US Army Corps of Engineers®
St. Paul District

Appendix H: Electrical System

Fargo-Moorhead Metropolitan Area
Flood Risk Management Project

Wild Rice River Structure

Engineering and Design Phase

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Appendix H: Electrical System

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H.1 ELECTRICAL SERVICE

H.1.1 Electrical Service Size

The electrical service proposed is 480V/277V 3 Phase, 150 Amps, from a primary 12,470 V utility. This is a moderate size and minimizes breaker, wire and conduit costs. This also reduces the potential for high fault currents and arc flash hazards.

H.1.2 CCEC Power Line and Transformer

Cass County Electrical Coop (CCEC), has an existing three phase power line to the North of 124th Ave South. This line runs East and West and is underground 15 KV service, (12,470 V three phase). A new power line will be routed south along 173rd Ave SE to the West end of the Dam Wall, Figure H1. The 15 KV service will be underground per the standards that CCEC now uses. The routing of the service will be along the service road used for bulkhead placement. The pad mounted transformer will be close to the dam wall and secondary conduits will go up the wall to the control building. A pad mounted sectional switch will be put along the county road at the entrance to the site, Figure H-2. This will provide a ready demarcation for maintenance.

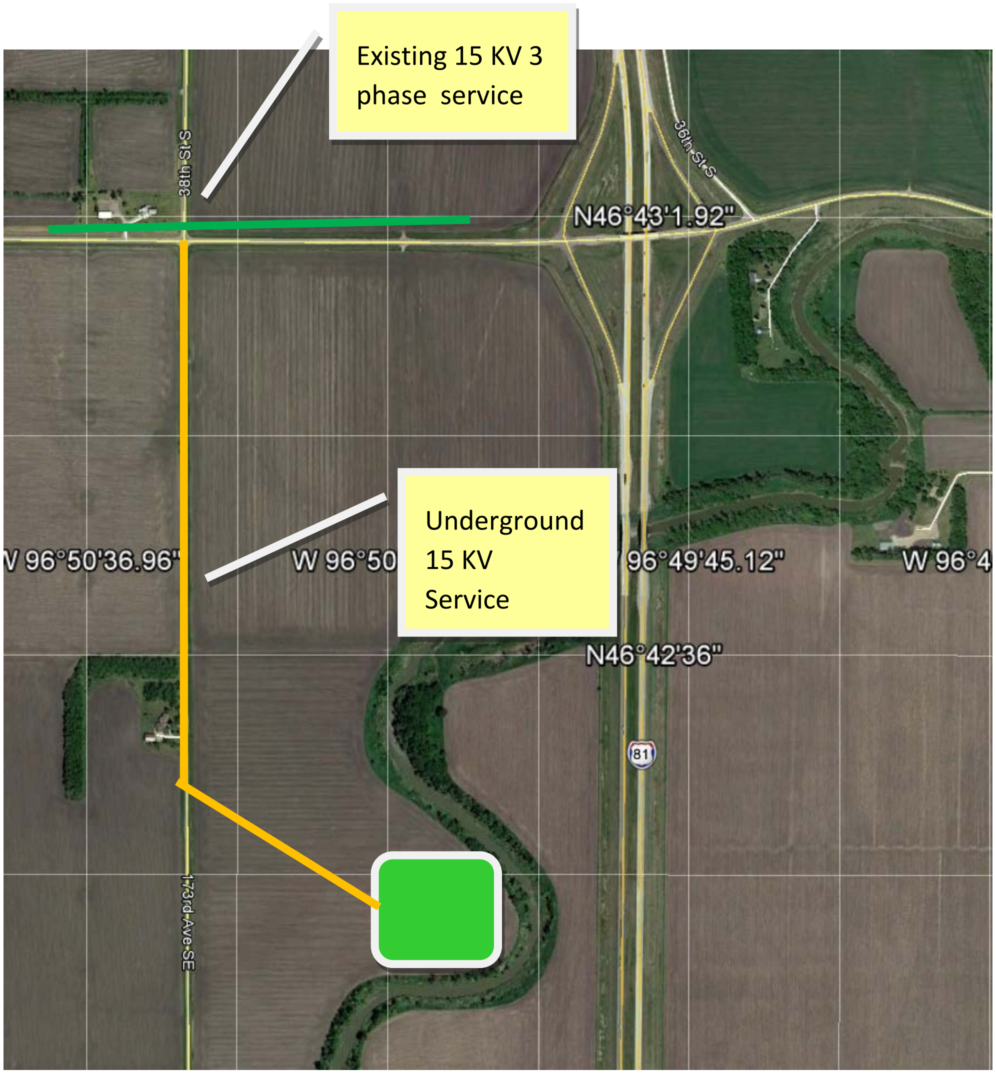

Figure H-1. Probable Power Routing.

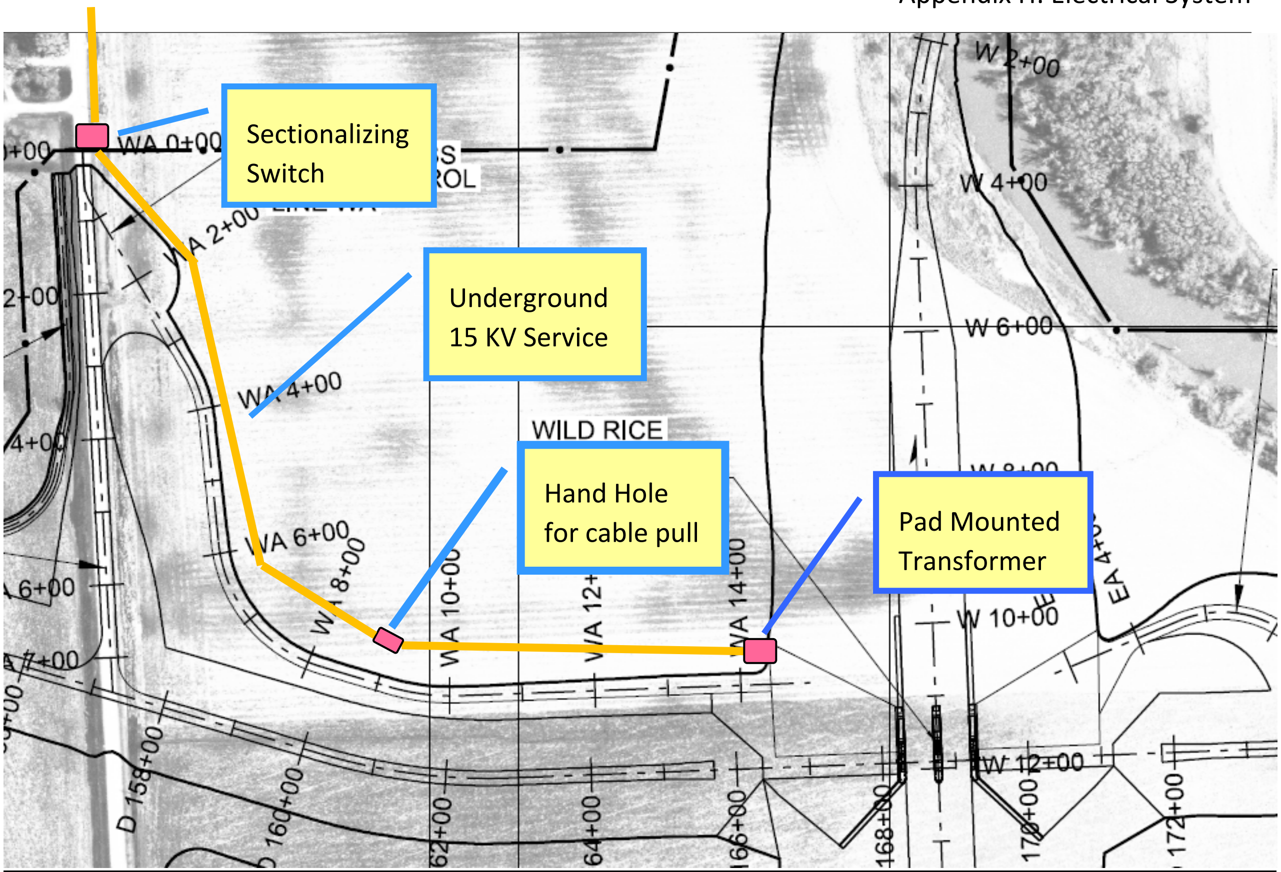

Figure H-2. Detailed Site Power Routing.

H.1.3 Backup Generator Connection

A 150 Amp Generator Receptacle will be mounted at a convenient point at the west end of the dam wall. This will allow for a range of generators. An associated disconnect switch will also be mounted with the receptacle.

H.1.4 Use of a Portable Standby Generator at this site.

Engineering manuals often require a fixed standby generator on site. The term "emergency generator" will not be used as this refers to a much higher standard such as in hospitals. The USACE document, Mechanical and Electrical Design for Lock and Dam Operating Equipment, EM 1110-2-2610, June 2013, indicates in section chapter 11, that a portable unit is sufficient. Paragraph section 11, 4, (a) Configuration, states that "Larger portable units sized up to 150 KW and perhaps larger are towable and installed on a trailer." Thus the design document allows the use of a portable generator. This site will be idle for long periods of time, and anticipation of a flood event is weeks away from the actual event.

H.1.5 Incoming Main Breakers

Two main 150 Amp breakers will be mounted in the main control panel. One for utility power and the other for the generator power. These breakers provide a consistent place for lockout/tag out, and a consistent place to make breaker trip settings to minimize unnecessary trips. But provide good fault and arc flash protection.

H.1.6 Kirk Key Interlocked Main Breakers

The two main breakers (utility and generator) will be "Kirk Key" interlocked. This is a commonly used system where a single key and lockouts are used to only allow one breaker to be energized at a time.

H.2 CONTROL BUILDING

H.2.1 Location and Function of the control building

The control building is proposed to be located on the pier of the structure. The control building size is constrained by the pier dimensions, and is proposed to be 10 feet wide by about 20 feet long. A door will be installed at each end for passage to the end of the pier. The control building will house the main control panel. There will be no outdoor control panels on the machinery hoist platform, except for safety disconnects and operator control stations for the hoists. Thus the control panel will have all of the power and control functionality. The electrical system will be simpler and require less breakers and feeders, than the diversion inlet structure.

H.2.2 Preliminary Main Control Panel Layout

The main control panel will be placed against one of the walls, and will be 20 inches deep by 90 inches high. And the panel will be approximately 132 inches long, including the transformer. A rough layout is shown below, Figure 3. The 37.5 KVA transformer will be mounted near the ceiling. A ceiling height of about 9 ft., makes installation and conduit routing easier.

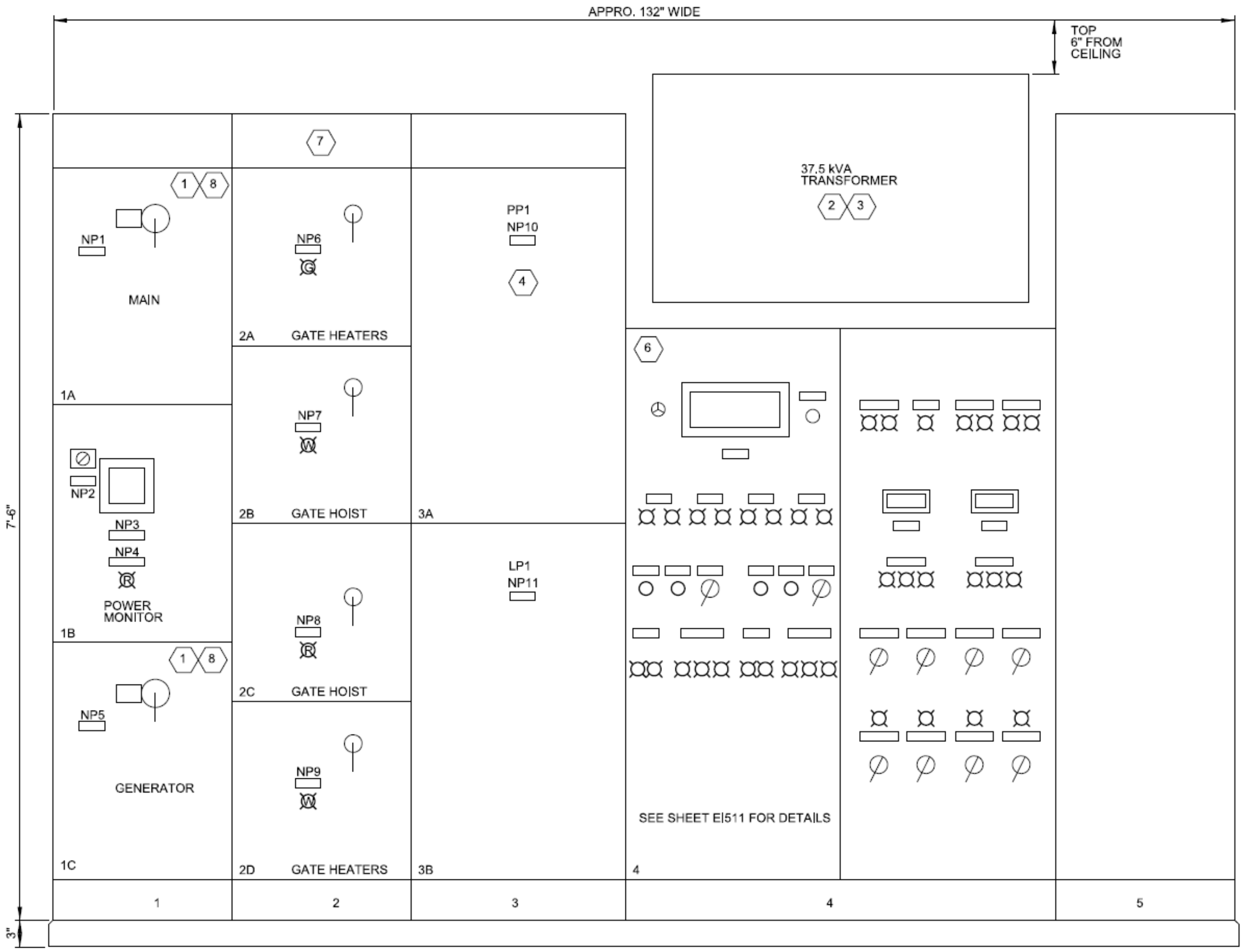

Figure H-3. Main Panel layout.

H.2.3 30 KVA 120 VAC single phase lighting transformer.

A 37.5 KVA single phase lighting transformer and associated lighting panel board will be provided in the main control panel lineup. This will provide all 120 VAC site power, including outdoor lighting, and interior heating.

H.2.4 Building Heating and Cooling.

The control building will not be a manned office, but be used on occasion for operating the gates and gate side seal heaters. As such, electric thermostat controlled unit heaters will be provided to keep the building at the desired temperature in the winter. A thermostatically controlled vent fan will be used to keep the building somewhat cooled during the summer. There should be no need for air conditioning as the PLC equipment can run at the indoor temperatures expected.

H.3 GATE SYSTEM CONTROLS

H.3.1 Gate Hoist Control

A custom reversing starter compartment will control the direction of the hoist motor. The pilot circuit/control will prevent the gate from over travel with inputs from redundant "full open" and "full closed", limit switches. A key switch will be provided for bypassing most of the automatic lockouts. This will be used for maintenance and emergency purposes. A control station will also be provided on the machinery deck. The gate lower limit of travel for normal operation will be set in the limit switches. A locked pushbutton control station will be up on the machinery deck and via key switch selection in the control building, will allow gate operation even if the PLC system is not available.

H.3.2 Hoist Motor

The motor design basis is about 6 HP, at 1790 RPM. The contractor will determine the exact motor for the hoist configuration. This motor HP size is small. The hoist motor load is almost negligible to the site capacity. Lockable disconnect switches will be provided on the machinery deck near the hoist machinery.

H.3.3 Hoist Motor Stall Torque

The motor design basis and specifications are intended to provide a motor that will stall before any other gate gear train or hoisting components are damaged. A class D induction motor design is specified. This type of induction motor has maximum toque at stall and the torque-speed curve falls off as the motor RPMs increases. The specifications indicate that the motor shall produce a maximum torque of twice the computed lifting torque at normal conditions. The specifications actually give a range of 200% +/- 10 % maximum torque.

H.3.4 Pole Mounted Alarm Horn and Strobe Beacon

An alarm horn and strobe beacon will be mounted on onto light poles on the machinery deck. There will be a horn and strobe for each gate system for redundancy. These alarms will be used to warn of an impending gate move. The horn/strobe can be operated from the control building or locally at the gate machinery.

H.3.5 Gate Heaters Control

Each gate has a left side and right side seal heater. These will be 480V, single phase and individually fused. Each heater is approximately a 40 foot curved loop that slides into a heater recess that will be part of the gate side seals on the pier and abutments. Gate heater systems may be prone to ground faults. A single ground current monitor for each gate will sense ground current. This will be displayed on the PLC system and an alarm limit setting will signal a ground fault and shut off the heaters to the respective gate. A contactor will be provided for both the left and right side heater, along with left and right side Hand-Off-Automatic switches. The gate side seal heaters will be controlled by the PLC when in auto. The PLC system will warn and shut down heaters on increased ground fault leakage.

The gate heaters are among the largest loads on the site. They will be in the range of 6 KW per gate.

H.3.6 60 Amp "Welding Receptacle"

A 60 Amp 480V three phase receptacle will be mounted conveniently at each gate machinery. This will provide convenient power for maintenance work. Breakers are provided in the main control panel for each receptacle. Additionally eight 20A, 120 VAC outdoor-in-use receptacles will be provided around the structure. And two 20 A, 120 VAC receptacles will be provided in the anchor galleries.

H.4 BASIC POWER CIRCUIT CALCULATIONS AND WIRE SIZES

H.4.1 Short Circuit Calculations

The maximum short circuit value for the 480V system is approximately 8000 Amps. This assumes a 75KVA utility transformer with 1.2 percent impedance. = 75,000/(1.73*480*0.012) = 7526 Amps.

The maximum short circuit value for the 120/240V system at the control building is determined by the 37.5 KVA lighting transformer. This value is approximately 11,160 Amps. For 37.5 KVA with 1.4 % impedance = 37,500/(240*0.014).

H.4.2 Breaker Interrupting Capacity

The 480V system breakers will have an interrupting capacity of 22,000 Amps. This is an economical and readily available rating. Also the 120/240V system breakers will also have the 22,000 Amp interrupting capacity.

H.4.3 Utility and Feeder Wire Sizes

The main utility 480V 150 Amp service transformer will be located adjacent to the control structure. The utility transformer is about 120 feet away from the control building, so wire sizing will be determined to minimize voltage drop. This calculation will use a 2/0 conductor. And figuring a maximum 150 Amp draw.

Using the NECVD = 0.866 * (2 * L * R * I) / 1000 from NEC Art. 215.2 and percentage drop VD% = ((VD / V) * 100) L is length of run, R is alternating current effective resistance from Chapter 9, table 9 of NEC code.

Voltage Drop = 0.866(2*120*0.11*150) /1000 = 3.4 Volts.

Percent Voltage Drop = 3.4/480 *100 = 0.7 %

This 0.7 Percent voltage drop at 150 Amps is a negligible value. Feeders to the gate side seal heaters, and the 60 Amp "welding receptacles" are relatively short, and no up wire sizing is required for voltage drop.

H.5 OUTDOOR LIGHTING

Lighting will be provided for the structure machinery platform and the roadway across the dam. This does not include the embankments. The design team has decided not to put lighting along the embankments or bulkhead service roads. The addition of poles are an impediment to designing embankments correctly.

H.5.1 Outdoor Lighting Control

The outdoor lighting will be controlled in zones. The PLC system can automatically turn on zones with separate schedules. Photo cell input, time schedules and diurnal sundown – sun up scheduling can be done. The lighting also can be controlled manually from the control building.

H.5.2 Outdoor Lighting Fixtures

The lighting fixtures will be LED mounted on square straight poles, about 20 ft height. The light fixtures are nominal 150 Watt, equivalent to 400 Watt HID fixtures. The fixtures will be sharp cutoff to horizon to minimize light pollution. On the machinery platform the light poles will be 15 feet. The light distribution is proposed to be type T5M, (circular pattern) with about 14,500 lumens, and a color temperature of 4000K. The fixture will have a single piece die-cast housing with thermal management.

H.5.3 Light Poles

The poles proposed will be the heavy duty square straight type, with the light fixture mounted close to the pole. The poles will be constructed of aluminum with dark bronze finish. The metal thickness will be 0.187 inches. And the poles will mount with the standard four bolt pattern, using 30 inch J-bolts embedded into concrete. No poles are located off of the structure or dam wall.

H.5.4 Structure and Machine Platform Lighting Levels

The minimum lighting levels are proposed to be about 0.7 Foot Candles, with an average to minimum lighting ratio of about 3:1.

H.6 CONTROLS AND PLC SYSTEM

H.6.1 PLC System Basics.

There will be a single PLC with all of the I/O at the control building. This differs from the Diversion Inlet Structure where there are remote I/O panels for each gate. This makes the system quite a bit simpler than the Diversion Inlet Structure. The PLC will have the same type of Operator Display Terminal with touch screen capability.

H.6.2 Controls Philosophy

All controls will be able to be operated without the PLC. This will require appropriate safeguards. The hoist gates will be able to be operated with hardwired switches, and indicators.

Gate heaters, and lighting will also be able to be operated without the PLC. The PLC system will provide more operator information, and allow some remote automatic control on the gate side seal heaters and lighting. The PLC system will provide alarm and event recording, and in the future can be tied to an area wide SCADA system. The definition of this area wide SCADA is beyond the scope of this project. Connection to an area wide SCADA system would undoubtedly use Ethernet protocols, and local internet providers. Area wide internet security will have to be implemented.

H.6.3 Tainter Gate Operational Limits

The control system will prevent unintended full gate closure of both gates at the same time. This is crucial for the aquatic ecosystem of the Wild Rice River, especially downstream of the structure. The intent of the Wild Rice River Structure is to allow normal river flow through the structure at all times, except in emergency situations. Thus in normal situations, personnel will be prevented from closing gates beyond a “normal near close” limit switch position. This will be set up in the gate limit switch unit. If bypassing contacts is done, the system will alarm the breach in operation. This will be logged in the alarm history and also signal a local audible alarm. Text messages on the PLC operator display will also alert to the breach in normal operation. It is contemplated that each operator will have a login password. However if the PLC is not operational, this will be a moot point.

In emergency situations, a “supervisory login” to the PLC system can be done. This will also be logged in the PLC event history. And then “both gates full closed” operation can be done.

H.6.4 Controls and Tainter Gates – Dogged in Full Open

The Tainter gates will normally be dogged in the full open position. This relieves the tension on the hoist and wire ropes. The controls must be locked out in multiple modes and locations to prevent un-intended hoist operation while the gates are dogged. An operational manual will provide a detailed and step by step procedure to lock out and when needed to re-engage the hoist and controls.

H.7 SITE CAMERA SYSTEM

H.7.1 Camera locations

The Cameras will be mounted and positioned to observe both upstream and downstream of each gate system. And also for the structure entry at both the East and West sides. The design includes eight cameras. The cameras will connect to a computer based (DVR), video monitor system. The cameras and software can be configured to specifically record for the last two weeks of surveillance. The cameras and software can be programmed to automatically zoom into motion or out of normal occurrences. The cameras will be mounted on the light poles.

H.7.2 Camera Capabilities

The Cameras will be "power over Ethernet" type. And have "pan, tilt, zoom" capability. The cameras will also have low light ability. Ethernet surge arrestors will be put on all Ethernet cables routed from the cameras into the camera computer.

H.7.3 Camera System Video Computer

The Cameras will first connect to Ethernet surge arrestors and then to a switch to provide surge protection isolation from the DVR computer. The video computer will be a current typical small business type system which is based upon Linux operating system and stores video surveillance on flash and hard drives.

H.7.4 Technical Guidelines and References

1. ***NFPA 70: National Electrical Code***, 2017 Edition.

H.7.5 Reference Documents

Links to or copies of the following documents are on the project Extranet site at: https://extranet.dse.usace.army.mil/sites/Divisions/MVD/MVP/FargoMoorhead/ [accessible within USACE] or https://onecorps.usace.army.mil/sites/Divisions/MVD/MVP/FargoMoorhead/ [accessible outside of USACE]
Final Feasibility Study and Environmental Impact Statement, Fargo-Moorhead Metropolitan Area Flood Risk Management, July 2011
Project Design Guidelines for the overall FMM Project and Reach-Specific Design Guidelines, February 2012
Value Based Design Charrette, Fargo-Moorhead Wild Rice Structure, November 2016
Mechanical and Electrical Design for Lock and Dam Operating Equipment, EM 1110-2-2610, 30 June 2013.

H.8 LIST OF FIGURES