US Army Corps of Engineers®
St. Paul District

Appendix N: Engineering Considerations

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Outlet Structure and Reach 1

Engineering and Design Phase

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Table of Contents

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N.1 INTRODUCTION

The Fargo Moorhead Reach 1 construction project, as depicted in Figure 1, is located at the downstream (north) end of the diversion channel where it extends from the confluence of the diversion channel and the Red River of the North to Station 227+00. Reach 1 is part of the 35 mile diversion channel project. Reach 1 includes the outlet structure (outlet from the diversion channel to the Red River of the North), the Diversion Channel from the outlet structure to station 227+00, County Drain 30 and its associated inlet structure. County Road 31 (173rd Avenue SE) and County Road 4 (25th Street SE) currently cross Reach 1's alignment. A single bridge will carry the traffic from these roads across the diversion. The design and construction of this bridge, 1,000 feet of diversion channel, and the realignment of Drain 29 are a local sponsor responsibility.

Major work items include the following:

- Outlet Structure
- Diversion Channel with Sinuous Low-Flow Channel
- County Drain 29
- County Drain 30 Inlet Structure
- Excavated Material Berms and Levees
- Rock Ramp/Fish Passage Structures
- County Rd 31/4 Bridge
- Vegetation

N.2 HYDRAULICS

N.2.1 Rock Ramp Diversion Outlet

The rock ramp diversion outlet serves two main hydraulic purposes. The first goal is to safely convey flood flows from the diversion channel to the Red River of the North. The second is to provide adequate opportunity for fish passage from the Red River to the diversion channel, and ultimately the Rush River, for a wide range of flow conditions. In order to provide the best opportunity for fish passage, a number of design aspects of the structure have been altered from typical Red River Basin fish passage structures. Since this passage will be on a newly constructed channel rather than an existing river channel, further modifications can be made to improve the chance for fish passage. A list of these modifications and engineering considerations for construction are as follows:

1) The overall slope of the outlet, at 2%, is flatter than the slopes of most fish passages.

2) The vertical drop between each boulder weir, and therefore each pool elevation, is 0.5 ft. While some fish passages utilize drops of 0.8-1.0 ft or higher, a smaller drop should allow for greater chance for passage of a wider variety of species at a minimal additional cost. For this project, it is not desirable for adjacent pools to have greater than 0.5 ft of difference between them.
3) Boulders along each weir should be placed under the supervision of a hydraulic engineer or similar technical advisor. The boulders should be adjusted so that they provide adequate gaps for passage while maintaining the designed pool elevations.
4) Placement of irregularly shaped boulders should ensure that the top elevation of the boulders align and follow the boulder-weir profiles as specified in the plans.
5) Pools should also be shaped under the supervision of a hydraulic engineer or similar technical advisor. Riprap should be shaped to maximize pool depths while still ensuring that the minimum riprap thickness is met throughout the pool.
6) Riprap should be built up on either side of each boulder-weir to help embed the boulder and reduce the chance for boulder movement from ice and debris.
7) While all boulders will be required to meet the specifications for size and shape, those that minimally meet the requirements (smaller boulders) should be placed toward the ends of the boulder-weirs. Larger, heavier boulders should be placed toward the center of the boulder-weir to better resist impacts from ice and debris down the center of the channel.

N.3 GEOTECHNICAL

N.3.1 Diversion Channel Excavation

The excavation of the diversion channel will be made through different types of materials. These materials have not been differentiated in the bid package for measurement and payment; all materials are lumped together. It is anticipated that various methods of excavation will be used/required because the materials differ in properties.

N.3.1.1 Topsoil

Topsoil is anticipated to be 1 to 2 feet thick within Reach 1. Stripping of the topsoil and organics is only required beneath the embedded levee prism and any roadway subgrade. The topsoil should be readily distinguishable as it will be black compared to the gray or dark gray material beneath it.

The project will require more topsoil than is available in locations where stripping is required. The Contractor will need to strip additional areas to obtain the necessary quantity of topsoil for the project. The Contractor is responsible for determining the location and quantity to strip and stockpile. (See Specification Section 31 00 00.00 13 Paragraph 2.2.4 Topsoil)

N.3.1.2 Excavation

The materials required to be excavated vary in quality with depth. The upper-most material will be either Alluvium or Sherack, and will be able to support the construction equipment the best. This material will meet the requirements of impervious fill and will be used to construct the embedded levee

and roadway subgrade. It should also be used for any impervious structural backfill. The moisture content will increase with depth, especially below the groundwater table.

Below the upper layer, Oxidized Brenna and Brenna will be encountered. These materials will have the highest liquid limit and will provide the least support to construction equipment. These materials will also be located below the groundwater table, so the moisture contents will be high.

N.3.1.3 Muck Excavation

The diversion channel crosses existing drains and low areas where "muck" materials may be located. The muck material shall be removed prior to placement of any type of fill. The COR shall observe the conditions of the surface prior to allowing the Contractor to place any fill.

N.3.1.4 Groundwater and Seepage

The soils within Reach 1 are anticipated to be made up of silty clays. The borings and CPT soundings did not show any indication of pervious materials being located within the excavation extents. Because of this, it is hard to determine an accurate groundwater table and will likely vary seasonally. The boring logs and vibrating wire piezometer instruments indicate that the groundwater table could be anywhere from 5 to 25 feet below the ground surface, which is the best available information.

Due to the impervious nature of the soils, it is not anticipated that a significant amount of water will seep or flow into the excavation. Significant seepage could occur through more pervious seams such as silts and sands, if encountered. In the vicinity of Drain 30 and the abandoned Sheyenne River meander (STA 204+00 to 215+00), more seepage may be encountered as the soils here are siltier.

If there is major seepage entering the excavation, the Geotechnical and Geology Section shall be contacted.

N.3.1.5 Wells

There could be abandoned wells encountered within the excavation area. These wells were to be abandoned by the Local Sponsor demolition contractor per applicable state well codes and regulations. This means the well casing was filled with a lean cement or bentonite grout. The Contractor will be required to excavate and expose the well casing 3 feet below final grade and cut it off. The excavated area needs to be backfilled with impervious fill material. If it appears that the well was not properly abandoned or sealed, the Geotechnical and Geology Section shall be contacted.

N.3.1.6 Foundations and Other Underground Tanks

The Local Sponsor is responsible for the demolition of structures within the grading limits. House foundations and underground tanks will be removed and temporarily backfilled to prevent a hazard. The temporary backfill will be placed without any control. The Contractor is required to remove the temporary backfill and recompact it. If the temporary backfill falls within the slope of the diversion channel or beneath the EMB, the fill shall be reconstructed to 85% maximum dry density. If the temporary fill falls beneath the embedded levee, the fill shall be reconstructed to 90%. (See Specifications Section 31 00 00.00 13 Paragraph 3.13.3 Temporary Fill Locations.)

N.3.1.7 Rebound

The excavation of the channel will reduce the stresses in the underlying materials, allowing them to expand. The result is that the excavated surface will rebound. Due to the impervious nature of the soils, the rebound will occur over time. It is anticipated that some rebound will occur during the construction period and the rest will take years, maybe even decades. It will be important to monitor the grade of the diversion channel as it nears the final grade lines. It is not recommended to allow a long delay to occur between final grading of the excavation and the placement of the topsoil. The quantity surveys should be completed soon after each grading operations.

N.3.2 Excavation for Drain 30 Structure

A temporary excavation will be required for construction of the Drain 30 inlet structure. The Contractor is responsible for maintaining safe temporary excavations during project construction, and should submit an excavation plan in accordance with the specifications prior to excavating for the Drain 30 structure, including drawings and calculations certified by a registered professional engineer. USACE has conducted some slope stability analyses to provide input to the design. The analysis assumes the excavation would be open no longer than a single construction season. See Appendix D of the Reach 1 DDR for additional details.

N.3.3 Placement of Excavated Materials

The Contractor will need to plan the excavation such that the materials required for topsoil, the embedded levee, and the road subgrade are obtained from the upper portion of the excavation where Alluvium and Sherack are located. The majority of the excavated materials will be placed as random fill within the excavated material berms.

N.3.3.1 Embedded Levee

The Contractor is required to construct an embedded levee from STA 91+86 to STA 277+00. The embedded levee prism is similar to the standard Corps levee used within the Red River Valley, consisting of 1V:3H slopes and a 10 foot top width. The impervious fill used to construct it should come from the upper portion of the diversion excavation. The material only needs to be semi-compacted, meaning a minimum compaction of 90% of the Standard Proctor with a maximum lift thickness of 12 inches. There is no moisture requirement, but if the material is too wet, the Contractor may have a hard time working with the material and achieving required compaction.

N.3.3.2 Road Subgrade

The 36 inches of subgrade below any aggregate of road surfacing shall be compacted to 95% of the Standard Proctor and at a moisture content within 3 percentage points above and 2 percentage points below optimum moisture content, in lifts not exceeding 9 inches. There is a large portion of the road subgrade that will be on top of the EMB fill material, which is only placed at a minimum density of 85% of Standard Proctor. The Contractor may need to start compacting the EMB to a higher density below the road subgrade in order to have a stiffer foundation that the road subgrade can be compacted against to obtain a minimum density of 95% of Standard Proctor.

N.3.3.3 Excavated Material Berms

All the remaining excavated material that is not used as topsoil, levee, or road subgrade material will be placed within the EMBs as random fill. The random fill can be placed in lifts up to 18 inches thick and the minimum compaction is 85% of the Standard Proctor.

N.3.3.4 Topsoil

The placement of the topsoil requires the subgrade to first be deep disked and then incorporated into the subsoil (See Specification Section 32 92 19.01 13, 3.2 Site Preparation). This requirement will preclude the Contractor from placing topsoil during winter operations.

N.3.3.5 Swell / Shrink

It is expected that the excavated material will swell within the EMB. The EMBs have been designed to accommodate a net increase in volume of 15% of the plan excavation quantity. The actual amount of swell will depend on the method of operations the Contractor uses for excavation and how much the material is compacted by the equipment traffic. The excavated material will have a greater swell factor during winter operations.

N.3.4 Winter Operations

The team recognized that excavation of the diversion channel during winter conditions may be advantageous to the Contractor. In the specification, this is referred to as Winter Operations. It is defined as when the frost thickness is 3 inches or more. The intent is to allow the Contractor more time and flexibility to excavate the channel. Also, a frozen subgrade may facilitate operations at the base of the channel. With winter operations, there are a few unique constraints which are discussed below. The Contractor is required to provide a winter operations plans for review and approval. The plan shall detail how the earthwork operations will be done.

(Reference Specification Section 31 00 00.00 13 Paragraph 3.7 Winter Operations.)

N.3.4.1 Placement of Excavated Materials

The integrity of the inward one half of the EMB nearest the diversion channel shall be maintained. This is important as the slopes on the EMB will be seen as part of the project and sloughing and differential settlement of this slope may lead to unwarranted deficiencies being documented during inspections. To minimize this, the specifications require that the inward one half of the EMB consist only of unfrozen material placed on unfrozen subgrade. If the subgrade becomes frozen, it shall be removed to expose unfrozen subgrade.

The integrity of the outward one half is not as critical to the project performance and will not be subject to the same level of scrutiny during inspections. This allows the placement of materials to be relaxed. In the outward one half, the frozen subgrade must be scarified prior to placement of unfrozen materials. This will help the lifts bond together and help minimize potential shear surfaces.

When dealing with frost and frozen materials, it is important to minimize the potential for large voids within the EMB as this will lead to differential settlement. To reduce this potential but still provide some flexibility to the Contractor, the specifications indicate the excavated materials containing frost, chucks

of frozen materials measuring less than 8 inches can be placed within the outward third of the EMB in 18 inch lifts. If the material excavated contains chunks of frozen material greater than 8 inches or is completely frozen, this material needs to be temporarily stockpiled and reworked once it has thawed out.

N.3.4.2 Snow Removal

The Contractor will be required to keep the snow cleared from the work area. Snow shall not be incorporated into any portion of the EMB.

N.3.4.3 Final Grading

Final grading of the diversion channel excavation needs to be completed when conditions allow. If the thickness of the frozen rough graded channel is close to the thickness that is required to be removed to obtain the final grade, there is concern that the final grade will not be smooth and level. Also, if the final grade is established during the winter, the spring melt, runoff, and rain may disturb the final grade enough that regrading is required prior to placement of topsoil. Coordination between the Contractor and the Corps is recommended regarding the timing of final grading and final surveys.

N.3.5 Materials

N.3.5.1 Select Granular Fill

The select granular fill is used beneath the Drain 30 structure to reduce the frost heave potential. This select granular fill needs to be clean material (less that 5 percent passing the No. 200 sieve). Materials that are dirtier will increase the frost heave potential. It is very important to have the gradation tests completed prior to delivery of the material to the site to make sure it meets the specifications, and have gradations completed on the materials after it has been placed.

N.3.5.2 Riprap and Bedding

Erosion is a major concern for the diversion channel, and a significant amount of stone protection is required as part of the project. Most areas of stone protection consist of riprap underlain by bedding and permanent erosion control geotextile. Stone protection can consist of either field stone or quarried stone, but not both. All stone is subject to gradation testing prior to and during placement.

N.3.6 Instrumentation

As part of the project design, nested vibratory wire piezometer clusters were installed throughout Reach 1. The locations of these instruments are indicated on the plan sheets. These instruments are located outside the grading limits but still within the work limits. The Contractor shall be made aware of these locations and shall take precautions so as not to damage them.

N.3.7 Hazardous, Toxic, and Radioactive Wastes

The Phase I Environmental Site Assessment (ESA) found two properties with minor recognized environmental conditions (RECS). The Wayne and Gary Ohnstad property (Parcel No. 70000013646010) had some “junk vehicles” on it. The Palmer Inhnhken property (Parcel No. 70000013644020) had a

propane tank, 2 fuel tanks, and a septic tank. These are common to small agriculture and rural residential settings and if handled properly, will not be a risk.

In agriculture and rural setting, there could be additional areas found to contain HTRW which wasn't found during the Phase 1 ESA. The Contractor shall make the Corps aware of any HTRW that is encountered and dispose of it properly.

N.4 STRUCTURAL

The Drain 30 inlet to the diversion channel will be dual 60-inch-diameter reinforced concrete pipes (RCPs) between an upstream headwall structure and a downstream impact stilling basin. Energy dissipation will be provided by the impact stilling basin which extends the width of both pipes. A flap gate will be installed on each pipe to reduce the effect that flood waters in the diversion channel could have on the water levels in the county drain. Drain 30 enters the diversion under the west EMB at station 223+47.

N.4.1 Drain 30 Inlet Headwall Structure

The inlet headwall structure has a one foot key on the upstream side simply to prevent the structure from being undermined and removing the frost proof select granular fill. The two 60" reinforced concrete pipes should be cast into the headwall. There is a requirement for the geotextile fabric to be placed on the soil side of the wall at the joints so that material is not moved through the joints.

N.4.2 Drain 30 Dual 60" RCP Lines

There are two 60" pipes that need to be cambered due to settlement and rebound that will occur during the life of the project. The contractor is responsible for determining the lengths of each section of the pipes, but there are specific inverts the pipe has to meet along with the stationing for each invert. The contractor will need to set these pipe inverts and then fill in the void beneath the pipe with flowable concrete fill. The choice for the flowable fill is because the contractor will not be able to compact and use pipe bedding to avoid seepage paths through the embankment. There is a 40' drainage blanket on either end of the pipe that needs to be select granular fill not flowable concrete around the pipe, see SS201 in the plan set.

N.4.3 Drain 30 Outlet Impact Basin

The outlet impact basin has a pipe box on the upstream end which needs to be connected to the impact basin and have the pipes cast into. The rebar must tie each slab together, but the contractor can pour the slabs individually.

There is a key on the downstream end of the impact basin which has the only purpose of keeping the structure from being undermined and loosing the select granular fill that is required to keep the structure from heaving. The key needs to extend 1' past the select granular fill.

N.5 CIVIL

N.5.1 Existing Conditions

Existing topographic data utilized for the design and drawings is from Aerial Light Detection and Ranging (LIDAR) and ground survey campaigns performed in May 2011 by Merrick and Company through contract with the local sponsors. Detailed ground and hydrographic survey campaigns were performed between October 2011 and March 2012 by the St. Paul District Corps of Engineers survey crew and Anderson Engineering of MN in order to enhance the accuracy of the surface models. The coordinate system and projection of the existing condition data is NAD83 (2007), North Dakota State Plane Coordinate System, South Zone (U.S. Survey Feet). The elevation datum of the existing condition data is NAVD88 (U.S. Survey Feet).

N.5.2 Existing Utilities

All utility relocations will be performed prior to construction. Utility relocation plans will be provided to the contractor as a plan reference document.

The following table lists identified utilities within the construction limits of Reach 1:

Utilities Reach 1

UTILITY	CROSSING STATION	DESCRIPTION
ELECTRIC		
Cass County Electric	Underground line crosses at Station 39+99.	Line runs east-west along the south side of an un-named town road , intersects with power line running parallel (north – south) with 173rd Ave. SE Single Phase Underground.
Cass County Electric	Underground line crosses at Station 51+84	Line runs North-South along the east side of 173rd Ave. SE. Single Phase Underground.
Minnkota Power	Overhead line crosses Reach 1 center line at Station 54+12	Line runs North-South along the West side of 173rd Ave. SE width of project. 69KV transmission.
Cass County Electric	Overhead line crosses from the east to a point approximately 900 feet NE from center line at Station 58+00	Service line to farm stead.

UTILITY	CROSSING STATION	DESCRIPTION
Cass County Electric	Overhead line crosses at Station 202+70	Line runs North-South along the East side of 171st AVE SE
Minnkota Power	Overhead line crosses at Station 210+64	69 KV Transmission line, line runs North-South.
COMMUNICATION		
Century Link	Underground copper line crosses at Station 39+91	Line runs east-west along the south side of an un-named town road; crosses 173rd Ave. SE and runs north along the west side of 173rd Ave. SE. One 6-pair copper.
Century Link	Underground cooper line crosses at Station 52+34	Line runs North-South along the east side of 173rd Ave. SE width of project. One 6-pair copper.
Century Link	Two underground cooper lines cross at Station 156+09/156+20	Two 25 pair copper lines run east-west along the south side of 25th St. SE width of project.
Century Link	Underground cooper line crosses at Station 202+80	Two single pair cooper lines runs north-south along 171st Ave SE.
WATER		
Cass Rural Water Users, Inc.	Water Service line serves existing farmstead, ends at Sta. 58+00, 200' LT, extends to 173rd Ave. SE.	1 ½ "Service line to farmstead. Line runs parallel to 173rd Ave. SE along the west edge of R/W.
Cass Rural Water Users, Inc.	Station 84+00	Water line runs east- west along the north R/W of 24th St. SE
Cass Rural Water Users, Inc.	Station 153+81	1 ½" water main
Cass Rural Water Users, Inc.	Station 204+16	2" water line runs north-south along west edge of 171st Ave. SE

No known domestic wells have been identified within the Reach 1 project limits. All wells within the project limits are scheduled to be abandoned by the local sponsor prior to construction and will be filled with lean cement or a bentonite grout.

N.5.3 Care and Diversion of Water

N.5.3.1 Construction Phasing

The following construction phasing was considered during the design of Reach 1 to meet compliance with the NPDES Permit NDR10-0000 in conjunction with the temporary plug at the Outlet to the Red River.

1. Temporary Drain 29 Reroute to be constructed under Local Sponsors CR4/31 Bridge Contract
2. Excavate Temporary Plug (Sta. 30+00 – Sta. 33+50). Temporary Plug to remain in place until final stabilization in compliance with applicable NPDES permit is achieved upstream.
3. Construct Reach 1 upstream of temporary Plug (Sta. 33+50 - Sta. 81+86 and Sta. 91+86 - Sta. 216+00). Recommend construction phasing to establish final stabilization in compliance with applicable NPDES Permit NDR10-0000. Appendix 1-A. Erosion and Sediment Control Practices requires temporary sediment basins, or equivalent control where ten (10) or more acres of disturbed area drain to a common location prior to the runoff leaving the site or entering surface waters.
4. Construct Temporary Drain 30 Reroute
5. Construct Reach 1 (Sta. 216+00 - Sta. 227+00)
6. Construct Coffer Dam in Red River
7. Construct outlet into Red River downstream of Temporary Plug (Sta. 25+50.50- Sta. 30+00).
8. Construct Permanent Drain 29 Sta. LDO 2+51.29 – LDO 8+00
9. Remove Temporary Plug upon Final Stabilization upstream of Sta. 33+50.
10. Construct Outlet (Sta. 30+00-Sta. 33+50)
11. Construct Permanent Drain 29 Sta. LDO 8+00 - Sta. LDO 11+66.90
12. Fill in Temporary Drain 29
13. Construct Permanent Drain 30
14. Fill in Temporary Drain 30
15. Construct Left Bank Outlet Access Road

N.5.4 As-built Survey Considerations

Survey the constructed embedded levee top to develop an independent horizontal and vertical control line for the embedded levee. Survey the main channel toe to include on as-builts for use on future maintenance.

N.6 CULTURAL RESOURCES

N.6.1 Archaeological

For Reach 1, construction monitoring for deeply buried archeological sites is needed at the Red River in the diversion channel outlet area and the outlet areas for the temporary and permanent Drain 29 alignments.

In addition, prehistoric archeological site 32CS201, located north of Drain 30 and east of 171st Avenue SE near the Sheyenne River, has been determined eligible to the National Register of Historic Places. A separate cultural resources mitigation contract with professional archeologists to conduct archeological excavation of a portion of the site within the Project work limits will be awarded after the land parcels containing the site are acquired for the Project. The cultural resources mitigation must be completed prior to Project-related construction and earth-moving in this area. The cultural resources mitigation area will be shown as a temporary off-limits area on the Reach 1 construction drawings if mitigation is not completed by the time the Reach 1 construction contract is ready to be advertized. The Contracting Officer's Representative (COR) will notify the Contractor when cultural resources mitigation is completed and Reach 1 construction may proceed in that area.

In accordance with the cultural resources programmatic agreement, construction in select reaches of the project will need to be monitored by a qualified professional archeologist. Areas requiring construction excavation monitoring include river floodplains, terraces and oxbows, which are locations with high potential to contain buried archaeological sites. Construction monitoring is required within 100 meters (328 feet) of the bank of the rivers affected by the diversion channel, including at the Red River outlet area, the Lower Rush River inlet area, the Rush River inlet area, the Maple River structure area, the Sheyenne River structure area, the Wild Rice River structure area, and the Red River inlet structure area, as well as where the diversion channel crosses through the Drain 14 oxbow area south of the Maple River.

N.7 MECHANICAL

No Considerations Provided

N.8 ELECTRICAL

No Considerations Provided