Appendix K
Structural Engineering

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF PHOTOS

No table of figures entries found.

1 GENERAL

Two Rivers National Wildlife Refuge (Refuge) includes approximately 12,473 acres of riverine and floodplain habitat along the Illinois and Mississippi Rivers. Yorkinut Slough consists of approximately 4,331 acres, of which 1,801 acres are bottomland forest and wetland, and is located on the right descending bank of the Illinois River between River Miles 5 and 11 in Calhoun County, Illinois.

The study area is located within the Lower Illinois River Reach. The following documents the objectives for the Lower Illinois reach that apply to the Yorkinut Slough Habitat Rehabilitation and Enhancement Project (Project). The UMRR Reach objectives are:

- Hydraulics and hydrology: a more natural stage hydrograph,
- Biogeochemistry: reduced sediment loading and sediment resuspension in backwaters,
- Geomorphology: Restored lateral hydraulic connectivity,
- Habitat: Restored habitat connectivity and restored floodplain areas, and
- Biota: Viable populations of native species throughout their range in the Upper Mississippi River System (UMRS) at levels of abundance in keeping with their biotic potential, and restored diversity and extent of native communities throughout their range in the UMRS.

Improving water level management within the moist soil units (MSUs) is tied to the Project goal of creating a more natural stage hydraulics and hydrology. New proposed water structures will add the proper infrastructure to help achieve this objective. Modifications evaluated for the water structures include three types of planned actions: complete removal, removal and replacement and new installations. Structures deemed no longer needed due to berm modifications and subunits layout changes are proposed for complete removal. Undersized structures will be removed and replaced with bigger structures and new structures will be installed in various locations to increase capacity or due to berm modifications and subunits layout changes.

The Tentatively Selected Plan (TSP) is Alternative 3 Intermediate B, which has measures with components including the following:

- Berm construction and associated earthwork (approximately 12 acres)
- Berm enhancement and associated earthwork (approximately 8 acres)
- Berm deconstruction and associated earthwork (approximately 21 acres)
- Remove seven water control structures
- Install 10 water control structures
- Install 2 well pumps
- Well pump pipe installation (approximately 5400 ft.)
- Install 1 large gravity structure (~16' wide)
- Install 1 pump station
- Excavate 27 acres of channel
- Remove 13 acres of channel
- Excavate/re-grade acres of emergent wetlands (included in channel excavation acreage)
- Tree Planting (approximately 215 acres)
- Clearing and grubbing (approximately 5 acres)

- Timber stand improvement (approximately 632 acres).

1.1.1 Stop Log Structures

New stop log structures are intended to provide better infrastructure design, easier operations and easier access for maintenance (Photo 1). Stop log units can be made of different materials including wood, aluminum, steel and concrete or a combination of various materials. Stop logs can be manually placed or stacked with a logs lifter (Figure 1). Stop logs are required to be stored when not in use to avoid weather exposure damage and loss due to theft.

Photos 1 and 2 show two sets of stop logs made of different materials, aluminum and composite fiberglass, respectively. Figure 1 shows a system of stop logs, log lifter and embedded metals for guiding and sealing the logs.

Photo 1. Aluminum Stop Logs

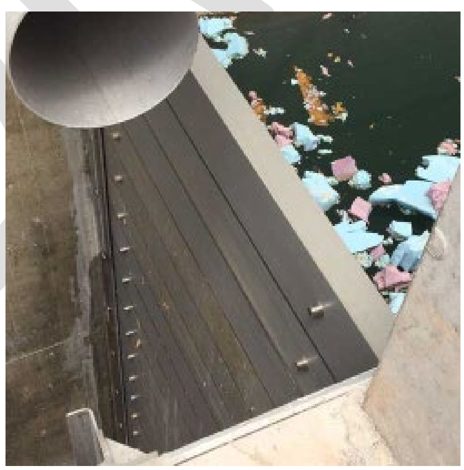

Photo 2. Composite Fiberglass Stop Logs

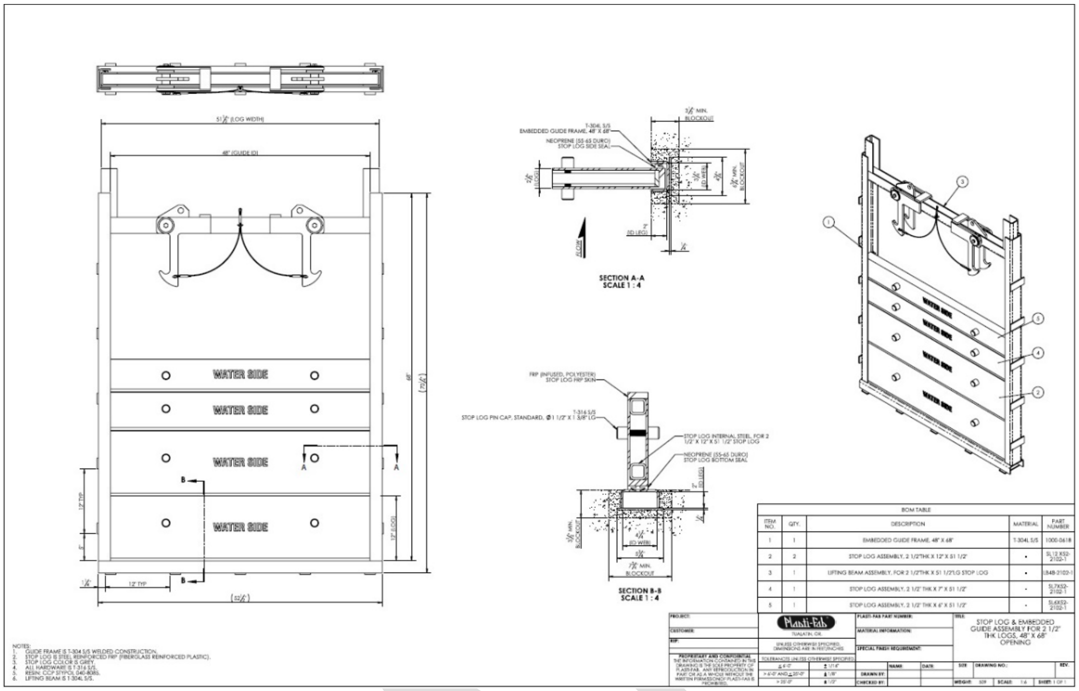

Figure 1. Plastifab® stop log, embedded guide assembly and stop log lifter sample drawing

The recess frames can be installed either on circular riser pipes or box culvert risers as shown in the figures below (Figures 2 through 4).

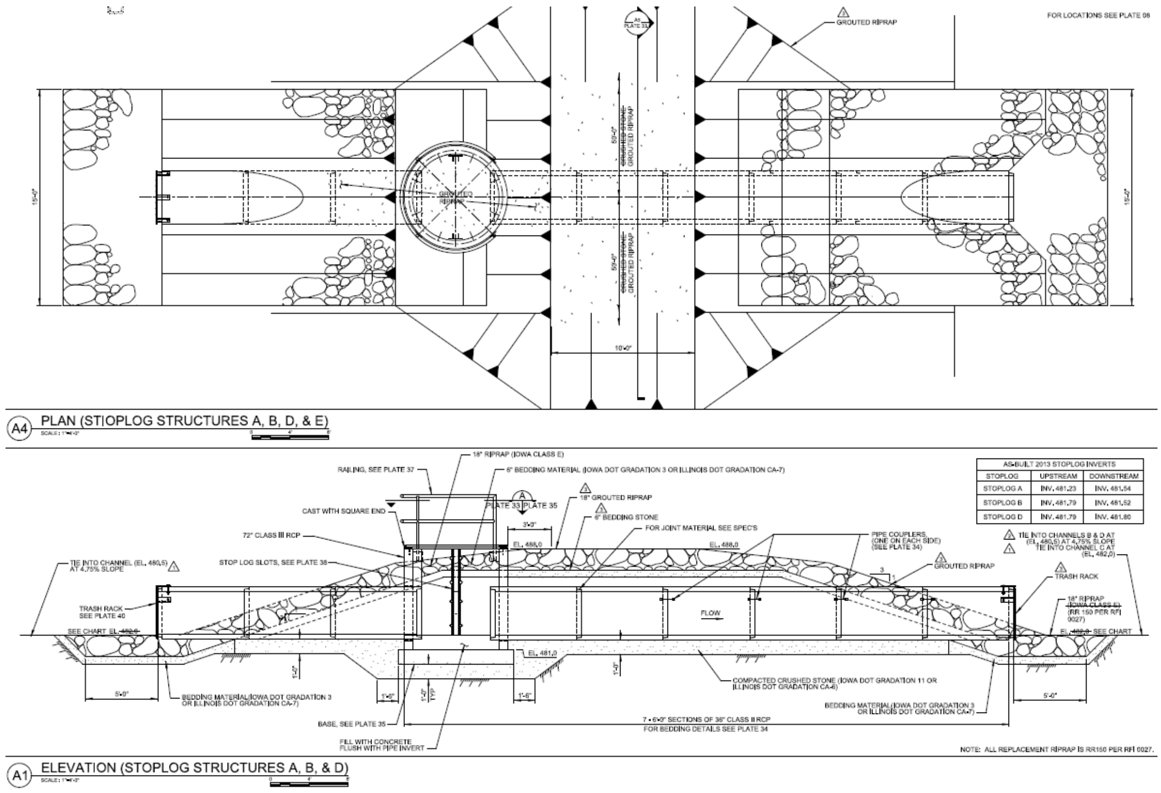

Figure 2. Sample drawing of circular RCP culvert with circular concrete stop log riser

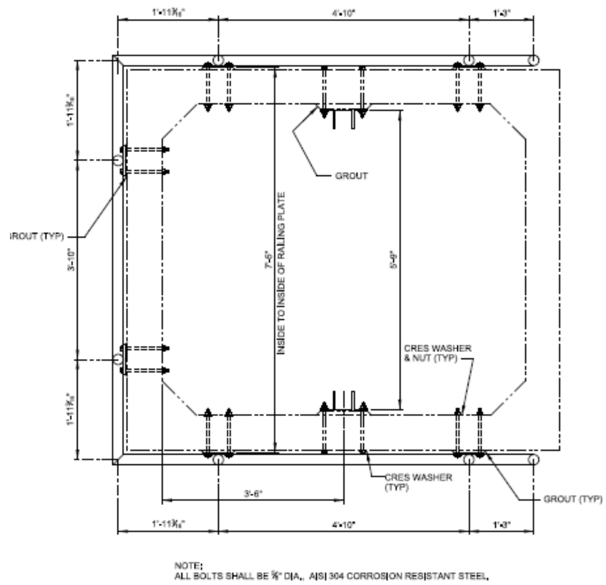

Figure 3. Top view drawing of stop log recesses installation on reinforced concrete box riser

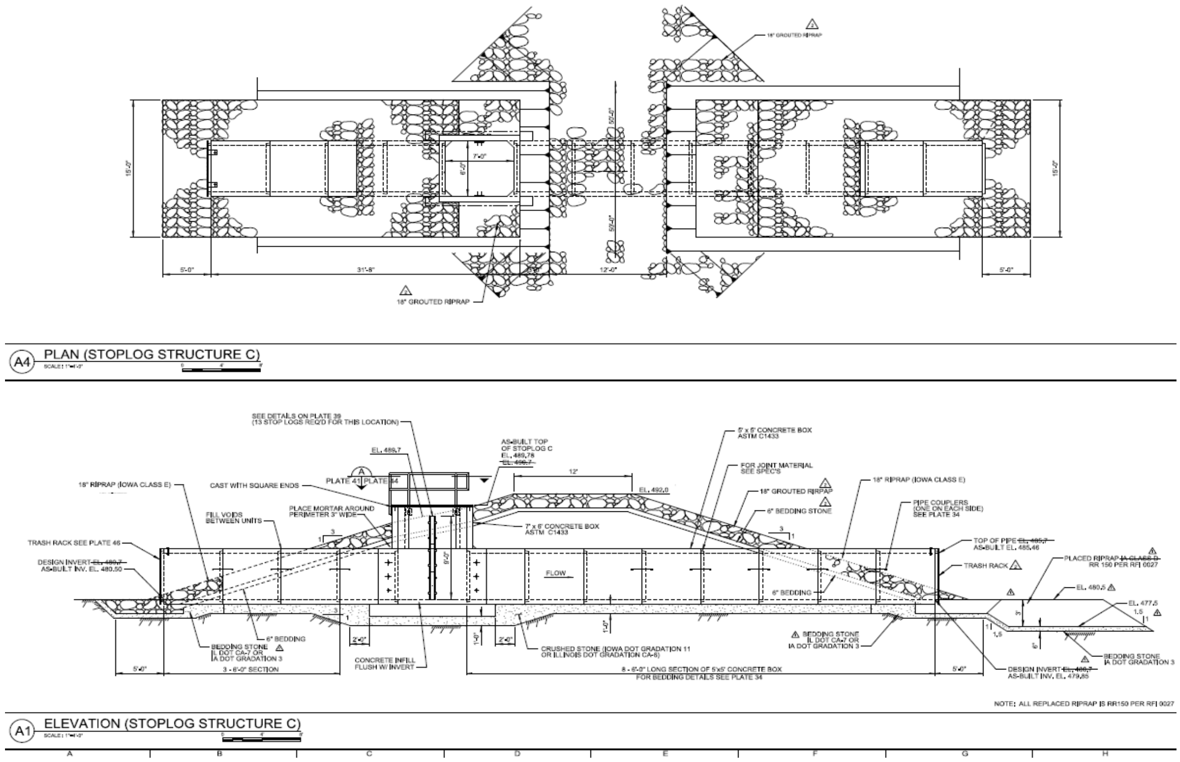

Figure 4. Sample drawing of reinforced concrete box culvert with reinforced concrete box stop log riser

1.1.2 Overshot Gates

An overshot gate provides for water movement and water depth control between two management units. They are known to be an effective replacement to stop logs. These types of gates stay in place after installation and can be manually or automatically controlled with a cable drum hoist. They are typically more expensive than stop log configurations and can require a larger reinforced concrete footprint. However, operational advantages include less travel between storage spaces and structures because the gates remain in place, and potentially less manpower for operation. Sample drawings are shown in Figures 6 and 7.

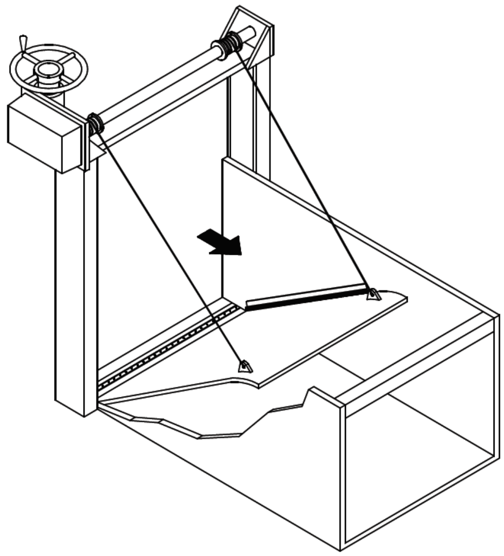

Figure 5. Overshot or tilting weir gate

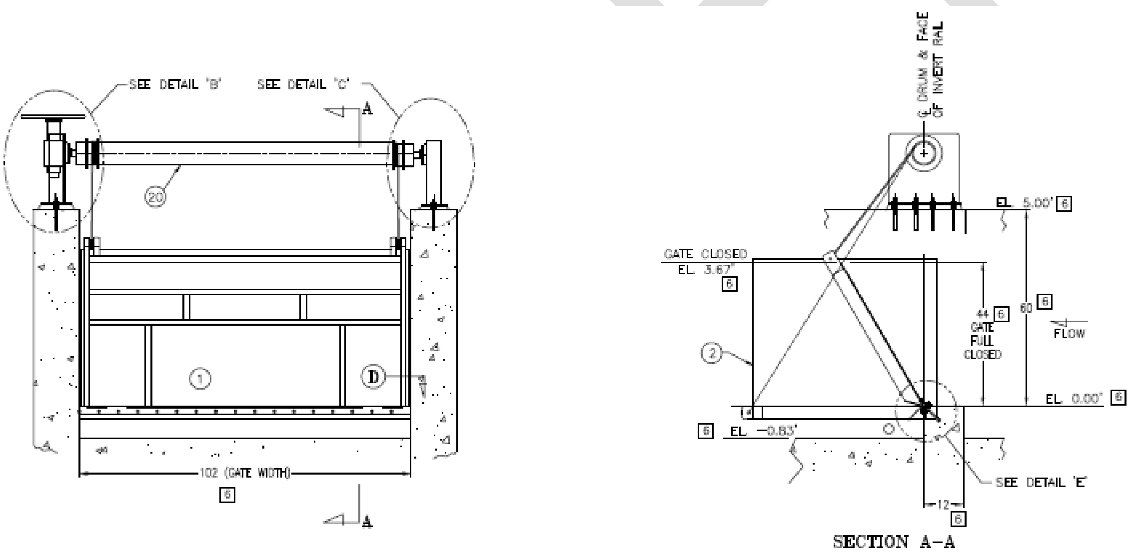

Figure 6. Sample drawing of overshot gate installation

1.1.3 Slide Gates

Slides gates are typically installed on reinforced concrete headwalls or on monoliths with flared end walls. They can also be installed on the face of a RCP or box culvert, with safe access to the gate operator provided by either by a walkway bridge or a grating platform. There are many types of slide gates that come in different shapes, but all are operated with upward/downward movements. Sluice-type slide gates allow flow through the opening when the leaf is lifted. Weir-type slide gates allow flow through the opening when the leaf is lowered. Slide gates can be manually or automatically operated. Structural portions of gate design include details associated with the installation hardware (e.g. blockouts for guide recesses and seal plates, anchorage or support of operators) and design of the reinforced concrete headwalls and flared end walls. Examples of slide gates and their installations are shown in Photos 3 through 6.

Photo 3. Single metal slide gate and frame

Photo 4. Metal slide gate installed on headwall face

Photo 5. Automatic slide gate installed on box culvert opening

Photo 6. Slide gate installed on reinforced concrete headwall structure

1.1.4 Pump Station

A pump station design involves the coordination of many disciplines and can take numerous forms. Pump station infrastructure can consist of a reinforced concrete monolith, a structural steel framework supporting an operating platform, or a sheet pile supported culvert inlet-outlet landing area. Depending on the infrastructure, pumps can be fixed within the station structure or brought to the station as needed. Pumps can be electric or diesel operated. In some cases diesel engines can be brought to the stations as needed to operate the pumps. For stations built within embankments, water can be conveyed into and out of the station by RCPs, concrete box culverts, or mortar-lined steel pipes.

Two primary aspects of the structural design of at pump station are strength and stability. The strength aspect considers the capacity of the structure's individual elements to withstand the loads applied and the stability aspect considers the capability of the structural system as a whole to resist undesirable movement like sliding, overturning, flotation and bearing. For a reinforced concrete station, the strength aspect is covered in the reinforced concrete design of the plant building or platform, depending on the layout, and the inlet and outlet structures. The plant building includes chamber and sump walls, beams, etc. The design of inlet and outlet structures include forebay, headwalls and flared end walls. The stability aspect of the design is analyzed using the weight of the structure versus the load combinations applied and the limits of the bearing capacity of the foundation materials. Different types of foundations can be utilized for pump stations such as slab on grade or pile founded depending on location soil properties.

Other designs include trash racks and miscellaneous metals.

Reinforced concrete designs are dependent on hydraulic needs and soil information obtained from the area, as well as operation and maintenance considerations.

Sample pump station and inlet/outlet structures section drawings are shown in Figures 7 through 11.

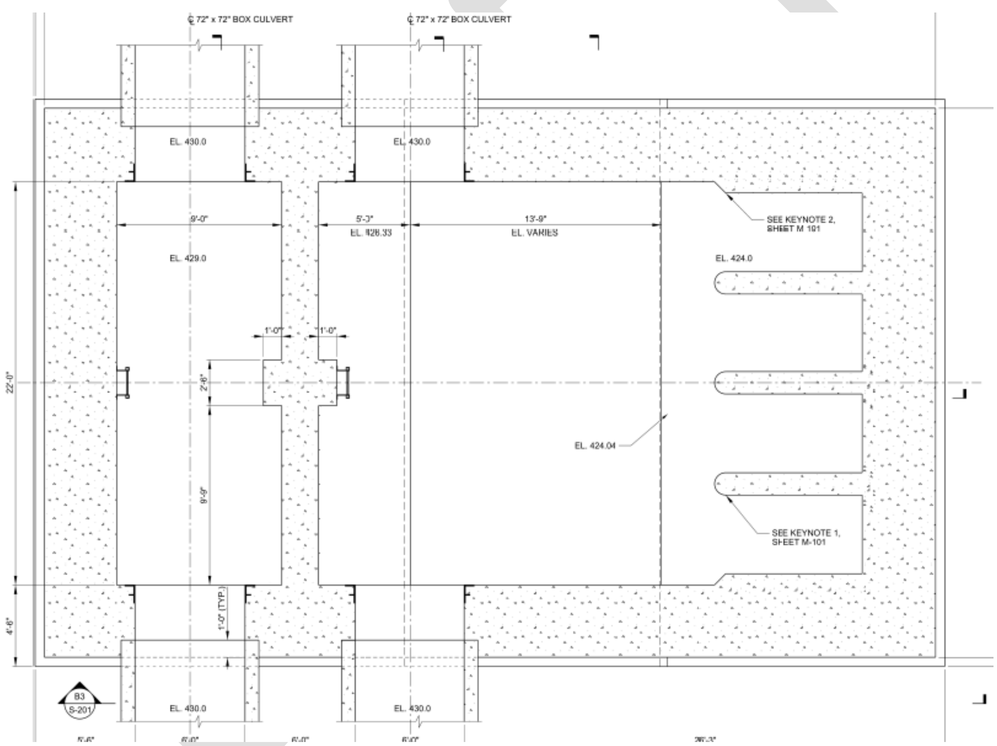

Figure 7. Sample drawing of section view of a pump station

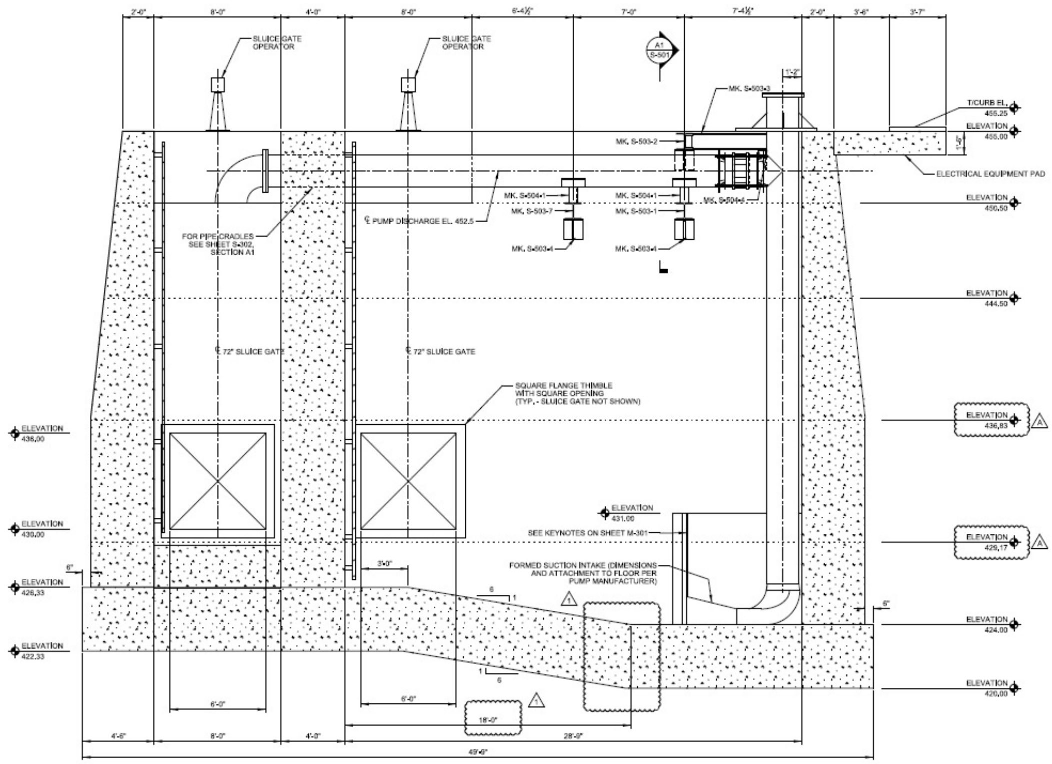

Figure 8. Sample drawing of section view of a pump station

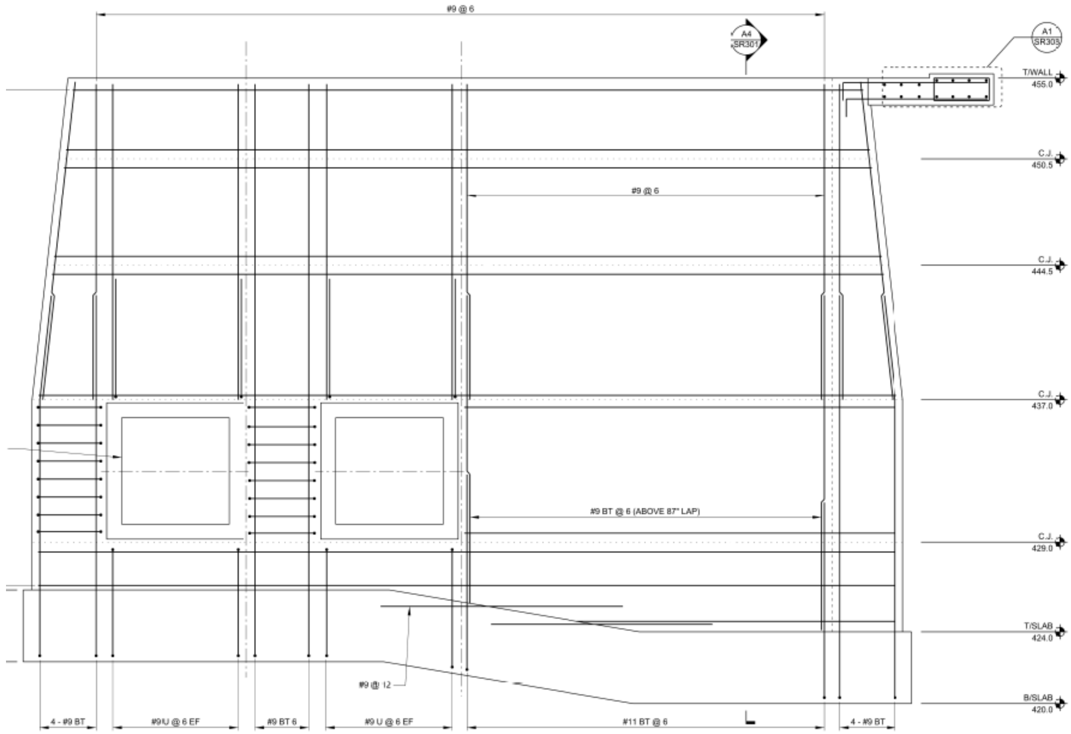

Figure 9. Sample drawing with reinforcement details of a pump station

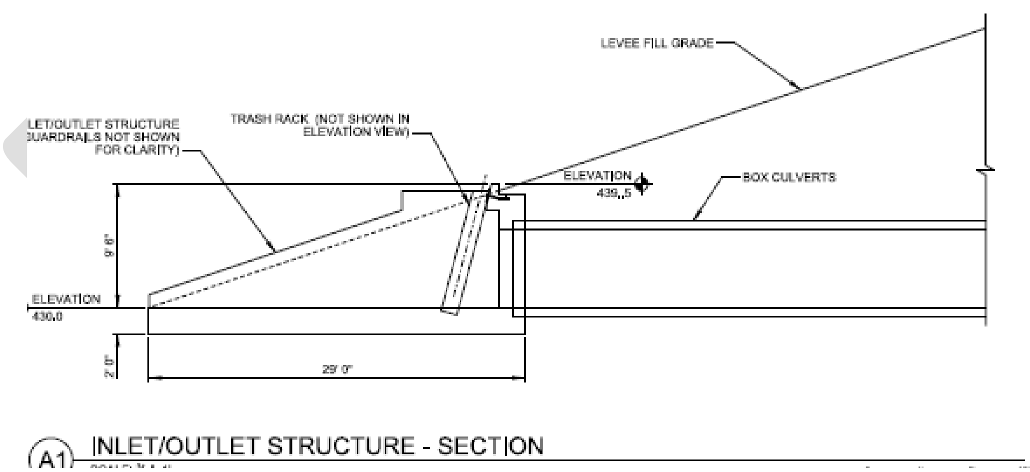

Figure 10. Sample drawing of inlet/outlet structure (applicable to pump station and gravity drains)

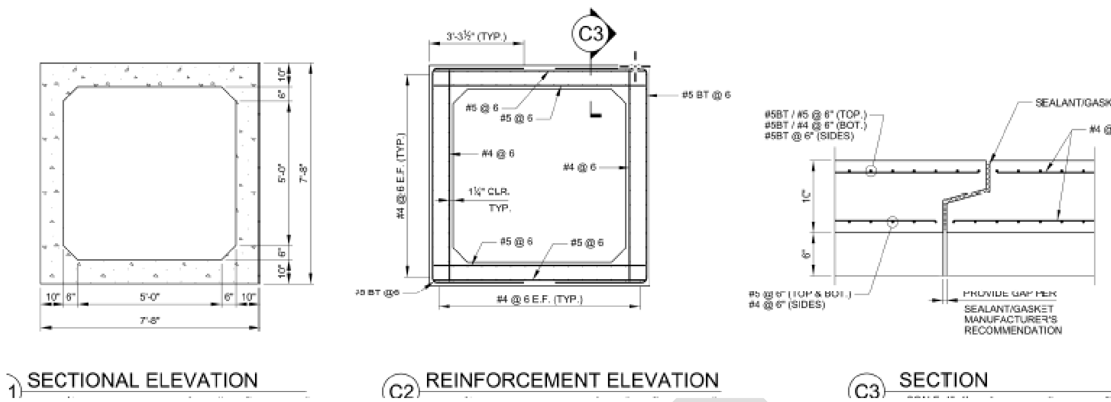

Figure 11. Sample drawings of different sections and details of a reinforced concrete box culvert

1.1.5 Miscellaneous Metals and FRP Items

The structural design of miscellaneous metals and fiberglass-reinforced plastic (FRP) includes guardrails, ladders, gratings, pump support beams, staff gages, installation hardware and others. Typical guardrail, rungs, and grating installation are shown in Photos 7 through 9.

Photo 7. Typical guardrail on headwall structure

Photo 8. Typical guardrail and rungs on headwall structure

Photo 9. Example of metal grating on top of gatewell structure

1.2 Assumptions

The following assumptions were made in order to calculate the reinforced concrete quantity of the stop log risers. See Figure 12 for stop log riser sketch.

Riser dimensions (H x W) = 5 ft x 5 ft

Wall thickness = 1 ft (conservative)

Top opening for Stop Logs access = 3 ft x 3 ft

Base dimensions (H x W) = 6 ft x 6 ft

Base thickness = 1 ft – 4 in

Wall openings for in/out RC box culvert pipes = 2 ft x 2 ft

Width from corner of wall to edge of culvert opening = 1 ft

Average fill above culvert pipes = 2 ft

"Freeboard" height between top of fill and top of riser = 1 ft

Out of the 30 new proposed control structures, 17 are stop log structures.

Riser walls = (1ft x 5ft x 5ft x 2) + (3ft x 5ft x 1ft x 2) = 80 cf.

Base = 1.33ft x 6ft x 6ft = 48 cf.

Culvert openings = -(2ft x 2ft x 1ft x 2) = -8 cf.

Net Volume of 1 riser structure = 120 cf.

Net Volume 19 risers = 120 cf. x 19 risers = 2,280 cf. of concrete

General quantities for RCPs, box culverts, headwalls, and flared end sections are included in *Appendix I - Civil Engineering* and costs have been assumed and accounted for.

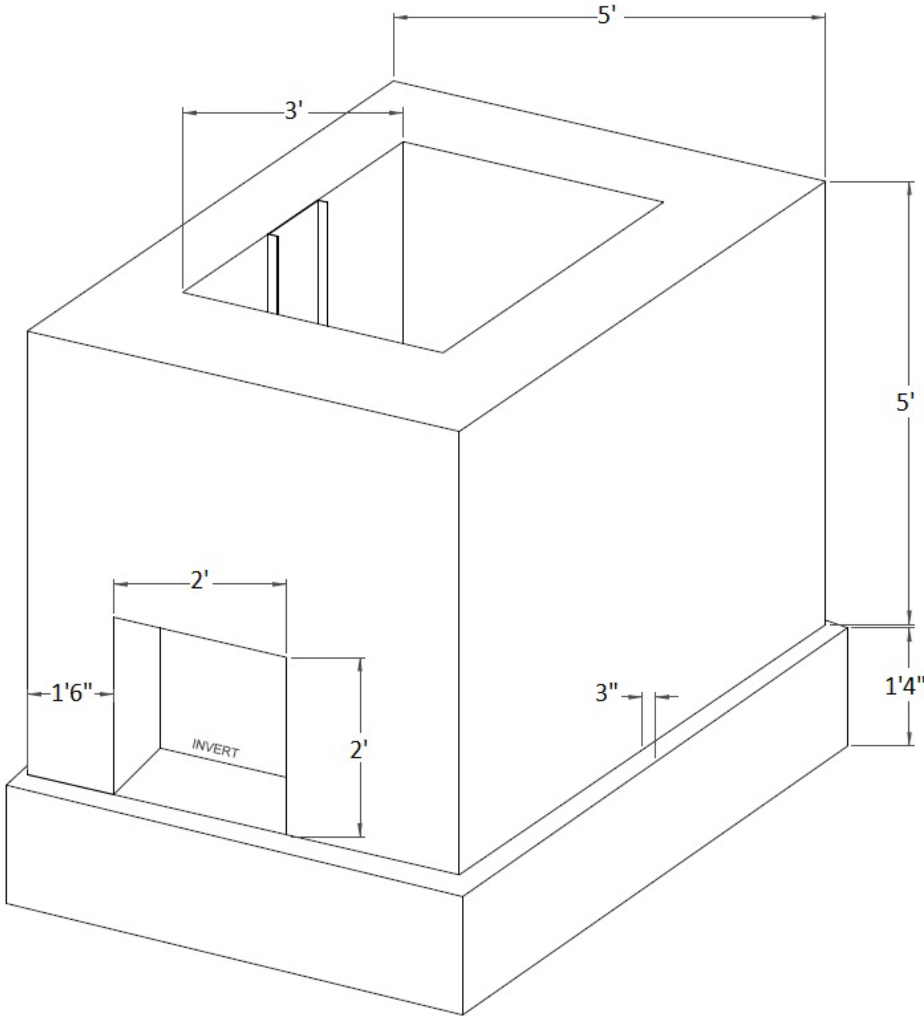

Figure 12. Sketch of new/proposed stop log riser design

1.3 Design Considerations

EM 1110-2-2100 Stability Analysis of Concrete Structures

EM 1110-2-2104 Strength Design for Reinforced Concrete Hydraulic Structures

EM 1110-2-2400 Structural Design and Evaluation of Outlet Works

EM 1110-2-2502 Retaining and Flood Walls

EM 1110-2-2504 Design of Sheet Pile Walls

EM 1110-2-2902 Conduits, Culverts and Pipes

EM 1110-2-2906 Design of Pile Foundations

EM 1110-2-3104 Structural and Architectural Design of Pumping Stations

EM 1110-2-6053 Earthquake Design and Evaluation of Concrete Hydraulic Structures

ACI 318-14

AISC Steel Construction Manual

MODOT/IDOT Culvert Design Guidelines

AASHTO Bridge Design

ASTM Standard Specifications