US Army Corps of Engineers®
St. Paul District

Appendix E: Civil-Site

Fargo Moorhead Metropolitan Area Flood Risk Management Project

Reach 2

Engineering and Design Phase

Doc Version: 97% Post-ATR

P2# 370365

21 June 2013

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Appendix E: Civil-Site

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Appendix E: Civil-Site

E.1 GENERAL

Civil design for this project will include demolition, levee and excavated material berm layout, access road layout, utility relocations, general grading, and storm water pollution prevention. This section summarizes the proposed layout, method of analyses, and support for preparation of the plans, specifications, and cost estimate.

E.2 DEMOLITION

Demolition will include clearing. See Section E.7 for demolition of utilities. Existing roads located within the proposed diversion, levees, and Excavated Material Berm (EMB) areas will require demolition. Based on the Reach 3 relocation/re-alignment of 27th Street SE, the Reach 2 contractor shall remove 170th Ave. SE.

E.3 DIVERSION CHANNEL LAYOUT

The control for the centerline of the diversion channel was set to flow tangent to and in alignment with the existing centerline of the Red River of the North. The control alignment for the Reach 2 project is 7,300 feet which begins at Station 227+00 and ends at Station 300+00.

E.4 LEVEES/EXCAVATED MATERIAL BERMS (EMB)

The EMBs on the sides of the diversion begin at Station 227+00 when looking downstream of the diversion. The EMB can be constructed to an overall maximum height of 20 feet post settlement as limited by the View Shed Analysis. It is more stringently restricted to 15 feet for geotechnical stability purposes. Additionally, to facilitate the recreation plan design the right EMB height is reduced to 14 feet to provide a required 250’ EMB top width beyond the maintenance corridor. The EMBs will continue along the length of the diversion up to the end of the Reach 2 project at Station 300+00. The alignment and configuration of the channel and excavated material berms are based on Hydraulic and Geotechnical considerations.

With the continuation of design, coordination with, and support of the local sponsor, final layout of the EMB’s will take into account earthwork balance of cut and fill, topsoil stripping requirements, as well as real estate acquisition.

The levee for Reach 2 is completely encapsulated within the right bank EMB, which will result in reduced operation and maintenance requirements. The levee shall extend from Station 227+00 for the full length of the reach to Station 300+00. The levee within Reach 2 shall have a 10-foot crown with 1V:3H side slopes and will have a minimum of 6-foot of cover.

Additional information on the design and layout of the levees and EMBs is available in the MFR, Attachment 1, Levees and Excavated Material Berms along the Diversion Channel.

E.5 DRAINAGE STRUCTURES

The local drainage on both sides of the diversion channel EMB will be collected in ditches running parallel to the EMB toe and located within the project right-of-way. The discharge from these ditches will be routed north to tie into the Reach 1 ditches which will ultimately discharge into the inlets at Cass County Drain 30.

E.6 ACCESS ROADS AND PARKING AREAS

The proposed roadway re-alignment of County Road 27th St. SE shall be designed and constructed by others; this coordination is ongoing. County Road 170th Avenue SE is to be abandoned, with the location of abandonment being coordinated.

It is anticipated that a road can be constructed to access the outlet by utilizing the 27th St. SE alignment when it is rerouted. Additional access roads can be designed and constructed by using the remaining northern portion of 170th Avenue SE and 171st Avenue SE alignments.

E.6.1 Geometric Design Criteria – Access Road

This will be summarized as the design progresses.

E.7 UTILITY INFORMATION

Utility information, including surveyed locations was obtained from Moore Engineering under contract with the local sponsor.

E.7.1 Existing Utilities

Utilities identified within the limits of Reach 2 include overhead electrical power lines; buried telephone lines; and a Natural gas line. A total of three encroachments were identified through review of utility mapping and field locates. Field locates were conducted in December of 2011 and January of 2012.

The following table lists utilities known to cross the diversion channel within Reach 2:

Table E-1: Utility Encroachments Reach 2

UTILITY	CROSSING STATION	DESCRIPTION
ELECTRIC		

UTILITY	CROSSING STATION	DESCRIPTION
Cass County Electric	Overhead line runs parallel to project alignment from Station 225+00 to 246+00 on the west side of 171st Ave SE	Line runs North/South west of 171st Ave SE likely along the edge of the EMB
COMMUNICATION		
Century Link	Underground telephone cable crosses at Station 285+40	Line runs North/South along the East side of 170th Ave SE then runs East/West along the North side of 27th St. SE
Natural Gas		
Magellan	6" dia. Natural gas line crosses at Station 296+05	Line runs nearly perpendicular to alignment (NW-SE)

E.7.2 Utility Relocations

Utility relocations will comply with the MVP MFR for Utility Relocation Requirements and local/state requirements. The non-federal sponsor made the determination that the local utilities and the FMM Diversion Authority will be handling the relocations within Reach 2, prior to construction. The electrical lines shall be relocated with proposed new location identified on plans. All relocation and demo for the communications lines will be complete with proposed new location identified on the plans. The natural gas line will be relocated to a depth beyond the project boundaries along the same alignment.

E.8 VEGETATION FREE ZONE (VFZ)/VEGETATION MANAGEMENT ZONE (VMZ)

The Vegetation Free Zone (VFZ)/Vegetation Management Zone (VMZ) will comply with the requirements in ETL 1110-2-571, as well as the criteria set forth in project specific guidance documents such as the Memo For Record (MFR) Levees and Excavated Material Berms along the Diversion Channel (provided in Appendix E Civil-Site, Attachment 1). The VFZ will be a minimum of 15' from the toe of stand-alone levees and partially embedded levees. The VMZ will extend 15' from the landside crown of the levees embedded within EMB's.

E.9 TECHNICAL GUIDELINES AND REFERENCES

A Policy on Geometric Design of Highways and Streets, Fifth Edition; American Association of State Highway and Transportation Officials (AASHTO); 2004.
Guidelines for Geometric Design of Very Low-Volume Local Roads, American Association of State Highway and Transportation Officials (AASHTO); 2001
EM 1110-2-1913, Design and Construction of Levees
ETL 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures
MVP MFR-Utility Relocation Requirements; Fargo-Moorhead Metropolitan Area Flood Risk Management Project

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Attachment E-1: MFR-001 Levees and Excavated Material Berms along the Diversion Channel

Fargo Moorhead Metropolitan Area
Flood Risk Management Project

Reach 2

Engineering and Design Phase

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MEMORANDUM FOR RECORD

SUBJECT: Fargo-Moorhead Metro Flood Risk Management (FMMFRM) Project – MFR-001 Levees and Excavated Material Berms along the Diversion Channel

PURPOSE

1. This memorandum for record (MFR) defines the plan to place material excavated from the diversion channel during construction along both banks of the diversion channel within Excavated Material Berms (EMBs). On the right bank of the channel, when looking downstream, a levee embankment will also be constructed as part of the EMB to reduce flood risk for the Fargo-Moorhead Metro (FMM) area. Requirements for both EMB and levees will be discussed, along with the impacts of the Vegetation-Free Zone and Vegetation-Management Zone requirements needed for the levees and EMBs.

BACKGROUND

2. The design for the Fargo-Moorhead Metropolitan Flood Risk Management (FMMFRM) Project is ongoing. The project will be the locally preferred plan (LPP) described in the *Final Feasibility Report and Environmental Impact Statement (FEIS), Fargo-Moorhead Metropolitan Area Flood Risk Management,* July 2011:

> *"The LPP diversion alignment would start approximately four miles south of the confluence of the Red and Wild Rice Rivers and extend west and north around the cities of Horace, Fargo, West Fargo and Harwood. It ultimately would re-enter the Red River north of the confluence of the Red and Sheyenne Rivers near the city of Georgetown, MN. Along the 36 mile path it would cross the Wild Rice, Sheyenne, Maple, Lower Rush and Rush Rivers and incorporate the existing Horace to West Fargo Sheyenne River diversion channel."*

3. The project features will include:

- Diversion channel with excavated material berms and levees.
- Gated control structures on the Red River of the North, the Wild Rice River of North Dakota, and Wolverton Creek.
- Fixed-crest diversion inlet control structure.
- Tieback embankments that, with the control structures, create a water storage/staging area at the upstream end of the project.
- Aqueduct structures that allow low flows of the Sheyenne and Maple Rivers to pass over the diversion.
- Drop inlet structures at a number of smaller drains.
- Diversion outlet structure.

EXCAVATED MATERIAL BERMS

4. The construction of the diversion channel will involve excavating a large quantity of material. To minimize the cost of construction, the haul distance to dispose of the material needs to be shortened as much as possible. Therefore, the excavated material will be placed adjacent to the diversion channel in what is referred to as an excavated material berm (EMB). With the large quantity of excavated material, the EMBs could be up to hundreds of feet wide at the base and over 100 feet wide at the top. It is assumed that the excavated material will generally be distributed evenly between the two sides of the channel. A typical section near the downstream end of the diversion channel can be seen in Figure 1. The typical configuration of the EMB is:

a. 50-foot offset from top of diversion channel side slope.

b. 15-foot height (above existing ground) at the EMB top closest to the channel.

c. Varying top width.

d. Side slope on diversion side of EMB is 1V:7H.

e. Side slope on landward side of EMB is 1V:6H.

f. Local drainage ditches offset minimum of 20 feet from outside toe of EMB.

5. Discussions regarding the ultimate use of the EMBs are ongoing and not yet finalized. The non-Federal sponsor is ultimately responsible for determining the end use of the EMBs and has developed a Draft Report, Fargo-Moorhead Area Diversion, Recreation and Use Master Plan, as well as the Technical Memorandum, Fargo-Moorhead Area Diversion Channel EMB Grading Guidelines for Reaches 1 and 2. The current concept proposed by the non-Federal sponsor is to incorporate recreational features, including an undulating landscape, into the EMBs on the right bank of the channel (a.k.a. interior EMB). On the left bank of the channel (a.k.a. exterior EMB), the end use is currently undefined. The non-Federal sponsor has requested that the footprint of the left bank EMB be minimized by slightly increasing the EMB height away from the channel. Excess material may also be made available to others for beneficial use such as construction of access roads and bridge embankments and non-Federal levees or ring dikes.

WATER SURFACE PROFILE WITHIN THE DIVERSION CHANNEL

6. Hydraulic modeling for the diversion channel and project is ongoing. The current Phase 6 hydraulic modeling effort incorporates changes in the diversion channel since completion of the FEIS. These changes include a modified cross section (including a larger low-flow channel), a slight increase in the slope of the diversion invert, and alignment modifications from the Maple River aqueduct to the outlet. Additional hydrology and hydraulics items are being developed that will require additional hydraulic modeling updates. The profiles provided in this MFR are based on the current Phase 6 hydraulic modeling effort.

7. For the 1 percent event, the water surface profile within the diversion channel is below the natural ground elevations for the upstream two-thirds of the diversion channel while it is above the natural ground for the downstream one-third of the diversion channel. For the 0.2

percent event, the water surface profile is above the natural ground along the downstream three-quarters of the diversion channel.

8. A water surface profile for a larger event was also computed. This water surface profile, referred to as the Diversion Levee Design Profile, is based on the maximum flow in the diversion occurring just before the Red River of the North and Wild Rice River control structures would be opened to prevent the loss of minimum freeboard on the tieback embankments. The current plan calls for the Red River of the North and Wild Rice River control structures to be opened at about 100,000 cubic feet per second (cfs). Due to the ongoing hydrology and hydraulic tasks, the Diversion Levee Design Profile presented in this MFR is taken to be 1 foot above the results of the Phase 6 hydraulic model effort to account for anticipated changes and uncertainty. For this given Diversion Levee Design Profile, water is above the natural ground for 90 percent of the diversion channel length.

9. The duration that diversion water will be above natural ground was investigated at 3 locations: 1) Drain 30 inlet, 2) Rush River inlet, 3) Lower Rush River inlet. The 1% event profile is above ground for about 9 days at the Drain 30 inlet, 3 days at the Rush River inlet, and 2.5 days at the Lower Rush River inlet. The 0.2% profile is above ground for about 13 days at the Drain 30 inlet, 5.5 days at the Rush River inlet, and 5 days at the Lower Rush River inlet. All culvert inlets will have flap gates to prevent spill-out flow. Open inlets will allow spill-out flow. At open inlets like the Rush and Lower Rush inlets, the spoil banks along the rivers will limit the extent of spill-out flooding, especially for the 1% event. Open inlets that do not have spoil banks immediately upstream will be subject to more extensive spill-out flooding, but spill-out flooding will not be worse than the existing condition for the corresponding frequency. Containment berms could be added where spoil banks are not present to limit the extent of spill-out flooding.

10. Table 1 summarizes the lengths in which the water surface is above natural ground for different flood events. Figure 2 shows the different water surface profiles through the diversion.

Table 1: Summary of Reaches with Water above Natural Ground

	Reach that Water Surface is Above Natural Ground [1]				Height Above Natural Ground (FT)	
Flood Event	Start	End	Length	% of Diversion Channel [2]	Average	Maximum [3]
1%	STA 27+68	STA 536+51	50,883	33%	2 to 3	3.0
0.2%	STA 27+68	STA 1223+03	119,535	77%	2 to 4	5.0
Diversion Levee Design Profile [4]	STA 27+68	STA 1438+58	141,090	91%	5 to 8	10.0

Notes:
(1) Water surface profiles based on Phase 6 Hydraulic modeling.
(2) Percentage is based on diversion length (155,289 FEET) from outlet structure (STA 27+68) to the Diversion Inlet (STA 1552+89).
(3) Maximum height neglects local drainage features. At the local drainage feautures, the maximum height may be slightly greater.
(4) The Diversion Design Profile is taken to be one foot above the Phase 6 hydraulic modeling results for the event which is associated with the maximum flow in the diversion occurring just before the Red River of the North and Wild Rice River control structures would be opened to prevent the loss of minimum freeboard on the tieback embankments.

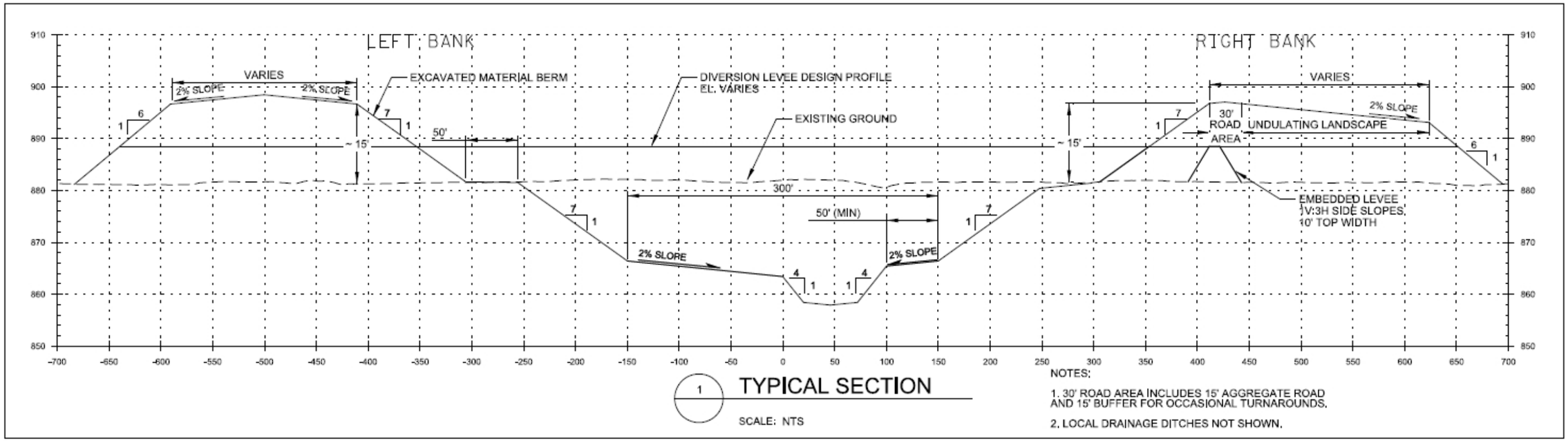

Figure 1: Typical Diversion Section on Downstream End of Project

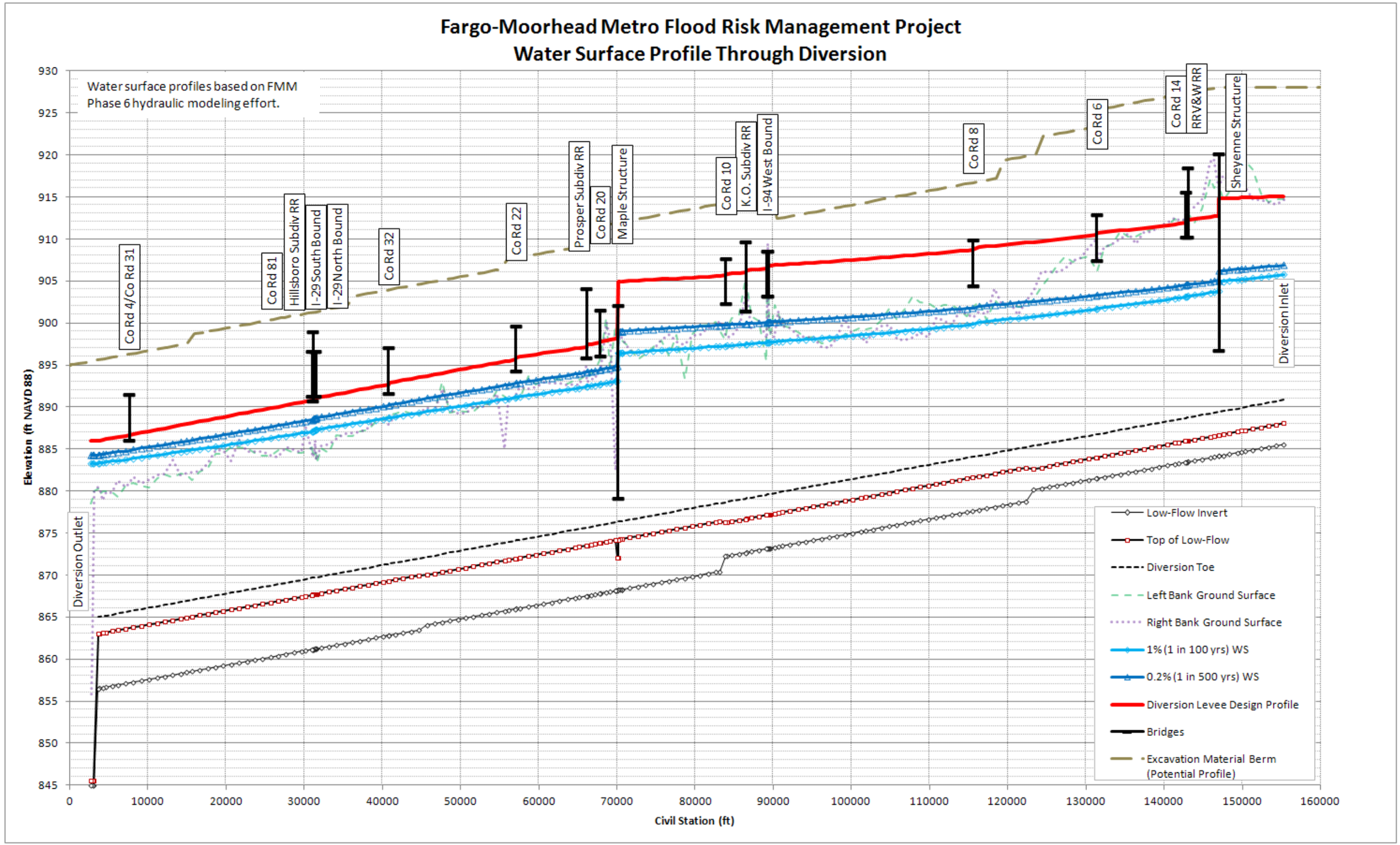

Figure 2: Water Surface Profiles versus Natural Ground Elevations

NEED FOR LEVEES

11. While the expected 1 percent profile is below existing ground for most of the diversion, it is above ground for the downstream portion of the diversion and the 90 percent assurance 1 percent profile is estimated to be above ground for about 75 percent of the diversion alignment. Also, in-town flood-fighting efforts are expected to occur up to a stage of 40 feet at the Fargo gage so a levee that provides risk reduction benefits up until in-town flood-fighting efforts cease is desired. To provide risk reduction benefits for the FMM area, a levee section will need to be incorporated into the right bank EMB and meet levee requirements (i.e., crest elevation, stability, seepage, vegetation-free/management zones, encroachments, construction, etc.). The integrity of the portion that is a levee must be maintained, and the end use of the EMB must not have any future impact to this levee section. The left bank EMB is not required to manage flood risk for the FMM area nor is the project claiming any benefits in the area outside the left bank EMB. From the Lower Rush River and downstream, the 1 percent event flood profile within the diversion is above the existing ground; however, it is lower than for existing conditions. Because the left bank EMB is not required for flood risk management, a levee portion will not be required on the left bank.

RIGHT BANK LEVEE REQUIREMENTS

12. The portion of the right bank EMB that acts as a levee will need to be designed, constructed, and maintained so that it is a reliable feature of the project. Many different factors must be considered when designing the EMB and levee; they are detailed below. The project delivery teams (PDTs) will complete the final design of the right bank levee and EMB.

Right Bank Levee Scenarios

13. Because the typical levee section is considerably smaller than the EMB, the levee will be a part of the overall EMB. Because there will be a massive amount of excavated material that will be placed adjacent to the diversion channel, the majority of the project will have the levee fully embedded within the EMB (see Figure 3). The embedded levee will result in reduced operation and maintenance requirements as well as reduced levee safety inspection requirements.

14. There will be areas of the project, such as near hydraulic structures and bridges, where a fully embedded levee will not be accomplished. In these areas, there may be a stand-alone levee (no associated EMB), or there may be a partially embedded levee (some associated EMB, but not the required minimum 6’ of cover). A stand-alone levee is shown in Figure 3. There could be many variations to a partially embedded levee, so a Figure is not presented. The Operation and Maintenance (O&M) and inspection requirements for stand-alone or partially embedded levees will be that of a traditional (non-embedded) levee. Closure structures may be required at the Maple River and/or Sheyenne River structures to limit the amount of flow that enters the risk reduction area during the levee design event.

Right Bank Levee Crest Elevation

15. The right bank levee is an essential component of the flood risk management system for the FMM area. It is assumed that flood-fighting efforts will continue within the FMM risk reduction area until the river stage at the gauge in Fargo exceeds 40 feet. The stage of 40 feet will be exceeded once the gates on the Red River of the North and Wild Rice River control structures are opened to prevent the loss of minimum freeboard on the tieback embankments. By releasing additional water into the FMM area, the water level in the risk reduction area will begin to rise and evacuation of the FMM area will be required. So that extensive flood fighting is not required along the right bank EMB while flood fighting efforts are taking place along the Red River in the risk reduction area, the right bank levee will be built to the Diversion Levee Design Profile plus overbuild to account for estimated settlement.

Right Bank Levee Typical Cross Section

16. The typical cross section used by the St. Paul District for levees within the Red River Valley is a compacted clay embankment with a 10-foot top width and 1V:3H side slopes. Because of the impervious nature of the levee fill and the foundation, seepage has not been an issue on existing levees, nor has stability been an issue for levees constructed away from the river channel. These levees have performed well under flood conditions. This typical cross section will be used for the right bank levee. This typical section is considerably smaller than the entire EMB. The stand-alone levee, and possibly the partially embedded levee top width may be increased to 15’ to allow for a maintenance road on the top of the levee.

Right Bank Embedded Levee

17. The fully embedded levee requires a minimum of 6’ of cover over the crest of the levee in all directions. The 6’ minimum cover was set after researching burrowing animal habits in the project area. It was determined that animals in this region will not burrow to a depth greater than 6’. Based on this research, animal burrows will not be a maintenance issue where the 6’ minimum cover is maintained.

18. As a way to locate the embedded levee in the future, the left side crest of the levee will be aligned with the top edge of the EMB which is also the left edge of the 15’ maintenance road.

Right Bank Embedded Levee Construction Requirements

19. The embedded levee section within the EMB will be constructed to the following requirements to ensure the integrity of the levee. These requirements are the minimum and may require further evaluation by the PDT during design.

a. Fill Material: Alluvium or Sherack materials shall be used as fill material. These formations will be located in the upper portion of the diversion channel excavation.

b. Stripping: All organic materials beneath the footprint of the levee shall be removed.

c. Inspection Trench: An inspection trench will not be required because the diversion channel will act as a large inspection trench. If any pervious layers are encountered during excavation, an analysis should be completed to determine if a cut-off trench will be needed.

d. Utilities and Drain Tile: If utilities and drain tile are encountered within the diversion channel excavation or they are known to be beneath the footprint of the levee, at a minimum, the utilities and drain tile shall be removed from beneath the footprint of the levee and extending out 15 feet from both toes of the levee. The exception would be utilities relocated as part of this project in compliance with MVP MFR for Utility Relocations.

e. Placement: The materials shall be placed in lifts of 12 inches or less.

f. Overbuild: The placement of the excavated material will cause the foundation to settle and consolidate. The levee section will be overbuilt to accommodate the estimated settlement. Overbuild will be determined by required settlement analysis.

g. Compaction: The fill material can be semi-compacted, meaning that compaction requirement is less than what is typically specified for levee construction. In the case of the embedded levee, the fill material will be required to be compacted to a minimum 90 percent of maximum dry density as determined by the standard proctor. It is likely that this compaction can be accomplished with minimal effort such as using a dozer or other equipment as the material is spread. Another approach would be to use a method specification to indicate the number of passes required of a dozer or compactor with a certain ground pressure.

h. Moisture Control: Moisture control will not be specified but this will not relieve the contractor from obtaining the required compaction.

i. Testing: Minimum testing will be completed on materials placed. Testing will include proctors, density, Atterberg limits, and grain size analysis.

j. Topsoil and Seeding: A minimum of 4 inches of topsoil shall be placed and seeded on any exposed surface of the levee.

Right Bank Stand-Alone or Partially Embedded Levee Construction Requirements

20. The stand-alone or partially embedded levee section along the right bank shall follow the minimum requirements for the embedded levee with the following exceptions, which are more stringent construction requirements. These requirements are the minimum and may require further evaluation by the PDT during design.

a. Placement: The material shall be placed in lifts of 9 inches or less.

b. Compaction: The fill material will be required to be compacted to a minimum 95 percent of maximum dry density as determined by the standard proctor.

c. Moisture Control: The moisture content of the fill material when compacted shall fall within the range of 2 percentage points below optimum moisture content and 3 percentage points above optimum moisture content as determined by the standard proctor.

d. Testing: More testing will be required than for the embedded levee. Final quantity will be determined by PDTs.

EMB REQUIREMENTS

21. The left bank EMB is not required to manage flood risk for the FMM area nor is the project claiming any benefits in the area outside the left bank EMB. Thus, it does not act as a levee and does not need to be designed or constructed as such. For some flood events the water surface profile within the diversion channel will be above the existing ground elevation; however, these levels are lower than existing condition water levels for the same events.

22. The remainder of the right bank EMB that is not a levee also does not have to follow criteria as stringent for the right bank levee. The design of the EMBs shall consider the following details.

23. There will be minimal EMB or no EMB near bridges and hydraulic structures. The PDT will define the minimal EMB width and slope based on end use and geotechnical analysis.

EMB Crest Elevation

24. The EMBs will typically rise approximately 15 feet above the natural ground, which is above the Diversion Levee Design Profile. From that point, the EMB's will typically rise at a 2% slope to a crest location, then slope down at 2% to the backside edge of the EMB. There may be locations where the EMB includes a step to a higher crest elevation. A stepped EMB may be desired in certain locations because it will allow for placement of more material in a minimal footprint. The PDT will balance excavation/fill quantities and determine if a stepped EMB provides the optimal layout. The maximum height of the EMB's is controlled by the required geotechnical stability analysis.

25. A viewshed analysis was performed on an estimated 18' high EMB for cultural resource coordination with the State Historical Preservation Office. If the EMB height exceeds 20' in height at any location, a new viewshed analysis must be performed. Coordinate with MVP if proposed EMB design height exceeds 20'.

26. The current concept is that the right bank EMB will include undulations that extend above and below the 2% slope of the base EMB. These undulations have yet to be designed and are not shown on the figures.

27. At locations where local drainage structures pass through the left bank EMB, the height may be reduced to decrease the load on the pipes and amount of settlement. At these locations, the minimum crest elevation will be at least 3 feet above the Diversion Levee Design Profile.

EMB Typical Cross Section

28. The EMBs will be very large due to the quantity of excavation required for construction of the diversion channel. Because of the impervious nature of the excavated material and the foundation and the substantial width of the EMB, seepage will not be an issue. The 1V:6H backslopes of the EMBs will also be stable.

29. In areas where the local drainage is routed into the diversion channel, the width of the left bank EMB may be decreased to reduce the length of local drainage structure pipe passing through it. The exact width shall be determined considering seepage, slope stability concerns, anticipated construction requirements, and recreational features.

EMB Location

30. The EMBs will be set back from the top of the diversion channel such that the stability of the diversion channel slope is maintained.

EMB Construction Requirements

31. The construction requirements of the EMBs can be less stringent than the right bank levee. Some considerations for construction requirements are listed below.

a. Stripping: Organic materials beneath the footprint of both the right and left EMBs shall be removed beginning at the diversion side toe of the EMBs and extending a minimum of 105 feet back from the diversion side toe. This coincides with the area beneath the slope of the EMB adjacent to the diversion channel. The remainder of the topsoil beneath the footprint of the EMB may be stripped to conserve as much topsoil as possible, or it can be left in place.

b. Inspection Trench: An inspection trench will not be required because the diversion channel will act as a large inspection trench. If any pervious layers are encountered during excavation, an analysis should be completed to determine if a cut-off trench will be needed.

c. Utilities and Drain Tile: If utilities or drain tile are encountered within the diversion channel excavation or they are known to be beneath the footprint of the EMB, the utilities and drain tile, at a minimum, shall be cut off at toes of the EMBs using a 6-foot wide trench that is backfilled with impervious material. This

shall be done for both the right and left bank EMBs. The exception would be utilities relocated as part of this project in compliance with MVP MFR for Utility Relocations.

d. Placement: The EMB should be constructed using lift thicknesses between 1 to 1.5 feet thick, especially on the EMB diversion side slopes adjacent to the diversion channel. At locations beyond the EMB diversion side slope, the lift thickness could be increased. The specified lift thickness should be based on how dense the EMB needs to be to accommodate the end use of the EMBs. The thicker the lifts, the less dense the EMB will be, which could lead to more settlement and less bearing capacity. Also, the less the compaction, the larger the EMB will be.

e. Compaction: The material placed in the EMB should be at a minimum compacted to its in situ density, or approximately 85 percent of maximum dry density as determined by the standard proctor. Additional compaction requirements may be required in order to construct an EMB that support the maintenance roads and any other features built on top of the EMBs.

f. Moisture Control: There will be no moisture control requirements for the EMBs.

g. Testing: The testing requirements for the EMBs will be similar to that required for levees but at less frequent intervals and will depend on what density is required for the EMBs.

h. Topsoil and Seeding: Topsoil thickness will be determined based on the end-use of the EMB. At a minimum, 4 inches of topsoil shall be placed and seeded on any exposed surface of the EMB. In locations where the end use includes woody vegetation plantings (outside of the VFZ and VMZ), the topsoil shall be a minimum of 12 inches.

VEGETATION FREE ZONE AND VEGETATION MANAGEMENT ZONE

32. The requirements for vegetation-free zones and vegetation-management zones are outlined in the USACE Technical Letter ETL 1110-2-571, “Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures.” The primary purpose of the vegetation-free zone (VFZ) is to provide reliable, unobstructed access to the dam or levee for surveillance, maintenance, and flood-fighting purposes. A secondary purpose of the VFZ is to provide distance between root systems and levees, which moderates the risk of potential piping and seepage due to root penetration and structural damage resulting from a wind-driven tree overturning. In addition to the VFZ, a vegetation-management zone (VMZ) can be specified in which vegetation is less stringently managed.

33. In the context of the FMMFRM project, the VFZ will require periodic maintenance and control of the vegetation within that zone. The control of the vegetation will require mowing or burning (if permitted) once each year for inspection. No woody vegetation or trees will be allowed within the VFZ.

34. The VMZ would be less stringent than the VFZ. The vegetation within the VMZ will be controlled so that vegetation will not jeopardize the integrity of the levee or access along the project. The control of woody vegetation will require mowing or burning (if permitted) once every two years. This VMZ will also be required in the diversion channel and a portion of the EMB so that woody vegetation and trees, which could reduce the hydraulic capacity of the diversion channel, will not be allowed to become established.

35. The three levee scenarios require different VFZs and VMZs, as indicated in Figure 3. Note that the VFZ/VMZ requirements are the same for the stand-alone and partially embedded levee scenarios.

Embedded Levee

36. As mentioned above, a majority of the project will be designed and constructed with a fully embedded levee. This embedded levee is not specifically addressed in ETL 1110-2-571, so the VFZ/VMZ requirements were developed by the PDT using what is felt to be a reasonable approach to vegetation management and access. The right bank embedded levee will have no Vegetation Free Zone, as there will be no inspection requirements for the levee itself. Instead, a VMZ will start 15’ from the outside edge of the maintenance road, and extend across the levee section to the left bank EMB. To control woody vegetation, mowing or burning every two years is believed to be sufficient. If woody vegetation is not controlled with this schedule, increased mowing or burning or chemical control may be necessary. To provide access for O&M and inspections, the 30’ wide maintenance road area (15’ gravel road with a 15’ buffer area for occasional turnarounds) will be required to be maintained in good condition and obstruction free.

Partially Embedded Levee and Stand-Alone Levee

37. A partially embedded levee is defined as a levee with some associated EMB, but without full 6’ embedment. A stand-alone levee is just the levee section with no associated EMB. For both of these scenarios, a VFZ is required that extends 15’ from the toe of the levee in both directions. On the channel side, a VMZ would then extend beyond the VFZ across the channel to the left bank EMB. In embedded levee transition reaches, the VFZ shall extend a minimum of 15’ longitudinally into the fully embedded levee section, which starts once 6’ of embedment is established.

O&M AND CORPS OF ENGINEERS (COE) INSPECTION REQUIREMENTS

Use of LiDAR to Aid the Inspection Process

38. Because of the magnitude of this project, LiDAR data will be collected for the diversion and EMBs as part of the levee inspection process. LiDAR collection will meet the following requirements:

- 1' contour accuracy, 0.5 meter nominal point spacing,
- ~2000' wide corridor that is 30 miles long,
- LiDAR collection every 2 years and after every large flood event,
- LiDAR used to update a steady HEC-RAS model of the diversion to assess effect on conveyance. Local sponsor will update and perform the RAS modeling and provide a report to COE.
- COE inspectors will review the LiDAR elevation data and the local sponsor's report prior to inspection.

VMZ O&M and Inspection Requirements

39. Mowing or burning of the VMZ will be required every 2 years. This should prevent the establishment of woody vegetation and facilitate LiDAR collection and inspection. The optimal time for mowing/burning is in the early spring before nesting, but wet conditions may require mowing/burning to be done in the fall. Mowing/burning in the fall should be done between late September and early November.

40. Mowing/burning needs to be coordinated with LiDAR collection as well as inspection work. For example, if mowing/burning is done in the fall then LiDAR collection may need to start in late September so data can be processed and local sponsor modeling/report can be complete before a late October / early November inspection.

41. Inspection will occur every year, but visual inspection will be limited to all structures, rock protection, access roads, and any areas that are suspect based on the LiDAR surveys.

42. LiDAR collection and inspection will also be performed after every large flood event. Mowing/burning may be required after the event if vegetation will limit LiDAR collection and inspection.

VFZ O&M and Inspection Requirements

43. Mowing or burning of the VFZ will be required every year for inspection. Additional mowing or burning may be necessary to ensure health and vigor of the species providing erosion protection. All requirements outlined in ETL 1110-2-571 will be adhered to.

SUMMARY

44. This MFR is intended to describe the requirements of the levees and EMBs along the diversion channel that are known to date and items that the PDTs need to evaluate and finalize during design. A summary of these items is listed below.

a. A levee will be required along the right bank of the diversion.

b. The height of the right bank levee will be defined by the Diversion Levee Design Profile and overbuild to account for anticipated settlement.

c. The typical section of the right bank levee is 1V:3H side slopes with a 10-foot top width. 15' top width may be used for the stand-alone and partially embedded levees to allow for a maintenance road on top of the levee.

d. The minimum construction requirements for the right bank levee are described above and vary depending on if it is an embedded levee or stand-alone levee.

e. The ultimate use of the EMBs has not been finalized.

f. EMB width will be determined by the PDT by balancing cut and fill volumes.

g. Right bank undulating landscape has not been finalized.

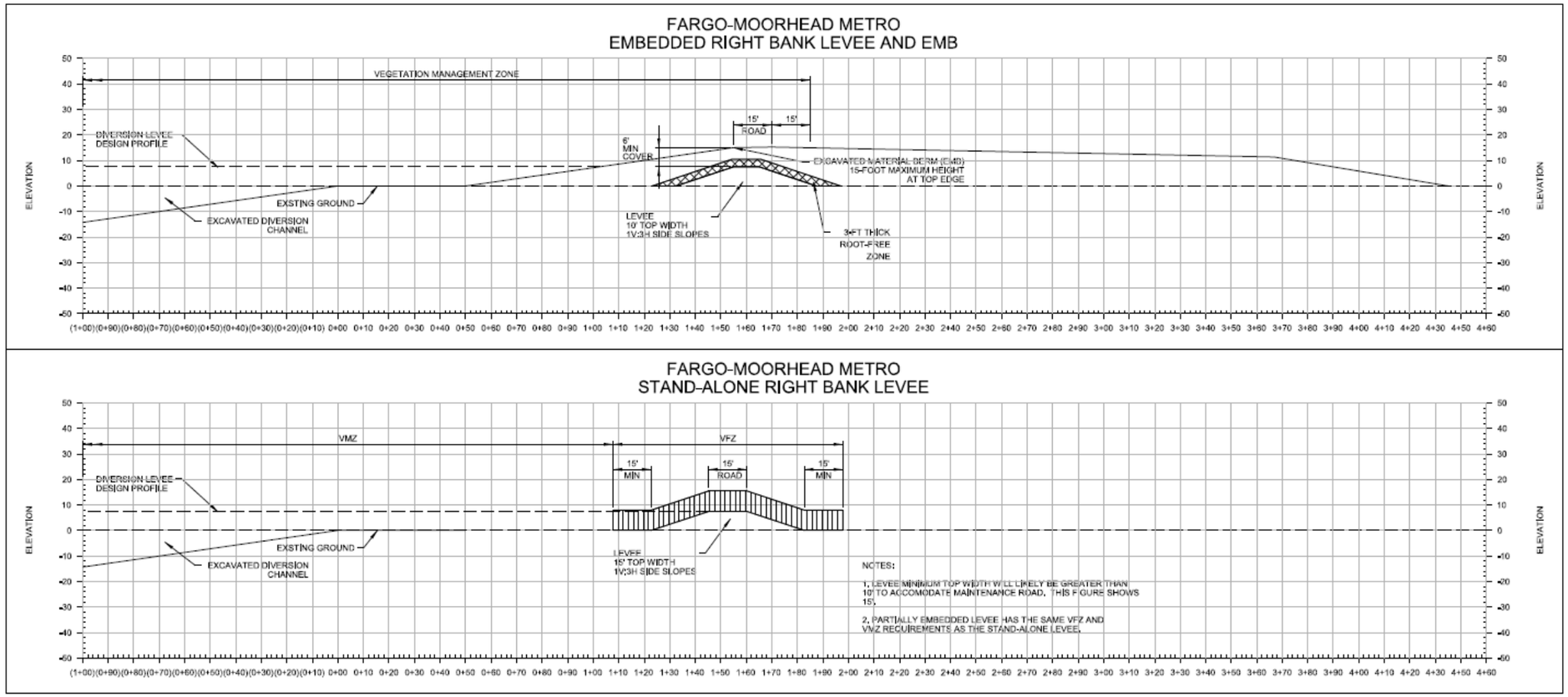

Figure 3: Embedded and Stand-alone Levees

REVIEW

45. The MFR underwent DQC review and ATR review prior to signoff.

CONTACT

46. Any questions concerning this MFR should be directed to Kurt Heckendorf, Lead Functional POC – Geotechnical Engineering, MVP.

SIGNATURES

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