUPPORT STRUCTURE





SHUT BRIDGE DOWN AND JACK COUNTERWEIGHT

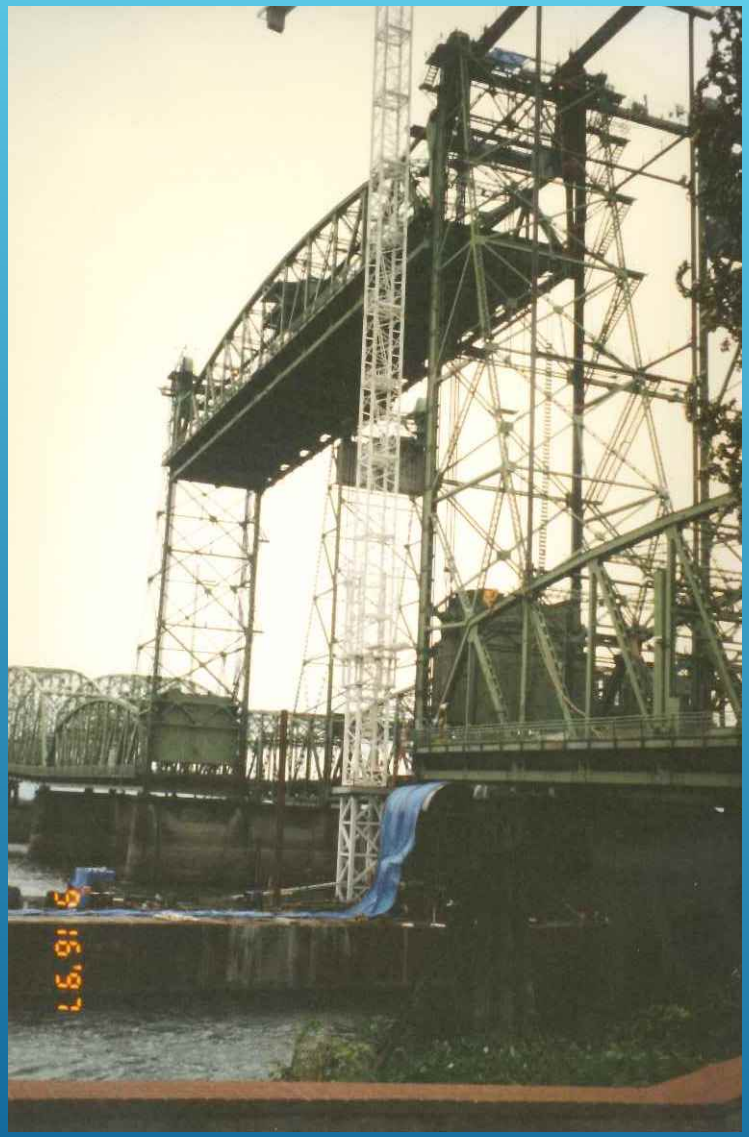


REMOVE OLD SHEAVE ASSEMBLIES

INSTALL NEW SHEAVE ASSEMBLIES

INSTALL NEW WIRE ROPES

CONNECT WIRE ROPES TO LIFT SPAN AND COUNTERWEIGHT



TEST OPERATION OF LIFT SPAN

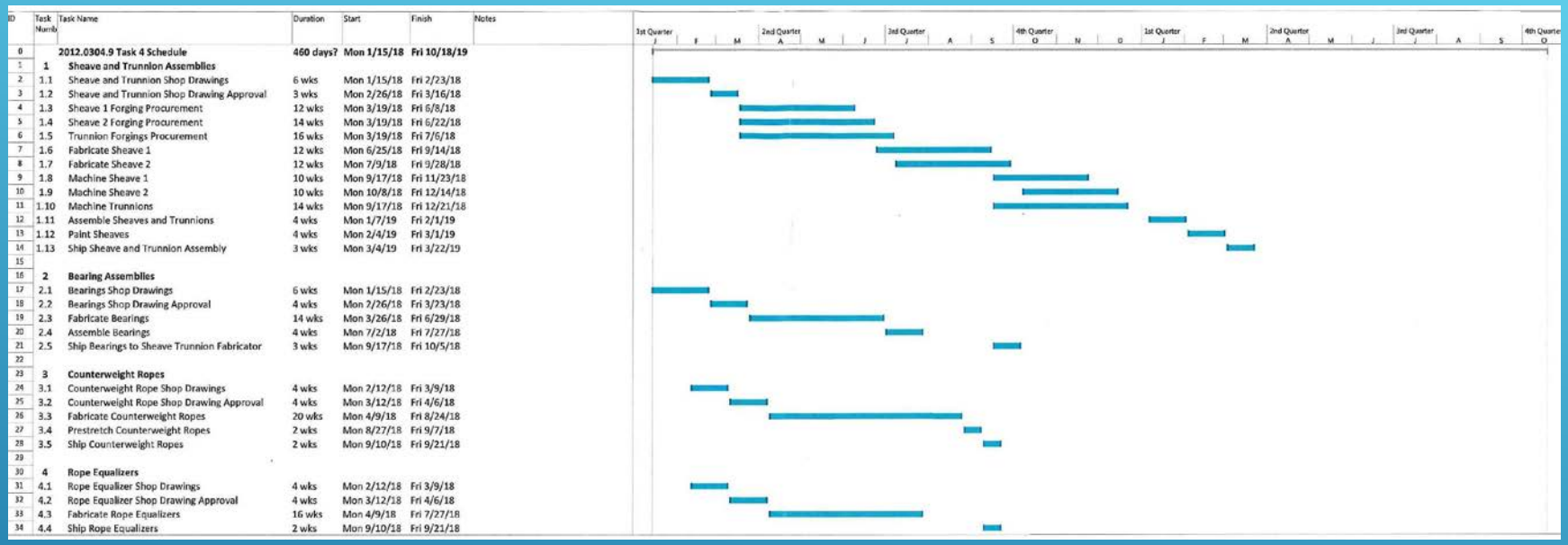
After installation of the new machinery the lift span is tested for proper function

Once accepted the bridge can be opened to vehicular and marine traffic

The counterweight support structure will be removed with minimal impacts on traffic

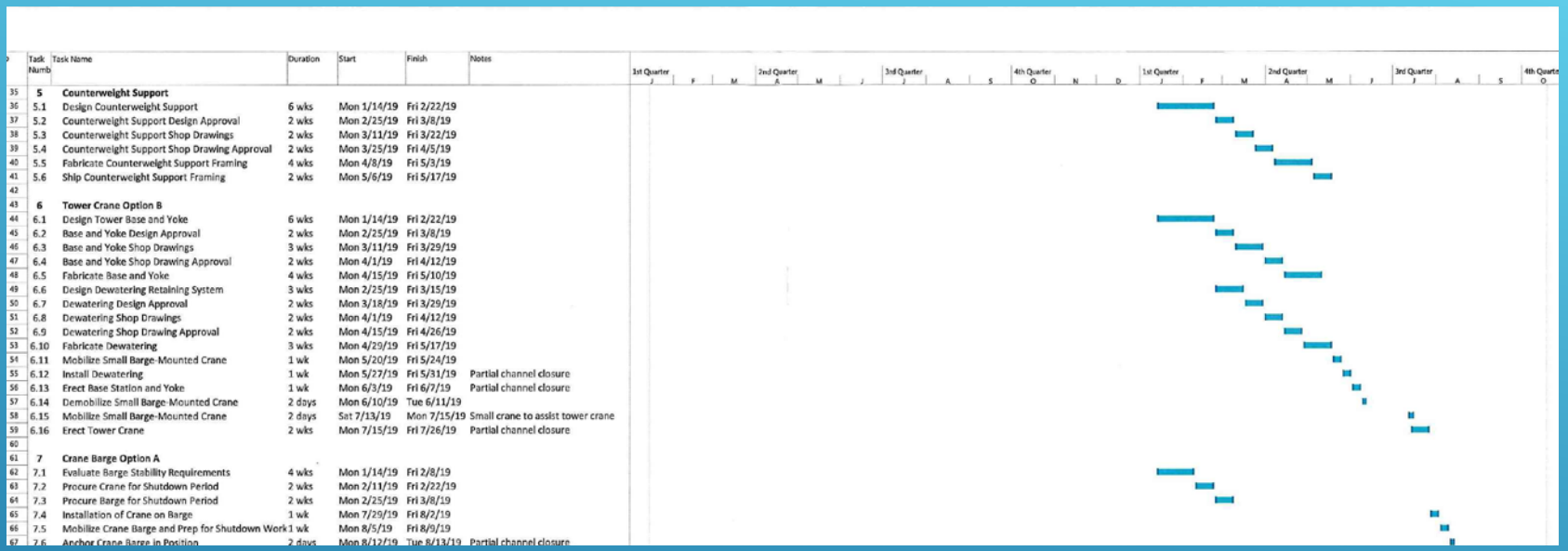
2019 REPLACEMENT

- Experience and lessons learned from the 1996 replacement will be incorporated into the 2019 project
- Traffic is much higher volume today but many of the unknowns of construction and traffic control have been eliminated
- Since this is not an emergency contract, bid prices could be lower compared to the previous work



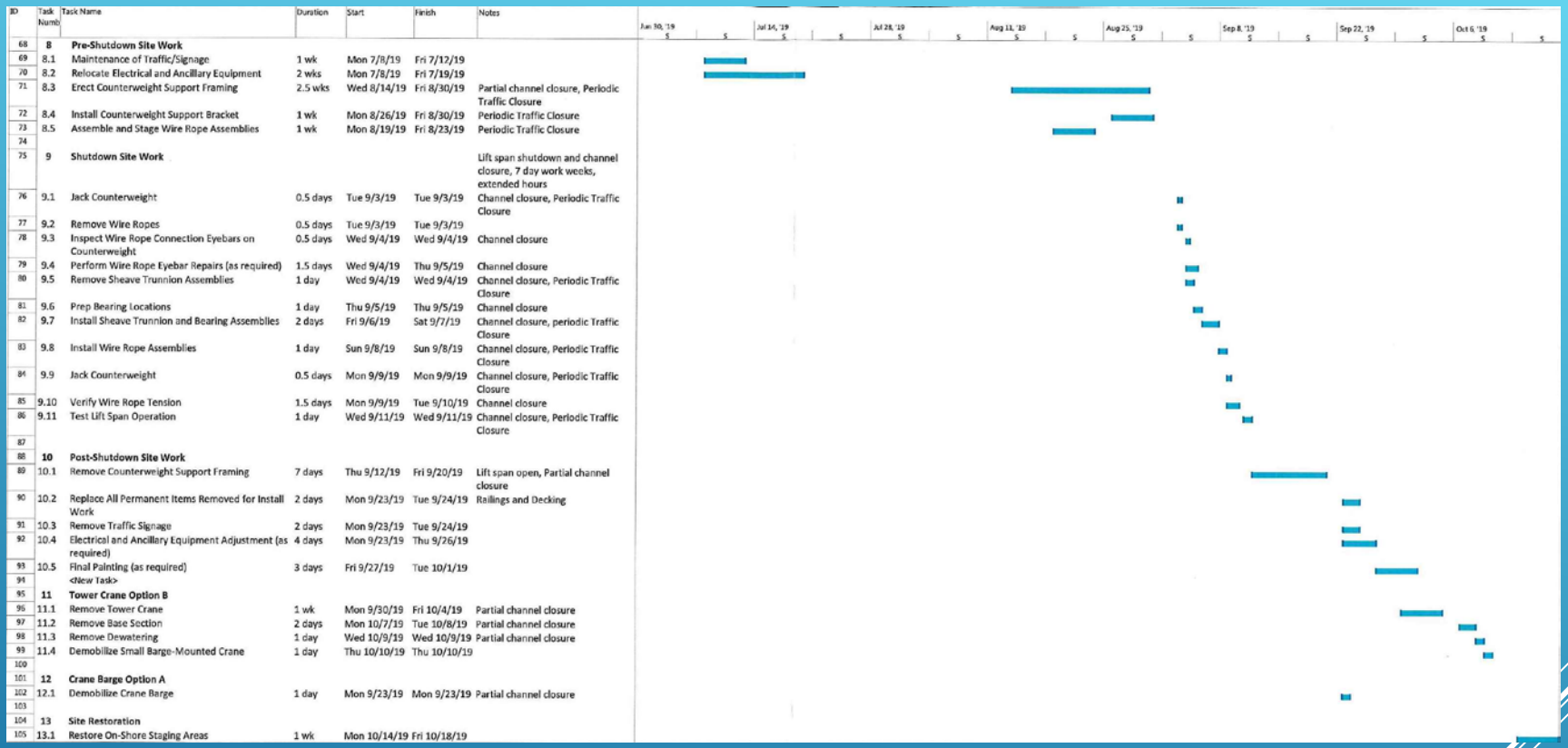
ID	Task Numb	Task Name	Duration	Start	Finish	Notes
0		**2012.0304.9 Task 4 Schedule**	**460 days?**	**Mon 1/15/18**	**Fri 10/18/19**	
1	**1**	**Sheave and Trunnion Assemblies**				
2	1.1	Sheave and Trunnion Shop Drawings	6 wks	Mon 1/15/18	Fri 2/23/18	
3	1.2	Sheave and Trunnion Shop Drawing Approval	3 wks	Mon 2/26/18	Fri 3/16/18	
4	1.3	Sheave 1 Forging Procurement	12 wks	Mon 3/19/18	Fri 6/8/18	
5	1.4	Sheave 2 Forging Procurement	14 wks	Mon 3/19/18	Fri 6/22/18	
6	1.5	Trunnion Forgings Procurement	16 wks	Mon 3/19/18	Fri 7/6/18	
7	1.6	Fabricate Sheave 1	12 wks	Mon 6/25/18	Fri 9/14/18	
8	1.7	Fabricate Sheave 2	12 wks	Mon 7/9/18	Fri 9/28/18	
9	1.8	Machine Sheave 1	10 wks	Mon 9/17/18	Fri 11/23/18	
10	1.9	Machine Sheave 2	10 wks	Mon 10/8/18	Fri 12/14/18	
11	1.10	Machine Trunnions	14 wks	Mon 9/17/18	Fri 12/21/18	
12	1.11	Assemble Sheaves and Trunnions	4 wks	Mon 1/7/19	Fri 2/1/19	
13	1.12	Paint Sheaves	4 wks	Mon 2/4/19	Fri 3/1/19	
14	1.13	Ship Sheave and Trunnion Assembly	3 wks	Mon 3/4/19	Fri 3/22/19	
15						
16	**2**	**Bearing Assemblies**				
17	2.1	Bearings Shop Drawings	6 wks	Mon 1/15/18	Fri 2/23/18	
18	2.2	Bearings Shop Drawing Approval	4 wks	Mon 2/26/18	Fri 3/23/18	
19	2.3	Fabricate Bearings	14 wks	Mon 3/26/18	Fri 6/29/18	
20	2.4	Assemble Bearings	4 wks	Mon 7/2/18	Fri 7/27/18	
21	2.5	Ship Bearings to Sheave Trunnion Fabricator	3 wks	Mon 9/17/18	Fri 10/5/18	
22						
23	**3**	**Counterweight Ropes**				
24	3.1	Counterweight Rope Shop Drawings	4 wks	Mon 2/12/18	Fri 3/9/18	
25	3.2	Counterweight Rope Shop Drawing Approval	4 wks	Mon 3/12/18	Fri 4/6/18	
26	3.3	Fabricate Counterweight Ropes	20 wks	Mon 4/9/18	Fri 8/24/18	
27	3.4	Prestretch Counterweight Ropes	2 wks	Mon 8/27/18	Fri 9/7/18	
28	3.5	Ship Counterweight Ropes	2 wks	Mon 9/10/18	Fri 9/21/18	
29						
30	**4**	**Rope Equalizers**				
31	4.1	Rope Equalizer Shop Drawings	4 wks	Mon 2/12/18	Fri 3/9/18	
32	4.2	Rope Equalizer Shop Drawing Approval	4 wks	Mon 3/12/18	Fri 4/6/18	
33	4.3	Fabricate Rope Equalizers	16 wks	Mon 4/9/18	Fri 7/27/18	
34	4.4	Ship Rope Equalizers	2 wks	Mon 9/10/18	Fri 9/21/18	

2019 SCHEDULE



	Task Numb	Task Name	Duration	Start	Finish	Notes
35	**5**	**Counterweight Support**				
36	5.1	Design Counterweight Support	6 wks	Mon 1/14/19	Fri 2/22/19	
37	5.2	Counterweight Support Design Approval	2 wks	Mon 2/25/19	Fri 3/8/19	
38	5.3	Counterweight Support Shop Drawings	2 wks	Mon 3/11/19	Fri 3/22/19	
39	5.4	Counterweight Support Shop Drawing Approval	2 wks	Mon 3/25/19	Fri 4/5/19	
40	5.5	Fabricate Counterweight Support Framing	4 wks	Mon 4/8/19	Fri 5/3/19	
41	5.6	Ship Counterweight Support Framing	2 wks	Mon 5/6/19	Fri 5/17/19	
42						
43	**6**	**Tower Crane Option B**				
44	6.1	Design Tower Base and Yoke	6 wks	Mon 1/14/19	Fri 2/22/19	
45	6.2	Base and Yoke Design Approval	2 wks	Mon 2/25/19	Fri 3/8/19	
46	6.3	Base and Yoke Shop Drawings	3 wks	Mon 3/11/19	Fri 3/29/19	
47	6.4	Base and Yoke Shop Drawing Approval	2 wks	Mon 4/1/19	Fri 4/12/19	
48	6.5	Fabricate Base and Yoke	4 wks	Mon 4/15/19	Fri 5/10/19	
49	6.6	Design Dewatering Retaining System	3 wks	Mon 2/25/19	Fri 3/15/19	
50	6.7	Dewatering Design Approval	2 wks	Mon 3/18/19	Fri 3/29/19	
51	6.8	Dewatering Shop Drawings	2 wks	Mon 4/1/19	Fri 4/12/19	
52	6.9	Dewatering Shop Drawing Approval	2 wks	Mon 4/15/19	Fri 4/26/19	
53	6.10	Fabricate Dewatering	3 wks	Mon 4/29/19	Fri 5/17/19	
54	6.11	Mobilize Small Barge-Mounted Crane	1 wk	Mon 5/20/19	Fri 5/24/19	
55	6.12	Install Dewatering	1 wk	Mon 5/27/19	Fri 5/31/19	Partial channel closure
56	6.13	Erect Base Station and Yoke	1 wk	Mon 6/3/19	Fri 6/7/19	Partial channel closure
57	6.14	Demobilize Small Barge-Mounted Crane	2 days	Mon 6/10/19	Tue 6/11/19	
58	6.15	Mobilize Small Barge-Mounted Crane	2 days	Sat 7/13/19	Mon 7/15/19	Small crane to assist tower crane
59	6.16	Erect Tower Crane	2 wks	Mon 7/15/19	Fri 7/26/19	Partial channel closure
60						
61	**7**	**Crane Barge Option A**				
62	7.1	Evaluate Barge Stability Requirements	4 wks	Mon 1/14/19	Fri 2/8/19	
63	7.2	Procure Crane for Shutdown Period	2 wks	Mon 2/11/19	Fri 2/22/19	
64	7.3	Procure Barge for Shutdown Period	2 wks	Mon 2/25/19	Fri 3/8/19	
65	7.4	Installation of Crane on Barge	1 wk	Mon 7/29/19	Fri 8/2/19	
66	7.5	Mobilize Crane Barge and Prep for Shutdown Work	1 wk	Mon 8/5/19	Fri 8/9/19	
67	7.6	Anchor Crane Barge in Position	2 days	Mon 8/12/19	Tue 8/13/19	Partial channel closure

2019 SCHEDULE



ID	Task Numb	Task Name	Duration	Start	Finish	Notes
68	**8**	**Pre-Shutdown Site Work**				
69	8.1	Maintenance of Traffic/Signage	1 wk	Mon 7/8/19	Fri 7/12/19	
70	8.2	Relocate Electrical and Ancillary Equipment	2 wks	Mon 7/8/19	Fri 7/19/19	
71	8.3	Erect Counterweight Support Framing	2.5 wks	Wed 8/14/19	Fri 8/30/19	Partial channel closure, Periodic Traffic Closure
72	8.4	Install Counterweight Support Bracket	1 wk	Mon 8/26/19	Fri 8/30/19	Periodic Traffic Closure
73	8.5	Assemble and Stage Wire Rope Assemblies	1 wk	Mon 8/19/19	Fri 8/23/19	Periodic Traffic Closure
74						
75	**9**	**Shutdown Site Work**				Lift span shutdown and channel closure, 7 day work weeks, extended hours
76	9.1	Jack Counterweight	0.5 days	Tue 9/3/19	Tue 9/3/19	Channel closure, Periodic Traffic Closure
77	9.2	Remove Wire Ropes	0.5 days	Tue 9/3/19	Tue 9/3/19	
78	9.3	Inspect Wire Rope Connection Eyebars on Counterweight	0.5 days	Wed 9/4/19	Wed 9/4/19	Channel closure
79	9.4	Perform Wire Rope Eyebar Repairs (as required)	1.5 days	Wed 9/4/19	Thu 9/5/19	Channel closure
80	9.5	Remove Sheave Trunnion Assemblies	1 day	Wed 9/4/19	Wed 9/4/19	Channel closure, Periodic Traffic Closure
81	9.6	Prep Bearing Locations	1 day	Thu 9/5/19	Thu 9/5/19	Channel closure
82	9.7	Install Sheave Trunnion and Bearing Assemblies	2 days	Fri 9/6/19	Sat 9/7/19	Channel closure, periodic Traffic Closure
83	9.8	Install Wire Rope Assemblies	1 day	Sun 9/8/19	Sun 9/8/19	Channel closure, Periodic Traffic Closure
84	9.9	Jack Counterweight	0.5 days	Mon 9/9/19	Mon 9/9/19	Channel closure, Periodic Traffic Closure
85	9.10	Verify Wire Rope Tension	1.5 days	Mon 9/9/19	Tue 9/10/19	Channel closure
86	9.11	Test Lift Span Operation	1 day	Wed 9/11/19	Wed 9/11/19	Channel closure, Periodic Traffic Closure
87						
88	**10**	**Post-Shutdown Site Work**				
89	10.1	Remove Counterweight Support Framing	7 days	Thu 9/12/19	Fri 9/20/19	Lift span open, Partial channel closure
90	10.2	Replace All Permanent Items Removed for Install Work	2 days	Mon 9/23/19	Tue 9/24/19	Railings and Decking
91	10.3	Remove Traffic Signage	2 days	Mon 9/23/19	Tue 9/24/19	
92	10.4	Electrical and Ancillary Equipment Adjustment (as required)	4 days	Mon 9/23/19	Thu 9/26/19	
93	10.5	Final Painting (as required)	3 days	Fri 9/27/19	Tue 10/1/19	
94		<New Task>				
95	**11**	**Tower Crane Option B**				
96	11.1	Remove Tower Crane	1 wk	Mon 9/30/19	Fri 10/4/19	Partial channel closure
97	11.2	Remove Base Section	2 days	Mon 10/7/19	Tue 10/8/19	Partial channel closure
98	11.3	Remove Dewatering	1 day	Wed 10/9/19	Wed 10/9/19	Partial channel closure
99	11.4	Demobilize Small Barge-Mounted Crane	1 day	Thu 10/10/19	Thu 10/10/19	
100						
101	**12**	**Crane Barge Option A**				
102	12.1	Demobilize Crane Barge	1 day	Mon 9/23/19	Mon 9/23/19	Partial channel closure
103						
104	**13**	**Site Restoration**				
105	13.1	Restore On-Shore Staging Areas	1 wk	Mon 10/14/19	Fri 10/18/19	

2019 SCHEDULE