US Army Corps of Engineers®
St. Paul District

Appendix N: Engineering Considerations

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Reach 5, Volumes 1 and 3: Stations 521+00 to 566+00 and 596+00 to 656+00

Engineering and Design Phase

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Appendix N: Engineering Considerations

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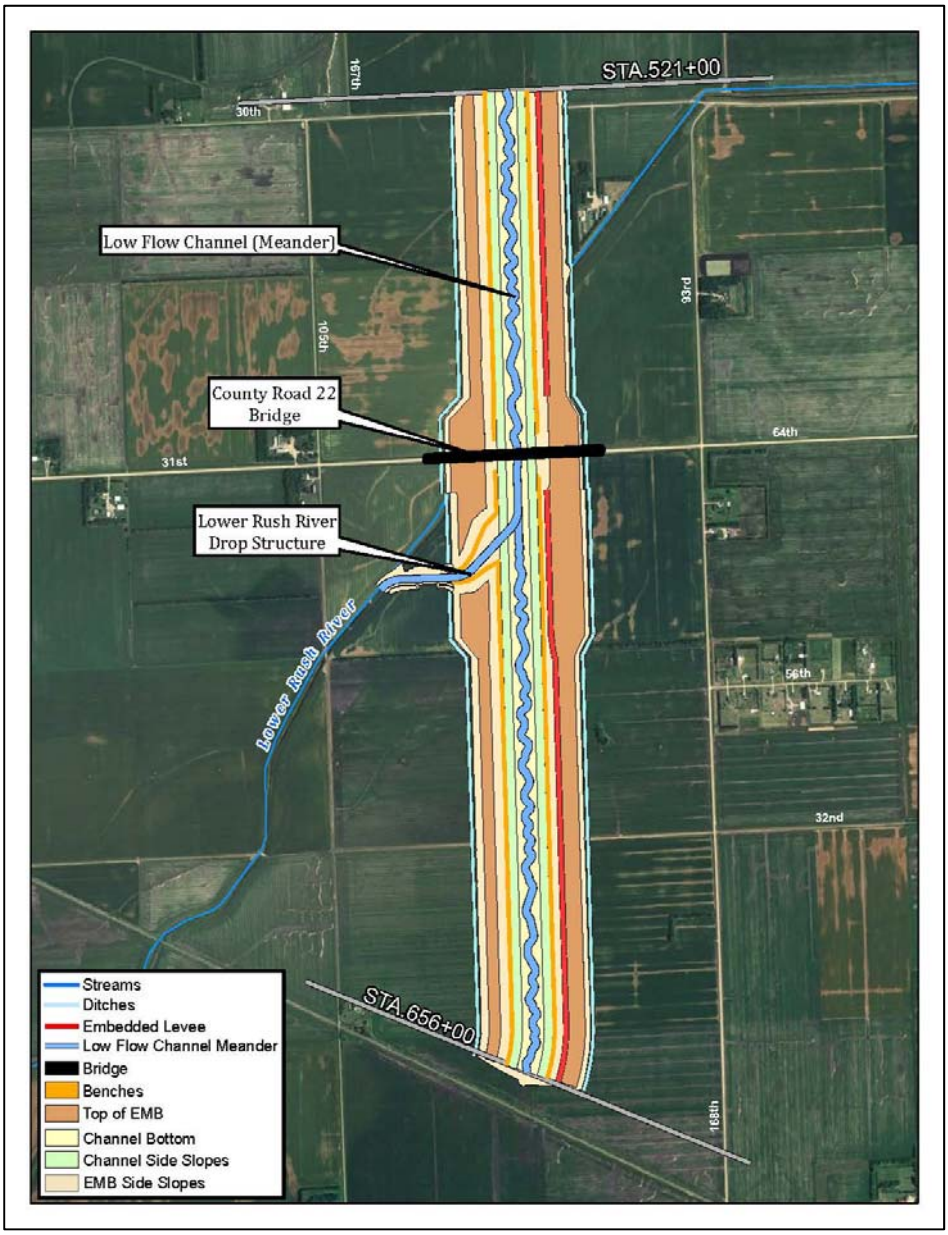
Appendix N: Engineering Considerations

N.1 INTRODUCTION

As depicted in Figure 1, Reach 5 Volumes 1 and 3 include the diversion channel beginning at the upstream end of Reach 4 (Sta. 521+00) and proceeding upstream to station 656+00, which is just north (downstream), of the County Road 20 and Burlington Northern Railroad bridges (Reach 6). The County Road 22 Bridge and the Lower Rush River Structure are included in Reach 5, although the bridge will be designed by the project sponsor and the Lower Rush River Structure, Reach 5 Volume 2, is being designed by MVS and will not be included in the review of Reach 5, Volumes 1 and 3. The major project components in Reach 5 include approximately 10,500 feet of diversion channel flanked on each side by excavated material berms (this excludes 1,000 feet of channel associated with the County Road 22 bridge and 2,000 feet of channel associated with the Lower Rush River Structure in Reach 5, Volume 2). An embedded levee is located within the right bank EMB. Within the main channel there will be sinuous low flow channel and wetland mitigation.

Figure N-1: Location Map – Reach 5



N.2 HYDRAULICS

N.2.1 Lower Rush River Inlet Structure

The Lower Rush River inlet structure was designed to pass the computed 500 year Lower Rush River discharge of 2,930 cfs into the diversion channel with no additional flow in the diversion channel from

other sources. This condition represents the worst case scenario during construction of the diversion. The inlet was designed giving consideration for fish passage, so a rock ramp fish passage design that will likely allows passage for a wide range of discharges was chosen. Upstream of the rock ramp, rock dikes will be constructed to increase the upstream 100 year water surface elevation for the with project condition in an attempt to match the existing 100 year water surface elevation. Additionally, an overflow weir will be placed along the right descending bank upstream of the rock ramp to minimize impacts during the 0.2% chance exceedance event.

To ensure some availability for fish passage in the Lower Rush Inlet structure, the following should be considered during construction:

1) 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.

2) 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.

3) 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.

4) 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.

5) 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 5. In areas near existing drainage and roadways, the topsoil depth may be deeper. Stripping of the topsoil and organics is only required beneath the embedded levee prism. 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 2.2.5 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. 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 the Lower Rush River, 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 5 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 indicate that the groundwater table could be anywhere from 2.3 to 10.2 feet below the ground surface. The vibrating wire piezometer instrument clusters in Reach 4 and Reach 6 indicate ground water is approximately 10 below the ground surface, but has shown higher fluctuations, likely due to precipitation.

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.

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

N.3.1.5 Wells

There were no residential structures within Reach 5, so wells should not be encountered. Any wells in the area 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 any wells are encountered, the Geotechnical and Geology Section shall be contacted.

N.3.1.6 Foundations and Other Underground Tanks

There were no residential structures within Reach 5, so there should not be any concern. If anything is encountered the Geotechnical and Geology Section shall be contacted.

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 Placement of Excavated Materials

The Contractor will need to plan the excavation such that the materials required for topsoil, embedded levee, and impervious fill below the aggregate surfacing, 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 (EMB).

N.3.2.1 Embedded Levee

The Contractor is required to construct an embedded levee throughout Reach 5. 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.3.2.2 Road Subgrade

The 36 inches of subgrade below any aggregate, meaning maintenance road, 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.3.2.3 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.3.2.4 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.3.2.5 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.3.3 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.3.3.1 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.3.3.2 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.3.3.3 Final Grading

Final grading of the diversion channel excavation will generally not be allowed during winter operations. 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. If the Contractor elects to complete final grading during the winter, the contractor is required to provide a plan for this. It should be noted that 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.3.4 Materials

N.3.4.1 Select Granular Fill

The select granular fill is used beneath any 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.3.4.2 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.3.5 Instrumentation

No nested vibratory wire piezometer clusters are installed in Reach 5, so there is no concern.

N.3.6 Hazardous, Toxic, and Radioactive Wastes

The Phase I Environmental Site Assessment (ESA) did not find any major issues within Reach 5. But due to the 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

No Considerations Provided

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

Utilities identified within the limits of Reach 5 include overhead electrical power lines; buried telephone lines (to include fiber optic); and buried water mains. A total of nine encroachments were identified through review of utility mapping and field locates. Field locates were conducted in December of 2011 and January of 2012.

Six encroachments are from overhead electric lines; one encroachment is from a buried fiber optic communication cable, one encroachment is from a buried unspecified communication cable, and one encroachment is from a water main crossing. No utilities were identified within the Lower Rush River reach.

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 utilities known to cross the diversion channel within Reach 5 including utilities along CR 22:

Table N-1: Utility Encroachments Reach 5

UTILITY	LOCATION	DESCRIPTION
ELECTRIC		
Cass County Electric	Overhead Electric Line	Line runs East – West along the

	Crosses Reach 5 at Control Line Sta. 524+10	south side of 76th Ave. N (30th Street SE), intersects with power line running northwest-southeast approximately 1000' west of 168th Ave. SE.
Cass County Electric	Underground Electric Line Crosses Reach 5 Control Line at Sta. 570+00	Line runs East – West along the north side of CTY RD 22 (31st Street).
Minnkota Electric	Overhead Transmission lines cross Reach 5 at Control Line Sta. 612+00 and 613+75.	Lines are large parallel transmission lines running East – West across project.
COMMUNICATION		
Midcontinent Fiber Optic	Underground fiber optic line crosses Reach 5 at Control Line Sta. 570+50.	Line runs East – West along the north side of CTY RD 22 (31st Street).
Century Link Telephone	Underground unspecified telephone line crosses Reach 5 at Control line Sta. 571+60	Line runs East – West along the south side of CTY RD 22 (31st Street).
WATER		
Cass Rural Water Users, Inc.	Underground water line crosses Reach 5 at Control Line Station 570+24	1 ½" water line runs East – West along the north side of CTY RD 22 (31st Street).

The Reach 5 design team will coordinate with MVP and local sponsor to obtain as-built information for any relocation to be done by others that is still located within the project limits.

No known domestic wells have been identified within the Reach 5 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 5 to meet compliance with the NPDES Permit NDR10-0000.

1. Construct the CR22 bridge with associated diversion channel and the temporary Lower Rush reroute under the Local Sponsors CR22 Bridge Contract (Sta. 566+00-576+00)
2. Construct Reach 5, Volume 1 (Sta. 521+00-566+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.
3. Construct Reach 5, Volume 2 diversion channel, associated excavated material berms (EMBs), and low flow channel from Sta. 576+00 to approximate Sta. 594+00.
4. Construct Lower Rush River Drop Structure.
5. Do not disturb temporary Lower Rush Reroute constructed under the CR22 bridge contract or connect the Lower Rush River to the drop structure until all downstream diversion channel reaches including the outlet connection to the Red River has final stabilization established.
6. Fill in Temporary Lower Rush Reroute including area within Reach 5, Volume 2 between Sta. 594+00-596+00.
7. Construct Reach 5, Volume 2 (Sta. 594+00-596+00)
8. Construct Reach 5, Volume 3 (Sta. 596+00-656+00)

   Note: Temporary erosion and sediment control practices upstream of Reach 5, Volume 1 at Sta. 521+00 constructed to prevent discharge downstream (including temporary sediment basins) to remain in place until final stabilization is achieved on all downstream diversion channel reaches including the outlet connection to the Red River.

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

No construction monitoring for deeply buried cultural resources sites is necessary for Reach 5.

N.7 MECHANICAL

No Considerations Provided

N.8 ELECTRICAL

No Considerations Provided