US Army Corps of Engineers®
St. Paul District

Appendix H: Electrical Design

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Diversion Inlet Structure

Engineering and Design Phase

P2# 370365

Doc Version: Post BCOE Comment Back Check

18 April 2016

This page is intentionally left blank

Appendix H: Electrical Design

Table of Contents

This page is intentionally left blank

Appendix H: Electrical Design

H.1 ELECTRICAL SERVICE

H.1.1 Electrical Service Size

H.1.1.1.1 The electrical service proposed is 480/277V 3 Phase, 200 Amps. 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

H.1.2.1.1 Cass County Electrical Coop (CCEC), has an existing three phase power line to the east of the site. This line runs North and South. A new power line will be routed near the control building, (figure H1). A 150 KVA pad mounted transformer will be installed to provide the 480 V three phase power.

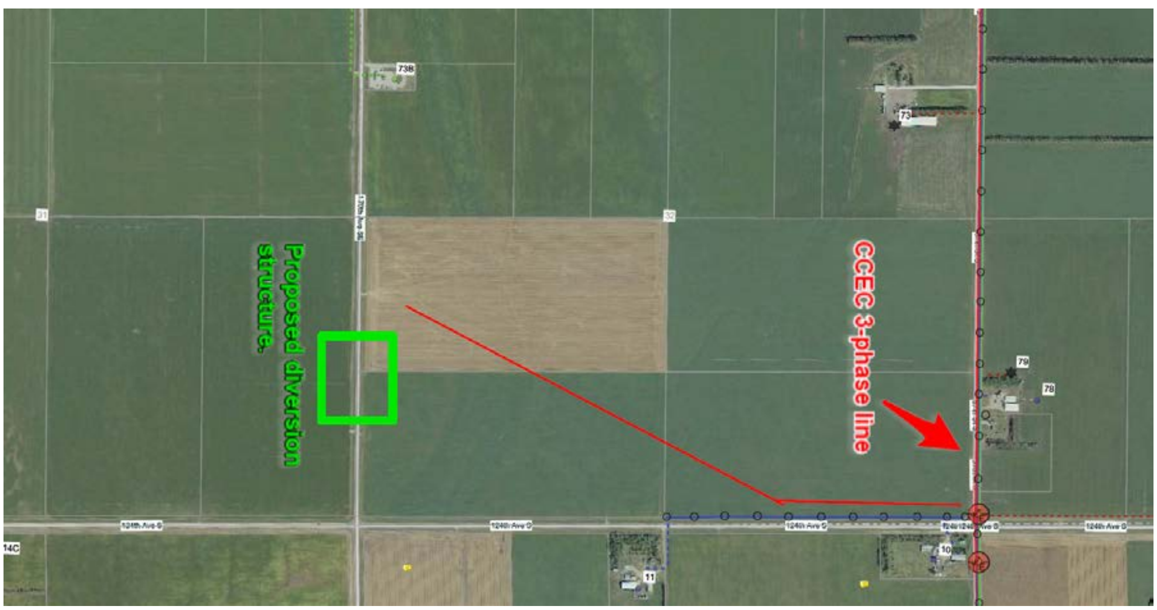

Figure H1. Existing CCEC three phase line and new proposed line to Diversion Structure site.

H.1.2.1.2 Electric metering will be at the transformer pad, per CCEC standard. This minimizes the equipment space required at the control building.

H.1.3 Back up Generator Connection

H.1.3.1.1 A 200 Amp generator receptacle will be mounted on the outside of the main control building. This will allow for a range of sizes of generators up a 200 Amp max, (approximately 150 KVA generator). No other switches or breakers will be mounted outside of the main control building.

H.1.4 Transfer Switch

H.1.4.1.1 A 260 Amp rated transfer switch, which is manual – electrically operated will be mounted inside of the building in the main control panel. This type of transfer switch will provide a center off position, and provide a consistent fast transfer connection to either normal power or generator. The transfer switch will not operate automatically since the generator will be portable. The transfer switch will also switch the neutral.

H.1.5 Incoming Main Breakers

H.1.5.1.1 Two main 200 Amp, breakers will be mounted in the main control panel. One for utility power, and the other for generator power. These breakers provide a consistent place for lockout-tagout, and a consistent place to make breaker trip settings to minimize unnecessary trips, but provide good fault and arc flash protection. The breakers are ahead of the transfer switch.

H.2 POWER FEEDERS AND MAIN CIRCUITS

H.2.1 Local Power Circuits at Main Control Building

H.2.1.1.1 The control building will have an outdoor mounted 480V three phase 60 Amp, “welding receptacle”. This will be on a 60 Amp feeder breaker.

H.2.1.1.2 A 37.5 KVA lighting – distribution transformer will connect to a 42 circuit lighting panel. Among the loads are all electric heat in the building, instant hot water heater, interior lighting and outdoor parking lot lighting. The instant hot water heater will have a demand load of about 14 KW.

H.2.2 Electrical Feeders to Diversion Structure

H.2.2.1.1 Three 150 Amp feeders will be routed out to the diversion structure via a duct bank and then to a conduit rack fixed to the East “T-Wall”. Each gate system will have a control panel and two of the three feeders will be able to provide power to the gate panel.

H.3 GATE SYSTEM CONTROL PANELS

H.3.1 Three nearly identical gate control panels

H.3.1.1.1 There will be three nearly identical gate control panels located up on the machinery level. Each panel will independently control it’s respective gate.

H.3.2 Dual Interlocked 150 Amp breakers

H.3.2.1.1 There will be dual Interlocked 150 Amp breakers in each gate panel will ensure that only one feeder is used at a time, but allows redundancy. The breakers are mounted side by side and a mechanical interlock prevents both breakers being energized.

H.3.2.1.2 The dual interlocked breakers will individually be able to be locked out.

H.3.2.1.3 The 150 Amp breakers will have an adjustable instantaneous trip to allow system coordination and minimize arc flash hazard.

H.3.3 Gate Heaters Control

H.3.3.1.1 Each gate has a left and right side seal heater. These will be 480V, single phase and individually fused. Gate heater systems may be prone to ground faults. A single ground current monitor will indicate ground current. This will be displayed on a local indicator and also wire into the PLC remote I/O. A contactor will be provided for both the left and right side, along with left and right side Hand-Off-Automatic switches. The gate side seal heater will be controlled by the PLC system when in auto. The PLC system warns and shuts down on increased ground fault leakage.

H.3.3.1.2 The gate heaters are the largest loads on the site. They will be in the range of 20-30 KW per gate.

H.3.4 Gate Hoist Control

H.3.4.1.1 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.

H.3.4.1.2 Hoist Motor. The hoist motor will be a custom motor with a class D torque speed curve. The class D curve has a maximum torque at stall. The motor is presently designed at 7.5 HP, at 1790 RPM. This could change. The motor HP size is small. Its load is almost negligible to the site capacity.

H.3.5 60 Amp “Welding Receptacle”

H.3.5.1.1 A 60 amp, 480V three phase receptacle will be mounted on the side of the gate control panel. This will provide convenient power for maintenance work. A breaker is provided in the gate control panel for this receptacle.

H.3.6 7.5 KVA lighting transformer and Lighting Panel

H.3.6.1.1 A 7.5 KVA 120/240 V single phase lighting transformer will be provided for local 120 VAC control within the control panel. This will provide power to convenience outlets, motor brake and panel heaters, and all of the site machinery platform and roadway lighting. A 12 circuit lighting panel will be built into the gate control panel.

H.4 BASIC POWER CIRCUIT CALCULATIONS AND WIRE SIZES

H.4.1 Short Circuit Calculations

H.4.1.1.1 The maximum short circuit value for the 480 V system is 15053 Amps. Assuming a 150 KVA utility transformer with 1.2 % impedance = 150,000/(480 * 1.2 * 0.016).

H.4.1.1.2 The maximum short circuit value for the 120/240 V system at the control building is 11,160 Amps. For a 37.5 KVA transformer with 1.4% impedance = 37,500/240*0.014).

H.4.2 Breaker interrupting capacity.

H.4.2.1.1 The 480V three phase breakers will have an interrupting capacity of 30,000 Amps. This is a moderate value and readily available.

H.4.2.1.2 The panel board 120/240 V breakers will have an interrupting capacity of 22,000 Amps.

H.4.3 Utility and Feeder wire sizes.

H.4.3.1.1 The main utility 480V 200 A will use 4/0 90deg C wire, THHN, THHN2. For a 60 foot run, this will minimize voltage drop at a full 200 Amps to 0.48%.

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*60*0.063 *200) /1000 = 1.31 Volts.

Percent Voltage Drop = 2.286/480 *100 = 0.27%

H.4.3.1.2 The 150 Amp feeders to the gates will also use 4/0 90 deg C wire, to minimize voltage drop. For a 300 foot run at 150 amps the voltage drop will be 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*300*0.063 *150) /1000 = 4.91 Volts.

Percent Voltage Drop = 4.91/480 *100 = 1.02%

H.5 FIBER OPTIC LOOP NETWORK

H.5.1 A single fiber optic loop Ethernet Network

H.5.1.1.1 A single fiber optic Ethernet network will be used to link both the PLC controls and site cameras.

H.5.1.1.2 The PLC controls will have remote I/O at each gate control panel linked to a PLC processor unit at the control building.

H.5.1.1.3 The site cameras will be located around the main control building and at each diversion structure gate.

H.5.2 A fiber optic loop network Setup.

H.5.2.1.1 A fiber optic loop network is fairly easy to set up and implement.

H.5.2.1.2 The same type of fiber optic switch is used at each gate control panel and the main panel at the control building.

H.5.2.1.3 The advantage of a fiber optic loop system is that it has redundancy on use of the fibers in one direction or the other. The system will fully work if there is a break in any fiber.

H.5.2.1.4 Modern state of the art fiber optic loop switches require no configuration. They automatically set up optimum Ethernet routing. These switches have a number of Cat 5/6 standard copper Ethernet ports to connect to local devices, (plc equipment and cameras).

H.6 24VDC BATTERY BACKED CONTROLS SUPPORT

H.6.1 Battery backed 24VDC system at all sites.

H.6.1.1.1 The 24 VDC system will provide power the PLC and PLC remote I/O. The PLC system will not be affected by power line drop outs and will remain operational during a power fail. The operational time during a power fail will be 2-4 hours.

H.6.1.1.2 The 24 VDC system will also provide power to the cameras and allow them to operate during a power fail.

H.7 PLC SYSTEM

H.7.1 The PLC system will consist of one main processor

H.7.1.1.1 The PLC system will have remote I/O at the gate control panels.

H.7.1.1.2 The communication will be Ethernet over the fiber optic loop system.

H.7.1.1.3 A typical PLC of this size and using this type of communications could easily scan and respond to conditions at the gate control panel within a tenth of a second.

H.7.2 Local Operator Display

H.7.2.1.1 A local operator display will be mounted on the main control panel. This unit will be almost desktop computer like. It will use touch screen technology and have a roughly 14 X 16 inch display and comparable screen resolution and color rendering as a desktop monitor.

H.7.3 Capability of the PLC to Communicate to a Remote Monitoring Site.

H.7.3.1.1 PLC systems can readily be connected to a variety of communications methods. One type is the use of VPN (Virtual Private Network) equipment using encryption. The remote control of gate movement is not recommended at this site.

H.8 SITE CAMERA SYSTEM

H.8.1 The site would use similar or identical cameras at all locations.

H.8.1.1 Power Over Ethernet Cameras

H.8.1.1.1 Cameras have evolved from the coaxial cable era to the connected over the Ethernet. Power, typically 48 VDC is now extended over the Cat 5/Cat6 cable to the camera. Standard power over Ethernet (POE) converters provide the power to the camera. These units will be on the 24 VDC system.

H.8.1.1.2 Typical outdoor rated cameras have zoom and pan controls so an operator can readily control the camera.

H.8.1.2 Transient Protection of Cameras and Ethernet System

H.8.1.2.1 Many of the cameras will be mounted on poles, not at the top but still in the area of potential lightning strikes. Standard off the shelf Cat5/Cat6 Ethernet surge protectors will be used to protect the POE converters and the Fiber Optic Loop switches.

H.9 SITE LIGHTING

H.9.1 General

H.9.1.1.1 The site lighting will use LED light fixtures mounted on square- straight poles. The light fixtures are nominal 150 Watt, equivalent to 400 Watt HID fixtures. With no up light and sharp cutoff to horizon. This will minimize light pollution. The specifications are 100 MPH wind load. Poles are generally 20 ft. height. On the gate machinery platform the pole heights are 15 ft.

H.9.2 Poles

H.9.2.1.1 The poles proposed are 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. The poles will mount with the standard four bolt pattern, using 30 inch J-bolts embedded into concrete. Pole bases in-ground will be the standard re-enforced concrete pedestal, cast down to 7 feet below grade for full frost protection.

H.9.3 Light Fixtures

H.9.3.1.1 The light fixtures will be a sharp cutoff, parking lot luminaire. The fixtures will be powered by 120 VAC, and draw about 150 Watts. The light distribution type is T5M, 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.9.4 Lighting Control

H.9.4.1.1 The lighting will be controlled in single fixture or small groups. Each of the parking lot light fixtures are individually controlled. Four Hand – Off-Auto switches are located in the main control panel for the four parking area lights. Each gate control panel also has four lighting control circuits. This includes lights for the individual gate areas and the dam approach roadways.

H.9.4.1.2 Automatic control will be done via the PLC system. A single photo cell located at the control building will provide an automatic night time – on signal. Any light fixtures or groups in auto will then be controlled to turn on at night. The system offers flexibility to choose which lights would be controlled automatically.

H.9.5 Light Level Calculations and Light Pole Locations.

H.9.5.1.1 Light pole placement and lighting calculations were done using a computer program. The entire site was included. The parking area including the main control building is shown in Figure H2. Most of the parking lot is illuminated to 1.2 Foot Candles or higher. This a good level of illumination.

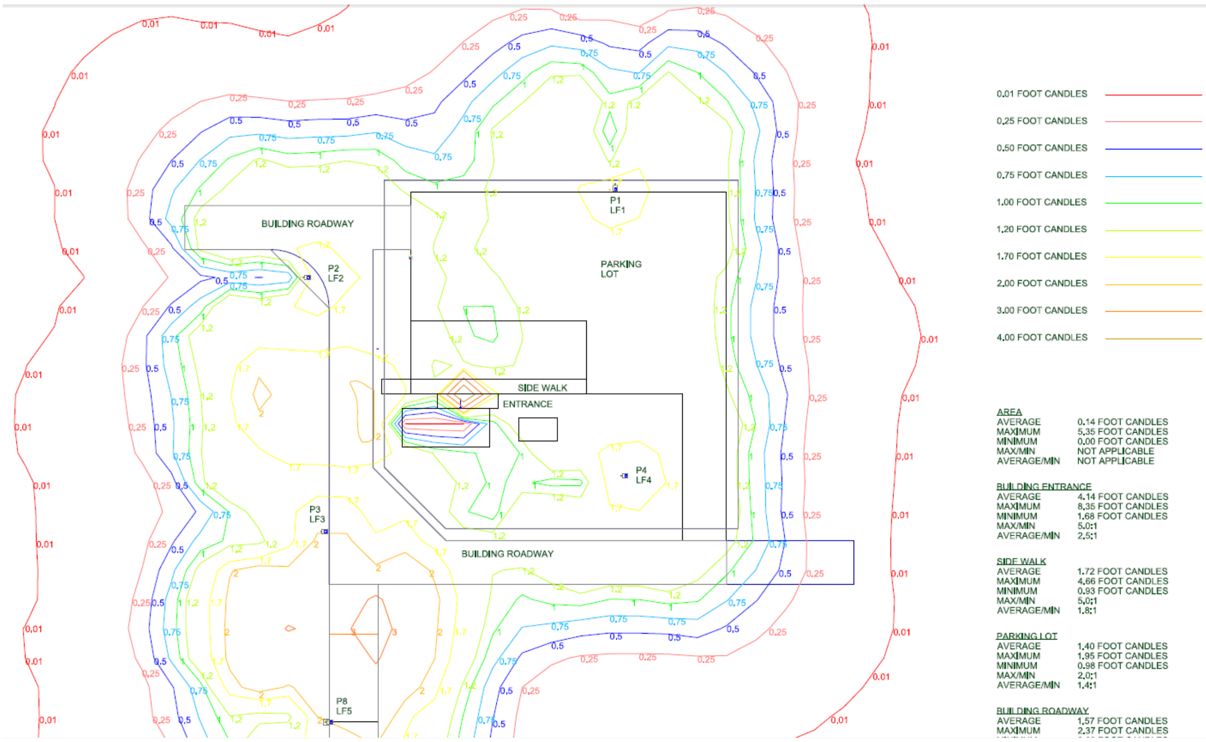

Figure H2. Parking Area Light level plot.

A portion of the lighting levels calculations is shown below, Figure H3.

<u>SIDE WALK</u>	
AVERAGE	1.72 FOOT CANDLES
MAXIMUM	4.66 FOOT CANDLES
MINIMUM	0.93 FOOT CANDLES
MAX/MIN	5.0:1
AVERAGE/MIN	1.8:1
<u>PARKING LOT</u>	
AVERAGE	1.40 FOOT CANDLES
MAXIMUM	1.95 FOOT CANDLES
MINIMUM	0.98 FOOT CANDLES
MAX/MIN	2.0:1
AVERAGE/MIN	1.4:1
<u>BUILDING ROADWAY</u>	
AVERAGE	1.57 FOOT CANDLES
MAXIMUM	2.37 FOOT CANDLES
MINIMUM	0.69 FOOT CANDLES
MAX/MIN	3.4:1
AVERAGE/MIN	2.3:1
<u>RIGHT DAM ROADWAY</u>	
AVERAGE	2.19 FOOT CANDLES
MAXIMUM	4.24 FOOT CANDLES
MINIMUM	1.49 FOOT CANDLES
MAX/MIN	2.8:1
AVERAGE/MIN	1.5:1

Figure H3. Parking Area Lighting Levels.

H.9.5.1.2 Gate Area Lighting. The gate area is well lit with light poles and fixtures at each junction point of the gate structure. Dual fixtures are used between gates 1 -2, and 2-3. The poles on the machinery deck are 15 ft. There are also roadway light poles at each end of the dam gates machinery, Figure H4.

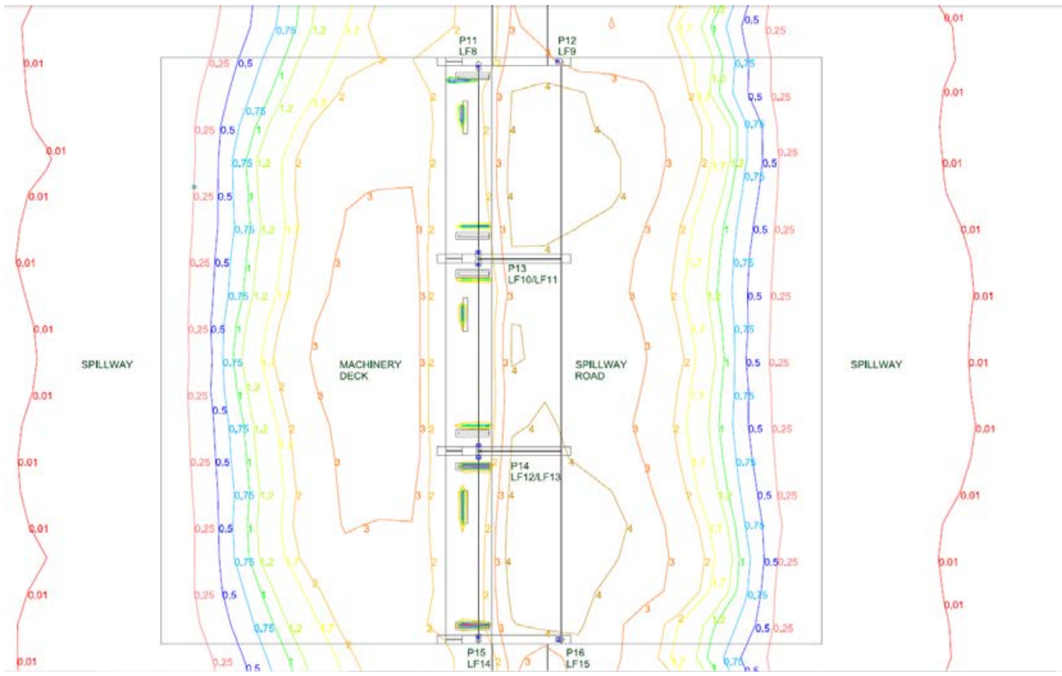

Figure H4. Gate Area Lighting.

.

The calculations for the Gate-structure areas are shown, Figure H5.

RIGHT DAM ROADWAY	
AVERAGE	2.19 FOOT CANDLES
MAXIMUM	4.24 FOOT CANDLES
MINIMUM	1.49 FOOT CANDLES
MAX/MIN	2.8:1
AVERAGE/MIN	1.5:1
SPILLWAY	
AVERAGE	1.38 FOOT CANDLES
MAXIMUM	2.96 FOOT CANDLES
MINIMUM	0.00 FOOT CANDLES
MAX/MIN	NOT APPLICABLE
AVERAGE/MIN	NOT APPLICABLE
SPILLWAY ROAD	
AVERAGE	3.26 FOOT CANDLES
MAXIMUM	4.57 FOOT CANDLES
MINIMUM	0.07 FOOT CANDLES
MAX/MIN	NOT APPLICABLE
AVERAGE/MIN	NOT APPLICABLE
MACHINERY DECK	
AVERAGE	5.71 FOOT CANDLES
MAXIMUM	10.08 FOOT CANDLES
MINIMUM	0.00 FOOT CANDLES
MAX/MIN	NOT APPLICABLE
AVERAGE/MIN	NOT APPLICABLE
LEFT DAM ROAD	
AVERAGE	1.96 FOOT CANDLES
MAXIMUM	3.99 FOOT CANDLES
MINIMUM	0.85 FOOT CANDLES
MAX/MIN	4.7:1
AVERAGE/MIN	2.3:1

Figure H5, Gate Structure Lighting Levels.

H.10 LIST OF FIGURES