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Principal Spillway Riser Tower and Reservoir at Fordville Dam – Grand Forks County, North Dakota

MIDDLE-SOUTH BRANCH FOREST RIVER DAM NO. 4 (FORDVILLE DAM)

Existing Conditions Assessment Report (DRAFT)

NRCS
Natural Resources Conservation Service

MIDDLE-SOUTH BRANCH FOREST RIVER DAM NO. 4 (FORDVILLE DAM)

EXISTING CONDITIONS ASSESSMENT REPORT

January 19th, 2021

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Walsh County Water Resource District

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I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Licensed Engineer under the laws of the State of North Dakota.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**
1 DAM SUMMARY DATA **3**
2 FIELD SURVEY **4**
2.1 DOWNSTREAM CHANNEL SURVEY 4
2.1.1 METHODS *4*
2.2 FORDVILLE DAM TOPOGRAPHIC SURVEY 4
2.2.1 METHODS *5*
2.2.2 CHANGES IN ELEVATION *5*
2.3 NORMAL POOL BATHYMETRIC AND SEDIMENTATION SURVEY 5
2.3.1 METHODS *5*
2.3.2 RESULTS *6*
3 REVIEW AND INSPECTION OF STRUCTURE **6**
3.1 PRINCIPAL SPILLWAY CONCRETE INLET STRUCTURE 7
3.2 PRINCIPAL SPILLWAY CONDUIT AND SAF STILLING BASIN 7
3.3 EMBANKMENT AND AUXILIARY SPILLWAY 9
4 DAM BREACH ANALYSIS AND HAZARD CLASSIFICATION **9**
4.1 PEAK BREACH DISCHARGE CRITERIA 9
4.2 BREACH RESULTS 9
4.3 HAZARD CLASSIFICATION 11
5 HYDROLOGIC AND HYDRAULIC MODELING **11**
5.1 HYDROLOGY MODEL 11
5.1.1 SUBBASIN BOUNDARIES *12*
5.2 HYDRAULIC (HEC-RAS) MODEL 12
5.2.1 STORAGE ROUTING *12*
5.2.2 CHANNEL BATHYMETRY AND HYDRAULIC STRUCTURES *13*
5.2.3 MANNING'S N-VALUES *13*
5.2.4 INFLOWS *13*
5.2.5 TAILWATER *13*
5.3 CALIBRATION AND VERIFICATION 14
5.3.1 JUNE 2016 CALIBRATION EVENT *14*
5.3.2 MAY 2010 VERIFICATION EVENT *16*
5.4 PROBABLE MAXIMUM PRECIPITATION 17
5.5 SPILLWAY DESIGN HYDROGRAPHS 18
5.5.1 PRINCIPAL SPILLWAY INFLOW HYDROGRAPH *18*
5.5.2 AUXILIARY SPILLWAY INFLOW HYDROGRAPH *19*
5.5.3 FREEBOARD INFLOW HYDROGRAPH *20*
6 GEOLOGIC INVESTIGATION **21**
7 SPILLWAY ADEQUACY **22**
7.1 SITES MODEL INPUTS 22
7.1.1 PRINCIPAL SPILLWAY INPUTS *22*
7.1.2 AUXILIARY SPILLWAY INPUTS *23*
7.2 PRINCIPAL SPILLWAY RESULTS 24
7.3 AUXILIARY SPILLWAY RESULTS 25
7.3.1 AUXILIARY SPILLWAY CAPACITY *25*

DRAFT

7.3.2 AUXILIARY SPILLWAY STABILITY *26*
7.3.3 AUXILIARY SPILLWAY INTEGRITY *26*
7.4 SUMMARY OF IDENTIFIED DEFICIENCIES 26
7.4.1 PRINCIPAL SPILLWAY *26*
7.4.2 AUXILIARY SPILLWAY *27*
8 REFERENCES 28
FIGURES 30

TABLES

Table 1-1: Fordville Dam Summary Data 3
Table 3-1: Fordville Dam Structural Deficiency Summary 8
Table 4-1: Residential Structures Impacted by a Breach of Fordville Dam 10
Table 5-1: Manning's n-Values by Land Use 13
Table 5-2: Peak Flow and Volume Comparison at USGS Gage near Fordville, ND in June 2016 15
Table 5-3: Peak Flow and Volume Comparison at USGS Gage at Minto, ND in June 2016 15
Table 5-4: Peak Flow and Volume Comparison at USGS Gage near Fordville, ND in May 2010 17
Table 5-5: Peak Flow and Volume Comparison at USGS Gage near Minto, ND in May 2010 17
Table 5-6: TR 210-60 Minimum Precipitation Data for High Hazard Dams 18
Table 5-7: Principal Spillway Inflow Hydrograph Data 18
Table 5-8: Auxiliary Spillway Inflow Hydrograph Data 20
Table 5-9: Freeboard Inflow Hydrograph Data 21
Table 7-1: Assumed Parameters for Auxiliary Spillway Integrity Analysis 23
Table 7-2: Principal Spillway Hydrograph SITES Output 24
Table 7-3: Freeboard Hydrograph SITES Output 25
Table 7-4: Auxiliary Spillway Stress Analysis 26

DRAFT

FIGURES

Figure 1-1: Fordville Dam Drainage Area
Figure 2-1: Downstream Channel Survey
Figure 2-2: Fordville Dam Topographic Survey
Figure 2-3: Fordville Dam Bathymetric Survey Data Points
Figure 2-4: Fordville Dam Existing Ground Surface Below the Normal Pool
Figure 2-5: Fordville Dam Sediment Depth in Reservoir
Figure 2-6: Fordville Dam Elevation-Storage Relationship
Figure 4-1: Fordville Dam Breach Outflow Hydrograph
Figure 4-2: Fordville Dam Breach Inundation – All
Figure 4-3: Fordville Dam Breach Inundation – 1
Figure 4-4: Fordville Dam Breach Inundation – 2
Figure 4-5: Fordville Dam Breach Inundation – 3
Figure 4-6: Fordville Dam Breach Inundation – 4
Figure 4-7: Fordville Depth Velocity Flood Danger Relationship for Homes Built on Foundations
Figure 5-1: HEC-RAS Model Schematic
Figure 5-2: 2016 Historic Event Rainfall
Figure 5-3: R/Tc Ratios - Calibrated
Figure 5-4: 2016 Historic Event – Peak Discharge near Fordville, ND (USGS Gage 05084000)
Figure 5-5: 2016 Historic Event – Peak Discharge near Minto, ND (USGS Gage 05085000)
Figure 5-6: 2010 Historic Event Rainfall
Figure 5-7: 2010 Historic Event – Peak Discharge near Fordville, ND (USGS Gage 05084000)
Figure 5-8: 2010 Historic Event – Peak Discharge near Minto, ND (USGS Gage 05085000)
Figure 5-9: Principal Spillway Mass Curves for Runoff Volume
Figure 5-10: Principal Spillway Inflow Hydrographs
Figure 5-11: Stability Design Mass Curves
Figure 5-12: Stability Design Inflow Hydrographs
Figure 5-13: Freeboard Design Mass Curves
Figure 5-14: Freeboard Design Inflow Hydrographs
Figure 7-1: Fordville Dam Elevation-Discharge Relationship
Figure 7-2: Fordville Dam Auxiliary Spillway Profile
Figure 7-3: Fordville Dam Eroded Auxiliary Spillway Profile

APPENDICES

Appendix A: As-Built Drawings
Appendix B: Field Survey Maps
Appendix C: Supporting Survey Information
Appendix D: Site Inspection Supporting Information
Appendix E: Geotechnical Engineering Report
Appendix F: SITES Stability Analysis Output

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EXECUTIVE SUMMARY

Middle-South Branch Forest River Dam No. 4, also known as Fordville Dam, is located in Sections 6 and 7 of Inkster Township (T154N, R55W), Grand Forks County, ND. The drainage area to Fordville Dam is approximately 49.3 square miles and is shown in **Figure 1-1** along with the entire Forest River Watershed area. The dam was built primarily to provide flood control along the Middle-South Branch Forest River, and secondarily to provide recreation opportunities. The dam was designed by the Soil Conservation Service, now the National Resource Conservation Service (NRCS), in 1974 and was constructed in 1978. Fordville Dam has a design life of 50 years. Information on critical elevations, storage capacities, and surface areas for Fordville Dam are displayed in **Table 1-1**. The dam and reservoir also serve as the Fordville Dam Recreation Area and RV Park which is owned and operated by the Grand Forks County Water Resource District.

The purpose of this report is to document the data collected and analysis conducted for items B.1 through B.5 under the Expected Accomplishments and Deliverables section in the Cooperative Agreement between the NRCS and the Walsh County Water Resource District to develop a Watershed Plan for the Middle-South Branch Forest River Watershed Forest River Dam # 4, Fordville Dam (the award identifying number is NR196633XXXXC006 and the agreement is dated August 9, 2019). The data and analysis described in this report will be used to facilitate the completion of the overall Watershed Plan.

Field survey data for the channel downstream of Fordville Dam, the dam embankment, spillways, and bathymetric survey data for the pool upstream of the dam was collected for this analysis. The survey data was used to determine the storage capacity of the dam, the topography of the embankment, and to develop accurate cross-sectional data for the South Branch Forest River channel downstream of the dam.

A site review and inspection of Fordville Dam was conducted by Houston Engineering Inc. (HEI) staff in September of 2020. The inspection showed that the principal spillway inlet structure, the low-level drawdown conduit, and the principal spillway conduit had minor deficiencies and no immediate action is required. The wingwalls at the outlet of the principal spillway showed significant deterioration. It is recommended that the deteriorated sections of the wingwalls be monitored and that a repair plan be put in place. The condition of the dam embankment and auxiliary spillways were determined to be in an adequate condition. Minor issues include a few small trees growing on the embankment and some pocket gopher mounds. There is also an extensive number of trees growing at the entrance of the auxiliary spillway and near the outlet of the auxiliary spillway.

A dam breach analysis was conducted and a hazard classification was determined for Fordville Dam. The peak discharge criteria for the breach was determined based on guidance from *Technical Release 210-60: Earth Dams and Reservoirs* (NRCS, 2019). The peak discharge resulting from a dam breach was determined to be approximately 103,000 cubic feet per second. The breach was simulated through the hydraulic model and mapped to show at-risk structures and roads within the breach zone. After review of the results of the breach scenario, it was determined that Fordville Dam is best classified as a high hazard dam.

Hydrologic and hydraulic models of the of the Forest River Watershed were used to develop appropriate inflow hydrographs to Fordville Dam and to accurately route flows downstream of the dam. Spillway design hydrographs were developed based on criteria in *Technical Release 210-60: Earth Dams and Reservoirs*

DRAFT

(NRCS, 2019). Principal spillway inflow hydrographs were developed for various rainfall and runoff scenarios. The probable maximum precipitation for the watershed was used to develop the freeboard and stability design hydrographs.

A geologic investigation was also conducted as part of this analysis. The investigation indicated that the current foundation drain fill does not meet state-of-the-practice criteria for seepage control. The investigation also concluded that the slope stability associated with the embankment at Fordville Dam is adequate and that it meets the current requirements in *Technical Release 210-60: Earth Dams and Reservoirs* (NRCS, 2019).

The adequacy of the principal and auxiliary spillways for Fordville Dam were determined by using the NRCS's SITES program. The principal spillway was determined to be inadequate based on criteria outlined in *Technical Release 210-60: Earth Dams and Reservoirs* (NRCS, 2019). Subsurface geologic data was used to determine the integrity of the auxiliary spillway for Fordville Dam. The auxiliary spillway was determined to be adequate in terms of spillway capacity, but inadequate in terms of integrity when simulating the freeboard design hydrograph.

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1 DAM SUMMARY DATA

Table 1-1: *Fordville Dam Summary Data*

General Data	
Year Designed	1974
Year Constructed	1978
Purpose	Flood Control and Recreation
Original Hazard Classification	Significant
Current Hazard Classification	High
Design Life	50 Years
Original Design Drainage Area	41.5 square miles
Revised Drainage Area (Direct)[1][2]	49.3 square miles
Maximum Dam Height	54.0 feet
Embankment Length	1,875 feet
Embankment Top Width	18 feet
Embankment Upstream Slope	3.5H:1V
Embankment Downstream Slope	2.5H:1V
Critical Elevations (NAVD88)[3]	
Principal Spillway SAF Stilling Basin Invert	1067.2 feet
Principal Spillway Conduit Outlet Invert	1078.8 feet
Principal Spillway Orifice Inverts (First Stage Inlet)	1106.0 feet
Principal Spillway Riser Tower Crest (Second Stage Inlet)	1117.4 feet
Auxiliary Spillway Crest	1124.2 feet
Top of Dam	1132.1 feet
Storage Capacities[3]	
Principal Spillway Orifice Invert (First Stage Inlet)	1,845 acre-feet
Principal Spillway Riser Tower Crest (Second Stage Inlet)	4,609 acre-feet
Auxiliary Spillway Crest	7,089 acre-feet
Top of Dam	10,894 acre-feet
Pool Surface Areas	
Principal Spillway Orifice Inverts (First Stage Inlets) [3]	168 acres
Principal Spillway Riser Tower Crest (Second Stage Inlet)[1]	317 acres
Auxiliary Spillway Crest[1]	421 acres
Other Features	
Principal Spillway Orifice Sizes	1 feet by 3.75 feet orifice
Principal Spillway Conduit Size	5 feet by 5 feet conduit
Principal Spillway Conduit Length	235 feet (from as-builts)
Principal Spillway Riser Tower Weir Length	30 feet
Auxiliary Spillway Width	400 feet

[1] Revised using LiDAR data collected in 2008.
[2] Includes non-contributing drainage area within the watershed

[3] Values based on survey data collected in 2020

2 FIELD SURVEY

Survey data obtained for this report was collected in the summer of 2020. Survey data for the Middle Branch Forest River and other streams in the Forest River Watershed has been collected by HEI intermittently beginning in 2013. The data collected specifically for this report includes surveyed cross sections for the downstream channel, a topographic survey of the dam embankment and auxiliary spillway, and a bathymetric survey in the reservoir upstream of the dam. Each of the survey processes is described in more detail in the following sub-sections.

2.1 DOWNSTREAM CHANNEL SURVEY

The channel survey conducted in the South Branch Forest River was completed in the spring of 2020. The extent of the survey spanned from the outlet of Fordville Dam to the confluence of the South Branch Forest River and the Middle Branch Forest River. The downstream channel survey data is shown in **Figure 2-1**. The survey consisted of river channel cross sections and river channel hydraulic structures along the South Branch Forest River.

2.1.1 METHODS

Cross sections were collected at a spacing of 50 feet beginning at the outlet of Fordville Dam to a location approximately 500 feet downstream of the outlet. A spacing of 1,000 feet was used between surveyed channel cross sections on the South Branch Forest River downstream of the outlet cross sections. Hydraulic structures downstream of the dam were also surveyed along with cross sections upstream and downstream of the structures.

One permanent survey benchmark was set (other than permanent benchmarks set for the dam embankment survey) for the downstream channel survey using GPS and MidStates Virtual Reference Station (VRS). The benchmark used is shown in **Figure 2-1.** The cross sections and profile of the downstream river channel were surveyed using real-time kinematic (RTK) global positioning system (GPS) equipment. Cross section data is supplemented with LiDAR collected in 2008 and 2009 (IWI, 2008-2009). The horizontal datum used throughout the downstream channel survey collect was NAD83 (Conus), GeoID12B, North Dakota State Planes, North. The vertical datum used was NAVD 1988.

2.2 FORDVILLE DAM TOPOGRAPHIC SURVEY

The topographic survey of Fordville Dam was conducted in the summer of 2020. Some of the elements of the dam that were surveyed include the dam centerline, edge of gravel, spot points for the upstream dam face, and spot points for the downstream dam face. The principal spillway concrete riser structure was surveyed as well with data points collected for the second stage weir inlet elevation and orifice openings in the riser. The conduit invert elevation at the outlet of the structure and elements of the Saint Anthony Falls (SAF) stilling basin were also collected. The auxiliary spillway was surveyed from the upstream side of the dam near the normal pool to downstream of the dam where the spillway enters back into the South Branch Forest River channel. The inlet elevation and outlet invert of a corrugated metal pipe drain located at the downstream end of the auxiliary spillway were also collected during the survey. **Figure 2-2** shows the topographic data collected at Fordville Dam. **Appendix B** contains additional maps showing the topographic survey collected at Fordville Dam. Supporting information on topographic survey data can be found in **Appendix C**.

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2.2.1 METHODS

A maximum spacing of 50 feet was used to collect cross sections across the dam. The maximum distance between profile shots for the top of dam and emergency spillway centerline was also 50 linear feet.

Five permanent survey benchmark control points were set for the topographic survey using GPS and MidStates VRS. A level circuit was run through all control points with a level to verify vertical accuracy and continuity. The control points used for the topographic survey of the dam are shown in **Figure 2-2**. A robotic total station was used to survey the profile of the dam, profile of the spillway, and elements of the principal spillway structure. RTK GPS equipment was used to survey cross sections of the dam. The horizontal datum used throughout the topographic survey collect was NAD83 (Conus), GeoID12B, North Dakota State Planes, North. The vertical datum used was NAVD 1988.

2.2.2 CHANGES IN ELEVATION

The topographic survey was compared to key elevations shown on the as-built drawings presented in **Appendix A.** Elevations in the as-built drawings reference the NGVD 1929 vertical datum. Elevations at the dam site can be converted from NGVD 1929 to NAVD 1988 by adding approximately 1.155 feet based on the Vertical Datum Conversion Program (VERTCON) available through the National Geodetic Survey (NGS, 2018). For example, the principal spillway orifice inverts are at elevation 1105.0 feet in the as-built drawings (NGVD 1929), so the elevation of the principal spillway orifice inverts would be at 1106.155 feet in NAVD 1988. The elevation of the principal spillway orifice inverts that was surveyed is approximately 1105.97 feet (NAVD 1988). Therefore, the elevation of the principal spillway orifice inverts is approximately 0.18 feet lower than expected. Similarly, the principal spillway second stage weir, and the SAF stilling basin invert were compared to the expected elevations after converting them to NAVD 1988 and both elevations were approximately 0.2 feet lower than expected. Therefore, any elevations that were not able to be surveyed are assumed to be equal to the as-built elevation plus the vertical conversion factor of 1.155 feet, minus 0.2 feet. For example, invert elevations of the conduit running through Fordville Dam were not able to be collected due to the inability to enter the principal spillway structure at the time of the survey, but the elevations associated with the conduit can be calculated by using the inverts in the as-built plans, plus 1.155 feet, minus 0.2 feet, or 1087.42 + 1.155 – 0.2 = 1088.38 feet.

The elevation of the auxiliary spillway crest was approximately 0.35 feet higher than expected and the elevation of the top of the dam was approximately 1.83 feet higher than expected. Differences between these elevations can be attributed to construction methods used over 50 years ago, to the estimated settlement of the dam being slightly different than what was expected, and to the road being resurfaced over the years.

2.3 NORMAL POOL BATHYMETRIC AND SEDIMENTATION SURVEY

The normal pool bathymetric and sediment surveys for the reservoir at Fordville Dam were done simultaneously in June of 2020. The elevation of the reservoir at the time of the survey was 1106.68 feet (NAVD 1988). The methods used and resulting stage-storage data is described in more detail in the following sub-sections.

2.3.1 METHODS

Bathymetry data for the reservoir upstream of Fordville Dam was collected using a GPS linked, multi-frequency sonar or, more specifically, Specialty Device Inc.'s BSS+ Sediment Profiling System. Core

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samples were collected to calibrate the sonar returns from the BSS+ System using a vibrating head core sampler. The grid spacing during the bathymetric survey did not exceed 350 feet in any direction. The survey data points collected are shown on **Figure 2-3**. The survey provided existing sediment elevation and the elevation of the original ground before construction of the dam. The existing sediment elevations are shown on **Figure 2-4**.

2.3.2 RESULTS

A cumulative sediment volume in the reservoir upstream of Fordville Dam was estimated based on the multi-frequency sonar data that was collected in the summer of 2020. The estimated volume of sediment that accumulated in the reservoirs since the construction of the dam in 1978 is 446 acre-feet. This equates to a sedimentation rate of 0.22 acre-feet per year per square mile of uncontrolled drainage area. The distribution of the sediment covers the length of the pool at varying depths. The sediment depth in the reservoir is shown in **Figure 2-5**.

A Supplemental Watershed Work Plan for Fordville Dam (Grand Forks, Nelson, and Walsh Counties, 1970) indicates that the sedimentation rate predicted was 0.12 acre-feet per year per square mile, and the total sediment storage available for Fordville Dam (based on the Watershed Work Plan) was estimated to be 130 acre-feet.

A stage-storage relationship for Fordville Dam was developed based on the bathymetric survey data collected in the summer of 2020 and LiDAR data (IWI, 2008-2009). Stage-storage curves were developed for both the existing condition of the reservoir (top of sediment) and the original reservoir condition when the dam was built (bottom of sediment). **Figure 2-6** shows the computed elevation-storage relationship for existing and original conditions, as well as the as-built elevation-storage curve for the dam. The as-built curve is similar to the bottom of sediment curve developed from the bathymetric survey. At a specific elevation, the difference between the storage of the bottom of sediment curve and top of sediment curve is the volume of sediment at that elevation. For example, at the low-level drawdown elevation of 1090.93 feet (NAVD88) the volume for the existing ground curve is 204 acre-feet and the volume for the original curve is 412 acre-feet. The difference of those two volumes is 208 acre-feet which would be the volume of sediment below the low-level drawdown elevation.

3 REVIEW AND INSPECTION OF STRUCTURE

Site inspections of Fordville Dam were conducted by Houston Engineering Inc. in September of 2020. The objective of the inspections was to assess the condition of all elements of the dam including the embankment, slope protection, concrete inlet structure, principal spillway conduit, SAF stilling basin, auxiliary spillway, and all related miscellaneous elements. A dam inspection checklist was used to record findings and is presented in **Appendix D**. Photographs were also taken during all inspection visits. Photographs of the dam site as well as photographs of any noted deficiencies during the site inspections are also presented in **Appendix D**. Previous inspection reports were reviewed to verify existing conditions and to evaluate deteriorating conditions. The reported conditions are based on observations of field conditions at the time of inspection and it is important to note that the condition of the various elements of the dam depend on numerous and constantly changing internal and external factors. Continued care, maintenance, and inspections are necessary to detect unsafe conditions.

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3.1 PRINCIPAL SPILLWAY CONCRETE INLET STRUCTURE

The reservoir level at the time of inspection was just below the first stage inlet orifice level of the principal spillway structure. A low-level draw down exists on the front side of the inlet structure consisting of a 24-inch diameter reinforced concrete pipe extending 44' upstream connecting to a concrete drawdown inlet with screw gate assembly. The 24-inch reinforced concrete pipe was inspected for potential damages and movement using a remotely operated vehicle. Video footage of the inside of the draw down pipe showed no significant signs of deterioration, movement, or separation of joints.

All visible sections of the concrete inlet structure exterior were inspected for potential damage or movement. No visible signs of deterioration or movement were noted on the exterior of the inlet structure. There were no signs of significant debris/trash accumulation around the first stage inlet and all trash racks appeared to be in good condition with minor surface corrosion. The interior portion of the concrete inlet structure was also able to be inspected due to the lack of flow going through the structure. The interior walls, floor, and roof did not show any significant signs of deterioration or cracking. A small crack was identified on lower portion of the inlet structure wall, just above the principal spillway conduit connection. A large amount of what appeared to be swallow nests were noted on the interior corners of the roof/wall connection.

Overall, all visible portions of the concrete inlet structure appear to be in good condition and appear to be structurally sound. No external evidence of any settlement or movement of the structure was observed. At this time, no immediate action is recommended. A summary of the deficiencies associated with the principal spillway concrete inlet structure is listed in **Table 3-1**.

3.2 PRINCIPAL SPILLWAY CONDUIT AND SAF STILLING BASIN

The principal spillway conduit consists of 5'x5' reinforced concrete box sections each 20' long with steel plates at each joint. At the time of inspection, the reservoir level was low enough to eliminate flow through the conduit for inspection. The principal spillway conduit was inspected for potential concrete deterioration and joint movement. The conduit joints were numbered to refence the locations of the observations made and are identified in the dam cross section view provided in **Appendix B**. The connection of the concrete inlet structure and principal spillway conduit (J15) showed damage and movement to the steel joint plate as well as a small amount of water trickling through the joint. All other steel joint plates were noted to contain minor surface corrosion but did not show any signs of movement or damage. J4 was noted to have some pre-formed joint filler material that was partially dislodged from the joint on the roof connection. One section of the principal spillway conduit (between J11 and J10) was also noted to have minor hairline cracking of the wall and roof sections. Photographs of the interior of the principal spillway conduit are provided in **Appendix D** and a summary of deficiencies is listed below in **Table 3-1**. Overall, the condition of the principal spillway conduit is adequate, and no immediate action is recommended.

Since flow was able to be cut-off through the principal spillway conduit, the SAF Stilling Basin was emptied via a pumping system to perform a total inspection of the structure. The floor and energy blocks were inspected and did not show significant damage or signs of deterioration. Both the south and north interior faces of the SAF Stilling Basin walls showed minor concrete spalling at the joints (J2 and J1) as well as some minor hairline concrete cracking near the mid-height of the wall at J2 and J1. Cracking was also noted near several fence post connections at the top of the walls. Both wingwall joints also showed some minor concrete spalling. No joints in the SAF Stilling Basin showed signs of significant movement or displacement. Both the north and south wingwall showed significant concrete deterioration and spalling as well as exposed

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rebar at the ends of the wingwalls at the normal water elevation. The spalling extends the length of wingwall on both the front and back face of the wingwalls. It is recommended for these extensive areas of concrete deterioration on the wingwalls be monitored and that a repair plan be created. Photographs of the SAF Stilling Basin are provided in **Appendix D** and a summary of deficiencies listed below in **Table 3-1**.

Table 3-1: *Fordville Dam Structural Deficiency Summary*

Deficiency Location	Description
Concrete Inlet Structure	▪ Minor surface corrosion noted on trash rack. ▪ Small crack identified in wall directly above principal spillway conduit connection.
Principal Spillway Conduit at J15	▪ Anti-seep collar at J15 shows damage and movement away from joint. A small amount of water was noted trickling from the joint.
Principal Spillway Conduit at J4	▪ Pre-formed joint filler material partially dislodged from the joint on the roof connection.
Principal Spillway Conduit Section Between J11 & J10	▪ Hairline cracking noted on both wall sections as well as roof.
SAF Stilling Basin at J2 & J1	▪ Minor concrete spalling noted at both joints on interior face of walls. Minor hairline cracking noted on both wall faces near joints at mid-height of walls.
SAF Stilling Basin at Top of Sidewalls	▪ Cracking was also noted near several fence post connections at the top of the walls.
SAF Stilling Basin at Wingwall Joints	▪ Minor hair line cracking noted on both interior wall faces near joints at normal water level height.
SAF Stilling Basin Wingwalls	▪ Both north and south wingwall showed significant section loss from concrete deterioration and spalling as well as exposed rebar at the ends of the wingwalls at the normal water elevation. Spalling extends the length of wingwall on both the front and back face of the wingwalls.
Toe Drains	▪ North toe drain could not be located.

Toe drains are located adjacent to the sidewalls of the SAF Stilling Basin and discharge into the plunge pool. At the time of inspection, the south toe drain was located and it was noted no water was discharging out of the pipe. The north drain outlet could not be located at the time of inspection. Overall, the condition of the toe drain that was located appears to be adequate and no immediate action is recommended. All structural elements should continue to be monitored on a regular basis.

3.3 EMBANKMENT AND AUXILIARY SPILLWAY

Overall, the condition of the dam embankment and auxiliary spillway were found to be in good condition. The vegetative cover of the upstream and downstream slopes was in good condition with no bare areas. Some lightly traveled vehicle trails were evident due to recent geologic investigation, survey, and inspection activities. A few small trees, less than 2 inches in diameter, were found growing on the embankment. Pocket gopher mounds were observed on the downstream slope with most located near the right (south) abutment. Trees and brush are growing on the entrance to the auxiliary spillway at the reservoir shoreline and at the downstream end near the outlet channel.

Deficiencies associated with the dam embankment and auxiliary spillway are noted in a Dam Inspection Form which is provided in **Appendix D**. **Appendix D** also contains photographs of the embankment and auxiliary spillway.

4 DAM BREACH ANALYSIS AND HAZARD CLASSIFICATION

The breach analysis and hazard classification of Fordville Dam were evaluated based on guidelines established in *TR 210-60* (NRCS, 2019). The sub-sections that follow describe how the breach analysis was conducted, the results from the dam breach scenario, and the resulting hazard classification associated with Fordville Dam.

4.1 PEAK BREACH DISCHARGE CRITERIA

The peak discharge criteria for the dam breach were developed using equations found in Chapter 1 of *Technical Release 210-60 Earth Dams and Reservoirs* (NRCS, 2019). Based on *TR 210-60*, the failure or breach of the dam is to be evaluated with the water surface elevation of the reservoir at the dam crest or the peak reservoir stage resulting from the probable maximum flood (PMF). The PMF occurs as a result of the runoff from a PMP event. Equations in Part I of *TR 210-60* were used to compute the peak breach discharge for Fordville Dam. The peak breach discharge calculated for the dam was approximately 103,000 cubic feet per second.

The downstream water surface profiles for the dam breach were developed using the HEC-RAS modeling program (U.S. Army Corps of Engineers, 2018). The extent of the model and elements used in the model are shown in **Figure 5-1** (details on the development of the HEC-RAS model are explained in Section 5.2.1). To meet the peak breach discharge, the elevation of the reservoir was set to the top of dam elevation, and the breach formation time was altered in the model to yield a peak flow of 103,000 cubic feet per second. The resulting outflow hydrograph from the breach simulation is shown in **Figure 4-1**.

4.2 BREACH RESULTS

The inundation produced from the simulated breach based on *TR 210-60* criteria is shown through the breach zone on **Figure 4-2**. **Figure 4-3** through **Figure 4-6** show more detailed views of the inundation mapping along with structures affected and roads overtopped throughout the breach zone. The breach zone was developed based on the requirements outlined in item B.1 under the Expected Accomplishments and Deliverables section in the Cooperative Agreement between the NRCS and the Walsh County Water Resource District. The extent of the breach zone is established at the point where the breach scenario water surface profile converges with the Federal Emergency Management Agency's (FEMA) base flood elevation (United States government, 2020). For Fordville Dam, the breach zone begins at Fordville Dam

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and extends downstream to a location where the water surface profile for the breach scenario is within half a foot of the FEMA flood zone A base flood elevation on the mainstem of the Forest River.

All residential structures impacted by the dam breach are summarized in **Table 4-1** and are labeled in **Figure 4-2** as well as **Figures 4-3** through **Figure 4-6**. Structures were identified within the HEC-RAS modeling extents via imagery made available through the National Agriculture Imagery Program (NAIP) (United States Department of Agriculture, 2019). **Table 4-1** provides data on maximum inundation depth of the structure, maximum velocity of flow at the structure location, and the amount of time it would take for the breach discharge to reach the structure. In addition to the residential structures impacted by the breach, an estimated 115 non-residential structures would be impacted. The additional structures consist mostly of agricultural storage facilities, grain bins, and other buildings used for agricultural production.

Roads downstream of Fordville Dam were considered for this analysis, but none of them would have an impact on the hazard classification of the dam. The criteria used to assess danger potential for roads within the breach zone is an average annual daily traffic (AADT) of greater than 400. This AADT value was chosen based on recommendations that were provided to the North Dakota State Water Commission for hazard classification of dams in North Dakota by Gannett Fleming Inc. in July of 2017 (Gannett Fleming Inc., 2017). If roads do not exceed 400 AADT, they were not considered for this analysis, and any roads with an AADT value greater than 400 within the breach zone did not overtop.

Table 4-1: *Residential Structures Impacted by a Breach of Fordville Dam*

Structure ID	Depth (ft)	Velocity (ft/s)	Arrival Time[1] (hours)
S1	18.75	2.97	2
S2	8.10	4.80	2
S3	5.09	3.55	3
S4	1.92	0.33	11
S5	0.61	4.54	13
S6	0.21	1.97	13
S7	1.45	0.46	12
S8	1.79	0.15	15
S9	1.93	0.18	15
S10	1.27	0.01	15
S11	0.72	0.55	19
S12	0.11	0.59	19
S13	0.59	0.20	22

[1] Breach arrival time is relative to the initiation of the dam breach

The structures listed in **Table 4-1** were analyzed further to determine if there is the potential for loss of life during a breach of the magnitude described. Depth and velocity flood danger level relationships established in *Downstream Hazard Classification Guidelines* (U.S. Bureau of Reclamation, 1988) were used to determine which structures have a high danger potential during a breach at Fordville Dam.

The chart from *Downstream Hazard Classification Guidelines* that shows the depth-velocity flood danger level relationship for houses built on foundations is shown on **Figure 4-7**. The structures corresponding to **Table 4-1** are also plotted on **Figure 4-7**. Structures plotted in the red fall in the category of high danger level, indicating that loss of life is likely. Structures in the yellow fall into what is called the judgement zone where some level of engineering judgement should be used to determine if the structure has a high or low danger potential. Structures plotted in the green area have a low danger level, and loss of life is not likely. **Figure 4-7** shows that there are two structures in the high danger (red) zone and one structure in the judgment (yellow) zone. For the purposes of this report, the structure in the judgement zone is assumed to be in the high danger category. Therefore, a total of three out of the thirteen total residential structures would have a high danger potential for loss of life if Fordville Dam were to breach with the magnitude described in Section 4.1. The three structures that have a high danger potential are shown as red triangles in **Figure 4-2** through **Figure 4-6**. The remaining structures that are in the low danger potential category are shown as green triangles in those same figures.

4.3 HAZARD CLASSIFICATION

Title 210, National Engineering Manual, Part 520 Subpart C "Dams" (NRCS, 2017) describes the hazard potential resulting from failure of dams. According to this guidance, a high hazard potential is "Dams where failure may cause loss of life or serious damage to homes, industrial or commercial buildings, important public utilities, main highways, or railroads."

A similar definition is outlined in Article 89-08 of the North Dakota Century Code (ND SWC, 2015) where a high hazard dam is defined as, "A dam located upstream of developed or urban areas where failure may cause serious damage to homes, industrial and commercial buildings, and major public utilities. There is potential for the loss of more than a few lives if the dam fails."

Based on the data presented in Section 4.2, Fordville Dam is classified as a high hazard dam.

5 HYDROLOGIC AND HYDRAULIC MODELING

5.1 HYDROLOGY MODEL

Several hydrologic modeling efforts have been completed or are currently underway for other projects in the Forest River Watershed. In 2011, the United States Army Corps of Engineers (USACE) along with local sponsors began work on the development of hydrologic models from Halstad, MN, to the international border (including the Forest River Watershed) using HEC-HMS (V.4.2.1) as part of the *Red River of the North Hydrologic Modeling – Phase 2* report (USACE, 2013). Methods developed as part of the Phase 2 study were aimed at developing a consistent method to analyze hydrology within the Red River Basin while still accounting for unique characteristics within each subwatershed.

Further development of the hydrologic model was done through the *Forest River Watershed Comprehensive Detention Plan* (Red River Joint Water Resource District, 2013). This effort focused on the development of potential storage sites in the watershed. Through the study, detail was added to the hydrologic model and input parameters were refined through calibration efforts beyond the Phase 2 report.

Recently, ongoing efforts toward a Watershed Plan through the Regional Cooperation Partnership Program (RCPP) have enabled further refinement of the hydrologic model for the Forest River Watershed. As part

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of the RCPP, an *Existing Conditions Hydrology and Hydraulics Report* for the Forest River Watershed was completed by Houston Engineering Inc. (2019). The hydrologic model detailed in that report was used for this assessment with some minor modifications. Changes to the model and other important elements associated with the hydrology of Fordville Dam are described in the following sub-sections.

5.1.1 SUBBASIN BOUNDARIES

Subbasins developed through previous modeling efforts included non-contributing drainage areas which were developed to evaluate potential for hydrologically closed basins within the watershed. Non-contributing drainage areas were used for the Principal Spillway Inflow Hydrograph simulation described in Section 5.5.1.

For the larger inflow hydrographs, including the stability design hydrograph (SDH) and freeboard hydrograph (FBH), all drainage area in the watershed upstream of Fordville Dam was assumed to contribute runoff. That is, non-contributing areas within the Fordville Dam watershed were changed to contributing areas when simulating the larger runoff events. For the drainage area to Fordville Dam, the non-contributing areas accounted for approximately 0.2 square miles of the total 49.5 square mile drainage area. In the current HEC-HMS model, the drainage area to Fordville Dam is split into two subbasins. The subbasins used in the HEC-HMS model for the entire Forest River Watershed can be seen in the *Existing Conditions Hydrology and Hydraulics Report* for the Forest River Watershed.

5.2 HYDRAULIC (HEC-RAS) MODEL

An unsteady HEC-RAS (v.5.0.7) model was developed and used to generate water surface profiles by hydraulically routing runoff hydrographs generated by the HEC-HMS model. The HEC-RAS model is used to evaluate the hazard classification of Fordville Dam by routing breach hydrographs through the downstream channel and to develop inundation extents for synthetic events to assist with the various scenarios to be evaluated for the Watershed Plan. The HEC-RAS model consists of channel cross sections, 1-dimensional storage areas, and 2-dimensional storage areas. The channel cross sections route flows in the Middle Branch Forest River which turns into the Forest River, the South Branch Forest River, Ardoch Coulee, and various intermittent tributaries. Cross sections on the Forest River span from Matejcek Dam to the crossing with US Interstate 29. Cross sections on the South Branch Forest River span from Fordville Dam to the confluence with the Forest River. 1-dimensional storage areas were used to represent the elevation-storage relationship in the Fordville Dam reservoir. 2-dimensional storage areas are located adjacent to the Forest River mainstem to route overland or breakout flows. Channel cross sections, 1-dimensional storage areas, and 2-dimensional storage areas in the HEC-RAS model schematic are shown on **Figure 5-1**.

5.2.1 STORAGE ROUTING

Storage routing is used to account for floodplain storage adjacent to the Forest River mainstem. Due to the complex routing of overland flooding, 2-dimensional storage areas are used for the Forest River Watershed. 2-dimensional storage areas allow the model to account for floodplain storage available for out of bank flows and are used to convey flows through the floodplain. Storage areas are connected to cross sections and other storage areas to hydraulically route flows through the floodplain. Internal storage connections are used to represent township roads that contain culverts or bridges to simulate flow through the roadways.

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Fordville Dam is modeled with a 1-dimensional storage area and the elevation-storage data was derived from LiDAR data. Flood storage in the model for Fordville Dam only includes LiDAR data and does not include the bathymetric data. This is not seen as a concern because the LiDAR data represents the flood storage above the normal pool elevation and any data below the normal pool is not relevant for the hydraulic simulations.

5.2.2 CHANNEL BATHYMETRY AND HYDRAULIC STRUCTURES

The channel shape and bathymetry of the South Branch Forest River was developed based on the survey data described in Section 2.1. Bridges and culvert crossings along the South Branch Forest River were also modeled using survey data. Channel bathymetry and structures used throughout the other portions of the HEC-RAS model are described in the *Existing Conditions Hydrology and Hydraulics Report* for the Forest River Watershed (Houston Engineering Inc., 2019).

5.2.3 MANNING'S N-VALUES

Manning's n-values are set within the HEC-RAS cross sections to account for channel roughness. NLCD land use GIS grids were used to generate a Manning's n-value grid. The NLCD land cover categories were aggregated into five land use types; channels, agricultural or cropland, wetlands, forested, or developed/barren land. Due to the cell size of the NLCD GIS grids (30 meters x 30 meters), portions of the river channels can be omitted from the NLCD grids. The NLCD grid was modified by generating a channel boundary and merging the channel with the NLCD grid. The NLCD grid was also used for flow routing computations in 2-dimensional areas. Manning's n-values were set through calibration and verification of the Forest River Watershed Plan HEC-RAS and HEC-HMS models as described in Section 5.3. The calibrated Manning's n-values in the existing conditions hydraulic model are shown in **Table 5-1**.

***Table 5-1**: Manning's n-Values by Land Use*

Land Use	Manning's n-Value
Channel	0.05
Agricultural / Cropland	0.06
Wetlands	0.05
Forested	0.11
Developed/Barren	0.08

5.2.4 INFLOWS

Hydrographs generated from the HEC-HMS model were applied to the HEC-RAS model. HEC-HMS junction hydrographs were applied at the upstream extents to cross sections or 1-dimensional storage areas within the HEC-RAS model. Further downstream, HEC-HMS subbasin hydrographs were applied to the cross sections and 1-dimensional storage areas within the HEC-RAS model.

5.2.5 TAILWATER

The tailwater boundary condition for the Forest River was estimated by entering a friction slope downstream of US Interstate 29. The slope was estimate from LiDAR data in the Forest River channel.

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5.3 CALIBRATION AND VERIFICATION

Two historic rainfall events were used for calibration and verification of the HEC-HMS and HEC-RAS models for the Forest River Watershed. A rainfall event in mid-June of 2016 was used to estimate model parameters in the Forest River hydrologic and hydraulic models. An event in May of 2010 was used to verify the parameters used in the models.

5.3.1 JUNE 2016 CALIBRATION EVENT

The hydrologic and hydraulic models were calibrated based on a rainfall event that occurred in the summer of 2016. Rainfall depths in the Forest River Watershed upstream of Lake Ardoch during the event ranged from 1.3 to 3.8 inches. The average total rainfall depth upstream of Lake Ardoch was approximately 2.7 inches. The majority of the rainfall that was modeled in the simulation occurred on June 17th from about 5 a.m. to 11 a.m. where an average of 2.2 inches of precipitation occurred. The remaining precipitation that was simulated occurred on June 19th from 3 a.m. to 7 a.m. Total rainfall depths throughout the Forest River Watershed during the event are shown on **Figure 5-2**.

Documented historic data that was used for calibration of the models included: observed rainfall depths at gaging stations, NEXRAD rainfall data, discharge measurements at the Forest River USGS Streamgage 05084000 near Fordville, ND, and discharge measurements at the Forest River USGS Streamgage 05085000at Minto, ND. The observed discharge hydrographs were used to derive daily flow volumes at the streamgages.

Runoff curve numbers for a 24-hour storm duration were initially applied for the calibration event. Curve numbers were adjusted to match the observed discharge volume through the USGS gage sites at Fordville and Minto. The final curve numbers used in the simulation were slightly higher than an AMC II condition for regions upstream of the Fordville gage and approximately equal to an AMC II condition downstream of the gage. This antecedent moisture condition was reviewed based on guidance from the *National Engineering Handbook (NEH)* (NRCS, 2004), and is valid based on a small rainfall event occurring in the a few days prior to the event.

During the simulation of the historic rainfall event, pool elevations for all dams in the watershed were set to the normal pool elevation. The small rainfall event that occurred prior to the historic rainfall event subsided approximately two days before the simulated event began. This would allow enough time to draw pool elevations down to, or near the normal pool elevation. Baseflow was added to the HEC-RAS model to match discharge at both USGS gages before the rainfall event.

Initial unit hydrograph parameters that were estimated in previous modeling efforts (Section 5.1) were further adjusted with the June 2016 rainfall event. Modifications were made to the storage coefficient (R) and time of concentration (Tc) values used in the Clark Unit Hydrograph transform during calibration. Final R/Tc ratios from calibration are shown on **Figure 5-3**. A similar procedure was followed when the models were calibrated for the *Existing Conditions Hydrology and Hydraulics Report* for the Forest River Watershed (Houston Engineering Inc., 2019).

Hydrographs in the hydraulic model were compared to the recorded discharge at the Forest River USGS Streamgage near Fordville, ND. The observed discharge hydrograph for the Streamgage near Fordville and simulated HEC-RAS model discharge hydrograph are shown on **Figure 5-4**. The simulated HEC-

DRAFT

RAS peak flow rate and volume are consistent with observed flow rates and volumes at the gage during the event.

Table 5-2 summarizes the peak flow rates and timing, as well as the 1-day through 3-day volumes centered on the peak flow rate (i.e. the 1-day through 3-day volumes were computed by finding the area under the hydrograph centered on the peak ±0.5 days, ±1.0 days, etc.). The observed discharge hydrograph for the Streamgage at Minto and simulated HEC-RAS model discharge hydrograph are shown on **Figure 5-5**. The simulated HEC-RAS peak flow rate and volume are consistent with observed flow rates and volumes at the gage during the event. **Table 5-3** summarizes the peak flow rates and timing, as well as the 1-day through 3-day volumes centered on the peak flow rate. Observed volumes at gaging sites beyond 3 days were not considered because of a second rainfall event that came through the watershed on June 19th. The hydrologic model uses the curve number runoff method. This runoff method does not account for initial abstraction that would occur during a second rainfall event in the hydrologic simulation. Therefore, the model results show a larger secondary peak from the second rainfall that occurred within the watershed.

***Table 5-2**: Peak Flow and Volume Comparison at USGS Gage near Fordville, ND in June 2016*

Source	Peak Flow (cfs)	Peak Flow Time	Volume (Ac-Ft)		
			1-Day	2-Day	3-Day
USGS Gage 05084000 at Fordville, ND	1,860	6/18/2016 3:00	2,610	3,681	4,394
HEC RAS Model	1,817	6/18/2016 4:00	2,587	3,570	4,281
%Difference	-2.3%	1 hour	-0.9%	-3.0%	-2.6%

***Table 5-3**: Peak Flow and Volume Comparison at USGS Gage at Minto, ND in June 2016*

Source	Peak Flow (cfs)	Peak Flow Time	Volume (Ac-Ft)		
			1-Day	2-Day	3-Day
USGS Gage 05085000 at Minto, ND	1,980	6/20/16 5:00	3,801	7,026	9,619
HEC RAS Model	1,916	6/20/16 5:00	3,521	6,354	8,778
%Difference	-3.23%	0 hours	-7.38%	-9.57%	-8.74%

Parameters in the HEC-RAS model were also established during calibration. These parameters include Manning's n-values, overbank reach lengths, and storage area connection coefficients. Initial values were set based on guidance from the *HEC-RAS User's Manual* (USACE, 2016) and *HEC-RAS Technical Reference Manual* (USACE, 2016). Manning's n-values were generally assumed to be a crop covered condition (crop development and mature crop). A sensitivity analysis on Manning's n-values was completed in the *Existing Conditions Hydrology and Hydraulics Report* for the Forest River Watershed (Houston Engineering Inc., 2019). Overbank reach lengths were digitized utilizing GIS and the resultant HEC-RAS model floodplain. Storage area connection coefficients were generally set based on Table 3-1 from the *HEC-RAS 2D Modeling User Manual* (USACE, 2016).

5.3.2 MAY 2010 VERIFICATION EVENT

After the hydrologic and hydraulic models were calibrated, a second historic event was simulated to verify the parameters in the calibration event. Most of the May 2010 rainfall event occurred from May 24th through the early hours of May 25th. Rainfall depths in the Forest River Watershed upstream of Lake Ardoch during the event ranged from 2.3 to 3.8 inches. The average total rainfall depth for the planning area was approximately 2.8 inches. Total rainfall depths from May 22nd to May 25th are shown on **Figure 5-6**.

Documented historic data that was used for calibration of the model included: observed rainfall depths at gaging stations, NEXRAD rainfall data, discharge measurements at the Forest River USGS Streamgage 05084000 near Fordville, ND, and discharge measurements at the Forest River USGS Streamgage 05085000 at Minto, ND. The observed discharge hydrographs were used to derive daily flow volumes at the streamgages.

Runoff curve numbers were adjusted to produce the quantity of runoff volume recorded at the USGS gaging station near Fordville, ND. 24-hour curve numbers for subbasins in the watershed were applied with an antecedent moisture condition that was slightly higher than average. This antecedent moisture condition was reviewed based on guidance from the *National Engineering Handbook (NEH)* (NRCS, 2004), and is valid because of the amount of precipitation occurring prior to the event.

The observed discharge hydrograph and the simulated HEC-RAS model discharge hydrograph at the USGS gage near Fordville, ND are shown in **Figure 5-7**. The peak flow rate from the measured data at the streamgage and the HEC-RAS modeled results differ by less than 1% near Fordville. In addition to a peak flow comparison, volume of runoff at the USGS gage near Fordville, ND was compared for several durations centered on the peak discharge. **Table 5-4** summarizes the peak flow rates and timing, as well as the 1 through 3-day volumes centered on the peak flow rate. The observed discharge hydrograph for the Streamgage at Minto and simulated HEC-RAS model discharge hydrograph are shown on **Figure 5-8**. The simulated HEC-RAS peak flow rate is lower than the observed peak flow and the timing of the Minto hydrographs are slightly off. This is due to the unknown levee elevations adjacent to the Forest River at breakout locations during the May 2010 event. Levees reconstructed and/or breached after the LiDAR collect (IWI, 2008-2009) caused uncertainty in the river geometrics at the time of the event. **Table 5-5** summarizes the peak flow rates and timing, as well as the 1-day through 3-day volumes centered on the peak flow rate.

The results from the May 2010 event at the USGS Streamgage near Fordville, ND verify the unit hydrograph parameters in the upper portion of the watershed, however, results at the USGS Streamgage at Minto, ND are highly dependent on the lower Forest River channel geometrics (i.e. levee breakout locations). Therefore, unit hydrograph parameters used downstream of Fordville, ND and upstream of Minto, ND in the June 2016 event will be used for the synthetic events because of its proximity (with respect to time) to present day conditions.

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***Table 5-4**: Peak Flow and Volume Comparison at USGS Gage near Fordville, ND in May 2010*

Source	Peak Flow (cfs)	Peak Flow Time	Volume (Ac-Ft)		
			1-Day	2-Day	3-Day
USGS Gage 05084000 at Fordville, ND	1,430	5/24/10 20:00	2,197	3,138	3,830
HEC RAS Model	1,431	5/24/10 20:00	2,084	3,074	3,782
%Difference	0.1%	-	-5.1%	-2.0%	-1.3%

***Table 5-5**: Peak Flow and Volume Comparison at USGS Gage near Minto, ND in May 2010*

Source	Peak Flow (cfs)	Peak Flow Time	Volume (Ac-Ft)		
			1-Day	2-Day	3-Day
USGS Gage 05084000 at Minto, ND	908	5/26/10 05:00	1,693	2,952	4,016
HEC RAS Model	823	5/26/10 21:00	1,578	2,875	3,809
%Difference	0.1%	-	-5.1%	-2.0%	-1.3%

5.4 PROBABLE MAXIMUM PRECIPITATION

The probable maximum precipitation (PMP) event for Fordville Dam was first developed using Hydrometeorological Report No. 51 (HMR51) (Schreiner & Riedel, 1978). HMR51 rainfall depths were extracted from the PMP charts in the back of the report. The charts are made available in a digital format on the National Weather Service's website. Rainfall depths were extracted from the PMP charts located on pages 48 to 77 of HMR51.

In addition to the PMP depths developed from HMR 51, PMP depths were also obtained based on a recent study for updated PMP depths in the state of North Dakota. Documentation for the updated PMP values has not been completed at this point, but the depths are considered usable by the steering committee overseeing the development of the PMP depths for the state of North Dakota (the NRCS is involved in the steering committee to develop statewide PMP depths). Two different storm types and various storm durations were simulated to determine the PMP scenario that would produce the largest and most conservative inflow to Fordville Dam.

The two storm types considered are a local PMP event and a general PMP event. A local storm is a high intensity rainfall event that occurs over a short period of time. Durations of the local PMP event do not exceed 24-hours. A general storm is not as intense as a local storm and typically occurs over a longer period of time. Available durations for general storms are 24 to 72 hours. A cool season PMP was also made available through the North Dakota PMP study, however, the cool season PMP was not considered for this analysis because it would not produce higher inflows than the general and/or local storms based on previous simulations done for larger drainage areas in the watershed. Typically, a cool season PMP is less likely to be the critical event for small watersheds.

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5.5 SPILLWAY DESIGN HYDROGRAPHS

Spillway design hydrographs were developed based on criteria in *Technical Release 210-60: Earth Dams and Reservoirs* (NRCS, 2019), also known as *TR 210-60*. Based on results previously presented in Section 4, Fordville Dam is classified as a high hazard dam. The minimum precipitation criteria outlined in *TR 210-60* for high hazard dams is shown in **Table 5-6**, and each of the design hydrographs is described in more detail in the following sub-sections.

Table 5-6: TR 210-60 *Minimum Precipitation Data for High Hazard Dams*

Design Event	Hydrologic Criteria [1]	Depth (inches)
Principal Spillway	P_{100}	7.73 [2] 4.7 [3]
Auxiliary Spillway	P_{100} + 0.26(PMP - P_{100})[4]	8.91 [5]
Freeboard	PMP	19.7 [5]

[1] P_{100} represents the precipitation for the 100-year return period
[2] Runoff depth based on *NEH Part 630 Chapter 21*. See Section 5.5.1
[3] Rainfall depth based on *NOAA Atlas 14*. See Section 5.5.1
[4] P_{100} depth used to calculate the Auxiliary Spillway depth utilized the NOAA Atlas 14 published depth for equivalent duration events.
[5] Depths represent the total rainfall depths that result in the maximum outflow from Fordville Dam during the simulation. See Sections 5.5.2 and 5.5.3

5.5.1 PRINCIPAL SPILLWAY INFLOW HYDROGRAPH

Based on *TR 210-60*, the principal spillway of a high hazard dam must pass the 100-year return period storm (minimum) with a duration not less than 10-days without activating the auxiliary spillway. For Fordville Dam, two methods were used to determine the critical event: runoff volume maps and runoff curve number procedure (NRCS, 2019).

Runoff volume maps presented in Figure 21-2 of *NEH Part 630 Chapter 21* (NRCS, 2019) were used to estimate the 100-year 10-day runoff at 4.7 inches. No areal reduction is applied to the 100-year 10-day runoff depth for the runoff volume maps.

The runoff curve number procedure was used to simulate summer rainfall events for the principal spillway criteria. Rainfall depths for a 10-day duration were obtained from *NOAA Atlas 14* (NOAA, 2017). Areal reduction factors were applied to the rainfall depths. The areal reduction factors were based on the drainage area to Fordville Dam and were obtained from *Technical Paper No. 49 – Two- to Ten-Day Precipitation for Return Periods of 2 to 100 Years in the Contiguous United States* (Miller, 1964). The resulting depth for the 10-day duration rainfall event considered for this analysis is shown in **Table 5-7** along with the runoff depths used to simulate the runoff volume maps procedure described previously.

Table 5-7*: Principal Spillway Inflow Hydrograph Data*

Method	Duration	Rainfall/Runoff Distribution	Rainfall/Runoff Depth (in)	Peak Inflow to Bylin (cfs)
Runoff Volume Maps	10-day	*TR 210-60* Curve A	4.7	1,456
Runoff Volume Maps	10-day	*TR 210-60* Curve B	4.7	1,677
Runoff Volume Maps	10-day	*TR 210-60* Curve C	4.7	1,859
Runoff Curve Number	10-day	Nested	7.73	1,074

DRAFT

Guidance from *NEH Part 630 Chapter 21* was used to develop the principal spillway mass curve, or runoff distribution curve, for the 10-day runoff event. For Fordville Dam, 1-hour time increments were used to develop the distribution. Using equation 21-2 from *NEH Part 630 Chapter 21*, the total runoff at any given time during the event can be calculated. These 1-hour values can then be arranged in either a decreasing order (Curve A), an increasing order (Curve B), or a critical stacking order (Curve C). The principal spillway mass curves are used with the 4.7 inches of runoff from the runoff volume maps in *NEH Part 630 Chapter 21* (NRCS, 2019) and are shown on **Figure 5-9**.

Rainfall events are simulated using nested distributions which are developed using a method described in in the *NEH, Part 630, Chapter 4* (NRCS, 2015). "Nesting" the distribution means that all shorter duration storms are contained, or "nested", within longer duration storms. That is, the 10-day storm contains the 5-minute storm, 10-minute storm, and so on. The nested distribution for the rainfall event used to produce the principal spillway hydrograph with the runoff curve number procedure is shown on **Figure 5-9.** Curve numbers used in the simulations represented average antecedent moisture conditions (AMC II).

Quick Return Flow (QRF) is the rate of discharge that persists beyond the flood period of the principal spillway hydrograph. Based on Figure 21-4 in *NEH, Part 630, Chapter 21*, the QRF for Fordville Dam is approximately 1.5 cubic feet per second, per square mile. This results in a QRF of approximately 74 cubic feet per second (cfs) for Fordville Dam.

The four different scenarios described were applied to the HEC-HMS model to develop inflow hydrographs at Fordville Dam. The resultant inflows to the dam were input into the SITES program and adequacy of the principal spillway was evaluated (See Section 7). The inflow hydrographs to Fordville Dam for all four scenarios relevant to the principal spillway hydrograph are shown on **Figure 5-10**. The peak inflow to Fordville Dam is listed in **Table 5-7**.

5.5.2 AUXILIARY SPILLWAY INFLOW HYDROGRAPH

The auxiliary spillway hydrograph, or stability design hydrograph, was developed by using NOAA Atlas 14 rainfall depths and the rainfall depths from the PMP event described in Section 5.4. The dimensionless rainfall distribution used with the HMR51 PMP depths was obtained from Figure 21-9 in Chapter 21, Part 630 of the National Engineering Handbook (NRCS, 2019) and is shown on **Figure 5-11**.

The dimensionless rainfall distributions used for the PMP depths associated with the updated statewide PMP study that is currently ongoing for the state of North Dakota were developed as part of that study. Rainfall distributions were developed based on historic PMP storm events. There are three distributions that were tested for this analysis including a synthetic distribution, a distribution representative of storms that produced a higher percentage of rainfall in the early stages of the storm (known as the 90th percentile distribution), and a distribution representative of storms that produced a higher percentage of rainfall in the latter stages of the storm (known as the 10th percentile distribution). The distribution that produced the highest peak inflow and outflow for Fordville Dam was determined to be the 10th percentile distribution for both the general and local PMP storms. The 10th percentile distribution for the 6-hour local storm is shown on **Figure 5-11**. Any additional precipitation encountered for the longer duration events was added uniformly to the beginning and the end of the distribution. More information on these distributions will be provided when documentation for the statewide PMP study is completed.

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Based on the guidance provided in *TR 210-60,* a short duration storm should be used to check the stability of vegetated auxiliary spillways. Therefore, durations of 6-hours and 24-hours were simulated with PMP depths from HMR51 and durations of 6-, 12-, and 24-hours were simulated with local storm PMP depths from the statewide PMP study. The storms produced from the different PMP sources and durations were simulated in the HEC-HMS model to develop inflow hydrographs at Fordville Dam for the stability design hydrograph. The resultant inflows to the dam were input into the SITES program and adequacy of the auxiliary spillway was evaluated (See Section 7). The inflow hydrographs to Fordville Dam for the three durations relevant to the auxiliary spillway hydrograph are shown on **Figure 5-12**. The peak inflow to Fordville Dam is listed in **Table 5-8**.

***Table 5-8**: Auxiliary Spillway Inflow Hydrograph Data*

PMP Source	Duration	Maximum Rainfall Depth (in)	Peak Inflow to Bylin (cfs)
HMR 51	6 – hour	9.08	3,880
	24 – hour	10.61	4,637
ND – Local	6 – hour	8.15	3,322
	12 – hour	8.87	3,749
	24 – hour	8.91	3,752

5.5.3 FREEBOARD INFLOW HYDROGRAPH

The minimum design event for the freeboard hydrograph (FBH) defined by *NEH 210-60* is the probable maximum precipitation event described in Section 5.4. The duration of the FBH was developed based on guidance from *TR 210-60*. That guidance states that both the 6- and 24-hour storm durations shall be analyzed, and *NEH, Part 630, Chapter 21* states that a storm duration equal to or greater than the time of concentration shall be analyzed. The time of concentration for the watershed upstream of Fordville Dam is greater than 30 hours. For this analysis, durations beyond the time of concentration for the watershed upstream of the dam were analyzed, and the most critical duration was evaluated for spillway adequacy. 24-hour curve numbers with an average antecedent moisture condition (AMC II) were used to simulate the events.

Four durations were analyzed using PMP depths obtained from HMR51. The four durations analyzed were the 6-, 24-, 48-, and 72-hour PMP events. The rainfall distribution used for each of those events was a SCS Type II distribution. This is a conservative distribution that is representative of distributions that have been used to simulate PMP events in the past. The SCS Type II distribution yields a similar result when compared to the NRCS's 5-point distribution described in Section 3 of Chapter 21, Part 630 in the National Engineering Handbook (NRCS, 2019), but can be easily applied to each of the durations being analyzed. The SCS Type II rainfall distribution is shown in **Figure 5-13**.

Three durations were analyzed for the local storm PMP depths obtained from the updated statewide PMP study for North Dakota including the 6-, 12-, and 24-hour durations. The rainfall distribution used to analyze the local storms was also developed from the statewide PMP study and was described in Section 5.5.2. The rainfall distribution that produced the highest peak inflow to Fordville Dam was the distribution that represented storms that produced a higher percentage of the total depth in the latter part of the event (10th percentile distribution). The 10th percentile distribution for the 6-hour local storm is shown on **Figure 5-11**.

DRAFT

Additional precipitation for the longer duration events was added uniformly to the beginning and the end of the distribution. The 24-hour distribution used for the local storm PMP event is shown in **Figure 5-13**.

Three durations were analyzed for the general storm PMP depths obtained from the updated statewide PMP study for North Dakota including the 24-, 48-, and 72-hour durations. The rainfall distribution used to analyze the general storms was also developed from the statewide PMP study. Similar to the local storm PMP, the 10th percentile distribution produced the highest peak inflow into Fordville Dam for the general storm PMP event when compared to the synthetic and 90th percentile distributions. Therefore, the 10th percentile distribution was used to simulate the general storm PMP events. Additional precipitation for the longer duration events was added uniformly to the beginning and the end of the distribution. The 24-hour distribution used for the general storm PMP event is shown in **Figure 5-13**.

The maximum PMP precipitation depth for each of the durations simulated is shown in **Table 5-9** along with the peak inflow to Fordville Dam. The resultant inflow hydrographs to the dam were input into the SITES program and adequacy of the auxiliary spillway was evaluated (See Section 7). The inflow hydrographs to Fordville Dam for all durations and storm types that were analyzed relevant to the freeboard hydrograph are shown on **Figure 5-14**.

***Table 5-9**: Freeboard Inflow Hydrograph Data*

PMP Source	Duration	Maximum Rainfall Depth (in)	Peak Inflow to Bylin (cfs)
HMR 51	6 – hour	20.50	11,256
	24 – hour	26.21	14,754
	48 – hour	28.36	15,345
	72 – hour	29.58	14,949
ND – Local	6 – hour	16.93	8,901
	12 – hour	19.61	10,632
	24 – hour	19.70	10,634
ND - General	24 – hour	19.46	10,166
	48 – hour	20.18	10,541
	72 – hour	20.22	10,564

6 GEOLOGIC INVESTIGATION

A geologic investigation was conducted by Gannett Fleming, Inc. The purpose of the geologic investigation was to develop subsurface profiles and geotechnical data for evaluation of the spillway integrity and for characterization of the embankment and foundation soils. The Geotechnical Engineering Report is provided in **Appendix E**.

Soil borings were done at six different locations for Fordville Dam. Several laboratory tests were conducted on soil samples obtained from the soil borings. The tests performed include tests for moisture content, unit weight, soil strength, and several others. A map showing the location of each soil boring is displayed in **Appendix E** along with the results of the laboratory tests conducted and the general findings from the geotechnical exploration.

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Geotechnical analyses were performed based on the data obtained from the geotechnical exploration. The analyses completed included the SITES analysis (see Section 7.1 for more information on inputs for the SITES program), drain fill compatibility analysis, seepage analysis, and slope stability analysis.

The compatibility analyses indicate that the shell material associated with the dam embankment are of sufficient gradation to protect against piping of the core material. The foundation drain fill material does not appear to meet state-of-the-practice gradation criteria for seepage control/conveyance due to being too coarse and/or too broadly graded. The North Dakota Department of Transportation (NDDOT) fine aggregate would be a more appropriate foundation drain fill material during any future rehabilitation efforts.

Seepage analyses through the dam embankment were performed to estimate the phreatic surface in the embankment during normal pool and flood surcharge pool levels for the purpose of evaluating slope stability. Shear strength tests were also completed to accurately predict slope stability of the embankment at Fordville Dam. Overall, model results indicate that the dam meets current *TR 210-60* requirements for normal pool, flood pool, and rapid drawdown conditions. Calculated factor of safety values for the upstream face of the embankment during rapid drawdown, the downstream face of the embankment during normal pool conditions, and the downstream face of the embankment during flood conditions are all higher than the required minimum factor of safety values (see Table 15 in the Geotechnical Engineering Report located in **Appendix E**).

7 SPILLWAY ADEQUACY

Spillway adequacy for Fordville Dam was evaluated using the NRCS's Water Resources Site Analysis Computer Program (USDA and Kansas State University, 2014), which is commonly referred to as SITES. Model inputs for the principal and auxiliary spillways for Fordville Dam were implemented and the spillways were analyzed to determine if they are able to pass the design hydrographs with sufficient capacity, stability, and integrity.

7.1 SITES MODEL INPUTS

Various inputs are required before the analysis of the principal and auxiliary spillways can be conducted. The elevation-storage relationship in the reservoir upstream of Fordville Dam (see Section 2.3.2) was implemented into the SITES model. Inflow design hydrographs discussed in Section 5.5 were also used in the SITES model for the various design events. Inputs for the geometry of the principal and auxiliary spillways of Fordville Dam are discussed in the following sub-sections. All input information can also be found in **Appendix F**.

7.1.1 PRINCIPAL SPILLWAY INPUTS

The principal spillway for Fordville Dam is a two-stage concrete riser tower. The riser tower consists of a 1-foot by 3.75-foot rectangular orifice opening for the first stage and an overflow weir that is approximately 30 feet in length for the second stage. Elevations of the orifice and overflow weir elevation of the riser tower were collected during the survey of the structure in the summer of 2020. The size of the orifice and overflow weir were determined from as-built drawings and verified by survey data. Information on the conduit going from the riser tower, through the embankment, and to the outlet of the structure was also entered. The length of the conduit was determined from as-built drawings and verified by aerial imagery. The conduit

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size was also determined from as-built drawings and was verified by survey in the field. The elevation of the conduit is based on survey data collected in the summer of 2020.

After all elements of the principal spillway were entered into the SITES program, an output stage-discharge curve for the principal spillway was produced. The resulting stage-discharge relationship for the principal spillway riser tower at Fordville Dam is shown in **Figure 7-1**.

7.1.2 AUXILIARY SPILLWAY INPUTS

The auxiliary spillway for Fordville Dam is an earthen channel that runs along the south side of the embankment. The spillway consists of a 400-foot bottom width, 3 to 1 channel side slopes, and has an exit slope of approximately 3% downstream of the spillway crest. Downstream of the 3% slope there is another approximately flat section in the spillway that continues for about 350 feet before the profile changes to a much steeper slope that is greater than 50% near the downstream end of the channel before it reaches the existing ground elevation near the South Branch Forest River. The resulting stage-discharge relationship for the auxiliary spillway at Fordville Dam is shown in **Figure 7-1**. Survey data of the auxiliary spillway was used to develop a surface profile of the spillway. The profile of the auxiliary spillway of Fordville Dam is provided in **Figure 7-2**.

During the geologic investigation at Fordville Dam, three soil borings were collected in the auxiliary spillway. Soil boring FD2020-212 is located on the west side of the road that runs over the dam embankment and is approximately 160 feet downstream of where the auxiliary spillway crest begins. The auxiliary spillway crest spans a total of 462 feet. Soil boring FD2020-213 is located on the east side of the road that runs over the dam embankment and is approximately 200 feet downstream of where the auxiliary spillway crest begins. FD2020-214 is located on the northern edge of the auxiliary spillway channel bottom near the end of the spillway crest. A map of all soil boring locations is provided in **Appendix E**. There are four geologic materials associated with the three soil borings located in the auxiliary spillway. The materials and their associated parameters are shown in **Table 7-1**. The material parameters shown in **Table 7-1** were developed based on laboratory test data and correlation with published values. Calculations for all parameters are included in the *Geotechnical Engineering Report* prepared by Gannett Fleming Inc., which is provided in **Appendix E**. The geologic profile of the auxiliary spillway materials used for the analysis is shown in **Figure 7-2**.

***Table 7-1**: Assumed Parameters for Auxiliary Spillway Integrity Analysis*

Material Description	Dry Density (lb/ft^3)	Headcut Index (K_h)	Percent Clay (%)	Plasticity Index	D_{75}/Rep. Diameter (mm)
Soil Cement	105	0.22	7	23	1.5
Clay	101	0.1	13	18	0.52
Silty Sand	100	0.061	9	9	1
Glaciolacustrine	75	0.0065	20	3	0.033

DRAFT

7.2 PRINCIPAL SPILLWAY RESULTS

The principal spillway hydrologic criteria for a high hazard dam is a 10-day, 100-year event. The rainfall and runoff events simulated were described in Section 5.5. To pass the criteria, the dam must be able to pass the design event without activation of the auxiliary spillway. Based on the results from the SITES analysis, the principal spillway hydrograph that would result in the highest auxiliary crest elevation is the Runoff Volume Maps procedure with incremental runoff depths occurring in a critical stacking order (Curve B) from **Figure 5-9**.

According to *TR 210-60*, the principal spillway capacity should empty at least 85 percent of the principal spillway hydrograph routed through the retarding pool in 10 days or less. If more than 15 percent of the retarding storage volume remains after 10 days, the elevation of the crest of the auxiliary spillway should be raised by adding the volume remaining after 10 days to the initial retarding storage volume to determine the raised auxiliary spillway crest elevation. The SITES program automates this process and the results reported reflect the additional storage needed to account for the 10-day drawdown requirements outlined *TR 210-60*.

The amount of time required to empty 85 percent of the volume associated with each of the principal spillway hydrographs is provided in **Table 7-2**. The 10-day drawdown requirement is not met for any of the principal spillway hydrographs that were simulated, therefore, the volume remaining after 10 days is added to the initial retarding storage volume for all principal spillway hydrographs. The auxiliary spillway crest would need to be raised approximately 6.7 feet for the most critical principal spillway hydrograph. The existing auxiliary spillway elevation and the resulting required spillway elevations for the various principal spillway inflow hydrographs are presented in **Table 7-2**.

***Table 7-2**: Principal Spillway Hydrograph SITES Output*

Parameter	Existing Condition	SITES Analysis Output for 100-year PSH Events			
		Runoff A	Runoff B	Runoff C	Rainfall (10-day)
Required Auxiliary Spillway Crest Elevation (feet, NAVD88)	1,124.2	1128.3	1130.9	1130.3	1126.3
Time to Drawdown 85% of Flood Storage (days)	-	29.3	25.2	23.8	>30.0
Required Flood Storage Volume (Acre-feet)		4144.9	5748.1	5601.5	3578.3
Amount Auxiliary Spillway Crest Needs to be Raised (feet)	-	4.1	6.7	6.1	2.1

DRAFT

7.3 AUXILIARY SPILLWAY RESULTS

Based on *TR 210-60* criteria, the auxiliary spillways of earthen dams should be analyzed for discharge capacity, stability (surface erosion potential), and integrity (breaching potential). The freeboard hydrograph is used to analyze the capacity and integrity of the dam. The design event for the freeboard hydrograph of a high hazard dam is a probable maximum precipitation event, which produces the probable maximum flood (PMF). The stability design hydrograph is used to assess the stability, or surface erosion potential, of the dam. The design event for the stability design hydrograph is a percentage of the PMP event. Hydrologic criteria for the auxiliary spillway events are discussed in Section 5.5 and a summary of the criteria used to size a high hazard dam is presented in **Table 5-6**. The results of the various hydrographs simulated using the SITES program are presented in the following sub-sections.

7.3.1 AUXILIARY SPILLWAY CAPACITY

To pass the auxiliary spillway capacity criteria described in *TR 210-60*, the dam must be able to pass the PMF through the principal spillway structure and the auxiliary spillway without overtopping the dam. Durations of 6-hours through 72-hours were simulated using PMP depths from HMR51 and using both local and general storm PMP depths obtained from the statewide PMP study for North Dakota. Results for the existing top of dam elevation and required top of dam elevation with PMP depths from all scenarios described are presented in **Table 7-3**.

The results show that the 24-hour local storm PMP event is the controlling duration and storm type for all events considered from the statewide PMP study for North Dakota. The dam would not need to be raised to pass the 24-hour local storm PMP event. The required top of dam elevation is higher when considering the 48-hour PMP event using depths from HMR51. Results from the analysis completed using the HMR51 depths was included for comparison purposes, however, the methods used to produce the HMR51 storm are considered obsolete and will not be used in future analyses.

***Table 7-3**: Freeboard Hydrograph SITES Output*

Parameter	Existing Condition	HMR51				Local Storm PMP			General Storm PMP		
		6 hour	24 hour	48 hour	72 hour	6 hour	12 hour	24 hour	24 hour	48 hour	72 hour
Peak Inflow (cfs)	-	11,256	14,754	15,345	14,949	8,901	10,632	10,634	10,166	10,541	10,564
Peak Outflow (cfs)	-	11,194	14,683	15,275	14,878	8,832	10,576	10,580	10,103	10,482	10,503
Required Top of Dam Elevation (feet, NAVD88)	1,132.1	1,128.3	1,129.3	1,129.4	1,129.3	1,127.7	1,128.2	1,128.2	1,128.0	1,128.2	1,128.2
Required Rise of Crest Elevation to Pass FBH (feet)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DRAFT

7.3.2 AUXILIARY SPILLWAY STABILITY

According to *TR 210-60*, a short-duration storm should be used to check the stability of vegetated auxiliary spillways. The stability of the auxiliary spillway for Fordville Dam was evaluated using the stability design hydrograph that utilized the 6-hour local storm PMP event from the statewide PMP study described previously (see Section 5.5.2 for information on the stability design inflow hydrograph). *TR 210-60* states that no damage should occur to vegetated spillways during passage of all flows up to the auxiliary spillway hydrograph (also known as the stability design hydrograph).

The soil and vegetal stress of the auxiliary spillway were analyzed to determine the overall stability of the auxiliary spillway. Properties of the topsoil, vegetation of the auxiliary spillway, and output shear stress information from the SITES program were used to calculate the stability of the auxiliary spillway. A spreadsheet made available by NRCS staff was used to develop the stress stability analysis. The spreadsheet uses criteria outlined in *TR 210-60* and concepts from Chapter 3 of the Agricultural Handbook Number 667 (Temple, Robinson, Ahring, & Davis, 1987) to develop allowable soil and vegetal stresses in the auxiliary spillway. **Table 7-4** below shows the allowable soil and vegetal stresses associated with the auxiliary spillway at Fordville Dam and it shows the resultant stresses obtained from the SITES program. Overall, the auxiliary spillway for Fordville Dam is considered unstable because the soil stresses produced during the stability design hydrograph are greater than the allowable stresses. The vegetation at Fordville Dam is considered stable, but both the soil and vegetal stresses must meet the allowable stress for the dam to be considered stable. The inputs used to compute allowable stresses and the SITES program outputs are provided in **Appendix F**.

***Table 7-4**: Auxiliary Spillway Stress Analysis*

Analysis Type	Allowable Stress	SITES 6-HR SDH Stress	Conclusion
Soil Stress	0.126 psf	0.928 psf	Soil Erodes
Vegetal Stress	4.20 psf	0.60 psf	Vegetation is stable

7.3.3 AUXILIARY SPILLWAY INTEGRITY

TR 210-60 requires that the auxiliary spillway pass the freeboard design hydrograph without breaching the control section of the auxiliary spillway. Based on the geologic profile and parameters described in Section 7.1.2, the SITES auxiliary spillway analysis shows that the auxiliary spillway will completely breach during passage of the freeboard hydrograph. **Figure 7-3** shows the eroded portion of the spillway during the freeboard hydrograph corresponding to the 24-hour local storm PMP event. The headcut produced during the freeboard hydrograph is approximately 52.3 feet deep. The auxiliary spillway integrity was evaluated for all storm types and durations that were used to develop the freeboard hydrographs for this analysis. The results of the SITES analysis are provided in **Appendix F**.

7.4 SUMMARY OF IDENTIFIED DEFICIENCIES

7.4.1 PRINCIPAL SPILLWAY

The principal spillway for Fordville Dam does not meet the criteria provided in *TR 210-60*. The results from the analysis indicates that the auxiliary spillway crest would need to be raised by approximately 0.5 feet to pass the principal spillway hydrograph. When the principal spillway hydrograph is routed through Fordville

DRAFT

Dam with the reservoir starting at normal pool elevation, the peak reservoir stage does not reach the auxiliary spillway. However, because the principal spillway does not adequately draw down the reservoir in 10 days, the additional storage that remains in the reservoir needs to be added to the peak storage. Therefore, the analysis shows that the current principal spillway is not adequate and raising the auxiliary spillway would be required for Fordville Dam.

The principal spillway outlet works could be modified to increase the discharge capacity through the spillway on the rising limb of the hydrograph and decrease draw down time on the trailing limb of the hydrograph. This is typically not looked upon favorably by residents downstream of the dam as it would cause increased discharge and inundation downstream of the dam.

According to *TR 210-60*, if a structural auxiliary spillway is implemented for the dam (possibly to address instability issues associated with the earthen spillway), it could serve a dual purpose as a principal spillway. Therefore, the principal spillway would no longer be required to pass the principal spillway hydrograph without accessing the auxiliary spillway.

7.4.2 AUXILIARY SPILLWAY

The auxiliary spillway capacity is sufficient to pass the freeboard hydrograph for Fordville Dam. The SITES analysis shows that if the width and height of the auxiliary spillway remains unchanged the dam would not have to be raised based on the current design.

The auxiliary spillway is considered unstable based on criteria outlined in *TR 210-60*. The soil stress encountered in the spillway during passage of the stability design hydrograph exceeds the allowable soil stress for the spillway. Widening the spillway would reduce flow depth and consequently reduce stresses on the spillway. Raising the auxiliary spillway would reduce the frequency with which the spillway is accessed and would cause reduced depths and stresses on the spillway surface. Reducing the auxiliary spillway slope near the outlet may also help to improve the stability in the auxiliary spillway channel. The current slope of the auxiliary spillway channel near the outlet is greater than 50%. Another solution to improving the stability of the auxiliary spillway is to implement a structural spillway design. This would prevent surface erosion and would not require drastic changes to the spillway layout.

The auxiliary spillway integrity is not sufficient to pass the freeboard hydrograph without breaching. Several different PMP storm durations and storm types were simulated and each one caused the auxiliary spillway to breach in the SITES model. One potential mitigation option to reduce shear stress and spillway erosion is to widen the auxiliary spillway. Another option would be to raise the auxiliary spillway elevation while trying to maintain the current top of dam elevation or minimize the amount rise needed for the dam. The implementation of a structural spillway is a solution that was mentioned for improving auxiliary spillway stability and would also help to prevent headcut erosion in the auxiliary spillway to improve the spillway integrity.

Structural auxiliary spillways have been installed for many NRCS dams in recent years. Roller compacted concrete in the auxiliary spillway has been a popular option for dam rehabilitations throughout the country. Articulated concrete blocks have also been implemented to reduce the likelihood of a dam failure during passage of the freeboard hydrograph. These are just a few examples of structural auxiliary spillway options that could be evaluated in the future.

DRAFT

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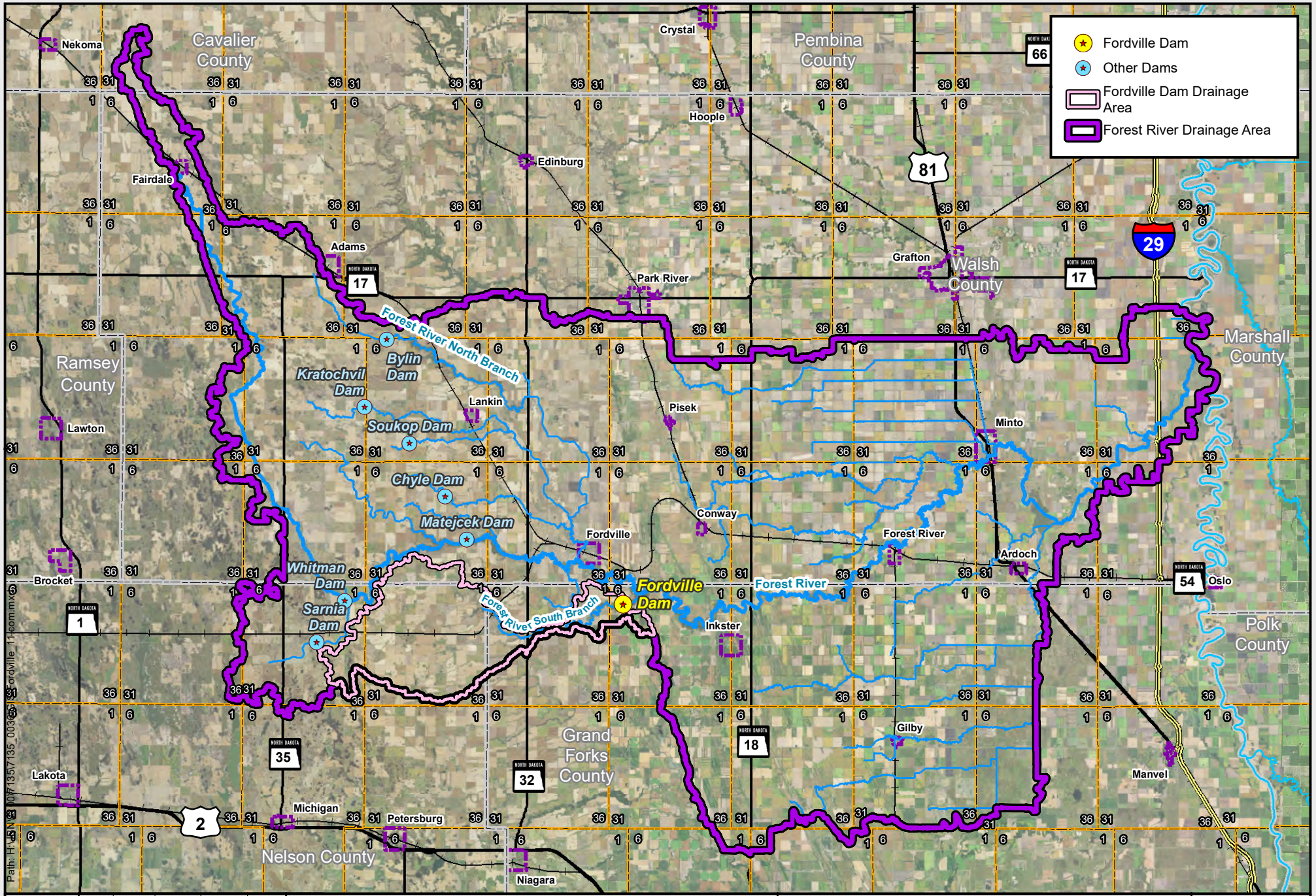
DRAFT

FIGURES

Figure 1-1: Fordville Dam Drainage Area
Figure 2-1: Downstream Channel Survey
Figure 2-2: Fordville Dam Topographic Survey
Figure 2-3: Fordville Dam Bathymetric Survey Data Points
Figure 2-4: Fordville Dam Existing Ground Surface Below the Normal Pool
Figure 2-5: Fordville Dam Sediment Depth in Reservoir
Figure 2-6: Fordville Dam Elevation-Storage Relationship
Figure 4-1: Fordville Dam Breach Outflow Hydrograph
Figure 4-2: Fordville Dam Breach Inundation - All
Figure 4-3: Fordville Dam Breach Inundation - 1
Figure 4-4: Fordville Dam Breach Inundation - 2
Figure 4-5: Fordville Dam Breach Inundation - 3
Figure 4-6: Fordville Dam Breach Inundation – 4
Figure 4-7: Fordville Depth Velocity Flood Danger Relationship for Homes Built on Foundations
Figure 5-1: HEC-RAS Model Schematic
Figure 5-2: 2016 Historic Event Rainfall
Figure 5-3: R/Tc Ratios - Calibrated
Figure 5-4: 2016 Historic Event – Peak Discharge near Fordville, ND (USGS Gage 05084000)
Figure 5-5: 2016 Historic Event – Peak Discharge near Minto, ND (USGS Gage 05085000)
Figure 5-6: 2010 Historic Event Rainfall
Figure 5-7: 2010 Historic Event – Peak Discharge near Fordville, ND (USGS Gage 05084000)
Figure 5-8: 2010 Historic Event – Peak Discharge near Minto, ND (USGS Gage 05085000)
Figure 5-9: Principal Spillway Mass Curves for Runoff Volume
Figure 5-10: Principal Spillway Inflow Hydrographs
Figure 5-11: Stability Design Mass Curves
Figure 5-12: Stability Design Inflow Hydrographs
Figure 5-13: Freeboard Design Mass Curves
Figure 5-14: Freeboard Design Inflow Hydrographs
Figure 7-1: Fordville Dam Elevation-Discharge Relationship
Figure 7-2: Fordville Dam Auxiliary Spillway Profile
Figure 7-3: Fordville Dam Eroded Auxiliary Spillway Profile

DRAFT



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AS SHOWN	NRI	PDL	7135-0036	12/18/2020

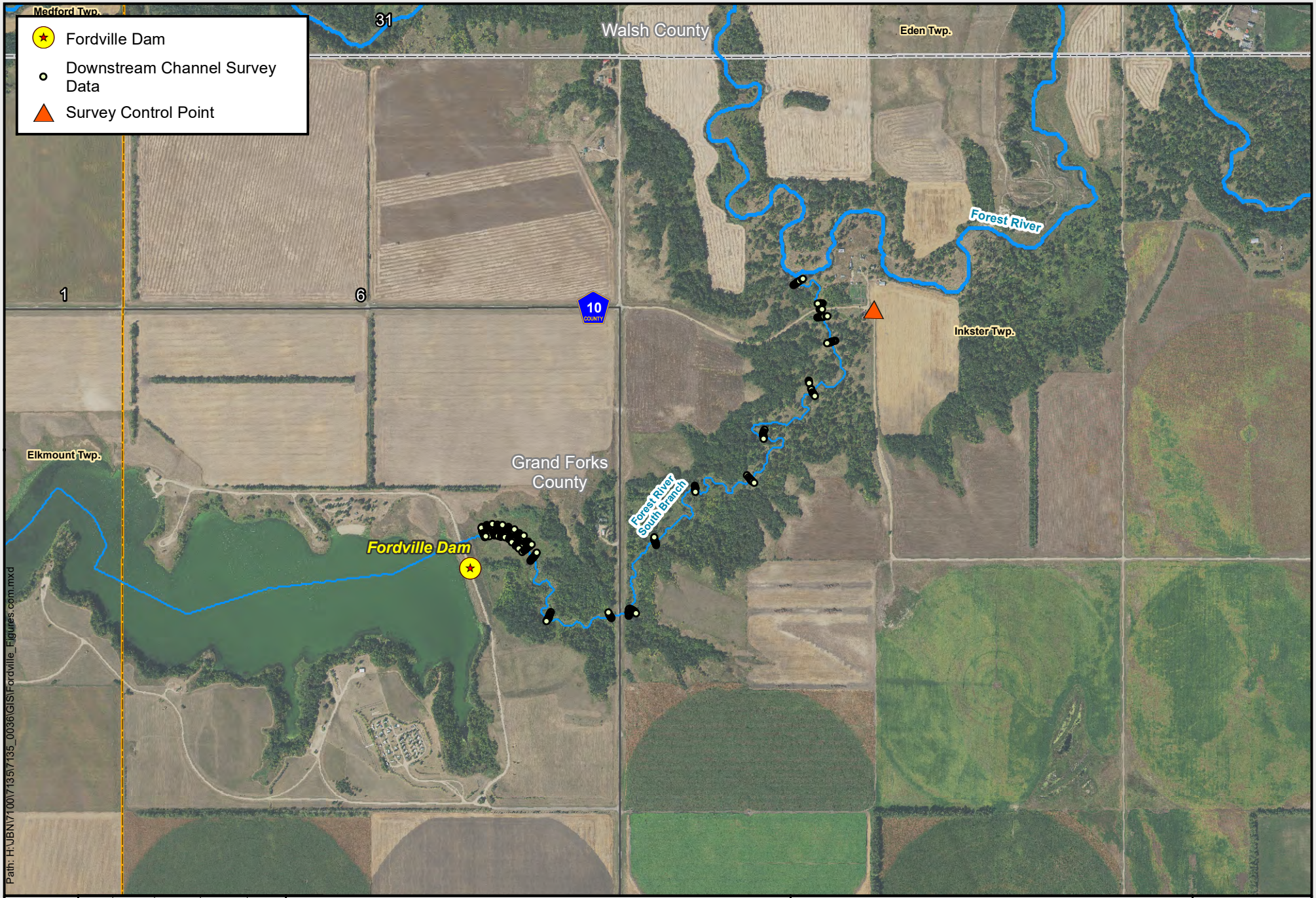
HOUSTON engineering, inc.

Figure 1-1: Fordville Dam Drainage Area

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 6 12 Miles

N W E S



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AS SHOWN	NRI	PDL	7135-0037	11/17/2020

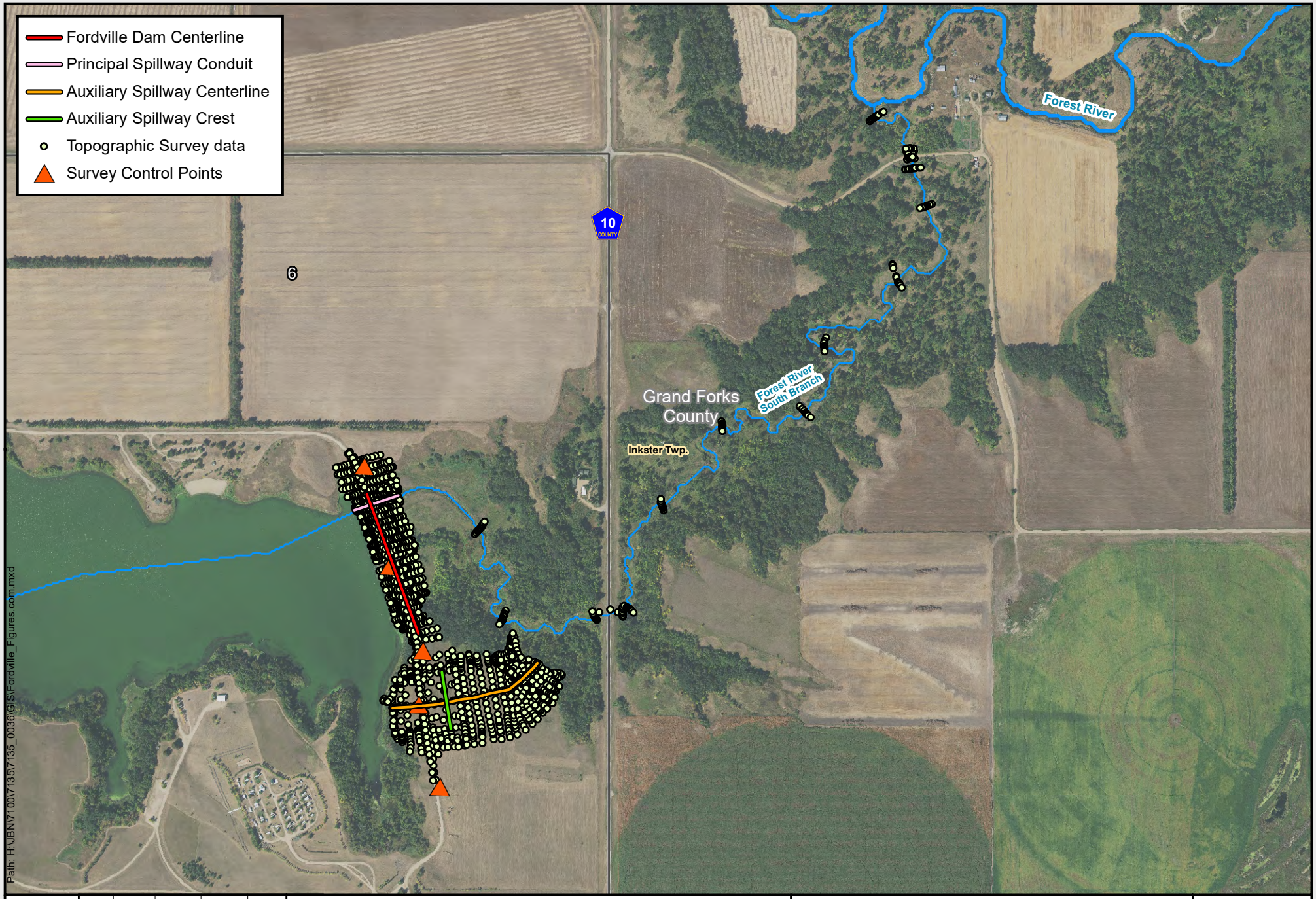
HOUSTON engineering, inc.

Figure 2-1: Downstream Channel Survey

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.25 0.5 Miles

N W E S



F2-2

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AS SHOWN	NRI	PDL	7135-0037	1/12/2021

HOUSTON engineering, inc.

Figure 2-2: Fordville Dam Topographic Survey

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.15 0.3 Miles

N
W E
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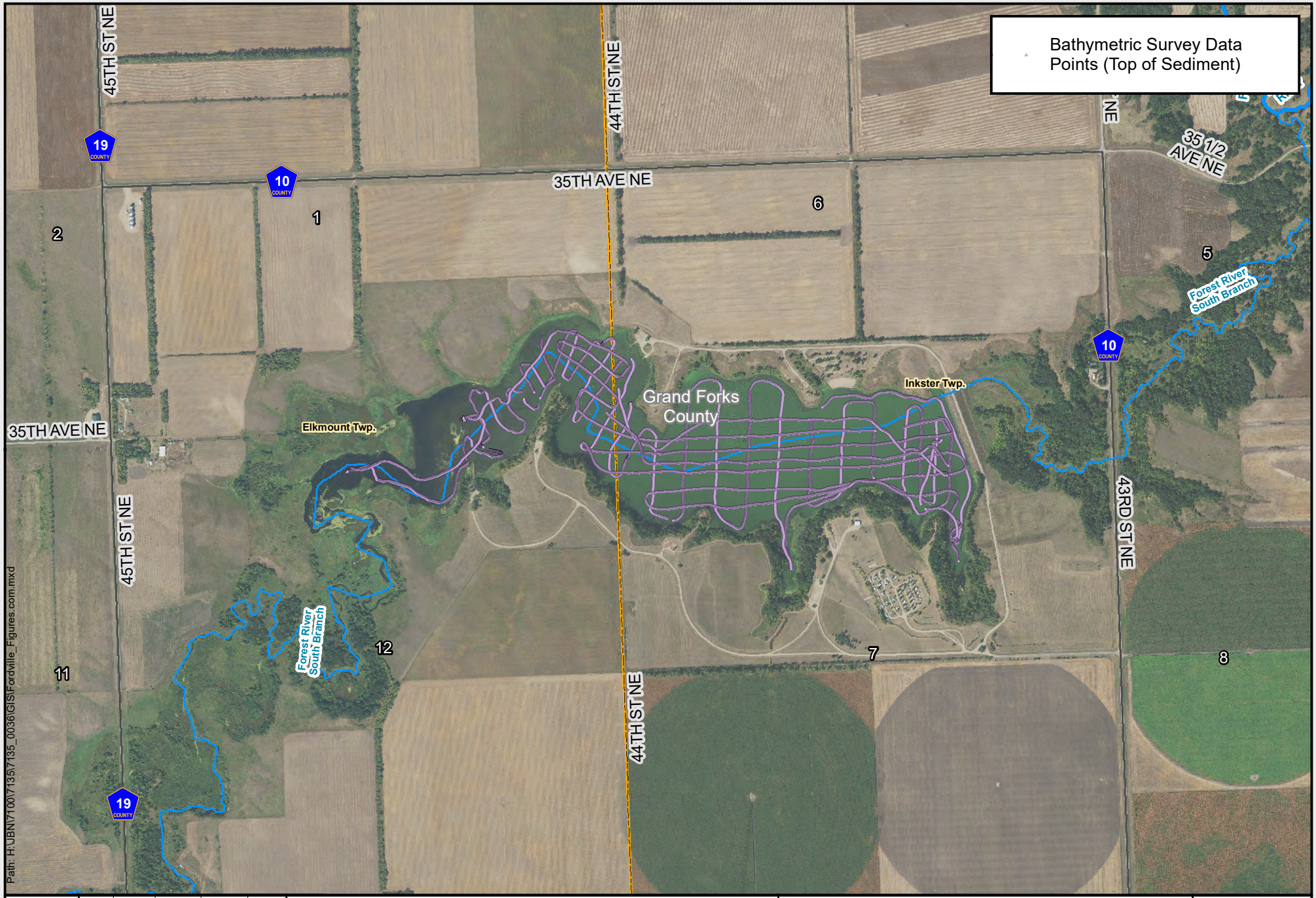


F2-3

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	1\14\2020

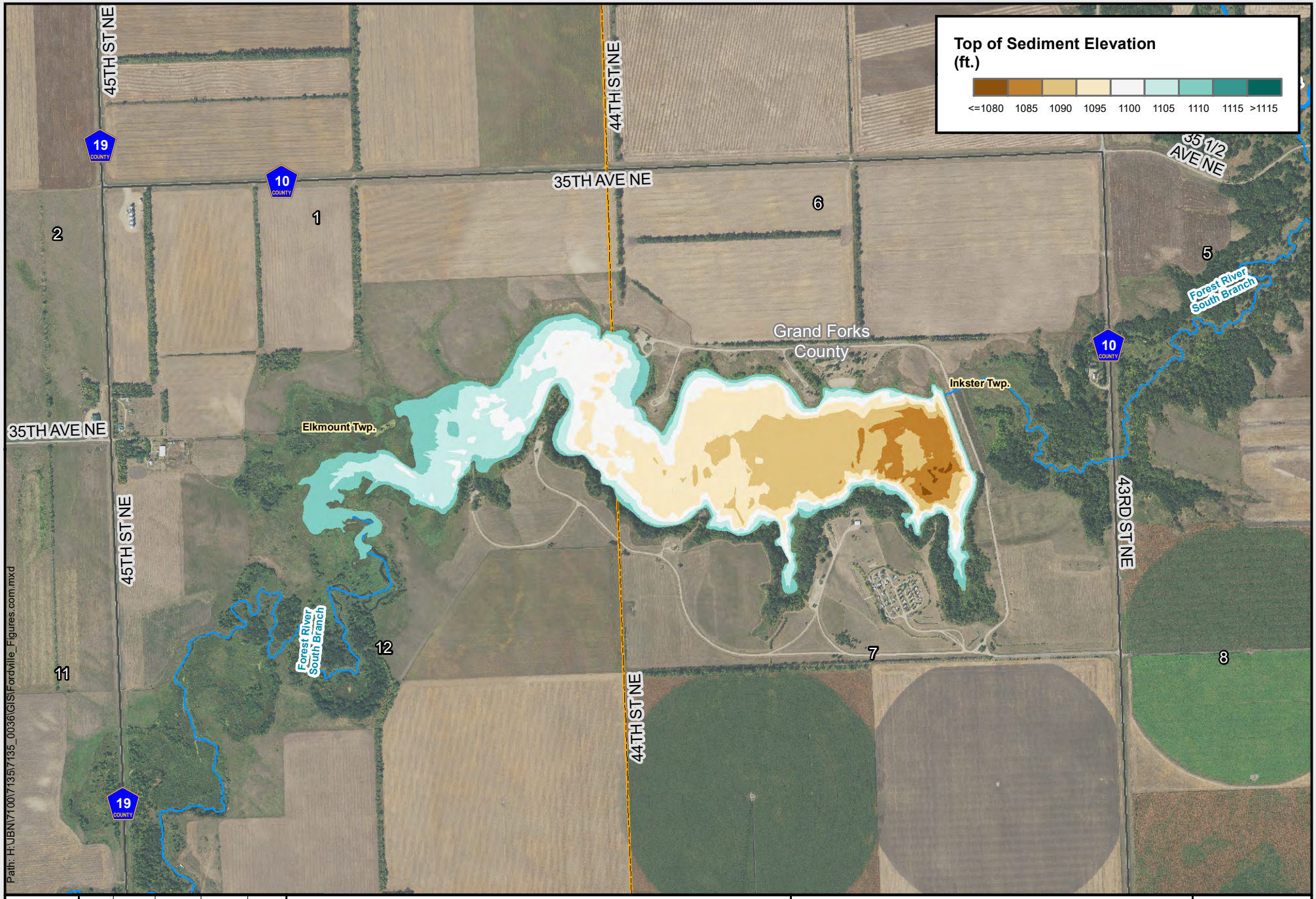
HOUSTON engineering, inc.

Figure 2-3: Fordville Dam Bathymetric Survey Data Points

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.25 0.5 Miles

N W E S



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F2-4

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	1/14/2020

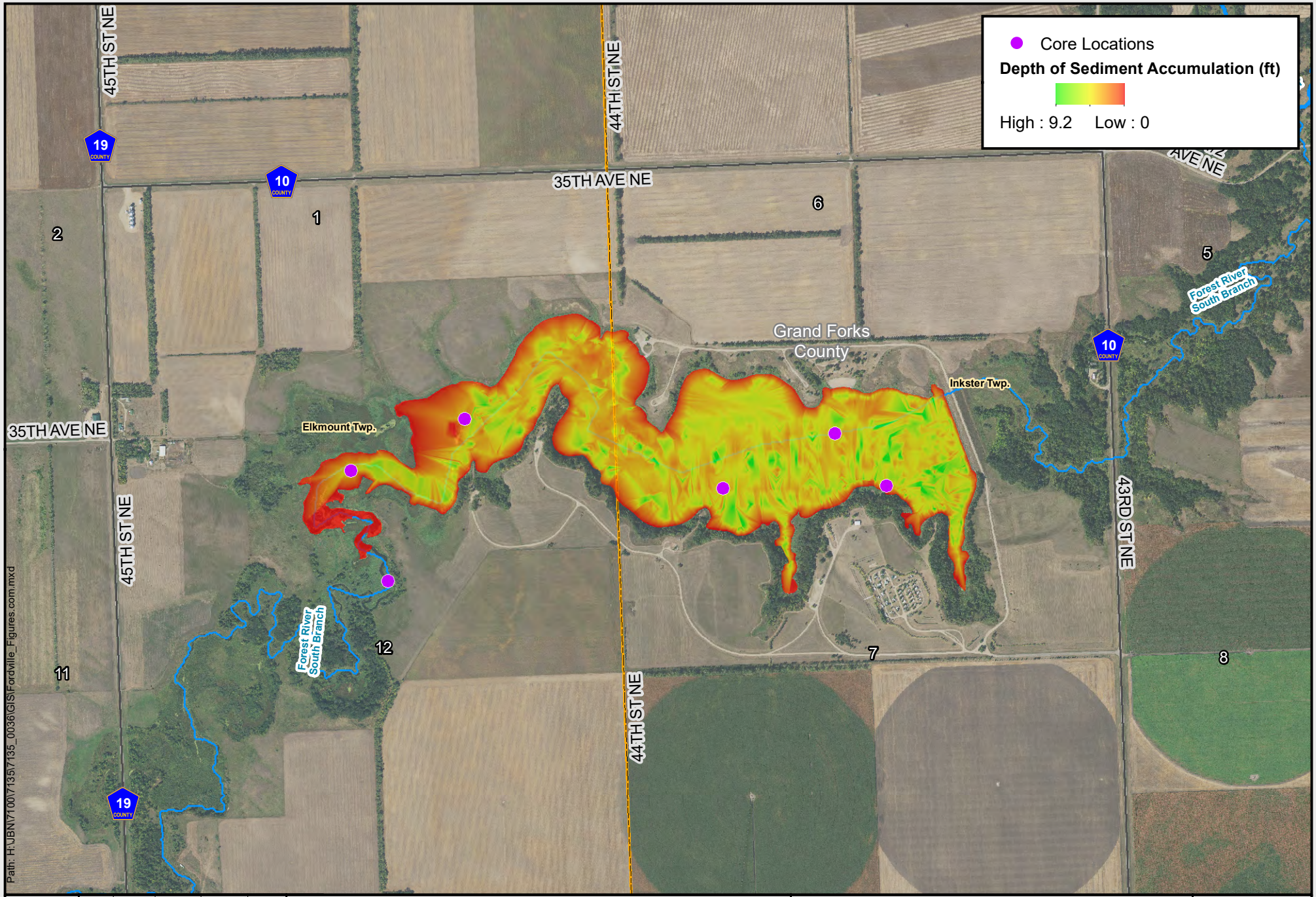
HOUSTON engineering, inc.

Figure 2-4: Fordville Dam Existing Ground Surface Below the Normal Pool

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.25 0.5 Miles

N W E S



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F2-5

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	1\14\2020

HOUSTON engineering, inc.

Figure 2-5: Fordville Dam Sediment Depth in Reservoir

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.25 0.5 Miles

N W E S

***Figure 2-6**: Fordville Dam Elevation-Storage Relationship*

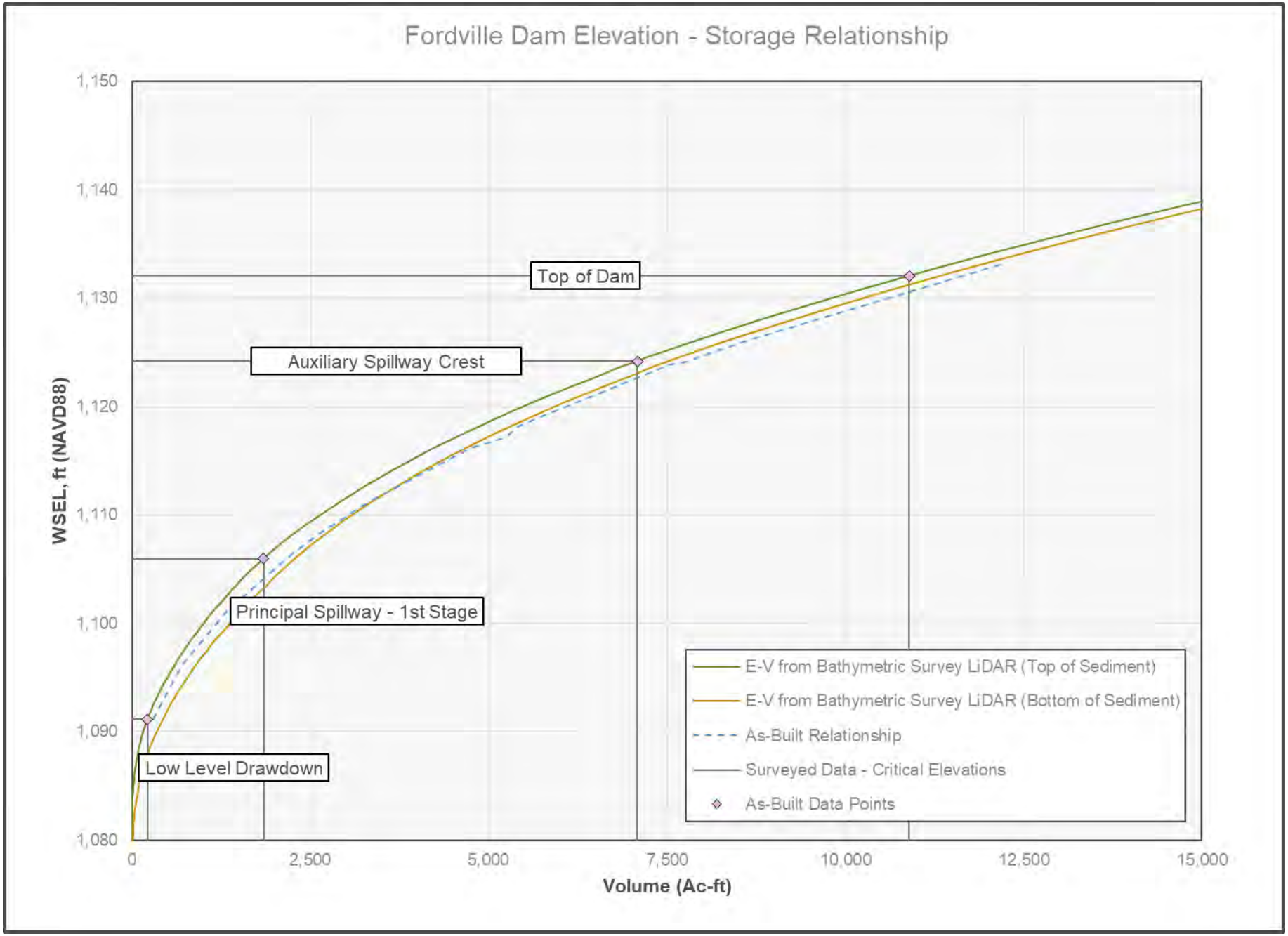
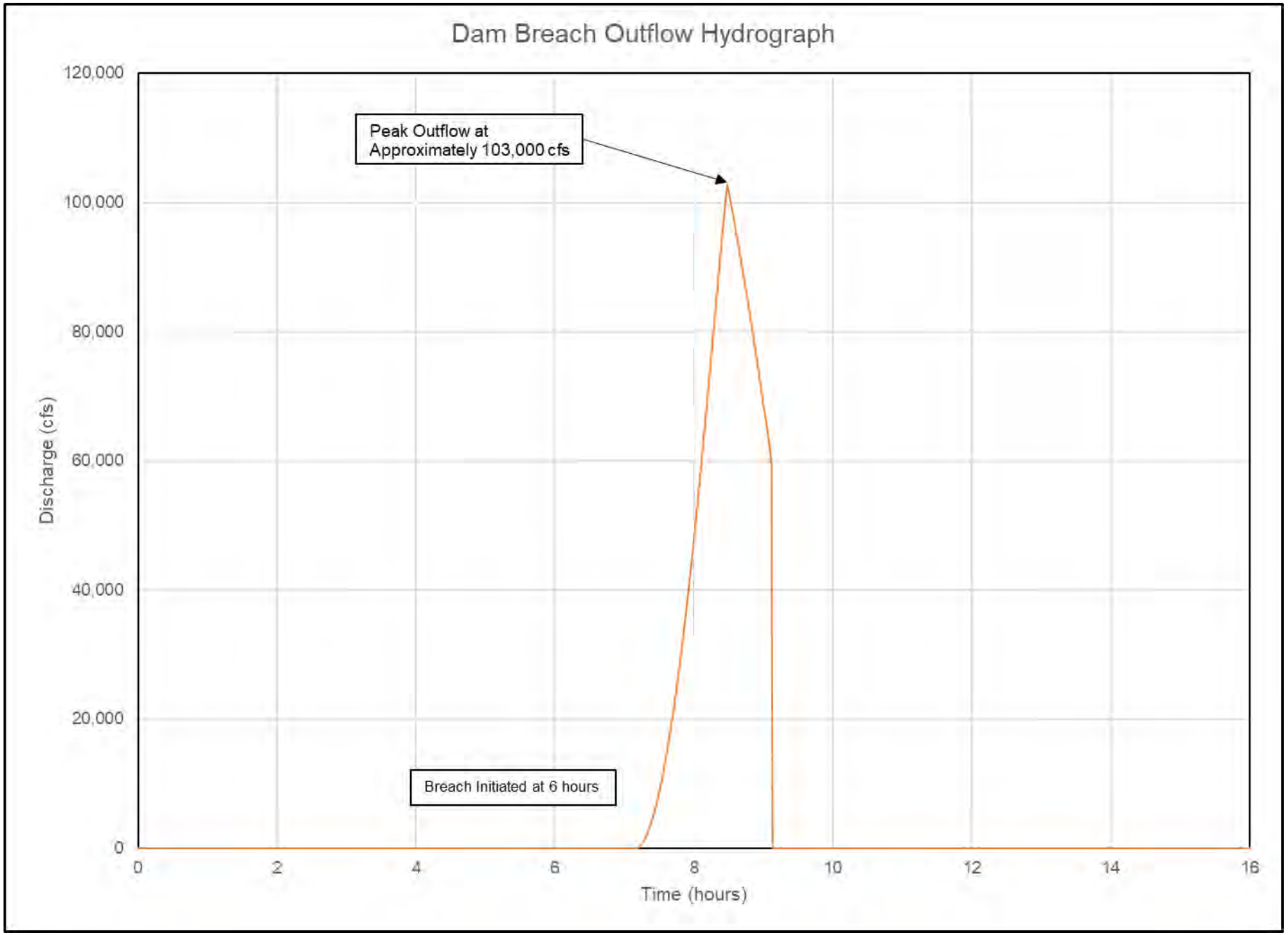
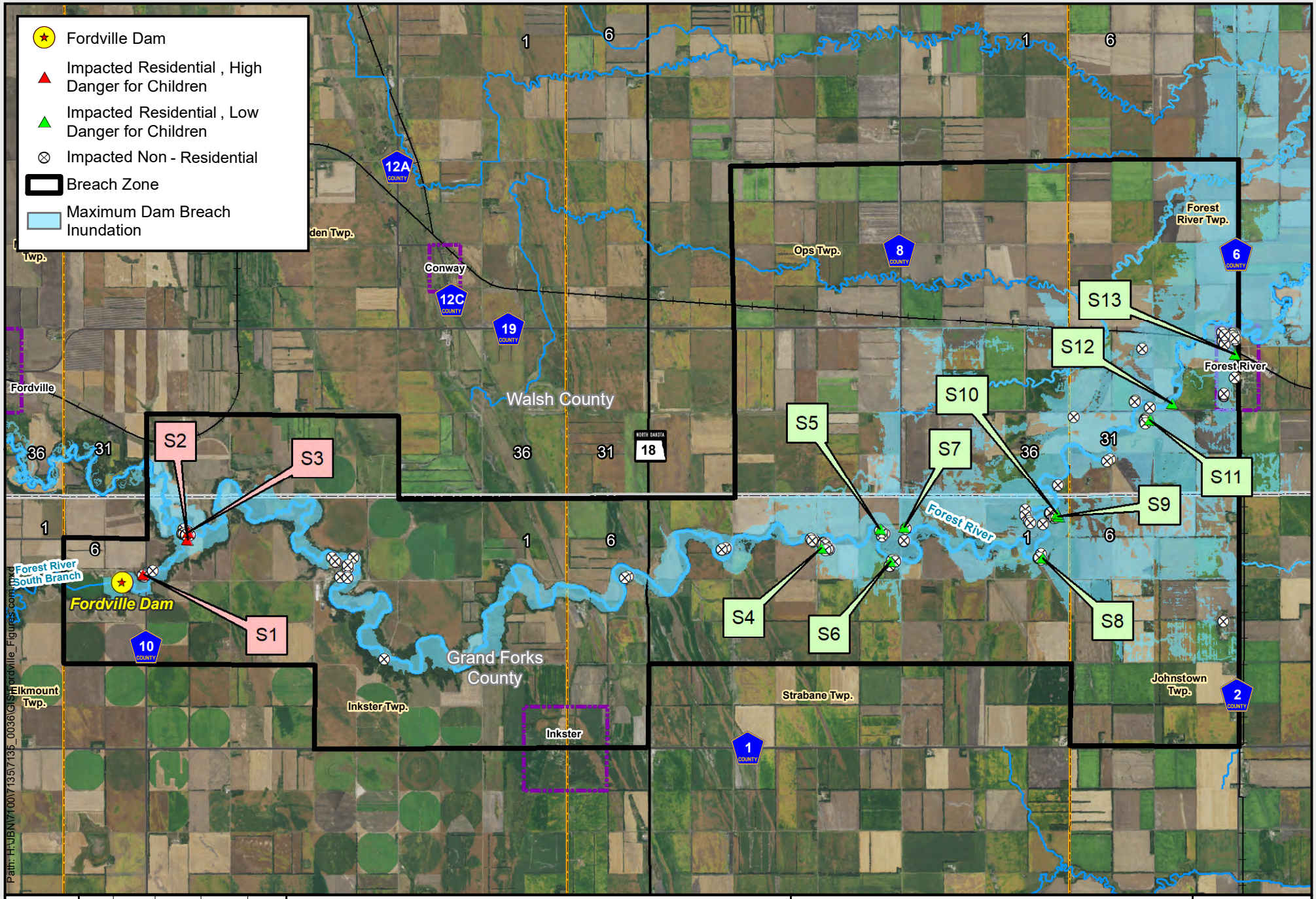


***Figure 4-1**: Fordville Dam Breach Hydrograph*





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F4-2

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	12/18/2020

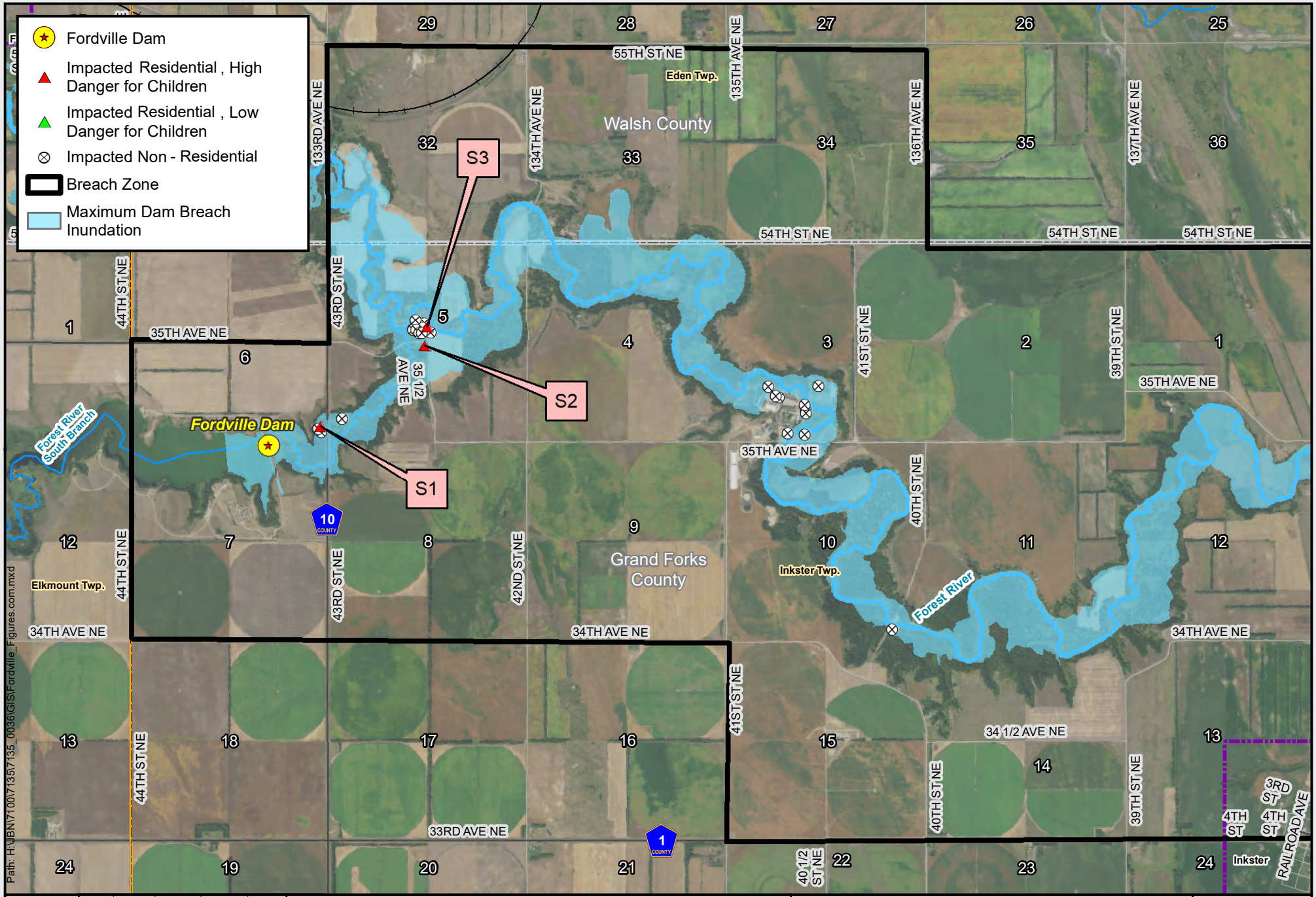
HOUSTON engineering, inc.

Figure 4-2: Fordville Dam Breach Inundation - All

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 1.5 3 Miles

N W E S



F4-3

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	12/18/2020

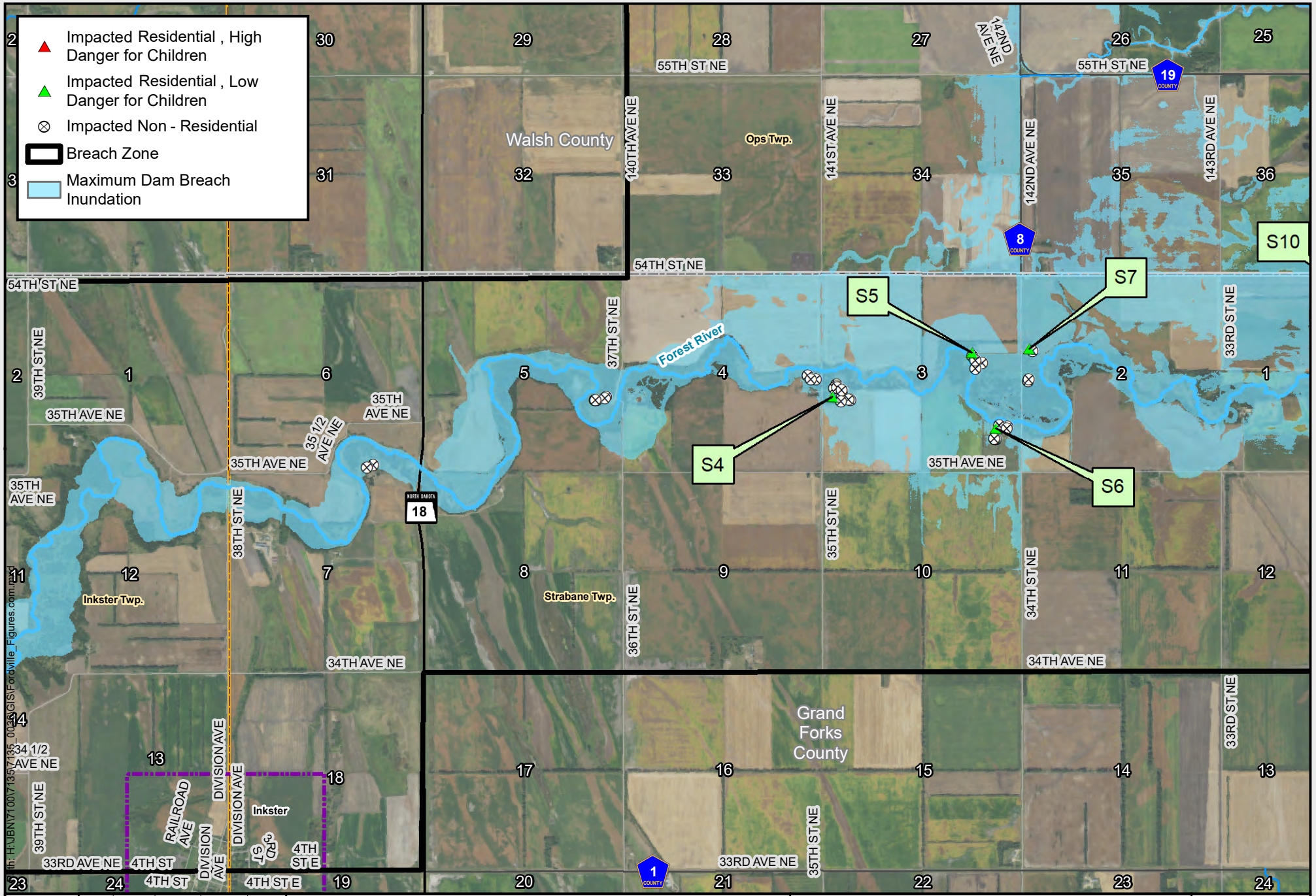
HOUSTON engineering, inc.

Figure 4-3: Fordville Dam Breach Inundation - 1

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.7 1.4 Miles

N W E S



F4-4

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	12/18/2020

HOUSTON engineering, inc.

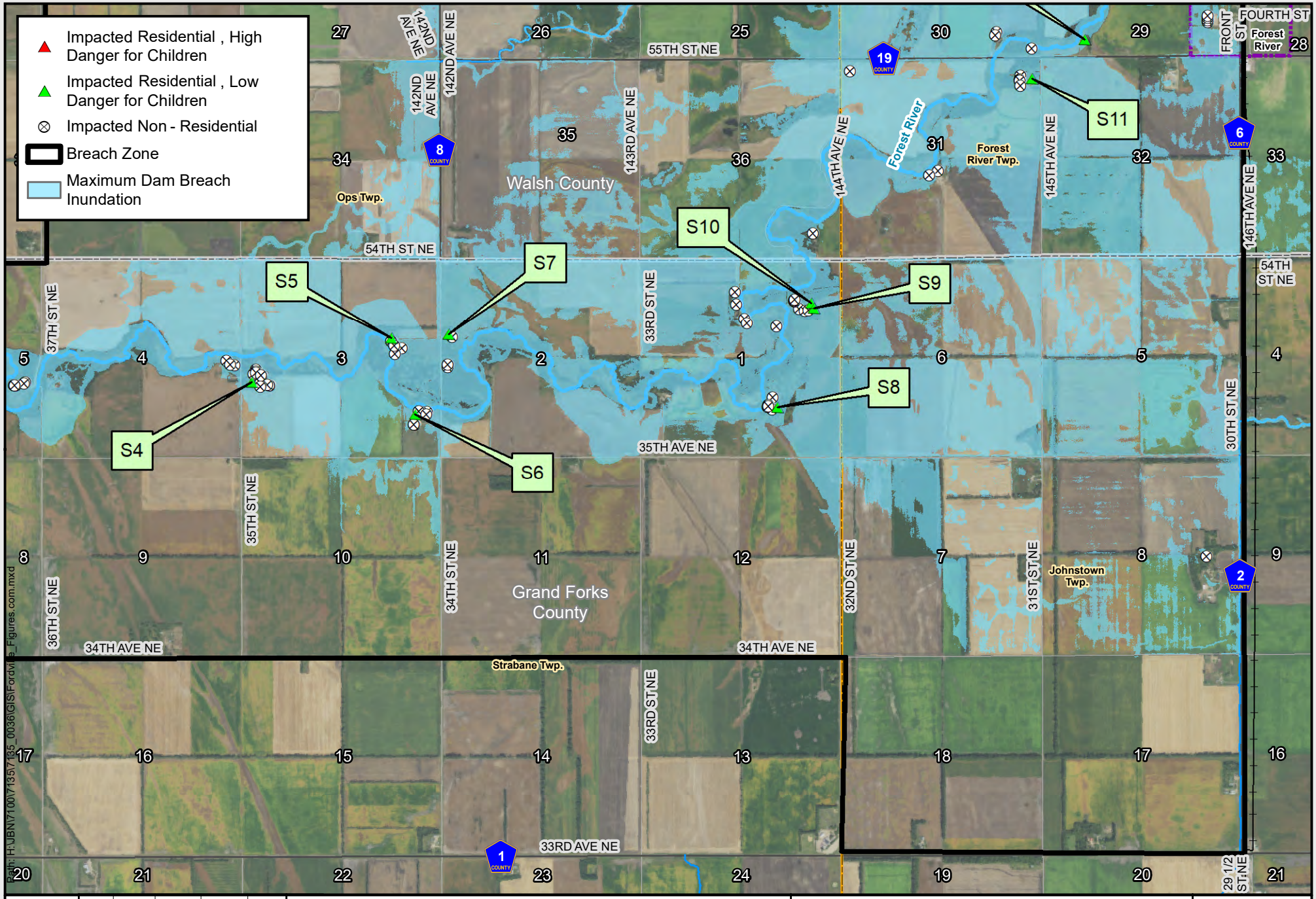
Figure 4-4: Fordville Dam Breach Inundation - 2

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.7 1.4 Miles

N W E S

Path: H:\JBN\7100\7135\7135_0037\GIS\Fordville_Figures.com.mxd



F4-5

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	12/18/2020

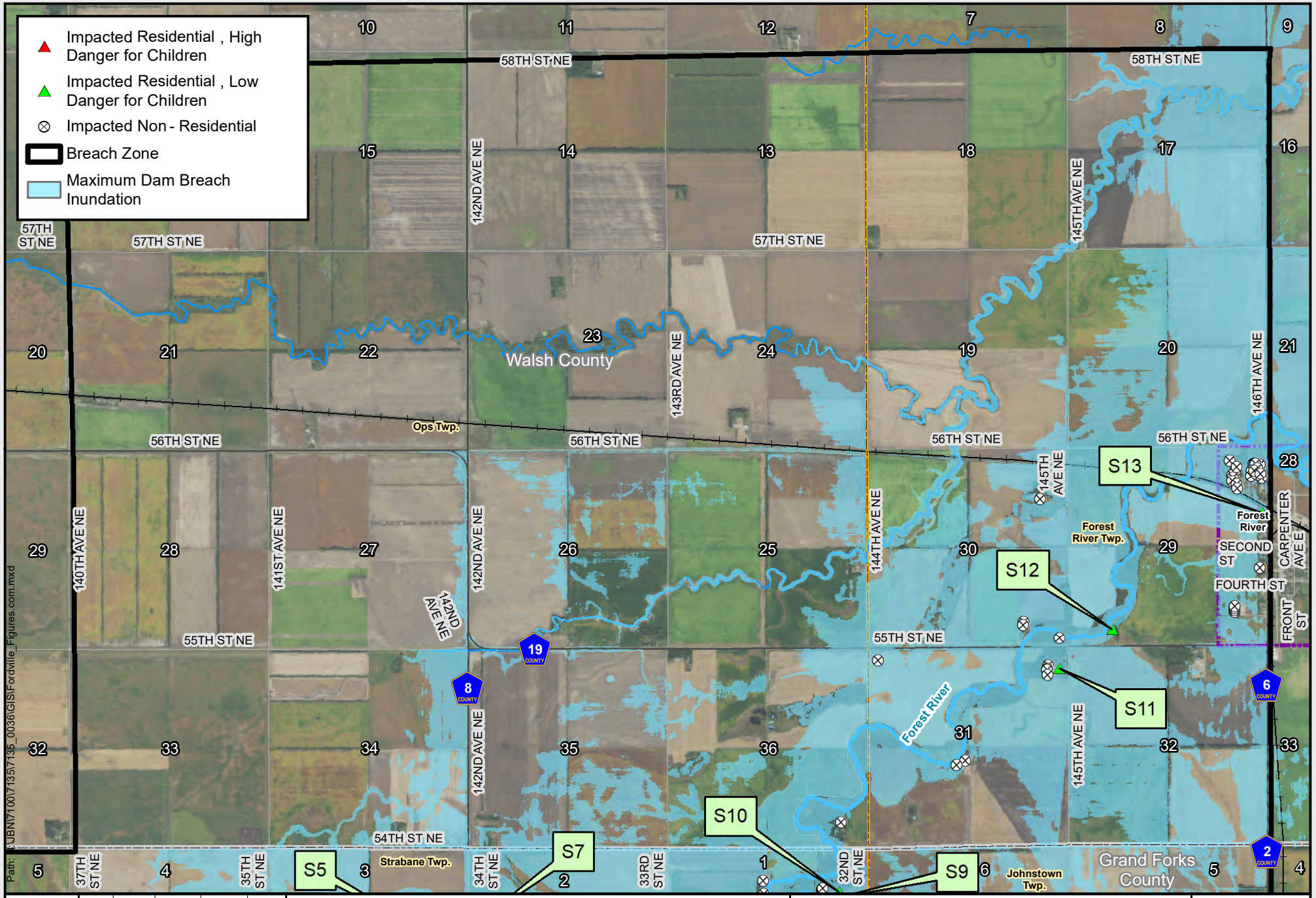
HOUSTON engineering, inc.

Figure 4-5: Fordville Dam Breach Inundation - 3

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 0.7 1.4 Miles

N W E S



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Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	12/18/2020

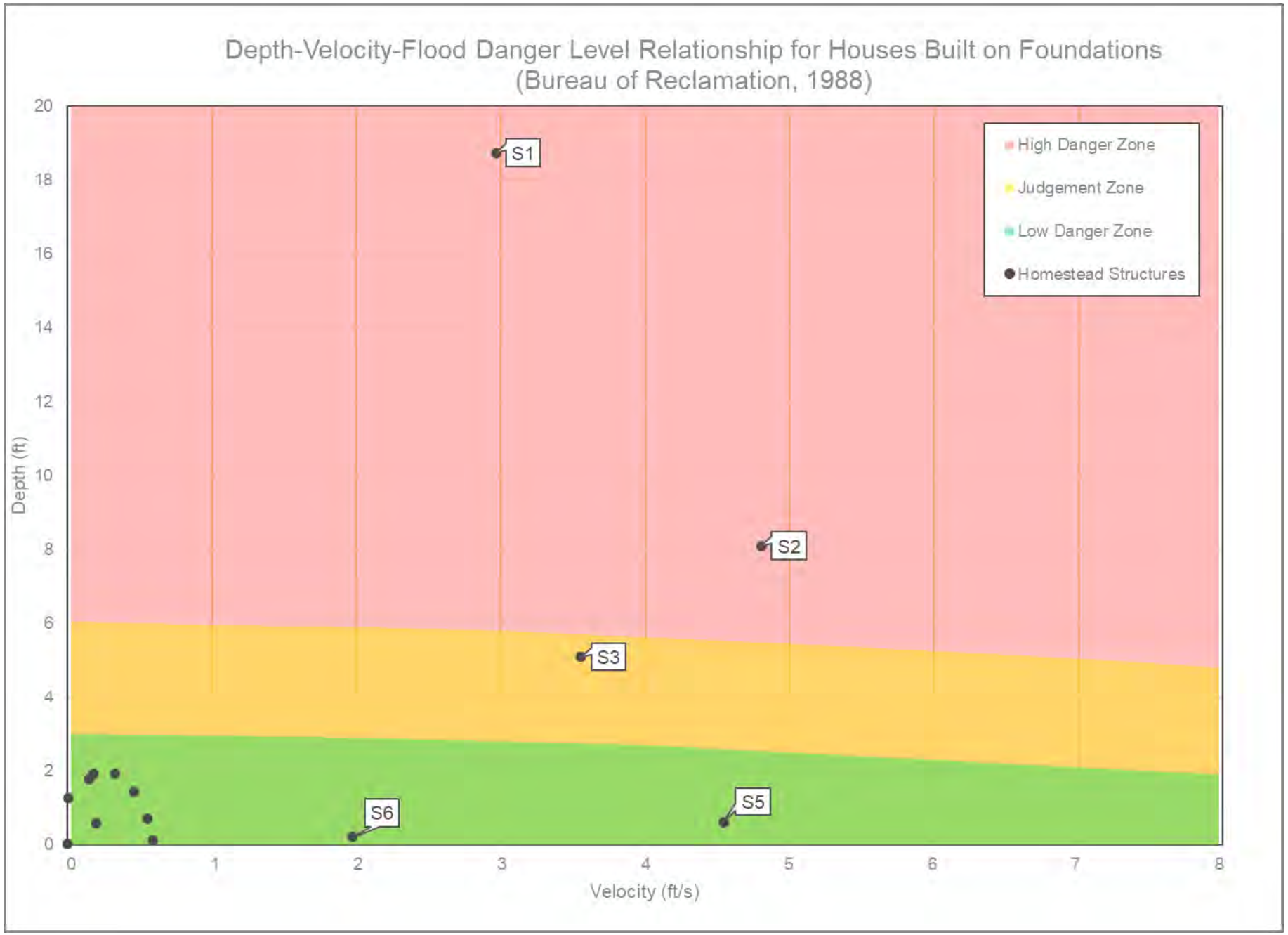
HOUSTON engineering, inc.

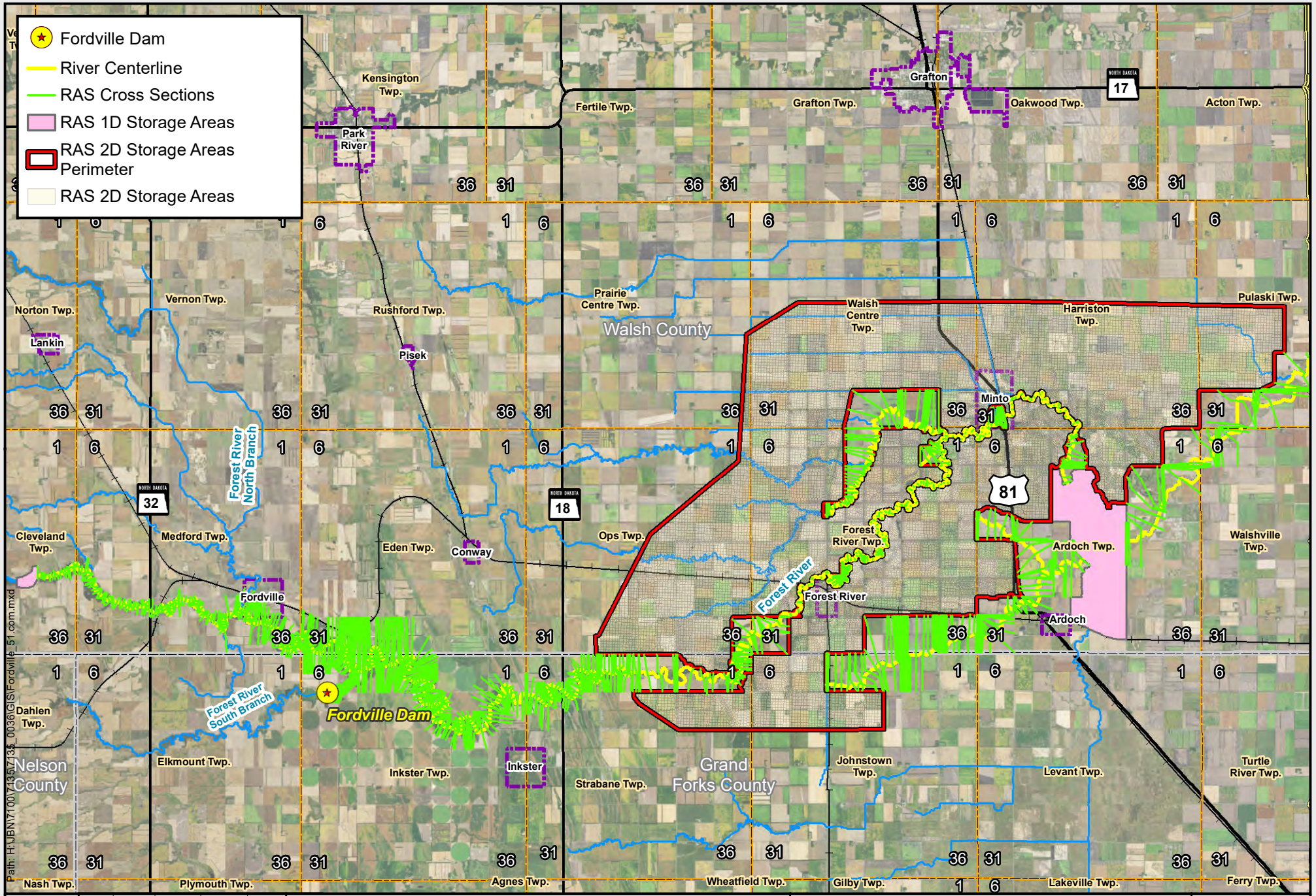
F4-6

Figure 4-6: Fordville Dam Breach Inundation - 4

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

Figure 4-7: *Depth-Velocity-Flood Danger Level Relationship for Houses Built on Foundations Downstream of Fordville Dam*





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AS SHOWN	NRI	PDL	7135-0037	12/14/2020

HOUSTON engineering, inc.

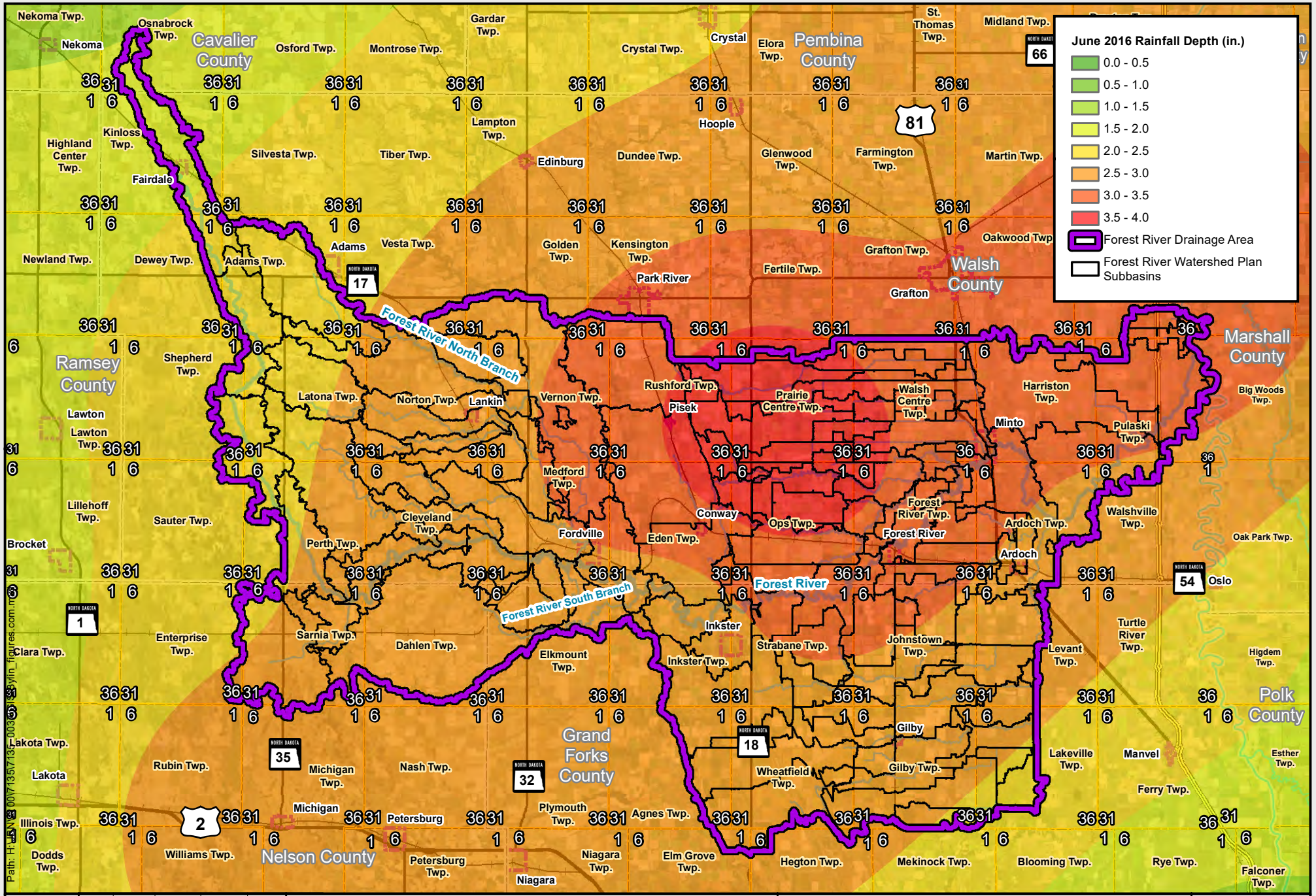
F5-1

Figure 5-1: HEC-RAS Model Schematic

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

0 3 6 Miles

N W E S



F5-2

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	1/14/2020

HOUSTON engineering, inc.

Figure 5-2: 2016 Historic Event Rainfall

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

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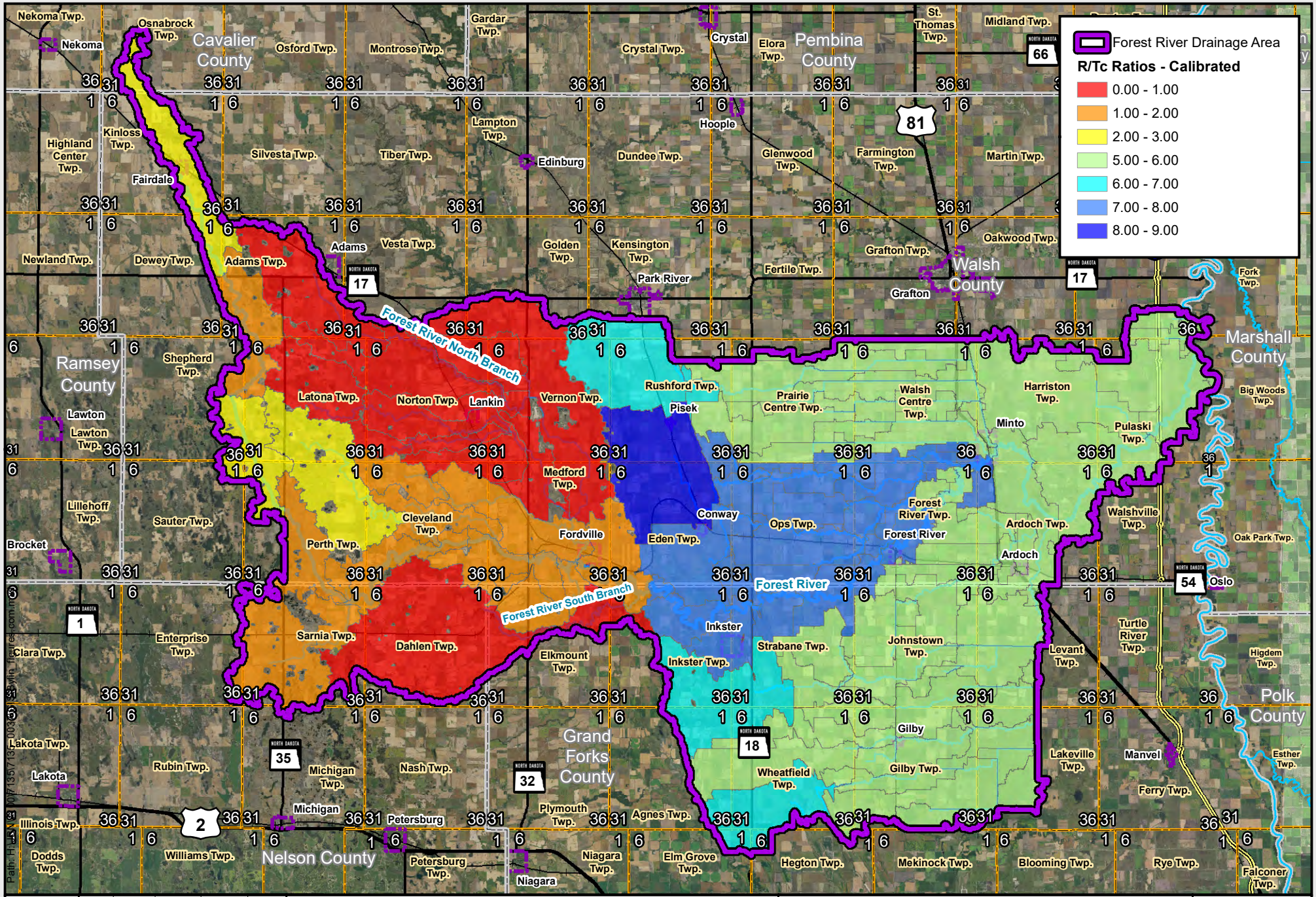


F5-3

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	1/7/2021

HOUSTON engineering, inc.

Figure 5-3: R/Tc Ratios - Calibrated

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

***Figure 5-4**: 2016 Historic Event - Peak Discharge near Fordville, ND (USGS Gage 05084000)*

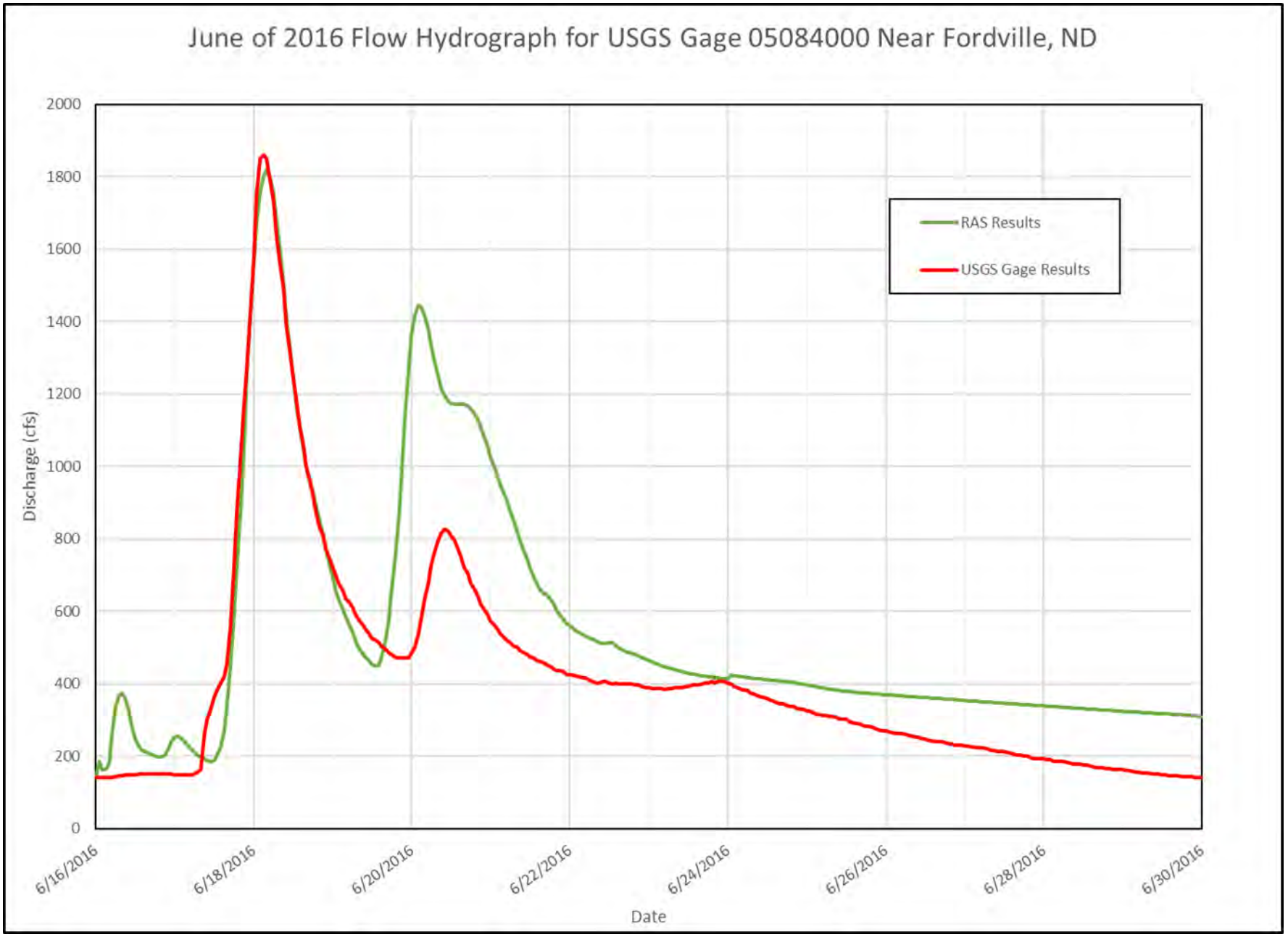
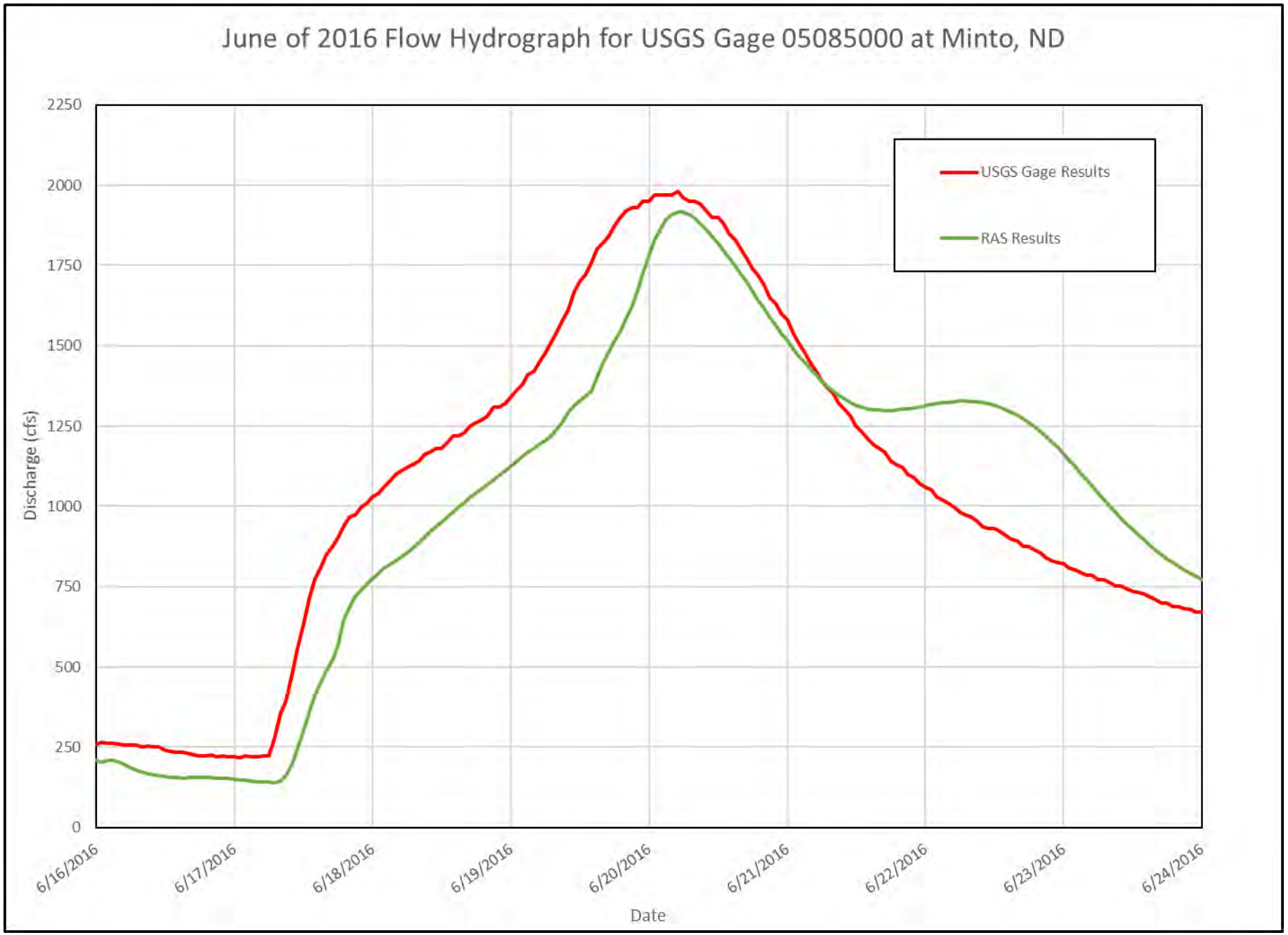
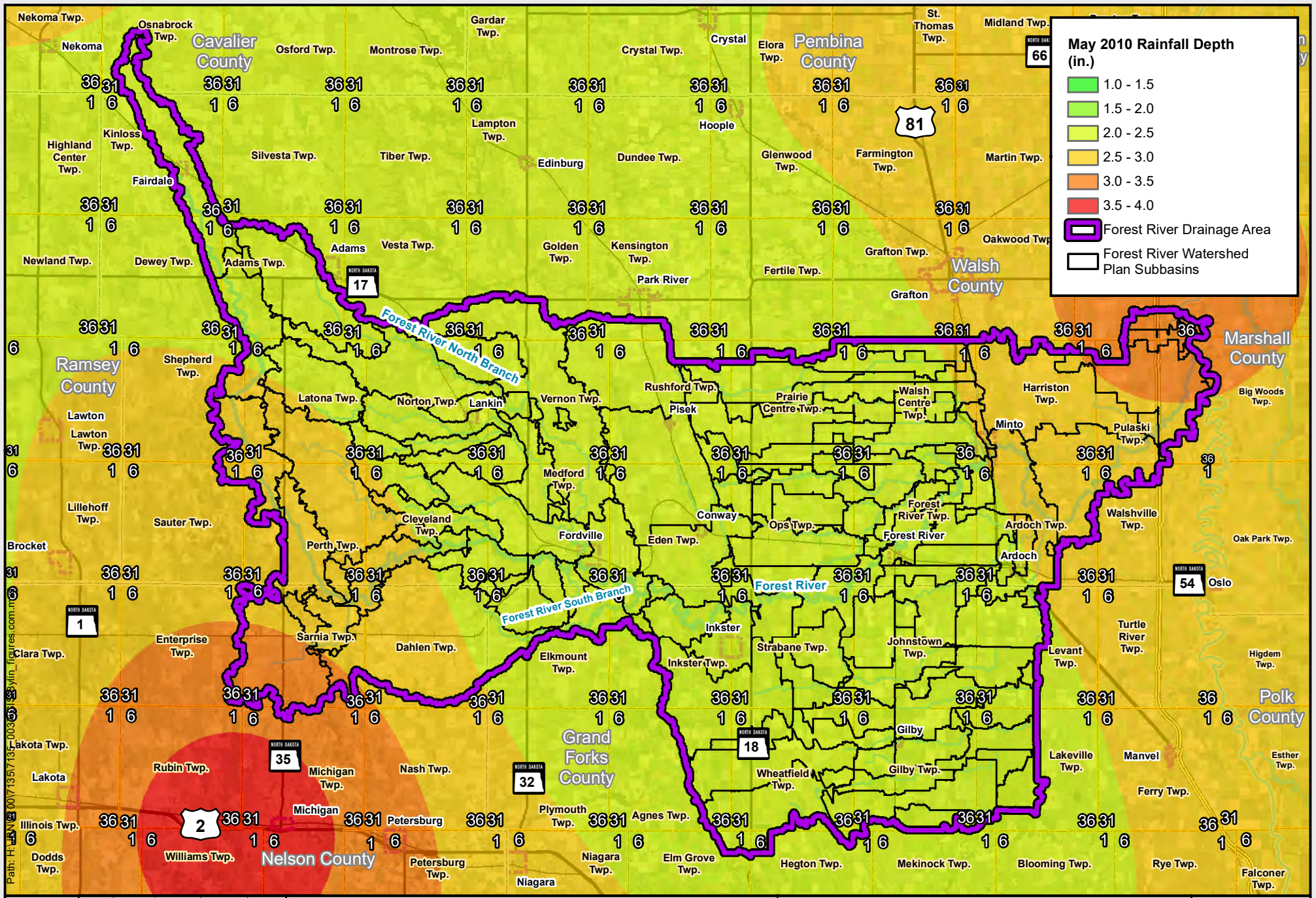


***Figure 5-5**: 2016 Historic Event - Peak Discharge near Minto, ND (USGS Gage 05084000)*





F5-6

Scale:	Drawn by:	Checked by:	Project No.:	Date:
AS SHOWN	NRI	PDL	7135-0037	1/14/2020

HOUSTON engineering, inc.

Figure 5-6 2010 Historic Event Rainfall

Middle-South Branch Forest River Dam No. 4 (Fordville Dam)
Existing Conditions Assessment Report
Forest River Joint Water Resource District

Path: H:\...\00\7135\7135-0037\GIS\Sbylin_figures.com.mxd

***Figure 5-7**: 2010 Historic Event - Peak Discharge near Fordville (USGS Gage 05084000)*

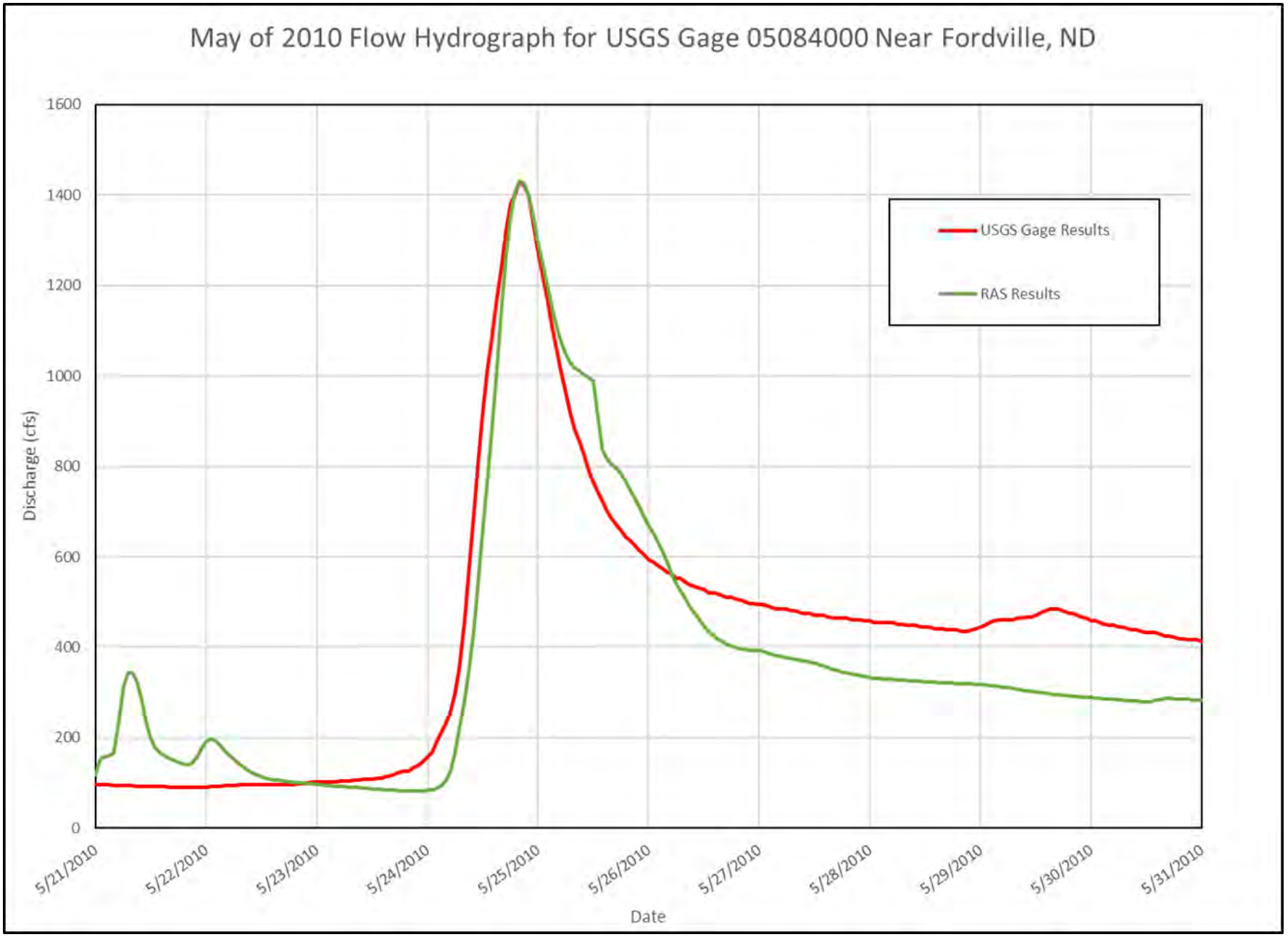


***Figure 5-8**: 2010 Historic Event - Peak Discharge near Minto (USGS Gage 05084000)*

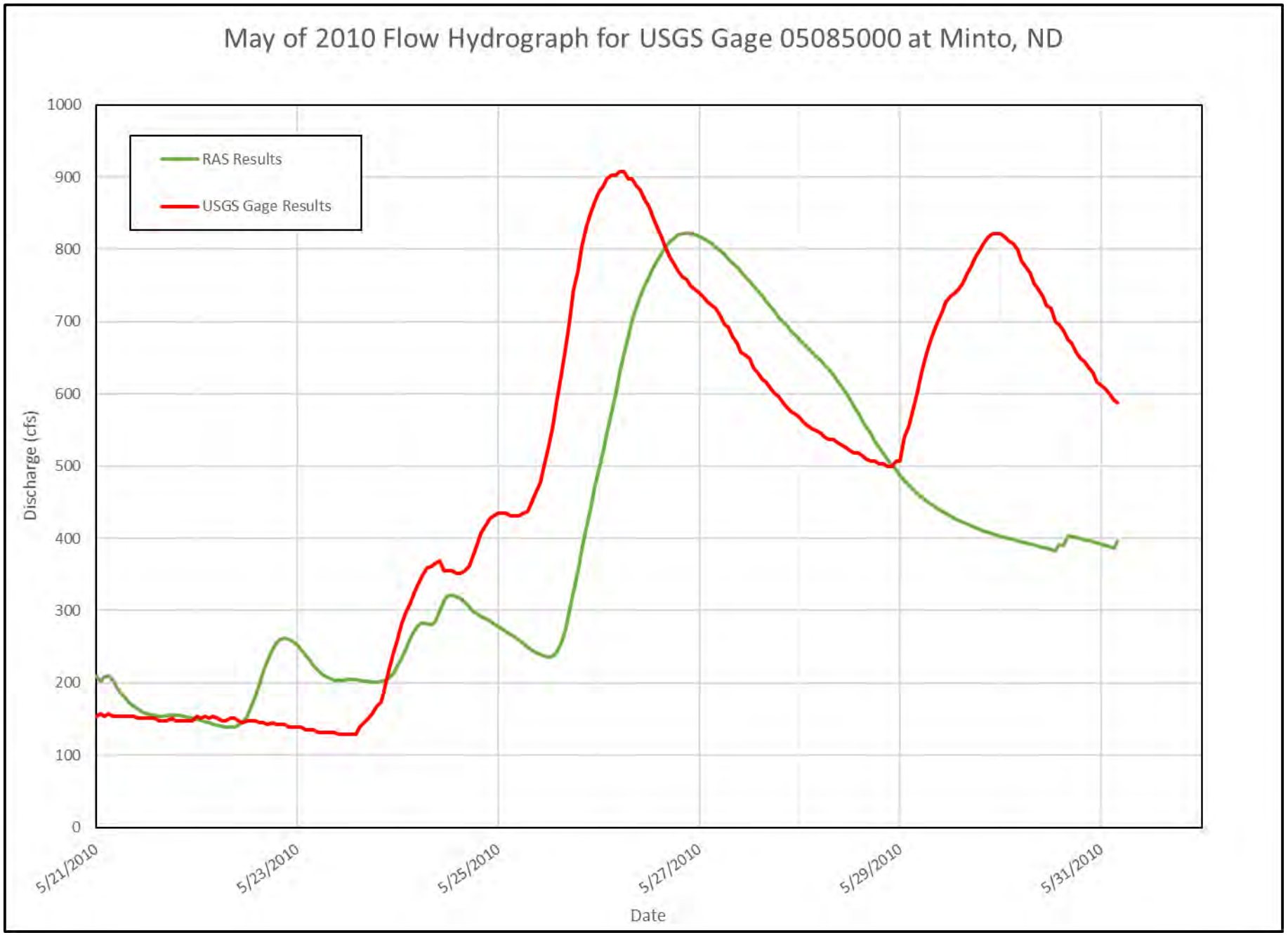


Figure 5-9: *Principal Spillway Mass Curves for Runoff Volume*

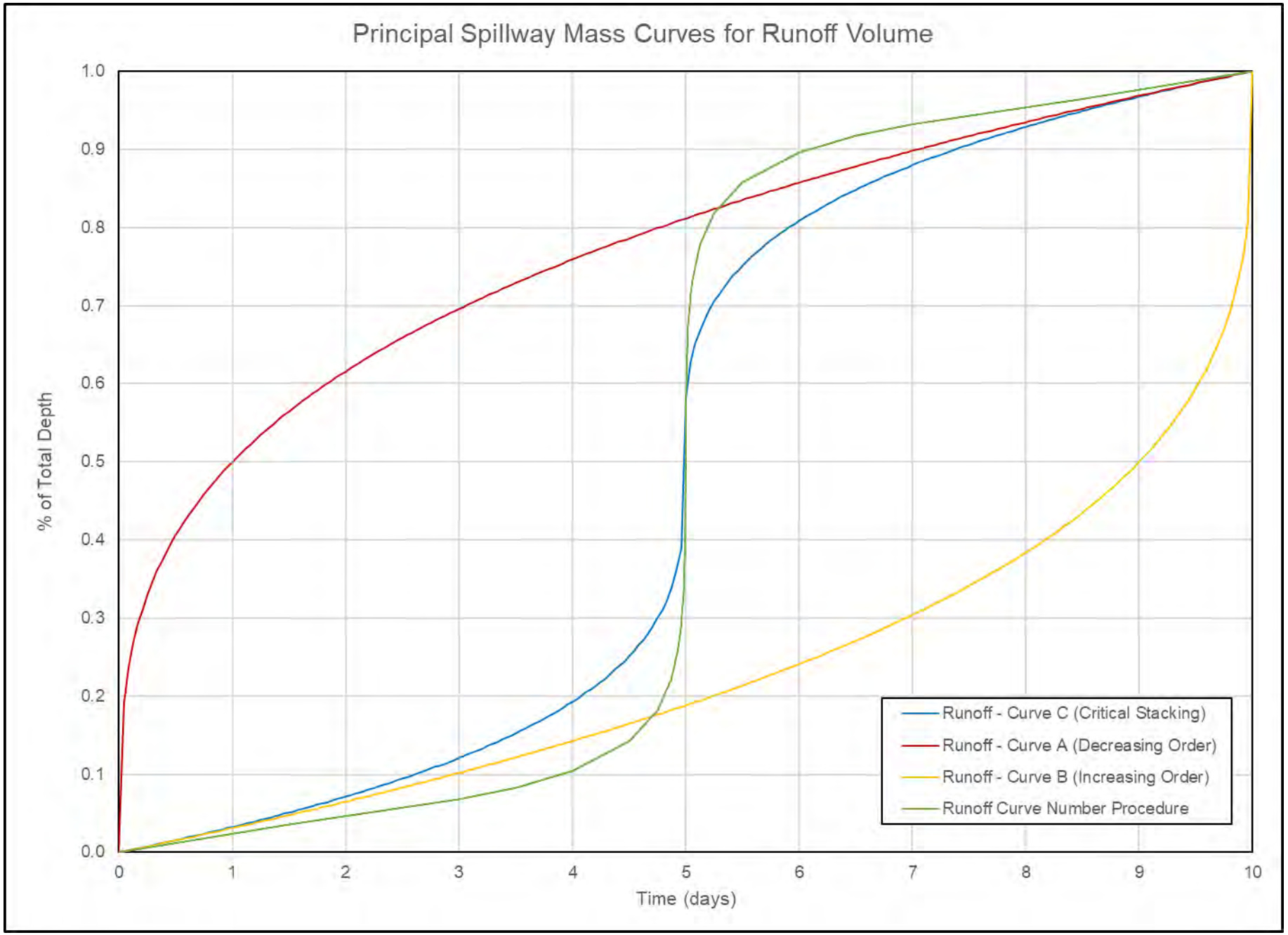


***Figure 5-10**: Principal Spillway Inflow Hydrographs*

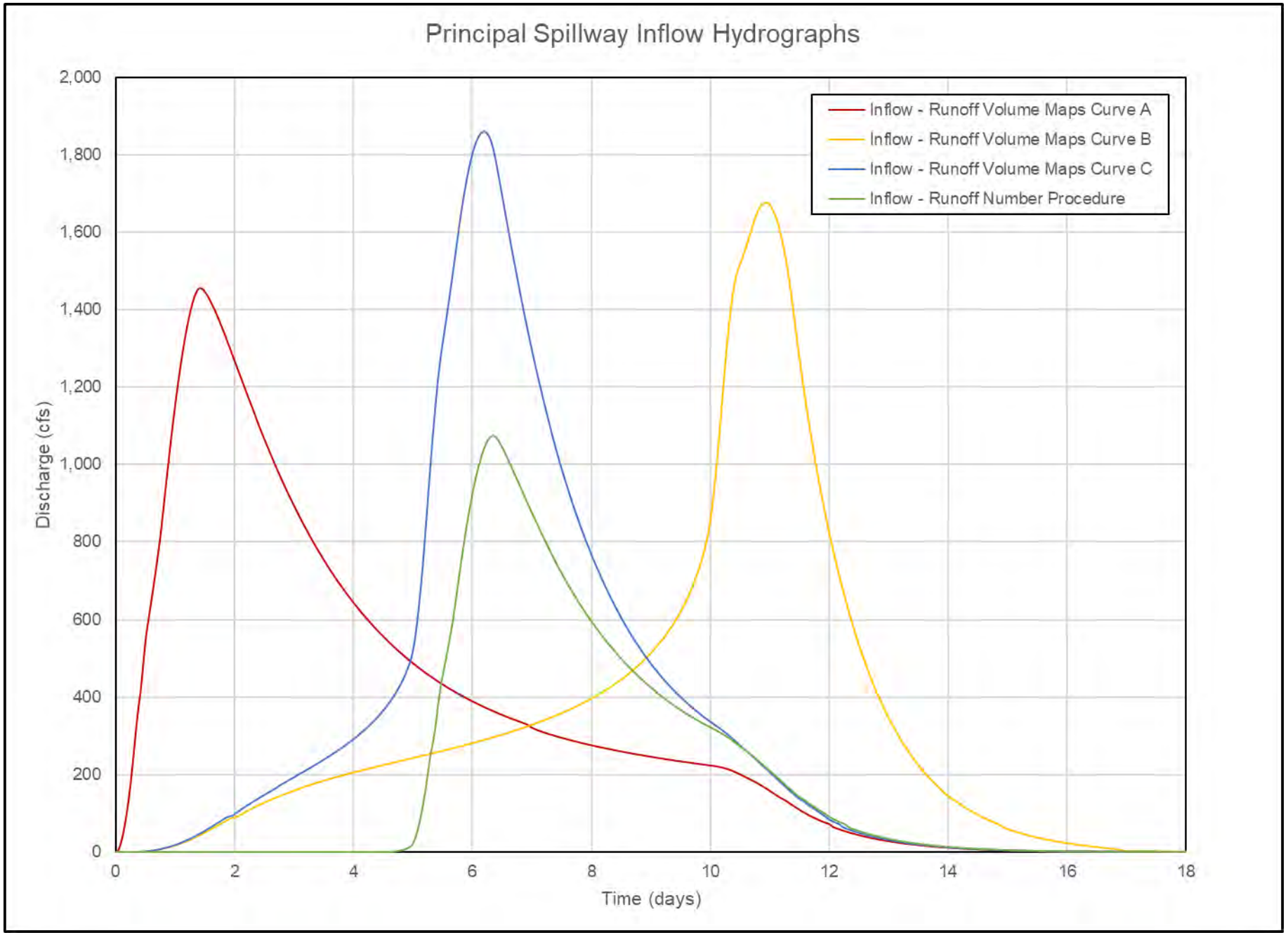


***Figure 5-11**: Stability Design Mass Curves*

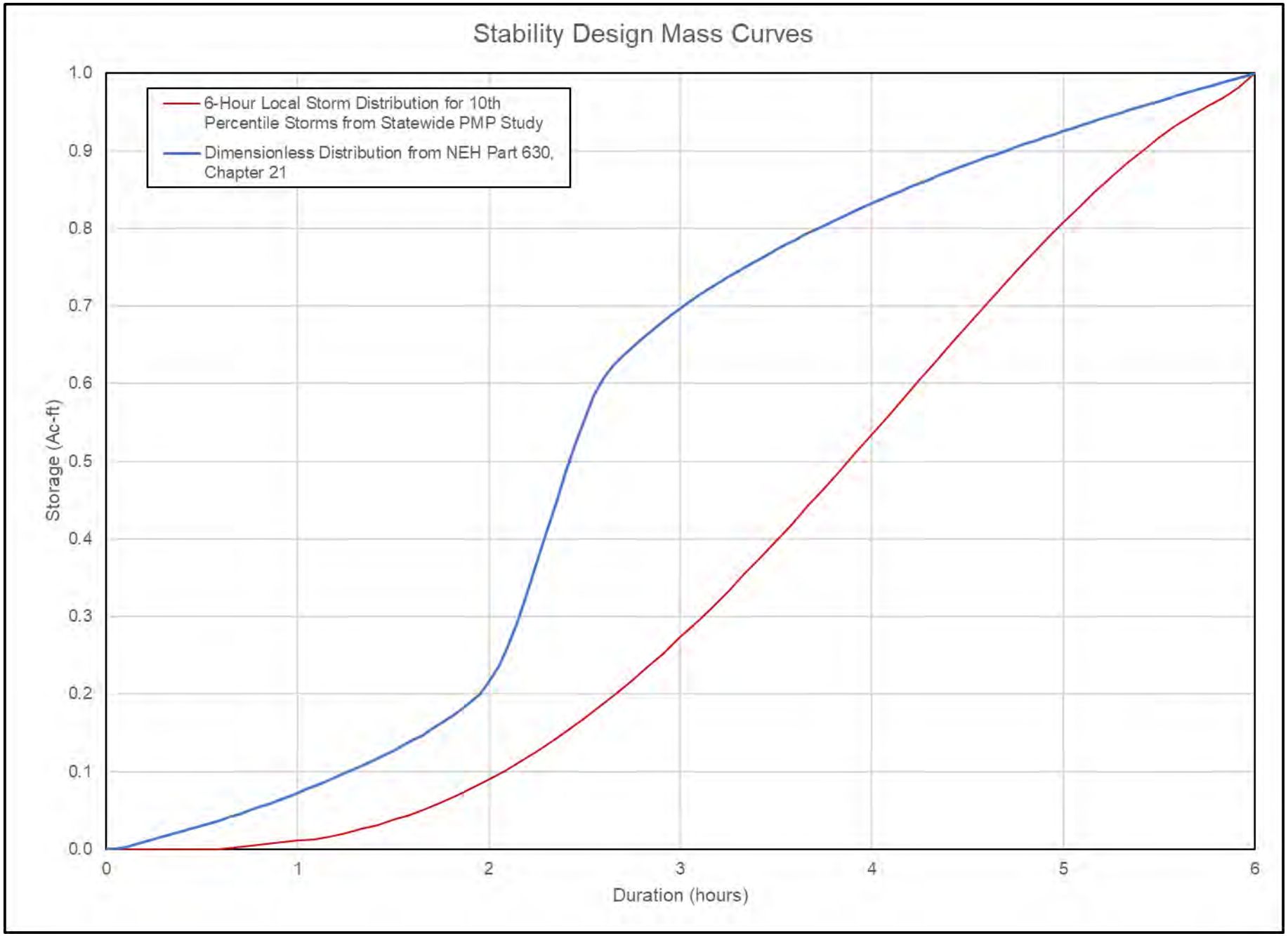


***Figure 5-12**: Stability Design Inflow Hydrograph*

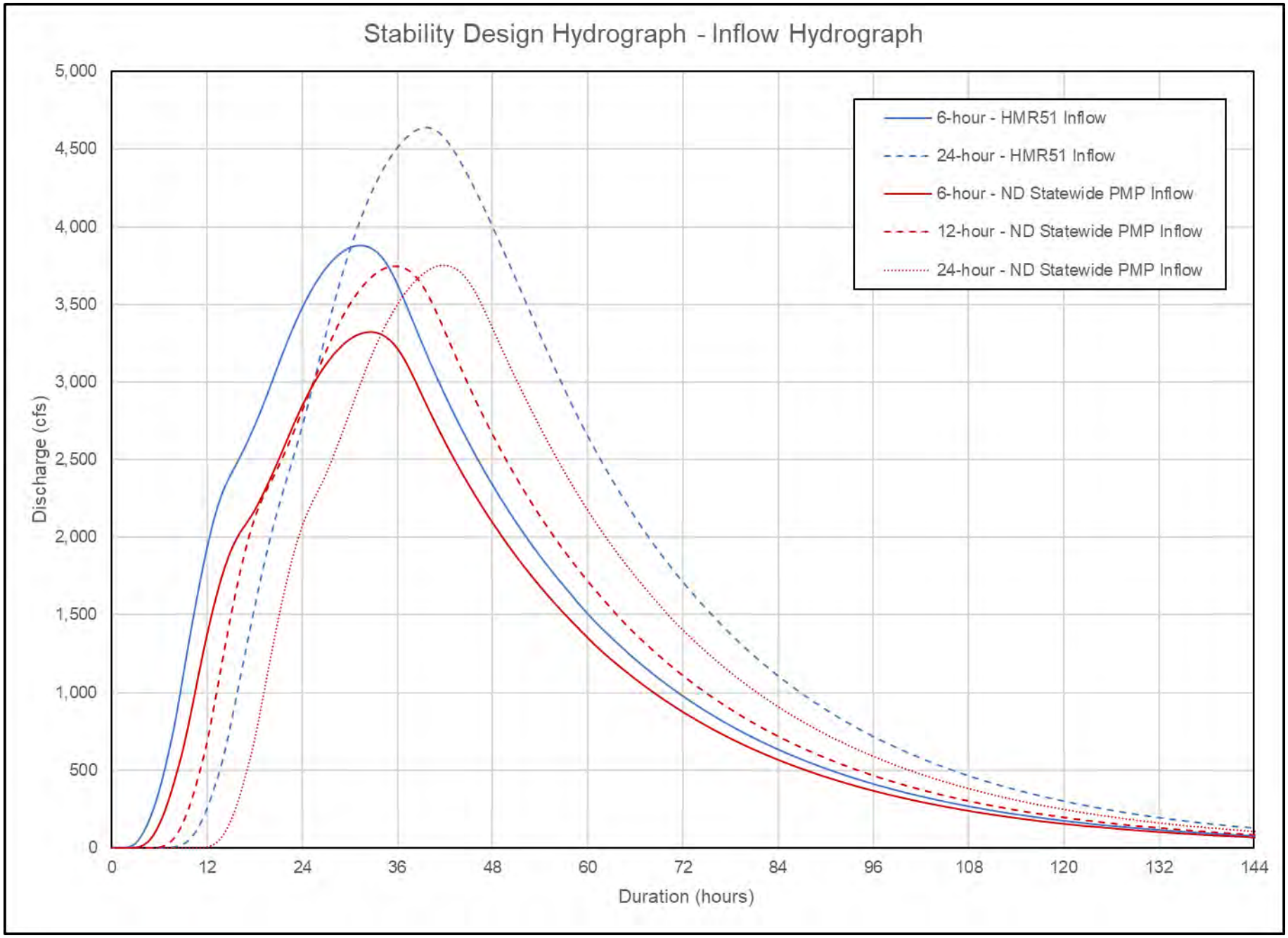


Figure 5-13: *Freeboard Design Mass Curves*

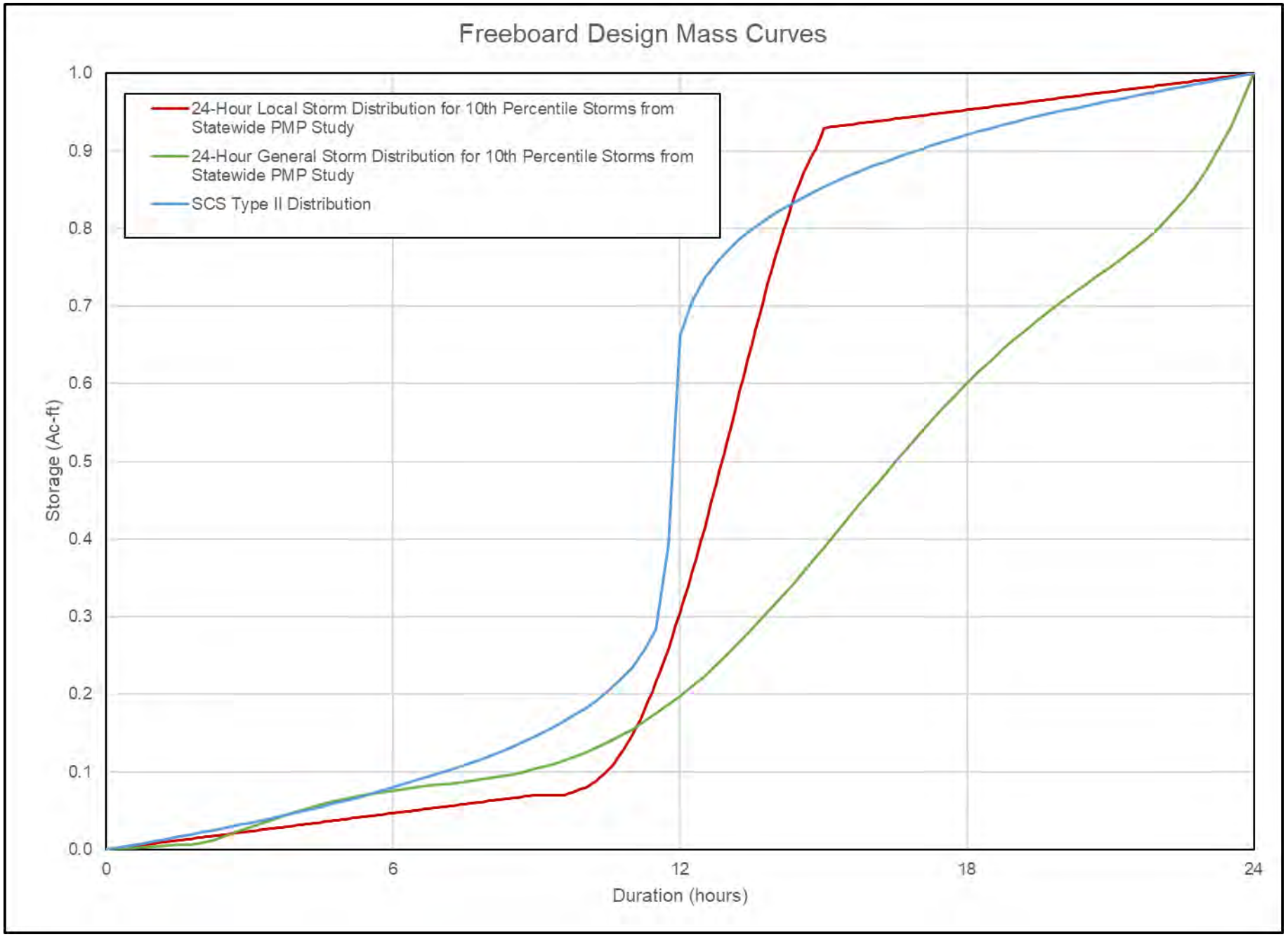


***Figure 5-14**: Freeboard Design Inflow Hydrographs*

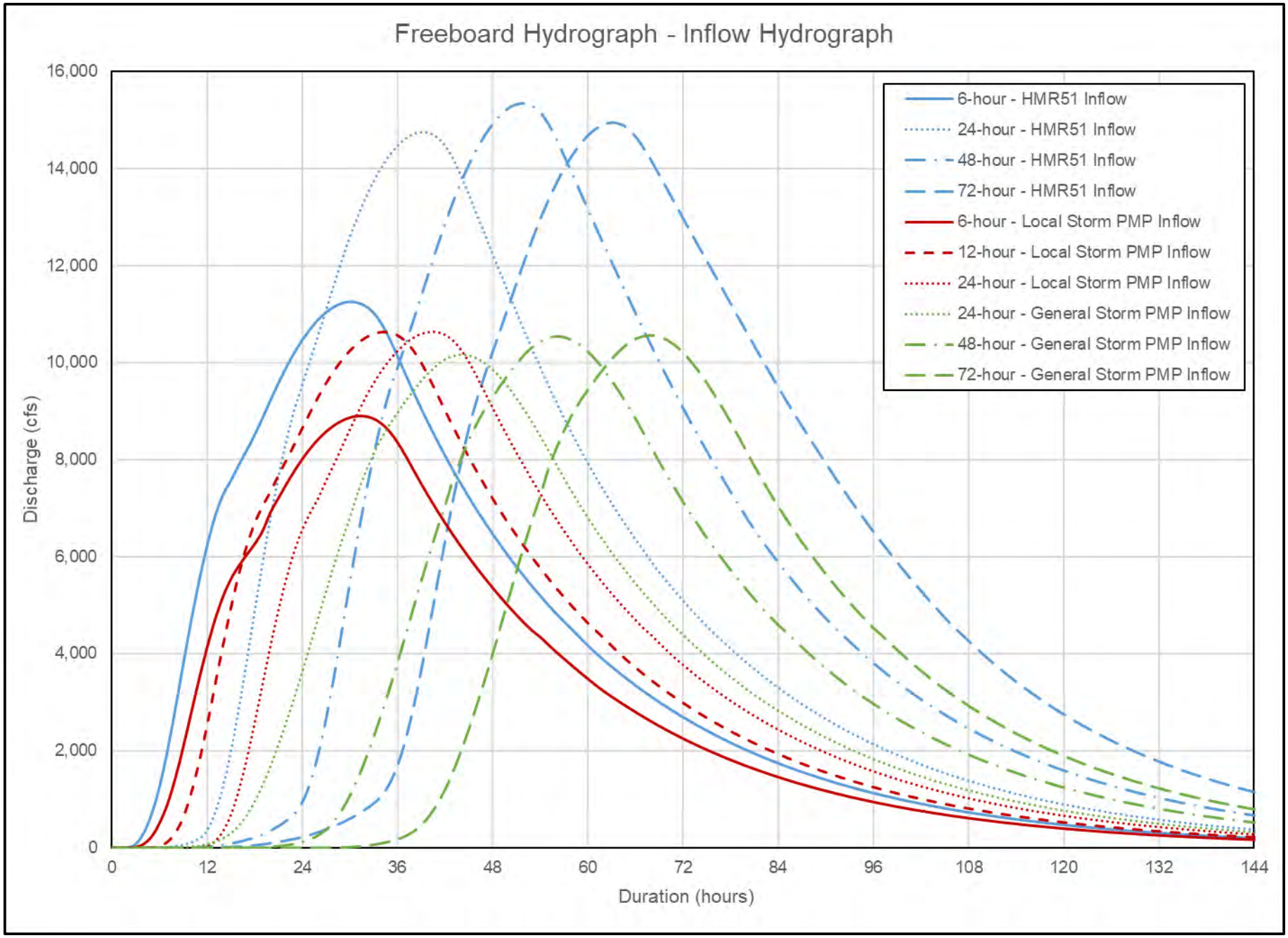


***Figure 7-1**: Fordville Dam Elevation-Discharge Relationship*

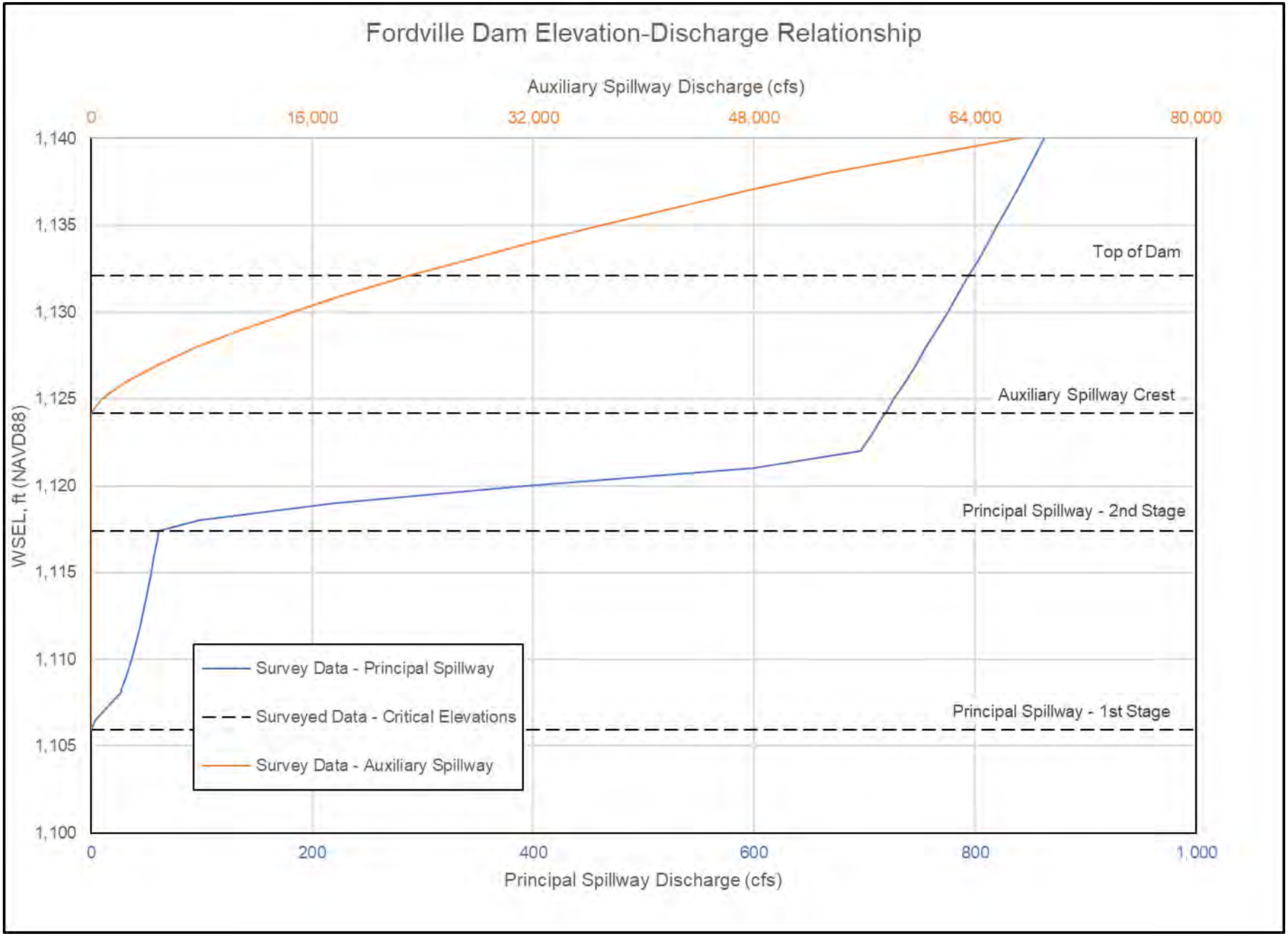


***Figure 7-2**: Fordville Dam Auxiliary Spillway Profile*

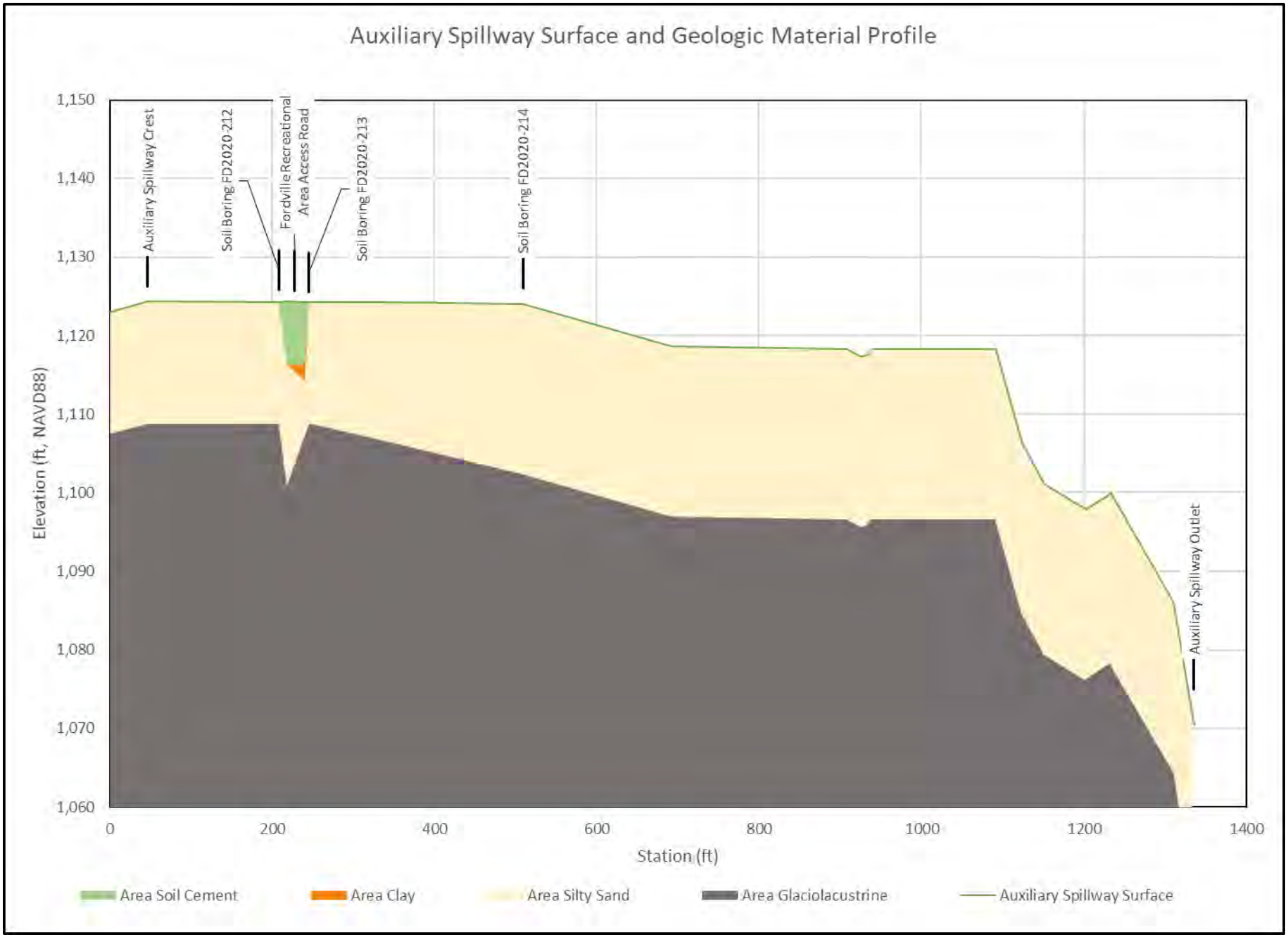
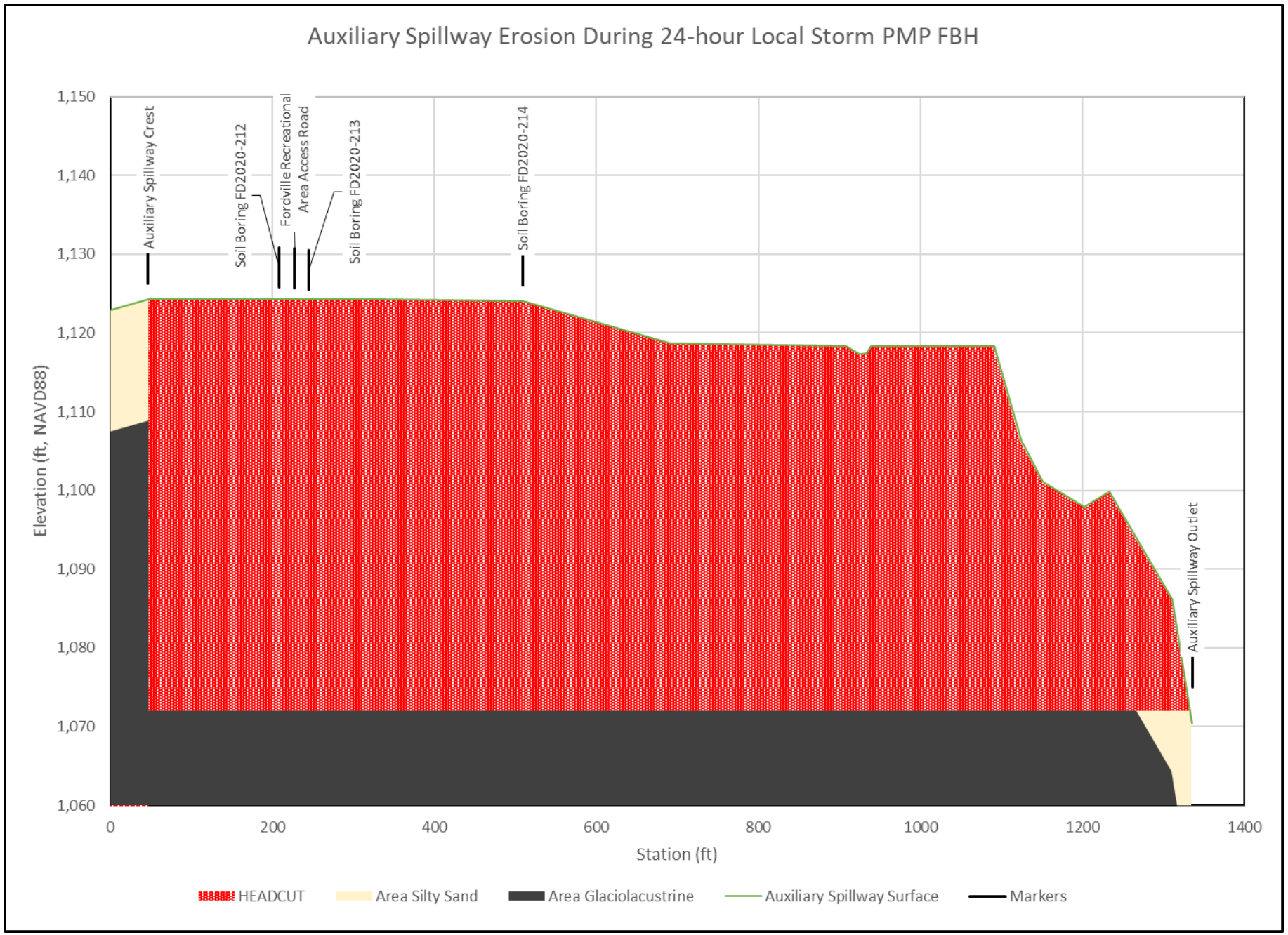


***Figure 7-3**: Fordville Dam Auxiliary Spillway Headcut Erosion from SITES Analysis*



APPENDIX A

As-Built Drawings

DRAFT

OFFICE COPY

MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

OFFICE COPY

GRAND FORKS COUNTY NORTH DAKOTA

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE

SPONSORING AGENCIES
EASTERN GRAND FORKS COUNTY SOIL CONSERVATION DISTRICT
WESTERN GRAND FORKS COUNTY SOIL CONSERVATION DISTRICT
NELSON COUNTY SOIL CONSERVATION DISTRICT
THREE RIVERS SOIL CONSERVATION DISTRICT
WALSH COUNTY SOIL CONSERVATION DISTRICT
WALSH COUNTY WATER MANAGEMENT DISTRICT

WITH ASSISTANCE BY
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

INDEX TO DRAWINGS

SHEET NO.	CONTENTS
1	COVER SHEET
2	LOCATION MAP RESERVOIR CAPACITY TABLE TABLE OF QUANTITIES DETAILS OF ANIMAL GUARDS
3 THRU 6	TOPOGRAPHIC MAP
7	PLAN VIEW OF DAM SITE
8	PROFILES ALONG CENTERLINE OF DAM AND EMERGENCY SPILLWAY LOG OF SOIL BORINGS
9	TYPICAL SECTIONS
10	FILL PLACEMENT DETAILS AND TYPICAL SECTIONS
11	FOUNDATION DRAIN DETAILS
12	PRINCIPAL SPILLWAY LAYOUT
13 THRU 15	DETAILS OF SAF OUTLET
16 THRU 21	DETAILS OF CHUTE
22 THRU 24	DETAILS OF TRANSITION
25 THRU 28	DETAILS OF CONDUIT
29	DETAILS OF PRINCIPAL SPILLWAY ANTISEEP COLLARS
30 THRU 34	DETAILS OF INLET
35	HIGH STAGE TRASH RACK
36	LOW STAGE TRASH RACK
37	DETAILS OF DRAWDOWN CONDUIT
38 AND 39	DETAILS OF DRAWDOWN INLET AND GATE
40	DETAILS OF EMERGENCY SPILLWAY DRAIN AND DROP INLET
BOTTOM SHEET	STANDARD DRAWING 5,R-10,000.47

NOT TO LEAVE OFFICE

SOIL CONSERVATION SERVICE

WE CERTIFY THAT THE PLANS AND DETAILED SPECIFICATIONS FOR THIS PROJECT WERE DEVELOPED BY THE SOIL CONSERVATION SERVICE AND ARE APPROVED.

Clinton G. Johnson — 1-10-74
STATE CONSERVATION ENGINEER — DATE

[illegible] — 5-2-75
HEAD, ENGINEERING AND WATERSHED PLANNING UNIT — DATE

5,E-29,772

STRUCTURE DATA

Class of Structure: B

Drainage Area (total): 26,560 Ac. 41.5 Sq.Mi.

(uncontrolled): 26,560 Ac. 41.5 Sq.Mi.

Time of Concentration: 12.5 Hours

Soil Cover Complex Number: 75 For A.M.C. II

Sediment Capacity Available: 221.2 Ac.Ft. below Elev. 1089

Total Sediment Capacity Available: 221.2 Ac.Ft.

Capacity Equivalents (Vol.): 0.10 In.

Retarding Capacity Provided: 5440 Ac.Ft.

Capacity Equivalents (Vol.): 2.46 In. 2/

Water Supply Provided: 1964 Ac.Ft.-Identify Uses (Recreation)

Principal Spillway:

Maximum Capacity (low stage): 60 c.f.s.

Maximum Capacity (high stage): 840 c.f.s.

10 Day Drawdown Elev.: 1116.2

Emergency Spillway:

Percent Chance Use: 1 % Storm Duration: 6 hr.

Type: Veg. "n" Value Used: 0.40

Emergency Spillway Hydrograph for Class: B Structures

Rainfall: 6.2 in.

Runoff: 3.45 in.

Peak Inflow: 6764 c.f.s.

Maximum Discharge - Emergency Spillway: 3350 c.f.s.

Maximum Water Surface Elev.: 1125.84

Velocity of Flow (Ve): 7.11 f.p.s.

Supplementary Data and Special Design Features:

1/ Principal spillway flood routing is based on D.A. = 32.9 mi.^{2} 8.6 mi.^{2} are defined as potholes.

2/ Based on full D.A. of 41.5 mi.^{2}

Freeboard Hydrograph for Class: B Structures

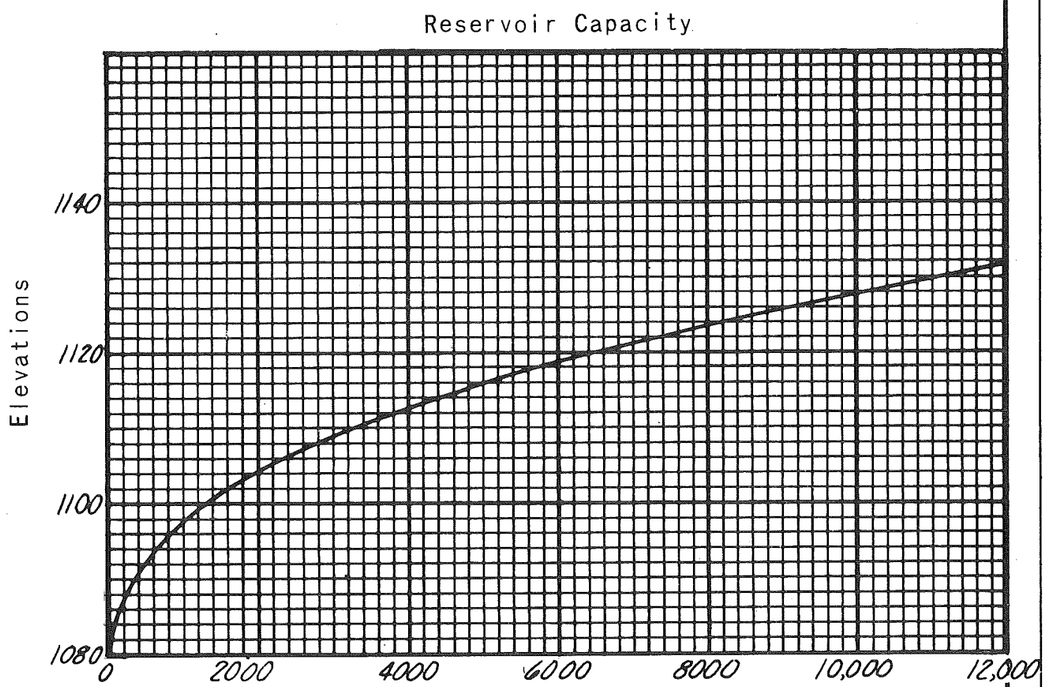
Rainfall: 11.2 in.

Runoff: 8.0 in.

Peak Inflow: 15,520 c.f.s.

Maximum Discharge - Emergency Spillway: 12,900 c.f.s.

Maximum Water Surface Elev.: 1129.01



Supplementary Data and Special Design Features:

DAM 4

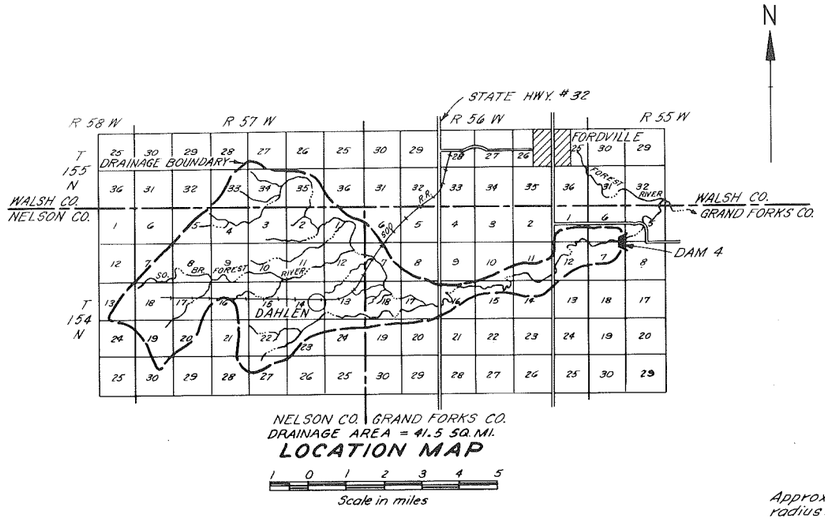
FLOODWATER RETARDING & RECREATION STRUCTURE

MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 7-71	Approved by	
Drawn		Title	
Traced		Title	
Checked C.E.M.	9-71	Sheet No. 1 of 1	Drawing No. 5,E-29,772-E



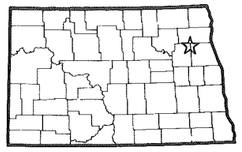
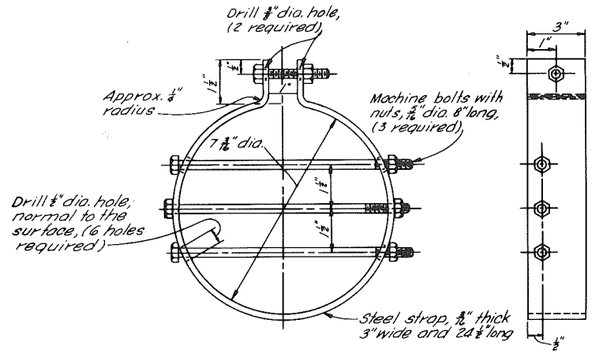


TABLE OF QUANTITIES

ITEM		UNIT	QUANTITY
CLEARING (212.6 ACRES)		ACRES	212.6
CLEARING AND GRUBBING (7 ACRES)		ACRES	7.0
EXCAVATION: COMMON	EMERGENCY SPILLWAY	CU.YD.	292,960
	INLET CHANNEL	CU.YD.	71
	CUTOFF TRENCH	CU.YD.	17,300
	OUTLET CHANNEL	CU.YD.	8,536
	STRUCTURAL	CU.YD.	1,446
	DEBRIS BASIN	CU.YD.	530
	CONDUIT TRENCH	CU.YD.	1,330
EARTH FILL, CLASS A, ZONE I		CU.YD.	70,590
EARTH FILL, CLASS A,		CU.YD.	246,100
DIVERSIONS		LIN.FT.	600
DRAIN FILL		CU.YD.	760
CONCRETE, CLASS 4000		CU.YD.	527.9
STEEL REINFORCEMENT		LB.	73,734
REINFORCED CONCRETE PRESSURE PIPE, 24" DIA.		LIN.FT.	51.25
ASBESTOS-CEMENT PIPE, 6" DIA., CLASS 150 WITH FITTINGS		LIN.FT.	78
ASBESTOS-CEMENT PIPE, 6" DIA., CLASS 150, PERFORATED		LIN.FT.	310
ASBESTOS-CEMENT PIPE, 8" DIA., CLASS 150 WITH FITTINGS		LIN.FT.	78
ASBESTOS-CEMENT PIPE, 8" DIA., CLASS 150, PERFORATED		LIN.FT.	440
LOOSE ROCK RIPRAP WITH BEDDING		CU.YD.	5,479
WATER CONTROL GATE AND APPURTENANCES		EACH	1
TRASH RACKS (3 REQUIRED)		LUMP SUM	
SALVAGING AND SPREADING TOPSOIL		SQ.YD.	86,400
SALVAGING AND SPREADING TOPSOIL, BORROW AREA C		SQ.YD.	87,000
24" DIA., C.M. PIPE, 0.079" WALL THICKNESS, ASBESTOS-BONDED, ASPHALT-COATED		LIN.FT.	34
SEEDING (INCLUDING MULCHING AND FERTILIZING)		ACRES	41.0
CHAIN LINK FENCE		LIN.FT.	112.0
SEEDING		ACRES	17.0
HAUL ROAD		LUMP SUM	
12" DIA. CAST IRON RING AND GRATING		EACH	1
12" DIA. CORRUGATED METAL PIPE RISER WITH 4" X 12" DIA. C.M.P. STUB		LUMP SUM	
12" DIA. C.M. PIPE, 0.064" WALL THICKNESS, ASBESTOS-TREATED, ASPHALT-COATED		LIN.FT.	198.0
12" DIA. PERFORATED C.M. PIPE, 0.064" WALL THICKNESS, ASBESTOS-TREATED, ASPHALT COATED		LIN.FT.	68.0
SOIL-CEMENT		CU.YD.	2,460
CEMENT (FOR SOIL-CEMENT)		BAG	8,610

RESERVOIR CAPACITY TABLE

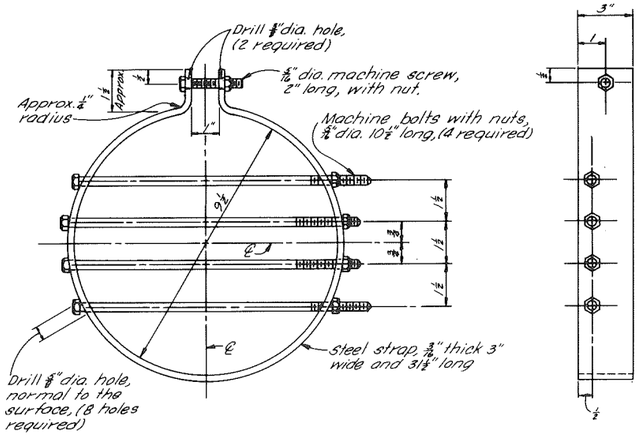
	ELEVATION	AREA-ACRES	STORAGE ACRE FEET	ACCUM. STORAGE ACRE FEET
	1080.0	0.00	0.00	0.00
	1085.0	29.39	73.47	73.47
APPROX. DRAWDOWN →	1090.0	57.15	216.35	289.82
	1095.0	107.86	412.53	702.35
	1100.0	144.16	630.05	1,332.40
F.L. OF ORIFICE →	1105.0	197.12	853.20	2,185.60
	1107.0	218.46	415.58	2,601.18
	1110.0	250.48	703.41	3,304.59
	1115.0	322.38	1,432.15	4,736.74
CREST OF INLET →	1116.5	342.33	498.53	5,235.27
	1117.0	348.98	172.83	5,408.10
	1117.5	355.63	176.15	5,584.25
	1118.0	362.28	179.48	5,763.73
	1118.5	368.93	182.80	5,946.53
	1119.0	375.58	186.13	6,132.66
	1119.5	382.23	189.45	6,322.11
	1120.0	388.88	192.78	6,514.89
CREST OF EMERG. SPLWY. →	1122.7	433.81	1,117.38	7,632.27
	1123.0	438.81	124.15	7,756.42
	1125.0	472.10	910.91	8,667.33
	1130.0	538.83	2,527.33	11,194.66



ANIMAL GUARD FOR 6"DIA. ASBESTOS CEMENT OUTLET DRAIN PIPE

TABLE OF QUANTITIES

ITEM NO.	ITEM	UNIT	QUANTITY
1	HEX. HEAD MACHINE SCREW, 5/16" DIA., 2" LONG WITH NUT	EACH	1
2	MACHINE BOLT, 5/16" DIA., 8" LONG, WITH NUTS	EACH	3
3	STEEL STRAP, 3/16" X 3"	IN.	24 1/2



ANIMAL GUARD FOR 8"DIA. ASBESTOS CEMENT OUTLET DRAIN PIPE

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
HEX. HEAD MACHINE SCREW, 5/16" DIA., 2" LONG WITH NUT	EACH	1
MACHINE BOLT, 5/16" DIA., 10 1/2" LONG, WITH NUTS	EACH	4
STEEL STRAP, 3/16" X 3" - 31 1/2" LONG	EACH	1

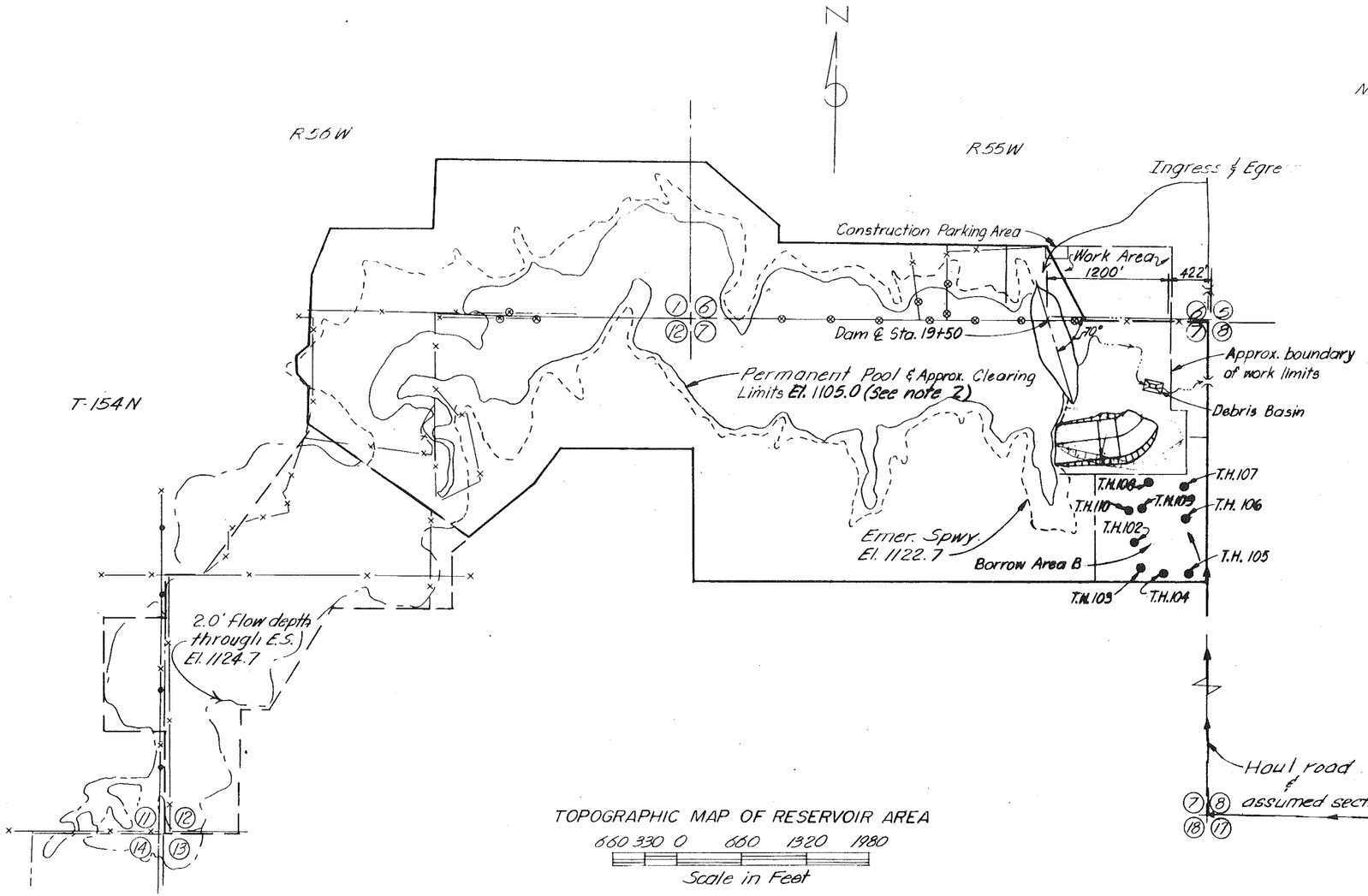
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY — NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S., E.J.P.	Date 12-71	Approved by	
Drawn		Title	
Traced		Title	
Checked		Sheet No 2 of 40	Drawing No. 5,E-29,772



NOTES:

1. All fences within the permanent pool shall be removed.
2. Clearing - Clear all areas upstream from dam below elevation 1107.0
3. Salvaging topsoil - Strip the topsoil from required excavation, and borrow areas and stock pile in locations approved by engineer.
4. Debris basin shall be constructed prior to stripping of dam foundation or emergency spillway
5. Construct debris basin with 3:1 side slopes, 100.0' bottom length, 20.0' bottom width and a depth of 4.0'. Exact location will be determined by engineer.
6. Dam ℄ Sta. 19+50 is tied to survey stake in proximity of section corner as follows; turn 70° left of forward line for a distance of 1200', turn 1° right for a distance of 422' to survey stake. Turn 91°40' left off forward line to the assumed north-south section line.

TOPOGRAPHIC MAP OF RESERVOIR AREA

660 330 0 660 1320 1980

Scale in Feet

Existing fence
Existing Fence to be removed
Power line
Permanent pool elev. (1105.0)
Emergency spillway elev. (1122.7)
2.0' Flow through emer. spwy. (1124.7)
Recreation take area boundary
Mitigation take area boundary
Work limits

DAM 4

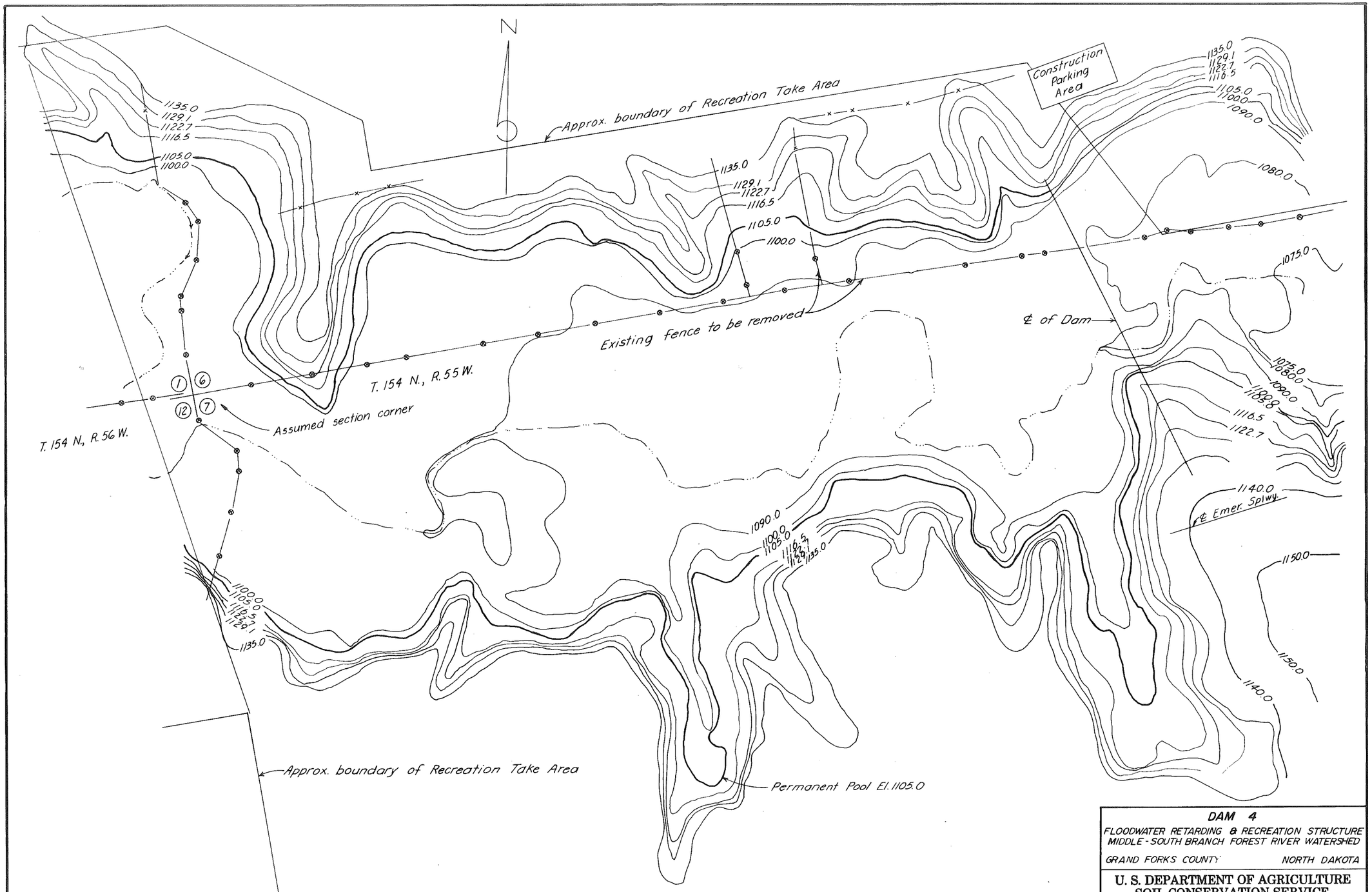
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S.	8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked C.E.M	10/71	Sheet No. 3 of 40	Drawing No. 5, E-29,772

SCS-313 (9-64) +C



TOPOGRAPHIC MAP OF RESERVOIR AREA

200 100 0 200 400 600

Scale in Feet

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
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Drawn D. L. V.	8/71	Title	
Traced		Title	
Checked R. D. S.	10/73	Sheet No. 4 of 40	Drawing No. 5, E-29,772

N

Assumed section line

Approx. Boundary of Recreation take area

Section 1, T154N, R56W

Section 12, T154N, R56W

Permanent Pool. El. 1105.0

Existing fence to be removed

Match Line

Match Line

1135.0
1129.1
1122.7
1116.5
1105.0
1100.0
1105.0
1100.0
1100.0
1116.5
1122.7
1129.1
1135.0
1116.5
1122.7
1129.1
1135.0
1116.5
1122.7
1129.1
1135.0

Approx. Boundary of Mitigation take area

Approx. Boundary of Recreation take area

TOPOGRAPHIC MAP OF RESERVOIR AREA

200 100 0 200 400 600

Scale in Feet

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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Drawn D. L. J.	8/71	Title	
Traced		Title	
Checked R. D. S.	10/73	Sheet No. 5 of 10	Drawing No. 5, E-29,772

U.S. GOVERNMENT PRINTING OFFICE 1969 O—349-378

SCS-ENG-313-C Rev. 5-69

N

T154N, R56W

House

1135

1129.1

1122.7

Assumed section lines

Assumed section corner

Quarter Line

Match Line

3-60" M.A.P.

60" C.M.P. Elev. 1123.6

Approx. Boundary of Mitigation take area

TOPOGRAPHIC MAP OF RESERVOIR AREA

200 100 0 200 400 600

Scale in Feet

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L. M. S.	Date 8/71	Approved by	
Drawn D. L. J.	8/71	Title	
Traced		Title	
Checked R. D. S.	10/73	Sheet No 6 of 40	Drawing No. 5, E-29,772

SCS-ENG-313-C Rev. 5-69

OUTLET CHANNEL CURVE DATA

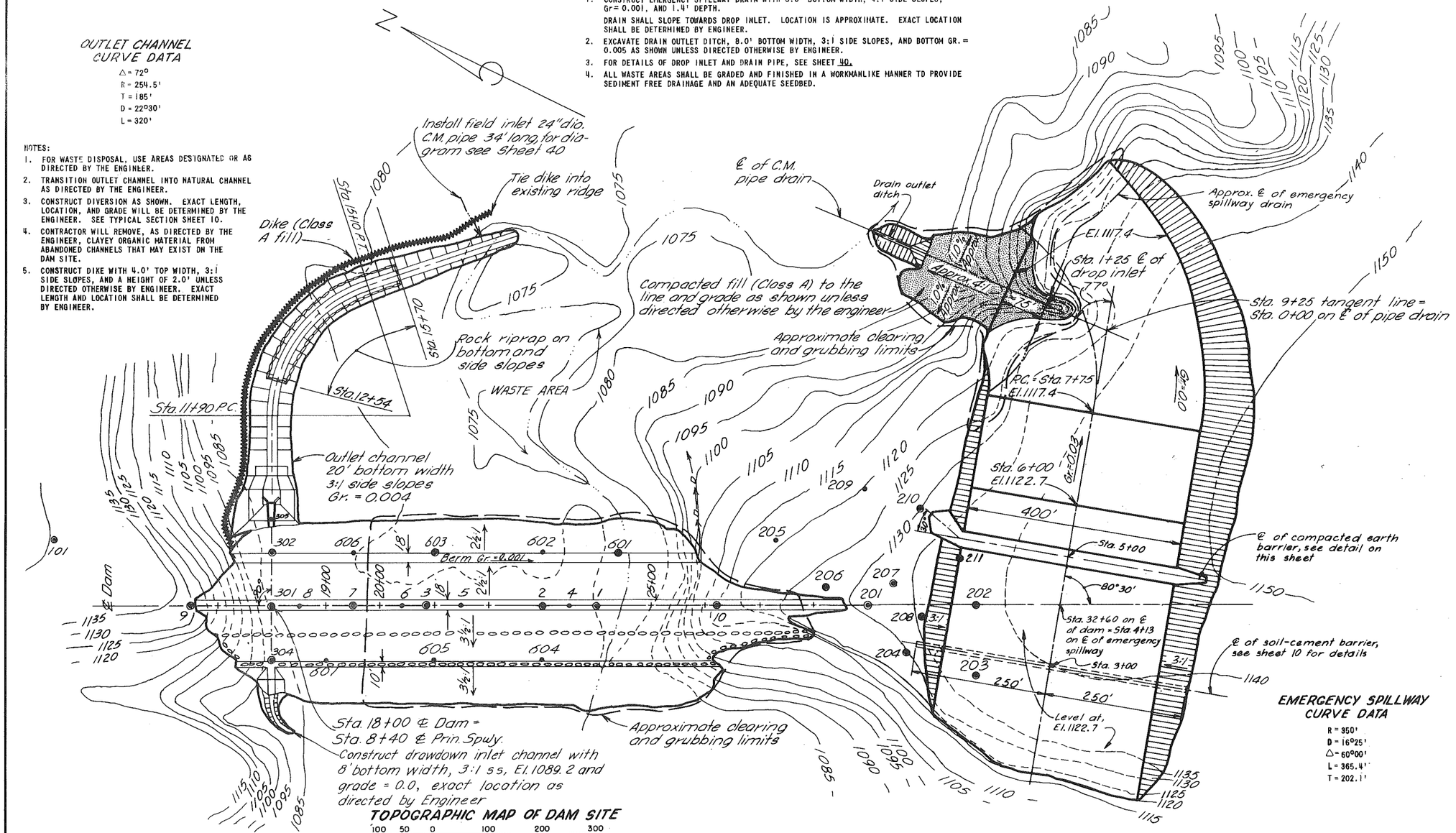
Δ = 72°
R = 254.5'
T = 185'
D = 22°30'
L = 320'

NOTES:

1. FOR WASTE DISPOSAL, USE AREAS DESIGNATED OR AS DIRECTED BY THE ENGINEER.
2. TRANSITION OUTLET CHANNEL INTO NATURAL CHANNEL AS DIRECTED BY THE ENGINEER.
3. CONSTRUCT DIVERSION AS SHOWN. EXACT LENGTH, LOCATION, AND GRADE WILL BE DETERMINED BY THE ENGINEER. SEE TYPICAL SECTION SHEET 10.
4. CONTRACTOR WILL REMOVE, AS DIRECTED BY THE ENGINEER, CLAYEY ORGANIC MATERIAL FROM ABANDONED CHANNELS THAT MAY EXIST ON THE DAM SITE.
5. CONSTRUCT DIKE WITH 4.0' TOP WIDTH, 3:1 SIDE SLOPES, AND A HEIGHT OF 2.0' UNLESS DIRECTED OTHERWISE BY ENGINEER. EXACT LENGTH AND LOCATION SHALL BE DETERMINED BY ENGINEER.

NOTES:

1. CONSTRUCT EMERGENCY SPILLWAY DRAIN WITH 8.0' BOTTOM WIDTH, 4:1 SIDE SLOPES, Gr= 0.001, AND 1.4' DEPTH.
   DRAIN SHALL SLOPE TOWARDS DROP INLET. LOCATION IS APPROXIMATE. EXACT LOCATION SHALL BE DETERMINED BY ENGINEER.
2. EXCAVATE DRAIN OUTLET DITCH, 8.0' BOTTOM WIDTH, 3:1 SIDE SLOPES, AND BOTTOM GR. = 0.005 AS SHOWN UNLESS DIRECTED OTHERWISE BY ENGINEER.
3. FOR DETAILS OF DROP INLET AND DRAIN PIPE, SEE SHEET 40.
4. ALL WASTE AREAS SHALL BE GRADED AND FINISHED IN A WORKMANLIKE MANNER TO PROVIDE SEDIMENT FREE DRAINAGE AND AN ADEQUATE SEEDBED.

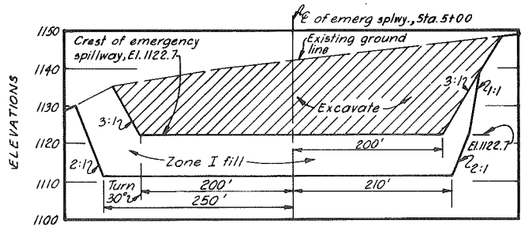


TOPOGRAPHIC MAP OF DAM SITE

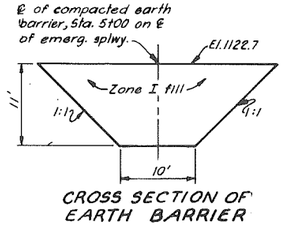
100 50 0 100 200 300
Scale in feet

EMERGENCY SPILLWAY CURVE DATA

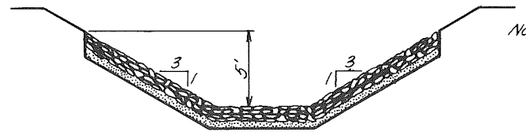
R = 350'
D = 16°25'
Δ = 60°00'
L = 365.4'
T = 202.1'



PROFILE ALONG ℄ OF COMPACTED EARTH BARRIER



CROSS SECTION OF EARTH BARRIER



Note: Place rock riprap 10' thick plus 0.5' bedding material measured vertically.

CROSS SECTION OF OUTLET CHANNEL SHOWING RIPRAP

DETAILS OF COMPACTED EARTH BARRIER

DAM 4

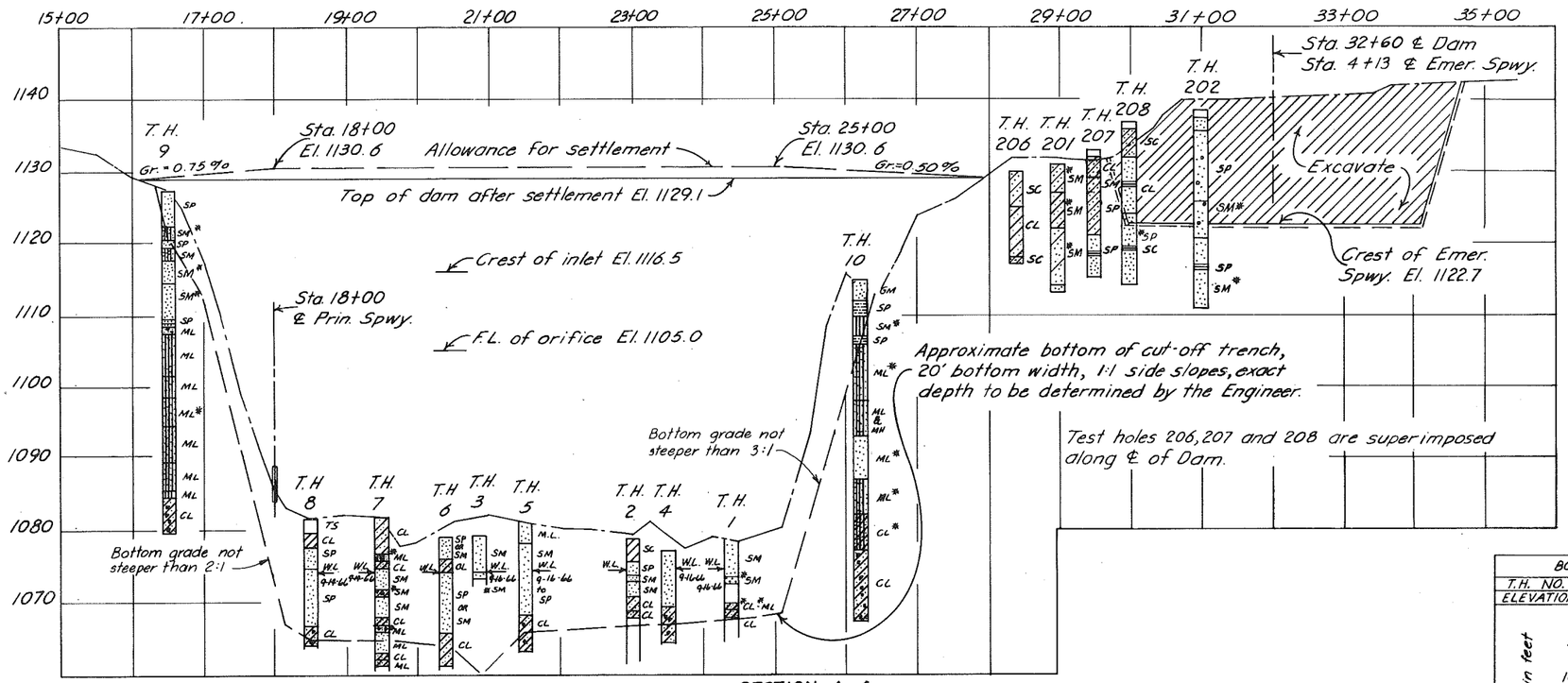
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S	8/71	Approved by	
Drawn D.L.J	8/71	Title	
Traced		Title	
Checked C.E.M	10/71	Sheet No 7 of 40	Drawing No 5, E-29,772

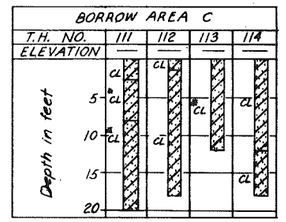
U.S. GOVERNMENT PRINTING OFFICE 1965 OP-793-928

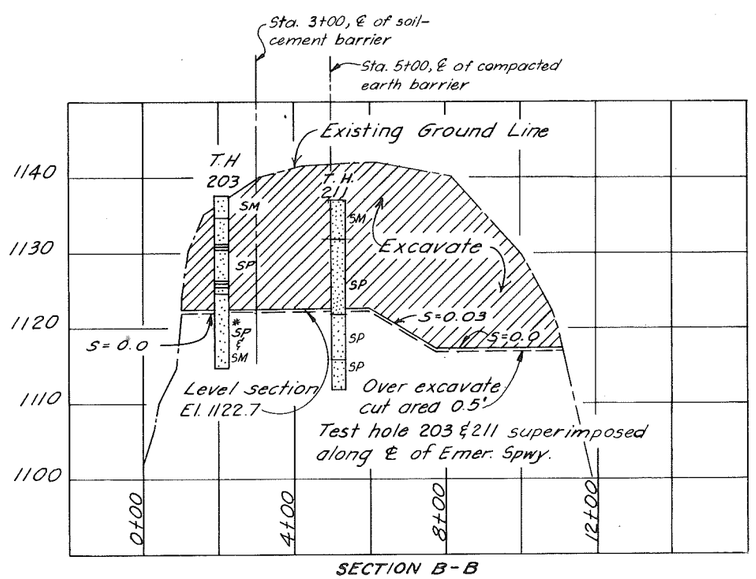
SCS-313 (9-64) -C



SECTION A-A

PROFILE ALONG & OF DAM

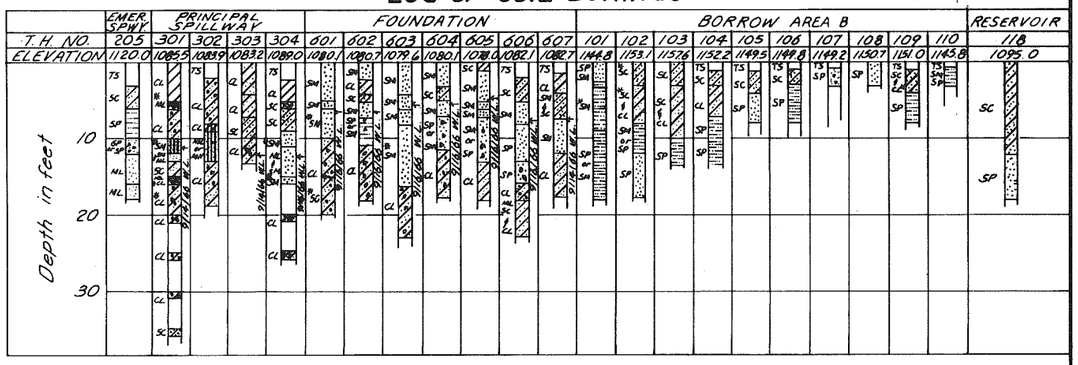




SECTION B-B

PROFILE ALONG & OF EMERGENCY SPILLWAY

LOG OF SOIL BORINGS



Notes:

1. For soils legend and symbols, see standard drawing 5, R-10,000.47.
2. Soil Exploration date Sept. 14, 1966.
3. → indicates groundwater at time of exploration.
4. The Unified Soil Classification symbols followed by an asterisk are based on laboratory classification. Those symbols without an asterisk are based on field classification and are subject to revision based on laboratory test.
5. Over excavate cut ared of Emergency Spillway 0.5'. Backfill with select topsoil material.
6. T.S = topsoil

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY — NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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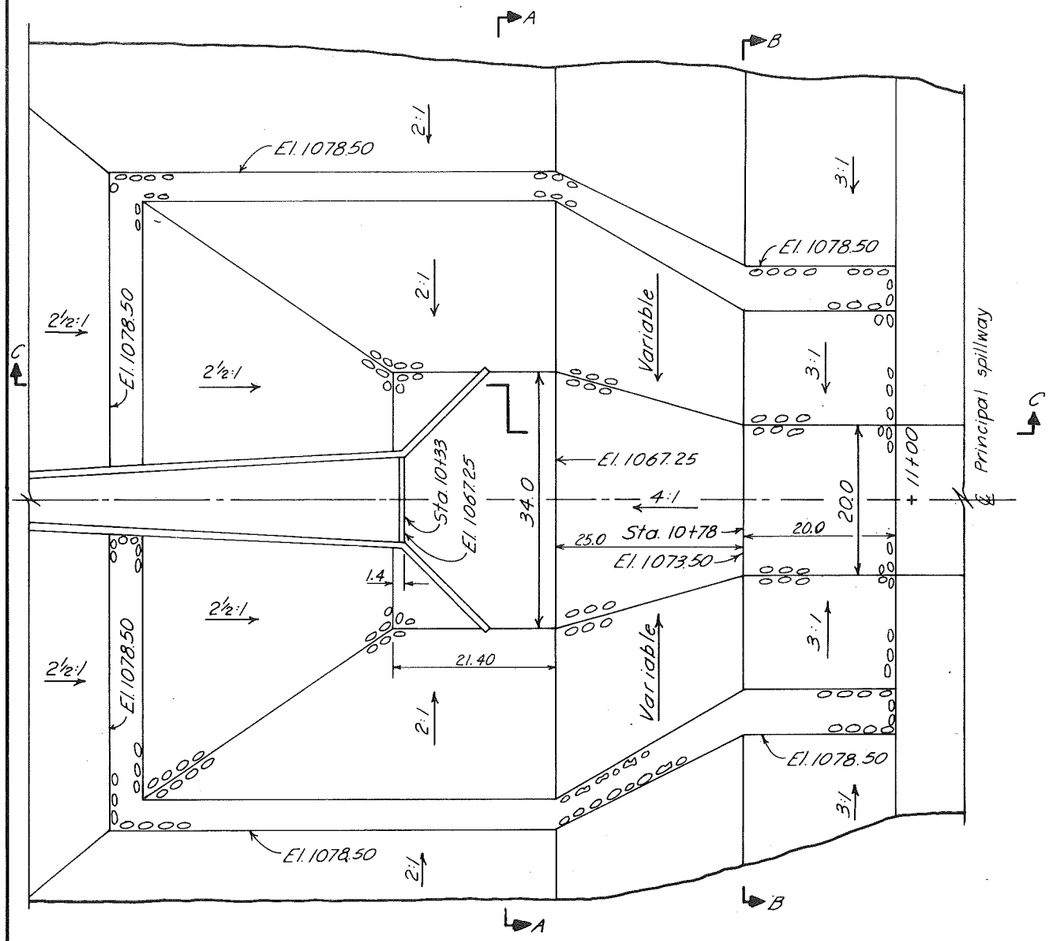
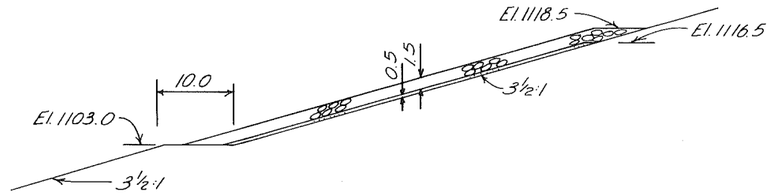
U.S. GOVERNMENT PRINTING OFFICE: 1966 OP—705-920

SCS-313 (9-64) -C

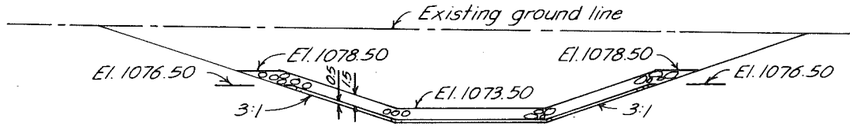


PLAN VIEW OF PRINCIPAL SPILLWAY OUTLET

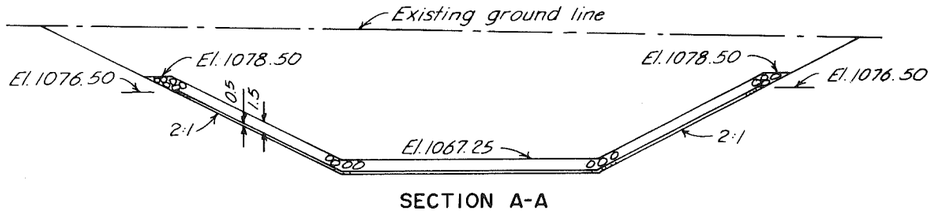


DETAIL OF ROCK RIPRAP & BEDDING ON UPSTREAM SLOPE

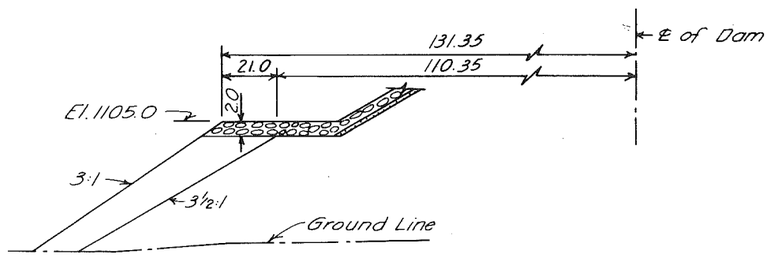
Note: Allowance for settlement not shown



SECTION B-B

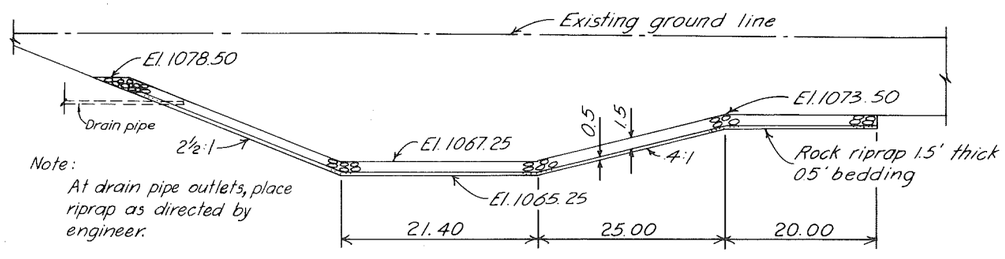


SECTION A-A



CROSS-SECTION DETAIL OF UPSTREAM LOCAL BERM

Not to scale



Note:
At drain pipe outlets, place riprap as directed by engineer.

SECTION C-C

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
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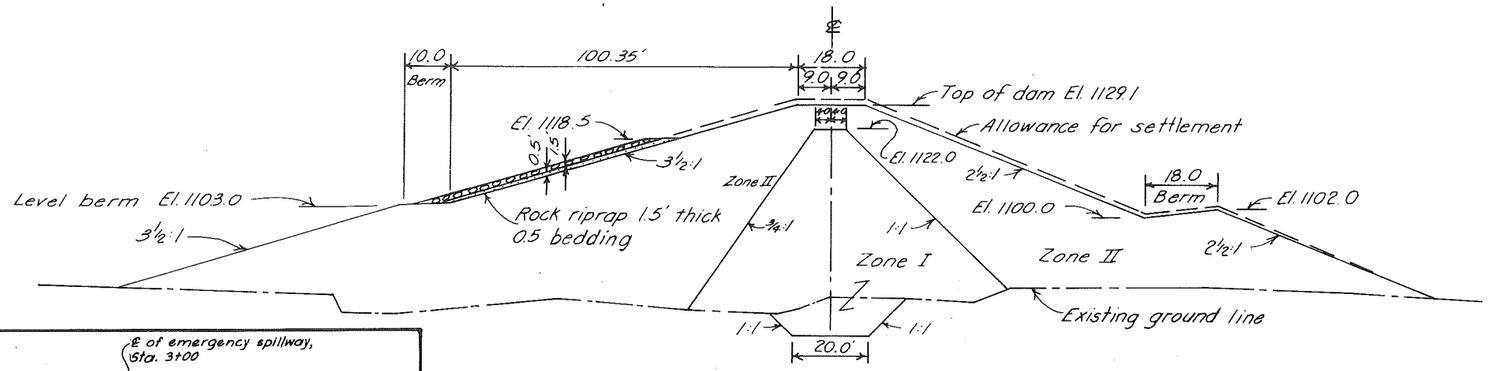
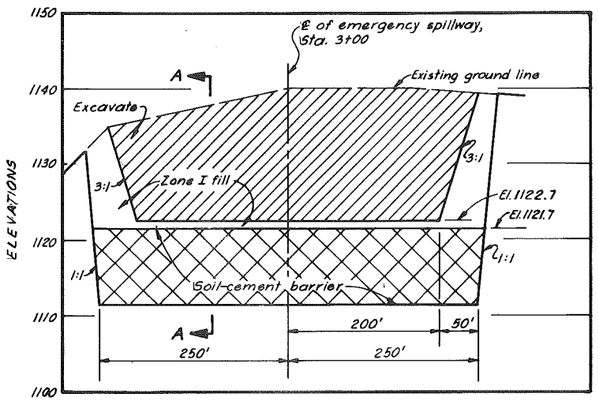
U.S. GOVERNMENT PRINTING OFFICE: 1965 O—732-959

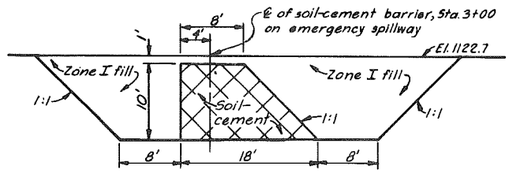


STATION 24+50
MAXIMUM CROSS SECTION OF DAM

20 0 20 40
Scale in feet

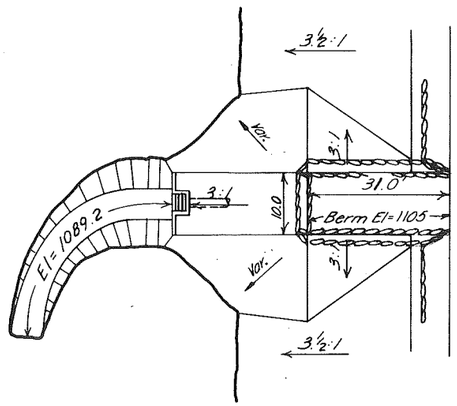


PROFILE ALONG ℄ OF SOIL-CEMENT BARRIER

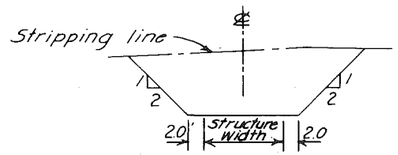


SECTION A-A

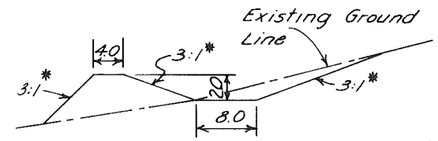
DETAILS OF SOIL-CEMENT BARRIER



PLAN VIEW OF UPSTREAM
LOCAL BERM AT RISER



TYPICAL SECTION - STRUCTURE EXCAVATION
BOX CONDUIT AND SAF



TYPICAL CROSS-SECTION OF DIVERSION

*SIDE SLOPES WILL BE AS SHOWN UNLESS DIRECTED OTHERWISE BY THE ENGINEER.

EMBANKMENT MATERIAL SOURCES AND PLACEMENT REQUIREMENT

SOURCE OF MATERIAL				PLACEMENT AND MOISTURE DENSITY REQUIREMENT							
LOCATION	APPROX. DEPTH (FT.) FROM	TO	UNIFIED SOIL CLASSIFICATION	DEPTH OF LIFT	MAX. SIZE ROCK FRAGMENTS	FILL. MATRIX SIZE TESTED	COMPACTION CLASS	REFERENCE TEST METHOD	REQ'D. (%) COMPACTION	ALLOWABLE MOISTURE RANGE FROM OPTIMUM(%)	FILL LOCATION
BORROW C	1	18	CL	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE I
EMERGENCY SPILLWAY	3	23	SM & SP	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
BORROW B	3	13	SM	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
EMERGENCY SPILLWAY	0	5	SC	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II

LABORATORY TEST INFORMATION ON TYPICAL MATERIALS

UNIFIED SOIL CLASSIFICATION	TEST HOLE III CL	TEST HOLE 201 SM	TEST HOLE 102 SC	TEST HOLE 109 CL
REFERENCE TEST METHOD	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698
MAXIMUM DRY DENSITY	106.0 P.C.F.	103.0 P.C.F.	98.0 P.C.F.	91.0 P.C.F.
OPTIMUM MOISTURE	18.0%	20.0%	21.5%	25.0%
DESCRIPTION	GLACIAL TILL	DELTA SEDIMENTS	DELTA SEDIMENTS	DELTA SEDIMENTS

NOTES:
1. LABORATORY TEST DATA ON THE SOIL INVESTIGATION IS AVAILABLE AT THE SCS WATERSHED OFFICE IN GRAFTON, NORTH DAKOTA.
2. FOR SOIL LEGEND AND SYMBOLS, SEE STANDARD DRAWING NO. 5,R-10,000.47.
3. MORE PLASTIC MATERIAL EXCAVATED FROM EMERGENCY SPILLWAY AND BORROW B IS TO BE SELECTIVELY PLACED ADJACENT TO THE UPSTREAM PORTION OF ZONE I, IN THE COMPACTED EARTH BARRIER AND ADJACENT TO THE SOIL-CEMENT BARRIER.
4. DO NOT BORROW CLOSER THAN 100' FROM BASE OF DAM UNLESS DIRECTED OTHERWISE BY THE ENGINEER IN THE FIELD.

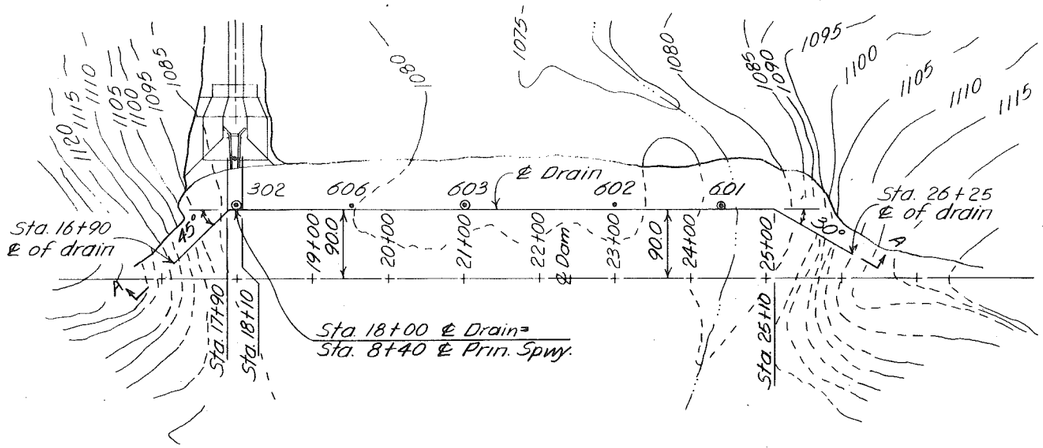
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S.	8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No 10 of 40	Drawing No 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE 1965 O—782-338

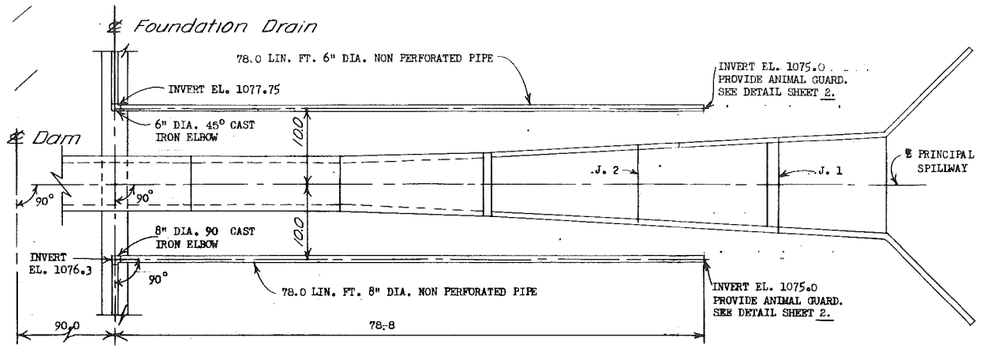
SCS-313 (9-64) -C

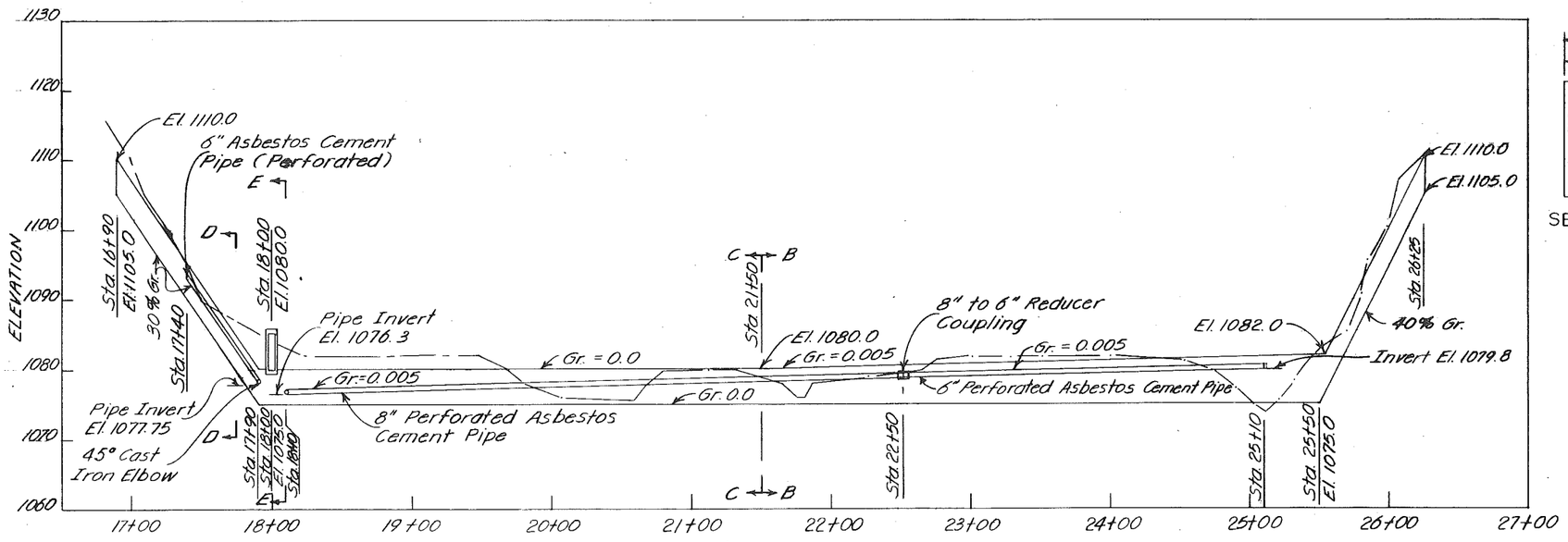


PLAN OF BASE OF DAM SHOWING FOUNDATION DRAIN

100 50 0 100 200 300

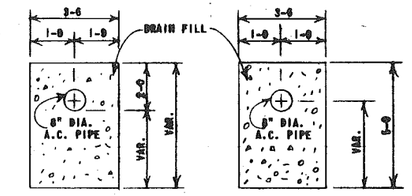
Scale in Feet





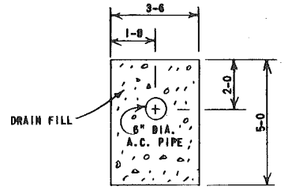
SECTION A-A

PROFILE ALONG ℄ OF TRANSVERSE FOUNDATION DRAIN



SECTION B-B

SECTION C-C



SECTION D-D

NOTES:

1. PROVIDE ANIMAL GUARD AT OUTLET END OF OUTLET PIPES. FOR DETAILS OF ANIMAL GUARDS, SEE SHEET 2.
2. PLUG UPPER END OF PIPES WITH 6" OF CONCRETE OR PREFABRICATED CAP.
3. THE DEPTH OF FILL OVER THE DRAIN PIPE SHALL BE AT LEAST 2' BEFORE PASSING HEAVY EQUIPMENT OVER THE PIPE.
4. WHERE THE TRANSVERSE DRAIN TRENCH IS ABOVE THE GROUND LINE, PLACE COMPACTED EARTH FILL TO ELEVATION AT TOP OF DRAIN AND EXCAVATE DRAIN IN COMPACTED FILL.
5. STA. 17+90 THRU STA. 25+10 OF THE DRAIN CENTERLINE COINCIDE WITH STA. 17+90 THRU 25+10 OF THE DAM CENTERLINE.
6. PLACE TWO LAYERS OF ROOFING FELT UNDER THE PRINCIPAL SPILLWAY CONDUIT AT ITS INTERSECTION WITH THE FOUNDATION DRAIN.
7. DRAIN PIPE WILL OUTLET THROUGH RIPRAP. PLACE RIPRAP AROUND OUTLET AS DIRECTED BY ENGINEER.

DRAIN FILL GRADATION

SIEVE SIZE	PERCENT PASSING
3"	100
1"	90 - 100
#4	45 - 70
#10	10 - 50
#16	0 - 35
#40	5

QUANTITIES

ITEM	UNIT	QUANTITY
DRAIN FILL MATERIAL	CU.YD.	660
8" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	440
8" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
6" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	310
6" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
8" DIA. 90° CAST IRON ELBOW	EACH	1
6" DIA. 45° CAST IRON ELBOW	EACH	1
8" TO 6" DIA. REDUCER COUPLING	EACH	1

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE

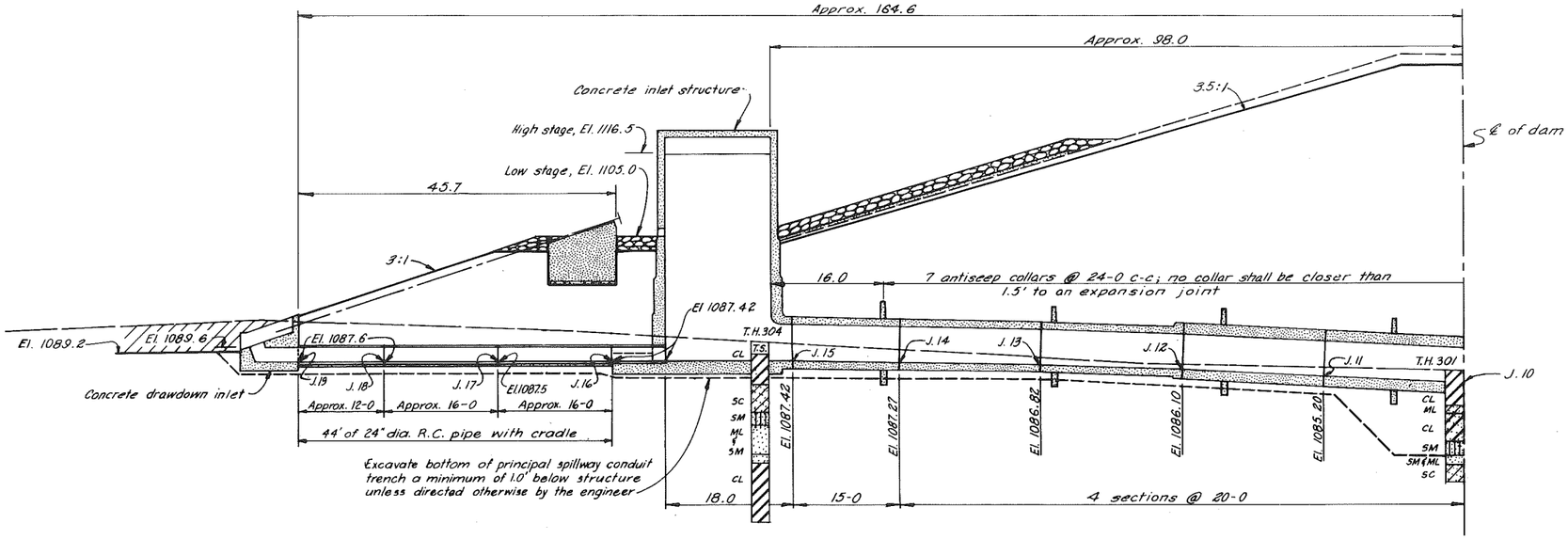
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

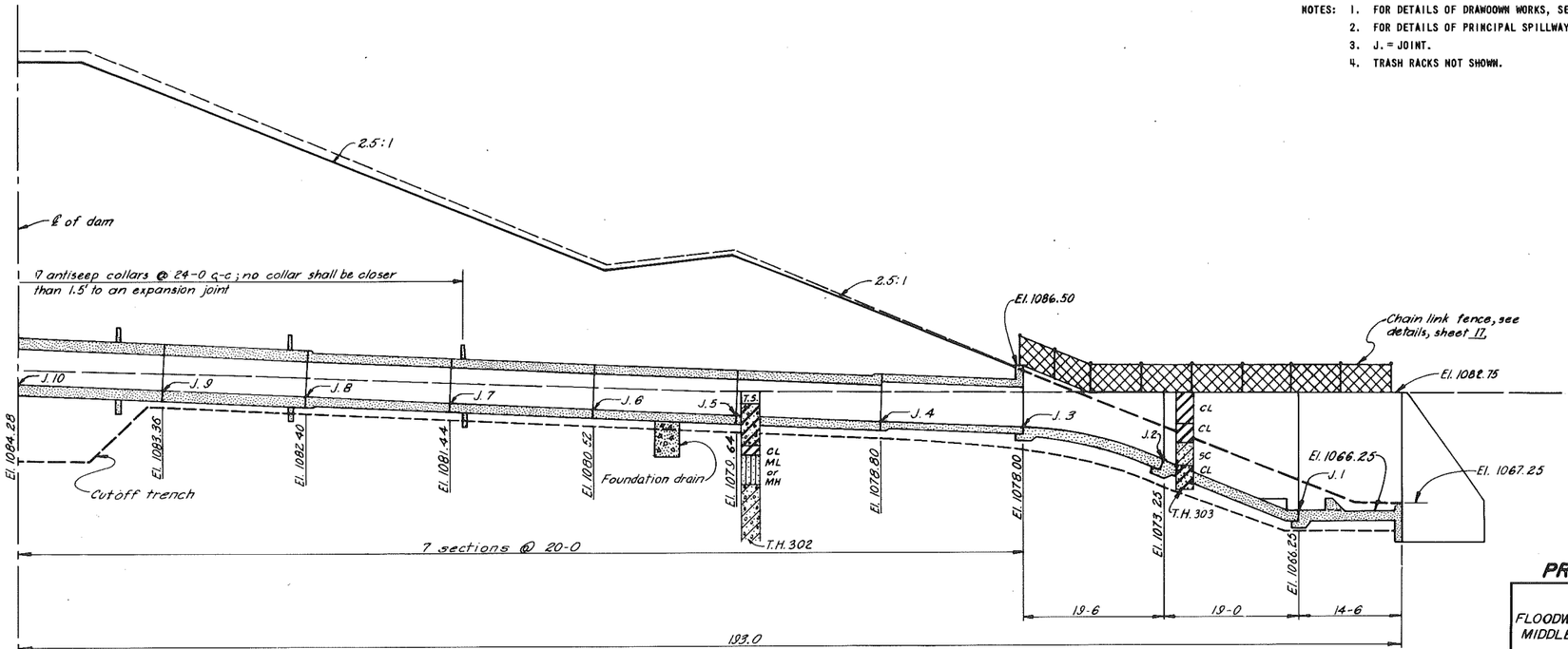
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 9/71	Approved by	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked C.E.M.	12/71	Sheet No. 11 of 40	Drawing No. 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE : 1969 O—354-743



NOTES:
1. FOR DETAILS OF DRAWOOWN WORKS, SEE SHEETS 37 TO 39.
2. FOR DETAILS OF PRINCIPAL SPILLWAY CONDUIT, SEE SHEETS 25 TO 28.
3. J. = JOINT.
4. TRASH RACKS NOT SHOWN.



PROFILE ALONG ℄ OF PRINCIPAL SPILLWAY

0 10 20 30 40
Scale in feet

PRINCIPAL SPILLWAY LAYOUT

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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Designed L.M.S.	9-71	Approved by	
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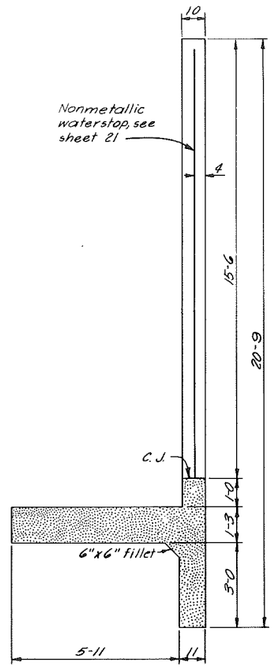
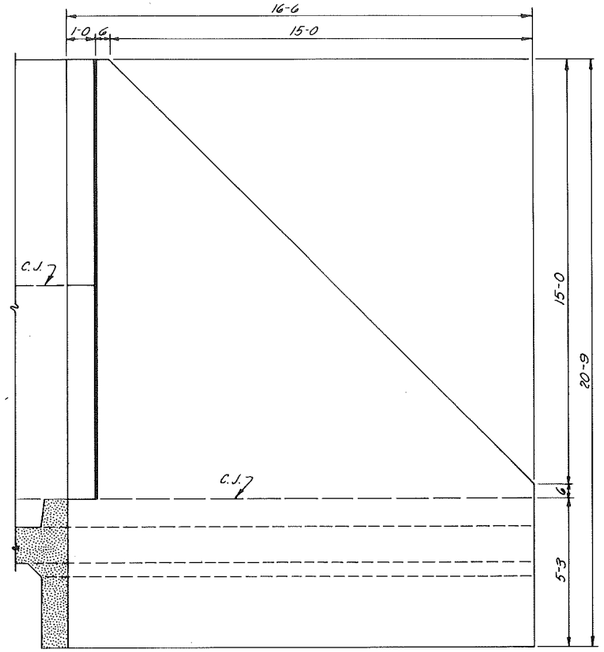
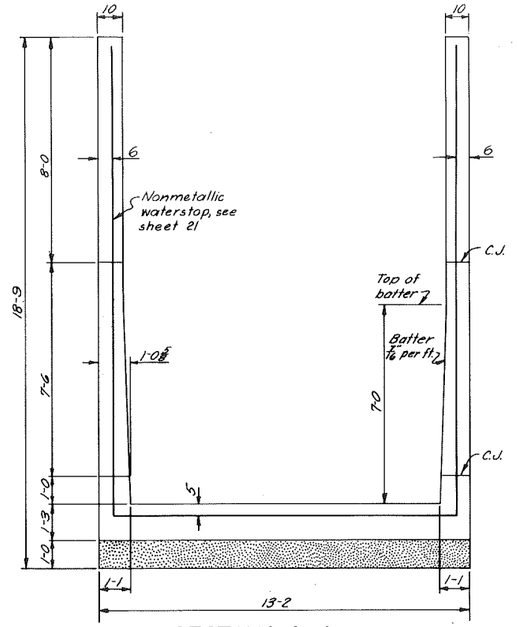
Traced		Title	
Checked R.D.S.	10-73	Sheet No. 12 of 40	Drawing No. 5,E-29,772



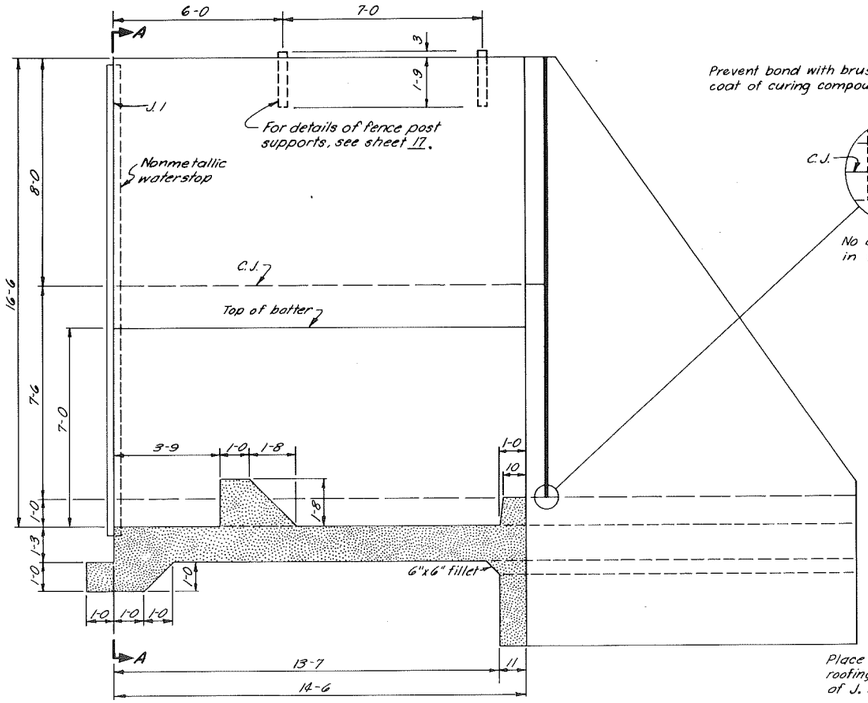
SECTION C-C



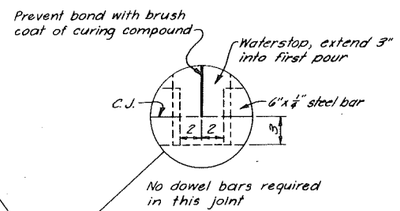
SECTION B-B

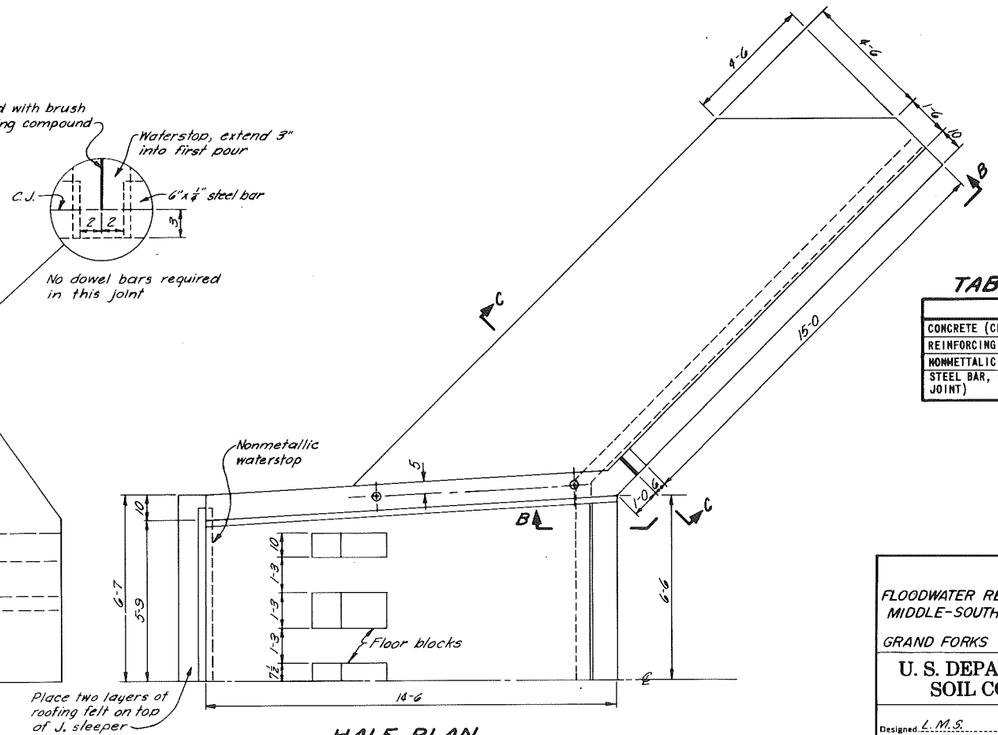


SECTION A-A



SECTION ON CENTERLINE





HALF PLAN

NOTES:

1. C.J. = CONSTRUCTION JOINT.
2. J.= JOINT.
3. FOR DETAILS OF WATERSTOP AND DOWEL BARS, SEE SHEET 21.
4. FOR DETAILS OF PLATE CONSTRUCTION JOINT, SEE SHEET 19.

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	52.9
REINFORCING STEEL	LB.	7,168.0
NONMETTALIC WATERSTOP	LIN.FT.	77-6
STEEL BAR, 6" X 1/4" (CONSTRUCTION JOINT)	LIN.FT.	92-0

0 1 2 3 4
Scale in feet

SAF OUTLET

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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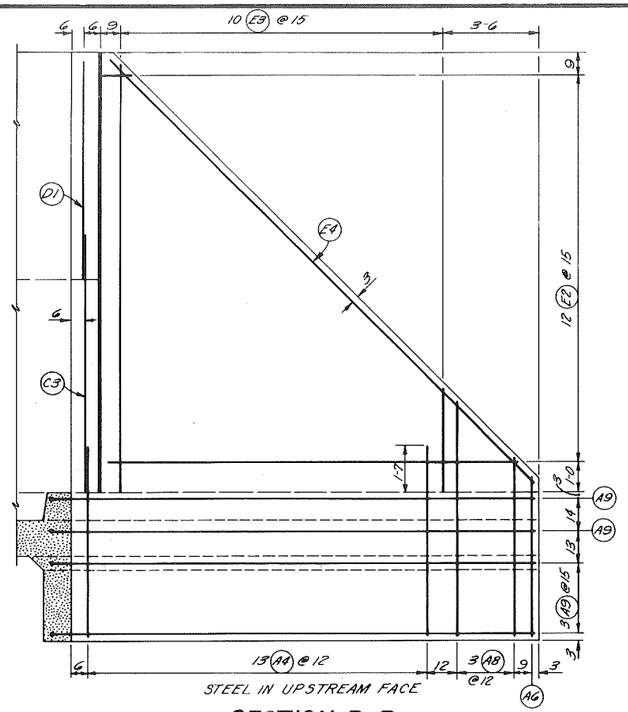
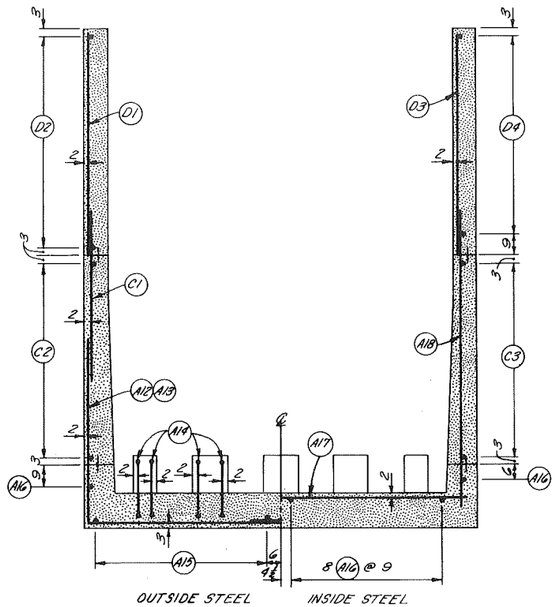
Drawn H.R.H.	12-71	Title	
Traced		Title	
Checked R.O.S.	10-71	Sheet No. 13 of 40	Drawing No. 5,E-29,772



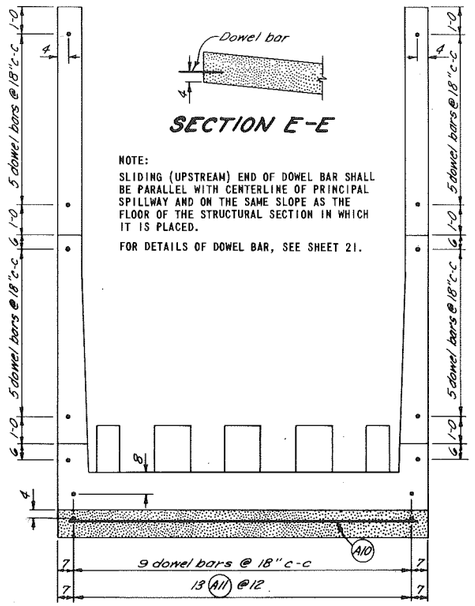
STEEL IN UPSTREAM FACE

SECTION B-B



OUTSIDE STEEL INSIDE STEEL

SECTION D-D

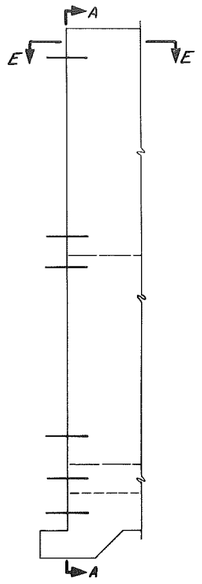


SECTION A-A

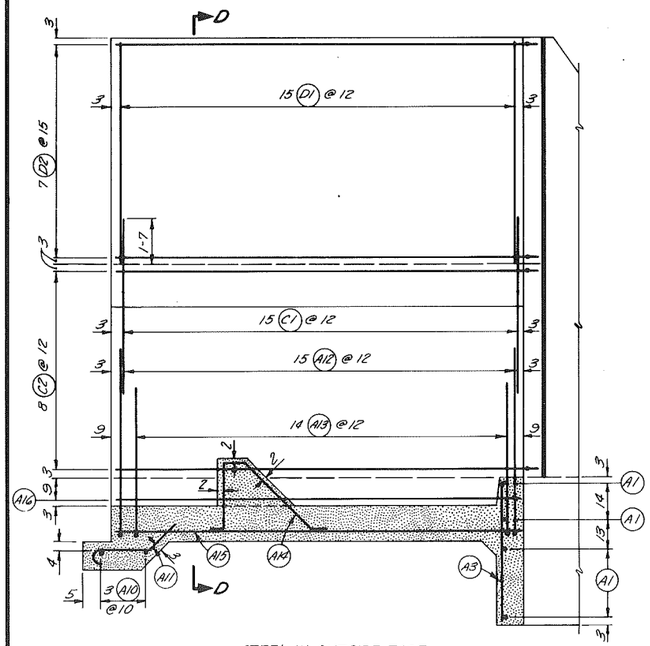
SECTION E-E

NOTE:
SLIDING (UPSTREAM) END OF DOWEL BAR SHALL BE PARALLEL WITH CENTERLINE OF PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH IT IS PLACED.

FOR DETAILS OF DOWEL BAR, SEE SHEET 21.



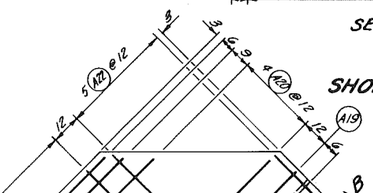
PARTIAL SIDEWALL ELEVATION

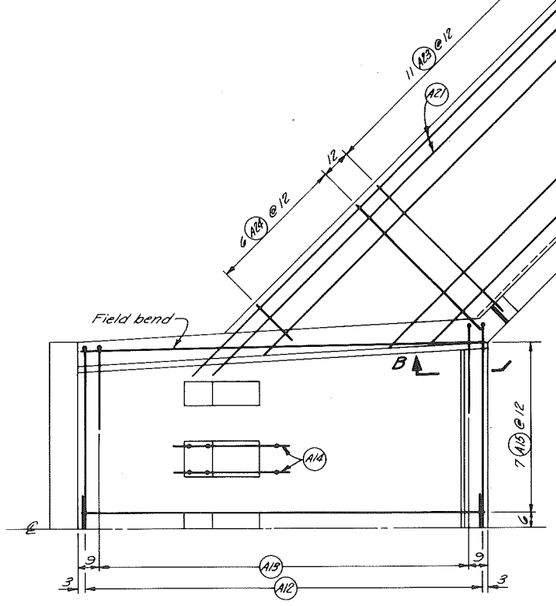


STEEL IN OUTSIDE FACE

SECTION ON CENTERLINE

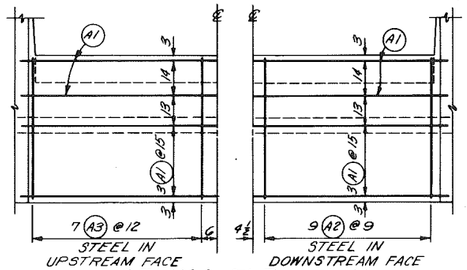
DETAILS OF JOINT I SHOWING LOCATION OF DOWEL BARS





STEEL IN BOTTOM FACE

HALF PLAN



STEEL IN UPSTREAM FACE

STEEL IN DOWNSTREAM FACE

TOEWALL ELEVATION

0 1 2 3 4
Scale in feet

SAF OUTLET

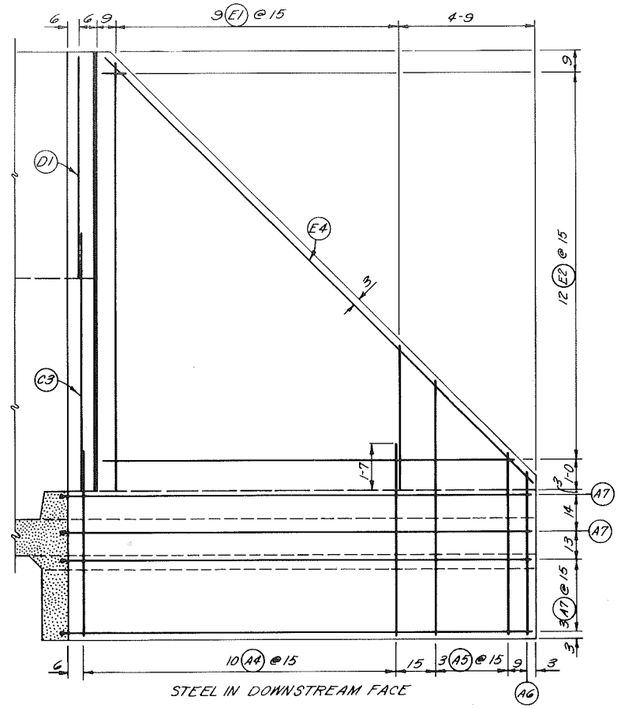
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

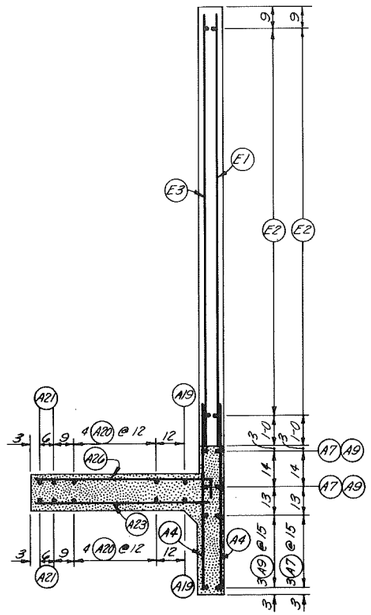
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 10-71	Approved by	
Drawn H.R.H.	12-71	Title	
Traced		Title	
Checked R.D.S.	1-74	Sheet No 14 of 90	Drawing No. 5, E-29, 772



STEEL IN DOWNSTREAM FACE

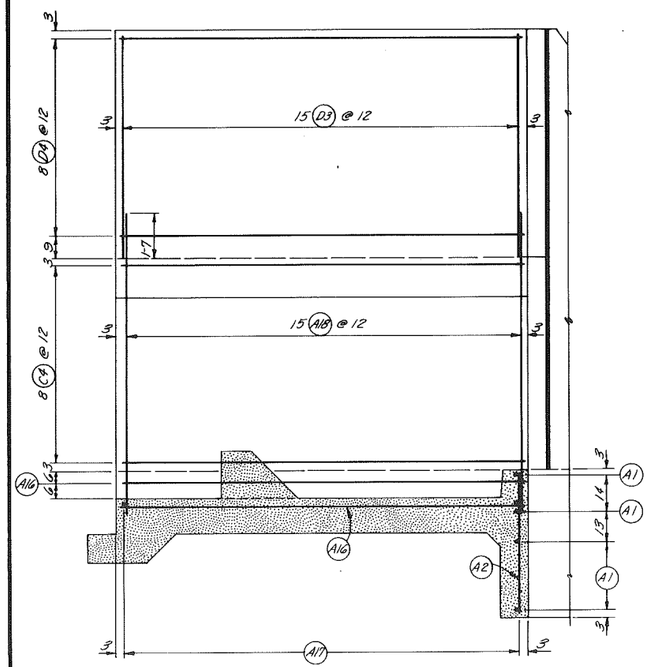
SECTION B-B



SECTION C-C

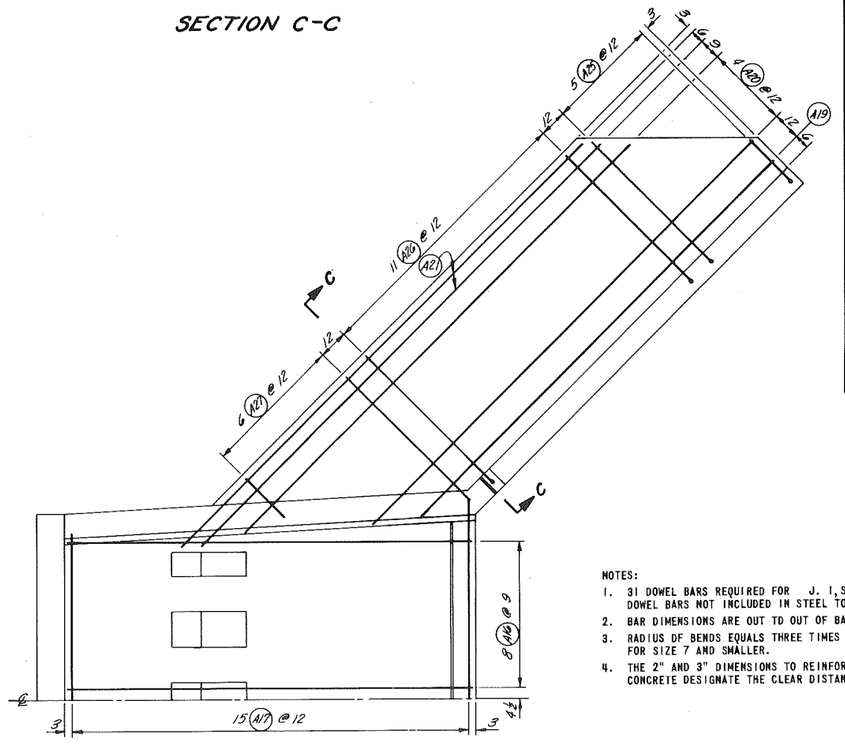
STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	985-0	658.0
5	4,311-5	4,497.0
6	195-0	293.0
7	841-6	1,720.0
TOTAL WEIGHT		7,168.0



STEEL IN INSIDE FACE

SECTION ON CENTERLINE



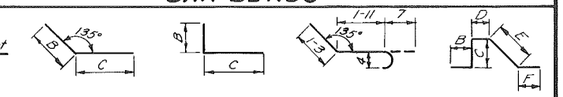
STEEL IN TOP FACE

HALF PLAN

NOTES:

1. 31 DOWEL BARS REQUIRED FOR J. I, SEE SHEET 14 FOR DETAILS. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR FOR SIZE 7 AND SMALLER.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.

BAR BENDS



TYPE 1 TYPE 19 TYPE 21 TYPE 24 TYPE 25

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	D	E	F
A1	5	10	13-6	135-0	1					
A2	7	18	4-10	87-0	1					
A3	5	14	4-10	67-8	1					
A4	5	46	7-0	322-0	1					
A5	5	2 SETS OF 3 BARS	6-6 TO 9-0 @ 1-3 INCR.	46-6	1					
A6	5	4	5-9	23-0	1					
A7	5	10	18-0	180-0	19	1-9	16-3			
A8	5	2 SETS OF 3 BARS	6-6 TO 8-6 @ 1-0 INCR.	45-0	1					
A9	5	10	18-3	182-6	19	1-9	16-6			
A10	5	3	12-9	38-3	1					
A11	5	13	3-9	48-9	24		SEE BAR BENDS			
A12	7	30	14-9	442-6	21	6-6	8-3			
A13	7	28	8-3	231-0	21	3-0	5-3			
A14	5	15	7-3	108-9	25	0-6	2-3	0-8	3-3	0-7
A15	4	14	14-3	199-6	1					
A16	5	20	14-3	285-0	1					
A17	6	1 SET OF 15 BARS	11-10 TO 14-2 @ 2" INCR.	195-0	1					
A18	5	30	10-6	315-0	1					
A19	5	4	17-9	71-0	1					
A20	4	16	19-3	308-0	1					
A21	7	4	20-3	81-0	1					
A22	4	2 SETS OF 5 BARS	2-0 TO 6-0 @ 1-0 INCR.	40-0	1					
A23	4	22	6-3	137-6	1					
A24	4	2 SETS OF 6 BARS	2-0 TO 6-2 @ 10" INCR.	49-0	1					
A25	4	2 SETS OF 5 BARS	2-9 TO 6-9 @ 1-0 INCR.	47-6	21	0-9	2-0 TO 6-0 @ 1-0 INCR.			
A26	4	22	7-0	154-0	21	0-9	6-3			
A27	4	2 SETS OF 6 BARS	2-3 TO 6-0 @ 9" INCR.	49-6	1					
C1	5	30	6-3	187-6	1					
C2	5	16	15-0	240-0	19	0-9	14-3			
C3	5	4	9-0	36-0	1					
C4	5	16	14-3	228-0	1					
D1	5	34	7-9	263-6	1					
D2	5	14	15-0	210-0	19	0-9	14-3			
D3	5	30	7-9	232-6	1					
D4	5	16	14-3	228-0	1					
E1	5	2 SETS OF 9 BARS	5-0 TO 15-0 @ 1-3 INCR.	180-0	1					
E2	5	4 SETS OF 12 BARS	0-9 TO 14-6 @ 1-4 INCR.	366-0	1					
E3	5	2 SETS OF 10 BARS	3-9 TO 15-0 @ 1-3 INCR.	187-6	1					
E4	5	4	21-0	84-0	1					

0 1 2 3 4
Scale in feet

SAF OUTLET

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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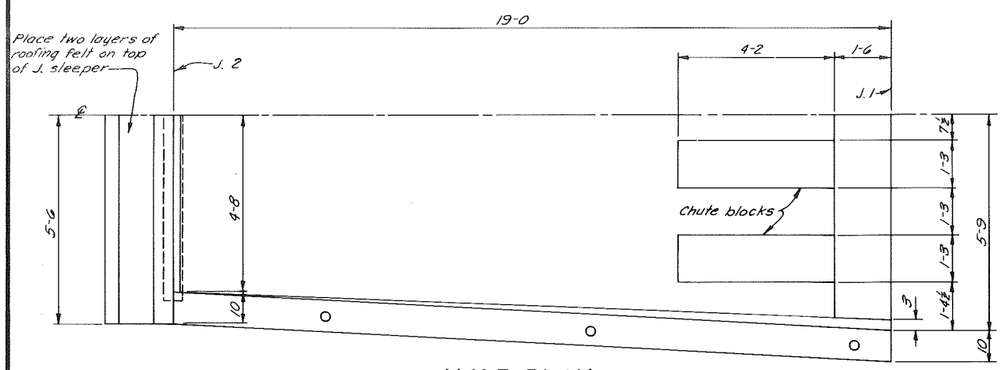
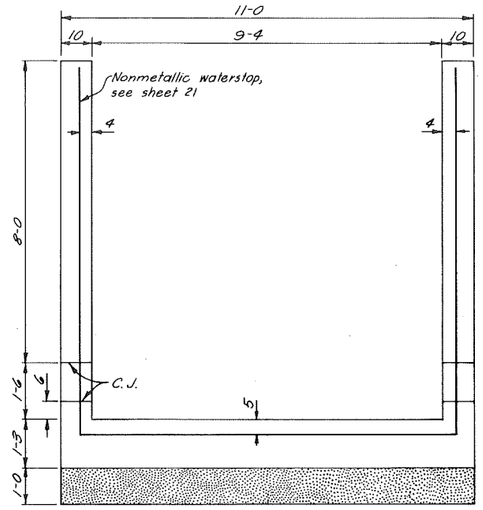


HALF PLAN

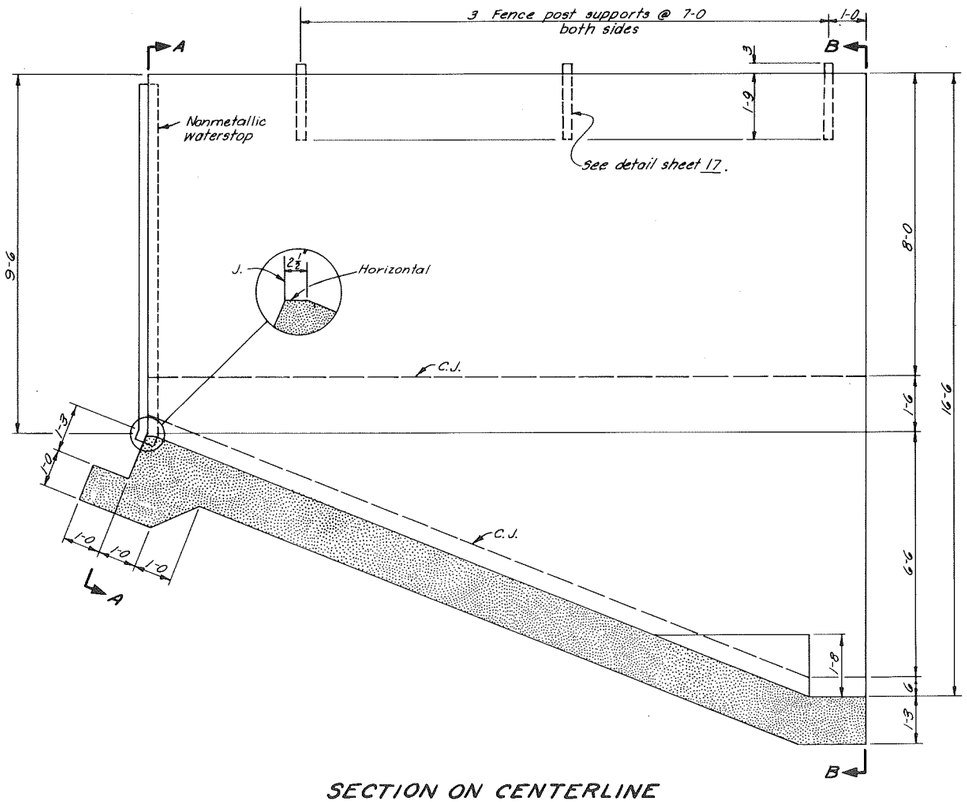
STRUCTURE SYMMETRICAL ABOUT ℄



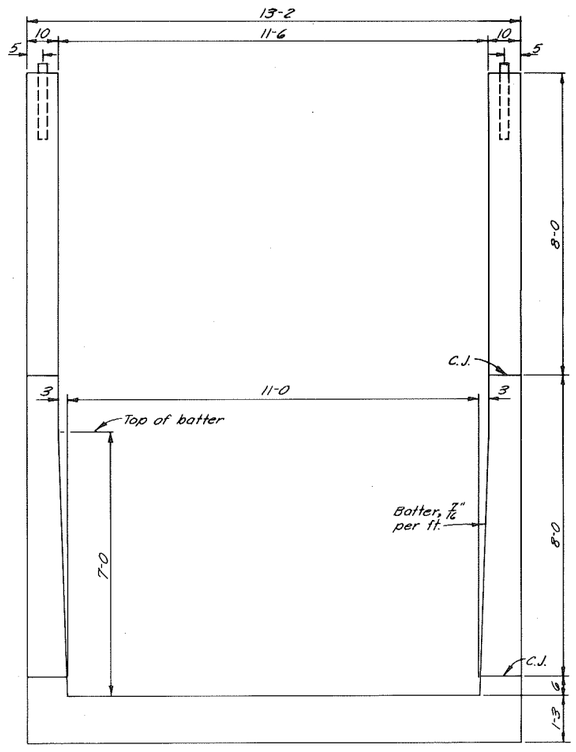
SECTION A-A

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	29.2
REINFORCING STEEL	LB.	5,250
NONMETALLIC	LIN.FT.	19-10
STEEL BAR, 6" X 1/4" (CONSTRUCTION JOINT)	LIN.FT.	79-0



SECTION ON CENTERLINE



SECTION B-B

NOTES:

1. J.= JOINT.
2. C.J.= CONSTRUCTION JOINT.
3. FOR DETAILS OF WATERSTOP AND DOWEL BARS, SEE SHEET 21.
4. FOR DETAILS OF PLATE CONSTRUCTION JOINT, SEE SHEET 19.

0 1 2 3 4

Scale in feet

DETAILS OF CHUTE (J. 1 – J. 2)

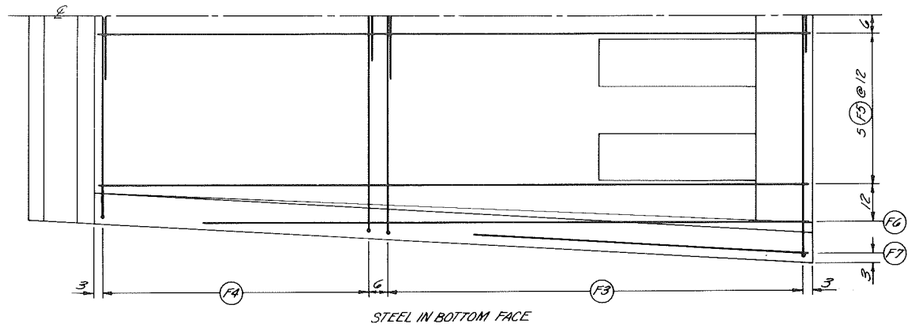
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

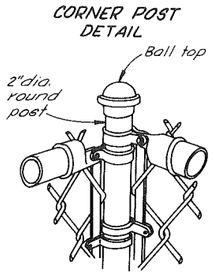
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

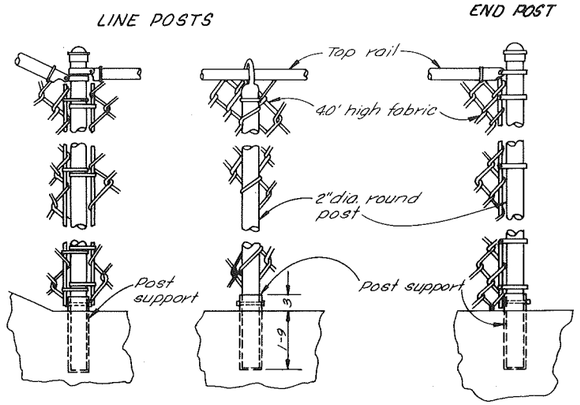
	Date	
Designed H.R.H.	10-71	Approved by
Drawn H.R.H.	12-71	Title
Traced		Title
Checked R.D.S.	1-74	Sheet No. 16 of 40 — Drawing No. 5,E-29,772



STEEL IN BOTTOM FACE

HALF PLAN

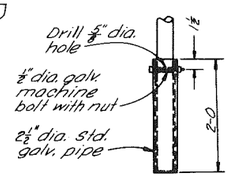




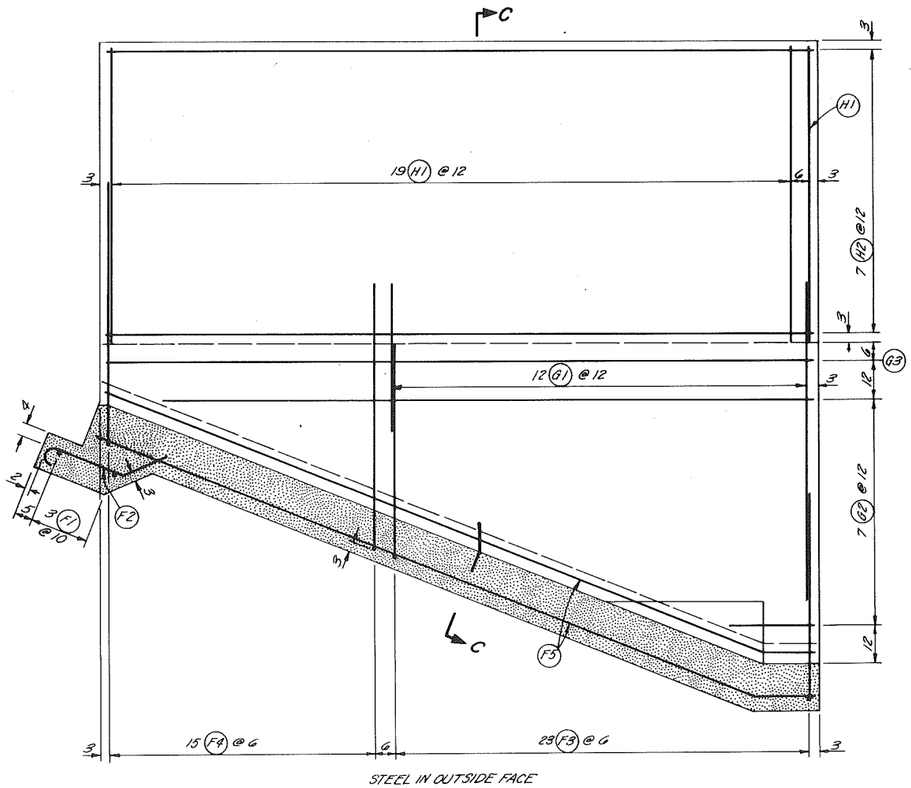
DETAILS OF CHAIN LINK FENCE

NOTES:

1. POST SUPPORTS ARE 2 1/2" DIA. STANDARD GALV. PIPE 2.0' LONG. SUPPORTS WILL BE EMBEDDED 21" IN CONCRETE. EMBEDDED ENDS SHALL BE CAPPED TO PREVENT CONCRETE FROM ENTERING PIPE.
2. FENCE POSTS SHALL BE BOLTED TO POST SUPPORTS WITH 0.5" DIA. GALV. MACHINE BOLTS 3" LONG.
3. FABRIC SHALL BE 9 GAUGE, GALVANIZED, 4.0' HIGH.
4. POSTS SHALL BE 2" DIA., GALVANIZED.
5. FABRIC TO BE INSTALLED TOWARDS OUTSIDE FACE OF CONCRETE WALL WITH POST ON THE INSIDE.

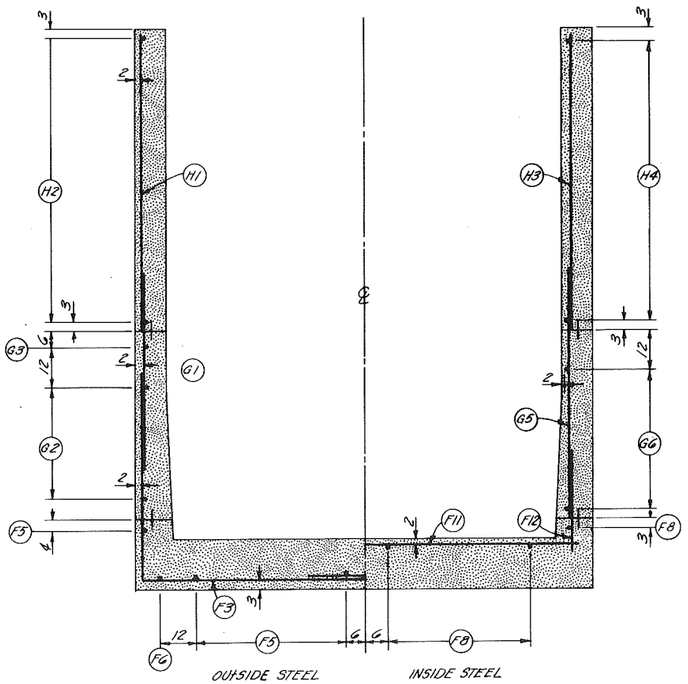


POST SUPPORT DETAIL
N. T. S.



STEEL IN OUTSIDE FACE

SECTION ON CENTERLINE



SECTION C-C

TABLE OF QUANTITIES FOR CHAIN LINK FENCE

ITEM	UNIT	QUANTITY
4.0' HIGH, 9 GAUGE FABRIC AND HARDWARE	LIN.FT.	112.0
2" DIA. O.D. STEEL POSTS, GALV.	EACH	18.0
2 1/2" DIA. I.S. STD. GALV. PIPE AS PER DETAIL	EACH	18.0

0 1 2 3 4
Scale in feet

DETAILS OF CHUTE (J. 1 – J. 2)

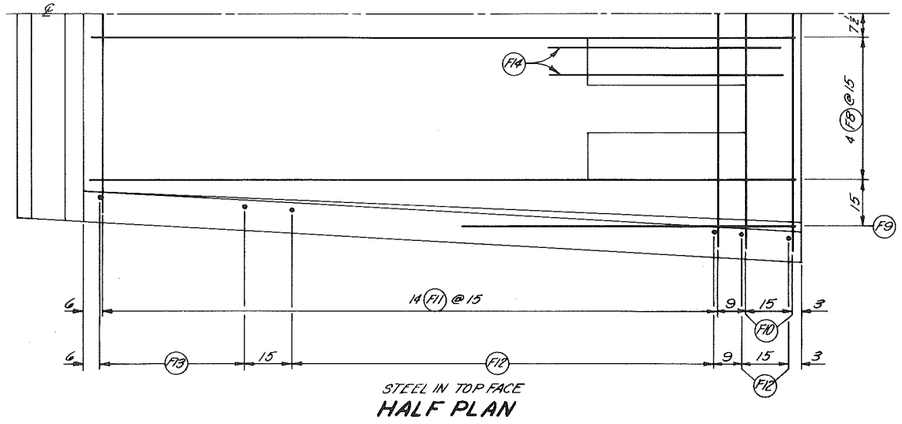
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

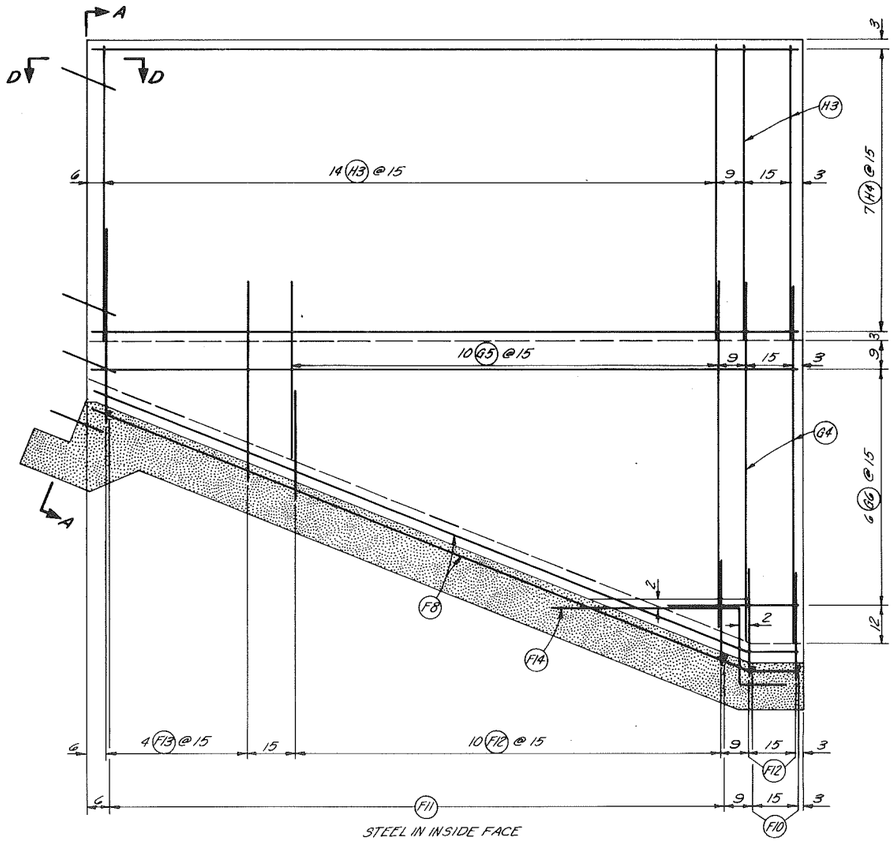
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.R.H.	Date 10-71	Approved by	
Drawn		Title	
Traced		Title	
Checked R.D.S.	1-74	Sheet No. 17 of 40	Drawing No. 5,E-29,772



STEEL IN TOP FACE

HALF PLAN



STEEL IN INSIDE FACE

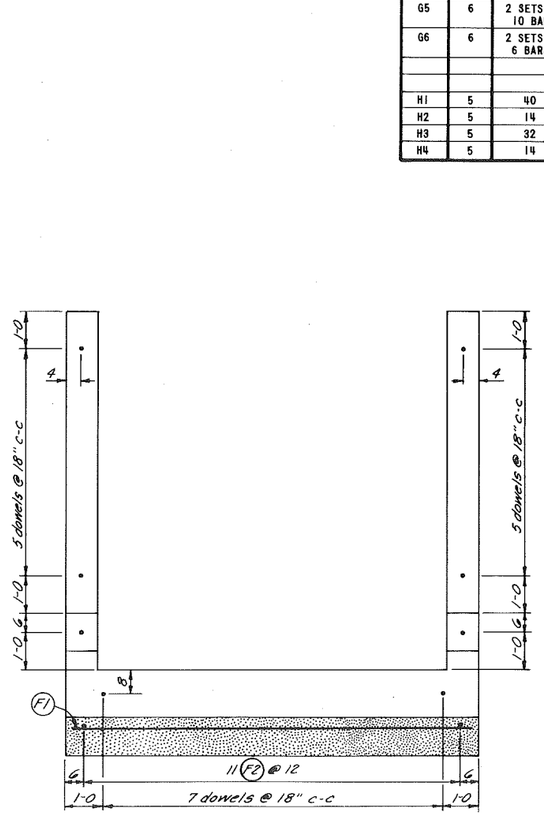
SECTION ON CENTERLINE

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	466-0	311.3
5	1,156-6	1,206.2
6	894-4	1,343.3
7	1,169-0	2,389.4
TOTAL WEIGHT		5,250.2

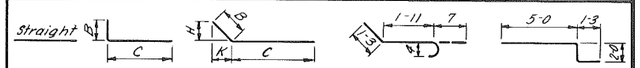
NOTES:

1. 19 DOWEL BARS REQUIRED FOR J. 2. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUAL THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSION TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.



SECTION A-A
DETAILS OF JOINT 2

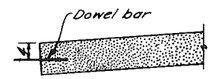
BAR BENDS



TYPE 1 TYPE 21 TYPE 23 TYPE 24 TYPE 31

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
F1	5	3	10-9	32-3	1				
F2	5	11	3-9	41-3	24		SEE BAR BENDS		
F3	7	46	13-0	598-0	21	5-6	7-6		
F4	7	30	14-0	420-0	21	7-0	7-0		
F5	4	12	20-3	243-0	23	1-6	18-9	0-7	1-5
F6	4	2	17-0	34-0	23	1-6	16-9	0-7	1-5
F7	4	2	9-3	18-6	23	1-6	7-9	0-7	1-5
F8	6	10	20-0	200-0	23	1-3	18-9	0-7	1-5
F9	6	2	9-3	18-6	23	1-3	8-0	0-7	1-5
F10	6	2	12-6	25-0	1				
F11	6	1 SET OF 14 BARS	10-4 TO 12-6 @ 2" INCR.	159-10	1				
F12	6	24	3-0	72-0	1				
F13	6	8	5-3	42-0	1				
F14	6	8	8-3	66-0	31		SEE BAR BENDS		
G1	7	2 SETS OF 12 BARS	4-0 TO 8-7 @ 5" INCR.	151-0	1				
G2	4	2 SETS OF 7 BARS	2-0 TO 17-0 @ 2-6 INCR.	133-0	1				
G3	4	2	18-9	37-6	1				
G4	6	4	9-9	39-0	1				
G5	6	2 SETS OF 10 BARS	4-9 TO 9-3 @ 6" INCR.	140-0	1				
G6	6	2 SETS OF 6 BARS	3-6 TO 18-6 @ 3-0 INCR.	132-0	1				
H1	5	40	7-9	310-0	1				
H2	5	14	18-9	262-6	1				
H3	5	32	7-9	248-0	1				
H4	5	14	18-9	262-6	1				



SECTION D-D

NOTE:

SLIDING (UPSTREAM) END OF DOWEL BAR SHALL BE PARALLEL WITH CENTERLINE OF PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH IT IS PLACED.

FOR DETAIL OF DOWEL BAR, SEE SHEET 21.

0 1 2 3 4
Scale in feet

DETAILS OF CHUTE (J. 1 — J. 2)

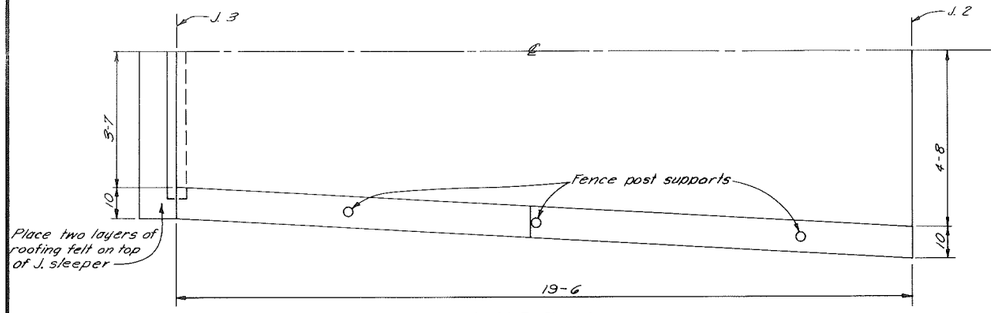
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

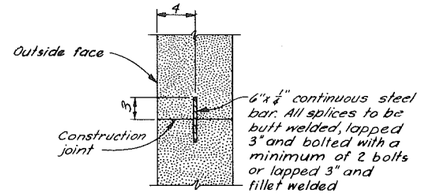
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

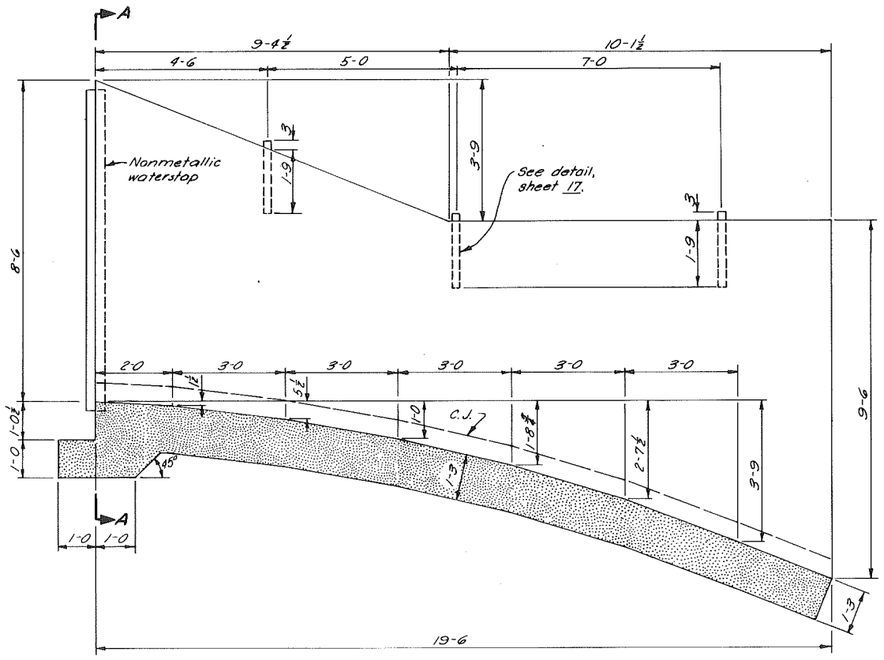
	Date		
Designed H.R.H.	10-71	Approved by.	
Drawn H.R.H.	12-71	Title	
Traced		Title	
Checked R.D.S.	1-74	Sheet No. 18 of 40	Drawing No. 5,E-29,772



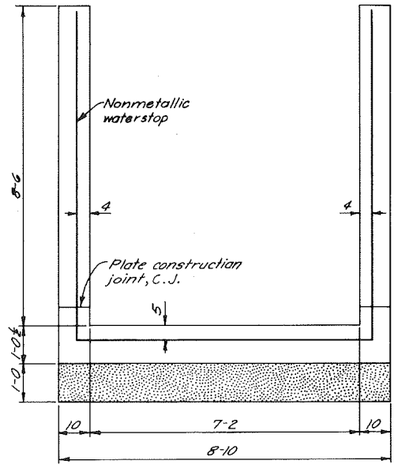
HALF PLAN
STRUCTURE SYMMETRICAL ABOUT ℄



DETAILS OF PLATE CONSTRUCTION JOINT (OUTLET TO JOINT 3)
(Not to scale)



SECTION ON CENTERLINE



SECTION A-A

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU. YD.	18.6
REINFORCING STEEL	LB.	3032
NONMETALLIC WATERSTOP	LIN. FT.	25-8
STEEL BAR, 6" X 1/4" (CONSTRUCTION JOINT)	LIN. FT.	40-0

NOTES:
1. J. = JOINT.
2. C.J. = CONSTRUCTION JOINT.
3. FOR DETAILS OF WATERSTOP AND DOWEL BARS, SEE SHEET 21.

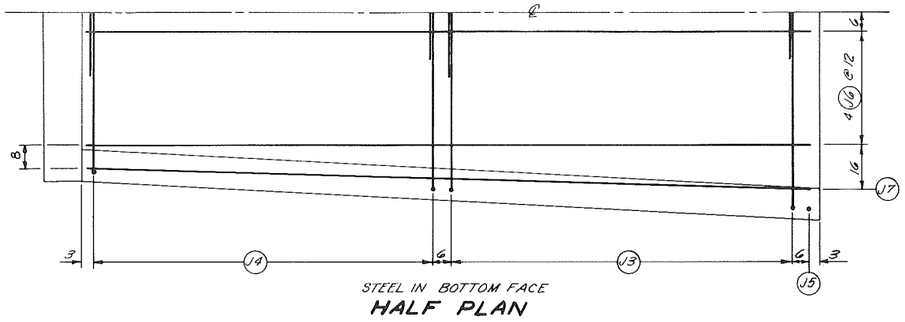
0 1 2 3 4
Scale in feet

DETAILS OF CHUTE (J2 – J3)

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

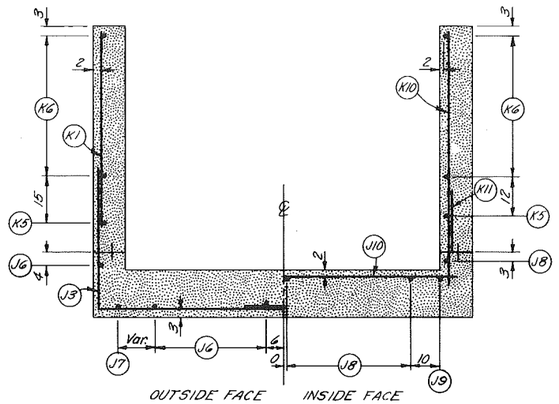
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S.	11-71	Approved by	
Drawn H.R.H.	12-71	Title	
Traced		Title	
Checked R.D.S.	1-74	Sheet No 19 of 40	Drawing No. S.E-29,772

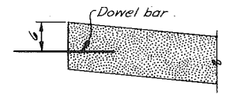


STEEL IN BOTTOM FACE

HALF PLAN



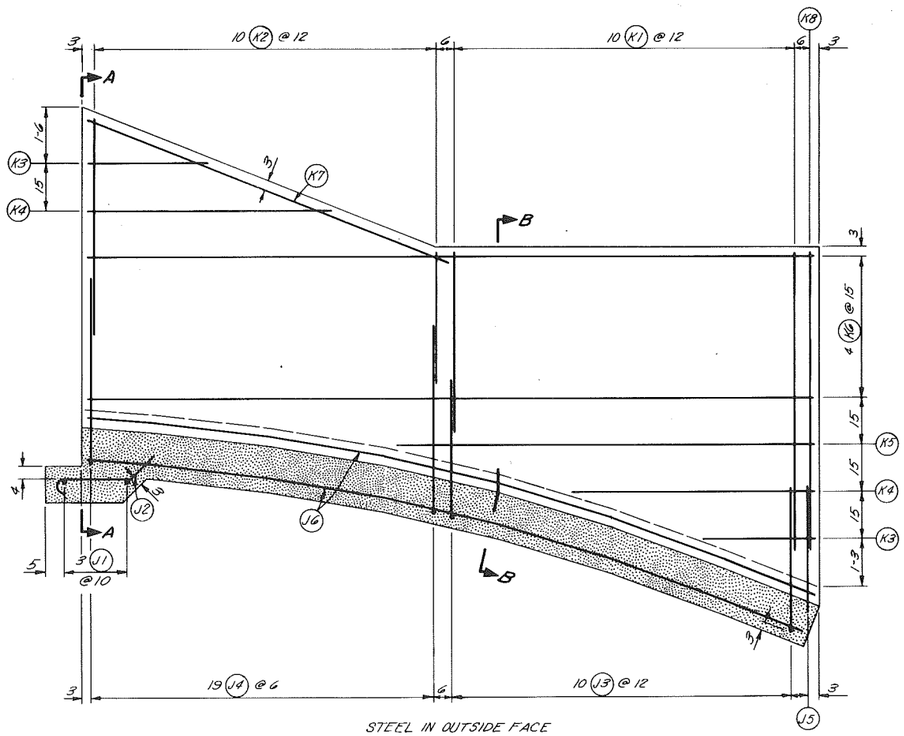
SECTION B-B



SECTION C-C
(Not to scale)

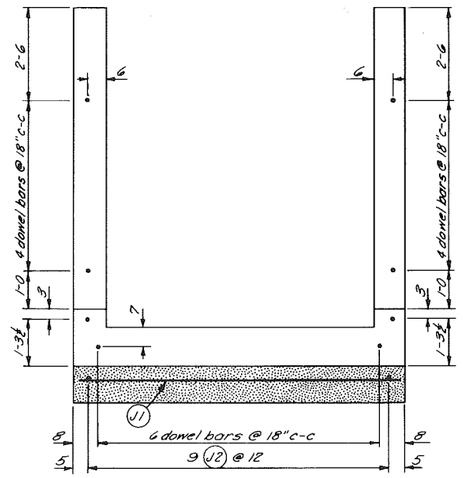
NOTE:
SLOING (UPSTREAM) END OF DOWEL BAR SHALL BE PARALLED WITH THE CENTERLINE OF THE PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH IT IS PLACED.

FOR DETAIL OF DOWEL BAR, SEE SHEET 21.

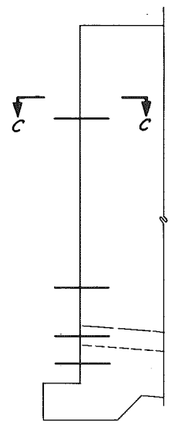


STEEL IN OUTSIDE FACE

SECTION ON CENTERLINE



SECTION A-A



PARTIAL SIDEWALL ELEVATION

DETAILS OF JOINT 3

0 1 2 3 4
Scale in feet

DETAILS OF CHUTE (J2 – J3)

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
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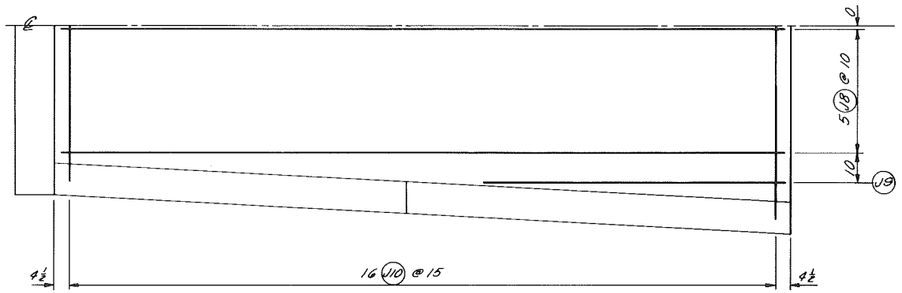
Checked R.D.S.	10-73	Sheet No. 20 of 40	Drawing No. 5,E-29,772



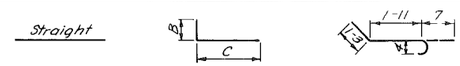
STEEL IN TOP FACE

HALF PLAN

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	195-0	130
5	1,334-10	1,392
6	148-0	222
7	630-0	1,288
TOTAL WEIGHT		3,032

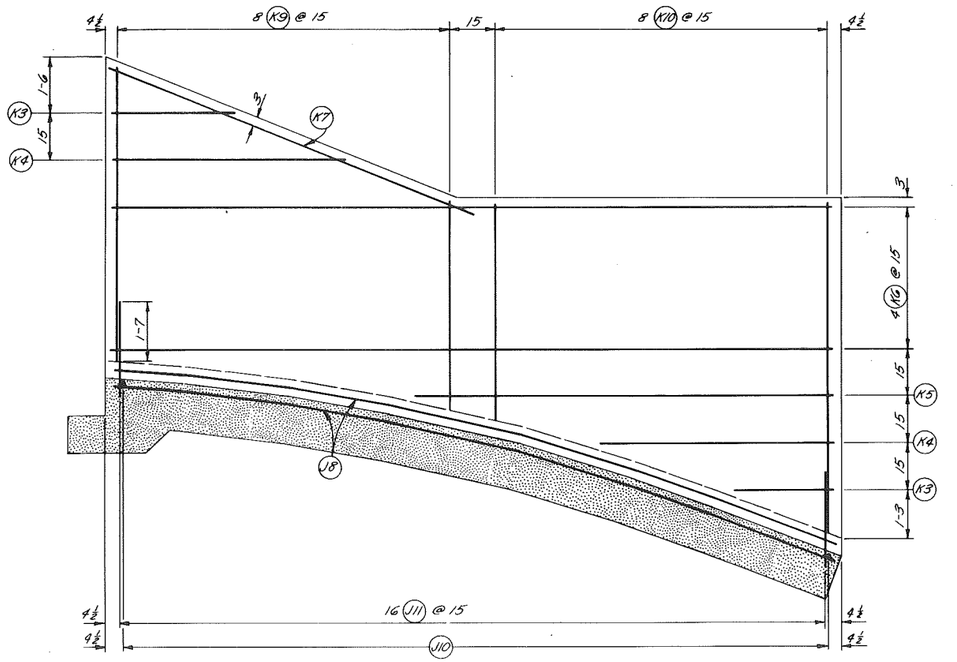
BAR BENDS



TYPE 1 TYPE 21 TYPE 24

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C
J1	5	3	8-6	25-6	1		
J2	5	9	3-9	33-9	24	SEE BAR BENDS	
J3	7	20	10-3	205-0	21	3-9	6-6
J4	7	38	11-0	418-0	21	5-0	6-0
J5	7	2	3-6	7-0	1		
J6	4	10	19-6	195-0		FIELD BEND	
J7	5	2	19-6	39-0		FIELD BEND	
J8	5	11	19-6	214-6		FIELD BEND	
J9	5	2	8-0	16-0		FIELD BEND	
J10	6	1 SET OF 16 BARS	8-0 TO 10-6 @ 2" INCR.	148-0	1		
J11	5	32	2-6	80-0	1		
K1	5	2 SETS OF 10 BARS	5-0 TO 8-0 @ 4" INCR.	130-0	1		
K2	5	2 SETS OF 10 BARS	3-6 TO 5-9 @ 3" INCR.	92-6	1		
K3	5	8	3-0	24-0	1		
K4	5	8	6-3	50-0	1		
K5	5	4	11-0	44-0	1		
K6	5	16	19-3	308-0	1		
K7	5	4	10-3	41-0	1		
K8	5	2	8-0	16-0	1		
K9	5	2 SETS OF 8 BARS	5-5 TO 7-9 @ 4" INCR.	105-4	1		
K10	5	2 SETS OF 8 BARS	5-9 TO 8-8 @ 5" INCR.	115-4	1		



STEEL IN INSIDE FACE

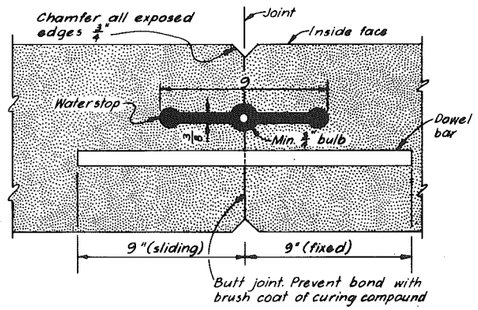
SECTION ON CENTERLINE

NOTES:

1. DOWEL BARS SHALL BE 3/4" DIA. SMOOTH STEEL BARS COATED ON SLIDING END TO PREVENT BOND. COATING SHALL BE OIL, ASPHALT, OR OTHER METHOD ACCEPTED BY THE ENGINEER.
2. NONMETALLIC WATERSTOP SHALL BE CLASS II, TYPE D, SIZE 20 WITH MIN. 3/4" INSIDE DIAMETER BULB.
3. DOWEL BARS ARE TO BE PLACED PARALLEL TO THE CENTERLINE OF THE PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH THE SLIDING (UPSTREAM) END WILL BE LOCATED.

NOTES:

1. 18 DOWEL BARS REQUIRED FOR J. 3, SEE SHEET 20 FOR DETAILS. DOWEL BARS ARE NOT INCLUDED IN THE STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.



DETAIL OF JOINTS 1, 2 & 3
(DOWEL BAR AND WATERSTOP)

Not to scale

0 1 2 3 4
Scale in feet

DETAILS OF CHUTE (J2 – J3)

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
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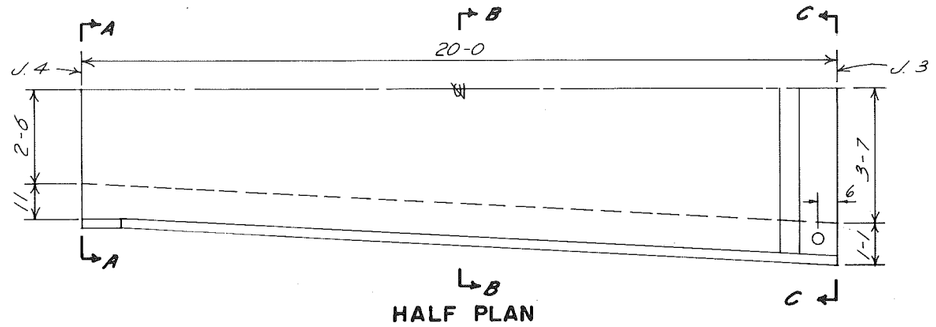
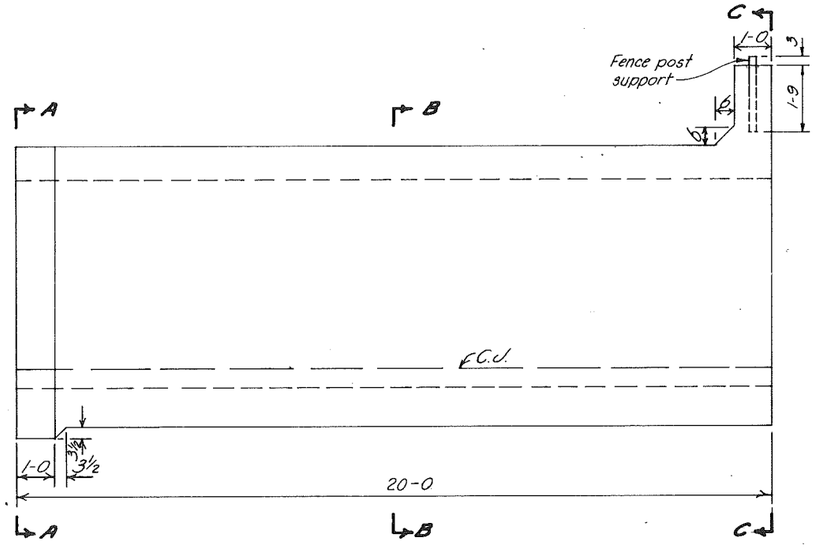
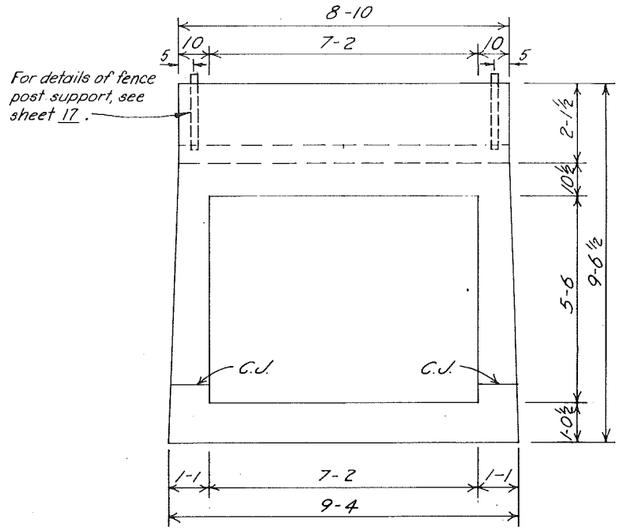


HALF PLAN

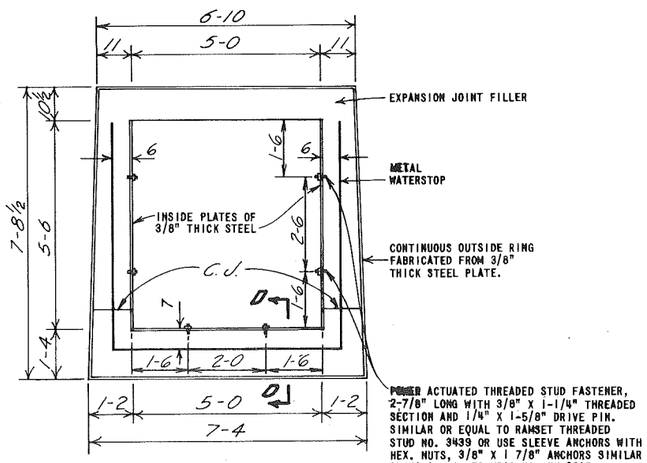


SIDEWALL ELEVATION

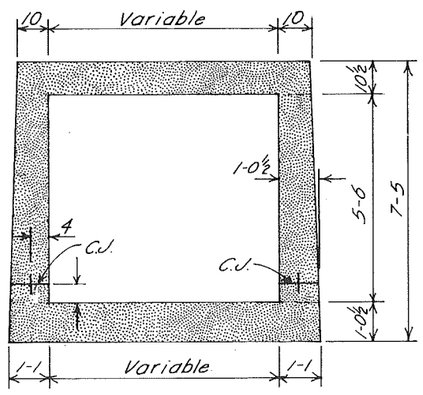


SECTION C-C

NOTES:
1. J.= JOINT.
2. C.J. = CONSTRUCTION JOINT.
3. FOR DETAILS OF SECTION D-D, SEE SHEET 24.
4. FOR DETAILS OF PLATE CONSTRUCTION JOINT, SEE SHEET 24.



SECTION A-A



SECTION B-B

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	20.0
REINFORCING STEEL	LB.	2,775
METAL WATERSTOP	LIN.FT.	18-2
STEEL BAR, 6" X 1/4", CONSTRUCTION JOINT	LIN.FT.	40-0

0 1 2 3 4
Scale in Feet

DETAILS OF TRANSITION

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

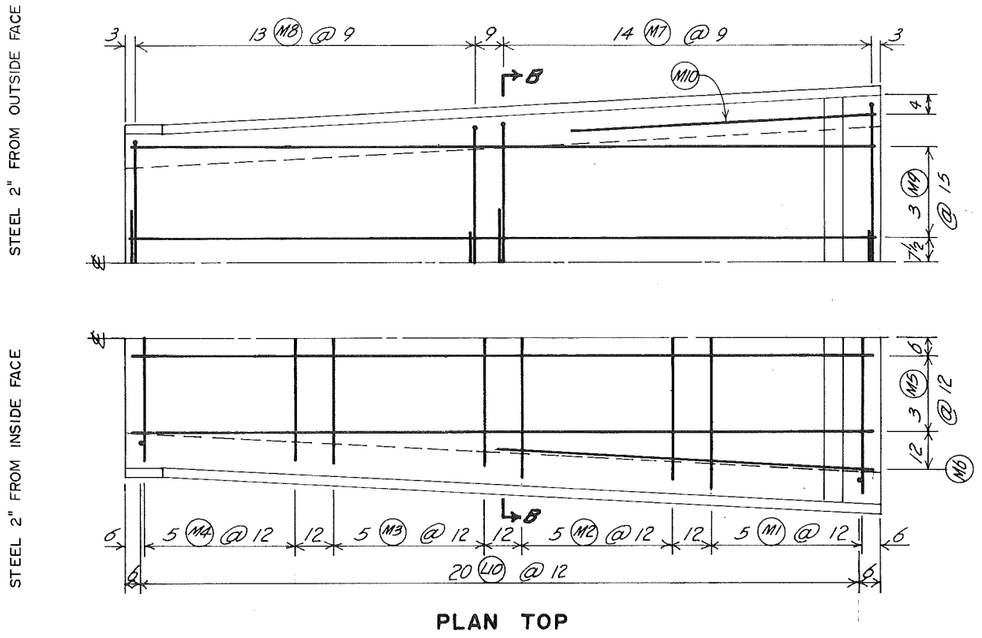
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

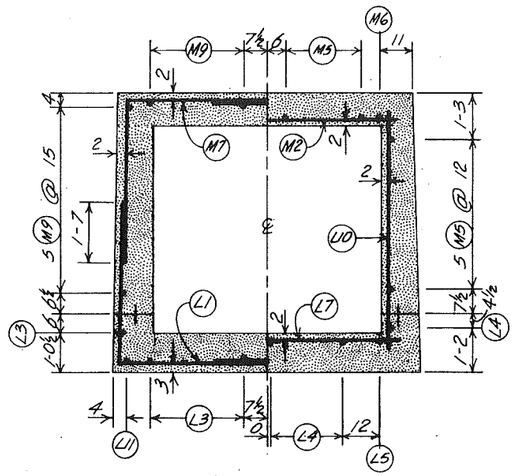
	Date		
Designed L.M.S.	10/71	Approved by	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked C.E.M.	12/71	Sheet No. 22 of 40	Drawing No. 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE 1969 O—347-930

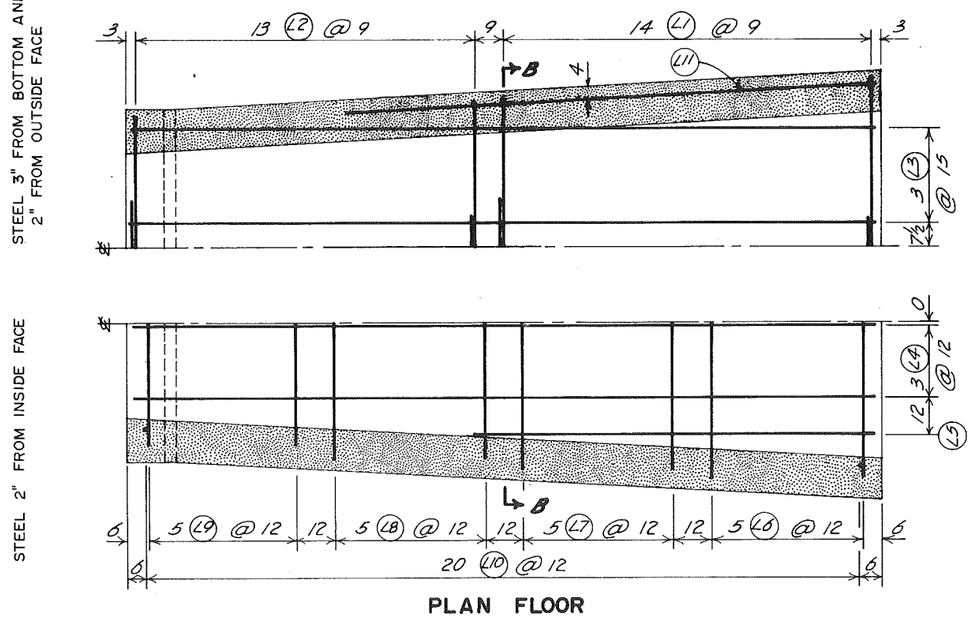
SCS-ENG-313 Rev. 4-69



PLAN TOP



SECTION B-B



PLAN FLOOR

0 1 2 3 4
Scale in Feet

DETAILS OF TRANSITION

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

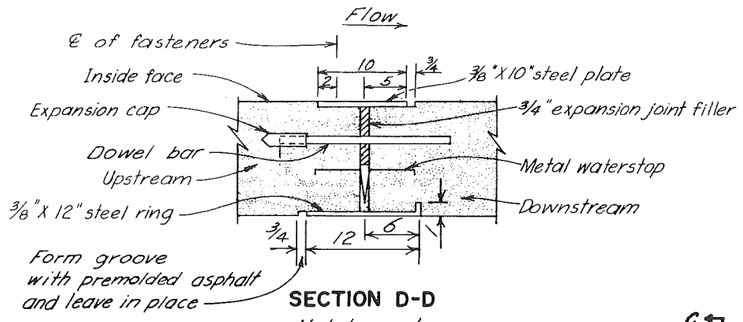
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S.	10/71	Approved by	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked C.E.M.	12/71	Sheet No 23 of 40	Drawing No. 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE : 1967 O - 277-695

SCS-313 (9-64)

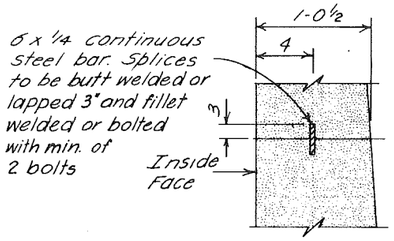
Note: Dowel bars shall be ¾" diameter X 18" long smooth steel bars coated on sliding end to prevent bond. Coating shall be oil, asphalt or other method accepted by the engineer.



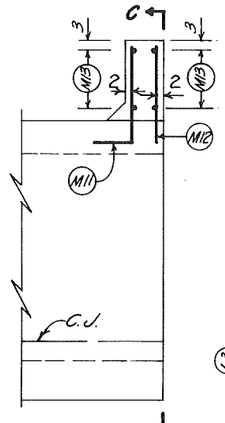
SECTION D-D
Not to scale

STEEL TOTALS

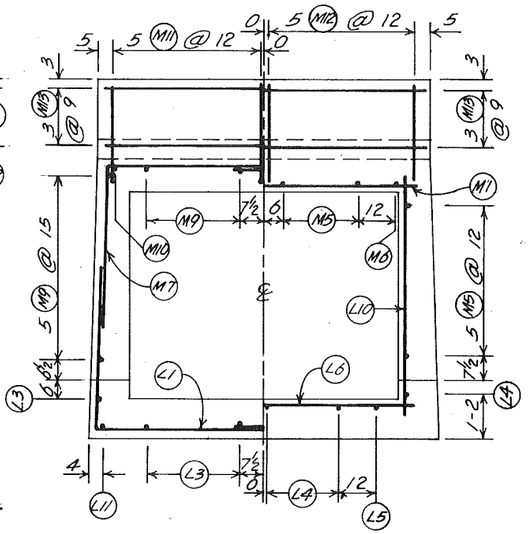
SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	569-0	380
5	1810-3	1,888
6	148-9	223
7	138-9	284
TOTAL WEIGHT		2,775



DETAILS OF PLATE CONSTRUCTION JOINT
J. 3 TO J. 4
Not to scale



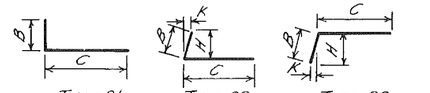
PARTIAL SIDEWALL ELEVATION



OUTSIDE FACE INSIDE FACE

SECTION C-C

BAR BENDS

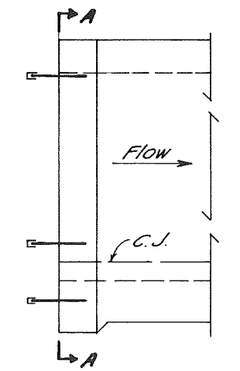


STEEL SCHEDULE

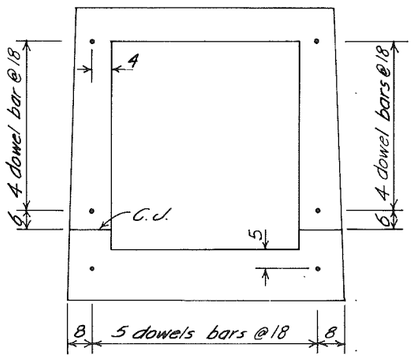
MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
L1	5	28	9-6	266-0	22	4-3	5-3	4-3	0-1 3/4
L2	5	26	9-0	234-0	22	4-3	4-9	4-3	0-1 3/4
L3	4	8	19-9	158-0	1				
L4	5	7	19-9	138-3	1				
L5	5	2	11-0	22-0	1				
L6	6	5	8-3	41-3	1				
L7	6	5	7-9	38-9	1				
L8	6	5	7-3	36-3	1				
L9	6	5	6-6	32-6	1				
L10	5	40	6-6	260-0	1				
L11	4	2	14-0	28-0	1				
M1	7	5	7-9	38-9	1				
M2	7	5	7-3	36-3	1				
M3	7	5	6-9	33-9	1				
M4	7	5	6-0	30-0	1				
M5	5	16	19-9	316-0	1				
M6	5	2	10-0	20-0	1				
M7	5	28	9-6	266-0	23	4-4	5-2	4-4	0-1 3/4
M8	5	26	9-0	234-0	23	4-4	4-8	4-4	0-1 3/4
M9	4	16	19-9	316-0	1				
M10	4	2	8-0	16-0	1				
M11	5	9	3-6	31-6	21	1-0	2-6		
M12	5	9	2-6	22-6	1				
M13	4	6	8-6	51-0	1				

NOTES:
1. 13 DOWEL BARS REQUIRED FOR J. 4. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. J. = JOINT.
6. C.J. = CONSTRUCTION JOINT.

DETAILS OF REINFORCING STEEL AT JOINT NO.3

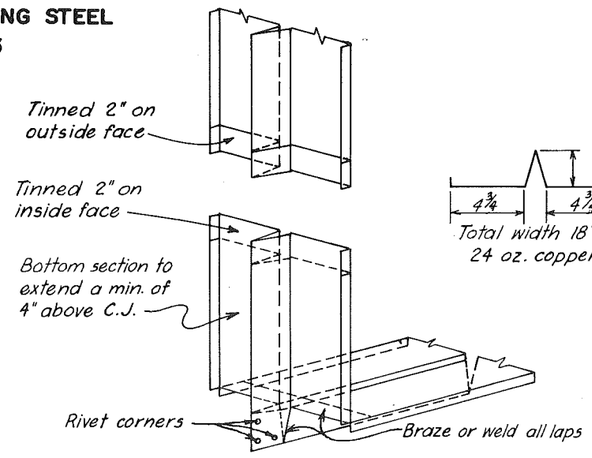


PARTIAL SIDEWALL ELEVATION

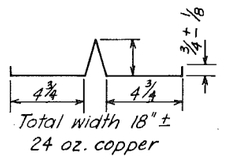


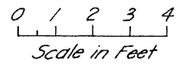
SECTION A-A

DETAILS OF JOINT NO. 4
SHOWING LOCATION OF DOWEL BARS



DETAIL OF METAL WATERSTOP
(J.4)
Not to scale





DETAILS OF TRANSITION

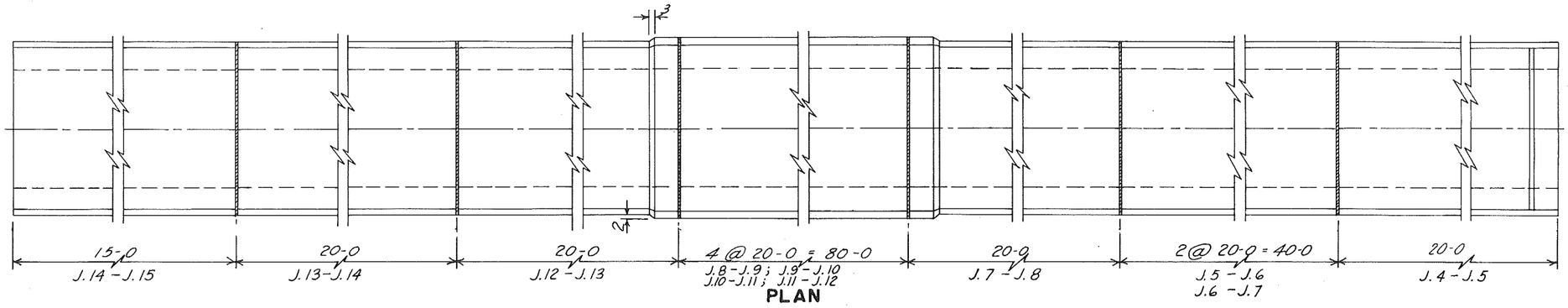
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE - SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

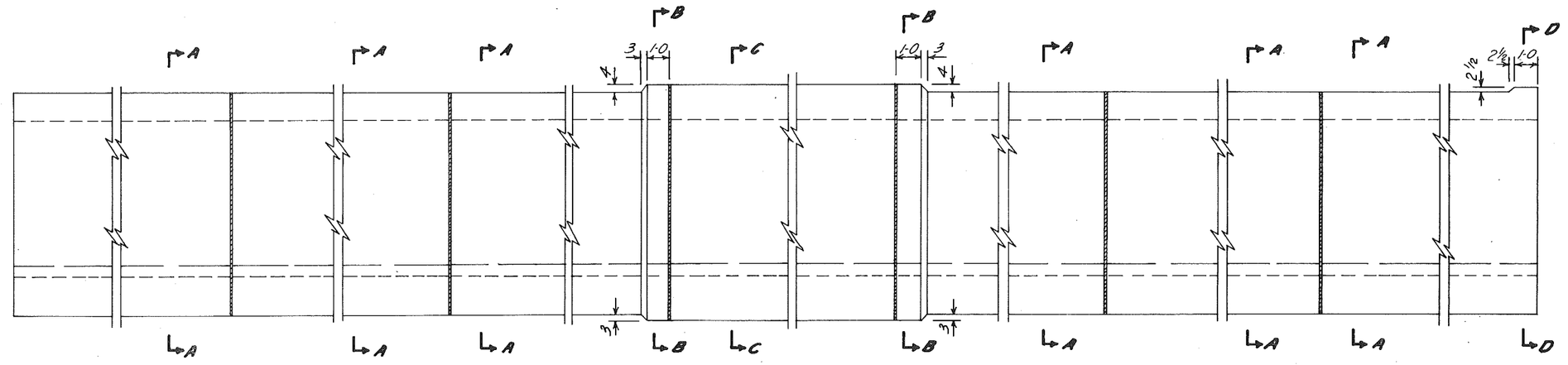
	Date		
Designed L.M.S.	10/71	Approved by	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked C.E.M.	12/71	Sheet No. 24 of 40	Drawing No. 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE : 1967 O - 237-005

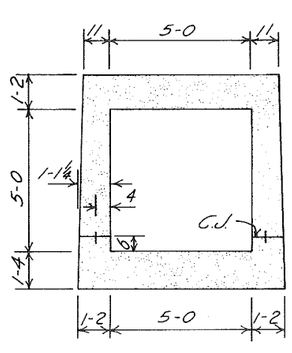
SCS-313 (9-64)



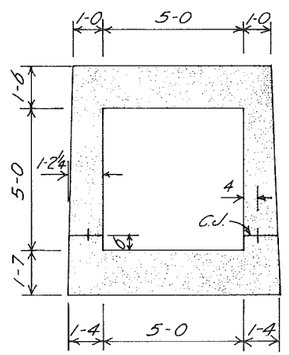
PLAN



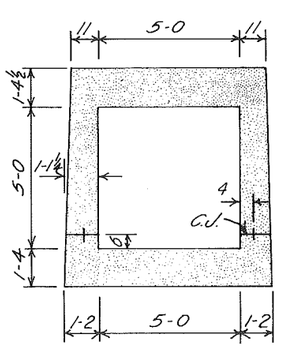
SIDEWALL ELEVATION



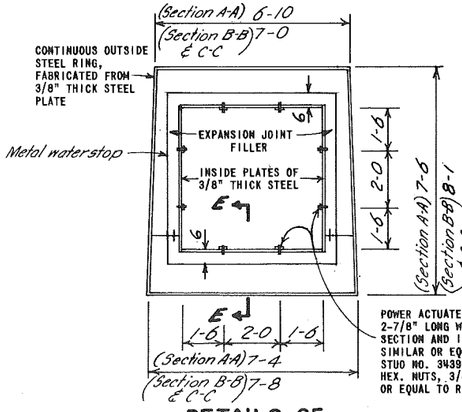
SECTION A-A



SECTION B-B & C-C



SECTION D-D



DETAILS OF JOINTS 5 THROUGH 15

NOTES:
1. C.J. = CONSTRUCTION JOINT.
2. J. = JOINT.
3. FOR DETAILS OF SECTION E-E, SEE SHEET 27.
4. FOR DETAILS OF CONSTRUCTION JOINT, SEE SHEET 27 AND 28.

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	242.5
REINFORCING STEEL	LB.	29,875
METAL WATERSTOP	LIN.FT.	264-0
STEEL BAR, 6" X 1/4" (CONSTRUCTION JOINT)	LIN.FT.	430-0
3/8" X 10" STEEL PLATE, EXPANSION JOINT (INSIDE)	LIN.FT.	220-0
STEEL PLATE, PER DETAIL, EXPANSION JOINT (OUTSIDE)	LIN.FT.	329-2

0 1 2 3 4
Scale in Feet

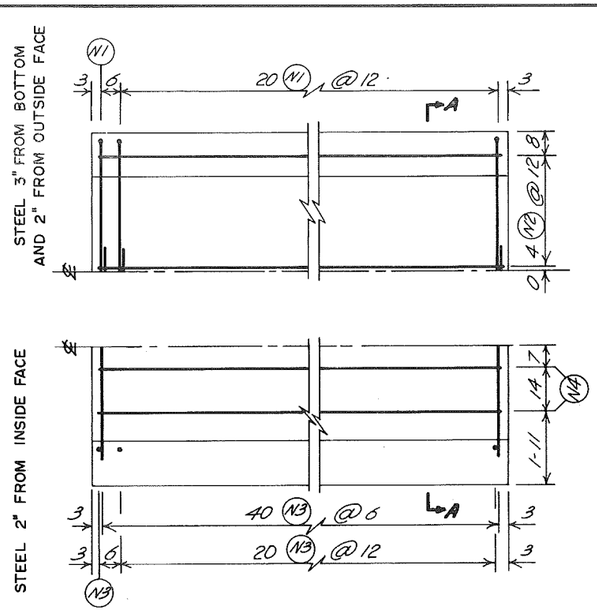
DETAILS OF CONDUIT

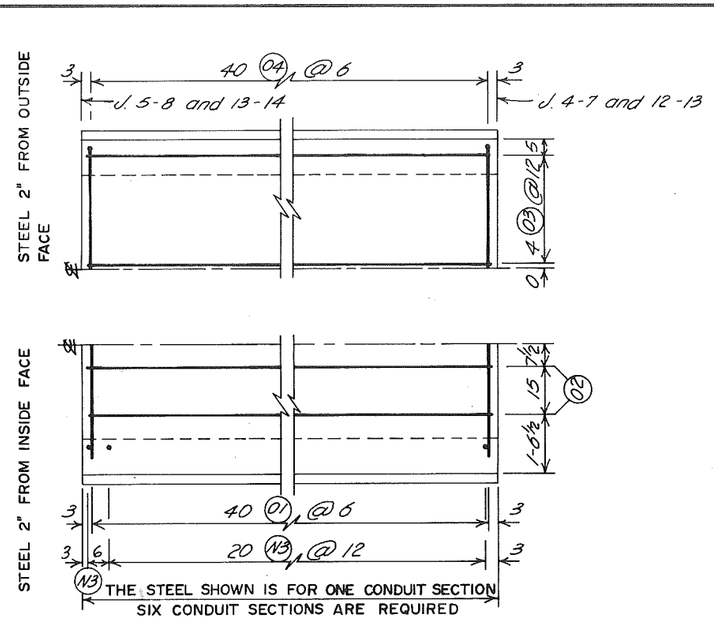
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

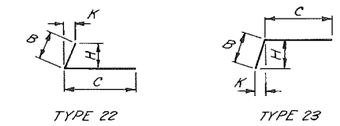
Designed	L.M.S. & C.E.M.	Date 9/71	Approved by
Drawn	D.L.J.	12/71	Title
Traced			Title
Checked		Sheet No 25 of 40	Drawing No 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE : 1969 O—349-778





BAR BENDS



STEEL SCHEDULE

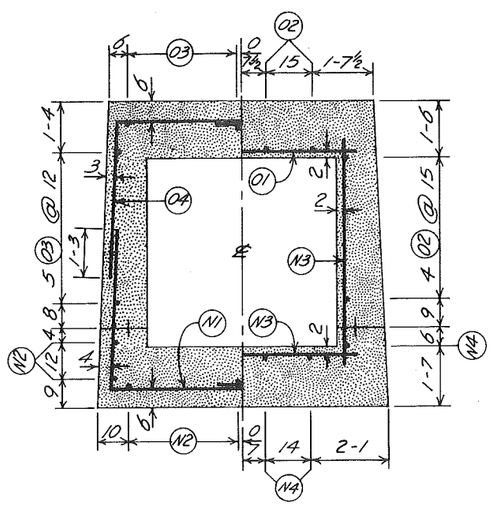
MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
N1	4	252	8-6	2142-0	22	4-3	4-3	4-3	0-1 3/4
N2	4	66	19-9	1303-6	1				
N3	5	492	6-0	2952-0	1				
N4	6	36	19-9	711-0	1				
01	5	240	6-0	1440-0	1				
02	6	72	19-9	1422-0	1				
03	4	102	19-9	2014-6	1				
04	4	480	8-3	3960-0	23	4-1 1/2	4-1 1/2	4-1 1/2	0-1 3/4

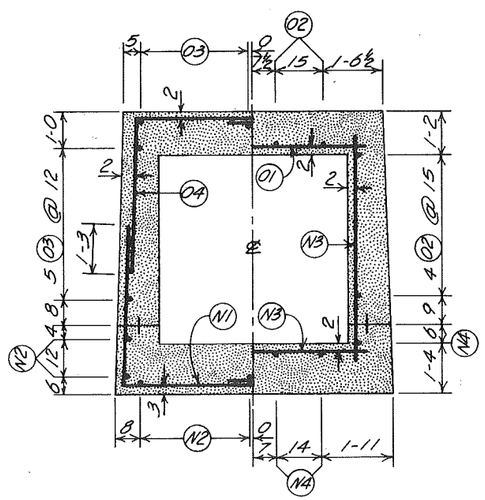
STEEL TOTALS

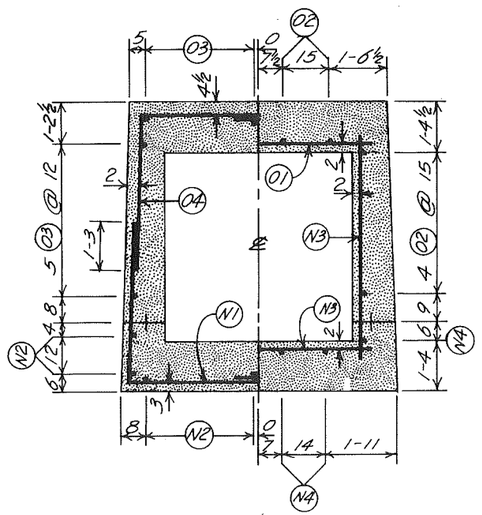
SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	9,420-0	6,293
5	4,392-0	4,581
6	2,133-0	3,204
TOTAL WEIGHT		14,078

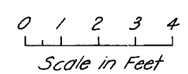
NOTES:

1. 96 DOWEL BARS REQUIRED FOR J. 5 - 8 AND 13-14. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. BAR MARKS (N3) AND (01) NEAREST JOINTS SHALL BE CUT TO CLEAR WATERSTOP.
6. SEE SHEET 25 FOR LOCATION OF SECTIONS B-B AND D-D.









DETAILS OF CONDUIT (J. 4-8, 12-14)

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

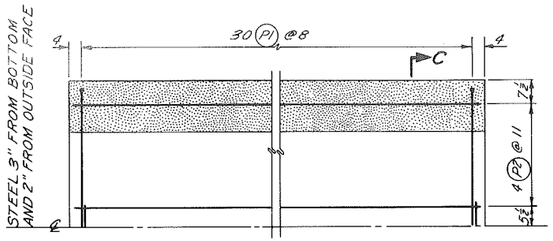
GRAND FORKS COUNTY NORTH DAKOTA

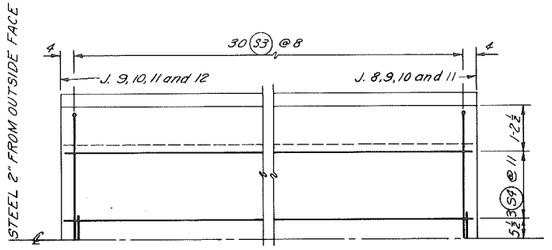
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

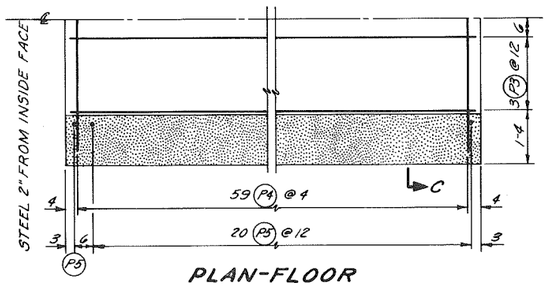
	Date	
Designed L.M.S & C.E.M.	9/71	Approved by
Drawn D.L.J.	12/71	Title
Traced		Title
Checked		Sheet No 26 of 40 / Drawing No 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE: 1969 O—347-928

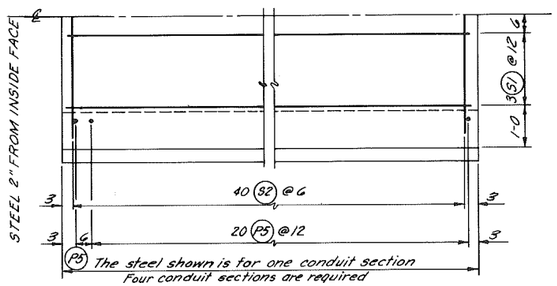
SCS-ENG-313 Rev. 4-69





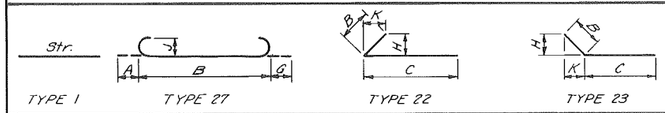


PLAN-FLOOR



PLAN-TOP

BAR BENDS

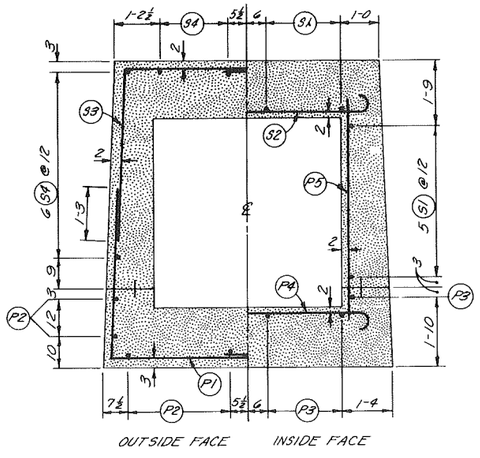


STEEL SCHEDULE

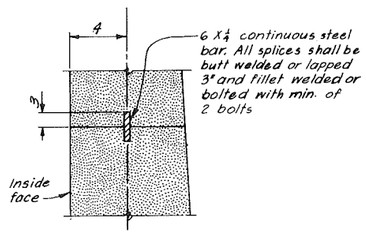
MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	A	B	C	G	H	J	K
P1	4	240	8-9	2100-0	22		4-4 1/2	4-4 1/2		4-4 1/2		0-1 3/4
P2	4	48	19-9	948-0	1							
P3	6	32	19-9	632-0	1							
P4	6	236	7-6	1770-0	27	0-8	6-2		0-8		0-6	
P5	6	168	6-6	1092-0	1							
S1	6	64	19-9	1264-0	1							
S2	7	160	7-9	1240-0	27	0-10	6-1		0-10		0-7	
S3	4	240	8-6	2040-0	23		4-6	4-0		4-6		0-1 3/4
S4	4	72	19-9	1422-0	1							

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	6,510-0	4,349
6	4,758-0	7,147
7	1,240-0	2,535
TOTAL WEIGHT		14,031

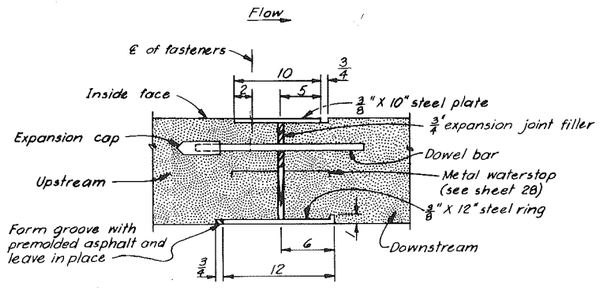


SECTION C-C



DETAILS OF PLATE CONSTRUCTION JOINT
J.5 - J.15
(Not to scale)

NOTE:
DOWEL BARS SHALL BE 3/4" DIA. X 18" LONG SMOOTH STEEL BARS COATED ON UPSTREAM END TO PREVENT BOND. COATING SHALL BE OIL, ASPHALT, OR OTHER METHOD APPROVED BY THE ENGINEER.



SECTION E-E
(Not to scale)

NOTES:
1. 64 DOWEL BARS REQUIRED FOR J. 9, 10, 11, AND 12. DOWEL BARS NOT INCLUDED IN STEEL TOTALS. SEE SHEET 28 FOR DETAILS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. BAR MARKS (P4) AND (S2) NEAREST CUT TO CLEAR WATERSTOP.
6. SEE SHEET 25 FOR LOCATION OF SECTIONS.
7. SEE SHEET 28 FOR DETAIL OF METAL WATERSTOP.

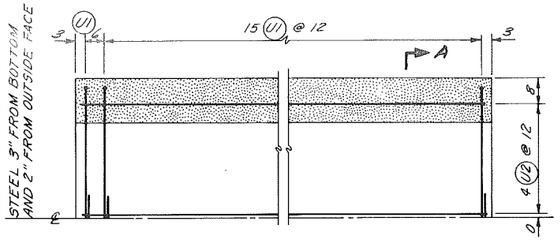
0 1 2 3 4
Scale in feet

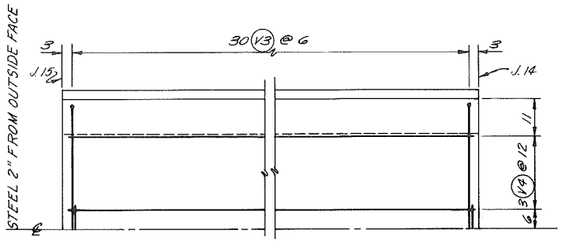
DETAILS OF CONDUIT (J. 8-J.12)

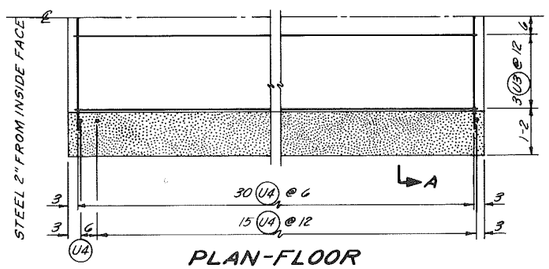
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

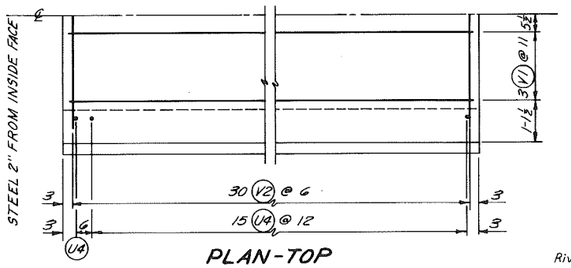
	Date		
Designed L.M.S., C.E.M.	9-71	Approved by	
Drawn D.L.J.	11-71	Title	
Traced		Title	
Checked		Sheet No. 27 of 40	Drawing No. 5, E-29, 772



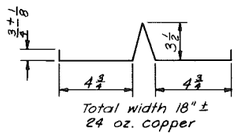


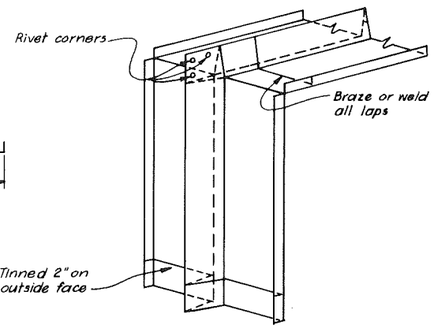


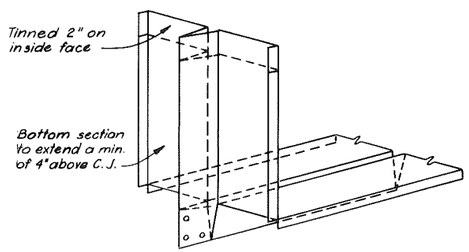
PLAN-FLOOR



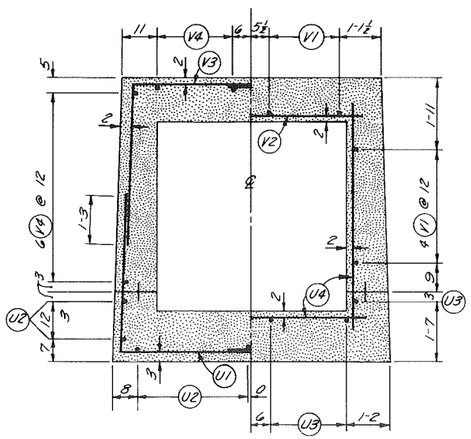
PLAN-TOP



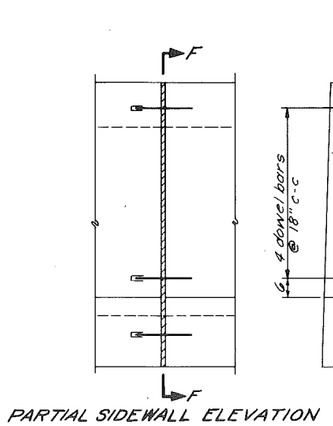




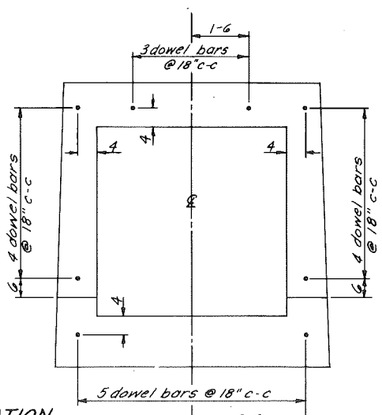
DETAIL OF METAL WATERSTOP
J. 5 THRU J. 15
Not to scale



SECTION A-A



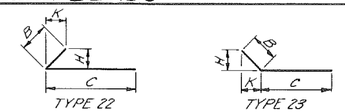
PARTIAL SIDEWALL ELEVATION



SECTION F-F

DETAILS OF JOINTS 5 THRU 15
SHOWING LOCATION OF DOWEL BARS

BAR BENDS



STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
U1	4	32	8-6	272-0	22	4-3	4-3	4-3	0-1 3/4
U2	4	11	14-9	162-3	1				
U3	6	8	14-9	118-0	1				
U4	5	62	6-0	372-0	1				
V1	5	14	14-9	206-6	1				
V2	5	30	6-0	180-0	1				
V3	4	60	8-3	495-0	23	4-1 1/2	4-1 1/2	4-1 1/2	0-1 3/4
V4	4	18	14-9	265-6	1				

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	1,194-9	798
5	758-6	791
6	118-0	177
TOTAL WEIGHT		1,766

NOTES:

1. 16 DOWEL BARS REQUIRED FOR J. 15. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. BAR MARKS (U4) AND (V2) NEAREST JOINTS SHALL BE CUT TO CLEAR WATERSTOP.
6. SEE SHEET 25 FOR LOCATION OF SECTIONS.

0 1 2 3 4
Scale in feet

DETAILS OF CONDUIT (J. 14 - J. 15)

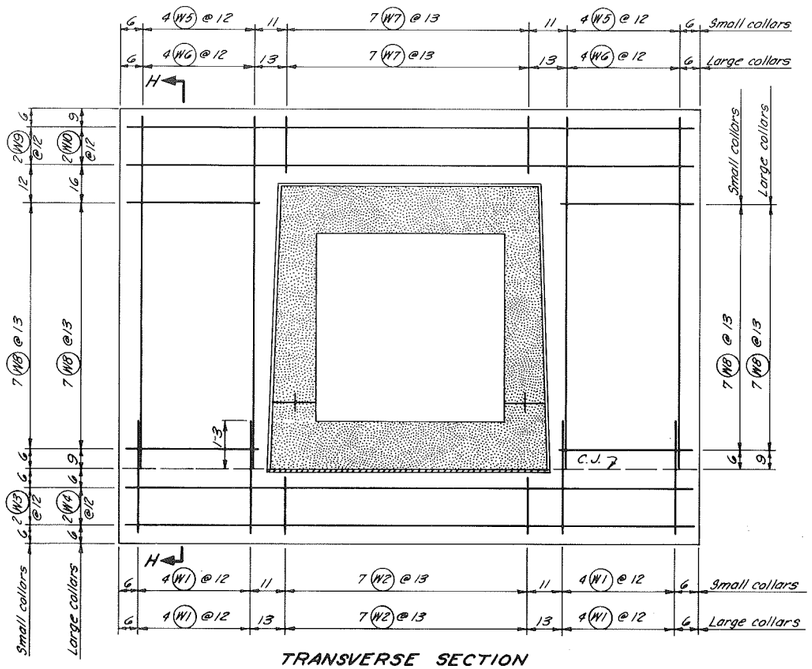
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

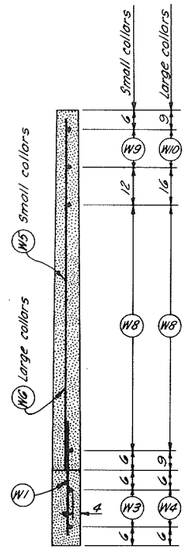
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S., C.E.M.	9-71	Approved by	
Drawn D.L.J.	11-71	Title	
Traced		Title	
Checked		Sheet No. 28 of 40	Drawing No. 5, E-29, 772

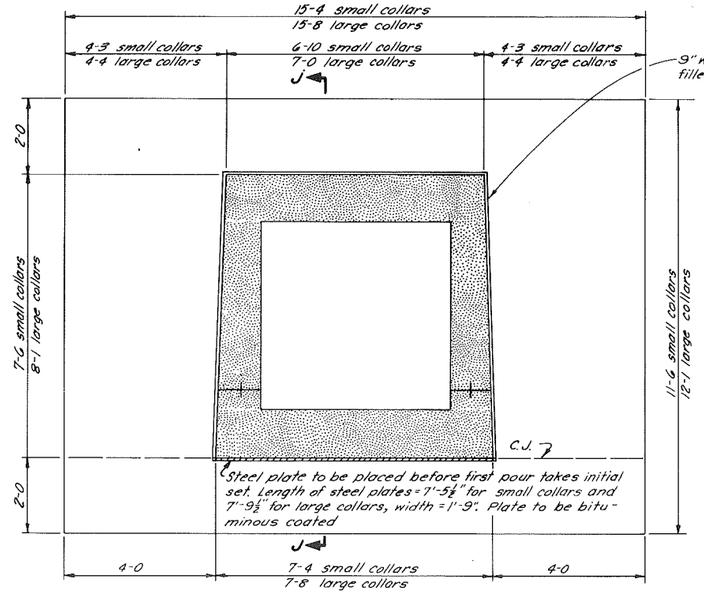


TRANSVERSE SECTION

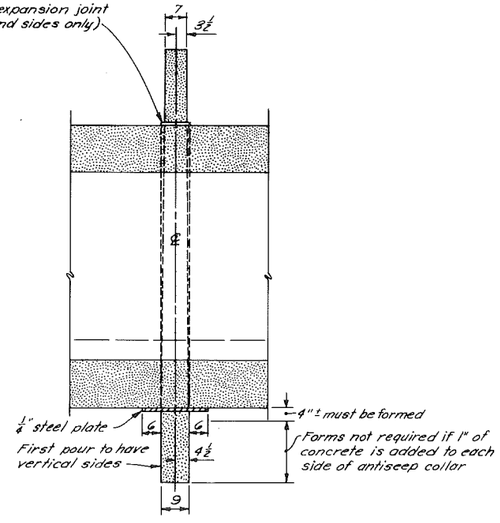


SECTION H-H

REINFORCING STEEL DETAILS OF ANTISEEP COLLARS



ELEVATION OF ANTISEEP COLLARS



SECTION J-J

BAR BENDS

Straight

TYPE 1

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE
W1	4	56	3-0	168-0	1
W2	4	49	1-6	73-6	1
W3	4	6	14-9	88-6	1
W4	4	8	15-0	120-0	1
W5	4	24	9-3	222-0	1
W6	4	32	9-9	312-0	1
W7	4	49	1-6	73-6	1
W8	4	98	3-6	343-0	1
W9	4	6	14-9	88-6	1
W10	4	8	15-0	120-0	1

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	1,609-0	1,075

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD	22.5
REINFORCING STEEL	LB.	1,075
1/4" X 1'-9" STEEL PLATE	LIN.FT.	53'-6 1/2"

NOTES:

1. C.J. = CONSTRUCTION JOINT.
2. SMALL COLLARS USED FROM JOINTS 6 TO 7 AND 12 TO 15.
3. LARGE COLLARS USED FROM JOINTS 8 TO 12.

0 1 2 3 4

Scale in feet

DETAILS OF ANTISEEP COLLARS

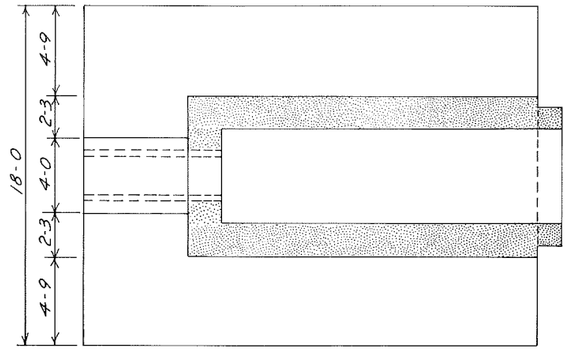
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

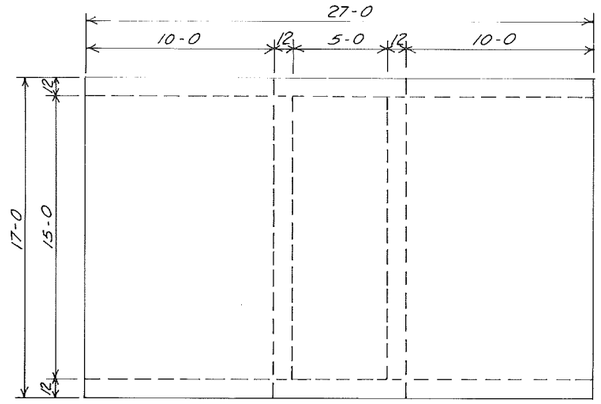
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

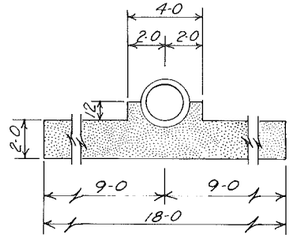
Designed C.E.M.	Date 12-71	Approved by	
Drawn		Title	
Traced		Title	
Checked L.M.S.	1-72	Sheet No 29 of 40	Drawing No. 5, E-29, 772



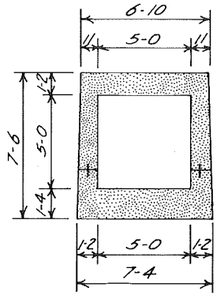
SECTION B-B



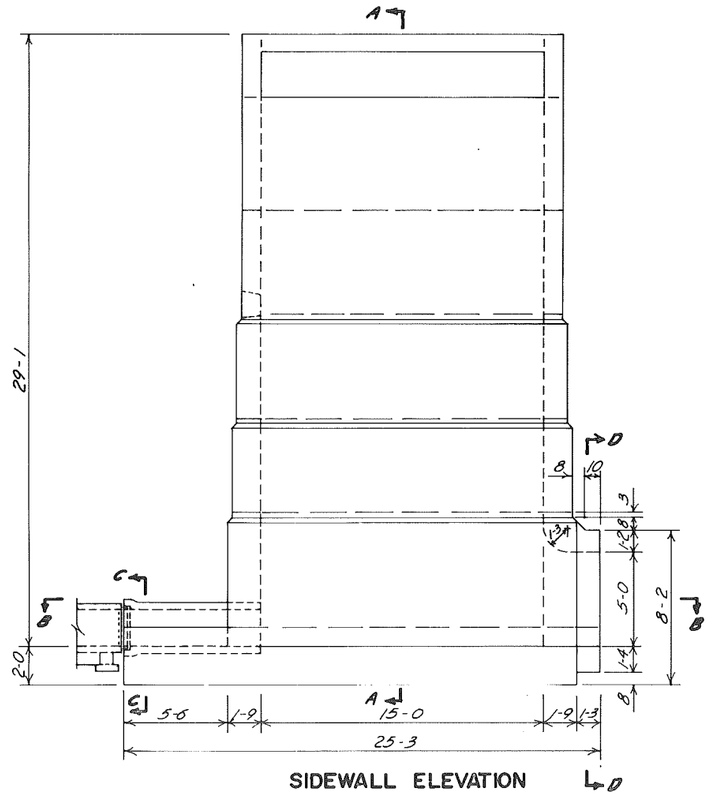
TOP PLAN



SECTION C-C



SECTION D-D



SIDEWALL ELEVATION

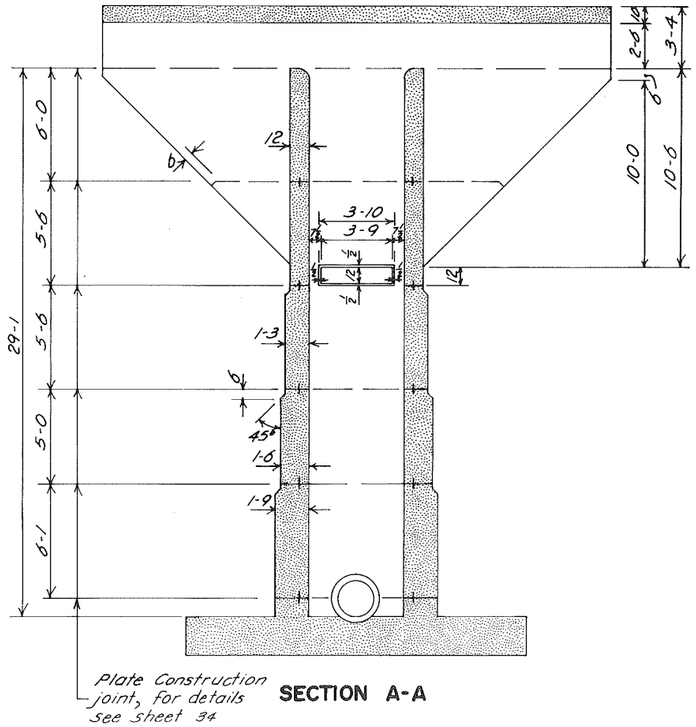


Plate Construction joint, for details see sheet 34

SECTION A-A

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	122.8
STEEL	LB.	23,304
1/4" X 6" STEEL PLATE	LIN.FT.	306

0 1 2 3 4
Scale in Feet

DETAILS OF R/C INLET

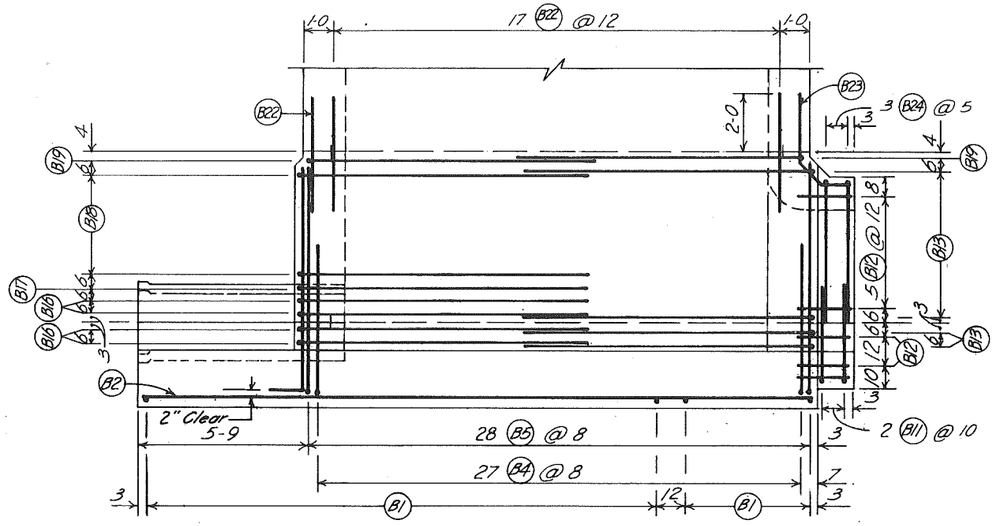
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

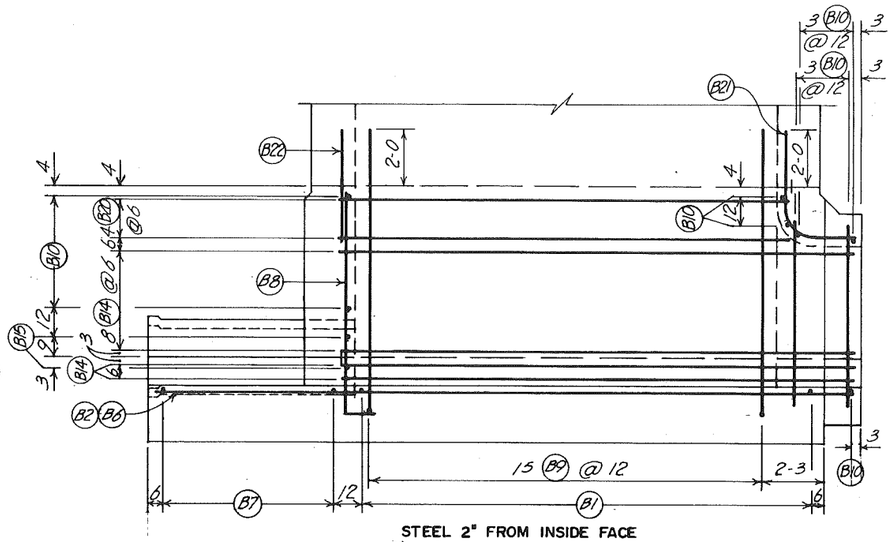
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed E.J.P. L.M.S.	Date 8/71	Approved by	
Drawn D.L.J.	10/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No 30 of 40	Drawing No. 5, E-29, 772



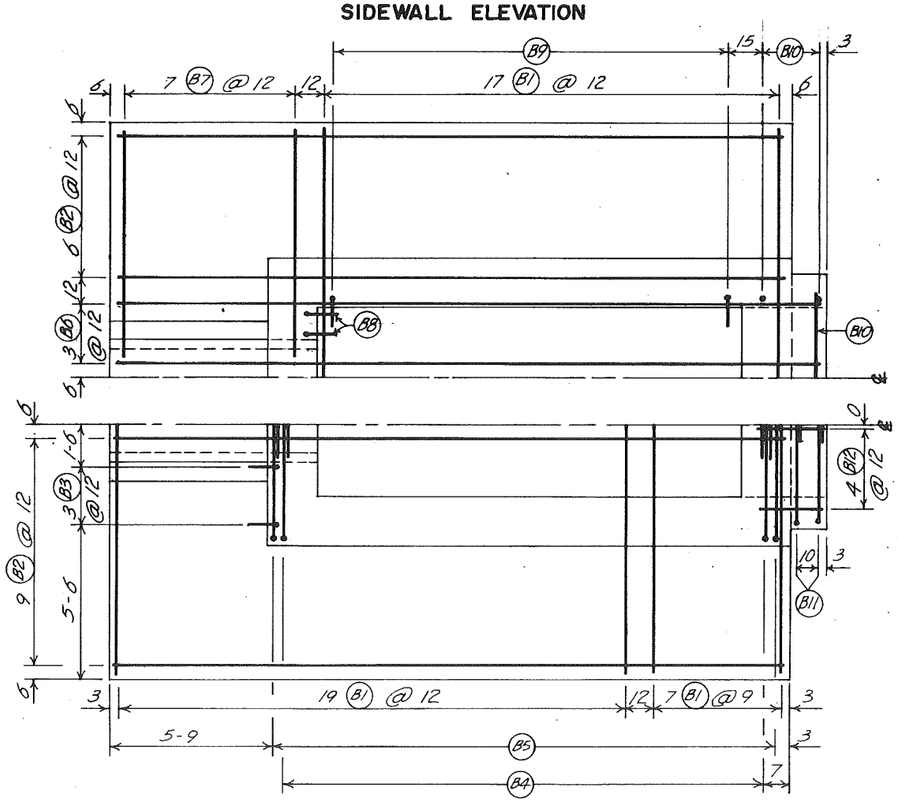
STEEL 2" FROM OUTSIDE FACE
AND 3" FROM BOTTOM OF FOOTING

SIDEWALL ELEVATION



STEEL 2" FROM INSIDE FACE
AND 2" FROM TOP OF FOOTING

SIDEWALL ELEVATION

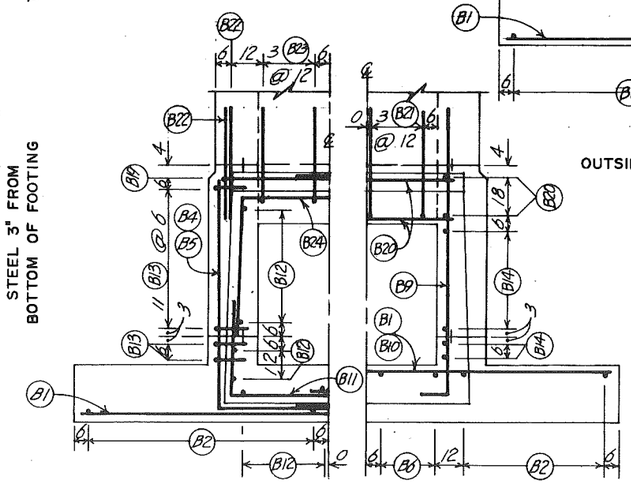


STEEL 2" FROM TOP OF FOOTING

STEEL 3" FROM BOTTOM OF FOOTING

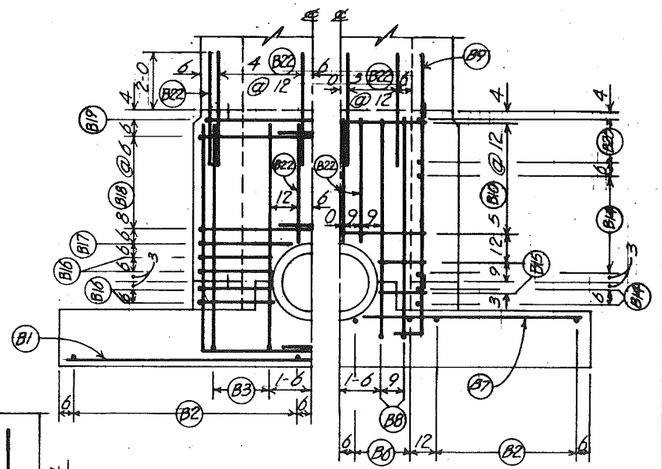
PLAN FOOTING

NOTE:
FIELD BEND OR CUT B6 BARS TO CLEAR DRAWDOWN PIPE BY 2".



OUTSIDE FACE INSIDE FACE

DOWNSTREAM ELEVATION



OUTSIDE FACE INSIDE FACE

UPSTREAM ELEVATION

0 1 2 3 4
Scale in Feet

DETAILS OF R/C INLET

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

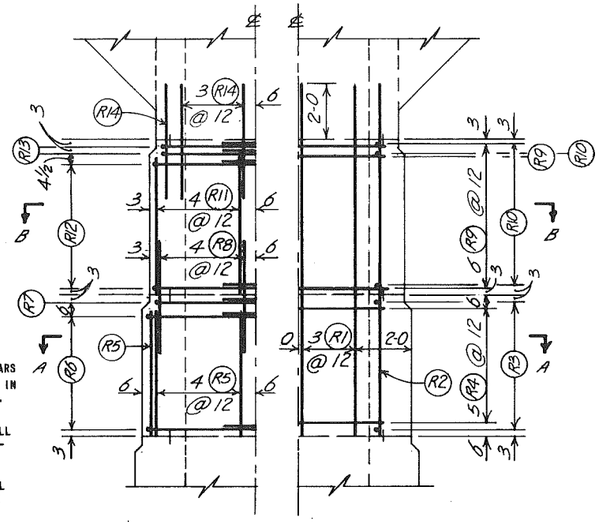
Designed E.J.P. / L.M.S.	Date 8/67 / 8/71	Approved by	
Drawn D.L.J.	10/71	Title	
Traced		Sheet No. 31 of 90	Drawing No. 5,E-29,772
Checked C.E.M.	10/71		

U.S. GOVERNMENT PRINTING OFFICE : 1963 O - 237-695

SCS-313 (9-64)

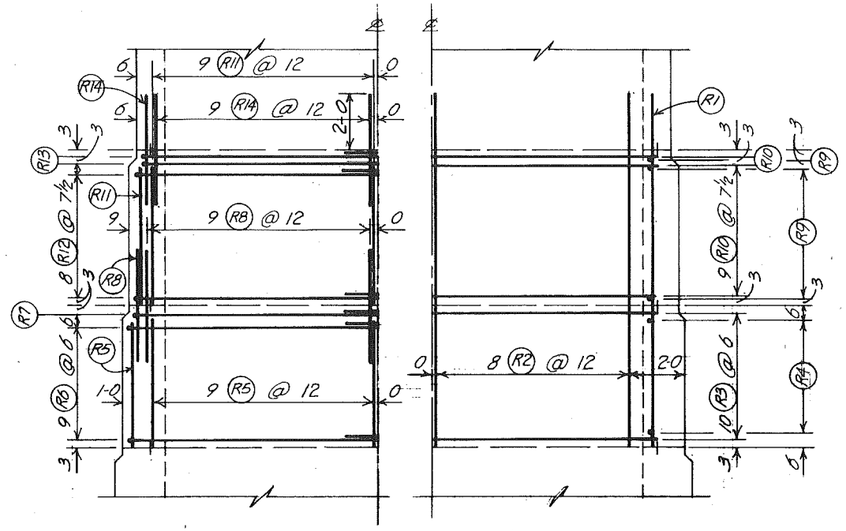
NOTES:

1. ELIMINATE THE 4 (R14) BARS IN THE UPSTREAM ENDWALL IN THE AREA OF THE ORIFICE.
2. MARK (R1) BARS PASSING THROUGH THE ORIFICE SHALL BE CUT 2" BELOW THE CONSTRUCTION JOINT.
3. THE STEEL PLATE IN THE CONSTRUCTION JOINT SHALL BE CUT 2" FROM THE EDGE OF THE ORIFICE.
4. ~~MARK~~ (R1) BARS PASSING ALONG SIDE ORIFICE SHALL BE MOVED TO CLEAR ORIFICE BY 2".
5. SEE SHEET 34 FOR ADDITIONAL STEEL REQUIREMENTS AT ORIFICE.



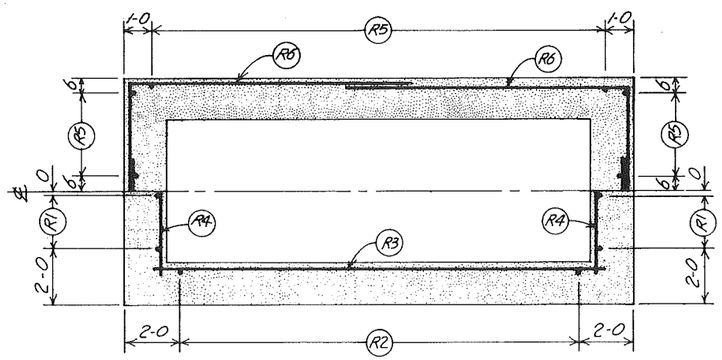
OUTSIDE STEEL INSIDE STEEL

ENDWALL ELEVATION

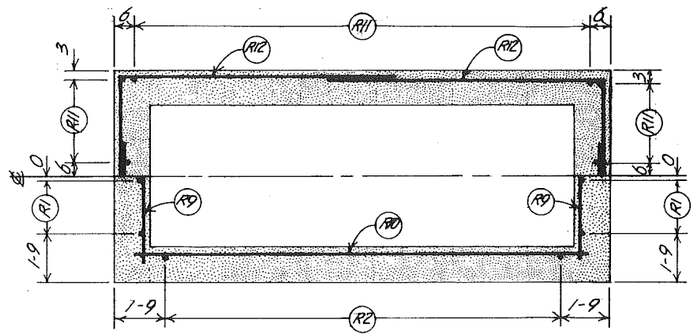


OUTSIDE STEEL INSIDE STEEL

SIDEWALL ELEVATION



SECTION A-A



SECTION B-B

0 1 2 3 4
Scale in Feet

DETAILS OF R/C INLET

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	E.J.P. / L.M.S.	8/67 / 8/71	Approved by
Drawn	D.L.J.	10/71	Title
Traced			Title
Checked	C.E.M.	10/71	Sheet No 32 of 40

Drawing No. 5,E-29,772

SCS-313 (9-64)

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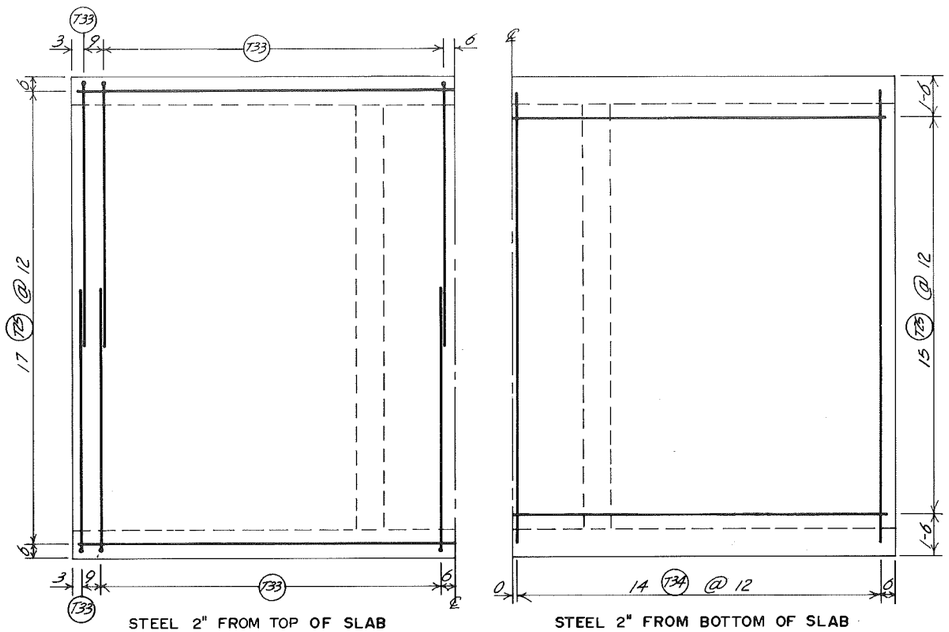
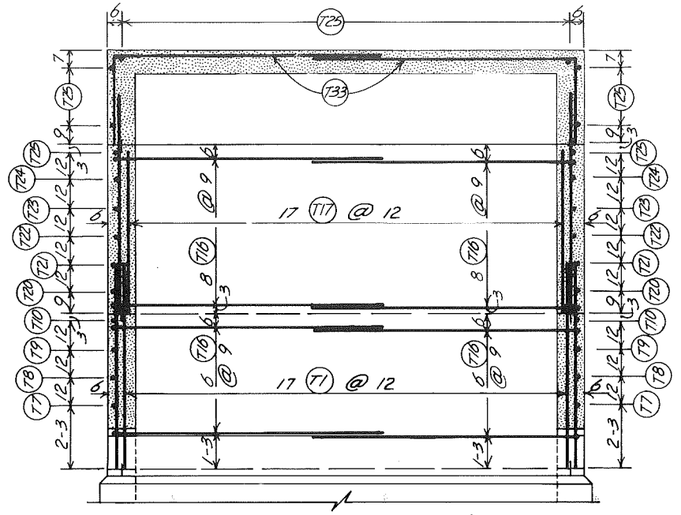


STEEL 2" FROM TOP OF SLAB

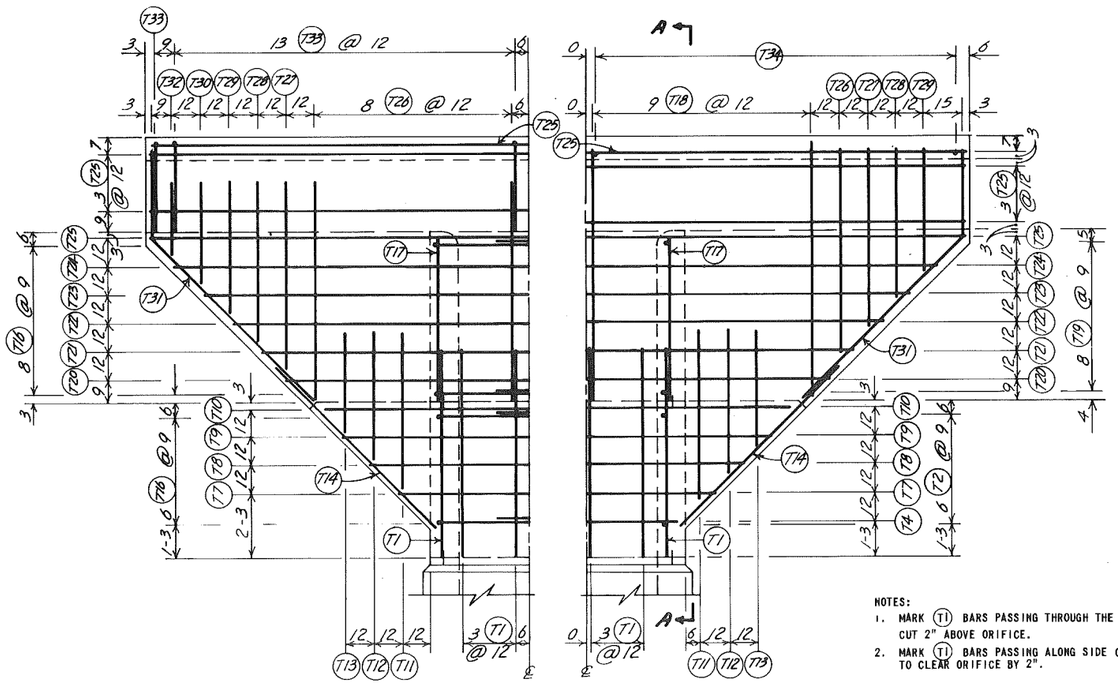
STEEL 2" FROM BOTTOM OF SLAB

PLAN COVER SLAB



STEEL 2" FROM OUTSIDE FACE

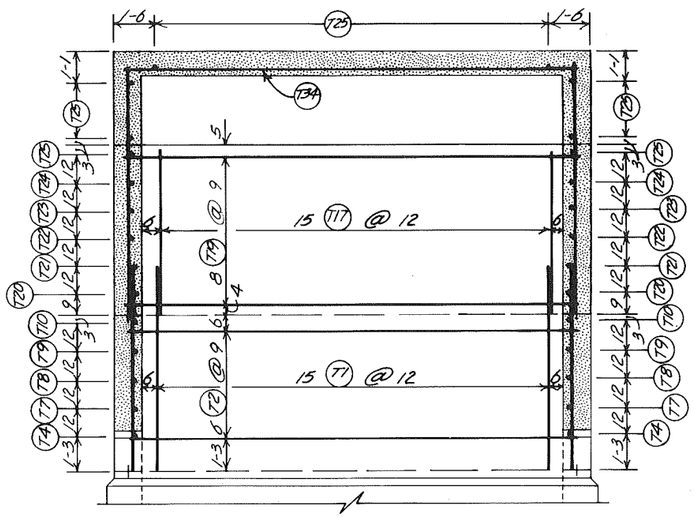
SECTION A-A



STEEL 2" FROM OUTSIDE FACE

STEEL 2" FROM INSIDE FACE

ENDWALL ELEVATION



STEEL 2" FROM INSIDE FACE

SECTION A-A

NOTES:
1. MARK (T1) BARS PASSING THROUGH THE ORIFICE SHALL BE FIELD CUT 2" ABOVE ORIFICE.
2. MARK (T1) BARS PASSING ALONG SIDE OF THE ORIFICE SHALL BE MOVED TO CLEAR ORIFICE BY 2".

0 1 2 3 4
Scale in Feet

DETAILS OF R/C INLET

DAM 4

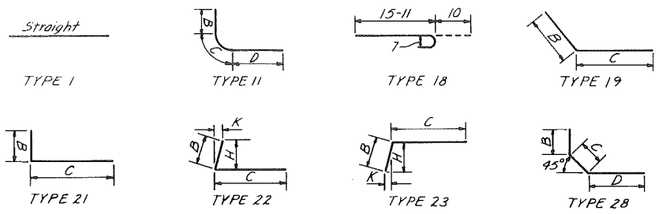
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed E.W.S.	Date 8/71	Approved by	
Drawn D.L.V.	10-71	Title	
Traced		Title	
Checked C.E.M.	10-71	Sheet No. 33 of 40	Drawing No. 5,E-29,772

BAR BENDS

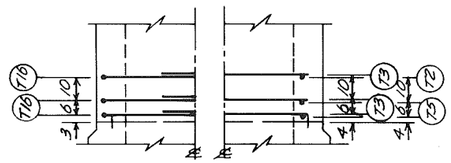


STEEL SCHEDULE

MARK	SIZE	QUAN-TITY	LENGTH	TOTAL LENGTH	TYPE	A	B	C	D	E	F	H	K
B1	6	43	17-6	752-6	1								
B2	6	30	23-6	705-0	1								
B3	6	6	9-0	54-0	21		1-0	8-0					
B4	7	54	10-6	567-0	21		5-3	5-3					
B5	7	56	13-3	742-0	21		5-3	8-0					
B6	6	6	24-9	148-6	1								
B7	6	14	8-0	112-0	1								
B8	7	4	8-9	35-0	21		1-0	7-9					
B9	6	30	11-0	330-0	21		1-0	10-0					
B10	6	17	6-0	102-0	1								
B11	4	4	7-6	30-0	22		3-4 1/2	4-1 1/2				3-4 1/2	0-1 1/2
B12	4	21	1-9	36-9	1								
B13	7	26	11-3	292-6	21		1-0	10-3					
B14	7	20	18-3	365-0	1								
B15	6	4	1-9	7-0	1								
B16	7	8	13-0	104-0	21		2-9	10-3					
B17	7	2	13-9	27-6	21		3-6	10-3					
B18	7	16	15-6	248-0	21		5-3	10-3					
B19	7	4	15-0	60-0	21		5-0	10-0					
B20	7	8	16-0	128-0	1								
B21	6	5	6-0	30-0	11		2-10	1-7	1-7				RADIUS = 12"
B22	6	52	4-0	208-0	1								
B23	6	6	4-3	25-6	28		2-4	1-2	0-9				
B24	4	6	9-0	54-0	23		5-0	4-0					
R1	6	10	12-6	125-0	1								
R2	6	30	12-6	375-0	1								
R3	7	20	16-0	320-0	1								
R4	6	10	6-0	60-0	1								
R5	6	50	4-6	225-0	1								
R6	7	36	15-0	540-0	21		5-0	10-0					
R7	7	4	14-6	58-0	21		4-9	9-9					
R8	6	50	4-0	200-0	1								
R9	6	14	6-0	84-0	1								
R10	7	20	16-0	320-0	1								
R11	6	50	5-0	250-0	1								
R12	7	32	14-6	464-0	21		4-9	9-9					
R13	7	8	14-0	112-0	21		4-6	9-6					
R14	6	42	4-0	168-0	1								
T1	5	86	7-3	623-6	1								
T2	7	14	16-0	224-0	1								
T3	5	4	6-0	24-0	1								
T4	5	2	7-0	14-0	1								
T5	7	4	16-9	67-0	18								
T6	NONE												
T7	5	4	9-0	36-0	1								
T8	5	4	11-0	44-0	1								
T9	5	4	13-0	52-0	1								
T10	5	4	14-6	58-0	1								
T11	5	8	5-6	44-0	1								
T12	5	8	4-6	36-0	1								
T13	5	8	3-6	28-0	1								
T14	5	8	8-0	64-0	1								
T15	7	4	10-9	43-0	21		1-3	9-6					
T16	7	64	14-0	896-0	21		4-6	9-6					
T17	5	64	5-9	368-0	1								
T18	5	34	9-0	306-0	1								
T19	7	16	16-0	256-0	1								
T20	5	4	17-0	68-0	1								
T21	5	4	19-0	76-0	1								
T22	5	4	21-0	84-0	1								
T23	5	4	23-0	92-0	1								
T24	5	4	25-0	100-0	1								
T25	5	48	26-6	1272-0	1								
T26	5	36	7-9	279-0	1								
T27	5	8	6-9	54-0	1								
T28	5	8	5-9	46-0	1								
T29	5	8	4-9	38-0	1								
T30	5	4	3-9	15-0	1								
T31	5	8	11-3	90-0	19		3-3	8-0					
T32	5	4	4-0	16-0	19		1-0	3-0					
T33	5	56	12-6	700-0	21		3-2	9-4					
T34	5	27	16-0	432-0	1								

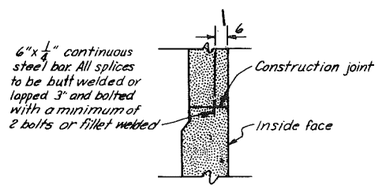
STEEL TOTALS

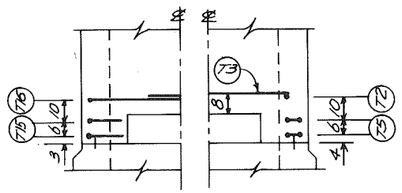
SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	120-9	81.0
5	5,059-6	5,277.0
6	3,961-6	5,950.0
7	5,869-0	11,996.0
TOTAL		23,304.0



STEEL 2" FROM OUTSIDE FACE — STEEL 2" FROM INSIDE FACE

DOWNSTREAM ENDWALL

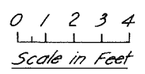




STEEL 2" FROM OUTSIDE FACE — STEEL 2" FROM INSIDE FACE

UPSTREAM ENDWALL

ADDITIONAL STEEL REQUIRED AROUND ORIFICE



DETAILS OF R/C INLET

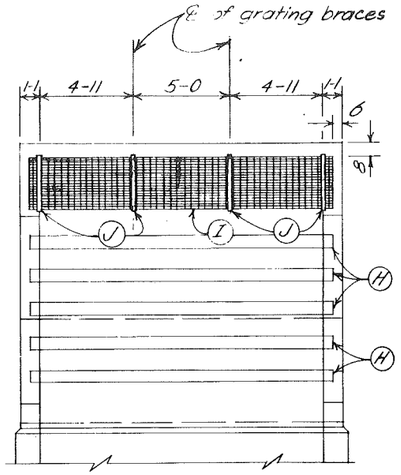
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

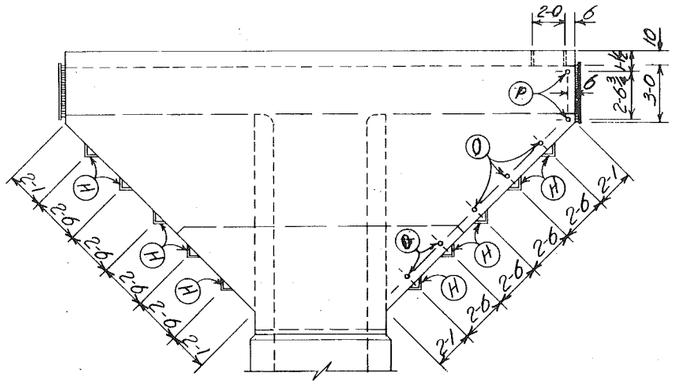
GRAND FORKS COUNTY — NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

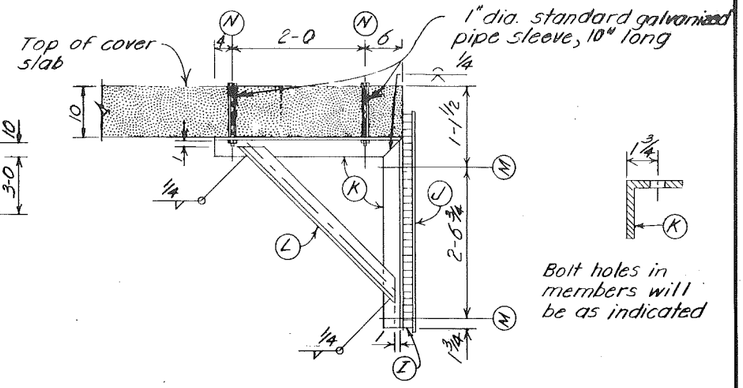
Designed E.J.P. L.M.S.	Date 6/61	Approved by	
Drawn D.L.J.	10-71	Title	
Traced		Title	
Checked C.E.M.	10-71	Sheet No. 34 of 40	Drawing No. 5,E-29,772



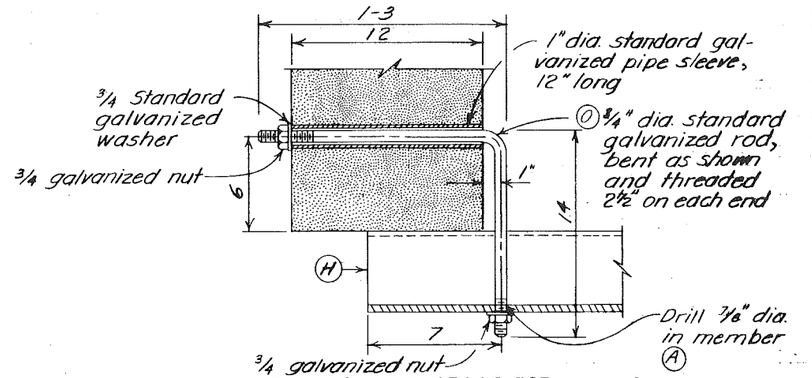
FRONT VIEW OF TRASH RACK



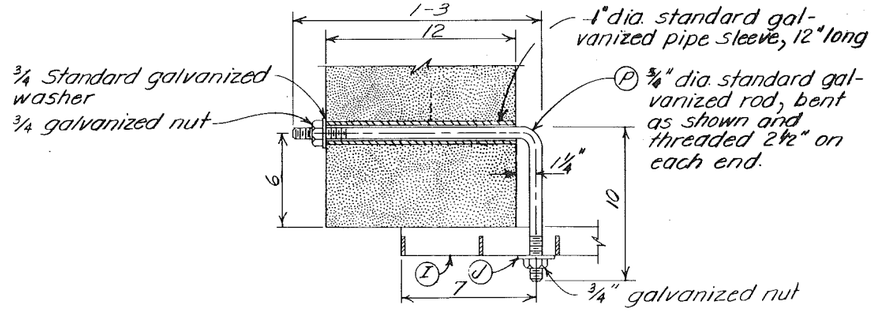
END VIEW OF TRASH RACK



DETAIL OF GRATING BRACE



DETAIL OF ANCHORAGE FOR ANGLES

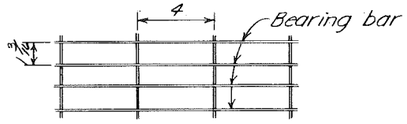


DETAIL OF ANCHORAGE FOR GRATING

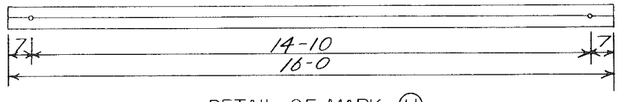
MATERIAL LIST

MARK	ITEM	QUANTITY
H	ANGLES 8" X 8" X 1/2", 16-0 LONG	10
J	GRATING: 16-0 LONG X 2-11 13/16 WIDE WITH 1 3/4" X 3/16" BEARING BARS	2
J	BAR 2" X 1/4" X 3-0	8
K	ANGLE 3" X 3" X 1/4", 2-10 LONG	8
L	ANGLE 3" X 3" X 1/4", 3-3 LONG	4
M	3/4" DIA. GALV. BOLT WITH NUT AND WASHER, 3 1/2" LONG	8
N	3/4" DIA. GALV. BOLT, 12" LONG WITH NUT AND WASHER AND WITH 1" DIA. STANDARD GALV. PIPE SLEEVE, 10" LONG AS PER DETAIL	8
O	3/4" DIA. GALV. ROD AS PER DETAIL WITH 1" DIA. STANDARD GALV. PIPE SLEEVE, 12" LONG AS PER DETAIL	20
P	3/4" DIA. GALV. ROD AS PER DETAIL WITH 1" DIA. STANDARD GALV. PIPE SLEEVE, 12" LONG AS PER DETAIL	8

WEIGHT OF ANGLES = 4,224 LB.
WEIGHT OF GRATING = 1,286 LB.



DETAIL OF GRATING SHOWING BEARING BAR SPACING



DETAIL OF MARK (H)

NOTES:
1. CLIP ENDS OF MEMBERS (K) AND (L) AS SHOWN.
2. GRATING BRACE ASSEMBLY IS TO BE WELDED FORMING A FRAME AS SHOWN. EIGHT HOLES MUST BE DRILLED TO ATTACH FRAME TO COVER SLAB AND GRATING TO FRAME.
3. ALL STRUCTURAL STEEL MEMBERS (WITH EXCEPTION OF GALVANIZED MEMBERS) TO BE PAINTED IN ACCORDANCE WITH SPECIFICATIONS.
4. THE NUTS ON THE 5/8" GALVANIZED RODS SHOULD BE DRAWN UP CAREFULLY TO AVOID STRESSING THE RODS.

DETAILS FOR HIGH STAGE TRASH RACK

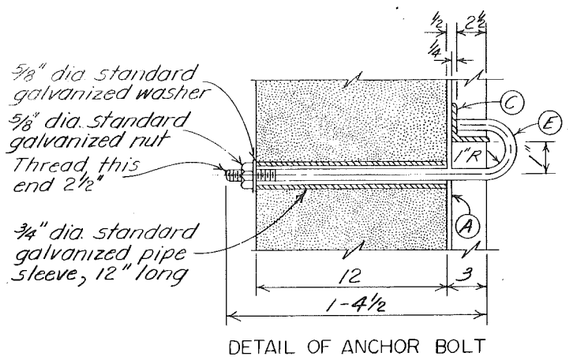
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

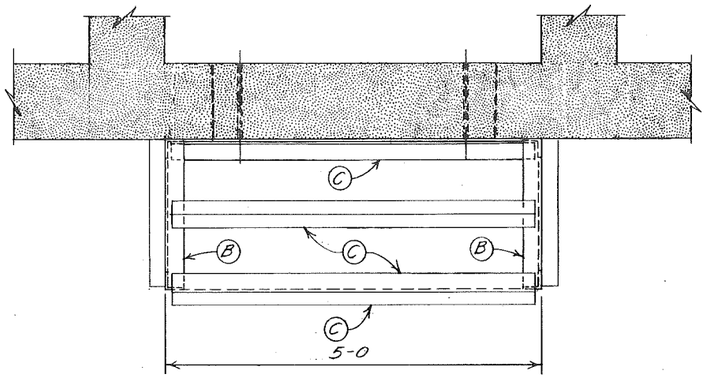
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	L.M.S. & H.R.H.	12/71	Approved by	
Drawn	D.L.J.	12/71	Title	
Traced			Title	
Checked	R.D.S.	1/74	Sheet No. 35 of 40	Drawing No. 5,E-29,772

SCS-ENG-313 Rev. 4-69



DETAIL OF ANCHOR BOLT



PLAN

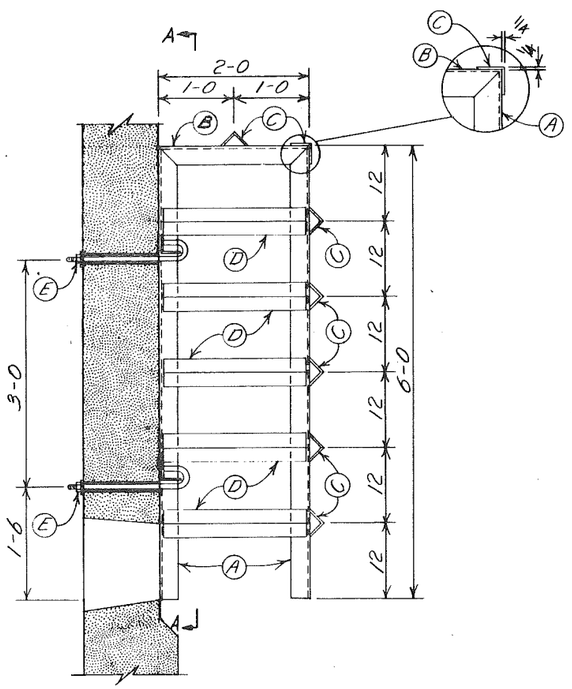
NOTES:

1. CLIP ENDS OF MEMBERS (A) AND (B) AS SHOWN.
2. ALL STRUCTURAL STEEL MEMBERS (WITH EXCEPTION OF GALVANIZED MEMBERS) TO BE PAINTED IN ACCORDANCE WITH SPECIFICATIONS.
3. ALL STRUCTURAL STEEL ANGLES TO BE SECURELY WELDED AT ALL JUNCTIONS.

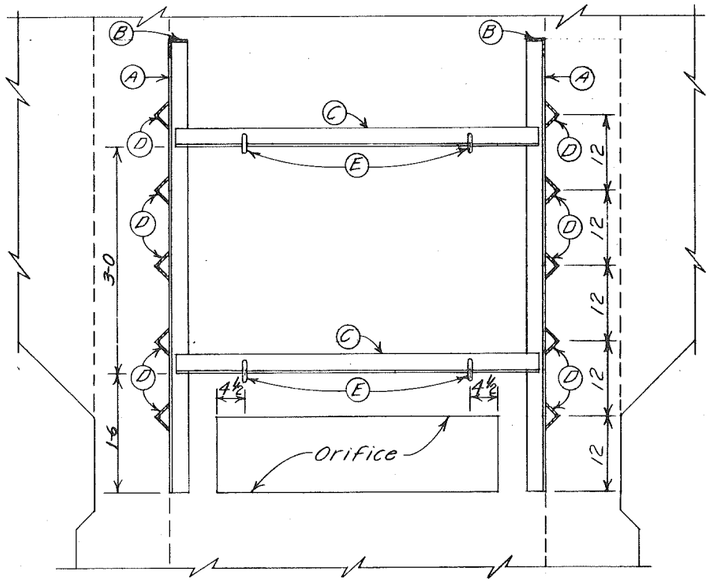
MATERIAL LIST

MARK	ITEM	QUANTITY
A	ANGLE 3" X 3" X 1/4", 6-0 LONG	4
B	ANGLE 3" X 3" X 1/4", 2-0 LONG	2
C	ANGLE 3" X 3" X 1/4", 4-11 LONG	9
D	ANGLE 3" X 3" X 1/4", 1-11 LONG	10
E	5/8" DIA. GALV. ROD (SEE DETAIL)	4

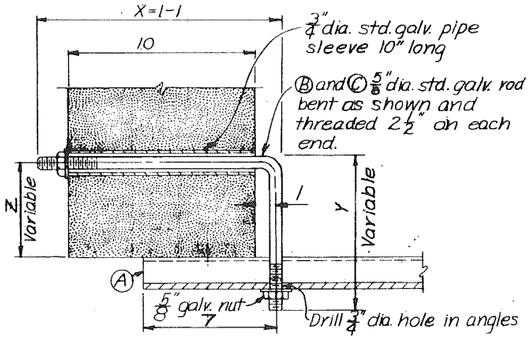
WEIGHT = 447 LB.



SIDE ELEVATION



SECTION A-A



DETAIL OF ANCHORAGE FOR ANGLES
DRAWDOWN INLET TRASH RACK
(Not to scale)

TABLE OF QUANTITIES FOR TRASH RACK
ON DRAWDOWN INLET STRUCTURE

MARK	ITEM	X	Y	Z	QUANTITY
A	ANGLE 2 1/2" X 2 1/2" X 1/4", 4-6 LONG				6
B	5/8" GALVANIZED ROD	1-1	8	5	8
C	5/8" GALVANIZED ROD	1-1	1-3	12	4

WEIGHT OF ANGLES - STEEL 111 LB.

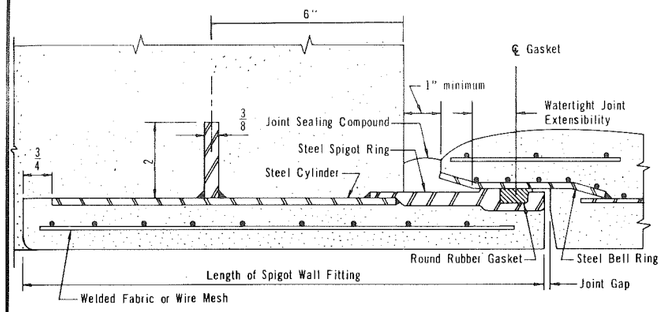
DETAILS OF ORIFICE TRASH RACK

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE - SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

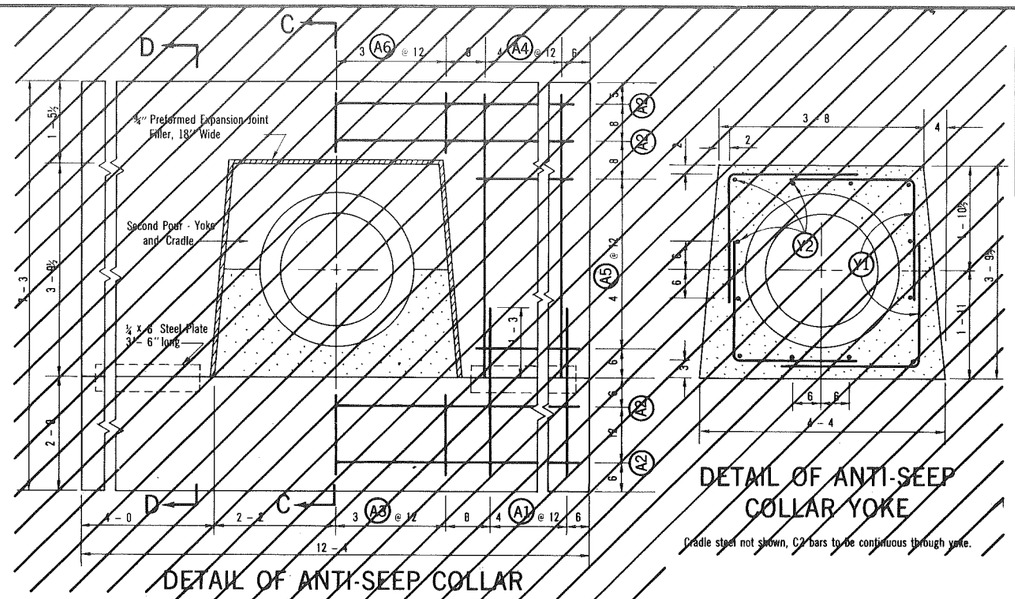
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S. & H.R.H.	Date 12/71	Approved by	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked		Sheet No 36 of 90	Drawing No. 5,E-29,772

SCS-ENG-313 Rev. 4-69



DETAIL A



DETAIL OF ANTI-SEEP COLLAR

Yoke and cradle steel not shown.

DETAIL OF ANTI-SEEP COLLAR YOKE

Cradle steel not shown, C2 bars to be continuous through yoke.

STEEL SCHEDULE

Cradle

Mark	Size	Total Quantity	Length	Type		Total Length
C_1	4	44	4 - 4	7		190-8
C_2	6	16	15 - 6	1		248-0
C_3	6	8	11 - 6	1		92-0

QUANTITIES

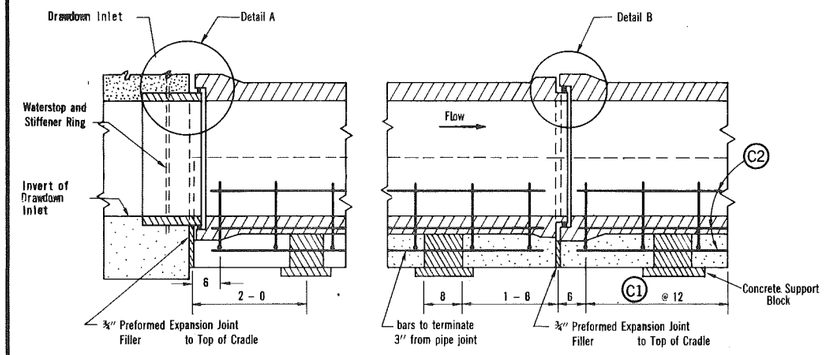
Concrete	Cu. Yds.
Anti-Seep Collar including Yoke	2,148
Each Additional Foot to Cradle	4.2
Cradle	
** Per Lineal Foot of Cradle	0.1823
Total	8.5
Steel	**Pounds**
Anti-Seep Collar including Yoke	1,200
Cradle	830

Concrete quantities are based on an outside diameter of pipe of 32 inches.
Steel quantities do not change with outside diameter of pipe.

* This quantity is given by
$2.128 - .0.0015\,\dfrac{15}{16}\,(D_f + 32)\,(D_f - 32)$ cu. yds.

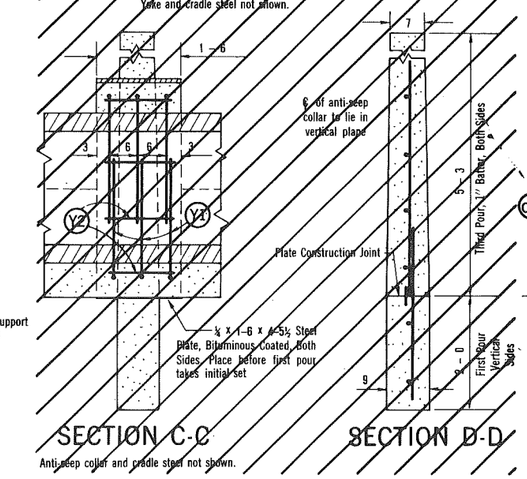
** This quantity is given by
$0.1923 - 0.0001010\,(D_f + 32)\,(D_f - 32)$ cu. yds.

D_f = outside diameter of pipe furnished, inches.



DETAIL OF SPIGOT WALL FITTING

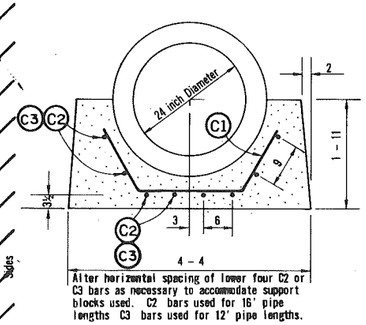
DETAIL OF PIPE JOINT



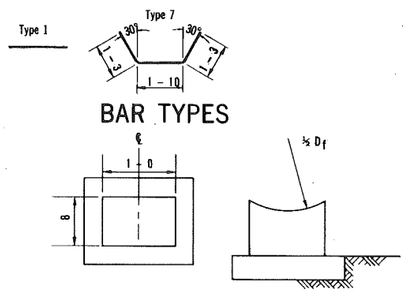
SECTION C-C

Anti-seep collar and cradle steel not shown.

SECTION D-D



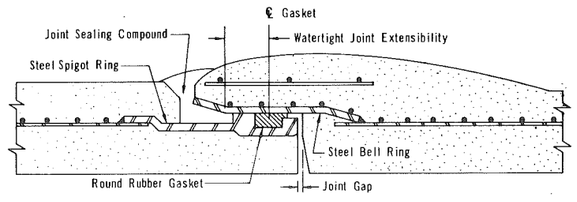
DETAIL OF CRADLE



BAR TYPES

SUGGESTED SUPPORT BLOCKS

Sufficient blocks shall be provided to support the pipe to the required line and grade. The Contractor shall determine the number and size of blocks required. Wedges may be used as an alternate.



DETAIL B

JOINT REQUIREMENTS

Length of Pipe Section	Minimun Joint Length	Minimum Joint Limiting Angle	
feet	inches	radians	degrees
16	2.75	0.0066	0°23'
12	2.75	0.0066	0°23'
8	2.75	0.0066	0°23'

For pipe length other than shown, joint requirements will be determined by the Engineer.

Where pipes of different length are connected, adjoining pipes shall meet the requirements of the longer pipe.

Prior to delivery of pipe, the pipe joint detail proposed for use shall be submitted to the Engineer for approval.

STRENGTH REQUIREMENTS

Inside Diameter of Pipe	Internal Load	External Load	
	Hydrostatic Pressure	Minimum 3-Edge Bearing Strength in Pounds per Lineal Foot of Pipe	
		Applicable Standard Specification	
		AWWA C-301	AWWA C-300
inches	Head of Water feet	Load to produce 0.001 inch crack one foot long	Load to produce 0.01 inch crack one foot long
24	40	2,850	3,800

The outside diameter of pipe assumed in design is 32 inches. Where the pipe furnished has an outside diameter greater than assumed in design, the three-edge bearing strength of the pipe furnished must not be less than the specified three-edge bearing strength multiplied by the ratio of the outside diameter of the pipe furnished to the outside diameter assumed in design.

STANDARD CONDUIT DETAILS
FOR
REINFORCED CONCRETE PRESSURE PIPE
PRINCIPAL SPILLWAY

STANDARD DWG. NO. ES-5024-CE

DATE 2-70 REV. 3-72 | SHEET 1 DF 1

Joint length equals watertight joint extensibility plus joint gap.

The pipe shall be drawn together so that the maximum joint gap does not exceed 3/8 inch for pipe laid on a straight line. For cambered pipe or pipe laid on a curved line, the joint gap at the closest point shall not exceed 3/8 inch.

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
L.M.S.	9-73	Title
Drawn		
Traced		Title
Checked		Sheet No 37 of 40 — Drawing No 5-E-29,772

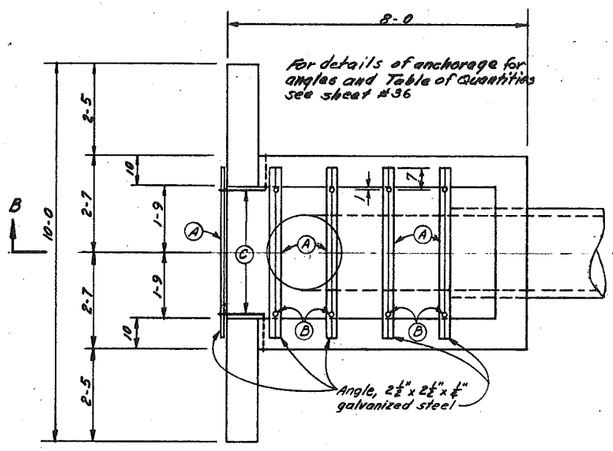
MATERIALS LIST FOR GATE & GATE LIFTING MECHANISM

ITEM	UNIT	QUANTITY
3" DIA. STD. GALV. PIPE WITH UNIONS & COUPLINGS	LIN. FT.	46-0
GATE STEM 1½" DIA. BRONZE	LIN. FT.	6-6
GATE STEM 1½" DIA. CARBON STEEL	LIN. FT.	47-6
STEM COUPLINGS	EACH	3
STEM SLEEVES	EACH	3
24" DIA. HANDWHEEL LIFT (EQUAL TO ARMCO HB-24) WITH BRONZE LIFT NUT	EACH	1
24" DIA. CAST IRON SLIDE GATE, RISING STEM, SPIGOT BACK AND BRONZE SEATS. (ARMCO MOD. 50-10 OR EQUAL)	EACH	1

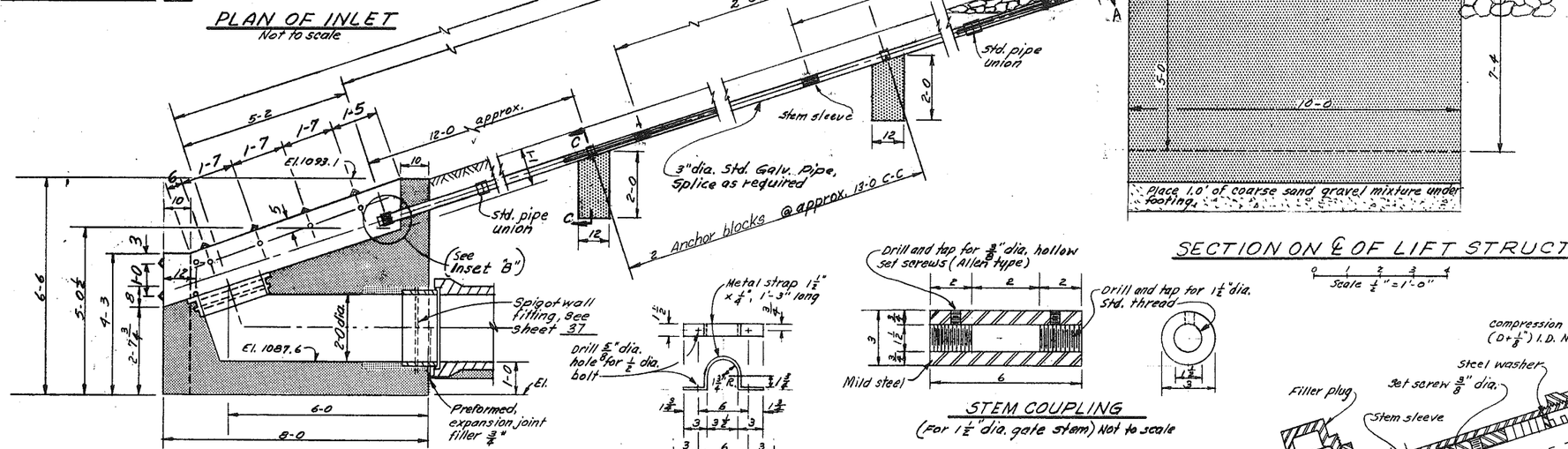
QUANTITIES FOR LIFT STRUCTURE, INLET STRUCTURE & ANCHOR BLOCKS

CLASS 4000 CONCRETE 10.1 Cu. Yds.
REINFORCING STEEL 595 Lbs.

NOTES:
1. Provide MMG-1 24"dia. cast iron Slide Gate, rising stem, spigot back and bronze seats (Armco Model 50-10 or equal) Set Gate frame & anchor bolts according to manufacturers specifications.
2. Fill Gate Stem Housing with 10W-30 or equal cylinder oil.
3. Trash Rack to be painted in accordance with specifications.
4. All bolts and nuts to be galvanized.
5. Length of the Gate Stem is measured from the center of the Gate to the base of the handwheel lift.
6. The inside of the inlet will be formed with steel forms which will be left in place upon completion.

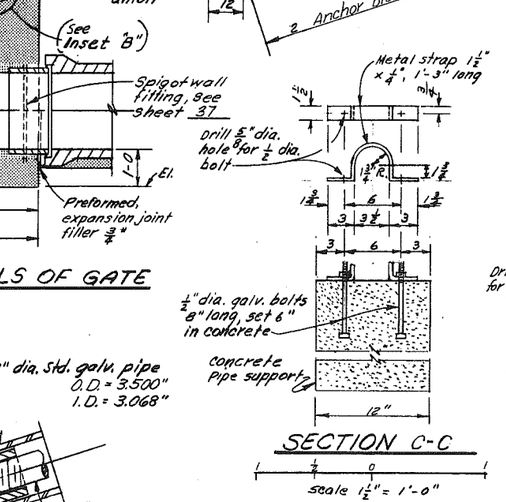


PLAN OF INLET
Not to scale



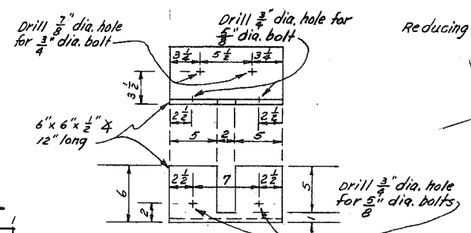
SECTION B-B SHOWING DETAILS OF GATE

SECTION ON & OF LIFT STRUCTURE
Scale ½" = 1'-0"

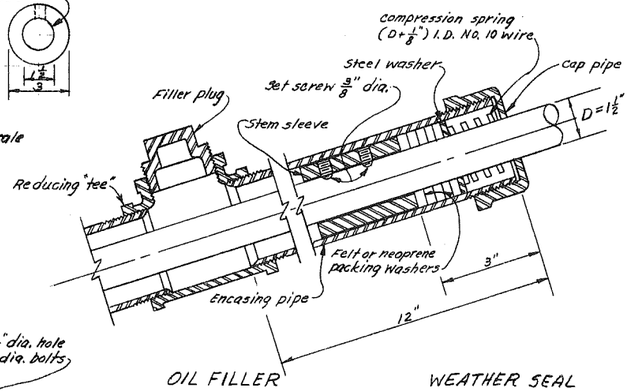


SECTION C-C
Scale 1½" = 1'-0"

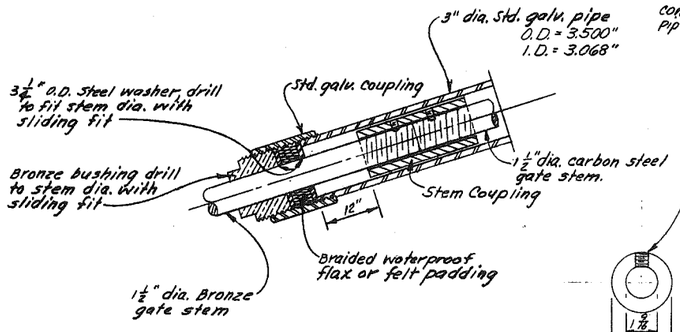
STEM COUPLING
(For 1½" dia. gate stem) Not to scale



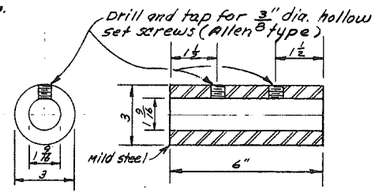
DETAIL OF BASE ANGLE FOR HANDWHEEL LIFT
N.T.S.



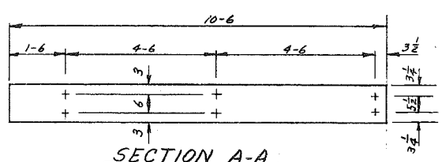
OIL FILLER WEATHER SEAL
INSET "A"
N.T.S.



INSET "B" OIL SEAL
NTS



STEM SLEEVE
(for pipe housing)
N.T.S.



SECTION A-A
Showing bolt location
N.T.S.

DETAILS OF DRAWDOWN

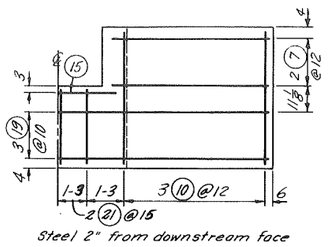
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

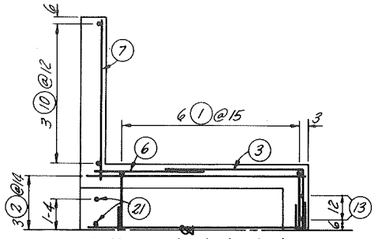
		Date		
Designed	L.M.S. C.E.M.	12/71	Approved by	
Drawn	J.R.D.	9/73	Title	
Traced			Title	
Checked	R.D.S.		Sheet No. 39 of 40	Drawing No. 5,E-29,772

U.S. GOVERNMENT PRINTING OFFICE : 1969 O—344-730

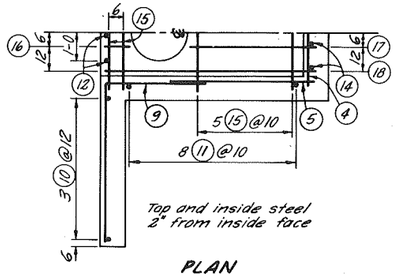
SCS-ENG-313-B Rev. 7-69



Steel 2" from downstream face

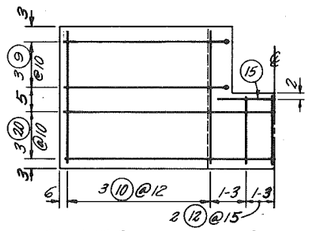


Bottom and outside steel
2" from outside face



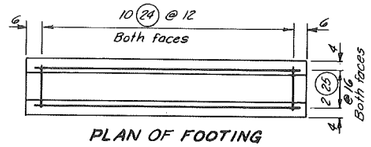
Top and inside steel
2" from inside face

PLAN

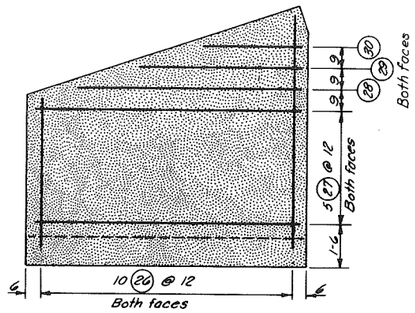


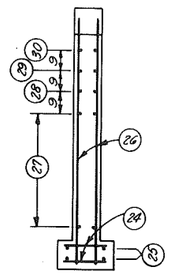
Steel 2" from upstream face

WINGWALLS



PLAN OF FOOTING

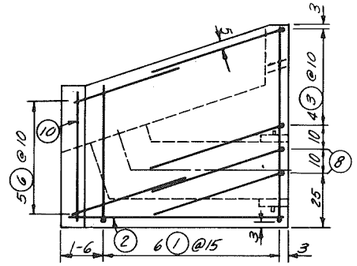




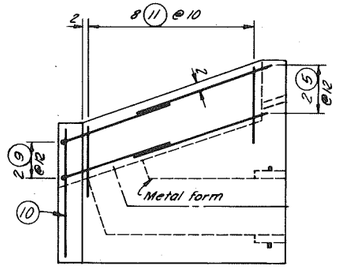
END VIEW

SECTION ON ℄

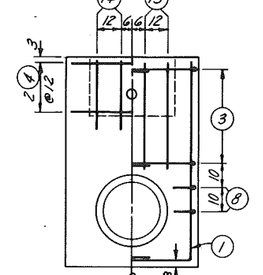
DETAILS OF LIFT STRUCTURE



Steel 2" from outside face



Steel 2" from inside face



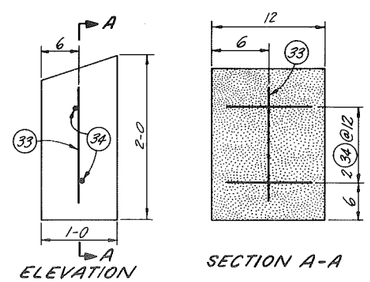
Steel 2" from upstream face

Steel 2" from downstream face

SIDEWALL ELEVATION

DOWNSTREAM END VIEW

DETAILS OF DRAWDOWN INLET



ELEVATION

SECTION A-A

DETAILS OF ANCHOR BLOCK

BAR SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C
1	4	2 SETS OF 6 BARS	7'-0" TO 9'-1" @ 5" INCR.	96-6	21	3-11 TO 6-0 @ 5" INCR.	3-1
2	4	5	7-6	37-6	1		
3	4	8	8-0	64-0	21	4-11	3-1
4	4	2	4-3	8-6	1		
5	4	4	5-0	20-0	1		
6	4	10	4-3	42-6	1		
7	4	4	3-0	12-0	1		
8	4	4	6-0	24-0	21	4-11	1-1
9	4	4	6-10	27-4	21	2-10	4-0
10	4	12	3-9	45-0	1		
11	4	16	1-9	28-0	1		
12	4	3	2-3	6-9	1		
13	4	4	2-9	11-0	1		
14	4	4	1-9	7-0	1		
15	4	7	4-6	31-6	1		
16	4	2	0-9	1-6	1		
17	4	2	4-9	9-6	1		
18	4	2	8-0	16-0	1		
19	4	3	9-6	28-6	1		
20	4	3	9-6	28-6	1		
21	4	3	2-6	7-6	1		
24	4	20	1-6	30-0	1		
25	4	4	9-6	38-0	1		
26	4	2 SETS OF 10 BARS	5'-3" - 8'-3" @ 4" INCR.	135-0	1		
27	4	10	9-6	95-0	1		
28	4	2	8-0	16-0	1		
29	4	2	5-9	11-6	1		
30	4	2	3-6	7-0	1		
33	4	2	1-6	3-0	1		
34	4	4	0-8	2-8	1		

BAR TOTALS

SIZE	LENGTH(FT.)	LBS.
4	891-3	595
	TOTAL	595

NOTES:
1. FOR BAR TYPE DETAILS, SEE SHEET 34.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.

Not to scale

ADAPTED FROM:
STRUCTURE NO. 9 (LEFT)
SHEET 21 OF 38
OTTER CREEK WATERSHED
IOWA COUNTY, WISCONSIN

DETAILS OF DRAWDOWN

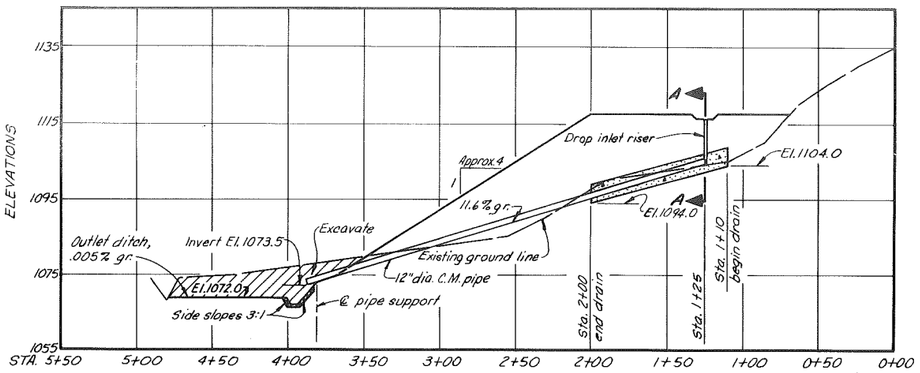
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

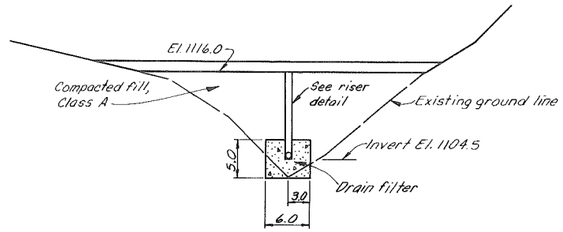
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S., C.E.M. Date 12-71
Drawn D.L.J. 5-68
Traced
Checked
Approved by
Title
Title
Sheet No. 39 of 40
Drawing No. 5,E-29,772



PROFILE ALONG ℄ OF C.M. PIPE DRAIN



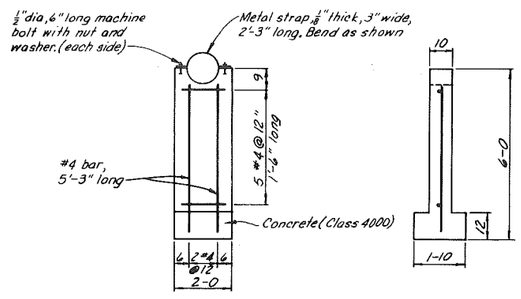
SECTION A-A

0 2 4 6 8 10

Scale in feet

TABLE OF QUANTITIES

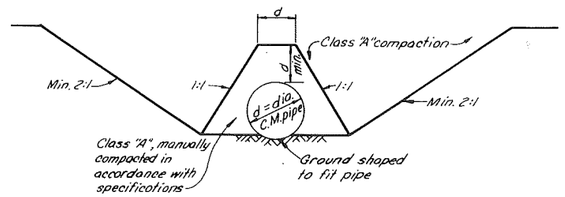
ITEM	UNIT	QUANTITY
EARTH FILL (CLASS A)	CU.YD.	6,484
DRAIN FILL	CU.YD.	100
12" DIA., C.M. RISER AS PER DETAIL, 0.064" WALL THICKNESS, ASBESTOS-TREATED, ASPHALT-COATED	EACH	1
12" DIA., C.M. PIPE, 0.064" WALL THICKNESS, ASBESTOS-TREATED, ASPHALT COATED	LIN.FT.	198
12" DIA., PERFORATED C.M. PIPE, 0.064" WALL THICKNESS, ASBESTOS-TREATED, ASPHALT COATED	LIN.FT.	68
CONCRETE, CLASS 4000	CU.YD.	0.8
STEEL REINFORCEMENT	LB.	22
ROCK RIPRAP WITH BEDDING	CU.YD.	34
12" DIA. NOMINAL CAST IRON RING AND GRATE, 40% MINIMUM, 65% MAXIMUM OPENING	EACH	1



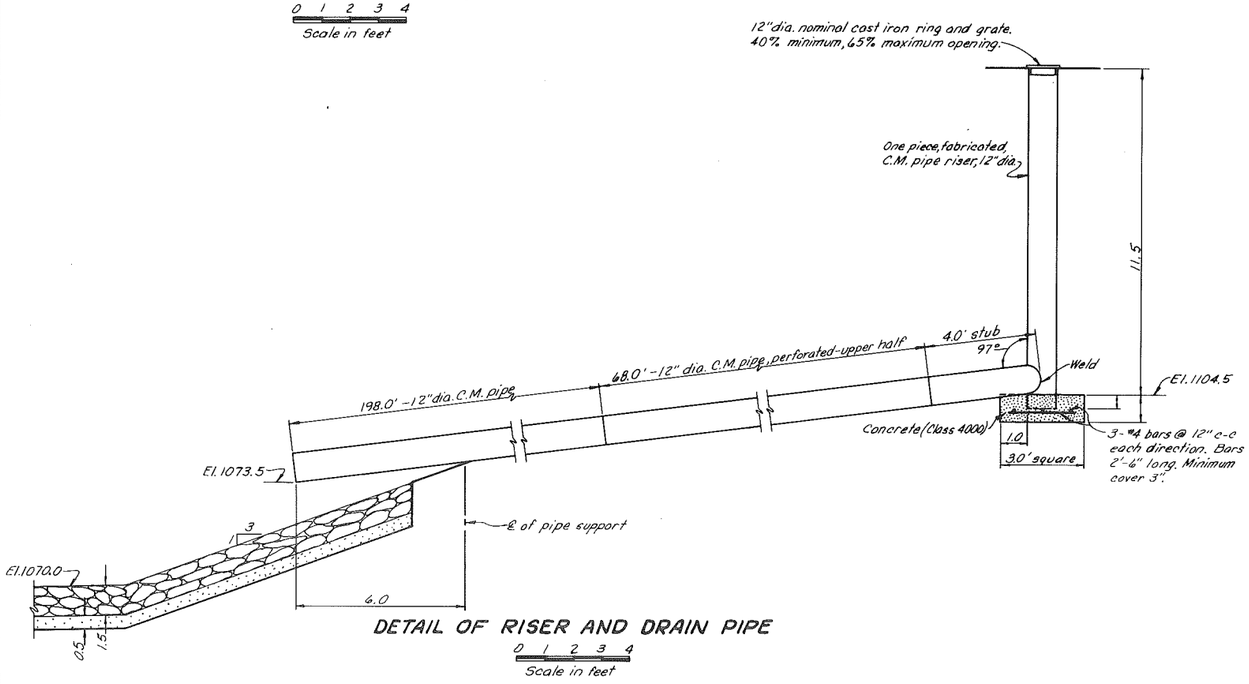
DETAIL OF CONCRETE PIPE SUPPORT

0 1 2 3 4

Scale in feet



TYPICAL DIAGRAM OF BACKFILL FOR C.M. PIPE



DETAIL OF RISER AND DRAIN PIPE

0 1 2 3 4

Scale in feet

NOTES:

1. LIMITS OF DRAIN FILTER WILL BE AS SHOWN UNLESS DIRECTED OTHERWISE BY THE ENGINEER.
2. FOR GRADATION OF FILTER MATERIAL, SEE SHEET 11.
3. CONSTRUCT PLUNGE POOL AS SHOWN WITH 2.0' BOTTOM WIDTH, 6.0' BOTTOM LENGTH, AND 3:1 SIDE SLOPES UNLESS DIRECTED OTHERWISE BY ENGINEER. PROVIDE 1.0' THICK ROCK RIPRAP PLUS 0.5' BEDDING MATERIAL. RIPRAP SIDES TO EL. 1073.5.
4. PERFORATED C.M. PIPE TO BE INSTALLED WITH PERFORATIONS TOWARD THE TOP.
5. ALL NUTS, BOLTS, AND WASHERS WILL BE GALVANIZED.

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY — NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	L.M.S.	1-74	Approved by	
Drawn	L.M.S.	1-74	Title	
Traced			Title	
Checked	R.D.S.	1-74	Sheet No. 40 of 40	Drawing No. 5,E-29,772

LEGEND

SYMBOLS

UNCONSOLIDATED MATERIAL

gravel
sand
silt
clay
cobbles, boulders
gravel, sandy
sand, gravelly
silt, gravelly
clay, gravelly
peat
gravel, silty
sand, silty
silt, sandy
clay, sandy
gypsi-ferous *
gravel, clayey
sand, clayey
silt, clayey
clay, silty
calcar-eous *
gravel, sand, silt
sand, silt, clay
organic silt
organic clay

* to be added to Standard Symbol when significant amounts of dispersed gypsum or calcified zones are present in the section.

CONSOLIDATED MATERIAL

Sedimentary Rocks

shale
sandstone
limestone
chalk
coal
calcareous shale
calcareous sandstone
cherty limestone
marl
gypsum
sandy shale
shaley sandstone
sandy limestone
chert
conglom-erate
siltstone
breccia
dolomite

Metamorphic Rocks

quartzite
slate
gneiss
schist
marble
soapstone talc serpentine

Igneous Rocks

intrusive
extrusive
pyroclastic

Undifferentiated

Other Symbols

○ hole logged only
◉ hole sampled
pit or trench

ABBREVIATIONS

aq	aquifer	fri	friable
cav.	cavities	lam	laminated
℄	centerline	mas	massive
con	concretions	TD	total depth
US	undisturbed samples	v.	very
DS	disturbed samples	w/	with
dip	dipping	wea	weathered
frac	fractured	WL	(date) groundwater level on a specified date

TEST HOLE NUMBERING SYSTEM

Centerline of dam	1 - 99
Borrow area	101 - 199
Emergency spillway	201 - 299
Centerline of outlet structure	301 - 399
Stream channel	401 - 499
Relief wells	501 - 599
	601 - 699
	701 - 799

UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOLS

GW Well graded gravels; gravel-sand mixtures
GP Poorly graded gravels
GM Silty gravels; gravel-sand-silt mixtures
GC Clayey gravels; gravel-sand-clay mixtures
SW Well graded sands; sand-gravel mixtures
SP Poorly graded sands
SM Silty sand
SC Clayey sands; sand-clay mixtures
ML Silts; silty, v. fine sands; sandy or clayey silts
CL Clays of low plasticity to medium plasticity; silty, sandy or gravelly clays
CH Clays of high plasticity; fat clays
MH Elastic silts; micaceous or diatomaceous silts
OL Organic silts and organic silty clays of low plasticity
OH Organic clays or silts of medium to high plasticity

Revised 2/63

IDENTIFICATION SYMBOLS FOR SOIL AND ROCK MATERIALS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

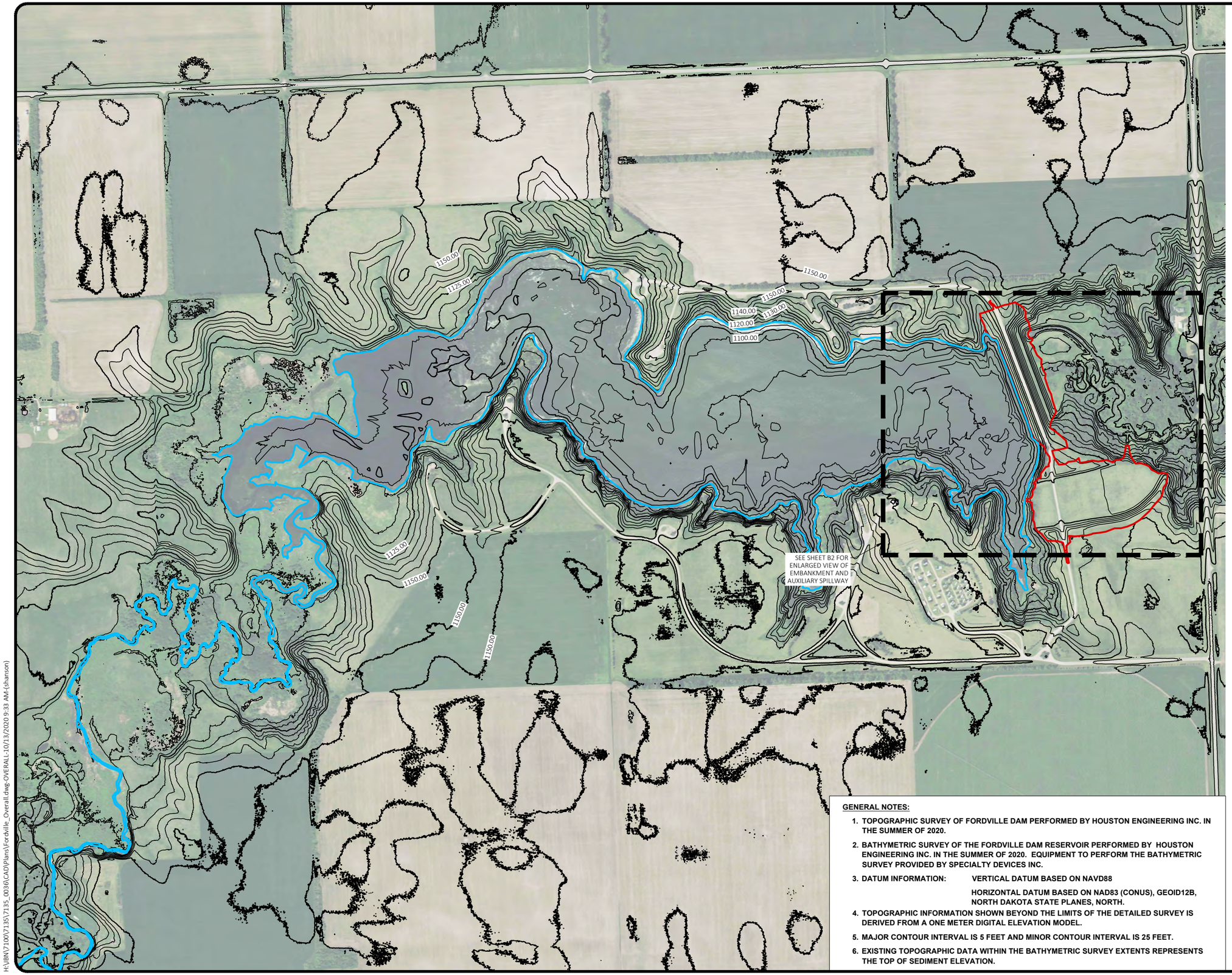
COMPILED	CHECKED	DATE	DRAWING NO.
		12/58	5,R-10,000.47

USDA-SCS-LINCOLN, NEBR. 1963

APPENDIX B

Field Survey Maps

DRAFT



N

400 0 400 800

Scale Feet

LEGEND

MAJOR CONTOURS 1360

MINOR CONTOURS

GROUND SURVEY LIMITS

BATHYMETRIC SURVEY LIMITS

GENERAL NOTES:

1. TOPOGRAPHIC SURVEY OF FORDVILLE DAM PERFORMED BY HOUSTON ENGINEERING INC. IN THE SUMMER OF 2020.
2. BATHYMETRIC SURVEY OF THE FORDVILLE DAM RESERVOIR PERFORMED BY HOUSTON ENGINEERING INC. IN THE SUMMER OF 2020. EQUIPMENT TO PERFORM THE BATHYMETRIC SURVEY PROVIDED BY SPECIALTY DEVICES INC.
3. DATUM INFORMATION: VERTICAL DATUM BASED ON NAVD88
   HORIZONTAL DATUM BASED ON NAD83 (CONUS), GEOID12B, NORTH DAKOTA STATE PLANES, NORTH.
4. TOPOGRAPHIC INFORMATION SHOWN BEYOND THE LIMITS OF THE DETAILED SURVEY IS DERIVED FROM A ONE METER DIGITAL ELEVATION MODEL.
5. MAJOR CONTOUR INTERVAL IS 5 FEET AND MINOR CONTOUR INTERVAL IS 25 FEET.
6. EXISTING TOPOGRAPHIC DATA WITHIN THE BATHYMETRIC SURVEY EXTENTS REPRESENTS THE TOP OF SEDIMENT ELEVATION.

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	Date	By

FORDVILLE DAM
OVERALL SITE PLAN

HOUSTON engineering, inc.

Drawn By	AJK,SMH
Checked By	PDL
Date	10-13-20
Scale	As Shown
Project No.	7135-0036
SHEET	B1

H:\BRN\7100\7135\7135_0036\CAD\Plans\Fordville_Overall.dwg OVERALL-10/13/2020 9:33 AM-(shanson)

CP# 5
N 442913.77
E 2636965.88
ELEV. 1138.30

WING WALL

PRINCIPAL SPILLWAY RISER

NORMAL POOL ELEV. 1105.97

5' x 5' RECTANGULAR CONDUIT

TOP OF DAM ℄
ELEV. 1132.08

BORING FD2020-11
ELEV. 1130.16
(GROUND)

BORING FD2020-608
ELEV. 1102.44
(GROUND)

BORING FD2020-609
ELEV. 1083.16
(GROUND)

CP# 4
N 442219.02
E 2637169.78
ELEV. 1131.54

ROAD ℄

EXISTING GUARD RAIL

EXISTING GUARD RAIL

12" CMP
INV. 1073.70

CP# 3
N 441635.45
E 2637422.78
ELEV. 1135.06

BORING FD2020-214
ELEV. 1124.07
(GROUND)

12" CMP

CATCH BASIN
RIM ELEV. 1117.04

18" CMP
W INV. 1121.99
E INV. 1122.34

AUXILIARY SPILLWAY ℄

BORING FD2020-212
ELEV. 1123.85
(GROUND)

BORING FD2020-213
ELEV. 1123.67
(GROUND)

AUXILIARY SPILLWAY
CREST ELEV. 1124.20

CP# 2
N 441256.12
E 2637406.87
ELEV. 1123.93

N

100 0 100 200
Scale Feet

LEGEND

- MAJOR CONTOURS — 1360
- MINOR CONTOURS
- GROUND SURVEY LIMITS
- BATHYMETRIC SURVEY LIMITS
- SOIL BORING
- CONTROL POINT
- TOPO SURVEY POINT
- GRAVEL
- DRAINAGE DIRECTION

NOTE:
1. REFER TO SHEET B1 FOR GENERAL NOTES.

2. MAJOR CONTOUR INTERVAL IS 10 FEET AND MINOR CONTOUR INTERVAL IS 2 FEET

PRELIMINARY
NOT FOR CONSTRUCTION

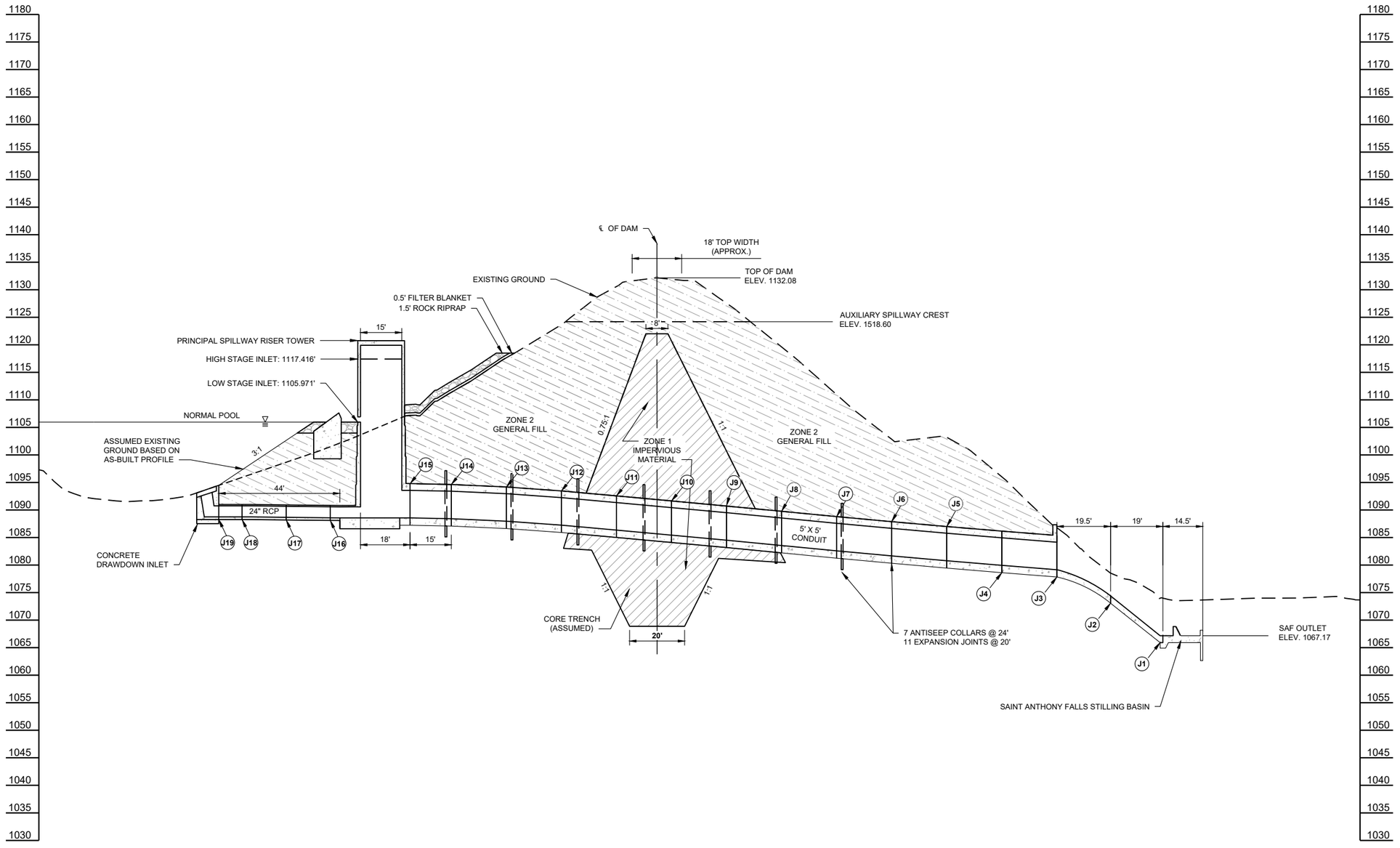
No.	Revision	Date	By

FORDVILLE DAM
EXISTING CONDITIONS TOPOGRAPHY

HOUSTON engineering, Inc.

Drawn By	AJK,SMH
Checked By	PDL
Date	10-13-20
Scale	As Shown
Project No.	7135-0036
SHEET	B2

H:\JBN\7100\7135\7135_0036\CAD\Plans\Fordville Topo.dwg-EX_CONDITIONS_TOPO-10/13/2020 9:35 AM-(shanson)



FORDVILLE PRINCIPAL SPILLWAY CROSS SECTION
NOT TO SCALE

LEGEND

- ZONE 1 IMPERVIOUS MATERIAL
- ZONE 2 GENERAL FILL
- CONCRETE
- RIPRAP

NOTES:
1. ALL ELEVATIONS REFERENCE NAVD88 VERTICAL DATUM
2. ELEVATIONS BASED ON AS-BUILT PLANS AND FIELD SURVEY DATA

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	Date	By

FORDVILLE DAM
EXISTING PRINCIPAL SPILLWAY CROSS SECTION

HOUSTON engineering, Inc.

Drawn By	RCG
Checked By	PDL
Date	10-20-20
Scale	As Shown
Project No.	7135-0036
SHEET	B3

H:\JBN\7100\7135\7135_0036\CAD\Plans\Cross Section at Spillway with hatches.dwg-FORDVILLE-11/10/2020 3:24 PM-(rglatt)

APPENDIX C

Supporting Survey Information

- Survey Field Notes
- Survey Processing Information
- HEI Survey Feature Code List
- Survey Points Collected

DRAFT

SURVEY FIELD NOTES

ELAN

ONE JOB FIELD BOOK

Project Name: FORDYCE DAM

Project Number: 7135-0036

Date: _____

_____

_____

16 Pages
50% cotton content
water-resistant paper

5-4-20
D. SUNDA
T. BUSS
C. GULAN
N. SHANE

7135-0036
FORDVILLE DAM
N.D. STATE PLANE NORTH
U.S. SURVEY FT.

TSCM- Pt # 1-5

- SET HEGA #1 WITH MDSTATES VRS
- SET HEGA #2-6 WITH GPS BASE

5-6-20
D. SUNDA
T. BUSS
C. GULAN
N. SHANE

AT SET ON HEGA #1 Ht = 5.83

- LEVEL THROUGH CONTROL POINTS #1-5
- START CROSS SECTIONS ON DAM AND SPILLWAY
  Pt # 5000 - 5392
  1000 - 1581

	+	⊼	−	ELEV.
B.M.	1.08	1145.12		1144.04
T.P.			14.71	1130.41
	1.00	1131.41		
C.P. #2			7.49	1123.92
	~~10.78~~	~~1134.70~~		
	12.42	1136.34		
C.P. #3			1.30	1135.04
	1.70	1136.74		
C.P. #4			5.19	1131.55
	6.12	1137.67		
T.P.			3.13	1134.54
	4.55	1139.09		
C.P. #5			0.77	1138.32
	0.26	1138.58		
T.P.			4.04	1134.54
	2.30	1136.84		
C.P. #4			5.29	1131.55
	5.52	1137.07		
C.P. #3			2.02	1135.05
	1.44	1136.49		
C.P. #2			12.57	1123.92
	6.00	1129.92		
T.P.			1.16	1128.76
	15.51	1144.27		
Close			0.23	1144.04

HECP #1 GPS 1144.04

Hub

HECP #2 GPS 1123.93

HECP #3 GPS 1135.06

HECP #4 GPS 1131.54

Spike 60D in Guardrail Post

HECP #5 GPS 1138.30

Spike in Post

HECP #4

HECP #3

HECP #2

Hub

HECP #1

5-7-20
T. Buss
N. Shasne

π HEC-1 $H_t = 5.62$

- Cross Sections

Rm # 1582-1624

5-8-20
T. Buss
N. Shasne

π HEC-1 $H_t = 5.56$

- Cross Sections

Rm # 1625-1757

5-18-20
D. Sunga
C. Gulan
T. Buss
N. Shasne

π HEC-1 $H_t = 5.50$

- Cross Sections

Rm # 1758-1776
5893-6092

6-12-20
D. Sunga
C. Gulan

π HEC-1 $H_t = 5.65$

- Stake Soil Borings

6-16-20
D. Sunga
C. Meyer

- Bathymetric + Sediment Survey

7-13-20
D. Sunga
C. Gulan
T. Berg

π HEC-1 $H_t = 4.30$

- Bankfull Survey

Rm # 6113-6222

SURVEY PROCESSING INFORMATION

Forest River Dam Rehab - Fordville Dam	**7135-0036**

Houston Engineering Inc.

1401 21st Avenue North

Fargo, ND 58102

USA

Phone: 701-237-5065

Fax: 701-237-5101

www.houstoneng.com

Project file data		**User information**		**Coordinate System**	
Name:	H:\Fargo\Dept\Survey\TBC\2020\7100\7135-0036 Forest River Dam Rehab - Fordville Dam.vce	Field operator:		Name:	United States/State Plane 1983
		Office operator:	Patrick Johanneck	Datum:	NAD 1983 (Conus)
Size:	731 KB			Zone:	North Dakota North 3301
Modified:	5/11/2020 6:53:25 PM (UTC:-5)			Geoid:	GEOID18 (Conus) trim
Time zone:	Central Standard Time			Vertical datum:	NAVD 1988
Reference number:	7135-0036			Calibrated site:	
Description:	7135-0036				
Comment 1:					
Comment 2:					
Comment 3:					

Additional Coordinate System Details

Local Site Settings			
Project latitude:	?	Ground scale factor:	1
Project longitude:	?	False northing offset:	0.000
Project height:	900.000	False easting offset:	0.000

Forest River Dam Rehab - Fordville Dam	**7135-0036**
Houston Engineering Inc.	Phone: 701-237-5065
1401 21st Avenue North	Fax: 701-237-5101
	www.houstoneng.com
Fargo, ND 58102	
USA	

Project file data		**User information**		**Coordinate System**	
Name:	H:\Fargo\Dept\Survey\TBC\2020\7100\7135-0036 Forest River Dam Rehab - Fordville Dam.vce	Field operator:	Dan Sunram, Tim Buss	Name:	United States/State Plane 1983
		Office operator:	Patrick Johanneck	Datum:	NAD 1983 (Conus)
Size:	826 KB			Zone:	North Dakota North 3301
Modified:	5/21/2020 12:01:55 PM (UTC:-5)			Geoid:	GEOID18 (Conus) trim
Time zone:	Central Standard Time			Vertical datum:	NAVD 1988
Reference number:	7135-0036			Calibrated site:	
Description:	7135-0036				
Comment 1:					
Comment 2:					
Comment 3:					

Additional Coordinate System Details

Local Site Settings			
Project latitude:	?	Ground scale factor:	1
Project longitude:	?	False northing offset:	0.000
Project height:	900.000	False easting offset:	0.000

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Modified:	6/16/2020 1:45:10 PM (UTC:-5)			Geoid:	GEOID18 (Conus) trim
Time zone:	Central Standard Time			Vertical datum:	NAVD 1988
Reference number:	7135-0036			Calibrated site:	
Description:	7135-0036				
Comment 1:					
Comment 2:					
Comment 3:					

Additional Coordinate System Details

Local Site Settings			
Project latitude:	?	Ground scale factor:	1
Project longitude:	?	False northing offset:	0.000
Project height:	900.000	False easting offset:	0.000

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Time zone:	Central Standard Time			Vertical datum:	NAVD 1988
Reference number:	7135-0036			Calibrated site:	
Description:	7135-0036				
Comment 1:					
Comment 2:					
Comment 3:					

Additional Coordinate System Details

Local Site Settings			
Project latitude:	?	Ground scale factor:	1
Project longitude:	?	False northing offset:	0.000
Project height:	900.000	False easting offset:	0.000

HEI SURVEY FEATURE CODE LIST

Description	Feature Code
Abutment	ABUT
AerialTarget	ATRGT
Air Con Unit	ACU
Air Release Valve	ARV
Anode	ANODE
Approach	APPR
Asphalt Area	AREAASP
Asphalt Edge	ASP
Azmuth Mark	AZI
Ballast Retainer	BRET
Beehive Center Inlet	BH
Beehive Rim (R-I)	BHRIM
BM	BM
Box Culvert Concrete	BXC
Brace Pole	BP
Breakline	BRK
Bridge	BR
Building	BLDG
Building Height	BLDGHT
Building Polygon	BLDGP
Bulkhead	BULKHEAD
Calculated Point	CALC
Canopy	CAN
Cast Iron Pipe	CIP
Catch Basin	CB
Cattails	CATTAIL
Cattle Guard	CTGD
Catwalk	CATWALK
Center of Sec Calc	CORCOSCALC
Center of Sec Found	CORCOSFD
Center of Sec Set	CORCOSSET
Check Shot	CHK
Column - Line	COL
Column - Point	COLUMN
CON JOINT	JNT
Concrete Area	AREACON
Concrete Edge	CON
Control Point	CP
Cor Metal Pipe	CMP
Cor Metal Pipe Arch	CMPA
Cor Plastic Pipe	CPP
COR16CALC	COR16CALC
COR16FD	COR16FD
COR16SET	COR16SET
Corner Tie	CORTIE
Crack	CRACK
Crushed Concrete	CC
Curb Gutter Line	GUT
Curb Top Back	TC
Dam	DAM
Deck	DECK
Deck Plate Girder	DPG
Depth Shots	DEPTH
Ditch Toe	TOE
Drain Tile	DRNTILE
Drainage Ditch	DRN
Dumpster Area	AREADUMP
Earth DIKE	DIKE
Edge of Field	EOF
Edge of Water	EOW
Elec Transformer	ELT
Elec. Vault	EVLT
Electric Box	ELBX
Electric Fence	FNEL
Electric Meter	ELM
Electric Plug in	ELPI
Evergreen Row	EVERGREENROW
Fence Barb Wire	FNB
Fence Chainlink	FNC
Fence Iron	FNI
Fence Silt	FNS
Fence Vinyl	FNV
Fence Wood	FNW
Fence Woven Wire	FNWW
Fiber Optic	UGFO
Fiber Optic Ped	FOP
Finished Floor	FINFLR
Flag Pole	FGP
Flood Light	FLDLT
FO Vault	FOVLT
Gas Filler Pipe	GFP
Gas Line	UGG
Gas Meter	GM

Description	Feature Code
Gate	GATE
Gate Valve Gas	GVG
Gate Valve Storm	GVST
Gate Valve Water	GVW
Gate Well Sanitary	SSGW
Gate Well Storm	STGW
GRAIN BIN	GB
Grass Area	AREAGRASS
Gravel Area	AREAGRV
Gravel Edge	GRV
Guard Post	GP
Guard Rail	GDR
Guy Pole	GYP
Guywire	GUY
Hand Rail	HDRAIL
Handicap Parking	HPKG
Handicap Ramp	HCR
Handicap Sign	HPKGSGN
Hedge Row	HEDGEROW
HEI Control Point	HECP
High Water	HW
Hydrant	HYD
Lamp Post	LPL
LandScape	LS
Landscape Area	AREALS
Landscape Block	LSBLOCK
Landscape Curb	LSCURB
Lift Station	LFST
Light Pole Concrete	LPC
Light Pole Steel	LPS
Light Pole Traf Sig	LPTS
Light Pole Wood	LPW
Loading DOCK	DOCK
Low Beam	LB
MailBox	MB
Manhole Electric	MHE
Manhole ForceMain	MHFS
Manhole Gas	MHG
Manhole Sanitary	MHS
Manhole Storm	MHST
Manhole Telephone	MHT
Manhole Unidentified	MHU
Manhole Water	MHW
Meander Cor Calc	CORMCCALC
Meander Cor Found	CORMCFD
Meander Cor Set	CORMCSET
Metal Grate	MG
Mile Post	MP
Misc. Tower	TWR
MNDOT Monument	MNDOT
Monitor Well	MWELL
NGS Monument	NGS
Oil Pipeline	UGO
Overhead Lines	OHL
Parapet	PARAPET
Park Bench	BENCH
Parking Bumper	BBLK
Parking Stripe	PKGS
PC	PC
Pergola	PERGOLA
PI	PI
Pier	PIER
Planter	PLTR
Point On Curve	OC
Point on Line	POL
Post Indicator Valve	PIV
Power Pole	PP
PowerPole Structure	PPS
PowerPole w Light	PPL
Property Cor Calc	CORPROPCALC
Property Cor FD	CORPROPFD
Property Cor Set	CORPROPSET
PT	PT
Push to walk	PTW
PVC Pipe	PVC
Quarter Cor Calc	CORQTRCALC
Quarter Cor FD	CORQTRFD
Quarter Cor Set	CORQTRSET
Radius Point	RADPT
Railroad	RAIL
RailRoad CL	RRCL
Random Point	RP
RCP Pipe	RCP

Description	Feature Code
Rein Conc Pipe Arch	RCPA
Retaining Wall	RTW
Right of Way Marker	RWM
RipRap Edge	RIP
River Centerline	RIVER
Road Centerline	RD
Road Shoulder Edge	SHLDR
Roof Drain	RFD
RR BALLAST	BLST
RR Crossing Concrete	RRXC
RR Crossing Rubber	RRXR
RR Crossing Timber	RRXT
RR Heater Vent Pipe	RRHTRVP
RR High Rail	RRHIR
RR Last Long Tie	RRLLT
RR Point of Frog	RRPOF
RR Point of Switch	RRPOS
RR Signal	RRSIG
RR Signal Hut	RRHUT
RR Switch	RRSWT
RR Switch Heater	RRHTR
RW Monument Calc	RWMONCALC
RW Monument FD	RWMONFD
RW Monument Set	RWMONSET
Sanitary Cleanout	SSCLN
Sanitary Locate	SSL
Section Cor Calc	CORSECCALC
Section Cor FD	CORSECFD
Section Cor Set	CORSECSET
SHRUB	SHRUB
Shrub Row	SHRUBROW
Sign	SGN
Sign multi posts	SGNS
Sign Overhang	SGNOH
Slough or Sluff	SLUFF
Soil Boring	SB
Spillway	SPL
SPOT	SPOT
Sprinkler	SPK
Sprinkler Valve	SPKV
Steps	STEPS
Stockpile	STOCKPILE
Storm Locate	STL
Stringer	STRINGER
Struc Plat Pipe Arch	SPPA
Swale	SWALE
Tank Above Grnd	TNKA
Tank Below Grnd	TNKU
Tele. Vault	TVLT
Telephone Ped	TPC
Telephone Pole	TP
Top of Water	TOW
Tower Legs	TWRS
Traffic Control Box	TSCB
Traffic Signal	TSG
Tree Deciduous	TREE
Tree Evergreen	EVERGREEN
Tree Row	TREEROW
Trench Drain	TDR
TV Ped	TVP
Undergr Missle Cable	UMC
Underground CableTV	UGCTV
Underground Electric	UGE
Underground Tele	UGT
Utility Marker	UMK
Utility Marker Elec.	UME
Utility Marker FO	UMFO
Utility Marker Gas	UMG
Utility Marker H2O	UMW
Utility Marker Oil	UMO
Utility Marker Tele	UMT
Vault Outline	VLT
Wall (Brick/Block)	WALL
Water Service Valve	WSV
WaterMain	WM
Weigh Scale	SCALE
WEIR Opening	WEIR
Well	WELL
Wetland Edge	WET
Wing Wall	WING
Witness Cor	CORWT
Woods Edge	WOODS

SURVEY POINTS COLLECTED

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
1	440687.54	2637575.016	1144.04	HECP
2	441256.122	2637406.871	1123.926	HECP
3	441635.449	2637422.778	1135.059	HECP
4	442219.024	2637169.779	1131.538	HECP
5	442913.774	2636965.883	1138.295	HECP
6	445225.459	2641269.905	1064.236	HECP
998	442908.668	2637103.601	1127.673	NAIL
999	442792.038	2636923.275	1125.775	RP
1000	441256.069	2637406.849	1123.931	chk 2
1001	441694.7	2637353.4	1131.756	SPOT
1002	441694.464	2637346.282	1132.061	SPOT
1003	441694.353	2637343.77	1131.754	SPOT
1004	441697.686	2637363.02	1132.029	SPOT
1005	441699.239	2637367.139	1132.248	SPOT
1006	441704.861	2637391.479	1132.363	SPOT
1007	441703.459	2637399.761	1131.717	SPOT
1008	441706.921	2637409.443	1131.157	SPOT
1009	441712.536	2637442.834	1129.401	SPOT
1010	441720.585	2637484.621	1127.195	SPOT
1011	441728.665	2637519.512	1125.304	SPOT
1012	441732.16	2637532.605	1124.417	SPOT
1013	441793.652	2637518.379	1121.414	SPOT
1014	441779.879	2637480.315	1123.187	SPOT
1015	441768.13	2637442.941	1125.266	SPOT
1016	441757.738	2637410.612	1127.9	SPOT
1017	441750.909	2637390.812	1129.083	SPOT
1018	441750.417	2637388.456	1129.297	SPOT
1019	441748.598	2637380.233	1131.254	SPOT
1020	441748.471	2637378.542	1131.566	SPOT
1021	441746.424	2637349.713	1131.435	SPOT
1022	441747.049	2637347.43	1130.995	SPOT
1023	441746.203	2637344.12	1130.286	SPOT
1024	441745.46	2637341.121	1129.148	SPOT
1025	441744.003	2637335.372	1128.465	SPOT
1026	441743.506	2637333.455	1127.661	SPOT
1027	441741.89	2637329.546	1125.815	SPOT
1028	441793.506	2637330.529	1130.835	SPOT
1029	441776.341	2637276.366	1107.243	SPOT
1030	441777.356	2637279.242	1108.719	SPOT
1031	441778.358	2637285.128	1111.626	SPOT
1032	441780.335	2637286.379	1113.882	SPOT
1033	441783.022	2637294.79	1119.489	SPOT
1034	441785.472	2637301.98	1120.946	SPOT
1035	441788.723	2637311.681	1123.186	SPOT
1036	441790.689	2637321.836	1126.658	SPOT
1037	441792.592	2637329.56	1130.472	SPOT
1038	441802.652	2637354.35	1131.428	SPOT
1039	441804.25	2637359.247	1131.011	SPOT
1040	441805.557	2637362.371	1129.844	SPOT
1041	441807.333	2637369.588	1127.168	SPOT
1042	441813.834	2637387.69	1124.247	SPOT
1043	441819.126	2637401.292	1122.261	SPOT
1044	441820.664	2637405.38	1122.144	SPOT
1045	441824.277	2637414.302	1122.679	SPOT
1046	441831.255	2637433.679	1121.306	SPOT
1047	441835.704	2637445.529	1120.989	SPOT
1048	441842.43	2637464.017	1120.156	SPOT
1049	441878.292	2637418.891	1120.744	SPOT
1050	441868.161	2637402.107	1117.369	SPOT
1051	441866.686	2637399.678	1117.141	SPOT
1052	441865.487	2637397.59	1117.258	SPOT
1053	441862.144	2637391.102	1118.273	SPOT
1054	441852.677	2637370.28	1122.862	SPOT
1055	441846.003	2637353.496	1127.331	SPOT
1056	441843.858	2637345.062	1130.528	SPOT
1057	441842.971	2637341.542	1131.293	SPOT
1058	441834.474	2637317.731	1131.163	SPOT
1059	441833.692	2637313.283	1130.551	SPOT
1060	441827.64	2637298.069	1124.423	SPOT
1061	441826.231	2637290.813	1121.802	SPOT
1062	441823.393	2637282.469	1121.083	SPOT
1063	441817.061	2637269.684	1116.917	SPOT
1064	441816.654	2637263.375	1115.015	SPOT
1065	441813.357	2637254.122	1111.241	SPOT
1066	441810.563	2637247.285	1109.692	SPOT
1067	441807.89	2637241.235	1107.346	SPOT
1068	441841.58	2637221.306	1107.473	SPOT
1069	441843.682	2637226.12	1108.675	SPOT
1070	441850.079	2637244.392	1113.241	SPOT
1071	441853.807	2637258.515	1116.744	SPOT
1072	441859.626	2637274.46	1121.705	SPOT
1073	441867.09	2637293.221	1128.216	SPOT
1074	441868.81	2637297.177	1130.092	SPOT
1075	441869.647	2637300.291	1131.304	SPOT
1076	441879.945	2637327.184	1131.377	SPOT
1077	441880.931	2637329.808	1130.776	SPOT
1078	441888.78	2637351.258	1123.215	SPOT
1079	441895.926	2637370.101	1116.854	SPOT
1080	441898.191	2637375.223	1115.853	SPOT
1081	441900.491	2637380.268	1115.57	SPOT
1082	441901.455	2637382.706	1116.557	SPOT
1083	441947.026	2637383.751	1105.698	SPOT
1084	441941.3	2637369.497	1108.565	SPOT
1085	441932.921	2637350.708	1116.157	SPOT
1086	441926.792	2637330.257	1124.309	SPOT
1087	441919.602	2637314.459	1130.95	SPOT
1088	441919.381	2637312.558	1131.394	SPOT
1089	441909.416	2637286.911	1131.681	SPOT
1090	441909.184	2637284.47	1131.285	SPOT
1091	441908.441	2637281.025	1130.325	SPOT
1092	441906.888	2637278.473	1128.602	SPOT
1093	441900.454	2637262.54	1122.548	SPOT
1094	441898.894	2637257.649	1121.541	SPOT
1095	441894.354	2637244.552	1117.518	SPOT
1096	441890.229	2637232.682	1113.861	SPOT
1097	441887.064	2637223.553	1111.95	SPOT
1098	441885.222	2637216.532	1109.597	SPOT
1099	441884.151	2637213.262	1108.432	SPOT
1100	441884.101	2637211.225	1107.439	SPOT
1101	441916.622	2637199.343	1107.431	SPOT
1102	441918.034	2637203.49	1109.57	SPOT
1103	441921.785	2637213.654	1112.361	SPOT
1104	441927.668	2637228.401	1116.221	SPOT
1105	441933.04	2637241.924	1120.496	SPOT
1106	441935.473	2637248.532	1122.665	SPOT
1107	441938.543	2637259.354	1126.365	SPOT
1108	441942.948	2637269.683	1130.82	SPOT
1109	441944.185	2637272.166	1131.528	SPOT
1110	441944.643	2637273.358	1131.718	SPOT
1111	441953.436	2637295.764	1131.815	SPOT
1112	441954.615	2637298.897	1131.437	SPOT
1113	441956.846	2637304.953	1128.934	SPOT
1114	441967.751	2637337.419	1115.764	SPOT
1115	441973.175	2637357.359	1107.245	SPOT
1116	441977.536	2637370.202	1102.285	SPOT
1117	441978.291	2637372.201	1101.804	SPOT
1118	441979.511	2637376.57	1101.816	SPOT
1119	441980.949	2637378.642	1102.221	SPOT
1120	441983.518	2637384.045	1101.864	SPOT
1121	441984.466	2637388.049	1100.49	SPOT
1122	441984.828	2637390.776	1099.77	SPOT
1123	441986.364	2637399.109	1098.832	SPOT
1124	441987.241	2637404.238	1098.947	SPOT
1125	442042.11	2637432.243	1085.723	SPOT
1126	442041.939	2637428.806	1086.896	SPOT
1127	442039.074	2637419.942	1086.71	SPOT
1128	442037.734	2637412.346	1087.637	SPOT
1129	442033.596	2637400.412	1091.167	SPOT
1130	442029.821	2637383.666	1098.007	SPOT
1131	442023.8	2637369.118	1103.507	SPOT
1132	442022.997	2637367.541	1103.461	SPOT
1133	442022.516	2637364.212	1102.998	SPOT
1134	442019.361	2637355.967	1101.864	SPOT
1135	442018.645	2637353.158	1102.146	SPOT
1136	442014.994	2637349.455	1104.158	SPOT
1137	442006.83	2637325.597	1114.705	SPOT
1138	441999.875	2637308.785	1122.09	SPOT
1139	441991.151	2637289.288	1130.137	SPOT
1140	441990.53	2637285.467	1131.438	SPOT
1141	441989.518	2637282.939	1131.712	SPOT
1142	441980.427	2637259.429	1131.689	SPOT
1143	441980.105	2637257.042	1131.023	SPOT
1144	441970.633	2637233.641	1122.069	SPOT
1145	441963.972	2637215.102	1116.333	SPOT
1146	441961.617	2637200.941	1112.442	SPOT
1147	441961.142	2637193.179	1110.615	SPOT
1148	441959.56	2637183.769	1107.456	SPOT
1149	441996.917	2637170.563	1107.367	SPOT
1150	442001.611	2637188.878	1112.817	SPOT
1151	442008.014	2637200.099	1116.839	SPOT
1152	442014.322	2637215.858	1122.006	SPOT
1153	442022.487	2637234.338	1128.49	SPOT
1154	442025.084	2637240.484	1131.189	SPOT
1155	442025.694	2637242.288	1131.613	SPOT
1156	442035.793	2637267.605	1131.505	SPOT
1157	442038.228	2637274.938	1128.702	SPOT
1158	442050.462	2637315.312	1111.878	SPOT
1159	442055.433	2637330.14	1105.51	SPOT
1160	442055.177	2637335.08	1103.279	SPOT
1161	442057.773	2637337.632	1101.579	SPOT
1162	442059.417	2637342.626	1102.059	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
1163	442063.185	2637351.458	1103.306	SPOT
1164	442064.737	2637355.801	1102.769	SPOT
1165	442076.55	2637382.707	1091.892	SPOT
1166	442085.151	2637402.534	1083.874	SPOT
1167	442089.76	2637418.789	1083.716	SPOT
1168	442138.442	2637403.279	1082.888	SPOT
1169	442133.014	2637388.128	1083.742	SPOT
1170	441254.867	2637414.206	1123.824	GUT1
1171	442123.403	2637360.418	1093.714	SPOT
1172	442115.817	2637335.845	1103.198	SPOT
1173	441699.256	2637357.311	1131.403	SPOT
1174	442114.771	2637330.889	1103.083	SPOT
1175	442109.127	2637321.03	1101.855	SPOT
1176	442108.676	2637319.515	1101.636	SPOT
1177	442108.233	2637317.255	1102.104	SPOT
1178	442095.945	2637284.423	1116.923	SPOT
1179	442084.568	2637253.692	1129.945	SPOT
1180	442082.864	2637249.832	1131.426	SPOT
1181	442081.761	2637246.517	1131.789	SPOT
1182	442072.902	2637225.589	1131.579	SPOT
1183	442072.273	2637222.275	1131.276	SPOT
1184	442065.954	2637204.452	1123.744	SPOT
1185	442064.39	2637196.013	1121.669	SPOT
1186	442055.558	2637178.881	1115.611	SPOT
1187	442052.928	2637167.923	1112.306	SPOT
1188	442048.257	2637150.036	1107.225	SPOT
1189	442090.085	2637134.562	1107.58	SPOT
1190	442096.485	2637148.631	1111.249	SPOT
1191	442105.133	2637165.486	1116.956	SPOT
1192	442111.394	2637183.031	1122.226	SPOT
1193	442117.088	2637198.823	1128.839	SPOT
1194	442118.82	2637203.734	1130.982	SPOT
1195	442119.884	2637207.785	1131.518	SPOT
1196	442129.375	2637228.614	1131.688	SPOT
1197	442130.305	2637231.883	1131.4	SPOT
1198	442132.214	2637235.478	1129.824	SPOT
1199	442144.856	2637266.383	1116.165	SPOT
1200	442157.245	2637295.292	1103.369	SPOT
1201	442158.121	2637298.289	1101.992	SPOT
1202	442158.398	2637299.545	1101.728	SPOT
1203	442159.554	2637303.218	1102.196	SPOT
1204	442164.536	2637315.522	1103.348	SPOT
1205	442164.974	2637316.924	1103.203	SPOT
1206	442174.689	2637339.978	1094.143	SPOT
1207	442186.243	2637365.729	1083.685	SPOT
1208	442195.531	2637390.281	1083.117	SPOT
1209	442235.856	2637369.837	1082.54	SPOT
1210	442228.97	2637350.476	1082.669	SPOT
1211	442217.098	2637319.4	1095.157	SPOT
1212	442208.406	2637299.693	1103.17	SPOT
1213	442207.558	2637296.985	1103.216	SPOT
1214	442204.024	2637285.605	1102.194	SPOT
1215	442202.762	2637281.853	1101.524	SPOT
1216	442201.937	2637277.23	1103.364	SPOT
1217	442188.821	2637246.162	1117.334	SPOT
1218	442178.893	2637220.761	1128.172	SPOT
1219	442177.247	2637215.741	1130.822	SPOT
1220	442176.658	2637213.514	1131.502	SPOT
1221	442166.716	2637188.919	1131.453	SPOT
1222	442165.94	2637185.881	1130.828	SPOT
1223	442164.189	2637182.224	1129.302	SPOT
1224	442156.933	2637161.033	1121.239	SPOT
1225	442150.674	2637144.68	1115.703	SPOT
1226	442145.459	2637130.193	1111.368	SPOT
1227	442140.253	2637115.721	1107.402	SPOT
1228	442180.39	2637100.232	1107.332	SPOT
1229	442190.27	2637117.724	1112.708	SPOT
1230	442199.783	2637139.823	1119.899	SPOT
1231	442210.016	2637164.305	1129.02	SPOT
1232	442211.921	2637169.021	1131.063	SPOT
1233	442213.56	2637171.41	1131.491	SPOT
1234	442221.623	2637193.964	1131.633	SPOT
1235	442222.464	2637197.068	1131.303	SPOT
1236	442223.069	2637200.759	1130.217	SPOT
1237	442236.319	2637230.992	1116.592	SPOT
1238	442249.678	2637258.845	1103.622	SPOT
1239	442250.057	2637260.253	1103.215	SPOT
1240	442250.725	2637262.055	1101.996	SPOT
1241	442252.497	2637266.391	1102.088	SPOT
1242	442257.782	2637279.35	1103.289	SPOT
1243	442258.605	2637281.293	1103.195	SPOT
1244	442269.46	2637307.27	1092.193	SPOT
1245	442279.732	2637331.358	1082.39	SPOT
1246	442289.394	2637351.675	1082.069	SPOT
1247	442334.079	2637336.968	1081.073	SPOT
1248	442332.284	2637323.145	1080.793	SPOT
1249	442326.335	2637306.023	1084.58	SPOT
1250	442310.999	2637262.052	1103.283	SPOT
1251	442310.128	2637259.951	1103.53	SPOT
1252	442305.401	2637243.455	1101.996	SPOT
1253	442304.266	2637241.065	1102.737	SPOT
1254	442293.637	2637208.937	1116.363	SPOT
1255	442281.983	2637174.36	1131.14	SPOT
1256	442281.511	2637173.29	1131.386	SPOT
1257	442272.107	2637148.41	1131.505	SPOT
1258	442271.13	2637145.476	1130.937	SPOT
1259	442269.422	2637142.017	1129.455	SPOT
1260	442262.255	2637119.935	1121.081	SPOT
1261	442254.884	2637095.011	1112.886	SPOT
1262	442252.738	2637087.793	1110.428	SPOT
1263	442249.719	2637074.786	1107.459	SPOT
1264	443006.699	2636863.253	1133.124	GRV
1265	442971.265	2636892.995	1133.298	GRV
1266	442938.162	2636915.66	1133.259	GRV
1267	442939.574	2636919.863	1133.307	GDR
1268	442896.955	2636936.504	1132.986	GDR
1269	442895.135	2636932.896	1132.923	GRV
1270	442851.12	2636950.002	1132.63	GRV
1271	442851.985	2636953.737	1132.721	GDR
1272	442808.566	2636970.551	1132.253	GDR
1273	442807.071	2636966.886	1132.235	GRV
1274	442763.2	2636984.517	1131.774	GRV
1275	442764.296	2636987.637	1131.9	GDR
1276	442723.292	2637003.694	1131.513	GDR
1277	442721.935	2637000.504	1131.642	GRV
1278	442679.693	2637016.706	1131.622	GRV
1279	442681.054	2637019.873	1131.621	GDR
1280	442639.768	2637035.754	1131.646	GDR
1281	442638.895	2637032.26	1131.702	GRV
1282	442593.619	2637049.771	1131.722	GRV
1283	442594.536	2637053.258	1131.65	GDR
1284	442551.396	2637069.886	1131.616	GDR
1285	442550.131	2637066.678	1131.778	GRV
1286	442507.605	2637082.894	1131.777	GRV
1287	442508.66	2637086.465	1131.621	GDR
1288	442465.247	2637103.133	1131.542	GDR
1289	442462.937	2637099.487	1131.765	GRV
1290	442419.576	2637116.407	1131.726	GRV
1291	442420.476	2637120.387	1131.397	GDR
1292	442379.715	2637136.184	1131.423	GDR
1293	442377.688	2637131.648	1131.776	GRV
1294	442332.989	2637148.932	1131.793	GRV
1295	442334.625	2637153.64	1131.293	GDR
1296	442290.543	2637170.382	1131.124	GDR
1297	442288.718	2637166.013	1131.843	GRV
1298	442242.334	2637183.943	1131.902	GRV
1299	442243.785	2637188.469	1131.371	GDR
1300	442201.455	2637204.805	1131.43	GDR
1301	442198.672	2637200.46	1131.889	GRV
1302	442153.768	2637218.322	1131.812	GRV
1303	442154.958	2637222.739	1131.461	GDR
1304	442112.612	2637239.479	1131.293	GDR
1305	442110.455	2637234.192	1131.832	GRV
1306	442067.203	2637251.215	1131.92	GRV
1307	442068.832	2637255.886	1131.229	GDR
1308	442026.692	2637272.154	1131.258	GDR
1309	442024.723	2637267.739	1131.886	GRV
1310	441980.914	2637284.874	1131.849	GRV
1311	441983.043	2637288.938	1131.337	SPOT
1312	441982.975	2637288.967	1131.328	GDR
1313	441939.898	2637305.701	1131.055	GDR
1314	441937.96	2637300.457	1131.837	GRV
1315	441893.411	2637317.943	1131.777	GRV
1316	441895.532	2637322.66	1131.108	GDR
1317	441847.527	2637341.252	1131.187	GDR
1318	441844.931	2637335.579	1131.736	GRV
1319	441800.966	2637350.707	1131.833	GRV
1320	441803.738	2637358.11	1131.175	GDR
1321	441759.255	2637375.13	1131.42	GDR
1322	441756.752	2637367.421	1132.025	GRV
1323	441711.082	2637382.786	1132.635	GRV
1324	441714.724	2637392.268	1131.945	GDR
1325	441669.481	2637409.269	1132.813	GDR
1326	441665.71	2637392.858	1133.133	GRV
1327	441616.987	2637396.817	1133.407	GRV
1328	441570.914	2637399.299	1132.729	GRV
1329	441519.692	2637402.717	1129.936	GRV
1330	441473.197	2637408.042	1126.831	GRV
1331	441425.583	2637414.774	1124.96	GRV
1332	441379.009	2637422.981	1124.083	GRV
1333	441332.773	2637432.319	1123.87	GRV

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
1334	441287.196	2637440.778	1123.819	GRV
1335	441242.223	2637448.882	1123.979	GRV
1336	441197.267	2637457.767	1124.146	GRV
1337	441152.479	2637466.522	1124.165	GRV
1338	441107.238	2637475.973	1124.811	GRV
1339	441061.504	2637485.65	1126.579	GRV
1340	441016.769	2637495.15	1128.941	GRV
1341	440970.329	2637504.728	1132.33	GRV
1342	440924.56	2637512.463	1135.496	GRV
1343	440878.431	2637520.788	1138.37	GRV
1344	440831.819	2637526.17	1140.253	GRV
1345	440783.451	2637534.069	1141.506	GRV
1346	440732.099	2637545	1142.381	GRV
1347	441009.057	2637267.653	1126.554	SPOT
1348	441029.073	2637255.806	1126.029	SPOT
1349	441040.915	2637248.663	1122.854	SPOT
1350	441042.572	2637247.976	1122.595	SPOT
1351	441043.874	2637248.501	1122.848	SPOT
1352	441052.725	2637248.6	1124.567	SPOT
1353	441086.314	2637243.148	1124.031	SPOT
1354	441100.517	2637240.61	1123.655	SPOT
1355	441099.131	2637232.116	1122.951	SPOT
1356	441135.961	2637246.693	1124	SPOT
1357	441135.968	2637235.047	1123.877	SPOT
1358	441180.395	2637239.153	1123.996	SPOT
1359	441191.929	2637235.5	1123.898	SPOT
1360	441190.245	2637228.729	1123.627	SPOT
1361	441190.483	2637226.652	1122.804	SPOT
1362	441228.862	2637229.738	1123.32	SPOT
1363	441253.696	2637222.001	1122.496	SPOT
1364	441278.91	2637218.761	1121.661	SPOT
1365	441299.525	2637218.96	1122.126	SPOT
1366	441287.002	2637204.024	1118.675	SPOT
1367	441287.461	2637166.186	1110.05	SPOT
1368	441287.5	2637163.731	1108.349	SPOT
1369	441273.716	2637157.738	1107.661	SPOT
1370	441272.584	2637160.435	1108.905	SPOT
1371	441266.294	2637180.125	1113.022	SPOT
1372	441267.104	2637191.927	1116.461	SPOT
1373	441319.859	2637229.071	1123.902	SPOT
1374	441356.949	2637238.814	1124.216	SPOT
1375	441357.197	2637232.609	1123.73	SPOT
1376	441357.815	2637227.996	1122.544	SPOT
1377	441384.602	2637249.166	1123.651	SPOT
1378	441395.21	2637250.76	1122.797	SPOT
1379	441399.774	2637251.094	1121.858	SPOT
1380	441408.297	2637253.319	1121.321	SPOT
1381	441416.854	2637254.928	1122.612	SPOT
1382	441418.22	2637244.794	1120.652	SPOT
1383	441423.033	2637236.996	1118.773	SPOT
1384	441460.381	2637285.944	1129.693	SPOT
1385	441464.94	2637282.818	1128.856	SPOT
1386	441467.25	2637280.814	1127.455	SPOT
1387	441507.152	2637299.712	1131.159	SPOT
1388	441490.17	2637300.703	1132.122	SPOT
1389	441467.726	2637300.577	1131.632	SPOT
1390	441434.886	2637300.887	1125.165	SPOT
1391	441426.843	2637301.269	1124.026	SPOT
1392	441421.993	2637301.944	1122.341	SPOT
1393	441414.599	2637302.426	1121.614	SPOT
1394	441410.007	2637302.565	1122.399	SPOT
1395	441403.361	2637303.502	1123.996	SPOT
1396	441319.846	2637312.784	1123.786	SPOT
1397	441244.606	2637321.857	1123.816	SPOT
1398	441176.646	2637330.968	1123.828	SPOT
1399	441111.704	2637340.126	1123.786	SPOT
1400	441070.048	2637349.753	1124.187	SPOT
1401	441061.231	2637351.398	1123.758	SPOT
1402	441056.911	2637352.428	1123.031	SPOT
1403	441053.668	2637352.586	1123.327	SPOT
1404	441040.783	2637353.855	1125.488	SPOT
1405	441008.371	2637357.158	1135.664	SPOT
1406	440992.493	2637360.031	1139.745	SPOT
1407	440976.348	2637361.504	1139.708	SPOT
1408	440951.997	2637361.284	1136.087	SPOT
1409	440923.684	2637356.546	1129.63	SPOT
1410	440987.669	2637302.04	1129.774	SPOT
1411	441001.688	2637300.096	1131.049	SPOT
1412	441012.916	2637298.645	1130.876	SPOT
1413	441020.936	2637298.182	1129.27	SPOT
1414	441028.36	2637297.679	1126.924	SPOT
1415	441043.189	2637296.416	1124.017	SPOT
1416	441046.611	2637296.029	1123.194	SPOT
1417	441052.127	2637295.508	1123.614	SPOT
1418	441060.851	2637295.022	1124.71	SPOT
1419	441135.159	2637289.178	1123.834	SPOT
1420	441213.168	2637283.621	1124.203	SPOT
1421	441285.225	2637281.645	1124.109	SPOT
1422	441359.599	2637279.087	1124.274	SPOT
1423	441396.767	2637273.541	1124.196	SPOT
1424	441406.404	2637272.588	1121.668	SPOT
1425	441411.236	2637272.582	1121.751	SPOT
1426	441426.523	2637272.092	1125.51	SPOT
1427	441563.25	2637344.255	1133.97	SPOT
1428	441488.227	2637342.928	1135.792	SPOT
1429	441476.09	2637343.245	1134.259	SPOT
1430	441451.509	2637347.701	1126.258	SPOT
1431	441441.142	2637348.766	1124.483	SPOT
1432	441435.217	2637349.501	1124.126	SPOT
1433	441428.431	2637351.228	1122.023	SPOT
1434	441417.878	2637353.347	1122.406	SPOT
1435	441411.978	2637354.267	1123.689	SPOT
1436	441246.721	2637383.16	1124.107	SPOT
1437	441127.59	2637404.057	1123.713	SPOT
1438	441079.875	2637409.77	1123.685	SPOT
1439	441070.287	2637410.958	1123.232	SPOT
1440	441064.101	2637411.954	1123.882	SPOT
1441	441052.78	2637413.764	1124.946	SPOT
1442	441026.138	2637417.879	1132.559	SPOT
1443	440998.83	2637422.973	1141.698	SPOT
1444	440948.854	2637435.033	1142.272	SPOT
1445	440921.746	2637441.327	1140.914	SPOT
1446	442617.725	2636913.592	1120.783	TOP STRUCTURE
1447	440924.14	2637483.31	1137.384	SPOT
1448	441009.934	2637467.894	1131.248	SPOT
1449	441043.527	2637461.411	1127.582	SPOT
1450	441081.976	2637453.72	1124.556	SPOT
1451	441165.788	2637439.007	1123.867	SPOT
1452	441243.609	2637426.032	1123.797	SPOT
1453	441355.54	2637402.861	1123.796	SPOT
1454	441407.075	2637392.52	1123.631	SPOT
1455	441416.911	2637391.066	1123.359	SPOT
1456	441422.884	2637390.022	1122.619	SPOT
1457	441427.452	2637389.184	1122.21	SPOT
1458	441433.524	2637387.978	1122.689	SPOT
1459	441439.26	2637387.311	1124.224	SPOT
1460	441481.939	2637382.435	1127.475	SPOT
1461	441528.717	2637375.243	1131.697	SPOT
1462	441571.186	2637370.04	1133.815	SPOT
1463	441585.216	2637367.262	1134.314	SPOT
1464	441620.612	2637416.869	1135.129	SPOT
1465	441557.08	2637428.895	1137.122	SPOT
1466	441508.421	2637443.214	1137.815	SPOT
1467	441481.559	2637446.035	1128.918	SPOT
1468	441463.664	2637449.35	1123.811	SPOT
1469	441434.08	2637454.947	1123.578	SPOT
1470	441427.017	2637392.095	1121.991	CMP invert 18" B
1471	441429.541	2637421.472	1122.342	CMP invert 18" E
1472	441429.544	2637428.684	1122.405	SPOT
1473	441431.296	2637435.437	1123.596	SPOT
1474	441339.921	2637470.757	1124.159	SPOT
1475	441263.262	2637484.84	1123.864	SPOT
1476	441161.725	2637503.674	1124.06	SPOT
1477	441098.44	2637511.317	1123.87	SPOT
1478	441079.136	2637516.168	1124.177	SPOT
1479	441039.708	2637526.676	1134.907	SPOT
1480	441009.612	2637534.145	1139.875	SPOT
1481	440966.37	2637544.979	1143.026	SPOT
1482	440912.547	2637556.905	1144.315	SPOT
1483	440961.725	2637590.806	1144.648	SPOT
1484	441010.059	2637577.043	1143.408	SPOT
1485	441021.248	2637573.746	1142.14	SPOT
1486	441068.678	2637560.61	1127.309	SPOT
1487	441083.555	2637556.607	1124.076	SPOT
1488	441172.81	2637535.445	1123.81	SPOT
1489	441295.248	2637510.972	1124.13	SPOT
1490	441413.454	2637486.976	1123.967	SPOT
1491	441472.245	2637477.837	1123.847	SPOT
1492	441501.07	2637475.346	1133.939	SPOT
1493	441515.325	2637472.594	1137.924	SPOT
1494	441584.014	2637458.179	1136.175	SPOT
1495	441589.29	2637515.644	1134.787	SPOT
1496	441524.363	2637525.572	1137.076	SPOT
1497	441512.434	2637527.73	1134.2	SPOT
1498	441484.894	2637532.098	1124.768	SPOT
1499	441392.328	2637548.668	1124.209	SPOT
1500	441277.954	2637563.578	1124.113	SPOT
1501	441152.448	2637585.635	1123.818	SPOT
1502	441091.303	2637594.98	1124.449	SPOT
1503	441059.256	2637604.711	1132.291	SPOT
1504	441025.526	2637615.729	1142.651	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
1505	441006.35	2637618.118	1144.273	SPOT
1506	440963.898	2637622.649	1144.497	SPOT
1507	440969.94	2637669.105	1144.739	SPOT
1508	441026.043	2637653.745	1144.047	SPOT
1509	441035.02	2637651.855	1142.423	SPOT
1510	441076.98	2637640.815	1129.431	SPOT
1511	441098.001	2637635.386	1124.35	SPOT
1512	441226.905	2637602.098	1124.064	SPOT
1513	441358.354	2637581.215	1124.124	SPOT
1514	441481.051	2637559.039	1124.838	SPOT
1515	441490.389	2637558.671	1124.949	SPOT
1516	441526.873	2637553.43	1135.524	SPOT
1517	441534.63	2637552.253	1136.427	SPOT
1518	441608.923	2637540.53	1132.332	SPOT
1519	441615.851	2637600.1	1130.396	SPOT
1520	441576.745	2637606.478	1132.218	SPOT
1521	441552.349	2637611.754	1134.853	SPOT
1522	441536.135	2637610.719	1134.413	SPOT
1523	441530.206	2637611.298	1133.111	SPOT
1524	441502.771	2637615.442	1124.923	SPOT
1525	441502.605	2637615.382	1124.81	SPOT
1526	441401.945	2637632.066	1124.179	SPOT
1527	441290.243	2637648.174	1124.125	SPOT
1528	441185.277	2637661.824	1124.348	SPOT
1529	441104.204	2637674.916	1124.572	SPOT
1530	441032.941	2637686.991	1144.212	SPOT
1531	441013.133	2637689.277	1145.93	SPOT
1532	440969.311	2637695.731	1145.624	SPOT
1533	440980.233	2637741.49	1148.078	SPOT
1534	441020.53	2637732.029	1147.931	SPOT
1535	441037.408	2637728.671	1146.504	SPOT
1536	441109.751	2637713.011	1124.754	SPOT
1537	441184.753	2637694.126	1124.267	SPOT
1538	441298.118	2637673.22	1123.984	SPOT
1539	441409.244	2637655.013	1123.932	SPOT
1540	441508.269	2637642.826	1124.377	SPOT
1541	441517.144	2637642.155	1126.808	SPOT
1542	441542.982	2637640.645	1134.458	SPOT
1543	441587.393	2637634.923	1130.795	SPOT
1544	441641.446	2637629.747	1127	SPOT
1545	442623.548	2636929.347	1120.763	TOP STRUCTURE
1546	442598.478	2636938.777	1120.76	TOP STRUCTURE
1547	442592.985	2636922.969	1120.886	TOP STRUCTURE
1548	442617.708	2636913.56	1116.902	STRUCTURE
1549	442623.55	2636929.373	1116.916	STRUCTURE
1550	442598.556	2636938.799	1116.903	STRUCTURE
1551	442622.375	2636929.867	1117.416	TOP WEIR ELEV
1552	442462.083	2637759.831	1080.63	SPOT
1553	442473.692	2637768.378	1079.256	SPOT
1554	442484.686	2637778.203	1073.313	SPOT
1555	442485.948	2637779.924	1070.588	SPOT
1556	442492.368	2637785.535	1069.754	DRN B
1557	442499.388	2637790.376	1070.771	SPOT
1558	442505.102	2637796.48	1071.309	SPOT
1559	442508.441	2637799.198	1072.852	SPOT
1560	442517.006	2637806.137	1073.267	SPOT
1561	442522.413	2637808.761	1077.323	SPOT
1562	442693.363	2637155.637	1078.769	INV 6W 7H OPENING
1563	442690.76	2637155.82	1087.328	RTW B RTW1 B
1564	442693.915	2637165.635	1083.682	RTW1
1565	442698.737	2637152.715	1087.378	RTW
1566	442702.972	2637162.141	1083.686	RTW
1567	442720.968	2637201.848	1083.608	RTW E WING B
1568	442722.018	2637202.402	1083.66	WING
1569	442728.276	2637204.721	1076.808	WING E
1570	442529.729	2637811.951	1079.163	SPOT
1571	442707.415	2637206.9	1083.739	RTW1 E WING B
1572	442707.029	2637208.168	1083.722	WING
1573	442703.191	2637216.268	1074.926	WING E
1574	442540.593	2637816.749	1078.771	SPOT
1575	442551.825	2637823.183	1077.957	SPOT
1576	442707.361	2637205.734	1085.68	FNC B
1577	442694.361	2637165.541	1086.742	FNC
1578	442691.259	2637156.006	1091.907	FNC
1579	442698.66	2637153.136	1091.731	FNC
1580	442702.511	2637162.321	1087.569	FNC
1581	442720.257	2637200.989	1084.511	FNC E
1582	441635.44	2637422.8	1135.058	CHK 3
1583	441932.27	2637993.941	1076.869	SPOT
1584	441915.62	2637986.194	1076.777	SPOT
1585	441910.604	2637985.562	1073.697	SPOT
1586	441897.489	2637981.137	1072.99	SPOT
1587	441895.328	2637979.6	1069.901	SPOT
1588	441879.968	2637973.551	1069.801	SPOT
1589	441876.628	2637973.156	1069.781	SPOT
1590	441874.554	2637972.794	1070.488	SPOT
1591	441871.473	2637972.466	1070.512	SPOT
1592	441869.599	2637972.049	1068.598	SPOT
1593	441865.235	2637974.329	1067.827	DRN
1594	441859.013	2637965.249	1069.351	SPOT
1595	441854.691	2637963.688	1074.735	SPOT
1596	441851.142	2637960.312	1077.499	SPOT
1597	441844.605	2637957.807	1079.962	SPOT
1598	441836.138	2637951.829	1081.679	SPOT
1599	441890.615	2638634.14	1072.483	SPOT
1600	441895.626	2638630.344	1071.788	SPOT
1601	441899.111	2638627.218	1070.238	SPOT
1602	441901.585	2638625.796	1066.693	SPOT
1603	441903.686	2638623.751	1065.657	DRN
1604	441907.15	2638621.633	1066.752	SPOT
1605	441913.171	2638618.048	1067.068	SPOT
1606	441915.288	2638617.363	1067.752	SPOT
1607	441917.048	2638615.7	1068.936	SPOT
1608	441925.392	2638609.042	1069.686	SPOT
1609	441935.242	2638604.487	1071.063	SPOT
1610	441949.377	2638599.326	1074.834	SPOT
1611	441945.943	2638649.09	1067.399	BXC B 10W 6H
1612	441950.208	2638778.094	1066.896	BXC E 10W 6H
1613	441920.798	2638814.195	1073.433	SPOT
1614	441927.325	2638813.622	1072.496	SPOT
1615	441930.706	2638814.35	1068.787	SPOT
1616	441945.214	2638814.559	1067.734	SPOT
1617	441947.006	2638813.846	1065.286	SPOT
1618	441948.89	2638813.825	1064.711	DRN
1619	441953.791	2638809.456	1065.161	SPOT
1620	441956.614	2638809.522	1067.323	SPOT
1621	441973.076	2638810.286	1067.531	SPOT
1622	441977.832	2638810.108	1070.805	SPOT
1623	441988.787	2638810.374	1071.477	SPOT
1624	441966.782	2638725.251	1087.999	SPOT X
1625	441966.718	2638725.268	1087.997	CHK 1624
1626	441998.078	2638821.343	1071.725	SPOT
1627	441989.599	2638838.404	1071.096	SPOT
1628	441985.532	2638848.938	1069.754	SPOT
1629	441979.487	2638857.44	1068.399	SPOT
1630	441978.653	2638859.187	1066.647	SPOT
1631	441975.4	2638861.265	1066.158	SPOT
1632	441971.038	2638865.748	1066.224	DRN
1633	441968.359	2638869.909	1065.601	SPOT
1634	441962.179	2638877.019	1076.266	SPOT
1635	441951.318	2638889.368	1076.524	SPOT
1636	442674.308	2639075.916	1072.824	SPOT
1637	442689.673	2639069.962	1071.299	SPOT
1638	442694.908	2639067.694	1066.641	SPOT
1639	442700.293	2639065.792	1065.061	SPOT
1640	442703.031	2639064.601	1063.394	SPOT
1641	442707.266	2639062.846	1063.092	DRN
1642	442714.384	2639061.276	1063.423	SPOT
1643	442715.472	2639059.906	1066.333	SPOT
1644	442725.752	2639053.512	1067.09	SPOT
1645	442738.884	2639053.732	1073.01	SPOT
1646	442754.145	2639051.403	1072.951	SPOT
1647	443312.204	2639457.341	1071.343	SPOT
1648	443296.902	2639463.221	1071.22	SPOT
1649	443286.676	2639464.535	1063.687	SPOT
1650	443281.439	2639464.517	1059.399	SPOT
1651	443279.327	2639465.638	1059.833	DRN
1652	443276.309	2639464.304	1060.267	SPOT
1653	443271.246	2639463.758	1061.948	SPOT
1654	443264.439	2639464.818	1065.729	SPOT
1655	443254.412	2639464.215	1068.181	SPOT
1656	443243.682	2639467.205	1067.962	SPOT
1657	445232.83	2640698.129	1060.487	WING B
1658	445243.731	2640686.495	1056.811	WING E
1659	445204.444	2640701.16	1060.497	WING B
1660	445191.589	2640692.672	1056.809	WING E
1661	445202.816	2640702.67	1058.443	ABUT B LOW MEMBER
1662	445234.73	2640698.929	1058.545	ABUT E
1663	445237.219	2640730.262	1060.528	WING B
1664	445248.762	2640738.985	1056.817	WING E
1665	445208.319	2640733.764	1060.535	WING B
1666	445199.56	2640745.557	1056.75	WING E
1667	445206.408	2640733.01	1058.473	ABUT B LOW MEMBER
1668	445238.299	2640729.333	1058.587	ABUT E
1669	445236.066	2640730.037	1060.464	CON B
1670	445232.178	2640698.443	1060.52	CON
1671	445204.881	2640701.778	1060.398	CON
1672	445208.996	2640733.158	1060.437	CON CLOSE
1673	445205.257	2640703.05	1055.223	SPOT
1674	445205.845	2640709.928	1051.379	SPOT
1675	445206.282	2640712.195	1049.64	SPOT

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1676	445207.125	2640717.497	1048.692	SPOT
1677	445207.585	2640722.518	1049.243	SPOT
1678	445208.122	2640726.156	1051.165	SPOT
1679	445208.832	2640730.961	1054.839	SPOT
1680	445269.893	2640735.65	1052.694	SPOT
1681	445268.783	2640716.196	1050.951	SPOT
1682	445269.688	2640712.812	1049.176	SPOT
1683	445269.325	2640711.976	1048.527	SPOT
1684	445269.47	2640708.278	1048.468	DRN B
1685	445267.802	2640702.624	1048.235	SPOT
1686	445267.14	2640700.51	1050.781	SPOT
1687	445265.527	2640681.61	1051.773	SPOT
1688	445120.474	2640681.694	1055.226	SPOT
1689	445122.571	2640696.956	1054.318	SPOT
1690	445124.84	2640707.96	1050.597	SPOT
1691	445128.475	2640726.56	1050.292	SPOT
1692	445129.032	2640729.461	1049.346	SPOT
1693	445131.218	2640743.881	1049.321	SPOT
1694	445131.976	2640747.325	1049.148	DRN
1695	445132.714	2640750.068	1049.601	SPOT
1696	445133.192	2640751.759	1050.719	SPOT
1697	445136.673	2640777.768	1056.269	SPOT
1698	445137.596	2640789.058	1056.436	SPOT
1699	444883.861	2640878.33	1059.267	SPOT
1700	444879.116	2640863.603	1058.955	SPOT
1701	444872.108	2640845.24	1052.405	SPOT
1702	444870.283	2640841.971	1051.904	SPOT
1703	444869.495	2640841.046	1050.646	SPOT
1704	444867.736	2640835.873	1049.519	DRN
1705	444864.92	2640830.338	1049.358	SPOT
1706	444864.621	2640827.813	1051.929	SPOT
1707	444860.951	2640819.868	1053.022	SPOT
1708	444858.437	2640809.414	1062.156	SPOT
1709	444853.618	2640794.111	1062.628	SPOT
1710	444452.74	2640616.314	1063.958	SPOT
1711	444445.284	2640617.663	1063.859	SPOT
1712	444426.926	2640622.302	1055.665	SPOT
1713	444369.244	2640644.681	1055.763	SPOT
1714	444362.452	2640647.878	1054.237	SPOT
1715	444332.153	2640659.194	1053.412	SPOT
1716	444326.963	2640660.531	1052.52	SPOT
1717	444322.801	2640664.296	1052.68	SPOT
1718	444319.442	2640667.385	1051.852	DRN
1719	444317.606	2640671.307	1052.279	SPOT
1720	444308.581	2640677.669	1063.378	SPOT
1721	444293.462	2640686.6	1062.276	SPOT
1722	443923.292	2640169.574	1066.072	SPOT
1723	443898.754	2640159.833	1065.638	SPOT
1724	443886.675	2640156.326	1059.482	SPOT
1725	443865.247	2640156.984	1057.747	SPOT
1726	443864.837	2640157.225	1057.679	SPOT
1727	443863.203	2640157.328	1055.666	SPOT
1728	443859.912	2640159.222	1055.414	DRN
1729	443853.219	2640161.106	1056.029	SPOT
1730	443848.609	2640161.536	1056.787	SPOT
1731	443840.308	2640161.837	1057.347	SPOT
1732	443835.337	2640162.197	1064.728	SPOT
1733	443827.683	2640162.149	1064.309	SPOT
1734	443437.094	2640001.643	1065.847	SPOT
1735	443419.614	2640020.423	1062.326	SPOT
1736	443406.62	2640033.531	1061.759	SPOT
1737	443392.426	2640043.427	1059.996	SPOT
1738	443391.133	2640044.676	1058.559	SPOT
1740	443386.476	2640049.012	1058.628	DRN E
1741	443381.024	2640056.247	1058.615	SPOT
1742	443379.243	2640058.286	1059.519	SPOT
1743	443373.836	2640063.579	1065.752	SPOT
1744	443363.019	2640080.58	1065.884	SPOT
1745	445450.7	2640421.782	1059.451	SPOT
1746	445458.319	2640431.286	1058.927	SPOT
1747	445466.059	2640439.45	1050.448	SPOT
1748	445473.023	2640450.01	1049.806	SPOT
1749	445478.814	2640455.726	1048.223	SPOT
1750	445480.762	2640458.41	1047.284	SPOT
1751	445481.979	2640461.437	1047.042	DRN
1752	445486.119	2640466.627	1047.392	SPOT
1753	445488.497	2640471.424	1047.577	SPOT
1754	445492.32	2640476.184	1049.34	SPOT
1755	445496.395	2640482.237	1051.352	SPOT
1756	445515.001	2640506.557	1053.42	SPOT
1757	445519.928	2640515.678	1055.396	SPOT
5000	441256.076	2637406.842	1123.887	CHK2
5001	442993.156	2637077.529	1131.476	SPOT
5002	442984.257	2637044.132	1137.18	SPOT
5003	442975.511	2637018.488	1140.788	SPOT
5004	442969.557	2636986.693	1141.941	SPOT
5005	442962.03	2636962.971	1140.959	SPOT
5006	442956.101	2636946.613	1139.023	SPOT
5007	442950.765	2636932.015	1135.815	SPOT
5008	442947.585	2636922.313	1133.632	SPOT
5009	442944.75	2636914.626	1133.237	SPOT
5010	442933.021	2636890.135	1132.992	SPOT
5011	442929.231	2636879.181	1130.48	SPOT
5012	442921.069	2636855.173	1126.029	SPOT
5013	442911.931	2636826.651	1121.33	SPOT
5014	442904.609	2636807.057	1118.561	SPOT
5015	442899.337	2636789.973	1116.497	SPOT
5016	442894.235	2636770.534	1116.56	SPOT
5017	442845.969	2636783.61	1114.363	SPOT
5018	442847.675	2636801.611	1114.399	SPOT
5019	442855.282	2636827.282	1117.242	SPOT
5020	442863.36	2636849.169	1120.979	SPOT
5021	442869.927	2636870.406	1124.176	SPOT
5022	442877.724	2636897.679	1128.276	SPOT
5023	442882.283	2636909.803	1131.592	SPOT
5024	442891.338	2636937.651	1132.913	SPOT
5025	442893.577	2636944.768	1133.217	SPOT
5026	442895.026	2636949.997	1133.783	SPOT
5027	442899.67	2636963.47	1136.521	SPOT
5028	442906.997	2636984.052	1138.739	SPOT
5029	442912.934	2637007.482	1139.296	SPOT
5030	442916.366	2637023.586	1138.404	SPOT
5031	442923.631	2637051.971	1136.109	SPOT
5032	442931.601	2637077.829	1132.448	SPOT
5033	442935.713	2637091.18	1130.522	SPOT
5034	442940.019	2637105.837	1126.792	SPOT
5035	442944.231	2637122.681	1120.739	SPOT
5036	442952.466	2637143.147	1119.192	SPOT
5037	442913.024	2637167.885	1113.502	SPOT
5038	442909.906	2637158.819	1112.5	SPOT
5039	442907.5	2637153.024	1113.161	SPOT
5040	442901.099	2637136.234	1118.512	SPOT
5041	442895.123	2637116.894	1124.782	SPOT
5042	442891.769	2637104.255	1126.789	SPOT
5043	442883.611	2637086.546	1127.966	SPOT
5044	442875.047	2637067.94	1130.277	SPOT
5045	442866.89	2637046.655	1133.063	SPOT
5046	442863.002	2637034.599	1134.059	SPOT
5047	442856.852	2637008.812	1134.379	SPOT
5048	442849.848	2636985.228	1134.149	SPOT
5049	442844.611	2636969.525	1132.936	SPOT
5050	442841.357	2636958.846	1132.643	SPOT
5051	442832.197	2636930.488	1131.461	SPOT
5052	442830.607	2636922.813	1129.355	SPOT
5053	442823.176	2636902.267	1125.022	SPOT
5054	442814.843	2636879.039	1120.702	SPOT
5055	442807.221	2636857.61	1117.059	SPOT
5056	442797.973	2636827.083	1113.114	SPOT
5057	442792.45	2636810.921	1112.45	SPOT
5058	442743.387	2636820.721	1108.861	SPOT
5059	442745.693	2636841.413	1110.571	SPOT
5060	442753.606	2636866.636	1114.393	SPOT
5061	442760.573	2636895.926	1119.37	SPOT
5062	442765.725	2636913.484	1122.078	SPOT
5063	442768.919	2636925.515	1123.725	SPOT
5064	442774.765	2636943.818	1128.156	SPOT
5065	442777.351	2636950.325	1130.699	SPOT
5066	442787.6	2636978.373	1132.116	SPOT
5067	442791.157	2636986.403	1131.864	SPOT
5068	442794.751	2636995.579	1130.636	SPOT
5069	442801.981	2637014.137	1129.922	SPOT
5070	442809.177	2637032.495	1127.632	SPOT
5071	442816.476	2637056.253	1123.162	SPOT
5072	442823.11	2637075.319	1119.161	SPOT
5073	442831.656	2637098.504	1114.318	SPOT
5074	442841.676	2637127.884	1110.505	SPOT
5075	442849.296	2637154.888	1108.424	SPOT
5076	442855.288	2637169.151	1108.052	SPOT
5077	442816.945	2637196.574	1093.853	SPOT
5078	442799.446	2637158.134	1094.406	SPOT
5079	442784.464	2637127.71	1096.02	SPOT
5080	442777.286	2637107.376	1100.243	SPOT
5081	442769.01	2637083.574	1106.87	SPOT
5082	442764.693	2637066.206	1111.025	SPOT
5083	442760.167	2637045.88	1115.945	SPOT
5084	442756.923	2637034.576	1118.191	SPOT
5085	442750.232	2637017.908	1123.755	SPOT
5086	442742.54	2636997.716	1131.273	SPOT
5087	442730.841	2636969.257	1130.975	SPOT
5088	442729.206	2636963.57	1128.68	SPOT
5089	442724.287	2636948.937	1123.43	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5090	442719.563	2636936.696	1120.388	SPOT
5091	442715.857	2636926.75	1118.474	SPOT
5092	442708.926	2636910.392	1116.728	SPOT
5093	442701.456	2636889.967	1114.021	SPOT
5094	442696.09	2636875.362	1112.093	SPOT
5095	442691.989	2636862.619	1109.969	SPOT
5096	442691.149	2636859.411	1107.425	SPOT
5097	442691.226	2636858.377	1106.139	SPOT
5098	442657.913	2636916.684	1106.634	SPOT
5099	442658.467	2636919.012	1107.908	SPOT
5100	442661.252	2636927.971	1110.673	SPOT
5101	442667.017	2636946.196	1116.299	SPOT
5102	442673.903	2636960.802	1120.825	SPOT
5103	442676.835	2636967.85	1123.546	SPOT
5104	442681.157	2636979.79	1127.833	SPOT
5105	442683.577	2636986.9	1130.857	SPOT
5106	442694.881	2637014.374	1131.638	SPOT
5107	442696.079	2637018.238	1130.815	SPOT
5108	442702.017	2637037.665	1123.167	SPOT
5109	442708.162	2637056.912	1114.514	SPOT
5110	442711.747	2637068.152	1109.684	SPOT
5111	442716.313	2637082.435	1104.113	SPOT
5112	442718.217	2637089.204	1103.488	SPOT
5113	442722.802	2637102.406	1103.525	SPOT
5114	442737.98	2637096.305	1103.646	SPOT
5115	442748.918	2637090.5	1104.763	SPOT
5116	442721.332	2637106.545	1102.462	SPOT
5117	442724.023	2637119.229	1098.374	SPOT
5118	442726.979	2637130.303	1093.458	SPOT
5119	442732.727	2637151.934	1085.6	SPOT
5120	442735.179	2637160.97	1082.543	SPOT
5121	442735.957	2637163.777	1081.174	SPOT
5122	442738.834	2637172.039	1079.502	SPOT
5123	442741.975	2637182.169	1077.496	SPOT
5124	442745.781	2637198.254	1075.707	SPOT
5125	442746.933	2637204.876	1074.924	SPOT
5126	442746.732	2637181.007	1078.956	SPOT
5127	442743.657	2637166.836	1081.222	SPOT
5128	442741.81	2637159.357	1083.258	SPOT
5129	442741.567	2637148.038	1087.404	SPOT
5130	442745.144	2637136.147	1091.441	SPOT
5131	442755.999	2637133.184	1092.938	SPOT
5132	442770.157	2637132.83	1093.793	SPOT
5133	442755.693	2637144.944	1090.701	SPOT
5134	442769.189	2637170.864	1089.728	SPOT
5135	442773.95	2637182.968	1089.435	SPOT
5136	442715.85	2637189.137	1074.252	SPOT
5137	442714.807	2637186.942	1075.571	SPOT
5138	442710.516	2637177.881	1078.411	SPOT
5139	442708.946	2637174.711	1078.645	SPOT
5140	442702.955	2637161.59	1083.718	SPOT
5141	442699.207	2637152.545	1087.359	SPOT
5142	442693.175	2637137.166	1095.174	SPOT
5143	442688.086	2637124.36	1100.927	SPOT
5144	442685.02	2637115.66	1103.483	SPOT
5145	442681.965	2637107.382	1102.928	SPOT
5146	442679.163	2637098.666	1102.406	SPOT
5147	442674.935	2637085.146	1107.866	SPOT
5148	442668.36	2637065.285	1117.157	SPOT
5149	442659.787	2637042.245	1127.098	SPOT
5150	442655.876	2637030.04	1131.658	SPOT
5151	442647.896	2637002.065	1131.06	SPOT
5152	442646.325	2636996.691	1129.1	SPOT
5153	442642.264	2636984.812	1124.236	SPOT
5154	442636.531	2636966.045	1118.291	SPOT
5155	442631.256	2636951.802	1113.195	SPOT
5156	442626.45	2636942.7	1110.281	SPOT
5157	442623.63	2636936.847	1107.154	SPOT
5158	442582.522	2636945.322	1106.868	SPOT
5159	442583.19	2636947.15	1107.759	SPOT
5160	442585.111	2636950.69	1108.094	SPOT
5161	442588.097	2636958.876	1110.831	SPOT
5162	442592.785	2636968.843	1114.196	SPOT
5163	442595.674	2636980.319	1117.454	SPOT
5164	442598.226	2636990.235	1120.388	SPOT
5165	442600.105	2636995.432	1121.828	SPOT
5166	442603.551	2637007.408	1126.981	SPOT
5167	442606.132	2637016.823	1130.822	SPOT
5168	442616.462	2637044.168	1131.54	SPOT
5169	442617.325	2637048.09	1130.858	SPOT
5170	442623.603	2637066.844	1123.482	SPOT
5171	442629.514	2637083.45	1116.158	SPOT
5172	442636.322	2637102.103	1107.703	SPOT
5173	442641.138	2637114.341	1102.444	SPOT
5174	442647.167	2637130.615	1103.312	SPOT
5175	442649.483	2637136.315	1101.928	SPOT
5176	442653.913	2637147.588	1097.494	SPOT
5177	442658.657	2637161.185	1091.258	SPOT
5178	442664.409	2637177.255	1083.844	SPOT
5179	442669.209	2637188.272	1080.969	SPOT
5180	442669.888	2637205.21	1080.249	SPOT
5181	442672.744	2637216.163	1080.17	SPOT
5182	442675.865	2637225.665	1079.833	SPOT
5183	442667.274	2637229.243	1083.277	SPOT
5184	442657.026	2637207.834	1084.484	SPOT
5185	442646.324	2637190.024	1085.989	SPOT
5186	442648.372	2637180.202	1086.371	SPOT
5187	442669.765	2637165.823	1087.208	SPOT
5188	442690.149	2637155.757	1087.209	SPOT
5189	442693.226	2637166.034	1081.934	SPOT
5190	442695.566	2637172.471	1078.45	SPOT
5191	442699.109	2637183.026	1076.107	SPOT
5192	442701.408	2637189.605	1074.708	SPOT
5193	442702.025	2637191.485	1073.608	SPOT
5194	442688.092	2637196.757	1074.853	SPOT
5195	442690.354	2637198.164	1072.999	SPOT
5196	442681.941	2637205.61	1073.814	SPOT
5197	442679.32	2637205.045	1074.142	SPOT
5198	442679.677	2637215.472	1075.021	SPOT
5199	442683.449	2637213.663	1073.659	SPOT
5200	442682.539	2637223.035	1075.456	SPOT
5201	442684.247	2637222.961	1074.02	SPOT
5202	442734.745	2637192.21	1074.029	SPOT
5203	442735.976	2637191.063	1074.67	SPOT
5204	442737.919	2637188.111	1075.795	SPOT
5205	442748.762	2637214.4	1074.122	SPOT
5206	442752.221	2637212.839	1075.308	SPOT
5207	442761.956	2637209.43	1077.168	SPOT
5208	442765.859	2637208.45	1078.961	SPOT
5209	442752.315	2637197.701	1077.185	SPOT
5210	442759.307	2637191.588	1081.044	SPOT
5211	442772.157	2637204.261	1085.555	SPOT
5212	442781.815	2637200.87	1089.245	SPOT
5213	442643.014	2637207.616	1085.114	SPOT
5214	442636.772	2637181.837	1087.576	SPOT
5215	442629.447	2637160.245	1096.161	SPOT
5216	442624.569	2637148.285	1101.612	SPOT
5217	442621.913	2637140.545	1103.278	SPOT
5218	442618.593	2637131.402	1102.767	SPOT
5219	442615.426	2637122.935	1102.48	SPOT
5220	442607.379	2637100.302	1112.297	SPOT
5221	442599.412	2637079.891	1121.523	SPOT
5222	442593.025	2637062.154	1128.847	SPOT
5223	442591.394	2637057.751	1130.963	SPOT
5224	442590.797	2637055.362	1131.586	SPOT
5225	442580.064	2637028.051	1130.984	SPOT
5226	442577.781	2637020.809	1128.179	SPOT
5227	442574.036	2637008.391	1123.123	SPOT
5228	442571.165	2637000.584	1120.401	SPOT
5229	442565.848	2636985.06	1115.369	SPOT
5230	442560.652	2636969.262	1110.657	SPOT
5231	442557.579	2636960.911	1108.062	SPOT
5232	442555.613	2636955.537	1106.757	SPOT
5233	442518.579	2636970.784	1106.545	SPOT
5234	442519.407	2636973.947	1107.917	SPOT
5235	442521.733	2636981.669	1110.111	SPOT
5236	442524.587	2636990.397	1112.928	SPOT
5237	442529.934	2637006.231	1117.333	SPOT
5238	442532.19	2637015.45	1120.303	SPOT
5239	442536.82	2637024.47	1123.768	SPOT
5240	442540.974	2637035.079	1128.083	SPOT
5241	442543.156	2637040.817	1130.733	SPOT
5242	442554.189	2637069.748	1131.627	SPOT
5243	442554.917	2637073.276	1130.364	SPOT
5244	442563.244	2637093.448	1121.362	SPOT
5245	442574.651	2637121.39	1108.448	SPOT
5246	442581.631	2637137.83	1102.283	SPOT
5247	442584.38	2637147.191	1103.258	SPOT
5248	442586.824	2637154.684	1103.353	SPOT
5249	442590.847	2637169.06	1098.231	SPOT
5250	442597.103	2637187.198	1090.64	SPOT
5251	442601.623	2637199.625	1086.3	SPOT
5252	442614.012	2637230.634	1085.177	SPOT
5253	442570.135	2637251.599	1084.106	SPOT
5254	442563.528	2637232.562	1083.874	SPOT
5255	442557.939	2637217.171	1084.536	SPOT
5256	442552.247	2637198.83	1091.672	SPOT
5257	442546.873	2637182.425	1098.984	SPOT
5258	442543.947	2637171.049	1103.514	SPOT
5259	442540.329	2637161.083	1102.771	SPOT
5260	442538.324	2637151.984	1102.391	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5261	442530.149	2637129.436	1111.627	SPOT
5262	442524.21	2637111.818	1119.514	SPOT
5263	442518.192	2637095.311	1126.799	SPOT
5264	442515.985	2637088.466	1130.335	SPOT
5265	442515.087	2637084.591	1131.468	SPOT
5266	442504.648	2637057.11	1131.091	SPOT
5267	442502.665	2637053.773	1129.916	SPOT
5268	442499.492	2637043.512	1125.792	SPOT
5269	442497.973	2637037.527	1123.292	SPOT
5270	442495.865	2637031.307	1121.474	SPOT
5271	442493.299	2637024.01	1118.225	SPOT
5272	442488.904	2637012.336	1114.752	SPOT
5273	442483.585	2636999.504	1110.802	SPOT
5274	442481.842	2636995.204	1109.717	SPOT
5275	442479.93	2636989.843	1108.262	SPOT
5276	442477.938	2636985.116	1106.305	SPOT
5277	442438.566	2637003.407	1106.851	SPOT
5278	442439.121	2637005.046	1107.092	SPOT
5279	442439.903	2637007.972	1108.46	SPOT
5280	442442.076	2637013.415	1109.908	SPOT
5281	442444.573	2637019.883	1112.26	SPOT
5282	442448.607	2637029.867	1115.264	SPOT
5283	442452.146	2637040.744	1118.427	SPOT
5284	442455.278	2637049.926	1122.26	SPOT
5285	442456.108	2637053.029	1123.094	SPOT
5286	442461.212	2637065.711	1127.854	SPOT
5287	442463.261	2637071.878	1130.923	SPOT
5288	442474.343	2637099.555	1131.574	SPOT
5289	442477.365	2637108.264	1128.229	SPOT
5290	442486.609	2637133.161	1117.098	SPOT
5291	442495.07	2637153.155	1108.168	SPOT
5292	442500.829	2637168.253	1102.262	SPOT
5293	442502.315	2637176.064	1103.012	SPOT
5294	442505.962	2637186.937	1103.651	SPOT
5295	442512.172	2637203.7	1095.761	SPOT
5296	442519.881	2637224.868	1086.804	SPOT
5297	442523.857	2637236.746	1082.649	SPOT
5298	442534.624	2637268.236	1082.596	SPOT
5299	442497.776	2637306.868	1081.434	SPOT
5300	442488.937	2637278.959	1081.396	SPOT
5301	442481.771	2637255.893	1083.316	SPOT
5302	442478.456	2637245.245	1085.423	SPOT
5303	442473.795	2637229.9	1091.14	SPOT
5304	442468.089	2637211.106	1099.744	SPOT
5305	442465.378	2637202.041	1103.594	SPOT
5306	442461.733	2637191.017	1103.092	SPOT
5307	442458.971	2637181.91	1102.348	SPOT
5308	442451.187	2637158.01	1112.113	SPOT
5309	442444.612	2637135.898	1122.221	SPOT
5310	442437.263	2637114.442	1131.391	SPOT
5311	442427.473	2637087.219	1131.178	SPOT
5312	442424.554	2637082.184	1129.13	SPOT
5313	442419.151	2637069.208	1124.146	SPOT
5314	442416.532	2637061.523	1121.74	SPOT
5315	442415.064	2637056.593	1119.119	SPOT
5316	442410.438	2637045.03	1115.47	SPOT
5317	442405.906	2637034.497	1112.21	SPOT
5318	442404.64	2637029.777	1110.299	SPOT
5319	442400.551	2637023.536	1108.102	SPOT
5320	442400.127	2637018.5	1106.867	SPOT
5321	442353.229	2637034.244	1106.726	SPOT
5322	442353.947	2637041.045	1107.886	SPOT
5323	442356.049	2637047.377	1109.964	SPOT
5324	442358.63	2637054.397	1112.03	SPOT
5325	442362.481	2637065.733	1115.477	SPOT
5326	442365.812	2637076.807	1119.705	SPOT
5327	442368.949	2637082.53	1122.244	SPOT
5328	442373.722	2637095.512	1127.062	SPOT
5329	442375.909	2637101.084	1129.404	SPOT
5330	442377.201	2637105.492	1131.016	SPOT
5331	442388.296	2637132.788	1131.411	SPOT
5332	442389.74	2637137.123	1129.951	SPOT
5333	442399.315	2637160.345	1119.39	SPOT
5334	442406.557	2637178.367	1110.935	SPOT
5335	442412.103	2637190.807	1105.294	SPOT
5336	442416.048	2637201.069	1102.07	SPOT
5337	442419.303	2637210.13	1103.35	SPOT
5338	442422.13	2637217.879	1103.564	SPOT
5339	442428.781	2637234.316	1097.154	SPOT
5340	442433.173	2637248.271	1090.8	SPOT
5341	442438.841	2637263.536	1085.151	SPOT
5342	442442.1	2637270.597	1082.887	SPOT
5343	442446.554	2637281.933	1081.678	SPOT
5344	442456.994	2637304.23	1080.395	SPOT
5345	442404.987	2637320.341	1078.897	SPOT
5346	442400.478	2637305.379	1079.382	SPOT
5347	442398.329	2637298.792	1079.42	SPOT
5348	442390.672	2637276.687	1085.924	SPOT
5349	442385.875	2637258.141	1093.42	SPOT
5350	442381.459	2637244.252	1099.603	SPOT
5351	442378.263	2637233.833	1103.552	SPOT
5352	442373.967	2637224.391	1102.966	SPOT
5353	442371.656	2637217.28	1102.192	SPOT
5354	442365.324	2637201.345	1107.86	SPOT
5355	442356.672	2637178.312	1118.688	SPOT
5356	442350.266	2637155.424	1128.061	SPOT
5357	442347.216	2637147.664	1131.558	SPOT
5358	442337.053	2637121.313	1131.203	SPOT
5359	442334.895	2637115.495	1129.096	SPOT
5360	442331.167	2637103.526	1124.243	SPOT
5361	442327.116	2637091.861	1119.519	SPOT
5362	442320.337	2637071.142	1112.565	SPOT
5363	442316.576	2637061.38	1109.97	SPOT
5364	442312.209	2637052.835	1107.086	SPOT
5365	442311.1	2637050.331	1106.72	SPOT
5366	442274.263	2637064.057	1106.665	SPOT
5367	442276.42	2637068.83	1108.225	SPOT
5368	442278.222	2637073.887	1109.707	SPOT
5369	442281.609	2637084.029	1112.402	SPOT
5370	442285.155	2637092.358	1115.414	SPOT
5371	442289.583	2637104.269	1118.771	SPOT
5372	442291.884	2637110.255	1120.998	SPOT
5373	442297.37	2637127.054	1127.541	SPOT
5374	442299.659	2637132.716	1130.319	SPOT
5375	442300.223	2637135.551	1131.214	SPOT
5376	442310.703	2637162.688	1131.371	SPOT
5377	442312.23	2637166.053	1130.283	SPOT
5378	442319.538	2637183.41	1122.05	SPOT
5379	442330.593	2637209.367	1110.242	SPOT
5380	442337.246	2637231.131	1102.067	SPOT
5381	442339.702	2637239.781	1103.045	SPOT
5382	442342.541	2637249.113	1103.64	SPOT
5383	442346.989	2637262.397	1098.169	SPOT
5384	442354.857	2637287.719	1087.03	SPOT
5385	442358.761	2637301.281	1082.33	SPOT
5386	442361.949	2637315.183	1079.859	SPOT
5387	442363.216	2637322.779	1079.829	SPOT
5388	442369.309	2637342.452	1080.188	SPOT
5389	442369.294	2637338.991	1079.375	SPOT
5390	442994.365	2636851.169	1132.749	GRV1 B
5391	442971.981	2636870.446	1132.986	GRV1
5392	442948.051	2636886.534	1133.054	GRV1
5393	442929.528	2636896.258	1132.908	GRV1
5394	442928.469	2636892.448	1132.72	GDR1 B
5395	442883.534	2636914.949	1132.318	GRV1
5396	442881.815	2636910.841	1131.734	GDR1
5397	442837.08	2636933.168	1132.03	GRV1
5398	442835.054	2636928.911	1131.41	GDR1
5399	442788.887	2636946.282	1130.977	GDR1
5400	442791.413	2636950.931	1131.665	GRV1
5401	442743.073	2636969.051	1131.338	GRV1
5402	442742.531	2636964.114	1130.825	GDR1
5403	442697.01	2636987.147	1131.419	GRV1
5404	442695.792	2636982.48	1130.912	GDR1
5405	442646.238	2637006.134	1131.428	GRV1
5406	442648.951	2637000.036	1130.841	GDR1
5407	442599.911	2637024.634	1131.506	GRV1
5408	442602.427	2637018.328	1130.994	GDR1
5409	442553.656	2637042.273	1131.545	GRV1
5410	442555.828	2637036.485	1130.863	GDR1
5411	442503.382	2637061.548	1131.507	GRV1
5412	442497.545	2637058.567	1130.942	GDR1
5413	442450.202	2637081.953	1131.633	GRV1
5414	442450.839	2637077.103	1130.999	GDR1
5415	442403.506	2637100.3	1131.509	GRV1
5416	442404.318	2637094.863	1130.928	GDR1
5417	442353.607	2637119.125	1131.67	GRV1
5418	442346.049	2637117.419	1131.119	GDR1
5419	442299.088	2637140.252	1131.756	GRV1
5420	442299.857	2637135.441	1131.267	GDR1
5421	442250.43	2637158.116	1131.608	GRV1
5422	442241.26	2637157.788	1131.09	GDR1
5423	442203.929	2637176.247	1131.67	GRV1
5424	442205.999	2637171.248	1131.171	GDR1
5425	442159.358	2637193.135	1131.581	GRV1
5426	442159.527	2637189.177	1131.066	GDR1
5427	442109.506	2637212.887	1131.605	GRV1
5428	442112.762	2637206.481	1131.112	GDR1
5429	442060.869	2637231.715	1131.592	GRV1
5430	442054.726	2637229.82	1131.405	GDR1
5431	442005.339	2637252.959	1131.854	GRV1

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5432	442008.155	2637247.551	1131.479	GDR1
5433	441962.681	2637270.032	1131.943	GRV1
5434	441961.217	2637265.773	1131.478	GDR1
5435	441915.548	2637288.236	1131.85	GRV1
5436	441914.705	2637283.618	1131.652	GDR1
5437	441866.801	2637306.687	1131.477	GRV1
5438	441856.463	2637306.111	1131.152	GDR1
5439	441818.748	2637324.788	1131.162	GRV1
5440	441820.328	2637319.604	1130.626	GDR1
5441	441775.433	2637340.889	1131.192	GRV1
5442	441774.353	2637337.134	1130.844	GDR1
5443	441731.577	2637357.185	1131.697	GRV1
5444	441728.12	2637355.473	1131.556	GDR1
5445	441704.571	2637364.428	1132.147	GDR1 E
5446	441703.993	2637366.729	1132.303	GRV1
5447	441651.908	2637376.552	1133.049	GRV1
5448	441612.839	2637378.84	1133.137	GRV1
5449	441567.548	2637381.723	1132.346	GRV1
5450	441527.259	2637384.223	1130.773	GRV1
5451	441478.533	2637391.315	1127.294	GRV1
5452	441442.682	2637397.079	1125.373	GRV1
5453	441404.213	2637403.18	1124.17	GRV1
5454	441364.332	2637409.27	1123.731	GRV1
5455	441325.848	2637415.876	1123.732	GRV1
5456	441281.972	2637424.252	1123.846	GRV1
5457	441242.369	2637431.494	1123.864	GRV1
5458	441202.487	2637438.614	1123.68	GRV1
5459	441162.373	2637446.212	1123.753	GRV1
5460	441119.786	2637454.826	1124.232	GRV1
5461	441077.648	2637461.971	1125.409	GRV1
5462	441029.93	2637470.245	1127.96	GRV1
5463	440985.052	2637479.126	1131.34	GRV1
5464	440946.245	2637486.425	1134.276	GRV1
5465	440906.484	2637493.345	1137.046	GRV1
5466	440860.235	2637502.627	1139.53	GRV1
5467	440781.673	2637517.47	1141.126	GRV1
5468	440728.421	2637527.963	1141.994	GRV1 E
5469	441483	2638386.712	1128.062	0
5470	441497.571	2638401.638	1123.362	0
5471	441506.227	2638393.217	1122.105	0
5472	441509.271	2638372.926	1120.777	0
5473	441490.267	2638374.109	1125.877	0
5474	441481.379	2638374.122	1127.468	0
5475	441489.003	2638357.121	1123.372	0
5476	441494.196	2638339.795	1119.582	0
5477	441512.437	2638349.761	1116.936	0
5478	441507.857	2638322.232	1118.037	0
5479	441501.357	2638314.581	1118.291	0
5480	441517.793	2638286.501	1118.555	0
5481	441526.135	2638290.853	1117.574	0
5482	441534.185	2638258.342	1118.977	0
5483	441539.284	2638261.906	1118.738	0
5484	441555.967	2638230.664	1118.851	0
5485	441568.317	2638240.933	1117.059	0
5486	441573.221	2638204.027	1119.017	0
5487	441584.634	2638206.843	1117.362	0
5488	441586.267	2638164.824	1118.967	0

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5489	441597.109	2638165.46	1118.235	0
5490	441584.764	2638124.006	1118.852	0
5491	441593.134	2638123.521	1118.126	0
5492	441585.987	2638079.358	1119.082	0
5493	441600.591	2638080.856	1116.904	0
5494	441592.972	2638044.66	1118.653	0
5495	441604.116	2638045.487	1117.763	0
5496	441597.261	2638015.006	1118.506	0
5497	441602.76	2637986.821	1118.345	0
5498	441607.757	2637966.006	1118.968	0
5499	441610.903	2637955.128	1118.718	0
5500	441612.833	2637951.486	1119.565	0
5501	441615.272	2637944.297	1121.426	0
5502	441617.326	2637939.524	1121.347	0
5503	441621.791	2637947.122	1120.816	0
5504	441624.836	2637956.844	1118.726	0
5505	441624.464	2637972.918	1117.208	0
5506	441628.685	2637992.001	1113.294	0
5507	441636.549	2638009.154	1108.903	0
5508	441651.406	2638019.336	1103.219	0
5509	441673.35	2638025.991	1098.264	0
5510	441701.363	2638031.709	1093.755	0
5511	441717.181	2638034.703	1091.924	0
5512	441743.088	2638036.726	1087.427	0
5513	441747.684	2638037.235	1086.391	0
5514	441032.445	2637996.59	1148.067	SPOT
5515	441075.652	2637989.831	1147.611	SPOT
5516	441092.676	2637986.333	1144.576	SPOT
5517	441126.676	2637980.044	1132.679	SPOT
5518	441151.577	2637974.697	1123.865	SPOT
5519	441166.546	2637972.108	1119.524	SPOT
5520	441206.666	2637964.309	1118.802	SPOT
5521	441261.734	2637953.01	1118.419	SPOT
5522	441308.072	2637945.178	1118.43	SPOT
5523	441353.155	2637935.645	1118.445	SPOT
5524	441392.492	2637927.374	1118.493	SPOT
5525	441437.944	2637917.113	1118.338	SPOT
5526	441478.757	2637907.967	1118.39	SPOT
5527	441516.885	2637898.031	1118.457	SPOT
5528	441558.209	2637887.29	1118.77	SPOT
5529	441570.004	2637884.559	1122.663	SPOT
5530	441581.387	2637881.148	1125.855	SPOT
5531	441599.192	2637876.81	1124.089	SPOT
5532	441625.371	2637870.109	1123.003	SPOT
5533	441604.611	2637927.448	1122.311	SPOT
5534	441593.3	2637930.926	1121.324	SPOT
5535	441584.566	2637934.444	1121.182	SPOT
5536	441572.925	2637939.48	1118.651	SPOT
5537	441559.004	2637944.871	1118.255	SPOT
5538	441517.885	2637960.277	1118.337	SPOT
5539	441487.802	2637968.392	1118.557	SPOT
5540	441447.66	2637974.079	1118.625	SPOT
5541	441408.386	2637983.827	1118.453	SPOT
5542	441368.603	2637992.028	1118.256	SPOT
5543	441326.492	2638001.755	1118.373	SPOT
5544	441285.719	2638014.362	1118.264	SPOT
5545	441240.483	2638025.899	1118.673	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5546	441201.963	2638029.245	1118.942	SPOT
5547	441182.035	2638030.843	1119.501	SPOT
5548	441158.728	2638035.524	1127.226	SPOT
5549	441134.713	2638039.619	1136.33	SPOT
5550	441113.818	2638042.282	1143.262	SPOT
5551	441096.586	2638045.541	1147.019	SPOT
5552	441067.67	2638050.696	1147.696	SPOT
5553	441048.071	2638054.192	1148.476	SPOT
5554	441070.1	2638105.772	1149.202	SPOT
5555	441111.665	2638092.144	1147.71	SPOT
5556	441132.07	2638087.159	1144.159	SPOT
5557	441155.504	2638082.507	1135.6	SPOT
5558	441181.254	2638078.853	1126.112	SPOT
5559	441203.328	2638076.144	1119.421	SPOT
5560	441244.026	2638067.903	1118.574	SPOT
5561	441290.171	2638057.693	1118.44	SPOT
5562	441336.526	2638052.292	1118.47	SPOT
5563	441380.34	2638042.299	1118.237	SPOT
5564	441422.567	2638032.748	1118.512	SPOT
5565	441469.273	2638025.424	1118.274	SPOT
5566	441512.449	2638016.488	1117.634	SPOT
5567	441520.655	2638023.196	1117.248	SPOT
5568	441524.5	2638026.778	1117.251	SPOT
5569	441528.906	2638030.846	1118.497	SPOT
5570	441549.347	2638050.855	1118.357	SPOT
5571	441573.62	2638008.834	1118.489	SPOT
5572	441556.169	2637992.899	1118.113	SPOT
5573	441551.782	2637988.721	1117.009	SPOT
5574	441548.412	2637985.569	1117.306	SPOT
5575	441545.744	2637982.863	1117.229	SPOT
5576	441541.545	2637978.779	1118.064	SPOT
5577	441563.022	2637950.202	1118.269	SPOT
5578	441569.485	2637956.517	1118.05	SPOT
5579	441573.668	2637961.091	1117.962	SPOT
5580	441578.131	2637965.372	1118.758	SPOT
5581	441586.33	2637972.984	1119.396	SPOT
5582	441604.253	2638012.814	1118.043	SPOT
5583	441620.584	2638030.783	1114.453	SPOT
5584	441636.714	2638038.871	1110.575	SPOT
5585	441658.956	2638040.649	1104.791	SPOT
5586	441658.924	2638047.794	1104.618	SPOT
5587	441659.499	2638055.26	1103.886	SPOT
5588	441686.32	2638056.877	1097.195	SPOT
5589	441687.764	2638048.559	1097.32	SPOT
5590	441688.196	2638039.073	1097.102	SPOT
5591	441719.758	2638040.807	1091.356	SPOT
5592	441719.955	2638048.498	1091.178	SPOT
5593	441721.319	2638058.477	1090.067	SPOT
5594	441744.162	2638058.801	1085.85	SPOT
5595	441739.84	2638047.474	1087.287	SPOT
5596	441743.482	2638048.236	1083.738	SPOT
5597	441749.113	2638039.723	1084.256	SPOT
5598	441742.645	2638043.735	1086.855	SPOT
5599	441743	2638053.53	1086.234	SPOT
5600	441745.712	2638052.961	1084.434	SPOT
5601	441751.883	2638055.756	1082.73	SPOT
5602	441749.952	2638061.985	1084.239	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5603	441777.233	2638049.989	1073.696	CMP B 12
5604	441723.017	2638069.284	1087.74	SPOT
5605	441688.45	2638071.283	1093.763	SPOT
5606	441658.479	2638081.245	1098.391	SPOT
5607	441632.936	2638094.961	1103.099	SPOT
5608	441610.274	2638111.803	1109.661	SPOT
5609	441607.474	2638071.73	1115.958	SPOT
5610	441620.109	2638061.723	1113.771	SPOT
5611	441634.97	2638057.113	1110.532	SPOT
5612	441634.504	2638050.873	1110.753	SPOT
5613	441614.902	2638051.641	1115.558	SPOT
5614	441559.073	2638080.497	1118.629	SPOT
5615	441532.122	2638062.033	1118.417	SPOT
5616	441516.184	2638050.277	1118.35	SPOT
5617	441510.309	2638045.738	1117.41	SPOT
5618	441505.735	2638042.505	1117.289	SPOT
5619	441501.207	2638039.318	1117.481	SPOT
5620	441495.419	2638034.888	1117.877	SPOT
5621	441504.244	2638046.069	1117.326	SPOT
5622	441504.458	2638048.079	1117.216	SPOT
5623	441506.128	2638047.234	1117.211	SPOT
5624	441505.812	2638045.345	1117.208	SPOT
5625	441443.712	2638050.418	1117.96	SPOT
5626	441463.358	2638065.385	1117.775	SPOT
5627	441473.922	2638072.585	1117.214	SPOT
5628	441478.716	2638076.178	1117.326	SPOT
5629	441483.189	2638079.532	1117.346	SPOT
5630	441486.948	2638082.898	1118.21	SPOT
5631	441515.066	2638100.586	1118.104	SPOT
5632	441550.024	2638122.995	1118.331	SPOT
5633	441549.237	2638169.17	1118.77	SPOT
5634	441520.93	2638139.774	1118.42	SPOT
5635	441488.505	2638121.525	1118.451	SPOT
5636	441465.33	2638108.356	1118.473	SPOT
5637	441460.478	2638105.111	1117.613	SPOT
5638	441457.234	2638102.187	1117.573	SPOT
5639	441453.498	2638099.192	1117.468	SPOT
5640	441448.132	2638094.276	1118.172	SPOT
5641	441418.912	2638070.386	1118.323	SPOT
5642	441365.988	2638093.049	1118.353	SPOT
5643	441398.758	2638117.501	1118.371	SPOT
5644	441420.443	2638129.16	1118.367	SPOT
5645	441425.309	2638132.292	1117.412	SPOT
5646	441429.494	2638135.276	1117.405	SPOT
5647	441433.478	2638137.911	1117.566	SPOT
5648	441438.328	2638141.088	1118.451	SPOT
5649	441471.426	2638160.831	1118.488	SPOT
5650	441503.124	2638187.989	1118.555	SPOT
5651	441530.973	2638211.96	1118.679	SPOT
5652	441508.856	2638257.012	1118.902	SPOT
5653	441480.353	2638226.425	1118.736	SPOT
5654	441447.837	2638198.176	1118.568	SPOT
5655	441414.832	2638168.939	1118.307	SPOT
5656	441411.344	2638165.758	1117.555	SPOT
5657	441407.675	2638162.14	1117.461	SPOT
5658	441404.233	2638158.346	1117.452	SPOT
5659	441398.132	2638154.417	1118.265	SPOT
5660	441363.364	2638136.869	1118.395	SPOT
5661	441336.082	2638125.02	1118.481	SPOT
5662	441298.253	2638102.812	1118.402	SPOT
5663	441268.876	2638133.388	1118.536	SPOT
5664	441301.369	2638159.779	1118.499	SPOT
5665	441339.689	2638180.581	1118.444	SPOT
5666	441368.963	2638194.221	1118.361	SPOT
5667	441374.566	2638197.006	1117.765	SPOT
5668	441379.588	2638199.9	1117.794	SPOT
5669	441383.391	2638202.447	1117.842	SPOT
5670	441386.114	2638203.88	1118.278	SPOT
5671	441421.623	2638228.718	1118.403	SPOT
5672	441448.764	2638257.615	1118.516	SPOT
5673	441479.228	2638290.658	1118.462	SPOT
5674	441462.184	2638319.258	1118.79	SPOT
5675	441424.862	2638300.314	1118.838	SPOT
5676	441387.421	2638281.758	1119.109	SPOT
5677	441351.462	2638257.874	1119.209	SPOT
5678	441324.319	2638233.016	1119.434	SPOT
5679	441294.728	2638201.409	1118.999	SPOT
5680	441266.693	2638169.254	1118.984	SPOT
5681	441240.794	2638135.336	1119.061	SPOT
5682	441219.511	2638105.013	1119.122	SPOT
5683	441252.357	2638100.022	1118.501	SPOT
5684	441327.026	2638217.801	1119.018	SPOT
5685	441341.603	2638233.078	1119.23	SPOT
5686	441350.295	2638239.597	1119.085	SPOT
5687	441366.227	2638245.199	1118.892	SPOT
5688	441367.002	2638239.849	1118.579	SPOT
5689	441360.245	2638237.507	1118.708	SPOT
5690	441357.951	2638236.649	1118.575	SPOT
5691	441353.377	2638234.254	1118.55	SPOT
5692	441347.808	2638230.185	1118.893	SPOT
5693	441342.697	2638224.096	1118.972	SPOT
5694	441451.437	2638339.687	1124.519	SPOT
5695	441440.056	2638358.46	1130.874	SPOT
5696	441430.446	2638370.808	1132.853	SPOT
5697	441422.712	2638380.995	1132.292	SPOT
5698	441415.641	2638388.983	1130.887	SPOT
5699	441385.204	2638365.048	1133.772	SPOT
5700	441390.531	2638353.667	1133.988	SPOT
5701	441397.201	2638341.941	1133.119	SPOT
5702	441402.411	2638333.524	1130.883	SPOT
5703	441410.973	2638318.05	1125.029	SPOT
5704	441375.096	2638297.777	1124.861	SPOT
5705	441365.385	2638314.014	1130.848	SPOT
5706	441357.114	2638326.779	1134.899	SPOT
5707	441350.007	2638337.214	1135.276	SPOT
5708	441337.432	2638357.055	1134.193	SPOT
5709	441297.665	2638342.931	1135.918	SPOT
5710	441314.518	2638316.166	1136.968	SPOT
5711	441319.813	2638308.565	1136.782	SPOT
5712	441324.311	2638300.552	1135.434	SPOT
5713	441337.368	2638280.772	1127.844	SPOT
5714	441306.474	2638250.672	1127.293	SPOT
5715	441294.536	2638264.498	1134.009	SPOT
5716	441286.558	2638274.24	1137.818	SPOT
5717	441278.654	2638283.85	1138.958	SPOT
5718	441260.266	2638308.478	1139.414	SPOT
5719	441226.405	2638278.544	1142.139	SPOT
5720	441239.956	2638263.04	1140.757	SPOT
5721	441250.077	2638252.203	1140.396	SPOT
5722	441258.461	2638242.781	1137.839	SPOT
5723	441277.361	2638223.649	1128.16	SPOT
5724	441246.34	2638186.192	1127.118	SPOT
5725	441220.64	2638209.801	1139.592	SPOT
5726	441204.86	2638223.602	1144.108	SPOT
5727	441181.699	2638243.332	1146.573	SPOT
5728	441148.616	2638207.897	1148.051	SPOT
5729	441170.857	2638191.4	1146.641	SPOT
5730	441182.961	2638181.987	1144.02	SPOT
5731	441207.994	2638163.365	1132.7	SPOT
5732	441224.992	2638150.597	1124.933	SPOT
5733	441198.918	2638110.775	1124.986	SPOT
5734	441171.629	2638123.265	1136.331	SPOT
5735	441150.842	2638137.037	1145.091	SPOT
5736	441135.031	2638146.811	1148.513	SPOT
5737	441105.312	2638162.308	1149.954	SPOT
5738	441030.901	2637940.197	1148.458	SPOT
5739	441065.636	2637934.918	1148.31	SPOT
5740	441074.383	2637932.835	1147.005	SPOT
5741	441099.652	2637925.285	1138.668	SPOT
5742	441127.579	2637918.3	1127.928	SPOT
5743	441150.511	2637912.313	1120.071	SPOT
5744	441191.961	2637900.705	1119.687	SPOT
5745	441236.595	2637890.909	1119.765	SPOT
5746	441278.516	2637879.542	1119.785	SPOT
5747	441324.352	2637869.545	1119.506	SPOT
5748	441366.703	2637860.894	1119.748	SPOT
5749	441411.002	2637849.304	1119.886	SPOT
5750	441454.592	2637839.8	1120.002	SPOT
5751	441496.421	2637828.986	1119.887	SPOT
5752	441541.871	2637819.595	1119.992	SPOT
5753	441555.96	2637816.06	1124.632	SPOT
5754	441573.889	2637810.983	1130.336	SPOT
5755	441594.811	2637805.006	1129.183	SPOT
5756	441611.888	2637801	1127.734	SPOT
5757	441619.475	2637745.424	1129.001	SPOT
5758	441611.278	2637746.856	1129.945	SPOT
5759	441583.203	2637753.576	1131.098	SPOT
5760	441562.693	2637757.846	1132.253	SPOT
5761	441554.963	2637760.127	1130.89	SPOT
5762	441543.869	2637761.63	1126.86	SPOT
5763	441530.856	2637762.14	1122.26	SPOT
5764	441504.701	2637764.27	1121.585	SPOT
5765	441460.769	2637770.229	1121.764	SPOT
5766	441417.684	2637780.93	1121.653	SPOT
5767	441375.683	2637787.862	1121.765	SPOT
5768	441335.369	2637796.112	1121.601	SPOT
5769	441293.478	2637806.325	1121.382	SPOT
5770	441253.514	2637815.023	1121.542	SPOT
5771	441211.05	2637826.91	1121.47	SPOT
5772	441171.14	2637839.804	1121.439	SPOT
5773	441138.836	2637848.715	1122.008	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5774	441111.09	2637853.205	1130.467	SPOT
5775	441083.227	2637856.305	1141.286	SPOT
5776	441067.03	2637858.493	1145.866	SPOT
5777	441056.422	2637859.382	1147.499	SPOT
5778	441043.481	2637860.495	1148.514	SPOT
5779	441001.633	2637863.315	1148.552	SPOT
5780	440992.811	2637806.01	1148.715	SPOT
5781	441032.923	2637799.044	1148.503	SPOT
5782	441048.403	2637796.609	1147.451	SPOT
5783	441059.859	2637794.468	1145.493	SPOT
5784	441091.836	2637788.758	1134.599	SPOT
5785	441122.918	2637783.829	1124.039	SPOT
5786	441164.601	2637774.413	1123.387	SPOT
5787	441204.318	2637765.337	1123.675	SPOT
5788	441245.822	2637753.917	1123.667	SPOT
5789	441289.467	2637743.951	1123.796	SPOT
5790	441328.869	2637734.868	1123.792	SPOT
5791	441371.578	2637723.801	1123.741	SPOT
5792	441410.615	2637718.593	1123.623	SPOT
5793	441452.04	2637709.916	1123.634	SPOT
5794	441495.483	2637700.579	1123.201	SPOT
5795	441516.868	2637695.886	1123.831	SPOT
5796	441529.906	2637693.743	1128.193	SPOT
5797	441546.142	2637691.819	1132.896	SPOT
5798	441558.07	2637691.26	1133.345	SPOT
5799	441583.232	2637689.992	1130.898	SPOT
5800	441606.267	2637689.172	1129.476	SPOT
5801	441599.76	2637641.102	1129.484	SPOT
5802	441558.483	2637651.009	1133.705	SPOT
5803	441545.531	2637654.189	1134.079	SPOT
5804	441536.306	2637655.77	1132.7	SPOT
5805	441525.321	2637655.206	1129.14	SPOT
5806	441509.784	2637655.957	1124.384	SPOT
5807	441474.393	2637661.551	1123.783	SPOT
5808	441425.908	2637668.958	1123.92	SPOT
5809	441385.883	2637675.597	1124.001	SPOT
5810	441343.078	2637683.643	1124.051	SPOT
5811	441297.648	2637692.713	1123.977	SPOT
5812	441254.9	2637700.929	1123.955	SPOT
5813	441213.758	2637710.064	1124.043	SPOT
5814	441169.012	2637720.181	1123.917	SPOT
5815	441128.588	2637729.713	1124.224	SPOT
5816	441113.573	2637732.879	1124.845	SPOT
5817	441094.869	2637736.616	1130.172	SPOT
5818	441067.722	2637741.202	1139.138	SPOT
5819	441041.266	2637746.704	1146.673	SPOT
5820	441025.429	2637748.543	1148.164	SPOT
5821	440986.958	2637754.463	1148.388	SPOT
5822	441226.825	2637222.792	1123.048	DRN B SPILLWAY CENTERLINE
5823	441229.327	2637243.073	1123.999	DRN
5824	441232.244	2637268.596	1124.32	DRN
5825	441236.238	2637310.571	1124.025	DRN
5826	441239.796	2637353.453	1123.816	DRN
5827	441246.451	2637402.154	1123.863	DRN
5828	441249.089	2637427.622	1123.531	DRN
5829	441250.017	2637434.317	1124.117	DRN
5830	441250.562	2637439.555	1124.341	DRN
5831	441252.196	2637449.105	1123.594	DRN
5832	441253.459	2637461.955	1122.875	DRN
5833	441254.237	2637469.048	1123.868	DRN
5834	441259.633	2637516.302	1124.096	DRN
5835	441267.873	2637560.229	1124.278	DRN
5836	441278.415	2637603.994	1123.949	DRN
5837	441289.506	2637650.714	1124.257	DRN
5838	441300.738	2637695.428	1124	DRN
5839	441307.955	2637724.467	1124.065	DRN
5840	441314.008	2637769.694	1122.522	DRN
5841	441323.601	2637812.462	1121.243	DRN
5842	441338.706	2637855.048	1119.983	DRN
5843	441352.343	2637900.951	1118.682	DRN
5844	441363.73	2637947.268	1118.172	DRN
5845	441373.167	2637990.328	1118.171	DRN
5846	441385	2638031.638	1118.052	DRN
5847	441410.41	2638065.172	1118.316	DRN
5848	441436.323	2638095.22	1118.324	DRN
5849	441442.517	2638101.997	1118.223	DRN
5850	441447.169	2638107.176	1117.351	DRN
5851	441450.401	2638110.692	1117.439	DRN
5852	441453.589	2638113.719	1117.475	DRN
5853	441457.022	2638117.616	1118.316	DRN
5854	441486.224	2638147.012	1118.469	DRN
5855	441515.097	2638174.106	1118.438	DRN
5856	441542.562	2638199.945	1118.531	DRN
5857	441568.548	2638221.626	1118.351	DRN
5858	441576.714	2638226.865	1117.115	DRN E
5859	441505.212	2638046.729	1117.042	CB CMP E 12
5860	442993.671	2636863.061	1133.36	RD B
5861	442965.04	2636885.437	1133.525	RD
5862	442935.177	2636904.228	1133.554	RD
5863	442899.213	2636920.412	1133.418	RD
5864	442863.463	2636934.431	1133.108	RD
5865	442812.201	2636954.927	1132.671	RD
5866	442763.059	2636973.406	1132.281	RD
5867	442715.539	2636991.713	1132.159	RD
5868	442675.297	2637007.117	1132.165	RD
5869	442636.935	2637022.348	1132.186	RD
5870	442598.173	2637036.909	1132.203	RD
5871	442557.814	2637052.325	1132.262	RD
5872	442516.492	2637068.07	1132.306	RD
5873	442473.709	2637083.953	1132.321	RD
5874	442430.516	2637100.937	1132.326	RD
5875	442386.366	2637117.965	1132.338	RD
5876	442335.32	2637137.928	1132.41	RD
5877	442287.526	2637156.283	1132.437	RD
5878	442240.519	2637174.378	1132.509	RD
5879	442203.323	2637188.498	1132.502	RD
5880	442154.334	2637206.943	1132.482	RD
5881	442106.597	2637225.41	1132.455	RD
5882	442056.42	2637244.399	1132.51	RD
5883	442003.323	2637264.666	1132.618	RD
5884	441959.83	2637281.093	1132.6	RD
5885	441907.643	2637301.075	1132.403	RD
5886	441860.972	2637319.025	1132.199	RD
5887	441813.231	2637337.365	1132.085	RD
5888	441769.713	2637354.157	1132.236	RD
5889	441730.305	2637367.008	1132.582	RD
5890	441690.429	2637378.113	1133.131	RD
5891	441653.322	2637384.404	1133.576	RD
5892	441618.917	2637387.811	1133.686	RD E
1758	442196.203	2638705.438	1079.839	RD B
1759	442148.434	2638706.981	1081.226	RD
1760	442089.539	2638709.204	1082.981	RD
1761	442036.836	2638710.607	1085.014	RD
1762	441982.746	2638712.635	1087.338	RD
1763	441927.108	2638714.139	1090.18	RD
1764	441873.962	2638716.187	1093.225	RD
1765	441814.039	2638718.473	1096.811	RD
1766	441750.412	2638720.624	1100.941	RD
1767	441684.282	2638722.974	1105.136	RD E
1768	445137.93	2640535.705	1063.751	RD B
1769	445171.601	2640586.501	1062.382	RD
1770	445196.39	2640635.89	1061.469	RD
1771	445215.885	2640698.194	1060.907	RD
1772	445225.199	2640757.282	1060.765	RD
1773	445231.6	2640815.309	1060.728	RD
1774	445238.117	2640879.038	1060.354	RD
1775	445245.045	2640943.373	1060.822	RD E
1776	445104.77	2640492.953	1065.384	RD
5893	442913.775	2636965.868	1138.337	CHK5
5894	442802.067	2637240.542	1089.429	SPOT
5895	442794.047	2637242.866	1088.346	SPOT
5896	442781.633	2637247.122	1082.959	SPOT
5897	442770.991	2637250.744	1078.785	SPOT
5898	442766.66	2637252	1078.143	SPOT
5899	442760.685	2637253.823	1075.776	SPOT
5900	442758.272	2637253.99	1075.24	SPOT
5901	442756.15	2637253.32	1073.441	SPOT
5902	442749.001	2637257.678	1071.887	SPOT
5903	442752.923	2637256.378	1072.733	SPOT
5904	442744.487	2637260.241	1071.372	SPOT
5905	442740.664	2637254.473	1073.979	SPOT ROCKS
5906	442744.872	2637252.498	1073.86	SPOT ROCKS
5907	442746.534	2637250.892	1073.981	SPOT ROCKS
5908	442748.333	2637248.816	1073.882	SPOT ROCKS
5909	442752.526	2637246.376	1074.529	SPOT ROCKS
5910	442756.353	2637245.752	1075.278	SPOT
5911	442764.222	2637243.309	1079.065	SPOT
5912	442770.577	2637241.627	1079.665	SPOT
5913	442782.359	2637236.856	1084.296	SPOT
5914	442791.66	2637233.632	1088.781	SPOT
5915	442822.085	2637288.241	1087.823	SPOT
5916	442807.629	2637291.345	1086.558	SPOT
5917	442794.841	2637294.661	1082.436	SPOT
5918	442784.965	2637297.949	1078.92	SPOT
5919	442778.987	2637299.52	1078.41	SPOT
5920	442774.542	2637300.801	1076.107	SPOT
5921	442769.725	2637301.393	1073.166	SPOT
5922	442765.867	2637303.252	1071.169	SPOT
5923	442761.483	2637304.001	1070.45	SPOT
5924	442757.384	2637305.175	1070.834	SPOT
5925	442751.775	2637306.045	1071.236	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
5926	442747.093	2637307.624	1071.949	SPOT
5927	442743.899	2637308.069	1074.479	SPOT
5928	442737.634	2637309.996	1076.946	SPOT
5929	442723.409	2637314.364	1081.699	SPOT
5930	442704.904	2637321.397	1081.362	SPOT
5931	442692.996	2637273.861	1081.257	SPOT
5932	442703.125	2637269.396	1079.317	SPOT
5933	442696.807	2637272.619	1081.268	SPOT
5934	442707.867	2637267.814	1078.932	SPOT
5935	442713.409	2637265.776	1076.671	SPOT ROCKS
5936	442716.11	2637263.905	1074.678	SPOT ROCKS
5937	442719.601	2637261.944	1074.285	SPOT ROCKS
5938	442724.315	2637260.917	1074.474	SPOT ROCKS
5939	442726.92	2637258.241	1074.268	SPOT ROCKS
5940	442733.993	2637256.037	1074.238	SPOT ROCKS
5941	442737.722	2637263.188	1071.461	SPOT
5942	442732.875	2637264.933	1071.684	SPOT
5943	442730.305	2637266.158	1072.312	SPOT
5944	442727.423	2637267.415	1073.185	SPOT
5945	442722.375	2637270.276	1074.256	SPOT
5946	442718.039	2637273.521	1077.818	SPOT
5947	442713.103	2637276.378	1079.486	SPOT
5948	442701.812	2637282.104	1081.253	SPOT
5949	442715.435	2637371.226	1082.569	SPOT
5950	442724.754	2637369.609	1081.172	SPOT
5951	442734.086	2637367.42	1081.415	SPOT
5952	442747.751	2637364.127	1078.313	SPOT
5953	442756.181	2637362.52	1074.685	SPOT
5954	442757.451	2637362.228	1072.847	SPOT
5955	442760.998	2637361.582	1072.141	SPOT
5956	442767.961	2637359.189	1071.964	SPOT
5957	442776.042	2637357.987	1071.705	SPOT
5958	442782.539	2637357.153	1074.155	SPOT
5959	442787.943	2637355.614	1077.2	SPOT
5960	442798.771	2637353.757	1082.545	SPOT
5961	442814.798	2637350.276	1084.508	SPOT
5962	442833.243	2637346.863	1084.568	SPOT
5963	442828.697	2637402.329	1083.78	SPOT
5964	442811.314	2637403.755	1084.03	SPOT
5965	442804.228	2637404.074	1081.502	SPOT
5966	442800.102	2637404.01	1081.307	SPOT
5967	442793.41	2637404.724	1077.734	SPOT
5968	442785.66	2637404.476	1074.618	SPOT
5969	442783.834	2637404.695	1074.407	SPOT
5970	442782.577	2637405.018	1072.518	SPOT
5971	442779.06	2637405.23	1071.488	SPOT
5972	442774.268	2637405.101	1071.536	SPOT
5973	442769.126	2637405.652	1071.551	SPOT
5974	442765.89	2637405.618	1071.977	SPOT
5975	442761.836	2637405.692	1074.033	SPOT
5976	442749.258	2637408.117	1078.685	SPOT
5977	442740.898	2637409.192	1081.558	SPOT
5978	442728.338	2637410.19	1080.983	SPOT
5979	442709.32	2637413.134	1083.316	SPOT
5980	442702.244	2637442.747	1083.431	SPOT
5981	442714.839	2637443.986	1082.351	SPOT
5982	442727.121	2637445.599	1080.574	SPOT
5983	442738.881	2637446.939	1081.468	SPOT
5984	442748.467	2637447.867	1077.267	SPOT
5985	442756.078	2637449.812	1074.336	SPOT
5986	442760.064	2637450.599	1071.718	SPOT
5987	442762.803	2637450.451	1071.036	SPOT
5988	442768.206	2637450.205	1071.654	SPOT
5989	442773.515	2637451.013	1071.528	SPOT
5990	442777.566	2637451.343	1071.743	SPOT
5991	442778.766	2637451.668	1074.028	SPOT
5992	442783.182	2637451.712	1074.376	SPOT
5993	442789.814	2637452.571	1077.612	SPOT
5994	442797.153	2637451.881	1080.831	SPOT
5995	442810.286	2637453.166	1083.731	SPOT
5996	442828.602	2637454.197	1083.605	SPOT
5997	442809.333	2637518.352	1082.021	SPOT
5998	442798.039	2637515.363	1083.466	SPOT
5999	442787.159	2637511.92	1081.298	SPOT
6000	442782.434	2637510.933	1080.872	SPOT
6001	442775.356	2637509.309	1076.987	SPOT
6002	442772.301	2637508.152	1075.915	SPOT
6003	442770.361	2637507.39	1073.251	SPOT
6004	442766.457	2637506.277	1071.482	SPOT
6005	442760.036	2637504.263	1071.105	SPOT
6006	442755.43	2637502.299	1071.337	SPOT
6007	442752.72	2637502.396	1071.328	SPOT
6008	442748.298	2637501.012	1071.802	SPOT
6009	442746.866	2637500.175	1073.029	SPOT
6010	442743.622	2637499.384	1074.826	SPOT
6011	442738.891	2637498.078	1075.649	SPOT
6012	442728.191	2637494.128	1081.118	SPOT
6013	442716.155	2637490.31	1079.613	SPOT
6014	442698.842	2637485.019	1082.401	SPOT
6015	442680.559	2637527.64	1080.789	SPOT
6016	442692.778	2637533.206	1079.494	SPOT
6017	442703.487	2637539.035	1080.304	SPOT
6018	442710.318	2637542.627	1076.548	SPOT
6019	442716.44	2637545.517	1074.202	SPOT
6020	442721.94	2637547.84	1073.835	SPOT
6021	442722.851	2637547.698	1072.142	SPOT
6022	442725.837	2637550.839	1071.02	SPOT
6023	442731.369	2637552.907	1071.596	SPOT
6024	442736.392	2637555.157	1070.99	SPOT
6025	442739.795	2637557.041	1071.476	SPOT
6026	442741.976	2637558.833	1073.35	SPOT
6027	442747.05	2637561.842	1075.563	SPOT
6028	442754.493	2637565.688	1080.213	SPOT
6029	442767.729	2637572.403	1083.218	SPOT
6030	442787.058	2637582.563	1081.106	SPOT
6031	442749.856	2637630.943	1080.825	SPOT
6032	442735.962	2637620.8	1082.736	SPOT
6033	442728.353	2637615.223	1080.487	SPOT
6034	442723.594	2637610.96	1079.941	SPOT
6035	442717.91	2637606.476	1075.851	SPOT
6036	442713.443	2637602.627	1073.78	SPOT
6037	442709.215	2637599.465	1072.253	SPOT
6038	442706.237	2637596.69	1071.21	SPOT
6039	442702.892	2637593.431	1070.94	SPOT
6040	442699.78	2637590.396	1071.127	SPOT
6041	442696.782	2637588.732	1072.053	SPOT
6042	442695.862	2637587.591	1073.64	SPOT
6043	442690.911	2637584.188	1074.592	SPOT
6044	442679.766	2637576.353	1080.656	SPOT
6045	442666.437	2637568.541	1079.335	SPOT
6046	442650.472	2637560.6	1081.996	SPOT
6047	442613.416	2637599.019	1081.915	SPOT
6048	442627.581	2637610.425	1079.25	SPOT
6049	442640.43	2637621.202	1080.047	SPOT
6050	442647.878	2637627.336	1076.905	SPOT
6051	442652.639	2637631.733	1073.464	SPOT
6052	442654.379	2637632.915	1072.253	SPOT
6053	442658.056	2637635.619	1071.779	SPOT
6054	442663.085	2637639.62	1071.45	SPOT
6055	442667.303	2637644.198	1070.665	SPOT
6056	442671.49	2637647.003	1071.865	SPOT
6057	442673.996	2637648.99	1071.902	SPOT
6058	442679.398	2637652.558	1074.817	SPOT
6059	442689.078	2637659.947	1080.278	SPOT
6060	442700.268	2637666.711	1082.742	SPOT
6061	442708.249	2637672.85	1081.047	SPOT
6062	442723.538	2637683.813	1080.661	SPOT
6063	442663.651	2637729.844	1080.056	SPOT
6064	442653.971	2637718.28	1081.845	SPOT
6065	442648.652	2637711.042	1080.544	SPOT
6066	442643.765	2637705.241	1080.015	SPOT
6067	442637.31	2637696.832	1076.72	SPOT
6068	442633.51	2637692.07	1074.238	SPOT
6069	442632.582	2637690.542	1071.492	SPOT
6070	442628.873	2637685.931	1070.364	SPOT
6071	442625.585	2637681.619	1070.014	SPOT
6072	442621.281	2637676.913	1070.506	SPOT
6073	442617.309	2637672.388	1070.583	SPOT
6074	442615.242	2637669.389	1073.974	SPOT
6075	442604.374	2637656.214	1079.428	SPOT
6076	442586.924	2637635.902	1080.91	SPOT
6077	442552.996	2637672.039	1079.5	SPOT
6078	442570.333	2637691.102	1079.621	SPOT
6079	442575.611	2637697.533	1076.296	SPOT
6080	442580.161	2637703.048	1073.831	SPOT
6081	442580.834	2637703.956	1072.096	SPOT
6082	442582.823	2637706.102	1070.339	SPOT
6083	442585.861	2637708.579	1070.108	SPOT
6084	442589.769	2637713.433	1070.381	SPOT
6085	442592.582	2637717.185	1070.456	SPOT
6086	442594.511	2637719.585	1070.548	SPOT
6087	442598.075	2637723.38	1074.521	SPOT
6088	442607.58	2637734.006	1079.597	SPOT
6089	442613.176	2637741.577	1079.657	SPOT
6090	442619.025	2637747.676	1080.978	SPOT
6091	442624.857	2637755.077	1079.015	SPOT
6092	442633.615	2637766.957	1078.511	SPOT
6116	442606.585	2636915.613	1105.971	ORIFICE
6119	437604.681	2626024.349	1141.073	SPOT
6120	437604.047	2626020.532	1140.516	SPOT
6121	437603.787	2626013.385	1137.396	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
6122	437603.341	2626007.511	1135.455	SPOT
6123	437602.539	2626003.198	1135.406	SPOT
6124	437601.832	2625999.73	1135.392	SPOT
6125	437601.243	2625996.585	1134.465	SPOT
6126	437600.814	2625993.928	1133.66	SPOT
6127	437599.533	2625987.357	1133.915	SPOT
6128	437598.368	2625980.088	1133.744	SPOT
6129	437597.883	2625975.504	1133.243	SPOT
6130	437597.532	2625973.143	1132.695	SPOT
6131	437596.869	2625968.08	1132.237	SPOT
6132	437596.491	2625964.757	1131.497	SPOT
6133	437596.603	2625965.37	1131.743	SPOT
6134	437596.416	2625963.174	1130.588	SPOT
6135	437595.914	2625960.213	1130.156	SPOT
6136	437595.563	2625958.325	1130.106	SPOT
6137	437595.369	2625956.455	1130.469	SPOT
6138	437590.031	2625973.743	1132.635	BKFL
6139	437594.107	2625933.887	1140.127	SPOT
6140	437593.431	2625940.396	1140.117	SPOT
6141	437594.175	2625943.135	1139.664	SPOT
6142	437594.412	2625946.939	1138.31	SPOT
6143	437594.617	2625948.824	1137.629	SPOT
6144	437594.53	2625949.67	1136.056	SPOT
6145	437594.599	2625951.3	1135.809	SPOT
6146	437594.962	2625952.59	1135.558	SPOT
6147	437594.946	2625953.577	1132.661	SPOT
6148	437602.7	2625955.879	1131.576	BKFL
6149	437650.72	2625940.413	1137.689	SPOT
6150	437645.268	2625946.735	1137.412	SPOT
6151	437641.243	2625951.134	1136.463	SPOT
6152	437636.78	2625956.093	1135.593	SPOT
6153	437634.597	2625958.296	1135.446	SPOT
6154	437632.034	2625960.839	1134.076	SPOT
6155	437629.477	2625964.015	1132.875	SPOT
6156	437628.267	2625965.621	1133.186	SPOT
6157	437626.868	2625966.576	1132.471	SPOT
6158	437625.549	2625968.133	1132.28	SPOT
6159	437624.969	2625969.181	1131.289	SPOT
6160	437624.256	2625970.145	1130.208	SPOT
6161	437622.672	2625971.959	1129.448	SPOT
6162	437620.796	2625973.607	1129.688	SPOT
6163	437619.043	2625975.422	1130.28	SPOT
6164	437618.672	2625976.308	1131.466	SPOT
6165	437615.803	2625978.617	1132.07	SPOT
6166	437614.22	2625980.603	1132.132	SPOT
6167	437611.244	2625985.409	1132.859	SPOT
6168	437608.004	2625989.152	1133.685	SPOT
6169	437602.25	2625995.879	1134.168	SPOT
6170	437599.411	2625999.418	1135.356	SPOT
6171	437592.782	2626009.949	1135.873	SPOT
6172	437581.323	2626016.976	1137.943	SPOT
6173	437574.187	2626025.599	1141.003	SPOT
6174	437567.804	2626032.719	1141.458	SPOT
6175	443838.16	2640068.201	1066.403	SPOT
6176	443844.619	2640072.514	1066.592	SPOT
6177	443848.149	2640075.517	1064.068	SPOT
6178	443851.895	2640078.932	1061.475	SPOT

ID	Northing (US survey foot)	Easting (US survey foot)	Elevation (US survey foot)	Feature Code
6179	443858.952	2640084.835	1060.852	SPOT
6180	443861.97	2640087.637	1059.83	SPOT
6181	443862.636	2640088.501	1058.088	SPOT
6182	443864.543	2640089.719	1056.73	SPOT
6183	443865.55	2640091.386	1055.083	SPOT
6184	443818.681	2640153.925	1065.499	SPOT
6185	443823.184	2640156.234	1065.75	SPOT
6186	443827.235	2640156.391	1064.414	SPOT
6187	443832.317	2640154.902	1064.51	SPOT
6188	443834.242	2640154.07	1064.078	SPOT
6189	443837.733	2640153.223	1057.474	SPOT
6190	443839.238	2640153.018	1056.578	SPOT
6191	443842.672	2640153.076	1056.545	SPOT
6192	443846.355	2640152.783	1056.096	SPOT
6193	443849.845	2640152.902	1056.085	SPOT
6194	443847.523	2640158.828	1057.176	BKFL
6195	443851.204	2640152.138	1055.833	SPOT
6196	443853.727	2640151.519	1055.609	SPOT
6197	443858.823	2640150.82	1055.362	SPOT
6198	443860.721	2640150.132	1055.459	SPOT
6199	443862.627	2640149.351	1056.884	SPOT
6200	443863.295	2640149.393	1057.464	SPOT
6201	443868.278	2640147.233	1058.129	SPOT
6202	443879.496	2640145.583	1058.201	SPOT
6203	443885.268	2640144.965	1058.485	SPOT
6204	443892.335	2640144.491	1059.395	SPOT
6205	443898.112	2640145.008	1062.731	SPOT
6206	443902.202	2640145.101	1064.53	SPOT
6207	443906.304	2640145.657	1065.674	SPOT
6208	443914.882	2640149.208	1065.566	SPOT
6209	443915.909	2640141.929	1065.493	SPOT
6210	443909.475	2640134.109	1065.565	SPOT
6211	443904.847	2640129.641	1065.106	SPOT
6212	443901.612	2640126.222	1062.944	SPOT
6213	443895.767	2640120.89	1058.529	SPOT
6214	443893.763	2640118.217	1058.277	SPOT
6215	443884.137	2640110.001	1057.578	SPOT
6216	443878.724	2640104.668	1057.185	SPOT
6217	443876.333	2640102.154	1056.562	SPOT
6218	443873.973	2640099.605	1056.586	SPOT
6219	443872.669	2640098.543	1056.308	SPOT
6220	443871.776	2640097.6	1055.891	SPOT
6221	443869.493	2640095.142	1055.626	SPOT
6222	443868.005	2640093.748	1055.527	SPOT

APPENDIX D

Site Inspection Supporting Information

- Inspection Report Checklist
- Site Inspection Photos

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INSPECTION REPORT CHECKLIST

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U.S. Department of Agriculture
Natural Resources Conservation Service

WATERSHED STRUCTURE INSPECTION REPORT

Date of Inspection Sept. 1, 2020 Common Name Fordville Dam

County Grand Forks Watershed Middle-South Branch Forest River Site Dam No. 4

Field Office _____ Sponsor _____

Legal Description, Sec 6&7 T 154N R 55W

"Yes" responses need explanation added to "Remarks" section. (i.e.: What? Where? Extent?)
"No" responses indicate problems not observed during inspection.
Views ("left" and "right") are as if looking downstream.

ITEM	YES	NO	REMARKS
1. General Conditions			
a. Alterations to dam?		X	
b. Development in downstream floodplain?		X	See additional remarks 1.b.
c. Development around reservoir?	X		Campsites, RV park, swimming beach, picnic area, boat access
2. Embankment			
a. Is vegetative cover inadequate?	X		
b. Are trees growing on either slope?	X		Small, scattered trees on both slopes
c. Is brush/weed control needed?	X		Some small areas of bush and weeds
d. Are trees growing at waterline?		X	
e. Is drift debris present?	X		Minor amount of small woody material
f. Are cracks, settlement, or bulges present?		X	
g. Are animal burrows present?	X		Scattered pocket gopher mounds
h. Are trails present?	X		Lightly used vehicle and animal tracks
3. Front Slope Protection			
a. Any wave damage observed?		X	
b. Is riprap inadequate?		X	
c. Are rodent holes present?		X	
4. Inlet Structure and Gate Valves			
a. Does concrete exhibit deterioration?		X	
b. Is concrete reinforcement exposed?		X	
c. Was leakage observed inside inlet?		X	
d. Any corrosion of metal appurtenances?		X	
e. Is debris guard obstructed?		X	
f. Is debris guard corroded?	X		Minor surface corrosion present on trash/debris guard
g. Is gate stem broken or bent?		X	
h. Are components missing?		X	
i. Was gate determined not operational?		X	
j. Has inlet been modified to alter water surface?		X	
5. Principal Spillway Conduit			
a. Is concrete conduit deteriorated?	x		See additional remarks 5.a.
b. Is metal conduit corroded?		x	
c. Was leakage observed at pipe joints?	x		See additional remarks 5.c.
6. Auxiliary Spillway			
a. Is vegetative cover inadequate?		X	
b. Any animal trails observed?	X		Lightly used and vegetated
c. Any vehicular trails observed?	X		Lightly used and vegetated
d. Is flow area obstructed?	X		See additional remarks 6.d.
e. Is control section disturbed?		X	

7. Principal Spillway Release Channel			
a. Does scour hole appear unstable?		X	SAF stilling basin in place.
b. Any boils observed?		X	
c. Is riprap inadequate?		X	
d. Any seepage observed?		X	
e. Is conduit outlet submerged?		X	Conduit discharges into SAF Stilling Basin.
f. Is conduit outlet not properly supported?		X	
g. Is outlet channel obstructed?		X	
h. Is outlet channel degrading?		X	
i. Is foundation drain submerged?		X	See additional remark 7.i.
j. Is foundation drain rodent barrier missing?		X	
k. Is foundation drain not functional?		X	
8. Access Road and Parking Areas			
a. Is surface erosion present?		X	
b. Is gravel surfacing inadequate?		X	
9. Boat Ramp			
a. Is sedimentation/erosion present?		X	
b. Is concrete slab deteriorated?		X	
10. Swimming Beaches		X	
a. Any wave damage observed?		X	
b. Is sidewalk/perimeter concrete deteriorated?			N/A
11. Easements/Landrights			
a. Are terms of landrights out of compliance?		X	
b. Are landrights boundaries being encroached upon?		X	

Additional Remarks (includes reference to above section, if applicable):

1.b Downstream development is discussed in Section 4 of the Existing Conditions Assessment Report for Fordville Dam.

5.a. One section of the principal spillway conduit (between J11 and J10) was also noted to have minor hairline cracking of the wall and roof sections.

5.c. The connection of the concrete inlet structure and principal spillway conduit (J15) showed damage and movement to the steel joint plate as well as a small amount of water trickling through the joint. All other steel joint plates were noted to contain minor surface corrosion but did not show any signs or movement or damage. J4 was noted to have some preformed joint filler material that was partially dislodged from the joint on the roof connection.

6.d. Both the entrance and exit of the auxiliary channel are densely populated with trees and brush.

7.i. The right (south) foundation drain was found, and no flow was observed. The left (north) foundation drain was not found and assumed to be covered with the riprap protection. No seepage was observed coming from where the drain outlet was expected to be located.

SAF Stilling Basin - Both the south and north interior faces of the SAF Stilling Basin walls showed minor concrete spalling at the joints (J2 & J1) as well as some minor hairline concrete cracking near the mid-height of the wall at J2 and J1. Cracking also noted near several fence post connections at the top of the walls. Both wingwall joints also showed minor concrete spalling. Both the north and south wingwall showed significant section loss from concrete deterioration and spalling as well as exposed rebar at the ends of the wingwalls at the normal water elevation. This spalling also extends the length of wingwall on both the front and back face of the wingwalls.

Sponsor Representative

NRCS Representative

SITE INSPECTION PHOTOS

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INLET STRUCTURE AND GATE VALVES

1. INSIDE CONCRETE INLET STRUCTURE

2. 8" CRACK ABOVE CONDUIT/WALL CONNECTION

3. INSIDE LOW-LEVEL DRAWDOWN PIPE

PRINCIPAL SPILLWAY CONDUIT

4. DAMAGED STEEL JOINT PLATE AT J15

5. DA MAGED STEEL JOINT PLATE AT J15

6. SEEPAGE THROUGH TOP OF JOINT 15

7. ROOF CRACKING ON BOX SECTION BETWEEN J10 AND J11

8. WALL CRACKING ON BOX SECTION BETWEEN J10 AND J11

9. WALL CRACKING ON BOX SECTION BETWEEN J10 AND J11

10. MINOR SURFACE CORROSION ON STEEL JOINT PLATE

11. DISLODGED PREFORMED JOINT FILLER AT J4

PRINCIPAL SPILLWAY RELEASE CHANNEL

12. CONCRETE SPALLING – INSIDE FACE AT J2

13. CONCRETE SPALLING – INSIDE FACE AT J2

14. CONCRETE SPALLING – INSIDE FACE AT J1

15. CONCRETE CRACKING AT FENCE POST CONNECTION

16. CONCRETE CRACKING ON INTERIOR FACE OF SIDEWALLS AT NORMAL WATER ELEVATION

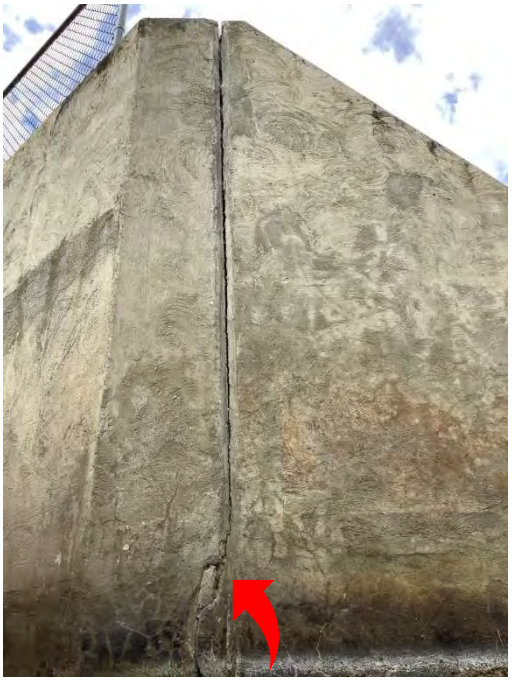
17. CONCRETE SPALLING – INSIDE FACE OF NE WINGWALL

18. CONCRETE SECTION LOSS AND EXPOSED REBAR NE WINGWALL

19. CONCRETE SECTION LOSS AND EXPOSED REBAR NE WINGWALL

20. CONCRETE SECTION LOSS AND EXPOSED REBAR SE WINGWALL

21. CONCRETE SPALLING – INSIDE FACE OF SE WINGWALL



22. CONCRETE SPALLING – NE WINGWALL JOINT

23. CONCRETE SPALLING – OUTSIDE FACE OF NE WINGWALL

24. CONCRETE SPALLING – OUTSIDE FACE OF SE WINGWALL

25. CONCRETE SPALLING – SE WINGWALL JOINT

26. DRAINED SAF STILLING BASIN

27. OUTLET CHANNEL

EMBANKMENT

28. DAM CREST

29. UPSTREAM EMBANKMENT SLOPE

30. POCKET GOPHER MOUNDS (DOWNSTREAM SLOPE)

31. SMALL TREES (DOWNSTREAM SLOPE)

32. WEEDS (DOWNSTREAM SLOPE)

33. WEEDS AND SMALL TREES (DOWNSTREAM SLOPE)

34. UPSTREAM EMBANKMENT SLOPE

AUXILIARY SPILLWAY

35. AUXILIARY SPILLWAY DRAIN INLET

36. AUXILIARY SPILLWAY DRAIN OUTLET

37. TREES AT AUXILIARY SPILLWAY ENTRANCE

38. AUXILIARY SPILLWAY ENTRANCE (LOOKING NW)

39. AUXILIARY SPILLWAY MIDWAY (LOOKING N)

40. AUXILIARY SPILLWAY EXIT (LOOKING NE)

41. TREES AT AUXILIARY SPILLWAY EXIT

APPENDIX E

Geotechnical Analysis Report

DRAFT

GEOTECHNICAL ENGINEERING REPORT

Middle South Branch Forest River Dam No. 4
(Fordville Dam)
Grand Forks County, North Dakota

National Inventory of Dams ID: ND00386

Prepared For
HOUSTON ENGINEERING, INC.
Fargo, North Dakota

Houston Project No. R007135-0036

Owner
GRAND FORKS COUNTY WATER RESOURCE DISTRICT
Grand Forks, North Dakota
and
WALSH COUNTY WATER RESOURCE DISTRICT
Grafton, North Dakota

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GF Project No. 066441

Greenwood Village, Colorado
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GEOTECHNICAL ENGINEERING REPORT
MIDDLE SOUTH BRANCH FOREST RIVER DAM NO. 4 (Fordville Dam)
GRAND FORKS COUNTY, NORTH DAKOTA

Table of Contents

Contents

1 INTRODUCTION 1

2 PROJECT DESCRIPTION AND LOCATION 1

3 GENERAL CONDITIONS 2
- **3.1 Physiography 2**
- **3.2 Soils Mapping 3**
- **3.3 Geologic Mapping 4**
- **3.3 Seismicity 6**

4 PREVIOUS STUDIES AND CONSTRUCTION RECORDS 7
- **4.1 Previous Subsurface Explorations 7**
- **4.2 Previous Laboratory Testing 11**
- **4.3 Dam and Spillway Construction 11**
- **4.4 Previous Repairs and Inspection Observations 14**
- **4.5 2015 Dam Assessment Report 15**

5 2020 PRELIMINARY GEOLOGIC INVESTIGATION 15
- **5.1 General 15**
- **5.2 Standard Penetration Testing 16**
- **5.3 Undisturbed Soil Sampling 16**
- **5.4 Rock Coring 17**
- **5.5 Piezometer Installation 17**
- **5.5 Field Crumb Dispersion Testing 17**
- **5.6 Lab Testing 18**
- **5.7 Subsurface Exploration Findings 19**

6. GEOTECHNICAL ANALYSES 21
- **6.1 Auxiliary Spillway SITES Analysis 21**
- **6.2 Compatibility Analyses 22**
- **6.3 Seepage Analyses 23**
- **6.4 Slope Stability Analyses 24**

7. REFERENCES 27

List of Figures

Figure 1. Typical Embankment Section from As-Built Drawings 19
Figure 2. Composite Shear Strength Envelope from Figure 5-2 in TR-60 25

List of Tables

Table 1. Reservoir Storage Capacity and Pool Area 1
Table 2. USDA Soil Map Units 4
Table 3. Dam Site Borings, Circa 1966 and 1979 9
Table 4. Borings in Borrow Areas B and C 10
Table 5. Laboratory Test Information on Typical Materials 11
Table 6. Left Abutment Filter and Drain Fill Gradations 13
Table 7. SPT Refusals and N-Value Ranges and Averages 16
Table 8. Summary of Undisturbed Soil Samples 17
Table 9. Field Crumb Dispersion Test Results 18
Table 10. Summary of Laboratory Classifications 19
Table 11. Geotechnical Input Parameters and Stratigraphy for use in SITES Analysis 22
Table 12. Existing Drain Fill Gradations 22
Table 13. Comparison of Observed and Modeled Piezometric Heads[1] 24
Table 14. Recommended Parameters for Slope Stability Analyses 25
Table 15. Embankment Slope Stability Analysis Results 26

List of Exhibits

Exhibit 1. Fordville Dam Location Map
Exhibit 2. Fordville Dam Vicinity Map
Exhibit 3. Physiographic Map of North Dakota (Anderson, 2018)
Exhibit 4. Physiographic Map of Grand Forks County (Hansen and Kume, 1970)
Exhibit 5. Glacial Features Map (Pedersen and Reid, 1969)
Exhibit 6. Geologic and Landform Map (Hansen and Kume, 1970)
Exhibit 7. Stratigraphic Cross Section (Hansen and Kume, 1970)
Exhibit 8. Surface Lithostratigraphic Unit Map (Manz, 2016)
Exhibit 9. As-Drilled Boring Location Plan

List of Appendices

Appendix A NRCS Custom Soil Resource Report
Appendix B As-Built Drawings
Appendix C Boring Logs
Appendix D Piezometer Construction Logs and Data
Appendix E Field Crumb Dispersion Tests
Appendix F Laboratory Test Reports
Appendix G Calculations

GEOTECHNICAL ENGINEERING REPORT
MIDDLE SOUTH BRANCH FOREST RIVER DAM NO. 4 (Fordville Dam)
GRAND FORKS COUNTY, NORTH DAKOTA

1 INTRODUCTION

This geotechnical engineering report (GER) summarizes data collected as part of the preliminary geologic investigation for Middle South Branch Forest River Dam No. 4, hereinafter referred to as Fordville Dam. The investigation was performed by Gannett Fleming, Inc (GF) as part of a subconsultant services agreement with Houston Engineering, Inc. and conducted pursuant to the Natural Resource and Conservation Service (NRCS) Statement of Work for its Cooperative Agreement 67-63633-18-XXX with the Walsh County Water Resource District (WCWRD). The purpose of the Statement of Work is to develop a Preliminary Supplemental Watershed Plan-Environmental Assessment (EA) of the Environmental Impact Statement (EIS) for Fordville Dam. The purpose of the preliminary geologic investigation was to develop subsurface profiles and geotechnical data for evaluation of the spillway integrity and for characterization of the embankment and foundation soils.

2 PROJECT DESCRIPTION AND LOCATION

Fordville Dam was constructed in 1978 for flood control and recreation. The dam is categorized as a high hazard structure per NRCS criteria and a significant hazard dam by both the United States Corps of Engineers (USACE) and North Dakota State Water Commission (NDSWC). The dam is 54.1 feet high, 1,875 feet long, and 18 feet wide at the crest. Fordville Dam is located on the Middle South Branch of the Forest River about three miles south-southeast of Fordville and about 5.7 miles west-northwest of Inkster in Grand Forks County, North Dakota, in Sections 6 and 7 of Township 154N, Range 55W. A location map of Fordville Dam is presented as Exhibit 1 and a vicinity map is presented as Exhibit 2. The access road to the boat ramp traverses the crest of the dam and provides access to the project from Grand Forks County Road 10.

Table 1 lists storage capacity of the reservoir and pool surface area at various pool levels per the NDSWC and the As-Built drawings (USDA, 1978), included in Appendix B. All elevations reported herein are referenced to NAVD88. Elevations referenced to the As-Built drawings are converted from NGVD29 to NAVD88 by adding a correction factor of 1.2 feet (NOAA, 2020).

Table 1. Reservoir Storage Capacity and Pool Area

Pool Level	Elevation (ft)	Volume (acre-ft)	Surface Area (acres)
Approximate Drawdown	1091.2	289.8	57.2
Normal (Riser Low-Stage Crest)	1106.2	2,185.6	197.1
Riser High-Crest Stage	1117.7	5,235.3	342.3
Auxiliary Spillway Crest	1123.9	7,632.3	433.8
Maximum Pool (Top of Dam)	1130.3	10,703.4	525.9

The total drainage area is 41.5 square miles per the As-Built drawings and NDSWC and includes portions of Walsh, Nelson, and Grand Forks Counties. The drainage area was revised to 45.4 square miles by the 2015 Dam Assessment Report (HDR/Kleinfelder). Below Fordville Dam, the Middle South Branch of the Forest River flows generally northeastward and joins the Forest River within a mile of Fordville Dam. The Forest River flows generally eastward and northward to its confluence with the Red River, which forms the border between North Dakota and Minnesota. The Red River flows northward into Canada and Lake Winnipeg, which is drained by the Nelson River into Hudson Bay.

3 GENERAL CONDITIONS

This section of the GER discusses physiography, soils, bedrock, seismicity, and geotechnical conditions based on published reports and maps, the As-Built drawings (SCS, 1978, 1979), the 2015 Dam Assessment Report (HDR/Kleinfelder), and summaries of operation and maintenance reviews provided by NRCS .

3.1 Physiography

Fordville Dam lies within the Red River Valley Section of the Central Lowland Province, which Waldkirch (1999) describes as a *"flat plain resulting from sedimentation on the floor of glacial Lake Agassiz; more than 95 percent of the area is gently sloping with local relief less than 25 feet in most places"*. Fordville Dam is situated east of the Pembina escarpment, which rises to the west and separates the Red River Valley Section from the topographically higher Glaciated Plains Section of the Central Lowland Province to the west.

Multiple geologic forces have combined to shape the Pembina Escarpment including preglacial differential erosion of the underlying shale bedrock, scouring and erosion by glaciers moving southward into North Dakota from the Keewatin center west of Hudson Bay, erosion by wave action along the shorelines of Glacial Lake Agassiz, and erosion by periodic outbursts of floodwater from ice-dammed lakes to the west (Bluemle, 2016; Bluemle, M.E., 1988). Areas of eolian sand are mapped by Anderson (2018) near the base of the Pembina escarpment within the Red River Valley Section to the north and south of Fordville Dam as shown in Exhibit 3.

Hansen and Kume (1970) place the easternmost boundary of the Glaciated Plains Section (referred to as the "Drift Plains District" in Exhibit 4) at the westernmost extent of glacial Lake Agassiz deposits, which occurs at an elevation ranging from 1,160 to 1,170 feet or more than 30 feet above the crest of Fordville Dam. Fordville Dam lies east of this boundary in the "Elk Valley Area," which Hansen and Kume (1970) describe as mainly a delta-outwash plain also including an end moraine and beach ridges.

Glacial rivers flowing eastward over the Pembina escarpment formed three large deltas in eastern North Dakota as they flowed into Glacial Lake Agassiz along its western shoreline (Upham, 1896; Willard, 1907; Pedersen and Reid, 1969; Bluemle, 2016). From south to north, which is the order in which they formed, these deltas are known as the Sheyenne Delta (in Ransom and Richland Counties), the Elk Valley Delta (in Walsh, Grand Forks, and Traill Counties), and the Pembina Delta (in Pembina County). As shown in Exhibit 5, Fordville Dam is situated within

the Elk Valley Delta, just west of the Edinburg Moraine. According to Bluemle (2016), the Glacial Elk River *"was probably a combination of the early Park, Forest and Turtle rivers, and it flowed southward between the edge of the glacier to the east and the upland to the west, from near Fordville on the north to beyond Galesburg on the south"*. The Elk Valley Delta was actively prograding during the Lockhart Phase of Glacial Lake Agassiz, approximately 11,600 to 10,900 years ago (Harris, Luther, Reid, 1996).

The Edinburg Moraine, located immediately to the east of Fordville Dam, has been interpreted as a medial moraine between the Dakota and Minnesota glaciers by Willard (1907) and as an end moraine by other authors including Hansen and Kume (1970), M. E. Bluemle, (1988), and J. P. Bluemle (2016). Based on studies of fast-moving ice known as "ice streams" and modern glacial analogies, Manz and Harris (2017) explain the development of the Edinburg Moraine as follows:

> *"The Edinburg moraine was, indeed, built by the same ice that deposited the Forest River Formation. It is not, however an end moraine as previously thought, but more likely an interlobate or medial moraine, constructed between two independent ice fronts, one advancing from the northwest (Des Moines lobe) and the other from the north (Red River lobe) and fed by ice streams originating deep within the waning Laurentide Ice Sheet. Tills of the Goose River Formation, to which the Inkster member has been reassigned, were deposited by the Des Moines lobe and thrust up and back into a high ridge by the ultimately dominant Red River lobe when the two came together near the western edge of the Agassiz basin.*

3.2 Soils Mapping

Soils information was obtained from the USDA online Web Soil Survey. Six soil units are mapped in the vicinity of the dam, spillway, and borrow areas as shown on the soils map on Page 9 of the Custom Soil Resource Report, which is provided as Appendix A. Table 2 summarizes the six soil units by occurrence from north to south across the valley. The left abutment is underlain by map unit 1463E soils, which form beach ridges derived from sandy and gravelly glaciofluvial deposits and have a typical profile consisting of gravelly sandy loam to a depth of 11 inches, very gravely loamy coarse sand to 22 inches, and very gravelly coarse sand to 79 inches.

The central portion of the stream valley is underlain by map unit I594A soils, which form stream terraces derived from fine-silty alluvium and have a typical profile consisting of silt loam to a depth of 60 inches.

The right abutment and the upstream and downstream ends of the auxiliary spillway (ASW) is underlain by soils of map units I422D and I365B, which form beaches derived from sandy and gravelly glaciofluvial deposits and have typical profiles consisting of loam to a depth of 7 inches, sandy loam to 11 inches, very gravelly loamy coarse sand to 22 inches, and very gravelly coarse sand to 79 inches (Sioux loam); and sandy loam to a depth of 17 inches, gravelly sand to 42 inches, and very gravelly sand to 79 inches (Arvilla sandy loam).

Table 2. USDA Soil Map Units

Unit Symbol	Unit Name	Landform - Parent Material
I463E	Sioux-Renshaw complex, 9 to 25 percent slopes	Beach ridges - Sandy and gravelly glaciofluvial deposits
I594A	LaDelle silt loam, 0 to 2 percent slopes	Stream terraces - Fine-silty alluvium
I422D	Sioux loam, 2 to 15 percent slopes	Beaches - Sandy and gravelly glaciofluvial deposits
I365B	Arvilla sandy loam, 0 to 6 percent slopes	Beaches - Sandy glaciofluvial deposits over sandy and gravelly glaciofluvial deposits
I163A	Inkster sandy loam, 0 to 2 percent slopes	Beaches - Loamy glaciofluvial deposits
G147D	Buse-Barnes-Darnen loams, 6 to 15 percent slopes	Moraines, ground moraines - Fine loamy till (Buse, Barnes); Escarpments - Fine loamy colluvium (Darnen)

The central portion of the ASW and Borrow Area B located south of the ASW are underlain by map unit I163A soils, which form beaches derived from loamy glaciofluvial deposits and have a typical soil profile consisting of sandy loam to a depth of 25 inches and loamy sand to a depth of 79 inches.

Borrow Area C is located approximately two miles southeast of the dam per Sheet 3 of the as built drawings. Borrow Area C is underlain by G147D soils, which include Buse, Barnes, and Darnen loams. The Buse and Barnes loams form moraines and ground moraines and are derived from fine loamy till. The Darnen loams form escarpments and are derived from fine loamy colluvium. The typical profile of these soils consists of loam to a depth of 79 inches.

3.3 Geologic Mapping

According to the geology report on Grand Forks County (Hansen and Kume, 1970), the main geologic units in the vicinity of Fordville Dam are, from youngest to oldest:

1) Recent Alluvium
2) Glacial outwash of the Elk Valley Delta
3) Till of the Edinburg Moraine
4) Glacial till of three drift sheets, and
5) Cretaceous age bedrock of the Greenhorn Formation

The location of the dam is shown on a portion of the geologic map of Grand Forks County in Exhibit 6, on a stratigraphic cross section of northern Grand Forks County in Exhibit 7, and on a surface lithostratigraphic unit map in Exhibit 8.

3.3.1 Recent Alluvium

Along the South-Middle Branch of Forest River, Hansen and Kume (1970) map alluvium, which they describe as *"organic-rich gravels, sands, silts and clays"* (Exhibit 6). The alluvium tends to be coarser in areas of till and beach deposits and finer textured where stream gradients are low, as in the areas of lacustrine sediments east of the beach ridges.

3.3.2 Glacial Outwash of the Elk Valley Delta

Hansen and Kume (1970, page 41) describe the development of the Elk Valley Delta as follows:

> *"A large increase in the amount of meltwater and runoff resulted in the deposition of coarser-grained material over the silts and clays initially deposited in the proglacial lake. Large deposits of valley train sand and gravel in northern Grand Forks County grade southward into the fine-grained sands, silts, and clays of south-central Grand Forks County. These deposits make up a delta-outwash plain (the Elk Valley delta) bounded on the east by a scarp."*

The described superposition of the sands and gravels of the glacial outwash on top of the silts and clays of the proglacial lake is illustrated in the stratigraphic cross section in Exhibit 7. In the vicinity of Fordville Dam (T. 154 N., Rs. 54 and 55 W.), *"the sediments of the outwash and delta plain consist of brownish-gray, thick-bedded, cross-stratified sandy gravel and gravelly sands"* (Hansen and Kume, 1970). Borrow Area B is mapped as outwash plain (Exhibit 6).

The uppermost deltaic deposits are mapped by Manz (2016) as the deltaic facies of the Holocene Sherack Formation as shown in Exhibit 8. North of Fordville, the lower part of the Elk Valley delta is composed of a shaley sand that extends beneath the Edinburg Moraine (Pederson and Reid, 1969; Harris, Luther, and Reid, 1996).

3.3.3 Till of the Edinburg Moraine

Borrow Area C was apparently developed in till of the Edinburg Moraine, which Hansen and Kume (1970) describe as a *"mostly unsorted mixture of stony brownish-gray and olive-gray clay, silt, sand and gravel"* (Exhibit 6). Manz (2016) ascribes a northwest (Riding Mountain) provenance to this part of the Edinburg Moraine based on the percentage of shale fragments versus the ratio of carbonate to crystalline fragments in the coarse sand fraction.

3.3.4 Glacial Till

The stratigraphic section (Exhibit 7) indicates the Elk Valley delta is underlain by till of three drift sheets. Hansen and Kume (1970) describe the till in Grand Forks County as *"an unsorted clayey mixture of stones, gravel, sand, silt, and clay, the composition of which varies over short distances."* The till of the three drift sheets have a combined thickness of approximately 180 feet. Hansen and Kume (1970) report that the till of the lower drift sheet is *"overlain by*

unoxidized, dark olive-gray lake sediments that were probably deposited during the closing phases of this glaciation," and the stratigraphic section (Exhibit 7) shows a deposit of sand and gravel separating the boulder-clay tills of the lower two drift sheets in the western part of Grand Forks County.

3.3.5 Bedrock

The bedrock surface is at about Elevation 920 feet, or nearly 210 feet below the crest of Fordville Dam. The underlying bedrock is mapped as the Cretaceous age Greenhorn Formation, which Hansen and Kume (1970, p. 15) describe as follows:

> *"The Greenhorn Formation consists of medium-dark-gray to dark-gray marlstone, calcareous shale, and thin beds of limestone. Interbedded with the shales, marlstones, and limestones are thin beds of light-bluish-gray bentonitic clays. Fossils of the minute coccolithophorids and the foraminifera, particularly Globigerina sp., are common; fragments and calcite prisms from the oyster Inoceramus sp., are also common. A minor constituent is crystals of pyrite."*

3.3 Seismicity

According to published mapping of earthquakes in North Dakota (Anderson, 2012), the closest earthquake to Fordville Dam occurred on November 15, 2008 near Goodrich, which is about 117 miles southwest of the dam. The 2008 Goodrich earthquake had a reported Modified Mercalli Earthquake Intensity value of II, which means the earthquake would have been felt only by a few persons at rest, especially on the upper floors of buildings.

A search of the USGS online earthquake catalog for earthquakes of Magnitude 1 or greater within 250 kilometers of Fordville Dam indicated only the 2008 Magnitude 2.6 Goodrich earthquake mentioned above. The USGS online catalog reported a depth of 18.0 kilometers for the 2008 Goodrich earthquake.

The Precambrian basement of eastern North Dakota is part of the Superior Craton, which is an extremely old and deformed but geologically stable region (Bluemle, 2018). The North Dakota Geological Survey (Bluemle, 2018) considers the state to be in an area of low earthquake probability:

> *"North Dakota is located in an area of low earthquake probability. Infrequent, small earthquakes may occur near or within the state, but it is unlikely they will cause any serious damage."*

The USGS Unified Hazard Tool assigns horizontal Peak Ground Accelerations of 0.0108 g, 0.0198 g, and 0.0483 g for return periods of 1,000 years, 2,500 years, and 10,000 years, respectively; however, these values assume a V_{S30} of 760 m/sec with no correction factor for site specific conditions.

4 PREVIOUS STUDIES AND CONSTRUCTION RECORDS

This section discusses previous field and laboratory testing based on the 1978 As-Built drawings of the original dam construction and the 1979 As-Built drawings of the repair of a landslide in the left (north) downstream abutment. HDR/Kleinfelder's 2015 dam assessment report references 1966 SCS Soil Mechanics Laboratory data, however, those data are not described or summarized in the 2015 report and are not available for use in preparing this report.

4.1 Previous Subsurface Explorations

Boring locations and graphical logs shown in the 1978 and 1979 As-Built drawings indicate at least 47 borings were drilled during previous subsurface explorations. The dam design subsurface investigation (circa September 1966) included ten borings along the centerline of the dam (TH-1 to TH-10), eleven borings in the right abutment and auxiliary spillway area (TH-201 to TH-211), four borings along the principal spillway (TH-301 to TH-304), seven borings along the upstream and downstream berms within the footprint of the dam (TH-601 to TH-607), one potential borrow area boring on the left abutment (TH-101), nine borings in Borrow Area B (TH-102 to TH-110), four borings in Borrow Area C (TH-111 to TH-114), and one boring in the reservoir area (TH-118). The subsurface investigation for the 1979 north abutment repair included five borings in the left abutment (TH-1, TH-2, TH-4, TH-5, and TH-6). For the purposes of this report, a "1979" prefix is added to the landslide repair borings to avoid confusion with the original design test holes.

Tabulations of the 33 borings drilled at the dam site and the 13 borings drilled in Borrow Areas B and C are provided in Table 3 and Table 4, respectively. The locations of the original dam site borings and borrow area borings are shown on Sheets 7 and 3, respectively, of the 1978 As-Built drawings. The location of reservoir boring, TH-118, is unknown. Corresponding graphic logs of the borings are provided on Sheet 8 of the 1978 As-Built drawings with the exception of two borings on the right abutment, TH-204 and TH-209. Locations and graphic logs of the five north abutment repair borings are provided on Sheet 1 of the 1979 As-Built drawings.

4.1.1 Valley Floor Area

Fifteen borings were drilled within the footprint of the embankment in the valley floor area, including locations along the dam centerline, upstream berm, and downstream berm. Boring depth ranged from six to 23 feet deep and predominantly encountered sandy soils, identified as poorly graded sand (SP) and silty sand (SM) with occasional clayey sand (SC) underlain by clay (CL) and silt (ML). Groundwater was typically observed at three to eight feet below ground surface.

4.1.2 Principal Spillway Area

Four borings (TH-301 to TH-304) were drilled 13 to 36 feet deep along the centerline of the principal spillway conduit and adjacent to the toeslope of the left abutment. These borings encountered finer textured soils, mostly clay (CL) and silt (ML, MH), with some interbeds of

clayey and silty sand (SC and SM). Groundwater was typically observed at eight to twelve feet below ground surface.

4.1.3 Left Abutment

Two borings, TH-101 and TH-9, were drilled on the left abutment as part of the original subsurface exploration in 1966. The borings indicate an overall fining-downward sequence consisting of poorly graded sand (SP) and silty sand (SM) from approximately El. 1146 to El. 1109, underlain by silt (ML) to El. 1085 feet, and then clay (CL) to El. 1080.

In 1979, five additional borings were drilled in the left abutment to depths ranging from 49 to 63 feet for repair of a landslide, which occurred in the abutment along and just downstream of the embankment groin above the principal spillway outlet. The location and graphic logs of the five borings are shown in Sheet 1 of the 1979 As-Built drawings. One boring was drilled on the dam crest and the four remaining borings were drilled in the left abutment downstream of the crest at elevations ranging from 1134.6 to 1122.9 feet.

The logs of the five 1979 landslide repair borings indicate mostly silty sand (SM) and poorly graded sand (SP) to an elevation ranging from approximately 1106 to 1109 feet. The upper, coarser soils are underlain by a 24- to 30-foot thick layer comprised mostly of silt (ML) to elevations ranging from approximately 1080 to 1084 feet, which is underlain by clay (CL) to the bottom of each boring. The measured groundwater level varied from approximately Elevation 1103 to 1106 feet in the four uppermost borings to 1098 feet in the lowest boring. The As-Built drawings suggest the head scarp of the landslide varied from approximately Elevation 1111 to 1106 feet, indicating that the slide occurred in the layer of finer textured soils near its upper contact with the coarser soils.

4.1.4 Right Abutment and Auxiliary Spillway Area

In the right abutment area, the 1978 as built drawings provide graphic logs for one test boring within the footprint of the embankment, four borings between embankment and the auxiliary spillway, and three borings within the auxiliary spillway.

Embankment Area

TH-10 was drilled to a depth of 48 feet in the right abutment and encountered mostly coarse-grained soils (GM, SP, and SM) from approximately Elevation 1116 to 1107 feet. Beneath the upper, coarse soils, the graphic log indicates about 24 feet of silt (ML and MH) to approximately Elevation 1083 feet underlain by 15 feet of clay to the bottom of the boring at approximately Elevation 1068 feet.

Table 3. Dam Site Borings, Circa 1966 and 1979

	Boring	Location[1]	Surface Elevation[2] (ft)	USCS Classification	Depth (ft)
Valley Floor	TH-8	Dam A; Station 18+50*	1083.2	cl, sp	18
	TH-7	Dam A; Station 19+50*	1083.2	cl, ml, sm	21
	TH-6	Dam A; Station 20+40*	1080.2	sp, sm, ol, cl	18
	TH-3	Dam A; Station 20+85*	1080.2	sm	6
	TH-5	Dam A; Station 21+50*	1082.2	ml, sm, sp, cl	18
	TH-2	Dam A; Station 23+00*	1080.2	sc, sp, sm, cl	12
	TH-4	Dam A; Station 23+50*	1078.2	sp, cl	13
	TH-1	Dam A; Station 24+00*	1080.2	sm, cl	13
	TH-601	DS Berm; Sta. 24+40, 100' DS*	1081.3	sm, cl, sc	20
	TH-602	DS Berm; Sta. 23+00. 100' DS*	1081.9	sm, cl, sc, sm, sp	18
	TH-603	DS Berm; Sta.21+00, 100' DS*	1080.8	sm, cl	23
	TH-604	US Berm; Sta. 23+00, 100' US*	1081.3	sm, sc, sp, cl	18
	TH-605	US Berm; Sta. 21+00, 100' US*	1079.2	sc, sm, sp, cl	18
	TH-606	DS Berm; Sta. 19+50, 100' DS*	1083.3	sc, sm, sp, cl, ml	23
	TH-607	US Berm; Sta. 19+00, 100' US*	1083.9	cl, sm, sc	18
Principle Spillway Alignment	TH-301	PSW; Dam A; Station 18+00*	1086.7	cl, ml, sm, sc	36
	TH-302	PSW; Sta. 18+00, 100' DS*	1085.1	cl, ml, mh	19
	TH-303	PSW; Sta. 18+00, 160' DS	1084.4	cl, sc	13
	TH-304	PSW; Sta. 18+00, 100' US*	1090.2	cl, sc, sm, ml	26
Left Abutment	TH-101	Lt. Abut, Sta. 14+00, 100' DS	1146.0	sp, sm	18
	TH-9	Lt. Abut; Dam A; Sta. 16+50	1128.2	sp, sm, ml, cl	48
	1979TH-1	Lt. Abut; Dam A; Sta. 16+70*	1131.7	Fill, sm, ml, sp, cl	49
	1979TH-2	Lt. Abut; Sta. 15+30, 30' DS	1134.7	sm, sc, sp, ml, cl	58
	1979TH-4	Lt. Abut; Sta. 15+30, 100' DS	1135.8	sm, sp, ml, cl	63.5
	1979TH-5	Lt. Abut; Sta. 15+30, 150' DS	1130.9	sm, ml, cl	53.5
	1979TH-6	Lt. Abut; Sta. 16+22, 155' DS	1124.1	sm, sp, sc, ml, cl	49
Right Abutment and Auxiliary Spillway	TH-10	Rt. Abut; Dam A; Sta. 26+20*	1116.2	gm, sp sm, ml, mh,	48
	TH-201	Rt. Abut; Dam A; Sta. 29+00	1132.2	sm	18
	TH-202	ASW; Dam A; Sta. 31+00	1139.7	sp, sm	27.5
	TH-203	ASW; Sta. 31+00, 130' US	1138.7	sm, sp	22.5
	TH-204	Rt. Abut; Sta. 29+73, 88' US	1131.2	-	-
	TH-205	Rt. Abut; Sta. 27+30, 120' DS	1121.2	sc, sp, gp, ml	18
	TH-206	Rt. Abut; Sta. 28+23, 33' DS	1131.2	sc, cl	13
	TH-207	Rt. Abut; Sta. 29+50, 40' DS	1134.2	cl, sm, sp	18
	TH-208	Rt. Abut; Sta. 30+00, 20' US	1138.2	sc, cl, sp	23
	TH-209	Rt. Abut; Sta. Sta. 29+00, 215'	1121.2	-	-
	TH-210	Rt. Abut; Sta. 30+00, 180' DS	1131.2	-	-
	TH-211	ASW; Sta. 30+70, 85' DS	1138.2	sm, sp	25

Notes: 1) * = within embankment footprint, DS = downstream, US = upstream
2) Converted to NAVD88

Table 4. Borings in Borrow Areas B and C

Boring	Location[1]	Surface Elevation[2] (ft)	USCS Classification	Depth (ft)
TH-102	Borrow Area B (south of ASW)	1154.3	sc, cl, sm, sp	17.8
TH-103	Borrow Area B (south of ASW)	1158.8	sc, cl, sp	13.5
TH-104	Borrow Area B (south of ASW)	1153.4	sc, cl, sp	13.5
TH-105	Borrow Area B (south of ASW)	1150.7	sc, sp	8
TH-106	Borrow Area B (south of ASW)	1151.0	sc, sp	8
TH-107	Borrow Area B (south of ASW)	1150.4	sp	3
TH-108	Borrow Area B (south of ASW)	1151.9	sp	3
TH-109	Borrow Area B (south of ASW)	1152.2	sc, cl, sp	8
TH-110	Borrow Area B (south of ASW)	1147.0	sm, sp	3
TH-111	Borrow Area C (NW¼, Sec 16, T154N, R55W)	-	cl	20
TH-112	Borrow Area C (NW¼, Sec 16, T154N, R55W)	-	cl	18
TH-113	Borrow Area C (NW¼, Sec 16, T154N, R55W)	-	cl	12
TH-114	Borrow Area C (NW¼, Sec 16, T154N, R55W)	-	cl	18

Notes: 1) * = within embankment footprint, DS = downstream, US = upstream
2) Converted to NAVD88

Right Abutment

The as built drawings provide graphic logs for four borings drilled from 13 to 23 feet deep in the right abutment between the embankment and the auxiliary spillway. These borings span the horizon from approximately Elevation 1138 to 1114 feet and encountered mostly silty and clayey sand (SM and SC) and poorly graded sand (SP) with some clay (CL) interbeds.

Auxiliary Spillway Area

Borings TH-202, TH-203, and TH-211 were drilled about 22.5 to 27.5 feet deep in the level section of the auxiliary spillway and encountered poorly graded sand (SP) and silty sand (SM).

4.1.5 Borrow Areas

Borrow Area B

Nine borings were drilled from three to eighteen feet deep in Borrow Area B, which is located south of the auxiliary spillway and west of the line between Sections 7 and 8 of Township 154N and Range 55W per the As-Built drawings. The borings encountered mostly poorly graded sand (SP) and silty to clayey sand (SM, SC). A four to seven-foot-thick layer of clay (cl) and clayey sand (SC) is shown in the graphic logs of three of the borings.

Borrow Area C

Four borings were drilled 12 to 20 feet deep in Borrow Area C, which is located 2 miles southeast of the dam. These borings encountered clay (CL) and are apparently located within the till of the Edinburg Moraine, which was used as a borrow source.

4.2 Previous Laboratory Testing

In the 1978 As-Built drawings, some USCS symbols in the graphic logs are marked by an asterisk, which indicates they were classified in a laboratory. Limited lab test data are provided in sheet 10 of the As-Built drawings (Appendix B) and summarized in Table 5.

Table 5. Laboratory Test Information on Typical Materials

Location	Boring	USCS	Maximum Dry Density[1] (lbs/ft^3)	Optimum Moisture[1] (%)	Description
Right Abutment	TH-201	SM	103.0	20.0	Delta Sediments
Borrow Area B	TH-102	SC	98.0	21.5	Delta Sediments
Borrow Area B	TH-109	CL	91.0	25.0	Delta Sediments
Borrow Area C	TH-111	CL	106.0	18.0	Glacial Till

Notes: 1) ASTM D698 Method A

4.3 Dam and Spillway Construction

4.3.1 Fill Placement

The embankment consists of an inner core (Zone I) and an outer shell (Zone II). Zone I is eight feet wide at its top (El. 1123.2) and has an upstream slope of ¾:1 and a downstream slope of 1:1 (H:V). Zone I is keyed into the foundation soils by a cut-off trench with a base width of 20 feet and 1:1 side slopes. The depth of the cut-off trench varies but is believed to extend approximately 20 feet below original grade at its deepest point at about Station 21+00. The Zone I material was sourced from clayey materials (CL) in Borrow Area C. A drawing note indicates that more plastic material excavated from the auxiliary spillway and from Borrow Area B was to be selectively placed adjacent to the upstream portion of Zone I.

The outer shell of Zone II has an upstream slope of 3.5:1 except where steepened to 2.5:1 at the top in order to widen the upstream crest from the design width of nine feet to a constructed width of 17 feet. A 10-foot wide level berm at El. 1104.2 on the upstream slope serves as the base for a layer of riprap extending upslope to El. 1119.7. The outer shell has a downstream slope of 2.5:1 and features an 18-foot wide berm at approximately El. 1102.2. The Zone II material was sourced from sandy materials (SP, SM, and SC) in Borrow Area B and the auxiliary spillway excavation.

4.3.2 Foundation Treatments

Per the 1978 As-Built drawings, clayey organic material within the limits of the embankment footprint was to be removed prior to fill placement. Additional foundation treatment occurred along the principal spillway conduit where the alignment was excavated and backfilled with compacted Zone I material.

Foundation treatments in the auxiliary spillway (ASW) include a soil-cement barrier at ASW Station 3+00 and a compacted earth barrier at ASW Station 5+00. According to the profile on Sheet 10 of the As-Built drawings, the soil-cement barrier is 500 feet long, and 10 feet deep. The soil-cement barrier is 8 feet wide at its crest and 18 feet wide at its base with a vertical upstream slope and 1:1 downstream slope. The trench excavation extends 8 feet upstream and 8 feet downstream of the barrier, has 1:1 side slopes, and is backfilled with Zone I fill. The top of the soil-cement barrier is at Elevation 1121.7 feet, and it is covered with 1 foot of Zone I fill. The compacted earth barrier is 10 feet wide and 460 feet long at its base, 10 feet high, has 1:1 side slopes, and it is covered with 1 foot of topsoil per Sheet 7 of the As-Built drawings.

4.3.3 Drains

Drains have been installed in the dam foundation, in the auxiliary spillway, and in the left abutment downstream of the dam.

Foundation Drain

Plans and profiles of the foundation drain are provided in Sheet 11 of the 1978 As-Built drawings. The foundation drain is 935 feet long and extends up both the left and right abutments to El. 1111.2 approximately 90 downstream of the dam centerline. The drain is 3.5 feet wide with a variable depth ranging from a minimum of five to seven feet deep. Seepage collected on the left abutment portion (left side) of the drain is conveyed via a 50-foot long, six-inch diameter perforated asbestos cement pipe (ACP) whereas the valley floor section (right side) of the foundation drain features 250 feet of 6-inch perforated ACP and 440 feet of 8-inch perforated ACP. Drainage from the left and right drains is conveyed to downstream outlets by 78 feet of non-perforated ACP having a diameter of 6 inches on the left side and 8 inches on the right side. The elevation of both downstream outlets is approximately 1076 feet. Per the 1978 As-Built drawings, the drain fill aggregate is a mixture of sand and gravel (see Table 12 in Section 6.2 for the gradation) and does not appear to match any modern commercially available aggregate.

Auxiliary Spillway Drain

The 1978 As-Built drawings show the auxiliary spillway (ASW) drain in plan view in Sheet 7 and in sections with details in Sheet 40. The riser section extends from El. 1117.2 to 1105.2 and consists of a 12-inch-diameter, asbestos-treated, asphalt-coated, corrugated metal pipe (CMP), embedded six inches into a one-foot-high by five-foot-square concrete slab at its base. Water exits the riser through 12-inch conduit, sloping about 7 degrees, and composed of a 4-foot stub, 40 feet of non-perforated CMP, 60 feet of perforated CMP, and 158 feet of non-perforated CMP. A 6-feet-tall concrete pipe support is located 6 feet from the downstream end of the pipe. The

invert of the outlet pipe is at El. 1073.7, and the pipe discharges onto a 1:3 slope armored with rock riprap and bedding. The lower part of the riser and upper part of the drain is constructed within a 125-foot-long drain filter, measuring six feet wide by five feet high. The bottom of the drain extends from El. 1105.2 to 1091.3. The drain filter gradation is the same as used in the foundation drain (Table 6).

Left Abutment Drain

During the embankment construction, a drain was installed in the left abutment downstream of the embankment as shown in Sheet 40 of the 1978 As-Built drawings. The abutment drain was located to the left of the principal spillway outlet and extended 120 feet from the toe of the embankment, trending roughly parallel to the outlet. The drain consisted of six-inch-diameter perforated PVC pipe placed within a three-foot-wide by three-foot deep trench backfilled with drain fill (Table 6) and was outlet within the principal spillway outlet basin.

The left abutment drain was replaced by a blanket filter drain during a landslide repair as indicated in the 1979 As-Built drawings. From the base of the landslide scarp, the abutment was laid back to a 3:1 slope from approximately El. 1110 to 1130. Below the landslide scarp, the abutment was excavated on a 1:1 slope to approximately El. 1080 and then at a flatter, variable slope to between approximately El. 1074. The 1:1 slope was blanketed with one foot of fine filter material and two feet of drain fill (measured normal to the slope). The flatter slope was blanketed with two feet of drain fill (measured normal to the slope), which was covered by a one-foot thick layer of coarse filter material at its toe. The blanket drain was covered by rock fill and topsoil and armored with a 1.5-foot-thick layer of riprap. The filter and drain fill gradations are shown in Table 6.

Table 6. Left Abutment Filter and Drain Fill Gradations

Fine Filter		Drain Fill		Coarse Filter	
Sieve Size	**% Passing**	**Sieve Size**	**% Passing**	**Sieve Size**	**% Passing**
3/8”	100	¾”	100	2”	100
#4	95 - 100	½”	90 - 100	1½”	90 - 100
#8	80 - 100	3/8”	40 - 75	1”	30 - 60
#16	50 - 85	#4	5 - 25	¾”	0 - 30
#30	25 - 60	#8	0 - 10	½”	0 - 10
#50	10 - 30	#16	0 - 5	-	-
#100	2 - 10	-	-	-	-
#200*	0 - 5	-	-	-	-

*Fines passing #200 sieve must be non-plastic.

4.4 Previous Repairs and Inspection Observations

Aside from the 1979 repair of the landslide and installation of the blanket filter drain in the left abutment, no other major repairs or modifications are known to have occurred at Fordville Dam. Some observations on the condition of the dam and its appurtenances are provided in HDR/Kleinfelder's 2015 dam assessment report and in the operations and maintenance summaries included in letters from the NRCS' District Conservationist to the Walsh County WRD for the years 2002 to 2005, 2007, 2008, 2010, and 2011. Pertinent observations are summarized below.

Abutments: *"Both left and right abutments appear in good condition with no evidence of erosion, seepage, or cracking"* (HDR/Kleinfelder, 2015).

Upstream Slope: "*The upstream slope is well vegetated and mowed. There was no evidence of seepage or depressions. Animal trails through the vegetation were observed"* (HDR/Kleinfelder, 2015).

Crest: *"The embankment crest is stable and well vegetated with the exception of the dirt road running along the center of the crest. The grass cover along the road is minimal"* (HDR/Kleinfelder, 2015).

Downstream Slope: *"The downstream slope is well vegetated and mowed. There were animal trails and several rodent holes in the embankment. A small tree was noted near the downstream berm and right abutment. There was no evidence of seepage or depressions"* (HDR/Kleinfelder, 2015).

Principal Spillway: *"Remove trees at inlet. Spurge and wormwood need control. Remove picnic table on inlet bank"* (NRCS, 2004). *"Joint of principal spillway right side spalling"* (NRCS, 2008). *"The principal spillway appears to be in good condition. There are no signs of deterioration or cracking on the riser structure. There was no vegetation lodged in the riser trash-rack."* (HDR/Kleinfelder, 2015).

Outlet: *"Some scouring at outlet – monitor. Some spurge at outlet"* (NRCS, 2003). *"Monitor corrosion on wingwall of outlet, sloughing at pool area – possible FEMA $$ for repair. Spurge and wormwood need control"* (NRCS, 2004). *"Shale area downstream of outlet does not revegetate--could use topsoil and seed. Right wingwall spalled and cracked, steel exposed--monitor"* (NRCS, 2008). *"Watch south wing wall-- some erosion of concrete"* (NRCS, 2010). *"Monitor south wing wall--some erosion of concrete"* (NRCS, 2011). *"The discharge area appears in fair condition. There is slight spalling of the concrete of the wing walls at the wall joints, but they otherwise remain intact. The chain link fence also appears in good condition. The plunge pool does not appear to have erosion problems"* (HDR/Kleinfelder, 2015).

Drains: *"Roger T. says there is a toe drain approximately 10 feet from centerline or 4 feet from wingwall on south side of outlet--it needs to be found under the rock and inspected. (North toe drain* [left abutment drain] *was removed with a repair in the 1970s)"* (NRCS, 2004). *"NRCS will try to locate toe drain: Incomplete."* (NRCS, 2005). *"I will check to see if toe drain ever*

flowed" (NRCS, 2007). *"Toe drain found in 2007--not flowing--would be nice to mark location of this on wall of outlet"* (NRCS, 2008). *"Toe drain is buried again"* (NRCS, 2010). *"Toe drain is buried. Roger will try to locate it with metal detector"* (NRCS, 2011). *"The two foundation drains were found not flowing and were difficult to locate in the riprap field near the principal spillway"* (HDR/Kleinfelder, 2015).

Auxiliary Spillway: *"The auxiliary spillway is well vegetated with grass cover and some brush. The spillway was mowed and appears to be well maintained. The drop inlet drain at the end of the spillway outlet was located under grass cover and surveyed. The discharge area at the end of the spillway has trees, brush and a noticeable change in elevation"* (HDR/Kleinfelder, 2015).

Reservoir Shoreline/Slopes: *"Most slopes along the reservoir shoreline appear stable and vegetated. However, small trees and brush are growing through the riprap, and driftwood is collecting on the front slope"* (HDR/Kleinfelder, 2015).

Access Roads and Gates: *"Repair broken posts along road (2)"* (NRCS, 2008). *"A locked gate located at the beginning of the access road to the dam prevents unauthorized entrance of vehicles"* (HDR/Kleinfelder, 2015).

4.5 2015 Dam Assessment Report

HDR/Kleinfelder's 2015 dam assessment included *"visual field inspections, hydrologic and hydraulic analysis to simulate the upstream watershed's response to 6-hour and 24-hour events, an evaluation of rehabilitation alternatives and associated construction cost estimates needed to address deficiencies."* The 2015 assessment concluded that:

"Fordville Dam does not currently meet the dam safety requirements established by the NRCS or SWC. The dam does not satisfy the TR-60 requirement of reaching reservoir drawdown within 10-days. Additionally, the dam is overtopped for both 6- and 24-hour FBH [Freeboard Hydrograph] *storm events. Both durations of SDH* [Spillway Design Hydrograph] *storms also result in breaching of the auxiliary spillway during high flows."*

5 2020 PRELIMINARY GEOLOGIC INVESTIGATION

5.1 General

GF oversaw the completion of six borings drilled from June 16-22, 2020 to develop profiles and geotechnical data for evaluation of the spillway integrity and for characterization of the embankment and foundation soils. The locations of the six test borings are shown in Exhibit 9, and boring logs and core box photos are provided in Appendix C.

Borings FD2020-212, -213, and -214 were drilled in the ASW to develop a geologic profile for use in evaluating the spillway integrity. Borings FD2020-11, and -608 were drilled within the dam embankment footprint to characterize embankment and foundation soils. Boring FD2020-609 is located at the downstream embankment toe. Borings FD2020-11, -608, and -609 are in alignment with one another, perpendicular to the dam centerline at Sta. 24+25, to provide an embankment cross section.

Interstate Drilling Services LLP (IDS) of Grand Forks, ND drilled the test borings. IDS is certified as a Monitoring Well Contractor (#427) and a Water Well Contractor (#201) in North Dakota.

5.2 Standard Penetration Testing

Hollow stem augers (3.25-inch ID) were used for drilling, and continuous SPT soil samples were collected using a 2-inch OD, 2.5-foot-long sampler in accordance with ASTM D1586. Blow counts from the Standard Penetration Testing (SPT) were summed every six inches and provide an indication of the relative density of granular soils and the relatively consistency of fine-grained cohesive soils. SPT results are typically expressed as an "N-value," which represents the number of blows required to advance the sampler over the depth interval of six to 18 inches (i.e., second and third six-inch increments) using a 140-pound hammer falling 30 inches or an equivalent autohammer. Table 7 lists the range and average N values based on the SPT results. The N values do not factor in cases where refusal occurred. SPT refusal is defined as when 50 hammer blows are insufficient to advance the sampler 6 inches and often indicative of a dense or hard material. Only one refusal N value was observed and occurred in FD2020-11 during the 112.5' to 113.8' sampling interval in foundation soils at boring termination.

Table 7. SPT Refusals and N-Value Ranges and Averages

Stratum	Boring	Number of Tests	N Values		
			Range	Mean	Median
Zone I	FD2020-11	17	8 - 36	19	17
Zone II	FD2020-11	8	7 - 28	20	24
	FD2020-608	9	11 - 45	25	26
Embankment Foundation	FD2020-11	21	10 - 93	35	24
	FD2020-608	24	7 - 48	24	21
	FD2020-609	26	3 - 73	22	24
Soil Cement	FD2020-212	3	16 - 48	29	23
Auxiliary Spillway Foundation	FD2020-212	4	15 - 39	23	20
	FD2020-213	6	5 - 19	12	12
	FD2020-214	9	8 - 15	11	10
Auxiliary Spillway Lacustrine	FD2020-212	11	2 - 7	4	3
	FD2020-213	11	3 - 8	4	4
	FD2020-214	8	2 - 8	4	5

5.3 Undisturbed Soil Sampling

A total of seven attempts at collecting undisturbed soils samples were made, six of which were successful in obtaining samples. Undisturbed sampling was conducted in accordance with ASTM D1587. A summary of the undisturbed soil sampling is presented in Table 8. Undisturbed tube samples were used for unit weight and moisture content testing to assist with establishing remolded

shear strength parameters for embankment soils and shear strength and permeability testing in foundation soils.

Table 8. Summary of Undisturbed Soil Samples

Boring	Sample ID	Depth (ft)	Recovery (ft)	Stratum
FD2020-11	U-1	37.5 – 38.5	1.0	Embankment Zone I
FD2020-213	U-1	20.0 – 22.3	2.3	ASW Foundation
FD2020-214	U-1	40.0 – 42.4	2.4	ASW Foundation
FD2020-608	U-1	10.0 – 11.0	0.9	Embankment Zone II
FD2020-608	U-2	27.5 – 30.0	0	Embankment Foundation
FD2020-608	U-3	55.0 – 57.0	1.8	Embankment Foundation
FD2020-609	U-1	30.0 – 32.0	2.0	Embankment Foundation

5.4 Rock Coring

Rock was not encountered during the subsurface exploration.

5.5 Piezometer Installation

Borings FD2020-11, -608, and -609 were equipped with vibrating wire pressure transducers, which were grouted in place in the borehole. Each boring was outfitted with two pressure transducers located at different depths and connected to a datalogger housed in a fiberglass or steel lockable enclosure affixed to a raised casing. Piezometer construction logs are provided in Appendix D. Piezometric data obtained from the vibrating wire pressure transducers through November 19, 2020 is also presented in Appendix D.

5.5 Field Crumb Dispersion Testing

Field crumb dispersion tests were performed on 15 soil samples in accordance with ASTM D6572 except that Solo No. 9 cups were used in lieu of ceramic bowls. Test results for soils from the dam borings are summarized in Table 9. The results indicated the embankment, foundation soils, and auxiliary spillway soils are generally non-dispersive. Photos of the field crumb dispersion tests are provided in Appendix E.

Table 9. Field Crumb Dispersion Test Results

Stratum		Boring	Sample Depth (ft)		Grade
Dam	Embankment	FD2020-11	30	40	1: Non-dispersive
		FD2020-608	15	17.5	1: Non-dispersive
		FD2020-609	2.5	7.5	1: Non-dispersive
	Outwash/Alluvium	FD2020-11	71.8	80	1: Non-dispersive
			102	109.3	2: Intermediate
		FD2020-608	40	42.5	2: Intermediate
			77.5	80	2: Intermediate
		FD2020-609	20	30	1: Non-dispersive
			63.2	67.5	1: Non-dispersive
Auxiliary Spillway	Till	FD2020-212	8	10	1: Non-dispersive
	Glaciolacustrine	FD2020-212	25	32.5	2: Intermediate
		FD2020-213	15.5	25	1: Non-dispersive
			40	45	1: Non-dispersive
		FD2020-214	21.7	30	1: Non-dispersive
			30	40	2: Intermediate

5.6 Lab Testing

Laboratory testing of soil samples collected during the 2020 subsurface exploration program was performed for use in geotechnical analysis. Soil gradation data was used for drain fill compatibility analysis, auxiliary spillway integrity parameter selection, and to estimate parameters for embankment seepage and stability models. All testing was performed in accordance with ASTM test standards.

The 2020 laboratory testing program was conducted by Terracon Consulting Engineers located in Grand Forks, ND. Soil testing included the following:

- 18 moisture content tests (ASTM D2216)
- 18 USCS Classifications: sieve (ASTM D422), hydrometer (ASTM D7928), and Atterberg Limits ASTM D4318)
- 6 Specific gravity tests (ASTM D854)
- 5 Unit weight of soil tests (direct measure)
- 4 Flexible wall permeability tests (ASTM D5084)
- 1 Direct shear tests (ASTM D3080)
- 3 Consolidated, undrained triaxial shear strength tests with pore pressures monitored (ASTM D4767)
- 11 Crumb dispersion tests (ASTM D6572)

The triaxial permeability, CU_{bar} shear strength, and direct shear strength tests performed on embankment soils utilized reconstituted specimens based on results from natural moisture content and unit weight testing. Strength and permeability testing completed on foundation soils utilized undisturbed Shelby tube samples. Laboratory soil classifications are presented in Table 10. Laboratory test results are included in Appendix F.

Table 10. Summary of Laboratory Classifications

Test Boring Number	Sample Depth (ft)	Stratum	USCS Class	Material Description	LL	PI	w%
FD2020-11	12.5 - 17.5	Zone II	SC	Clayey SAND	29	10	18
FD2020-11	37.5 - 38.5	Zone I	CL	Sandy lean CLAY	39	20	14
FD2020-11	52.5 - 57.5	Zone I	CL	Sandy lean CLAY	40	21	16
FD2020-11	67.5 - 70	Embankment Foundation	SC-SM	Silty, clayey SAND	24	4	30
FD2020-11	82.5 - 85	Embankment Foundation	ML	Sandy SILT	32	8	28
FD2020-11	100 - 102.5	Embankment Foundation	SC	Clayey SAND	32	10	24
FD2020-212	0 - 5	ASW Foundation	SC	Clayey SAND	45	23	15
FD2020-212	7.5 - 10	ASW Foundation	CL	Sandy lean CLAY	40	18	19
FD2020-212	10 - 15	ASW Foundation	SM	Silty SAND	32	6	18
FD2020-213	2.5 - 7.5	ASW Foundation	SM	Silty SAND	31	6	11
FD2020-213	20 - 22.3	ASW Foundation	ML	SILT	33	3	41
FD2020-214	5 - 10	ASW Foundation	SM	Silty SAND	43	15	19
FD2020-608	0 - 5	Zone II	SC	Clayey SAND	38	16	16
FD2020-608	10 - 11	Zone II	SC-SM	Silty, clayey SAND	27	6	23
FD2020-608	25 - 27.5	Embankment Foundation	SC	Clayey SAND	29	11	27
FD2020-608	55 - 57	Embankment Foundation	ML	Sandy SILT	34	3	26
FD2020-609	10 - 12.5	Embankment Foundation	CL	Lean CLAY w/ sand	39	15	34
FD2020-609	30 - 32	Embankment Foundation	ML	Sandy SILT	39	13	48

5.7 Subsurface Exploration Findings

The available data from all previous and current subsurface exploration programs were evaluated and considered in the current analyses. The following discussion is focused on the results of the 2020 exploration. The reader should take note that lower case USCS symbols indicate field classifications, performed in accordance with ASTM D2488, whereas upper case USCS symbols indicate laboratory classifications, performed in accordance with ASTM D2487.

5.7.1 Embankment

The typical embankment section, reproduced from As-Built Drawing Sheet 10 is shown in Figure 1 and indicates the embankment is comprised of two zones, a central clay core and a sandy shell.

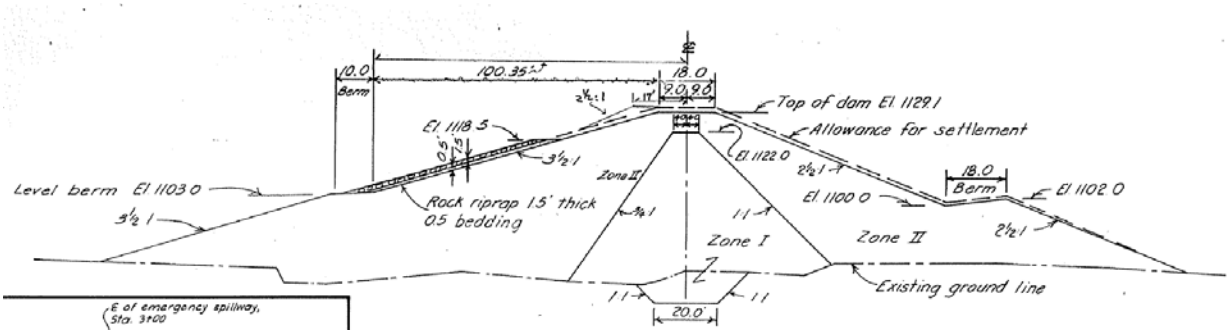

Figure 1. Typical Embankment Section from As-Built Drawings

Zone I

Zone I is located along the dam centerline and acts as an impervious core. Material from Zone I was sampled in boring FD2020-11 and was laboratory classified as a sandy lean clay (CL). This compares well with the As-Built drawings that indicate CL material from Borrow Area C was used to construct this embankment zone. However, the engineer's drilling log (Appendix C) indicates that the CL material starts at a depth of 19.5 feet (El. 1110.7) whereas the As-Built drawings indicate the top of Zone I to be at El. 1123.2. Subsequent laboratory testing of a sample collected between El. 1117.7 and El. 1112.7 was classified as a clayey sand (SC) with a gradation curve that closely resembled that of the Zone II shell material. This suggests that in the location of FD2020-11, the top of the Zone I core is 11.3 feet lower than that shown in the As-Built drawings. The engineer's drilling log indicates a relatively consistent material with N values ranging between 8 and 36 blows per foot (bpf) and averaging 19 bpf with pocket penetrometer readings ranging from 1.5 tons per square foot (tsf) to greater than 4.5 tsf. Laboratory testing confirms a relatively impermeable material with a measured hydraulic conductivity 7.7×10^{-8} cm/sec. Shear strength testing indicated a drained friction angle of 33°. Field and laboratory crumb dispersion testing indicates Zone I soils are non-dispersive.

Zone II

Zone II acts as shell material surrounding the Zone I impervious core and was sampled in boring FD2020-608. The soils that comprise Zone II were laboratory classified as clayey sand (SC) and silty, clayey sand (SC-SM). These material descriptions correlate well with the As-Built drawings that indicate soils classified as poorly-graded sand (SP), silty sand (SM), and clayey sand (SC) were utilized. The geologist's field logs indicate N values ranging between 7 and 45 bpf and averaging 22 bpf while pocket penetrometer readings range from 0 tsf to greater than 4.5 tsf. Crumb testing indicates Zone II soils are non-dispersive. Permeability testing on the Zone II soils indicates a permeability of 6.5×10^{-6} cm/sec and shear strength testing indicates a drained friction angle of 37°.

5.7.2 Embankment Foundation Soils

The foundation soils were encountered in borings FD2020-11, -608, and -609. This material was identified as outwash/alluvium and classified as silty, clayey sand (SC-SM), clayey sand (SC), sandy silt (ML), and silty clay (cl). These classifications are in general agreement with the pre-construction borings within the dam footprint that indicate SP, SM, SC, ML, and CL materials. Per the geologist's field logs, N values in the foundation soils ranged from 3 to 93 bpf and average 26 bpf. Pocket penetrometer readings ranged from 0 tsf to greater than 4.5 tsf and averaging approximately 3.5 tsf – the average is approximate due to the almost half of the pocket penetrometer readings being greater than 4.5 tsf. Dispersion testing of foundation soils beneath the embankment are non-dispersive to intermediate. Two permeability tests were conducted on separate undisturbed samples obtained from the outwash/alluvium that yielded 3.5×10^{-6} cm/sec and 2.2×10^{-8} cm/sec. Shear strength testing yielded a drained friction angle of 32°.

5.7.3 Auxiliary Spillway Soils

Auxiliary spillway (ASW) soils were encountered in borings FD2020-212, FD2020-213, and FD2020-214 and indicated the presence of sandy alluvium (SM) overlain by glaciolacustrine silt (ML). The soil cement barrier was encountered in FD2020-212 and was classified as a clayey sand (SC). A 2.5-foot thick layer of sandy lean clay (CL) was encountered immediately below the soil cement barrier and above the silty sand. Per the engineer's drilling logs, the N-values of the sandy ASW soils ranged from 5 to 39 bpf with an average of 14 bpf, while the glaciolacustrine soils had N-Values ranging from 2 to 8 bpf with an average of 4 bpf. The soil cement barrier yielded N-values ranging from 16 to 48 bpf with an average of 29 bpf. No refusal blow counts were noted in any of the ASW soils. The lone pocket penetrometer reading obtained in the soil cement barrier was 2.75 tsf while the glaciolacustrine silt averaged 0 tsf – only one of the 32 readings registered higher than 0 tsf, a 0.3 tsf reading in FD2020-212 from 17.5'-20.0' below ground surface. Dispersion testing on spillway soils indicates non-dispersive or intermediate. No permeability or shear strength testing was completed on spillway soils.

6. GEOTECHNICAL ANALYSES

6.1 Auxiliary Spillway SITES Analysis

The following geotechnical engineering parameters were developed for use in the auxiliary spillway integrity analysis (SITES). The SITES evaluation will be completed under the Hydraulics task and results will be included in that report. Headcut erodibility index was determined following guidelines given in National Engineering Handbook, Chapter 52, *Field Procedures for Headcut Erodibility Index* (NRCS, 1997). Other parameters were developed from laboratory test data and correlation with published values. Appendix G contains the calculations for the recommendations.

Two test borings were drilled near the control section of the existing ASW. FD2020-212 was drilled approximately 36 feet left of the ASW centerline at the soil-cement barrier whereas FD2020-213 was drilled approximately 150 feet right of the ASW centerline approximately 20 downstream of the soil-cement barrier. A third boring, FD2020-214 was drilled on the inside edge of the spillway (approx. 200 feet left of ASW centerline) approximately 290 feet downstream of the soil-cement barrier. A summary of the SITES model geotechnical input parameters is presented in Table 11.

Table 11. Geotechnical Input Parameters and Stratigraphy for use in SITES Analysis

Strata	Dry Unit Weight (pcf)	% Clay	K_h	D_{75} (mm)	PI	FD2020-212 Depth (ft)	FD2020-213 Depth (ft)	FD2020-214 Depth (ft)
Soil Cement	105	7	0.22	1.5	23	0 - 8	N/A[1]	N/A[1]
Clay	101	13	0.1	0.52	18	8 - 10	N/A[1]	N/A[1]
Till (SM)	100	9	0.061	1	9	10 - 17	0 - 15.5	0 - 21.7
Glaciolacustrine (ML)	75	20	0.0065	0.033	3	17 - 45	15.5 - 45	21.7 - 45

Notes: 1) Soil cement and clay strata not encountered in FD2020-213 or FD2020-214.

6.2 Compatibility Analyses

Modern embankment dams are designed to control seepage and reduce the risks of seepage problems related to soil migration. A series of calculations were completed to evaluate compatibility of existing materials and to design drain aggregates to filter site soils. The calculations were performed using the procedures in Chapter 26 of the National Engineering Handbook Part 633 (NRCS, 2017) and are included in Appendix G. Results are summarized below.

Zone II (shell) embankment soils are predominantly clayey sand and the Zone I (core) embankment is predominantly sandy lean clay. The overburden soils immediately below the embankment are generally sandy (e.g., SC-SM, SC, etc.) before transitioning to finer silts and clays (ML, CL, etc.). Compatibility analyses indicate that the Zone II (shell) and sandy foundation soils are of a sufficient gradation to protect against piping of the Zone I (core).

Per the As-Built drawings, the existing foundation drain built during original construction is comprised of an apparent non-standard mixture of sand and gravel, ranging in size from three inches to 0.167 inches (i.e., the #40 sieve). The drain fill gradation from As-Built sheet 11 of 40 is reproduced in Table 12.

Table 12. Existing Drain Fill Gradations

Sieve Size	Percent Passing
3 inches	100
1 inch	90 - 100
#4	45 - 70
#10	10 - 50
#16	0 - 35
#40	5

By inspection, the drain fill does not meet state-of-the-practice gradation criteria for seepage control/conveyance due to being too coarse and/or too broadly graded. Gradational analyses of the foundation soils indicate that the existing drain fill is too coarse to provide adequate filtration. Gradational analyses of the Zone II soils against the drain fill indicates general compatibility, although the drain fill's broad gradation present concern regarding segregation during placement. Drain fill lack of compatibility with foundation soils and coarseness / broad gradation of drain fill is considered a deficiency with respect to current dam safety criteria. Lack of filtration can lead to foundation soil particle migration into the drain. ND DOT fine aggregate would be an appropriate aggregate selection for drain fill adjacent the foundation soils if required during a future rehabilitation effort. Per the gradational analysis, if drain fill aggregate adjacent the existing Zone II soils is required for future dam rehabilitation work, a custom aggregate gradation would need to be designed to meet filtration/drainage requirements.

6.3 Seepage Analyses

Gannett Fleming performed seepage analyses to estimate the phreatic surface in the embankment during normal pool and flood surcharge pool levels for the purpose of evaluating slope stability. Seepage conditions were analyzed at the maximum-height embankment cross section, Station 24+50, which is the approximate location of the 2020 test borings. The analyses model was developed using stratigraphy interpreted from the historic As-Built drawings and supplemented with existing topography and subsurface data from borings FD2020-11, FD2020-608 and FD2020-609. Seepage modeling was performed using the SEEP/W module of GeoStudio 2020, Version 10.2 by GEO-SLOPE International.

Permeabilities of site soil and rock strata were estimated based on laboratory testing and engineering judgment based on material descriptions and gradations. A detailed summary of the inputs and assumptions used to generate the seepage model are included in Appendix G.

A seepage model was created to calibrate soil and rock layer permeabilities using observed piezometer data from August 2020 through November 2020 to improve understanding of the phreatic surface and pore pressures in the dam and foundation. In the calibration process, permeabilities of subsurface strata were adjusted until the seepage model results matched reasonably well with the observed piezometer data. Table 13 compares the actual head observed in the piezometers to the predicted head modeled in SEEP/W for steady-state seepage at Normal Pool (see Appendix G for the model output). In general, the piezometric heads measured by the piezometers correlate well with the calibrated model.

Embankment seepage models were created to estimate the steady state phreatic surface at normal pool and at a flood surcharge pool for evaluation of slope stability, as discussed in Section 6.4.

Table 13. Comparison of Observed and Modeled Piezometric Heads[1]

Piezometer	Observed in Field[2] (ft)	Modeled (ft)	Delta[3] (ft)
FD2020-11 Upper	1083.7	1081.5	-2.2
FD2020-11 Lower	1080.3	1088.4	8.1
FD2020-608 Upper	1077.8	1077.2	-0.6
FD2020-608 Lower	1075.2	1080.1	4.9
FD2020-609 Upper	1073.6	1076.7	3.1
FD2020-609 Lower	1073.2	1077.6	4.4

Notes:
1) For normal pool conditions.
2) Average observed head over a 30-day period from 10/21/20 to 11/19/20.
3) Negative delta value indicated modeled head is lower than field observed head.

6.4 Slope Stability Analyses

Gannett Fleming performed slope stability analyses of the upstream and downstream embankment slopes based on the requirements of TR-60 (NRCS, 2019). Analyses were performed at the cross section representing the maximum height of the dam and utilizing pore water pressures computed by the seepage modeling. Slope stability modeling was performed using the SLOPE/W program, module of GeoStudio 2020, Version 10.2 by GEO-SLOPE International. Existing embankment slope geometry is based on the site topography data, rather than as-built drawings. Based on survey data, the existing upstream slope is approximately 2.5H:1V near the crest and transitions to a 3.5H:1V at approximately El. 1124, which continues to the toe of slope, interrupted by a ten-foot-wide bench at approximately El. 1106, near the normal pool shoreline. The existing downstream slope is approximately 2.5H:1V and contains one bench at El. 1102.

Recommended shear strength parameters were determined based on the results of the subsurface exploration and laboratory testing programs. Table 14 summarizes the recommended shear strengths and unit weights for site soils.

The shear strength parameters of Zone I embankment fill and foundation outwash/alluvium were determined based on results of consolidated, undrained (CU_{bar}) triaxial shear strength with pore pressures monitored. The triaxial test results were evaluated with respect to shear strength guidance provided in the U.S. Corps of Engineers EM 1110-2-1902 (2003). A linear Mohr-Coulomb failure envelope was constructed for the Mohr circles at failure such that two thirds of the Mohr circle points of tangency are above the line and one-third below, in accordance with EM 1110-2-1902, Appendix D, Section D-6.b.1. The Mohr circles and the recommended design failure envelope are plotted together for both effective stress and total stress conditions in Appendix G. The shear strength parameters of the Zone II embankment fill were determined based on results of remolded direct shear testing.

Table 14. Recommended Parameters for Slope Stability Analyses

Material	Unit Weight	Shear Strength Parameters				
		Effective Stress		Total Stress		Bilinear Stress
		Cohesion, c'	Friction Angle, Φ'	Cohesion, c	Friction Angle, Φ	Normal Stress[1], σ_N
	(pcf)	(psf)	(degrees)	(psf)	(degrees)	(psf)
Zone I (Core)	133	0	33	576	25	3146
Zone II (Shell)	121	0	37	See Note 2		2005
Drain Fill	110	0	36	0	36	-
Sandy Alluvium	110	0	34	0	34	-
Outwash/Alluvium	120	0	32	317	21	1315

Notes:

1) The normal stress, σ_N, is the normal stress coordinate of the intersection of the effective stress and total stress failure envelope (TR-60 Figure 5-2 is replicated as Figure 2) and is calculated with the equation: $\sigma_N = \frac{c - c'}{\tan\phi - \tan\phi}$
2) Total stress parameters are conservatively estimated to be equal to Zone I since Zone II soil strength was determined via direct shear test results unlike Zone I and Foundation soils which were tested via CU Triaxial tests.
3) The sandy alluvium overburden and drain fill are considered to be free draining and therefore effective stress parameters are utilized for the rapid drawdown model.

Figure 5–2: Mohr-Coulomb Envelope for Upstream Drawdown

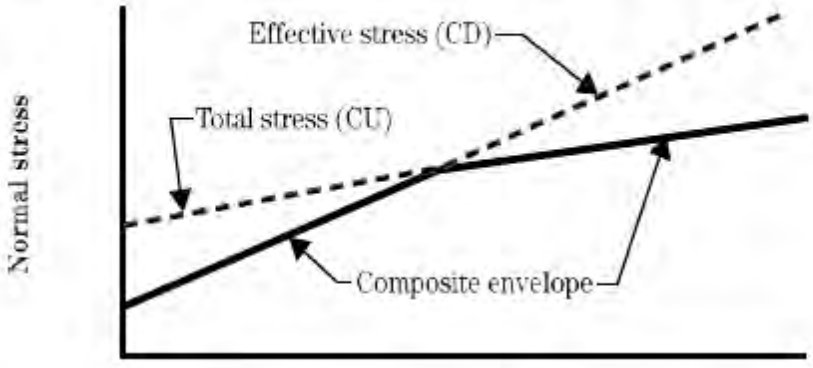

Figure 2. Composite Shear Strength Envelope from Figure 5-2 in TR-60

The SLOPE/W model utilizes effective strength parameters for the normal pool, steady-state seepage condition. To analyze the flood surcharge condition, the SLOPE/W model utilizes a composite envelope (bilinear strength), i.e., the lowest of the effective or consolidated total stress failure envelope as required by TR-60. SLOPE/W requires the input of both effective and total

stress parameters as well as the normal stress of the intersection of the two failure envelopes to perform a bilinear strength analysis. These parameters are presented in Table 14

Rapid drawdown stability of the existing upstream slope was evaluated in accordance with TR-60 using the composite failure envelope. It was assumed that rapid drawdown was instantaneous from normal pool to the elevation of the lowest lake drain invert, El. 1090.8 as indicated on the historic As-Built drawings and adjusted to NAVD88. The piezometric line is then drawn to closely match the piezometric surface from the normal pool stability model downstream of the Zone I core.

Evaluation of the SLOPE/W model results indicate that the dam meets current TR-60 requirements for normal pool, flood pool, and rapid drawdown conditions. Slope stability analysis results are included in Appendix G and summarized in Table 15. The required minimum factors of safety indicated in Table 15 are from TR-60, Table 5-3 and are utilized to assess downstream embankment stability for normal pool and flood surcharge pool, and upstream slope stability during a rapid drawdown condition

Table 15. Embankment Slope Stability Analysis Results

Analysis	Required Minimum Factor of Safety	Calculated Minimum Factor of Safety
Rapid Drawdown (Composite Strength Failure Envelope)	1.2	2.1
Downstream Slope (Existing), Normal Pool, Steady-State Seepage	1.5	2.3
Downstream Slope (Existing), Flood Surcharge Pool, Steady-State Seepage	1.4	1.7

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EXHIBITS

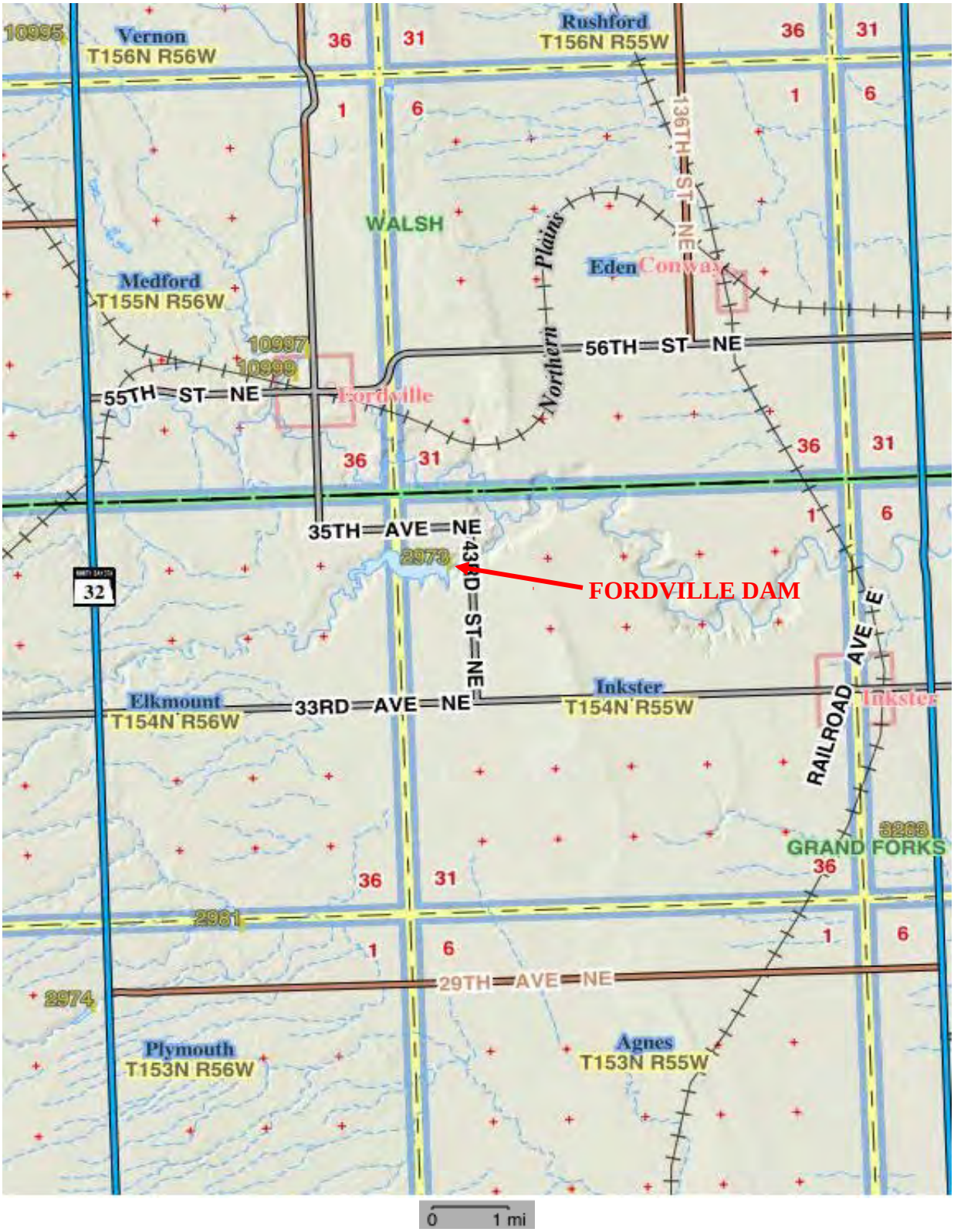


Exhibit 1. Fordville Dam Location Map

Exhibit 2. Fordville Dam Vicinity Map

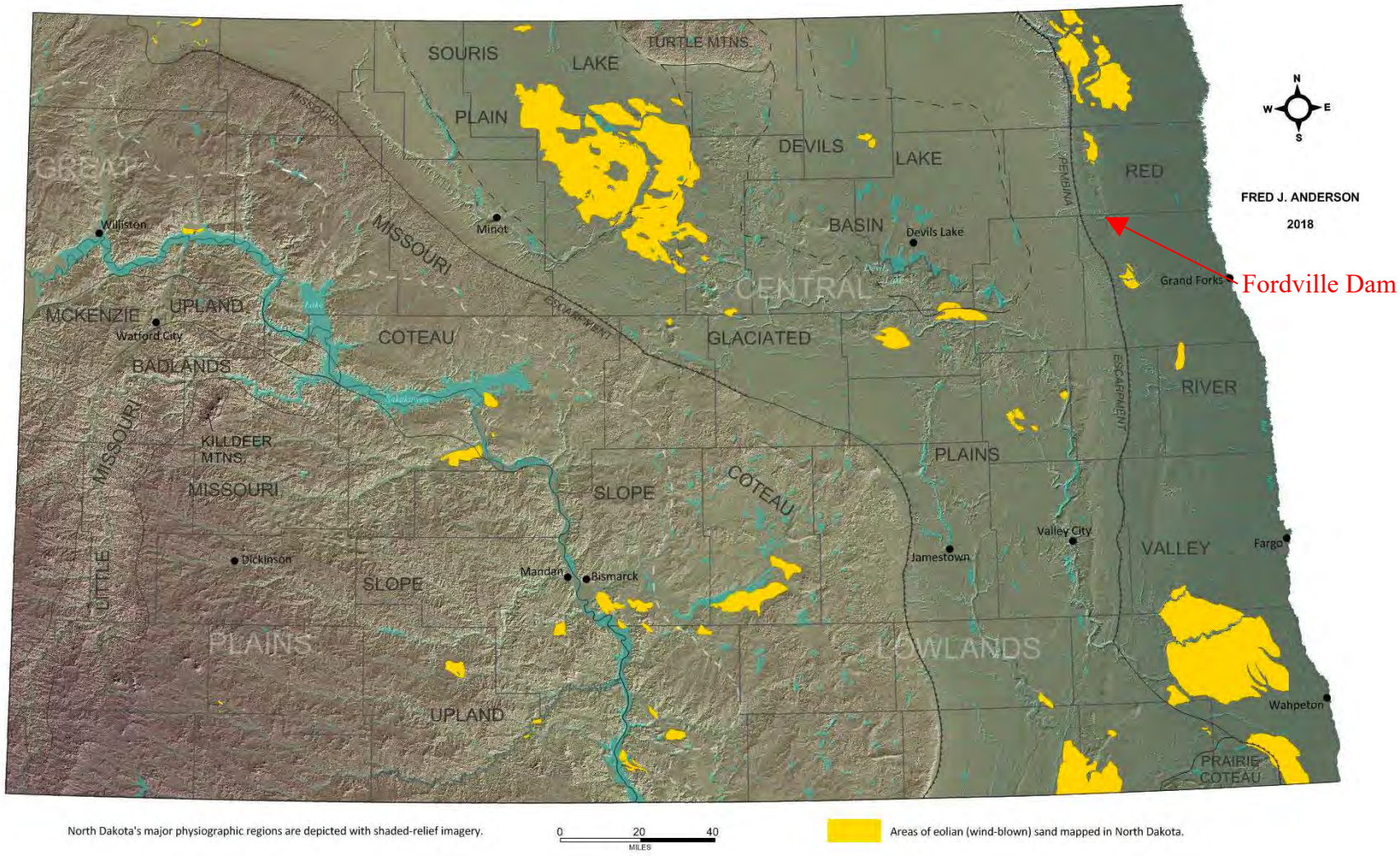


Exhibit 3. Physiographic Map of North Dakota (Anderson, 2018)

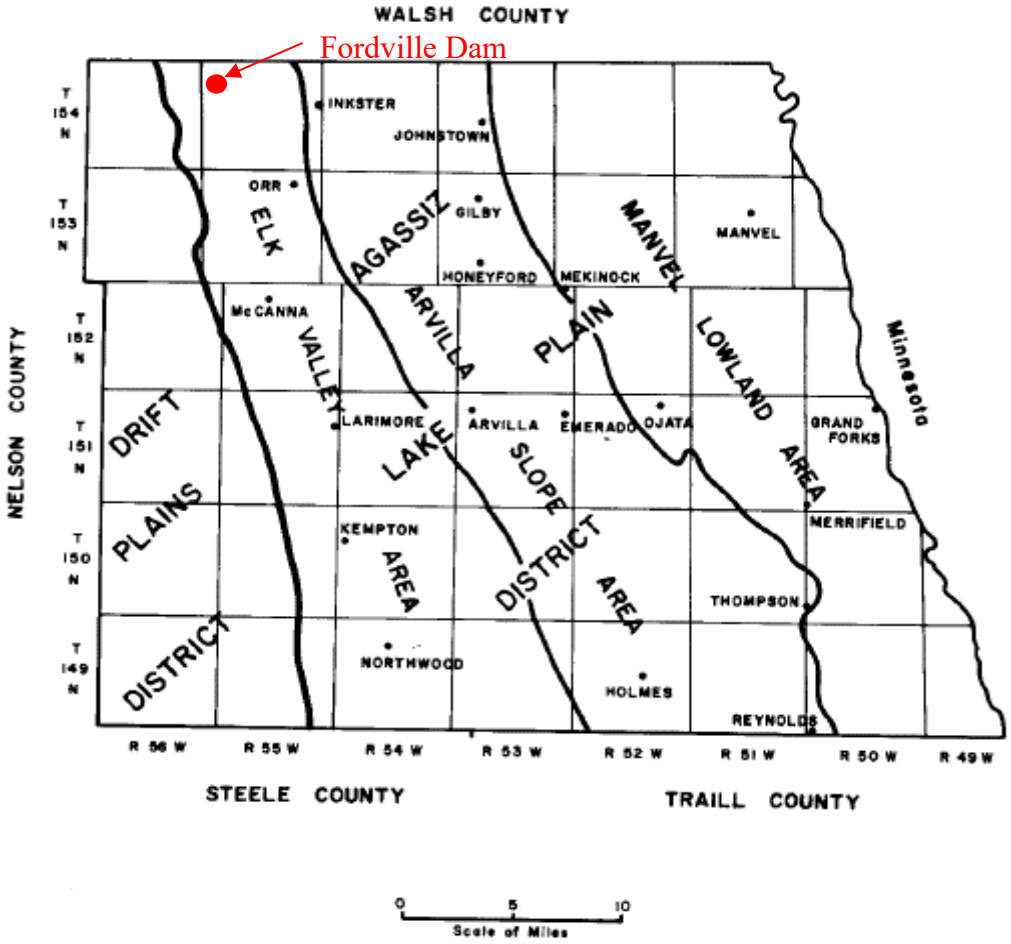


Exhibit 4. Physiographic Map of Grand Forks County (Hansen and Kume, 1970)

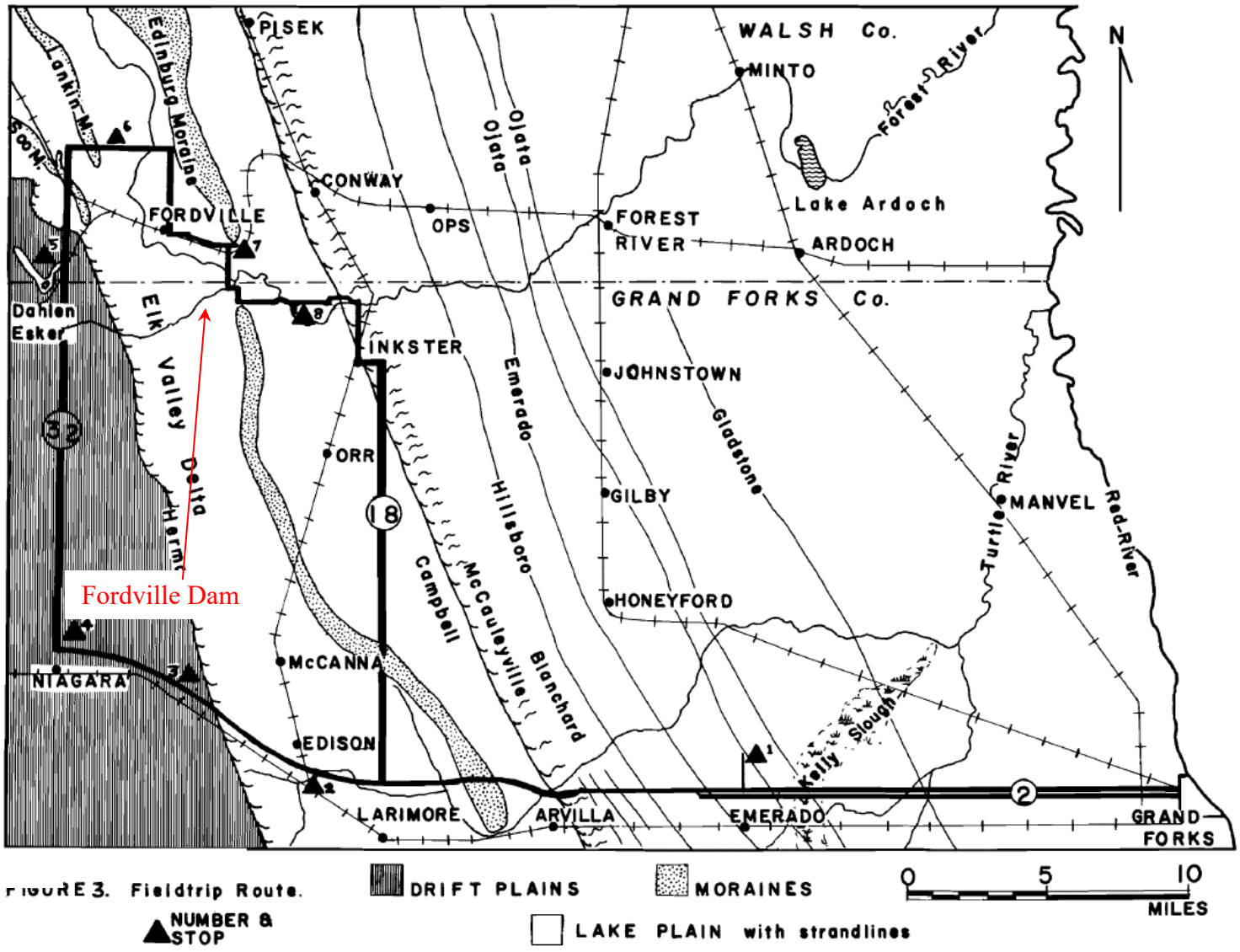
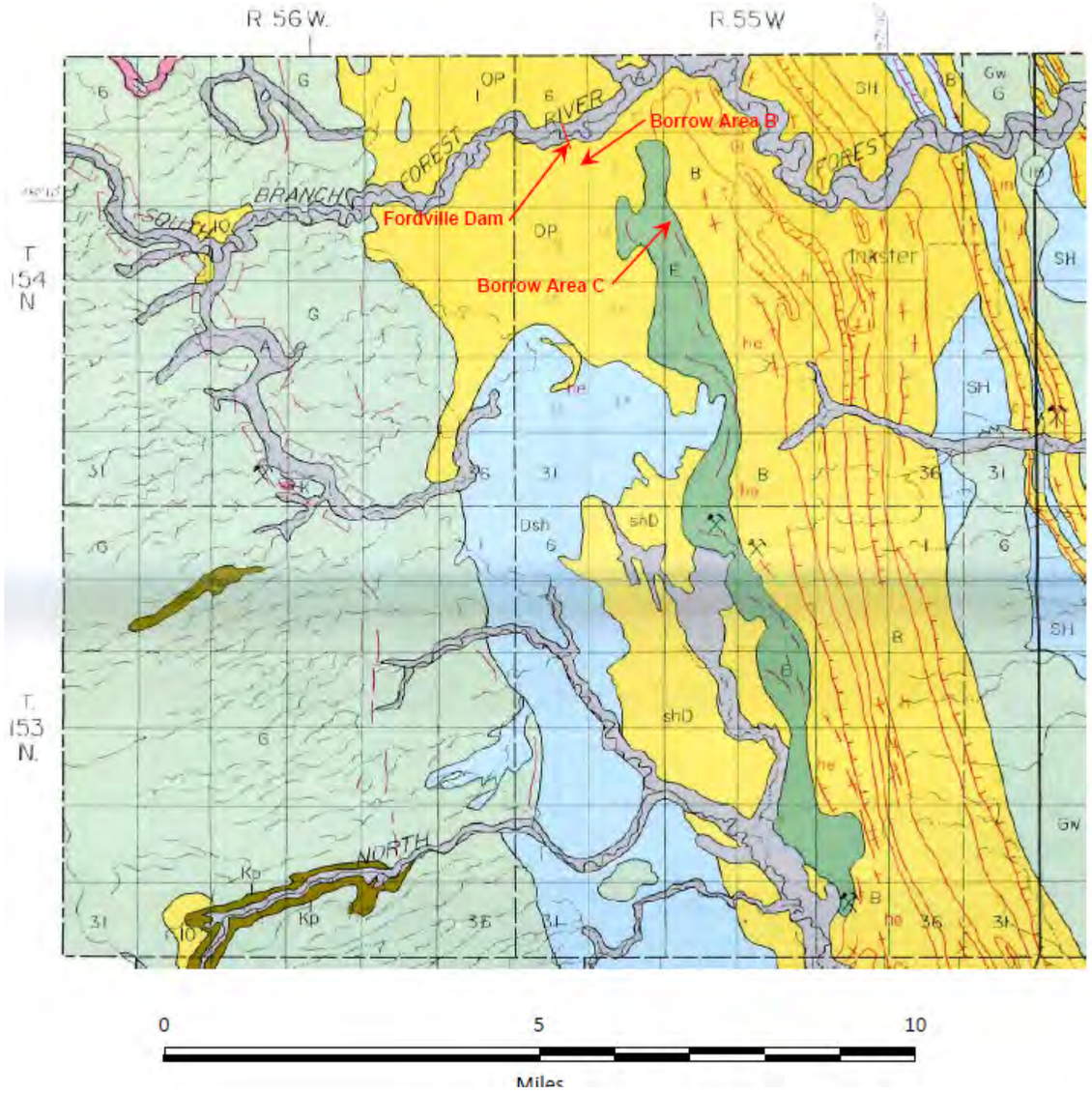


FIGURE 3. Fieldtrip Route.

Exhibit 5. Glacial Features Map (Pedersen and Reid, 1969)



EXPLANATION

SYMBOL	DESCRIPTION
A	**Alluvium** Flood deposits mostly of dark gray clay and silt in trenches along streams.
SH	**Shore Deposits** Thin deposits of stratified yellowish-gray and olive-gray clay and silt; underlies a flat surface; deposits are local.
SH	Mostly thin deposits of stratified brownish-gray sand and some gravel; underlies a sloping but relatively flat surface.
Dsh	**Deltaic Deposits** Interlaminated yellowish-gray and olive-gray clay and silt; underlies a surface of very low relief.
shD	Stratified brownish-gray, occasional gravel; underlies gently undulating surface of very low relief broken by beach ridges and occasional low sand dunes
O	**Outwash Deposits** Stratified brownish-gray sand and some gravel; underlies moderately undulating surface.
B	**Beach Deposits** Ridged deposits of brownish-gray sand and gravel; stratified. Ridges are from 3 to 15 feet high; formed in a series of shore deposits along the receding margin of Glacial Lake Agassiz.
I	**Ice Contact Deposits** Stratified, brownish-gray sand and gravel deposited in contact with glacial ice; includes ridges, eskers, linear disintegration ridges, and mounds or kames.
G	**Moraines** Ground Moraine - Mostly unsorted mixture of stony brownish-gray and olive-gray clay, silt, sand, and gravel; underlies a low to moderate undulating surface that has closed depressions and low knobs.
Gw	Ground Moraine, Waterworn - Ground moraine beveled to almost flat surface by Glacial Lake Agassiz.
E	End Moraine - Mostly unsorted mixture of stony brownish-gray and olive-gray clay, silt, sand and gravel. Deposited in form of ridges of moderate to high relief, superimposed low ridges; few closed depressions.
Kp	**Pierre Formation** Olive-gray to dark gray thinly bedded shale. Base of formation is thin unit of alternating light yellowish-gray and dark gray bentonite clays.

Landforms

P	Plain	K	Kame		Linear Till Ridges
	Beach Ridge		Scarp		Sand and Gravel Pit

Exhibit 6. Geologic and Landform Map (Hansen and Kume, 1970)

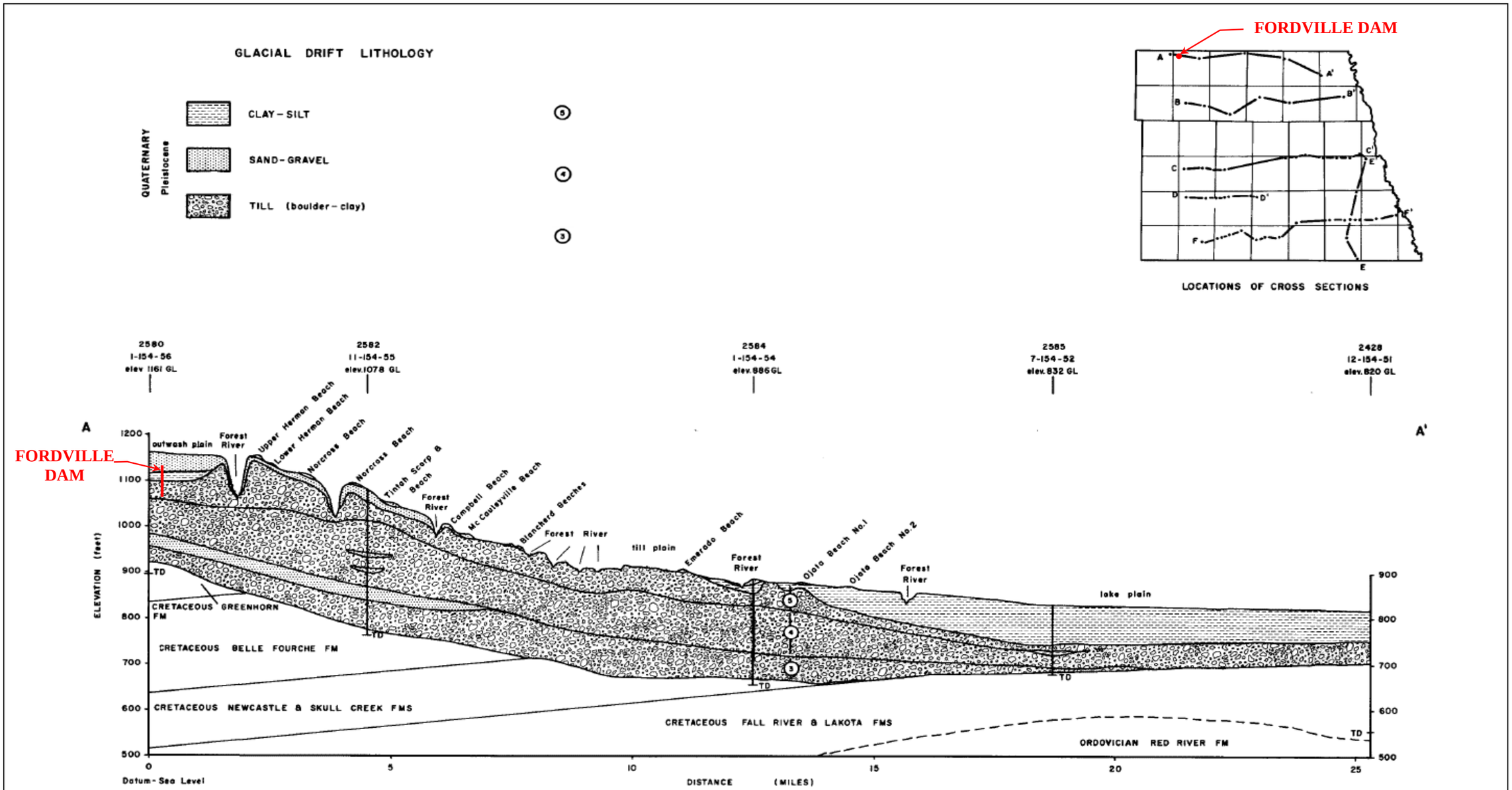


Exhibit 7. Stratigraphic Cross Section (Hansen and Kume, 1970)

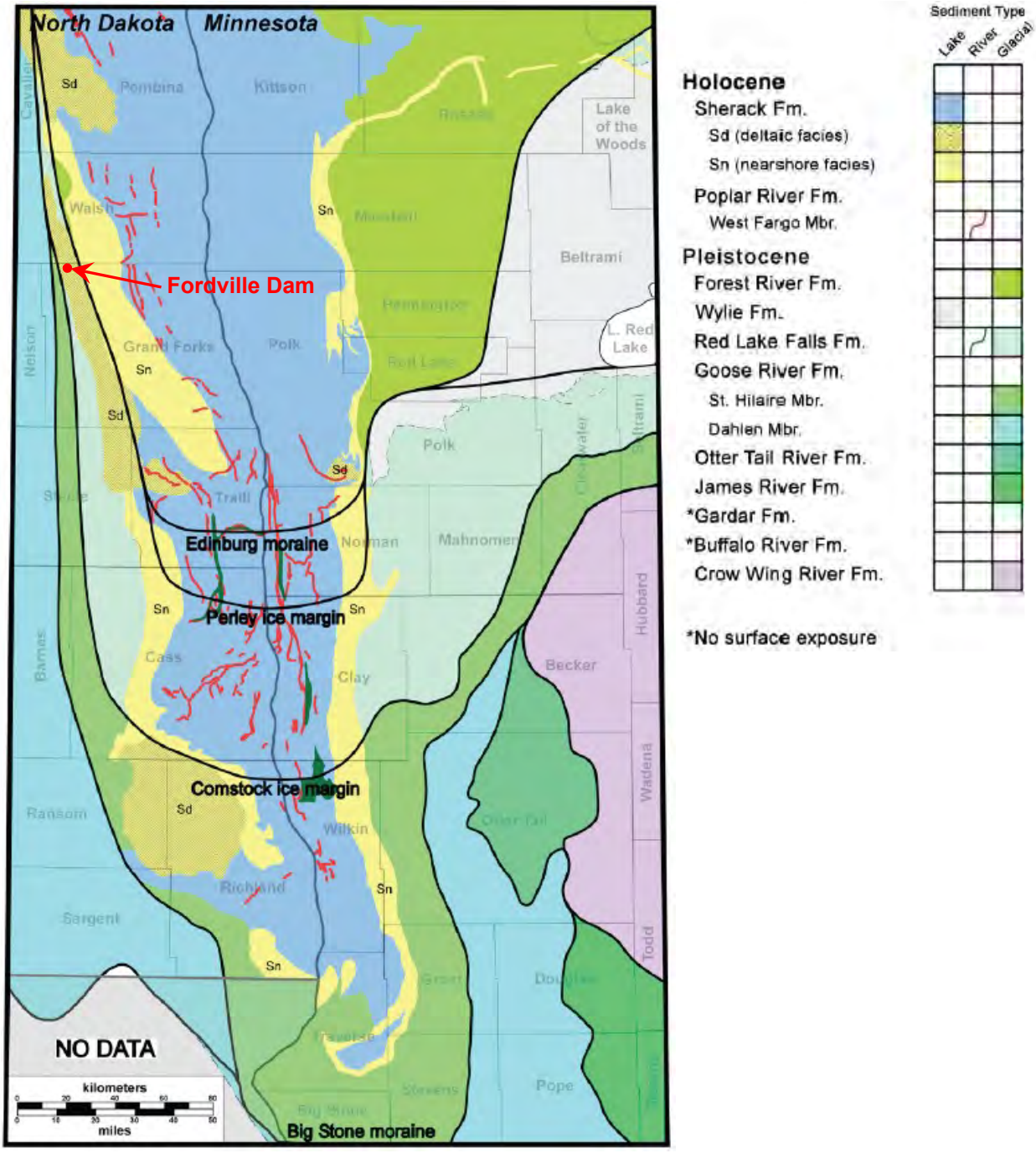


Exhibit 8. Surface Lithostratigraphic Unit Map (Manz, 2016)

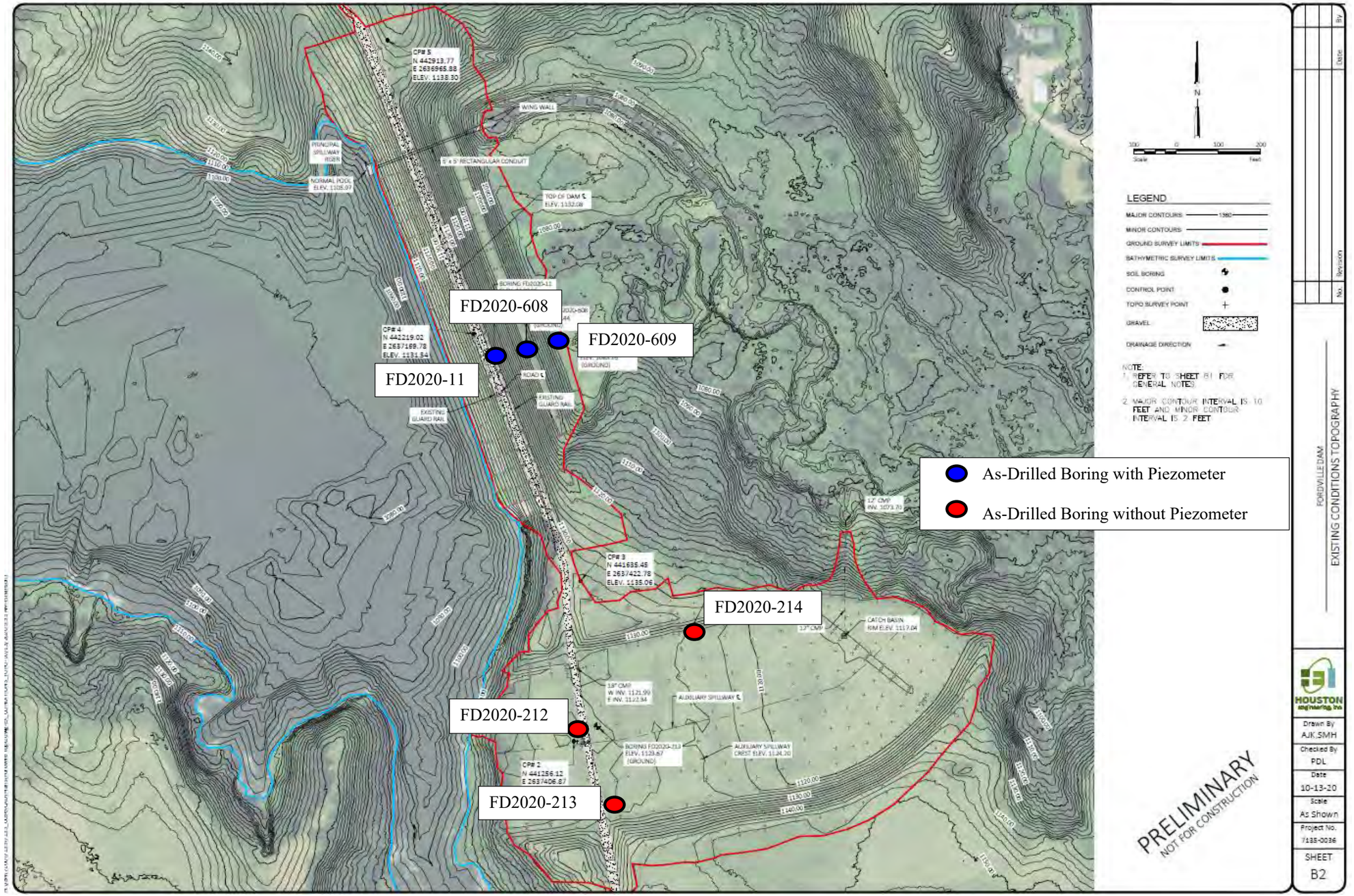


Exhibit 9. As-Drilled Boring Location Plan

APPENDIX A

NRCS Custom Soil Resource Report

United States Department of Agriculture

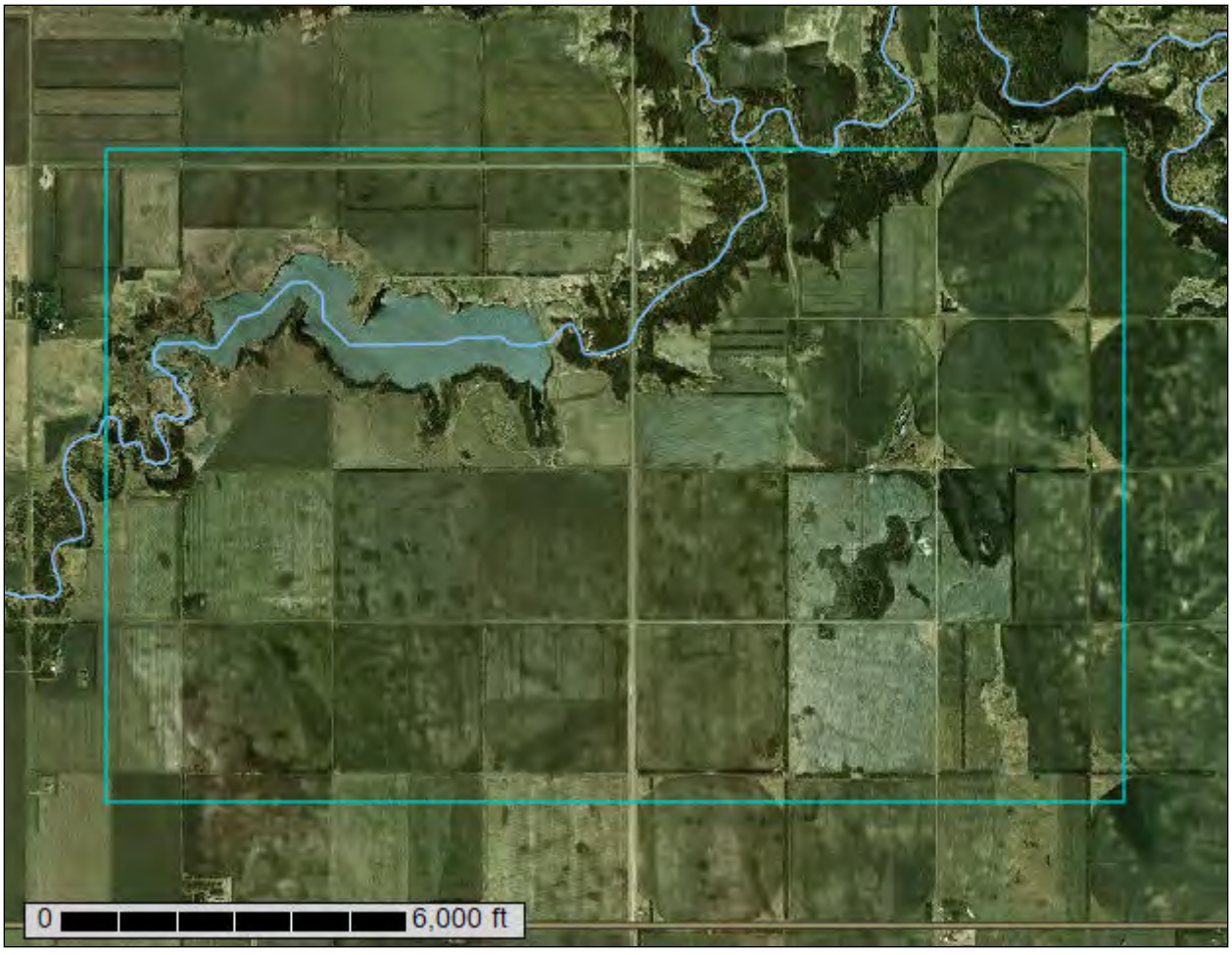
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Grand Forks County, North Dakota

Fordville Dam



November 13, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

Preface.....2
How Soil Surveys Are Made.....5
Soil Map.....8
Soil Map.....9
Legend.....10
Map Unit Legend.....11
Map Unit Descriptions.....12
Grand Forks County, North Dakota.....14
G143C—Barnes-Buse-Langhei loams, 6 to 9 percent slopes.....14
G144B—Barnes-Buse loams, 3 to 6 percent slopes.....17
G147D—Buse-Barnes-Darnen loams, 6 to 15 percent slopes.....20
I146B—Lamoure-Fluvaquents, channeled complex, 0 to 6 percent slopes, frequently flooded.....24
I161A—Vang loam, 0 to 2 percent slopes.....26
I162A—Walsh loam, 0 to 2 percent slopes.....28
I163A—Inkster sandy loam, 0 to 2 percent slopes.....29
I231A—Dovray silty clay, 0 to 1 percent slopes.....31
I365B—Arvilla sandy loam, 0 to 6 percent slopes.....33
I376A—Colvin silty clay loam, 0 to 1 percent slopes.....35
I422A—Renshaw loam, 0 to 2 percent slopes.....36
I422D—Sioux loam, 2 to 15 percent slopes.....38
I463E—Sioux-Renshaw complex, 9 to 25 percent slopes.....40
I479B—Fairdale-Fluvaquents, channeled complex, 0 to 6 percent slopes, frequently flooded.....43
I496A—Embden-Wyndmere fine sandy loams, 0 to 2 percent slopes.....45
I594A—LaDelle silt loam, 0 to 2 percent slopes, occasionally flooded.....48
I628A—Bearden-Overly silty clay loams, 0 to 2 percent slopes.....49
References.....53

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

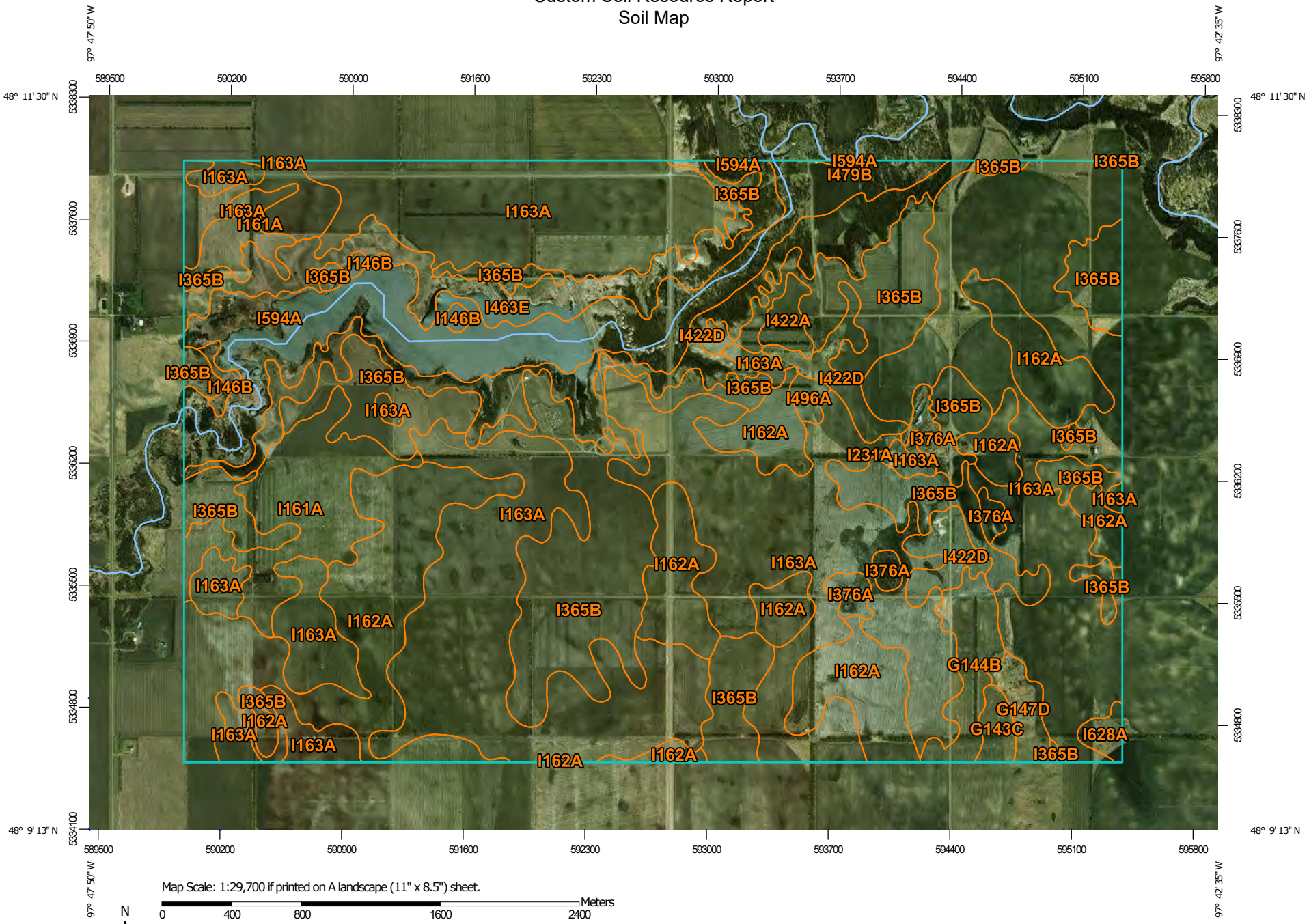
After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map



Map Scale: 1:29,700 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 400 800 1600 2400

Feet: 0 1000 2000 4000 6000

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Grand Forks County, North Dakota
Survey Area Data: Version 24, Jun 11, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 7, 2012—Feb 28, 2017

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
G143C	Barnes-Buse-Langhei loams, 6 to 9 percent slopes	18.9	0.4%
G144B	Barnes-Buse loams, 3 to 6 percent slopes	63.0	1.4%
G147D	Buse-Barnes-Darnen loams, 6 to 15 percent slopes	29.8	0.6%
I146B	Lamoure-Fluvaquents, channeled complex, 0 to 6 percent slopes, frequently flooded	18.3	0.4%
I161A	Vang loam, 0 to 2 percent slopes	221.1	4.8%
I162A	Walsh loam, 0 to 2 percent slopes	653.9	14.1%
I163A	Inkster sandy loam, 0 to 2 percent slopes	1,888.1	40.8%
I231A	Dovray silty clay, 0 to 1 percent slopes	4.5	0.1%
I365B	Arvilla sandy loam, 0 to 6 percent slopes	786.2	17.0%
I376A	Colvin silty clay loam, 0 to 1 percent slopes	50.1	1.1%
I422A	Renshaw loam, 0 to 2 percent slopes	20.8	0.4%
I422D	Sioux loam, 2 to 15 percent slopes	281.5	6.1%
I463E	Sioux-Renshaw complex, 9 to 25 percent slopes	177.8	3.8%
I479B	Fairdale-Fluvaquents, channeled complex, 0 to 6 percent slopes, frequently flooded	2.3	0.1%
I496A	Embden-Wyndmere fine sandy loams, 0 to 2 percent slopes	11.1	0.2%
I594A	LaDelle silt loam, 0 to 2 percent slopes, occasionally flooded	384.1	8.3%
I628A	Bearden-Overly silty clay loams, 0 to 2 percent slopes	13.5	0.3%
Totals for Area of Interest		**4,625.2**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas

shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Grand Forks County, North Dakota

G143C—Barnes-Buse-Langhei loams, 6 to 9 percent slopes

Map Unit Setting

National map unit symbol: 2pwz5
Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Barnes and similar soils: 26 percent
Buse and similar soils: 25 percent
Langhei and similar soils: 18 percent
Minor components: 31 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Barnes

Setting

Landform: Ground moraines, moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 7 inches: loam
Bw - 7 to 14 inches: loam
Bk - 14 to 37 inches: loam
C - 37 to 79 inches: loam

Properties and qualities

Slope: 6 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B

Ecological site: R055BY064ND - Loamy
Forage suitability group: Loam (G055BY100ND)
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Description of Buse

Setting

Landform: Ground moraines, moraines
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Nose slope, rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 7 inches: loam
Bk - 7 to 40 inches: loam
C - 40 to 79 inches: loam

Properties and qualities

Slope: 6 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R055BY068ND - Thin Loamy
Forage suitability group: Limy Upland (G055BY400ND)
Other vegetative classification: Limy Upland (G055BY400ND)
Hydric soil rating: No

Description of Langhei

Setting

Landform: Ground moraines, moraines
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Crest, rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 6 inches: loam

Bk - 6 to 24 inches: loam
C - 24 to 79 inches: loam

Properties and qualities

Slope: 6 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R055BY068ND - Thin Loamy
Forage suitability group: Limy Upland (G055BY400ND)
Other vegetative classification: Limy Upland (G055BY400ND)
Hydric soil rating: No

Minor Components

Svea

Percent of map unit: 14 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R055BY059ND - Loamy Overflow
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Sioux

Percent of map unit: 5 percent
Landform: Outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R055BY069ND - Very Shallow
Other vegetative classification: Not suited (G055BY000ND)
Hydric soil rating: No

Tonka

Percent of map unit: 3 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R055BY071ND - Wet Meadow
Other vegetative classification: Wet (G055BY900ND)

Hydric soil rating: Yes

Lanona

Percent of map unit: 3 percent
Landform: Ground moraines, moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R055BY062ND - Sandy
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Cresbard

Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R055BY056ND - Clayey
Other vegetative classification: Clayey Subsoil (G055BY210ND)
Hydric soil rating: No

Parnell

Percent of map unit: 3 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R055BY070ND - Shallow Marsh
Other vegetative classification: Not suited (G055BY000ND)
Hydric soil rating: Yes

G144B—Barnes-Buse loams, 3 to 6 percent slopes

Map Unit Setting

National map unit symbol: 2pwz2
Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Barnes and similar soils: 28 percent
Buse and similar soils: 27 percent
Minor components: 45 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Barnes

Setting

Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 7 inches: loam
Bw - 7 to 16 inches: loam
Bk - 16 to 37 inches: loam
C - 37 to 79 inches: loam

Properties and qualities

Slope: 3 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 48 to 79 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B
Ecological site: R055BY064ND - Loamy
Forage suitability group: Loam (G055BY100ND)
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Description of Buse

Setting

Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 7 inches: loam
Bk - 7 to 40 inches: loam
C - 40 to 79 inches: loam

Properties and qualities

Slope: 3 to 6 percent
Depth to restrictive feature: More than 80 inches

Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: R055BY068ND - Thin Loamy
Forage suitability group: Limy Upland (G055BY400ND)
Other vegetative classification: Limy Upland (G055BY400ND)
Hydric soil rating: No

Minor Components

Balaton

Percent of map unit: 14 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R055BY068ND - Thin Loamy
Other vegetative classification: Limy Upland (G055BY400ND)
Hydric soil rating: No

Svea

Percent of map unit: 14 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R055BY059ND - Loamy Overflow
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Tonka

Percent of map unit: 5 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R055BY071ND - Wet Meadow
Other vegetative classification: Wet (G055BY900ND)
Hydric soil rating: Yes

Langhei

Percent of map unit: 4 percent
Landform: Ground moraines
Landform position (three-dimensional): Rise

Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R055BY068ND - Thin Loamy
Other vegetative classification: Limy Upland (G055BY400ND)
Hydric soil rating: No

Parnell

Percent of map unit: 3 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R055BY070ND - Shallow Marsh
Other vegetative classification: Not suited (G055BY000ND)
Hydric soil rating: Yes

Cresbard

Percent of map unit: 3 percent
Landform: Ground moraines
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R055BY056ND - Clayey
Other vegetative classification: Clayey Subsoil (G055BY210ND)
Hydric soil rating: No

Renshaw

Percent of map unit: 2 percent
Landform: Terraces
Landform position (three-dimensional): Tread
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R055BY063ND - Shallow Gravel
Other vegetative classification: Very Droughty Loam (G055BY130ND)
Hydric soil rating: No

G147D—Buse-Barnes-Darnen loams, 6 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2pwyv
Elevation: 980 to 2,130 feet
Mean annual precipitation: 17 to 24 inches
Mean annual air temperature: 37 to 46 degrees F
Frost-free period: 120 to 150 days
Farmland classification: Not prime farmland

Map Unit Composition

Buse and similar soils: 28 percent
Barnes and similar soils: 26 percent
Darnen and similar soils: 23 percent

Minor components: 23 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Buse

Setting

Landform: Ground moraines, moraines
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Nose slope, rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Fine-loamy till

Typical profile

A - 0 to 7 inches: loam
Bk - 7 to 40 inches: loam
C - 40 to 79 inches: loam

Properties and qualities

Slope: 9 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: R055BY068ND - Thin Loamy
Forage suitability group: Limy Upland (G055BY400ND)
Other vegetative classification: Limy Upland (G055BY400ND)
Hydric soil rating: No

Description of Barnes

Setting

Landform: Ground moraines, moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope, rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-loamy till

Typical profile

Ap - 0 to 7 inches: loam
Bw - 7 to 14 inches: loam
Bk - 14 to 37 inches: loam

C - 37 to 79 inches: loam

Properties and qualities

Slope: 9 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 1 percent
Maximum salinity: Nonsaline to very slightly saline (1.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: R055BY064ND - Loamy
Forage suitability group: Loam (G055BY100ND)
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Description of Darnen

Setting

Landform: Escarpments
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Fine-loamy colluvium

Typical profile

Ap - 0 to 8 inches: loam
A - 8 to 24 inches: loam
AB - 24 to 29 inches: loam
Bw1 - 29 to 34 inches: loam
Bw2 - 34 to 79 inches: loam

Properties and qualities

Slope: 6 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0

Available water capacity: High (about 10.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: R055BY064ND - Loamy
Forage suitability group: Loam (G055BY100ND)
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Minor Components

Langhei

Percent of map unit: 9 percent
Landform: Ground moraines, moraines
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Crest, rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R055BY068ND - Thin Loamy
Other vegetative classification: Limy Upland (G055BY400ND)
Hydric soil rating: No

Langhei, very stony

Percent of map unit: 6 percent
Landform: Ground moraines, moraines
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Crest, rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R055BY068ND - Thin Loamy
Other vegetative classification: Not suited (G055BY000ND)
Hydric soil rating: No

Swenoda

Percent of map unit: 3 percent
Landform: Ground moraines, moraines
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope, rise
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R055BY062ND - Sandy
Other vegetative classification: Loam (G055BY100ND)
Hydric soil rating: No

Sioux

Percent of map unit: 3 percent
Landform: Outwash plains
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R055BY069ND - Very Shallow
Other vegetative classification: Not suited (G055BY000ND)
Hydric soil rating: No

Lowe, occasionally flooded

Percent of map unit: 2 percent
Landform: Drainageways
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R055BY071ND - Wet Meadow
Other vegetative classification: Wet (G055BY900ND)
Hydric soil rating: Yes

l146B—Lamoure-Fluvaquents, channeled complex, 0 to 6 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 2ptx2
Elevation: 750 to 1,250 feet
Mean annual precipitation: 19 to 24 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Lamoure, frequently flooded, and similar soils: 45 percent
Fluvaquents, frequently flooded, channeled, and similar soils: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Lamoure, Frequently Flooded

Setting

Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Silty alluvium

Typical profile

A - 0 to 27 inches: silty clay loam
Cg1 - 27 to 34 inches: silty clay loam
Cg2 - 34 to 43 inches: silt loam
Ab - 43 to 52 inches: loam
Cg - 52 to 60 inches: sandy loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained

Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: OccasionalFrequentNoneRare
Frequency of ponding: Rare
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 3.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D
Ecological site: R056XY102ND - Wet Meadow
Forage suitability group: Wet (G056XY900ND)
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Description of Fluvaquents, Frequently Flooded, Channeled

Setting

Landform: Swales on flood plains
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 16 inches: fine sandy loam
Cg - 16 to 80 inches: stratified loamy sand to silt loam

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: OccasionalFrequentNoneRare
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 8.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Ecological site: R102CY999NE - Non-Site
Forage suitability group: Not suited (G056XY000ND)
Other vegetative classification: Not suited (G056XY000ND)
Hydric soil rating: Yes

Minor Components

Rauville

Percent of map unit: 9 percent
Landform: Oxbows, depressions
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY101ND - Shallow Marsh
Other vegetative classification: Not suited (G056XY000ND)
Hydric soil rating: Yes

Ladelle

Percent of map unit: 6 percent
Landform: Terraces, flood plains
Landform position (two-dimensional): Shoulder, toeslope
Landform position (three-dimensional): Tread, talf
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

I161A—Vang loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2mbms
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Vang and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Vang

Setting

Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Loamy glaciofluvial deposits over sandy and gravelly glaciofluvial deposits

Typical profile

Ap - 0 to 12 inches: loam
Bw - 12 to 26 inches: clay loam
2C - 26 to 79 inches: gravelly loamy coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2s
Hydrologic Soil Group: B
Ecological site: R056XY094ND - Loamy
Forage suitability group: Droughty Loam (G056XY120ND)
Other vegetative classification: Droughty Loam (G056XY120ND)
Hydric soil rating: No

Minor Components

Walsh

Percent of map unit: 5 percent
Landform: Deltas
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Binford

Percent of map unit: 5 percent
Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY093ND - Shallow Gravel
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

Divide

Percent of map unit: 5 percent
Landform: Beaches
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY087ND - Limy Subirrigated

Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

Brantford

Percent of map unit: 5 percent
Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY093ND - Shallow Gravel
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

I162A—Walsh loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2pyx1
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Walsh and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Walsh

Setting

Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy colluvium

Typical profile

Ap - 0 to 10 inches: loam
Bw - 10 to 22 inches: loam
C - 22 to 79 inches: loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 48 to 79 inches
Frequency of flooding: None
Frequency of ponding: None

Available water capacity: High (about 11.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2c
Hydrologic Soil Group: B
Ecological site: R056XY088ND - Loamy Overflow
Forage suitability group: Overflow (G056XY500ND)
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Minor Components

Tiffany

Percent of map unit: 7 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R056XY102ND - Wet Meadow
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Vang

Percent of map unit: 5 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Droughty Loam (G056XY120ND)
Hydric soil rating: No

Inkster

Percent of map unit: 3 percent
Landform: Beaches
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

I163A—Inkster sandy loam, 0 to 2 percent slopes

Map Unit Setting

National map unit symbol: 2qkvq
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days

Farmland classification: All areas are prime farmland

Map Unit Composition

Inkster and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Inkster

Setting

Landform: Beaches
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Loamy glaciofluvial deposits

Typical profile

Ap - 0 to 7 inches: sandy loam
Bw - 7 to 17 inches: sandy loam
BC - 17 to 25 inches: sandy loam
C - 25 to 79 inches: loamy sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to very high (0.14 to 14.17 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 7.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: R056XY088ND - Loamy Overflow
Forage suitability group: Overflow (G056XY500ND)
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Minor Components

Tiffany

Percent of map unit: 6 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R056XY102ND - Wet Meadow
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Divide

Percent of map unit: 5 percent
Landform: Beaches
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY087ND - Limy Subirrigated
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

Sioux

Percent of map unit: 4 percent
Landform: Beaches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R056XY100ND - Very Shallow
Other vegetative classification: Very Shallow To Gravel (G056XY003ND)
Hydric soil rating: No

I231A—Dovray silty clay, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 1nyss
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Dovray and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Dovray

Setting

Landform: Drainageways
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Clayey glaciolacustrine deposits

Typical profile

Ap - 0 to 8 inches: silty clay
A - 8 to 24 inches: clay
ABg - 24 to 38 inches: clay
Bg - 38 to 46 inches: clay

Cg - 46 to 79 inches: clay

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 8.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C/D
Ecological site: R056XY102ND - Wet Meadow
Forage suitability group: Wet (G056XY900ND)
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Minor Components

Fargo

Percent of map unit: 10 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY084ND - Clayey
Other vegetative classification: Clayey Subsoil (G056XY210ND)
Hydric soil rating: Yes

Grano

Percent of map unit: 3 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R056XY101ND - Shallow Marsh
Other vegetative classification: Not suited (G056XY000ND)
Hydric soil rating: Yes

Hegne

Percent of map unit: 2 percent
Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY084ND - Clayey
Other vegetative classification: Clayey Subsoil (G056XY210ND)
Hydric soil rating: Yes

I365B—Arvilla sandy loam, 0 to 6 percent slopes

Map Unit Setting

National map unit symbol: 1nyxt
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Arvilla and similar soils: 84 percent
Minor components: 16 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Arvilla

Setting

Landform: Beaches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Sandy glaciofluvial deposits over sandy and gravelly glaciofluvial deposits

Typical profile

Ap - 0 to 8 inches: sandy loam
Bw - 8 to 17 inches: sandy loam
2Bk - 17 to 42 inches: gravelly sand
2C - 42 to 79 inches: very gravelly sand

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Available water capacity: Low (about 3.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: R056XY093ND - Shallow Gravel

Forage suitability group: Very Droughty Loam (G056XY130ND)
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

Minor Components

Fordville
Percent of map unit: 6 percent
Landform: Beaches
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Droughty Loam (G056XY120ND)
Hydric soil rating: No

Embden
Percent of map unit: 3 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Divide
Percent of map unit: 3 percent
Landform: Beaches
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY087ND - Limy Subirrigated
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

Sioux
Percent of map unit: 2 percent
Landform: Beaches
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R056XY100ND - Very Shallow
Other vegetative classification: Very Shallow To Gravel (G056XY003ND)
Hydric soil rating: No

Hecla
Percent of map unit: 2 percent
Landform: Beaches
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY090ND - Sands
Other vegetative classification: Sand (G056XY300ND)

Hydric soil rating: No

l376A—Colvin silty clay loam, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 1nyy4
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Prime farmland if drained

Map Unit Composition

Colvin and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Colvin

Setting

Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Fine-silty glaciolacustrine deposits

Typical profile

Ap - 0 to 9 inches: silty clay loam
Ak - 9 to 14 inches: silty clay loam
Bkg - 14 to 31 inches: silty clay loam
Cg - 31 to 79 inches: silty clay loam

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low (0.01 to 0.14 in/hr)
Depth to water table: About 0 to 18 inches
Frequency of flooding: None
Frequency of ponding: Occasional
Calcium carbonate, maximum content: 45 percent
Gypsum, maximum content: 3 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 11.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D

Ecological site: R056XY102ND - Wet Meadow
Forage suitability group: Wet (G056XY900ND)
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Minor Components

Colvin, slightly saline
Percent of map unit: 10 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY102ND - Wet Meadow
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Bearden, moderately saline
Percent of map unit: 5 percent
Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY089ND - Saline Lowland
Other vegetative classification: Saline (G056XY895ND)
Hydric soil rating: No

Perella
Percent of map unit: 5 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY102ND - Wet Meadow
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

l422A—Renshaw loam, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 1tbl2
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition
Renshaw and similar soils: 70 percent
Minor components: 30 percent

Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Renshaw

Setting

Landform: Beaches
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium over sandy and gravelly glaciofluvial deposits

Typical profile

Ap - 0 to 7 inches: loam
Bw - 7 to 16 inches: loam
2Bk - 16 to 25 inches: gravelly loamy sand
2C - 25 to 79 inches: gravelly coarse sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 12 percent
Available water capacity: Low (about 4.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: R056XY093ND - Shallow Gravel
Forage suitability group: Very Droughty Loam (G056XY130ND)
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

Minor Components

Sioux

Percent of map unit: 10 percent
Landform: Beaches
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R056XY100ND - Very Shallow
Other vegetative classification: Very Shallow To Gravel (G056XY003ND)
Hydric soil rating: No

Embden

Percent of map unit: 10 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow

Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Fordville

Percent of map unit: 5 percent
Landform: Beaches
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Droughty Loam (G056XY120ND)
Hydric soil rating: No

Divide

Percent of map unit: 5 percent
Landform: Beaches
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY087ND - Limy Subirrigated
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

I422D—Sioux loam, 2 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2ptxl
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Sioux and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sioux

Setting

Landform: Beaches
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy and gravelly glaciofluvial deposits

Typical profile

Ap - 0 to 7 inches: loam

ABk - 7 to 11 inches: sandy loam
BCk - 11 to 22 inches: very gravelly loamy coarse sand
C - 22 to 79 inches: very gravelly coarse sand

Properties and qualities

Slope: 2 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6s
Hydrologic Soil Group: A
Ecological site: R056XY100ND - Very Shallow
Forage suitability group: Very Shallow To Gravel (G056XY003ND)
Other vegetative classification: Very Shallow To Gravel (G056XY003ND)
Hydric soil rating: No

Minor Components

Renshaw

Percent of map unit: 5 percent
Landform: Beach ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY091ND - Sandy
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

Arvilla

Percent of map unit: 5 percent
Landform: Beach ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY093ND - Shallow Gravel
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

Parnell

Percent of map unit: 4 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Concave
Ecological site: R056XY101ND - Shallow Marsh

Other vegetative classification: Not suited (G056XY000ND)
Hydric soil rating: Yes

Coe

Percent of map unit: 4 percent
Landform: Beach ridges
Landform position (two-dimensional): Summit, shoulder
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R056XY100ND - Very Shallow
Other vegetative classification: Very Shallow To Gravel (G056XY003ND)
Hydric soil rating: No

Vang

Percent of map unit: 2 percent
Landform: Beaches
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Concave
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Droughty Loam (G056XY120ND)
Hydric soil rating: No

I463E—Sioux-Renshaw complex, 9 to 25 percent slopes

Map Unit Setting

National map unit symbol: 1nyzh
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Sioux, gravelly sandy loam, and similar soils: 50 percent
Renshaw and similar soils: 30 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Sioux, Gravelly Sandy Loam

Setting

Landform: Beach ridges
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Sandy and gravelly glaciofluvial deposits

Typical profile

Ap - 0 to 7 inches: gravelly sandy loam
ABk - 7 to 11 inches: gravelly sandy loam
BCk - 11 to 22 inches: very gravelly loamy coarse sand
C - 22 to 79 inches: very gravelly coarse sand

Properties and qualities

Slope: 15 to 25 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Excessively drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 10 percent
Available water capacity: Very low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: A
Ecological site: R056XY100ND - Very Shallow
Forage suitability group: Very Shallow To Gravel (G056XY003ND)
Other vegetative classification: Very Shallow To Gravel (G056XY003ND)
Hydric soil rating: No

Description of Renshaw

Setting

Landform: Beach ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy alluvium over sandy and gravelly glaciofluvial deposits

Typical profile

Ap - 0 to 7 inches: loam
Bw - 7 to 16 inches: loam
2Bk - 16 to 25 inches: gravelly loamy sand
2C - 25 to 79 inches: gravelly coarse sand

Properties and qualities

Slope: 9 to 15 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 12 percent
Available water capacity: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: R056XY093ND - Shallow Gravel
Forage suitability group: Very Droughty Loam (G056XY130ND)
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

Minor Components

Sioux, sandy loam

Percent of map unit: 10 percent
Landform: Beach ridges
Landform position (two-dimensional): Shoulder, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Ecological site: R056XY100ND - Very Shallow
Other vegetative classification: Very Shallow To Gravel (G056XY003ND)
Hydric soil rating: No

Arvilla

Percent of map unit: 6 percent
Landform: Beach ridges
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY093ND - Shallow Gravel
Other vegetative classification: Very Droughty Loam (G056XY130ND)
Hydric soil rating: No

Barnes

Percent of map unit: 2 percent
Landform: Moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Loam (G056XY100ND)
Hydric soil rating: No

Fordville

Percent of map unit: 2 percent
Landform: Beaches
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Droughty Loam (G056XY120ND)
Hydric soil rating: No

l479B—Fairdale-Fluvaquents, channeled complex, 0 to 6 percent slopes, frequently flooded

Map Unit Setting

National map unit symbol: 1tbm3
Elevation: 750 to 1,250 feet
Mean annual precipitation: 19 to 24 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: Not prime farmland

Map Unit Composition

Fairdale, nearly level, occasionally flooded, and similar soils: 35 percent
Fluvaquents, frequently flooded, channeled, and similar soils: 25 percent
Minor components: 40 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Fairdale, Nearly Level, Occasionally Flooded

Setting

Landform: Flood plains, terraces
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear, convex
Across-slope shape: Linear
Parent material: Fine-loamy alluvium

Typical profile

Ap - 0 to 7 inches: silt loam
C - 7 to 48 inches: stratified loam to silt loam
Ab - 48 to 67 inches: silt loam
C' - 67 to 80 inches: silty clay loam

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: NoneOccasionalRare
Frequency of ponding: None
Calcium carbonate, maximum content: 35 percent
Gypsum, maximum content: 2 percent
Available water capacity: Very high (about 12.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2c

Hydrologic Soil Group: B
Ecological site: R056XY088ND - Loamy Overflow
Forage suitability group: Overflow (G056XY500ND)
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Description of Fluvaquents, Frequently Flooded, Channeled

Setting

Landform: Swales on flood plains
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Alluvium

Typical profile

A - 0 to 16 inches: fine sandy loam
Cg - 16 to 80 inches: stratified loamy sand to silt loam

Properties and qualities

Slope: 0 to 6 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: About 0 to 12 inches
Frequency of flooding: OccasionalFrequentNoneRare
Frequency of ponding: Frequent
Calcium carbonate, maximum content: 15 percent
Maximum salinity: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water capacity: Moderate (about 8.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6w
Hydrologic Soil Group: A/D
Forage suitability group: Not suited (G056XY000ND)
Other vegetative classification: Not suited (G056XY000ND)
Hydric soil rating: Yes

Minor Components

Fairdale, gently sloping, occasionally flooded

Percent of map unit: 15 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread, talf
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Fairdale, wooded, occasionally flooded

Percent of map unit: 10 percent
Landform: Flood plains, terraces
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear, convex

Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow
Other vegetative classification: Not suited (G056XY000ND)
Hydric soil rating: No

Cashel, occasionally flooded
Percent of map unit: 5 percent
Landform: Alluvial flats
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow
Other vegetative classification: Clayey Subsoil (G056XY210ND)
Hydric soil rating: No

La prairie, rarely flooded
Percent of map unit: 4 percent
Landform: Terraces, flood plains
Landform position (three-dimensional): Tread, talf
Down-slope shape: Convex, linear
Across-slope shape: Linear
Ecological site: R056XY094ND - Loamy
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Hegne
Percent of map unit: 3 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY084ND - Clayey
Other vegetative classification: Clayey Subsoil (G056XY210ND)
Hydric soil rating: Yes

Moritz, moderately saline, occasionally flooded
Percent of map unit: 3 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY089ND - Saline Lowland
Other vegetative classification: Saline (G056XY895ND)
Hydric soil rating: No

I496A—Embden-Wyndmere fine sandy loams, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 1tbn3

Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Embden and similar soils: 45 percent
Wyndmere and similar soils: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Embden

Setting

Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Loamy glaciolacustrine deposits

Typical profile

Ap - 0 to 8 inches: fine sandy loam
A - 8 to 14 inches: fine sandy loam
Bw - 14 to 25 inches: fine sandy loam
Bk - 25 to 44 inches: fine sandy loam
C - 44 to 79 inches: fine sandy loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Available water capacity: Moderate (about 8.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: A
Ecological site: R056XY088ND - Loamy Overflow
Forage suitability group: Overflow (G056XY500ND)
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Description of Wyndmere

Setting

Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Loamy glaciolacustrine deposits

Typical profile

Ap - 0 to 9 inches: fine sandy loam
Ak - 9 to 15 inches: fine sandy loam
Bk - 15 to 27 inches: fine sandy loam
C - 27 to 79 inches: loamy fine sand

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 14.17 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 3 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: Moderate (about 7.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3e
Hydrologic Soil Group: B
Ecological site: R056XY087ND - Limy Subirrigated
Forage suitability group: Subirrigated (G056XY700ND)
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

Minor Components

Mantador

Percent of map unit: 10 percent
Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Ecological site: R056XY095ND - Subirrigated
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

Tiffany

Percent of map unit: 5 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY102ND - Wet Meadow
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Delamere

Percent of map unit: 5 percent
Landform: Flats
Landform position (three-dimensional): Talf

Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY095ND - Subirrigated
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

l594A—LaDelle silt loam, 0 to 2 percent slopes, occasionally flooded

Map Unit Setting

National map unit symbol: 2ptxd
Elevation: 750 to 1,250 feet
Mean annual precipitation: 19 to 24 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Ladelle and similar soils: 90 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ladelle

Setting

Landform: Stream terraces
Landform position (three-dimensional): Riser
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Fine-silty alluvium

Typical profile

Ap - 0 to 20 inches: silt loam
Bw - 20 to 30 inches: silt loam
Bk - 30 to 50 inches: silt loam
C - 50 to 60 inches: silt loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: NoneOccasionalRare
Frequency of ponding: None
Calcium carbonate, maximum content: 15 percent
Available water capacity: High (about 12.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified

Land capability classification (nonirrigated): 2c
Hydrologic Soil Group: B
Ecological site: R056XY094ND - Loamy
Forage suitability group: Overflow (G056XY500ND)
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Minor Components

Fairdale
Percent of map unit: 5 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY088ND - Loamy Overflow
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Lamoure
Percent of map unit: 3 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY102ND - Wet Meadow
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Rauville
Percent of map unit: 2 percent
Landform: Flood plains
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY101ND - Shallow Marsh
Other vegetative classification: Not suited (G056XY000ND)
Hydric soil rating: Yes

I628A—Bearden-Overly silty clay loams, 0 to 2 percent slopes

Map Unit Setting
National map unit symbol: 2pgbd
Elevation: 750 to 1,480 feet
Mean annual precipitation: 20 to 26 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 110 to 160 days

Farmland classification: All areas are prime farmland

Map Unit Composition

Bearden and similar soils: 55 percent
Overly and similar soils: 25 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Bearden

Setting

Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex
Across-slope shape: Linear
Parent material: Fine-silty glaciolacustrine deposits

Typical profile

Ap - 0 to 8 inches: silty clay loam
ABk - 8 to 15 inches: silty clay loam
Bk - 15 to 39 inches: silty clay loam
C - 39 to 79 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat poorly drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 18 to 42 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 40 percent
Gypsum, maximum content: 3 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Sodium adsorption ratio, maximum: 2.0
Available water capacity: High (about 10.9 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: C
Ecological site: R056XY087ND - Limy Subirrigated
Forage suitability group: Subirrigated (G056XY700ND)
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

Description of Overly

Setting

Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Fine-silty glaciolacustrine deposits

Typical profile

Ap - 0 to 10 inches: silty clay loam
Bw - 10 to 17 inches: silty clay loam
Bk - 17 to 38 inches: silty clay loam
C - 38 to 79 inches: silty clay loam

Properties and qualities

Slope: 0 to 2 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.14 to 1.42 in/hr)
Depth to water table: About 36 to 60 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 30 percent
Gypsum, maximum content: 2 percent
Maximum salinity: Nonsaline to slightly saline (0.0 to 4.0 mmhos/cm)
Available water capacity: High (about 10.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2c
Hydrologic Soil Group: C
Ecological site: R056XY088ND - Loamy Overflow
Forage suitability group: Overflow (G056XY500ND)
Other vegetative classification: Overflow (G056XY500ND)
Hydric soil rating: No

Minor Components

Kindred

Percent of map unit: 8 percent
Landform: Flats
Landform position (three-dimensional): Talf
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: R056XY095ND - Subirrigated
Other vegetative classification: Subirrigated (G056XY700ND)
Hydric soil rating: No

Perella

Percent of map unit: 7 percent
Landform: Depressions
Landform position (three-dimensional): Talf
Down-slope shape: Concave
Across-slope shape: Linear
Ecological site: R056XY102ND - Wet Meadow
Other vegetative classification: Wet (G056XY900ND)
Hydric soil rating: Yes

Bearden, moderately saline

Percent of map unit: 5 percent
Landform: Flats
Landform position (three-dimensional): Rise
Down-slope shape: Convex

Across-slope shape: Linear
Ecological site: R056XY089ND - Saline Lowland
Other vegetative classification: Saline (G056XY895ND)
Hydric soil rating: No

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APPENDIX B

As-Built Drawings

AREA OFFICE - GRAND FORKS

MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE

SPONSORING AGENCIES

EASTERN GRAND FORKS COUNTY SOIL CONSERVATION DISTRICT
WESTERN GRAND FORKS COUNTY SOIL CONSERVATION DISTRICT
NELSON COUNTY SOIL CONSERVATION DISTRICT
THREE RIVERS SOIL CONSERVATION DISTRICT
WALSH COUNTY SOIL CONSERVATION DISTRICT
WALSH COUNTY WATER MANAGEMENT DISTRICT

WITH ASSISTANCE BY
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

INDEX TO DRAWINGS

SHEET NO.	CONTENTS
1	COVER SHEET
2	LOCATION MAP RESERVOIR CAPACITY TABLE TABLE OF QUANTITIES DETAILS OF ANIMAL GUARDS
3 THRU 6	TOPOGRAPHIC MAP
7	PLAN VIEW OF DAM SITE
8	PROFILES ALONG CENTERLINE OF DAM AND EMERGENCY SPILLWAY LOG OF SOIL BORINGS
9	TYPICAL SECTIONS
10	FILL PLACEMENT DETAILS AND TYPICAL SECTIONS
11	FOUNDATION DRAIN DETAILS
12	PRINCIPAL SPILLWAY LAYOUT
13 THRU 15	DETAILS OF SAF OUTLET
16 THRU 21	DETAILS OF CHUTE
22 THRU 24	DETAILS OF TRANSITION
25 THRU 28	DETAILS OF CONDUIT
29	DETAILS OF PRINCIPAL SPILLWAY ANTISEEP COLLARS
30 THRU 34	DETAILS OF INLET
35	HIGH STAGE TRASH RACK
36	LOW STAGE TRASH RACK
37	DETAILS OF DRAWDOWN CONDUIT
38 AND 39	DETAILS OF DRAWDOWN INLET AND GATE
40	DETAILS OF EMERGENCY SPILLWAY DRIFT AND GRADE
BOTTOM SHEET	STANDARD DRAWING S.R.10.000.47

CONSTRUCTION BEGUN - AUGUST 21, 1975
CONSTRUCTION COMPLETED - NOVEMBER 15, 1978
CONTRACTOR - [illegible] CONSTRUCTION CO. WALHALLA, N.D.
PROJECT ENGINEER - ROBERT A. BIRD
PROJECT ENGINEER - JEAN M. SELTNESS
PROJECT INSPECTOR - STEPHEN W. HOVEY
PROJECT INSPECTOR - LAVERN L. JEFFERSON

BENCH MARK - USGS-WSAN-61 ELEV.-1152.02 M.S.L.
BM-A... CAP - SW CORNER OF NW¼ SEC. 5, T-154, R-55
BENCH-MARK CAP - 156' N.W. FROM N.W. CORNER OF RISER ELEV. - 1119.02 M.S.L.
BENCH-MARK CAP-104' LEFT OF LOW WATER CT 16+75 ELEV. - 1116.38 M.S.L.

AS BUILT
NOV 15 1978
AS-BUILT

SOIL CONSERVATION SERVICE

WE CERTIFY THAT THE PLANS AND DETAILED SPECIFICATIONS FOR THIS PROJECT WERE DEVELOPED BY THE SOIL CONSERVATION SERVICE AND ARE APPROVED.

Clinton P. Johnson — 1-10-74
STATE CONSERVATION ENGINEER — DATE

HEAD, ENGINEERING AND WATERSHED PLANNING UNIT — 5-2-75 DATE

Sheet 1 of 40

5,E-29,772

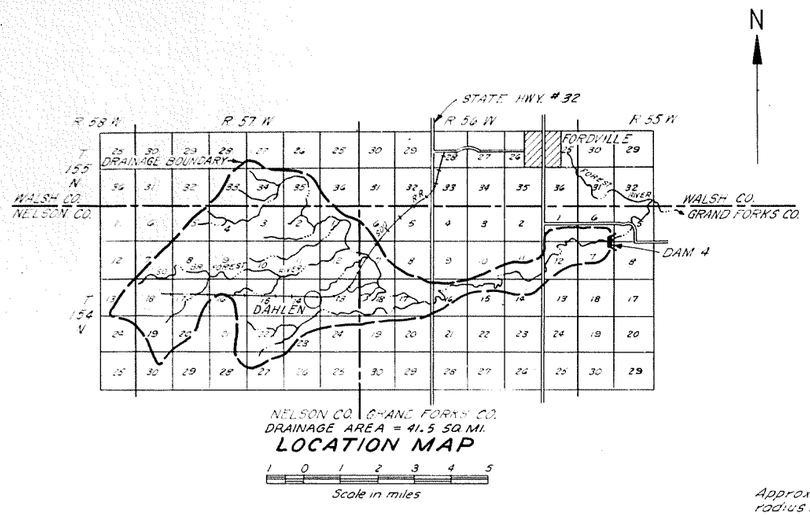
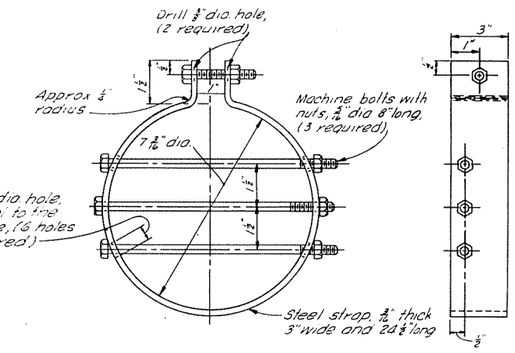


TABLE OF QUANTITIES

ITEM		UNIT	QUANTITY	AS-BUILT QUANTITY
CLEARING (212.6 ACRES)		ACRES	212.6	212.6
CLEARING AND GRUBBING (7 ACRES)		ACRES	7.0	7.0
EXCAVATION: COMMON	EMERGENCY SPILLWAY	CU.YD.	292,960	
	INLET CHANNEL	CU.YD.	71	57.3
	CUTOFF TRENCH	CU.YD.	17,300	16,746.9
	OUTLET CHANNEL	CU.YD.	8,236	7,695.3
	STRUCTURAL	CU.YD.	1,476	0
	DEBRIS BASIN	CU.YD.	530	2198.8
	CONDUIT TRENCH	CU.YD.	1,330	5,917.0
EARTH FILL. CLASS A. ZONE 1		CU.YD.	70,590	92,986.1
EARTH FILL. CLASS A.		CU.YD.	246,100	236,847.6
DIVERSIONS		LIN.FT.	600	240.
DRAIN FILL		CU.YD.	750	849.3
CONCRETE. CLASS 4000		CU.YD.	527.9	528.3
STEEL REINFORCEMENT		LB.	73,734	74,000.
REINFORCED CONCRETE PRESSURE PIPE. 24" DIA.		LIN.FT.	51.25	51.25
ASBESTOS-CEMENT PIPE. 6" DIA.. CLASS 150 WITH FITTINGS		LIN.FT.	78	78
ASBESTOS-CEMENT PIPE. 6" DIA.. CLASS 150. PERFORATED		LIN.FT.	310	310
ASBESTOS-CEMENT PIPE. 8" DIA.. CLASS 150 WITH FITTINGS		LIN.FT.	78	78
ASBESTOS-CEMENT PIPE. 8" DIA.. CLASS 150. PERFORATED		LIN.FT.	440	440
LOOSE ROCK RIPRAP WITH BEDDING		CU.YD.	5,479	5,690.8
WATER CONTROL GATE AND APPURTENANCES		EACH	1	1
TRASH RACKS (3 REQUIRED)		LUMP SUM		LUMP SUM
SALVAGING AND SPREADING TOPSOIL		SQ.YD.	86,400	151,408.0
SALVAGING AND SPREADING TOPSOIL. BORROW AREA C		SQ.YD.	87,000	76,288.9
24" DIA.. C.M. PIPE. 0.079" WALL THICKNESS. ASBESTOS-BONDED. ASPHALT-COATED		LIN.FT.	34	34.0
SEEDING (INCLUDING MULCHING AND FERTILIZING)		ACRES	41.0	50.4
CHAIN LINK FENCE		LIN.FT.	112.0	112.0
SEEDING		ACRES	17.0	15.8
HAUL ROAD		LUMP SUM		LUMP SUM
12" DIA. CAST IRON RING AND GRATING		EACH	1	1
12" DIA. CORRUGATED METAL PIPE RISER WITH 4" X 12" DIA. C.M.P. STUB		LUMP SUM		LUMP SUM
12" DIA. C.M. PIPE. 0.064" WALL THICKNESS. ASBESTOS-TREATED. ASPHALT-COATED		LIN.FT.	198.0	198.0
12" DIA. PERFORATED C.M. PIPE. 0.064" WALL THICKNESS. ASBESTOS-TREATED. ASPHALT COATED		LIN.FT.	68.0	68.0
SOIL-CEMENT		CU.YD.	2,460	2,456.0
CEMENT (FOR SOIL-CEMENT)		BAG	8,610	8,956.0
DRAIN FILL (ABUTMENT DRAIN)		TONS		119.9
JUTE MESH (WATERWAY)		LIN. FT.		100.



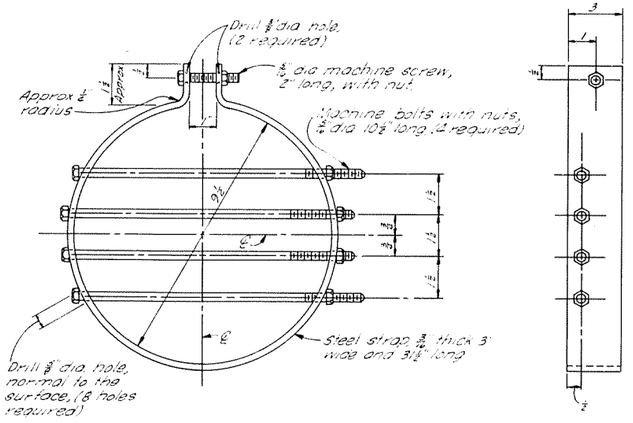
ANIMAL GUARD FOR 6"DIA. ASBESTOS CEMENT OUTLET DRAIN PIPE

RESERVOIR CAPACITY TABLE

	ELEVATION	AREA-ACRES	STORAGE ACRE FEET	ACCUM. STORAGE ACRE FEET
	1080.0	0.00	0.00	0.00
	1085.0	29.39	73.47	73.47
APPROX. DRAWDOWN	1090.0	57.15	216.35	289.82
	1095.0	107.86	412.53	702.35
	1100.0	144.16	630.05	1,332.40
F.E. OF ORIFICE	1105.0	197.12	853.20	2,185.60
	1107.0	218.46	415.58	2,601.18
	1110.0	250.48	703.41	3,304.59
	1115.0	322.38	1,432.15	4,736.74
CREST OF INLET	1116.5	342.33	498.53	5,235.27
	1117.0	348.98	172.83	5,408.10
	1117.5	355.63	176.15	5,584.25
	1118.0	362.28	179.48	5,763.73
	1118.5	368.93	182.80	5,946.53
	1119.0	375.58	186.13	6,132.66
	1119.5	382.23	189.45	6,322.11
	1120.0	388.88	192.78	6,514.89
CREST OF EMERG. SPLWY.	1122.7	433.81	1,117.38	7,632.27
	1123.0	438.81	124.15	7,756.42
	1125.0	472.10	910.91	8,667.33
	1130.0	538.83	2,527.33	11,194.66

TABLE OF QUANTITIES

ITEM NO.	ITEM	UNIT	QUANTITY
1	HEX. HEAD MACHINE SCREW. 5/16" DIA.. 2" LONG WITH NUT	EACH	1
2	MACHINE BOLT. 5/16" DIA.. 8" LONG. WITH NUTS	EACH	3
3	STEEL STRAP. 3/16" X 3"	IN.	24 1/2



ANIMAL GUARD FOR 8"DIA. ASBESTOS CEMENT OUTLET DRAIN PIPE

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
HEX. HEAD MACHINE SCREW. 5/16" DIA.. 2" LONG WITH NUT	EACH	1
MACHINE BOLT. 5/16" DIA.. 10 1/2" LONG. WITH NUTS	EACH	4
STEEL STRAP. 3/16" X 3" - 31 1/2" LONG	EACH	1

AS BUILT

NOV 15 1978

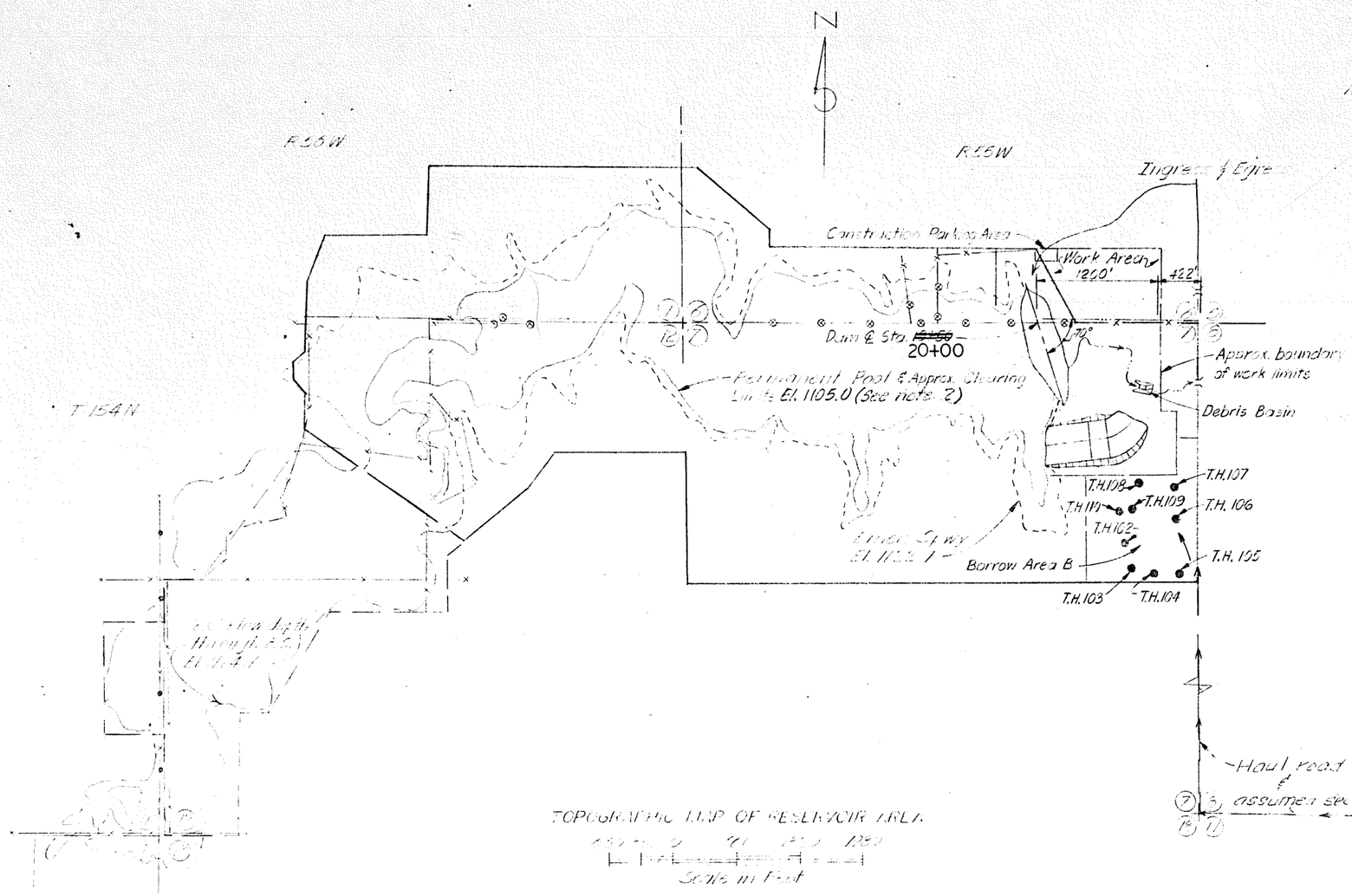
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S. E.J.P.	Date 12-71	Approved by	
Drawn		Title	
Traced		Title	
Checked		Sheet No. 2 of 40	Drawing No. 5E-29,772



NOTES:

1. All fences within the permanent pool shall be removed.
2. Clearing - Clear all areas upstream from dam below elevation 1107.0
3. Salvaging topsoil - Strip the topsoil from required excavation and borrow areas and stock pile in locations approved by engineer.
4. Debris basin shall be constructed prior to stripping of dam foundation or emergency spillway.
5. Construct debris basin with 3:1 side slopes, 100.0' bottom length, 20.0' bottom width and a depth of 4.0'. Exact location will be determined by engineer.
6. Dam & Sta. ~~19+55~~ 20+00 is tied to survey stake in proximity of section corner as follows; turn 70° left of forward line for a distance of 1200', turn 1° right for a distance of 422' to survey stake. Turn 91°40' left off foward line to the assumed north-south section line.

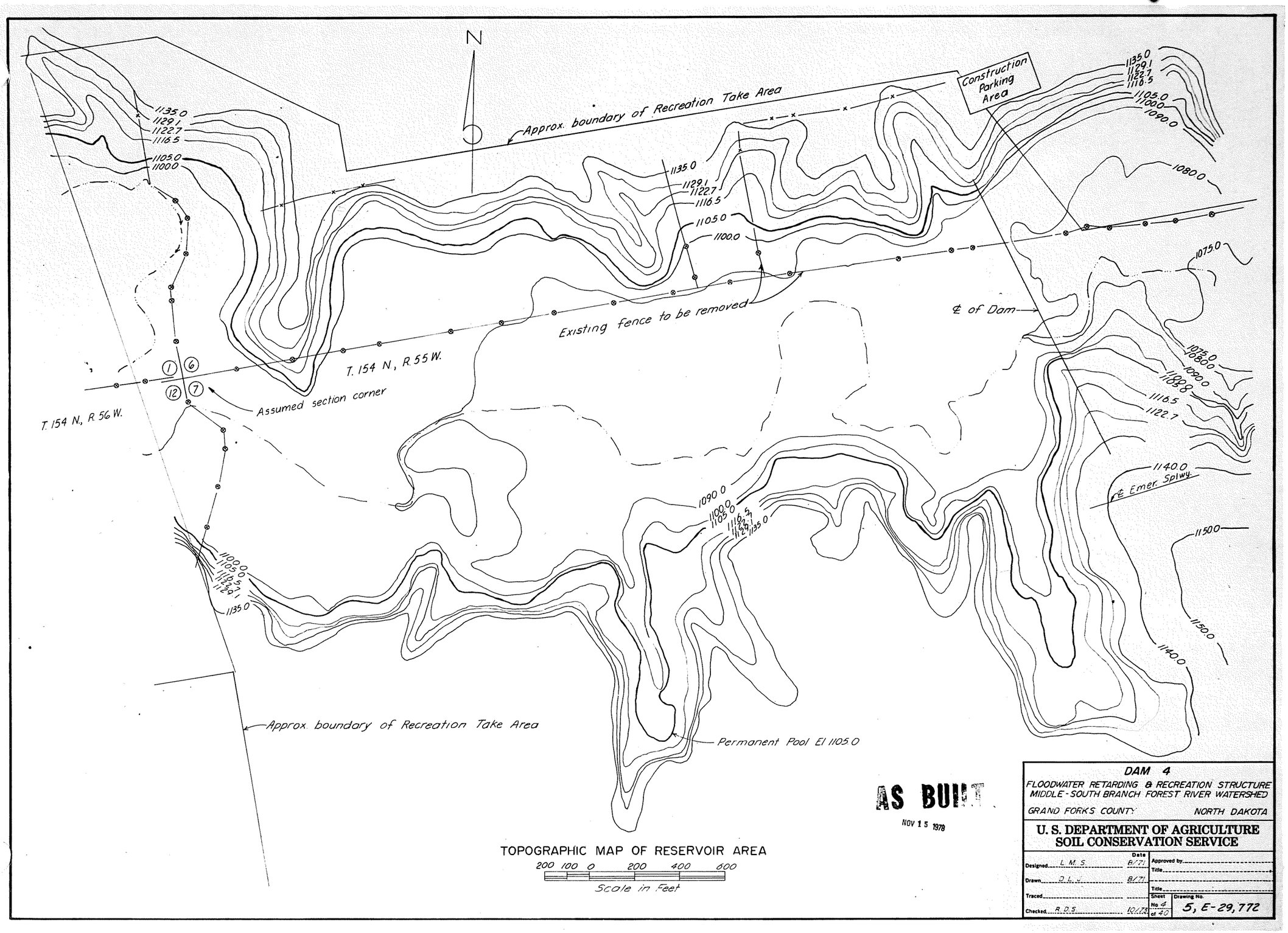
AS BUILT
NOV 15 1978

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No. 3 of 40	Drawing No. 5, E-29, 772

SCS-313 (9-64)



TOPOGRAPHIC MAP OF RESERVOIR AREA

200 100 0 200 400 600

Scale in Feet

AS BUILT

NOV 15 1978

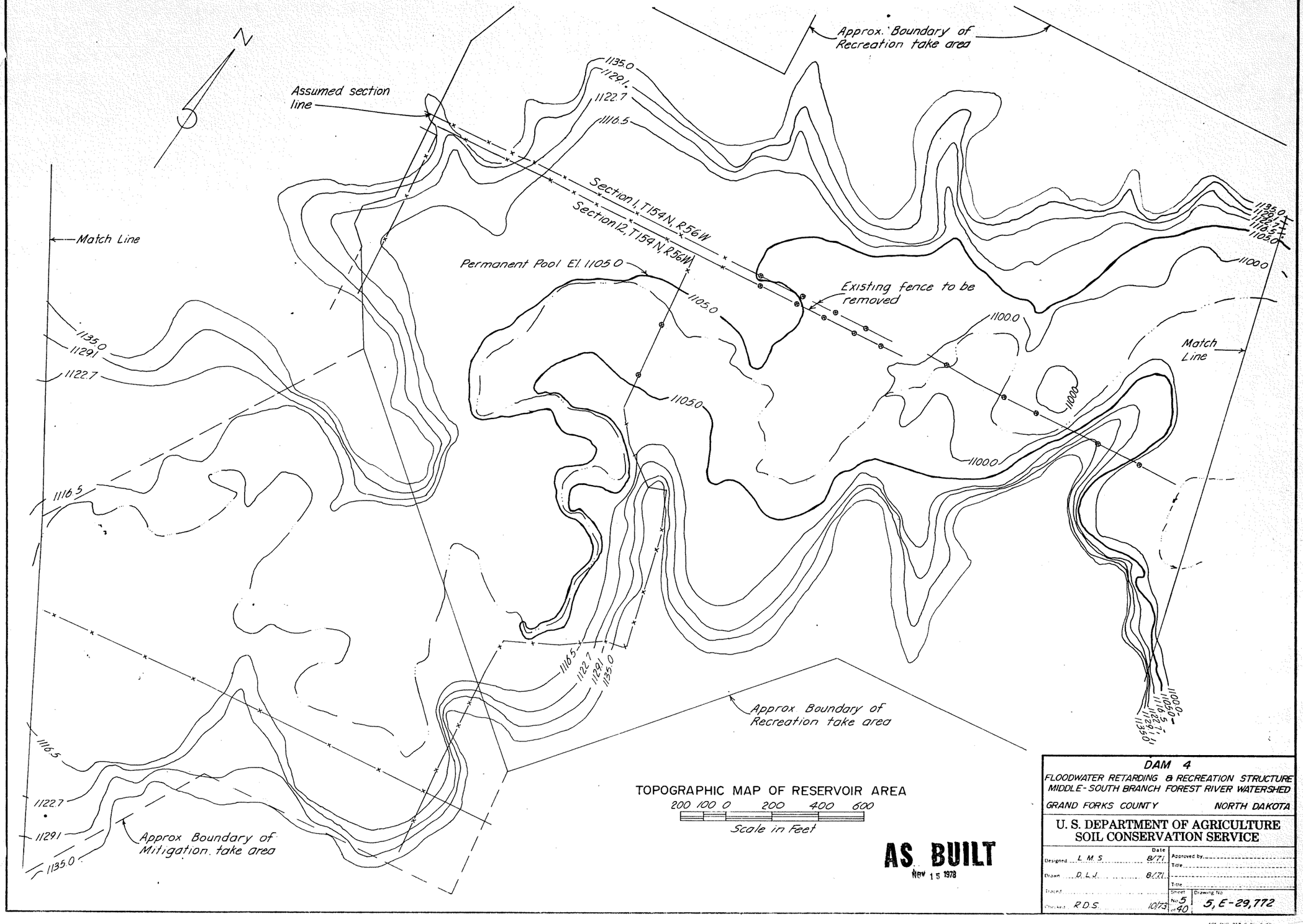
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	L. M. S.	8/71	Approved by
Drawn	D. L. V.	8/71	Title
Traced			Title
Checked	R. D. S.	10/73	Sheet No. 4 of 40 — Drawing No. 5, E-29,772



DAM 4

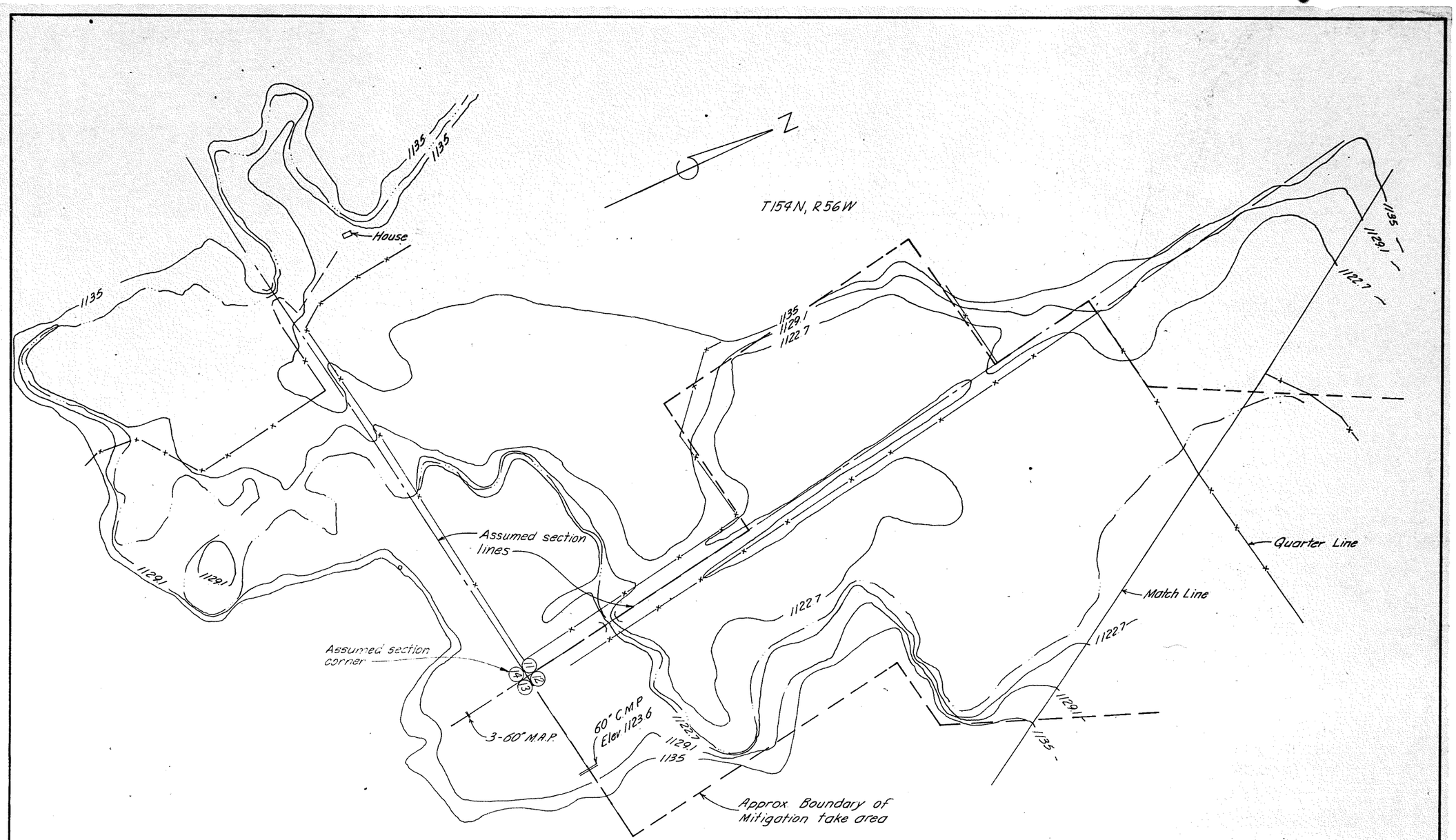
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S.	8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked R.D.S.	10/73	Sheet No. 5 of 40	Drawing No. 5, E-29,772

SCS-ENG-313-C Rev. 5-59



TOPOGRAPHIC MAP OF RESERVOIR AREA

200 100 0 200 400 600

Scale in Feet

AS BUILT

NOV 15 1978

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L. M. S	Date 8/71	Approved by	
Drawn D. L. J.	8/71	Title	
Traced		Title	
Checked R. D. S.	10/73	Sheet No. 6 of 40	Drawing No. 5, E-29,772

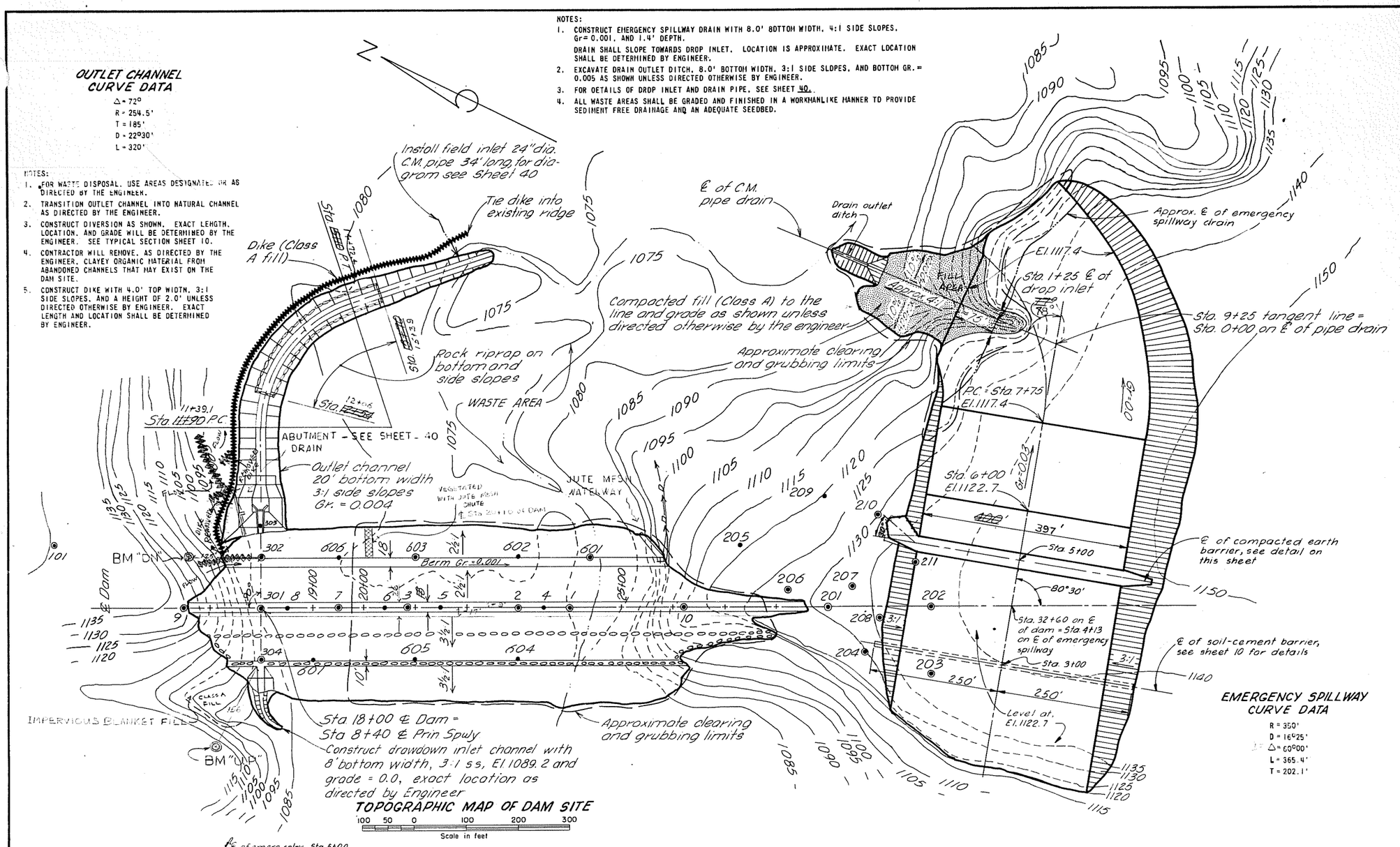
SCS-ENG-313-C Rev. 5-69

OUTLET CHANNEL CURVE DATA

Δ = 72°
R = 254.5'
T = 185'
D = 22°30'
L = 320'

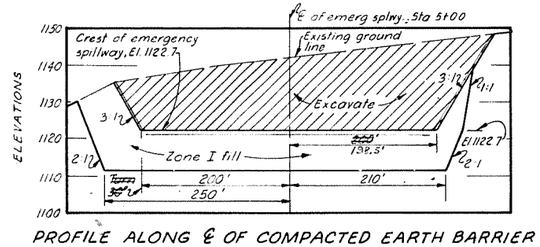
NOTES:
1. FOR WASTE DISPOSAL, USE AREAS DESIGNATED OR AS DIRECTED BY THE ENGINEER.
2. TRANSITION OUTLET CHANNEL INTO NATURAL CHANNEL AS DIRECTED BY THE ENGINEER.
3. CONSTRUCT DIVERSION AS SHOWN. EXACT LENGTH, LOCATION, AND GRADE WILL BE DETERMINED BY THE ENGINEER. SEE TYPICAL SECTION SHEET 10.
4. CONTRACTOR WILL REMOVE, AS DIRECTED BY THE ENGINEER, CLAYEY ORGANIC MATERIAL FROM ABANDONED CHANNELS THAT MAY EXIST ON THE DAM SITE.
5. CONSTRUCT DIKE WITH 4.0' TOP WIDTH, 3:1 SIDE SLOPES, AND A HEIGHT OF 2.0' UNLESS DIRECTED OTHERWISE BY ENGINEER. EXACT LENGTH AND LOCATION SHALL BE DETERMINED BY ENGINEER.

NOTES:
1. CONSTRUCT EMERGENCY SPILLWAY DRAIN WITH 8.0' BOTTOM WIDTH, 4:1 SIDE SLOPES, Gr = 0.001, AND 1.4' DEPTH.
   DRAIN SHALL SLOPE TOWARDS DROP INLET. LOCATION IS APPROXIMATE. EXACT LOCATION SHALL BE DETERMINED BY ENGINEER.
2. EXCAVATE DRAIN OUTLET DITCH, 8.0' BOTTOM WIDTH, 3:1 SIDE SLOPES, AND BOTTOM GR. = 0.005 AS SHOWN UNLESS DIRECTED OTHERWISE BY ENGINEER.
3. FOR DETAILS OF DROP INLET AND DRAIN PIPE, SEE SHEET 40.
4. ALL WASTE AREAS SHALL BE GRADED AND FINISHED IN A WORKMANLIKE MANNER TO PROVIDE SEDIMENT FREE DRAINAGE AND AN ADEQUATE SEEDBED.

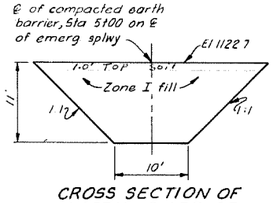


TOPOGRAPHIC MAP OF DAM SITE

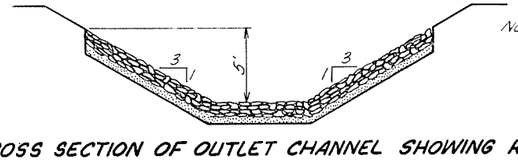
100 50 0 100 200 300
Scale in feet



PROFILE ALONG ℄ OF COMPACTED EARTH BARRIER



CROSS SECTION OF EARTH BARRIER



CROSS SECTION OF OUTLET CHANNEL SHOWING RIPRAP

Note: Place rock riprap 10" thick plus 0.5' bedding material, measured vertically.

DETAILS OF COMPACTED EARTH BARRIER

EMERGENCY SPILLWAY CURVE DATA

R = 350'
D = 16°25'
Δ = 60°00'
L = 365.4'
T = 202.1'

AS BUILT
NOV 15 1978

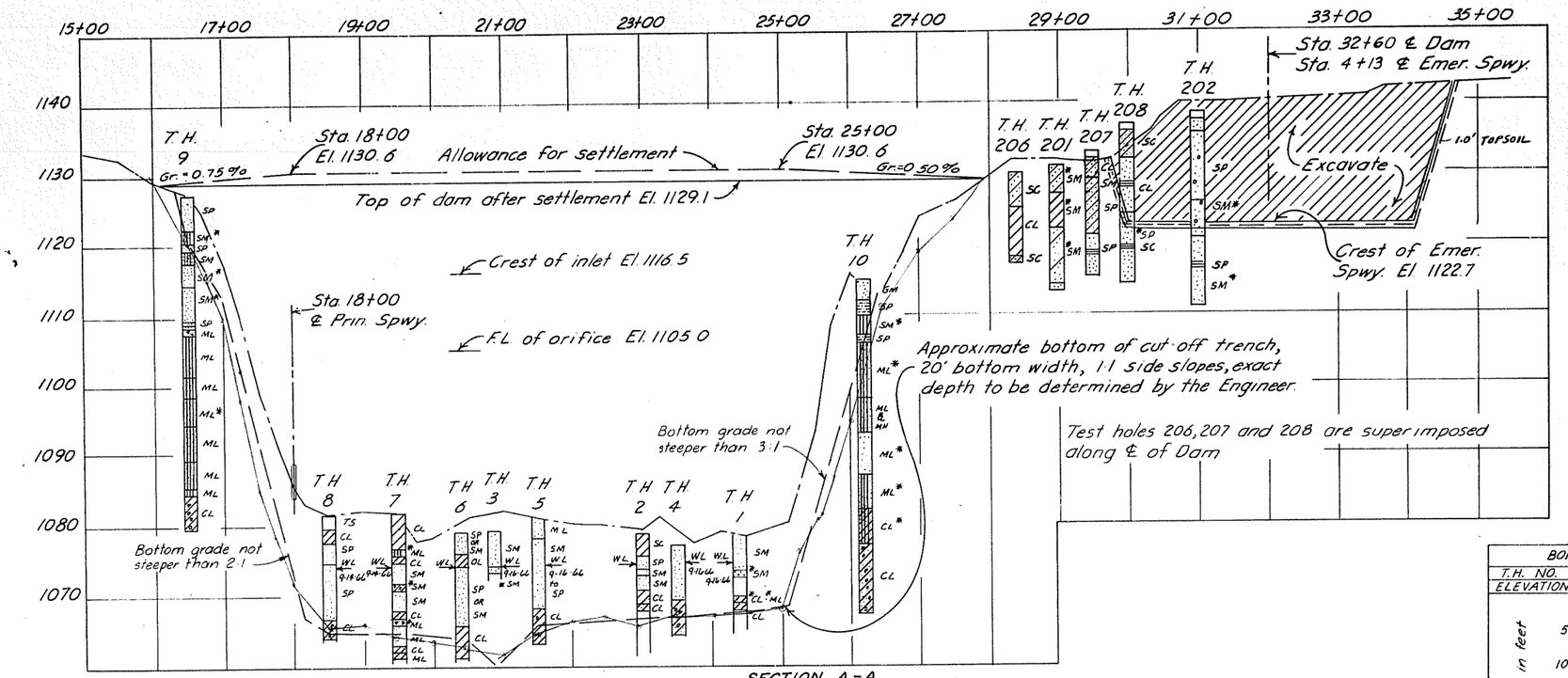
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	L M S	8/71
Drawn	D L J	8/71
Traced		
Checked	C E M	10/71

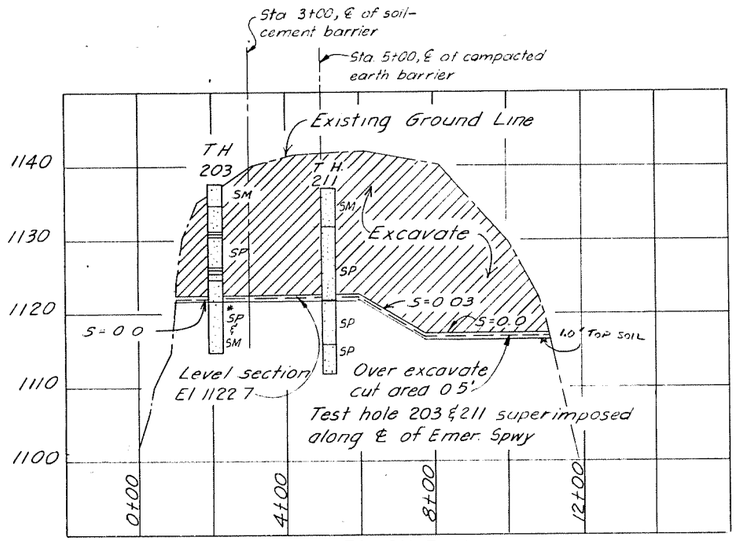
Approved by:
Title:
Title:
Sheet No. 7 of 40
Drawing No. 5, E-29,772

SCS-313 (9-64)-C



SECTION A-A

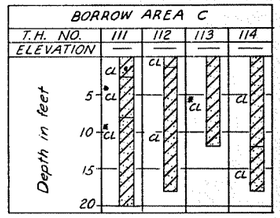
PROFILE ALONG & OF DAM

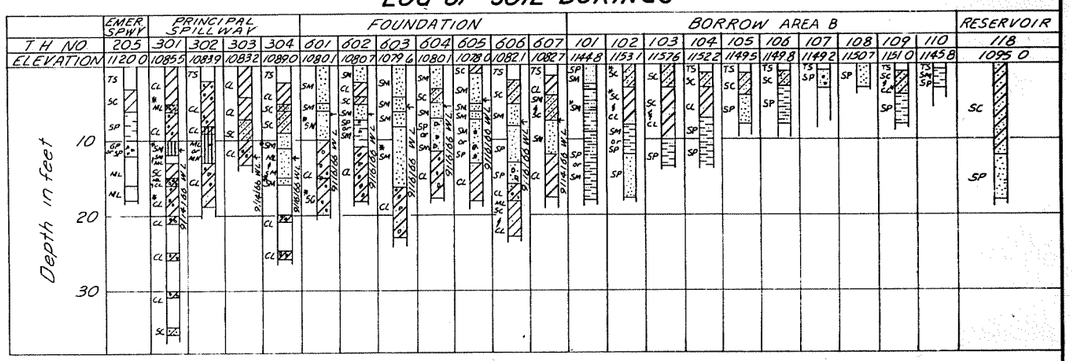


SECTION B-B

PROFILE ALONG & OF EMERGENCY SPILLWAY

LOG OF SOIL BORINGS





AS BUILT

NOV 15 1978

Notes

1. For soils legend and symbols, see standard drawing 5, R-10,000 47.
2. Soil Exploration date Sept 14, 1966
3. → indicates groundwater at time of exploration
4. The Unified Soil Classification symbols followed by an asterisk are based on laboratory classification. Those symbols without an asterisk are based on field classification and are subject to revision based on laboratory test
5. Over excavate cut area of Emergency Spillway 0.5': Backfill with select topsoil material
6. TS = topsoil

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE

MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY — NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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Drawn D.L.J.	8/71	Title	
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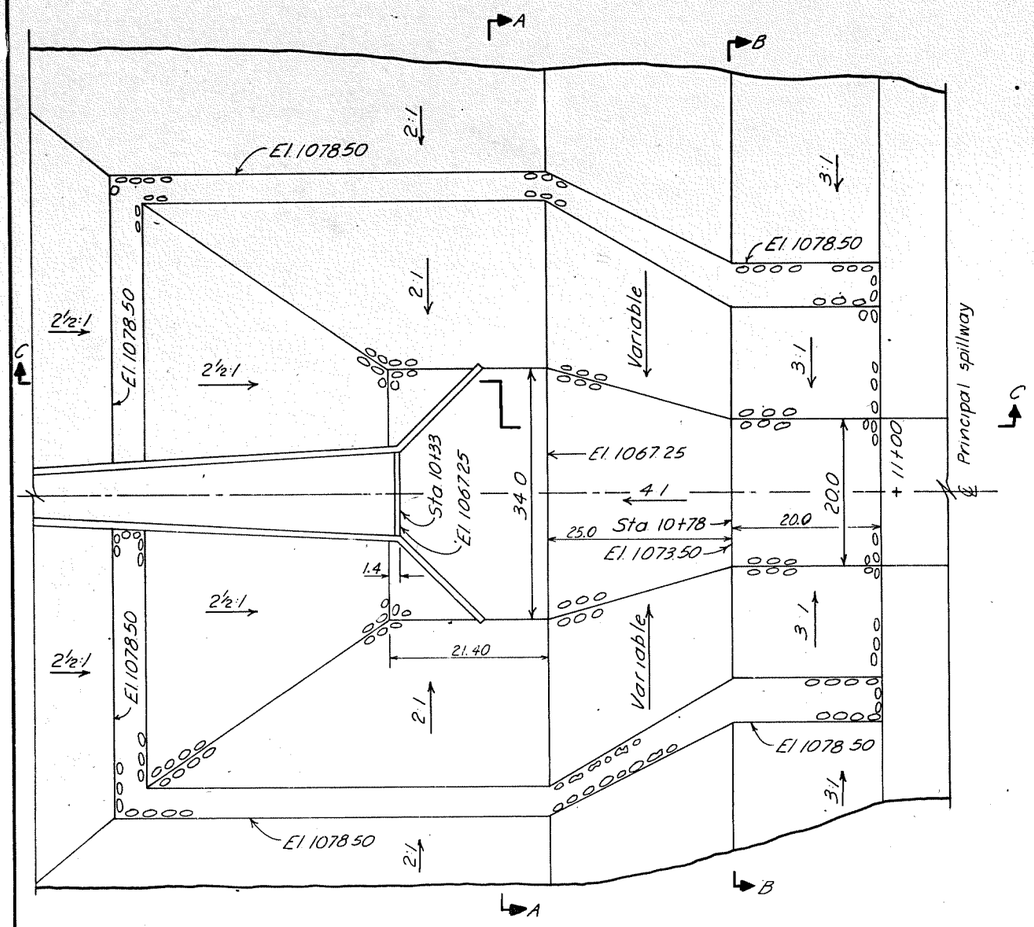
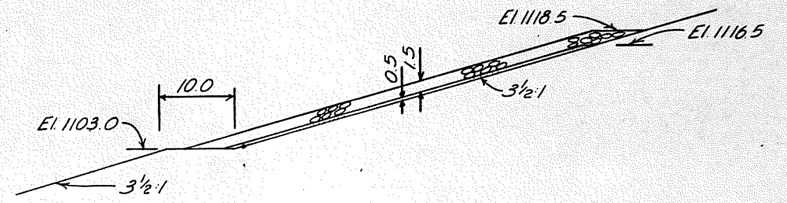
Checked C.E.M.	10/71	Sheet No. 8 of 40	Drawing No. 5,E-29,772

SCS-313 (9-64) -C

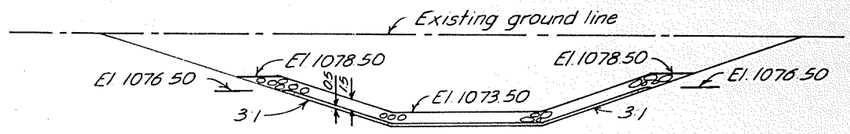


PLAN VIEW OF PRINCIPAL SPILLWAY OUTLET

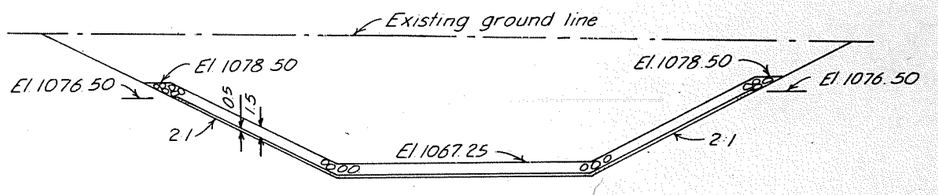


DETAIL OF ROCK RIPRAP & BEDDING ON UPSTREAM SLOPE

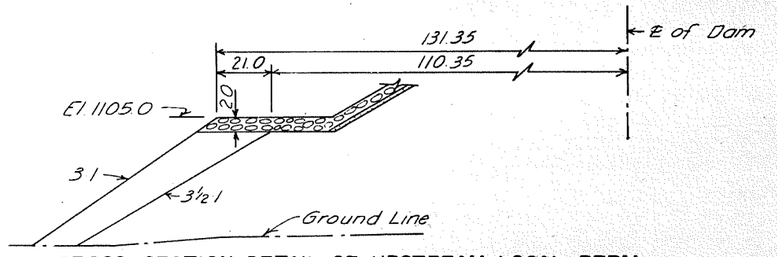
Note: Allowance for settlement not shown



SECTION B-B

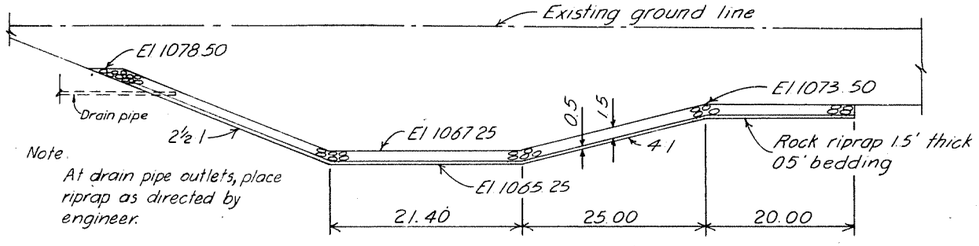


SECTION A-A



CROSS-SECTION DETAIL OF UPSTREAM LOCAL BERM

Not to scale



SECTION C-C

AS BUILT

NOV 15 1978

DAM 4

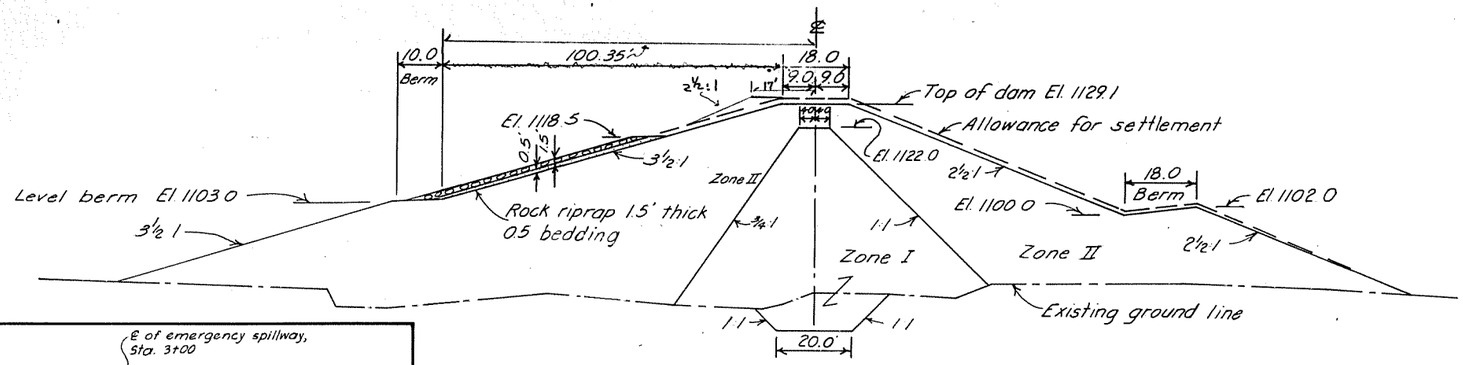
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

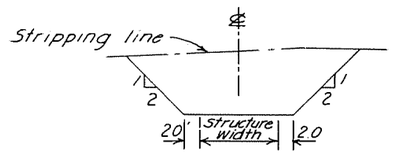
		Date	
Designed	L.M.S.	8/71	Approved by
Drawn	D.L.J.	8/71	Title
Traced			Title
Checked	C.E.M.	10/71	Sheet No. 9 of 40 — Drawing No. 5,E-29,772

SCS-313 (9-64) -C

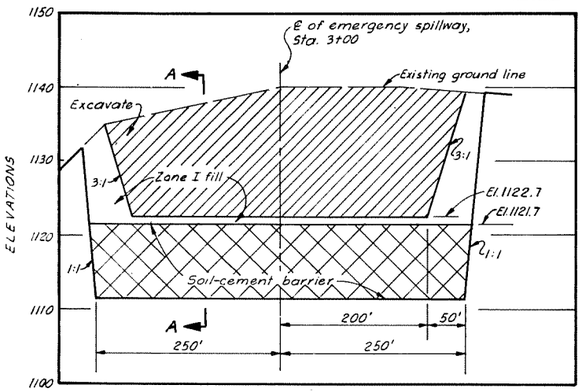


STATION 24+50
MAXIMUM CROSS SECTION OF DAM

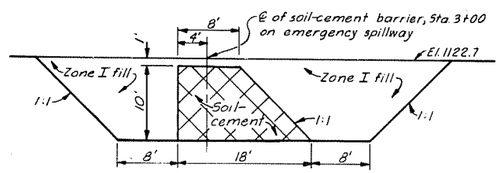
20 0 20 40
Scale in feet



TYPICAL SECTION - STRUCTURE EXCAVATION
BOX CONDUIT AND SAF

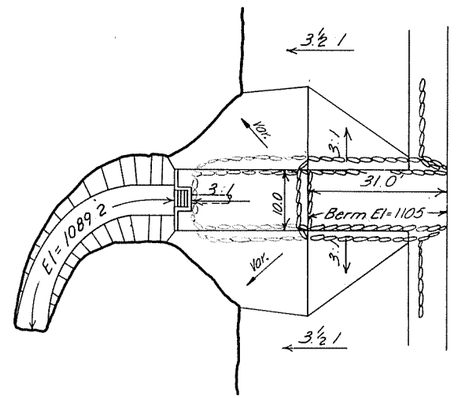


PROFILE ALONG ℄ OF SOIL-CEMENT BARRIER

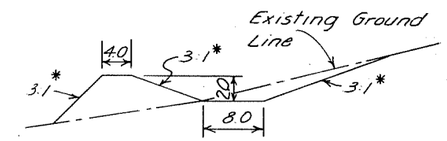


SECTION A-A

DETAILS OF SOIL-CEMENT BARRIER



PLAN VIEW OF UPSTREAM
LOCAL BERM AT RISER



TYPICAL CROSS-SECTION OF DIVERSION

* SIDE SLOPES WILL BE AS SHOWN UNLESS DIRECTED OTHERWISE BY THE ENGINEER.

EMBANKMENT MATERIAL SOURCES AND PLACEMENT REQUIREMENT

SOURCE OF MATERIAL				PLACEMENT AND MOISTURE DENSITY REQUIREMENT							
LOCATION	APPROX. DEPTH (FT.) FROM	TO	UNIFIED SOIL CLASSIFICATION	DEPTH OF LIFT	MAX. SIZE ROCK FRAGMENTS	FILL MATRIX SIZE TESTED	COMPACTION CLASS	REFERENCE TEST METHOD	REQ'D. (%) COMPACTION	ALLOWABLE MOISTURE RANGE FROM OPTIMUM(%)	FILL LOCATION
BORROW C	1	18	CL	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE I
EMERGENCY SPILLWAY	3	23	SM & SP	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
BORROW B	3	13	SM	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
EMERGENCY SPILLWAY	0	5	SC	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II

LABORATORY TEST INFORMATION ON TYPICAL MATERIALS

UNIFIED SOIL CLASSIFICATION	TEST HOLE III CL	TEST HOLE 201 SM	TEST HOLE 102 SC	TEST HOLE 109 CL
REFERENCE TEST METHOD	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698
MAXIMUM DRY DENSITY	106.0 P.C.F.	103.0 P.C.F.	98.0 P.C.F.	91.0 P.C.F.
OPTIMUM MOISTURE	13.0%	20.0%	21.5%	25.0%
DESCRIPTION	GLACIAL TILL	DELTA SEDIMENTS	DELTA SEDIMENTS	DELTA SEDIMENTS

NOTES:

1. LABORATORY TEST DATA ON THE SOIL INVESTIGATION IS AVAILABLE AT THE SCS WATERSHED OFFICE IN GRAFTON, NORTH DAKOTA.
2. FOR SOIL LEGEND AND SYMBOLS, SEE STANDARD DRAWING NO. 5-R-10.000.47.
3. MORE PLASTIC MATERIAL EXCAVATED FROM EMERGENCY SPILLWAY AND BORROW B IS TO BE SELECTIVELY PLACED ADJACENT TO THE UPSTREAM PORTION OF ZONE I. IN THE COMPACTED EARTH BARRIER AND ADJACENT TO THE SOIL-CEMENT BARRIER.
4. DO NOT BORROW CLOSER THAN 100' FROM BASE OF DAM UNLESS DIRECTED OTHERWISE BY THE ENGINEER IN THE FIELD.

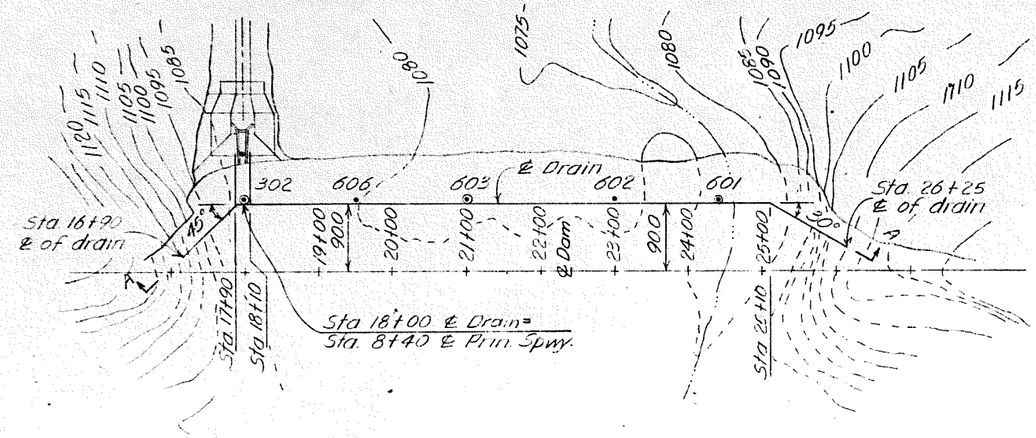
AS BUILT
NOV 15 1978

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No. 10 of 40	Drawing No. 5,E-29,772

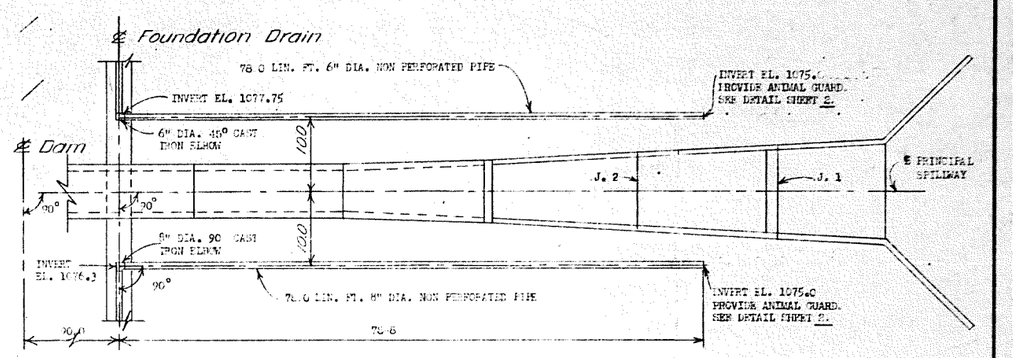
SCS-312-10-A41

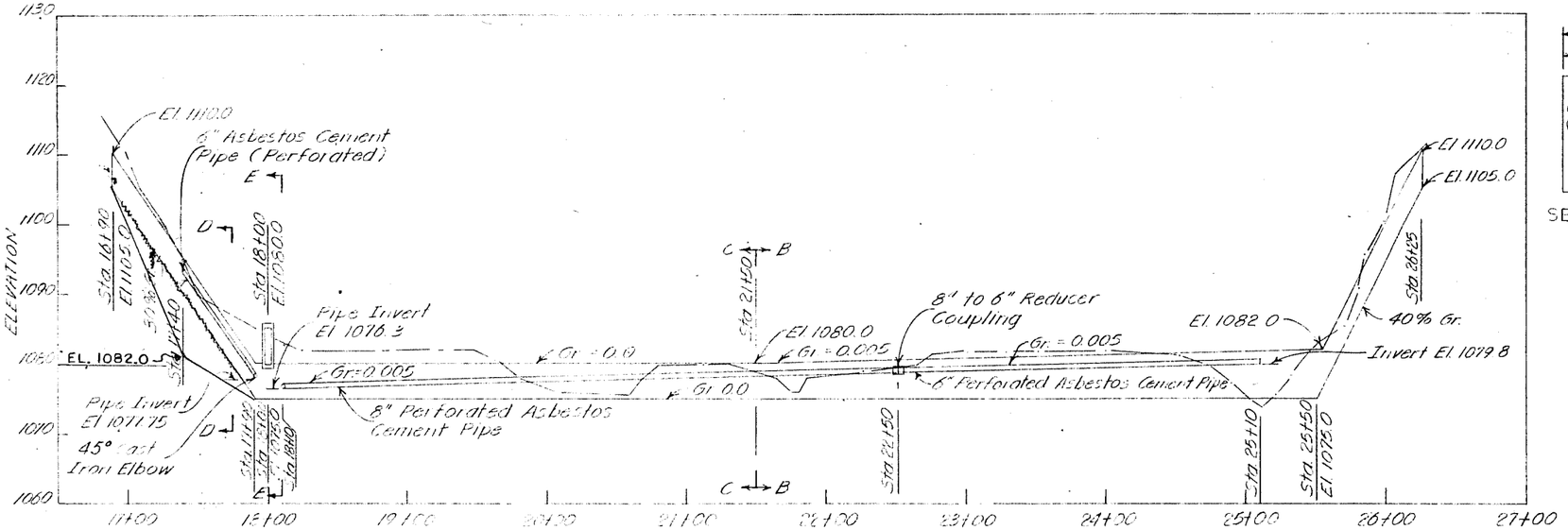


PLAN OF BASE OF DAM SHOWING FOUNDATION DRAIN

100 50 0 100 200 300

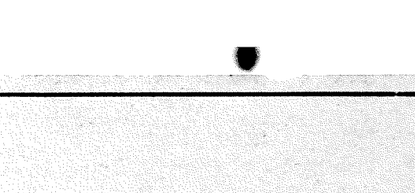
Scale in Feet



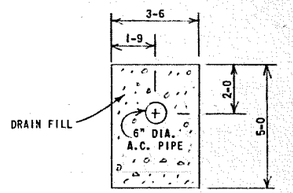


SECTION A-A

PROFILE ALONG ℄ OF TRANSVERSE FOUNDATION DRAIN



SECTION B-B SECTION C-C



SECTION D-D

AS BUILT

NOV 15 1978

NOTES:

1. PROVIDE ANIMAL GUARD AT OUTLET END OF OUTLET PIPES. FOR DETAILS OF ANIMAL GUARDS, SEE SHEET 2.
2. PLUG UPPER END OF PIPES WITH 6" OF CONCRETE OR PREFABRICATED CAP.
3. THE DEPTH OF FILL OVER THE DRAIN PIPE SHALL BE AT LEAST 2' BEFORE PASSING HEAVY EQUIPMENT OVER THE PIPE.
4. WHERE THE TRANSVERSE DRAIN TRENCH IS ABOVE THE GROUND LINE, PLACE COMPACTED EARTH FILL TO ELEVATION AT TOP OF DRAIN AND EXCAVATE DRAIN IN COMPACTED FILL.
5. STA. 17+90 THRU STA. 25+10 OF THE DRAIN CENTERLINE COINCIDE WITH STA. 17+90 THRU 25+10 OF THE DAM CENTERLINE.
6. PLACE TWO LAYERS OF ROOFING FELT UNDER THE PRINCIPAL SPILLWAY CONDUIT AT ITS INTERSECTION WITH THE FOUNDATION DRAIN.
7. DRAIN PIPE WILL OUTLET THROUGH RIPRAP. PLACE RIPRAP AROUND OUTLET AS DIRECTED BY ENGINEER.

DRAIN FILL GRADATION

SIEVE SIZE	PERCENT PASSING
3"	100
1"	90 - 100
#4	45 - 70
#10	10 - 50
#16	0 - 35
#40	5

QUANTITIES

ITEM	UNIT	QUANTITY
DRAIN FILL MATERIAL	CU.YD.	660
8" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	440
8" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
6" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	310
6" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
8" DIA. 90° CAST IRON ELBOW	EACH	1
6" DIA. 45° CAST IRON ELBOW	EACH	1
8" TO 6" DIA. REDUCER COUPLING	EACH	1

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE

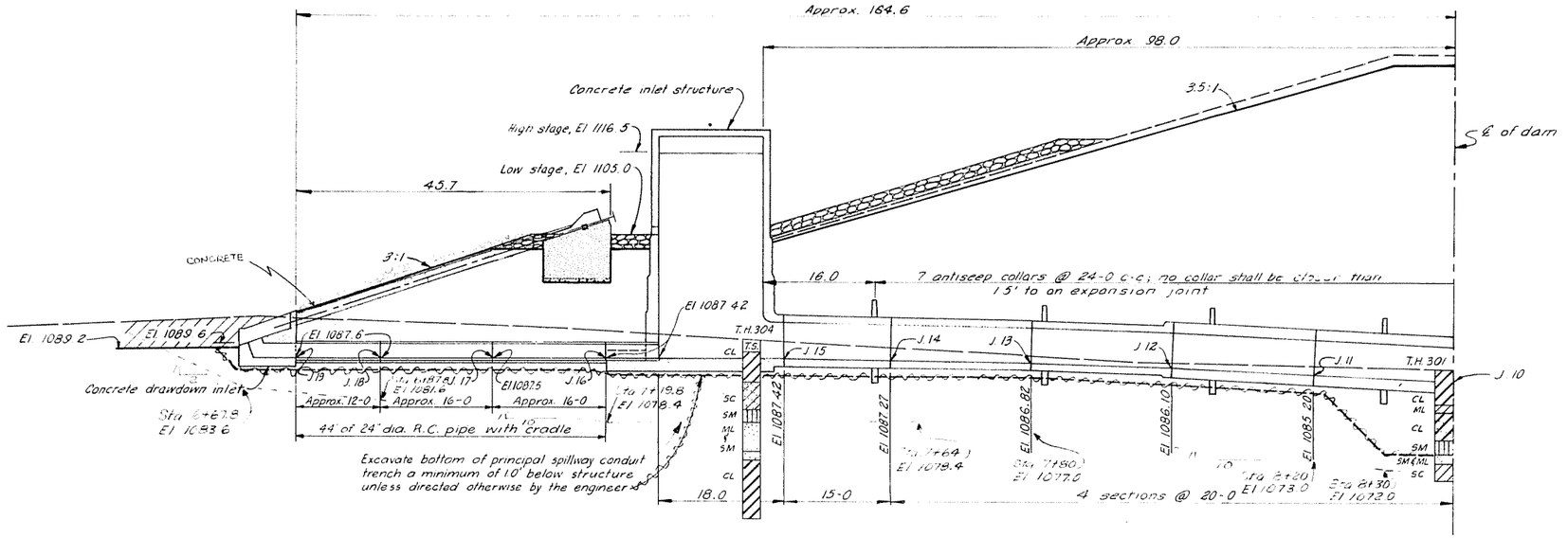
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	L.M.S.	9/71	Approved by	
Drawn	D.L.J.	12/71	Title	
Traced			Title	
Checked	C.E.M.	12/71	Sheet No. 11 of 40	Drawing No. 5-E-29,772

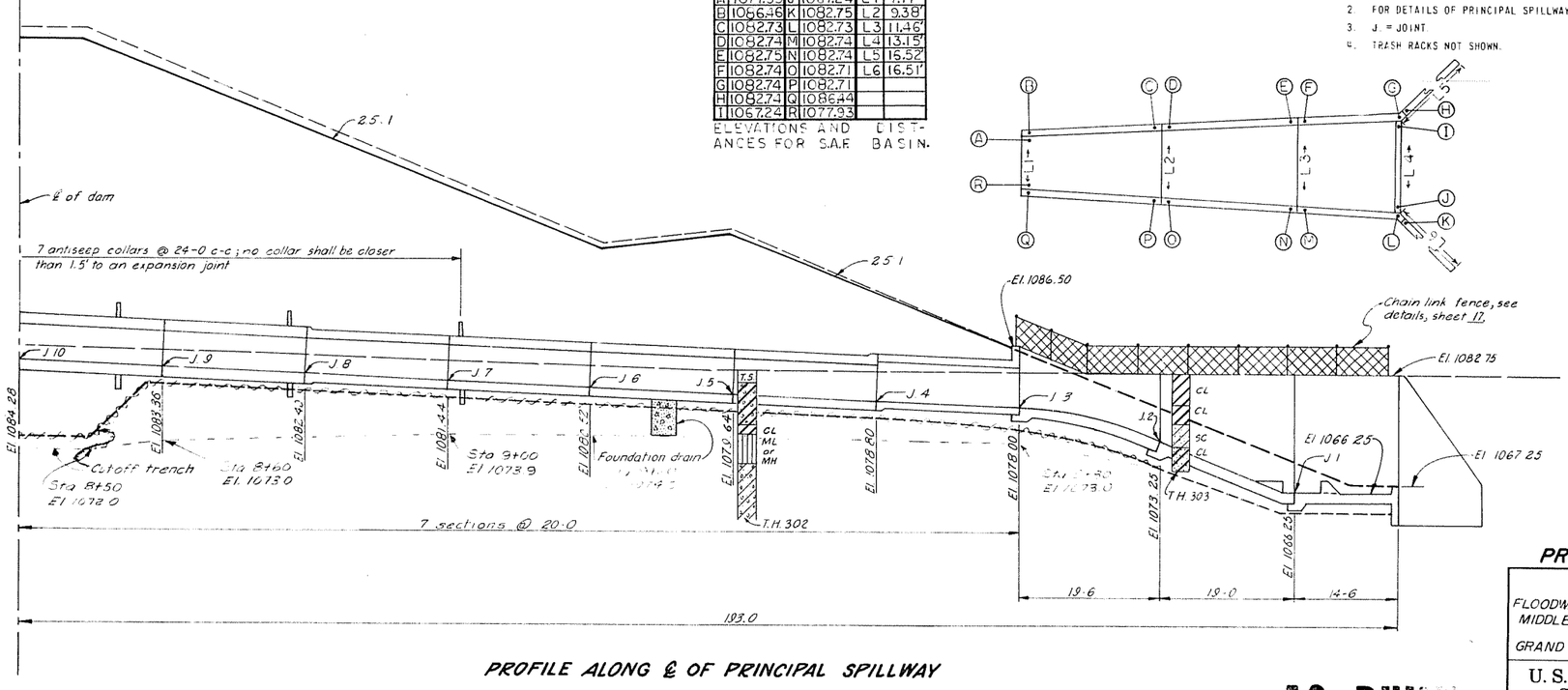
SCS-ENG-21-B Rev. 7-69



A	1077.95	J	1067.24	L1	7.17'
B	1066.46	K	1082.75	L2	9.38'
C	1082.73	L	1082.73	L3	11.46'
D	1082.74	M	1082.74	L4	13.15'
E	1082.75	N	1082.74	L5	16.52'
F	1082.74	O	1082.71	L6	16.51'
G	1082.74	P	1082.71		
H	1082.74	Q	1086.44		
I	1067.24	R	1077.93		

ELEVATIONS AND DISTANCES FOR S.A.E. BASIN.

NOTES:
1. FOR DETAILS OF DRAWDOWN WORKS, SEE SHEETS 37 TO 39
2. FOR DETAILS OF PRINCIPAL SPILLWAY CONDUIT, SEE SHEETS 25 TO 28
3. J. = JOINT.
4. TRASH RACKS NOT SHOWN.



JOINT	BEFORE FILL		AFTER FILL	
	US	DS	US	DS
J. 4		1075.69	1078.64	
J. 5	1080.00		1079.54	1079.44
J 6	1080.49	1080.40	1080.37	1080.28
J 7		1081.35	1081.30	1081.20
J. 8		1082.21	1082.05	1082.01
J. 9	1081.45		1083.06	1082.90
J.10	1084.20	1084.09	1083.82	1083.74
J.11	1085.09	1085.02	1084.68	1084.63
J.12	1085.91	1085.82	1085.57	1085.47
J.13	1086.72	1086.64	1086.46	1086.38
J.14	1087.20	1087.14	1087.02	1086.96
J.15		1087.36	1087.20	1087.21

NOTE: ELEVATIONS WERE TAKEN ONE FOOT UPSTREAM, AND ONE FOOT DOWNSTREAM FROM EACH JOINT. MEASUREMENTS WERE TAKEN ABOVE BATTER.

REVISED 1-75

PROFILE ALONG ℄ OF PRINCIPAL SPILLWAY

0 10 20 30 40
Scale in feet

AS BUILT
NOV 15 1978

PRINCIPAL SPILLWAY LAYOUT

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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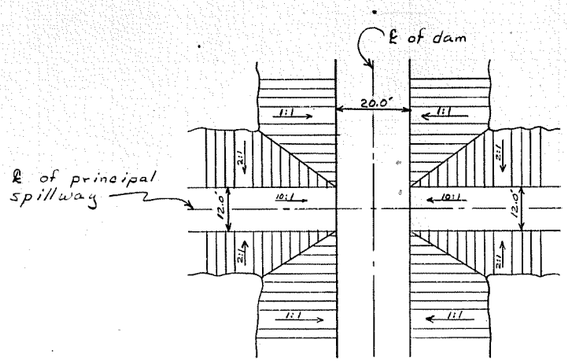
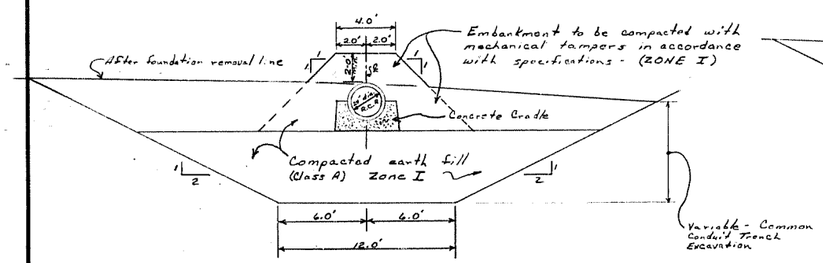
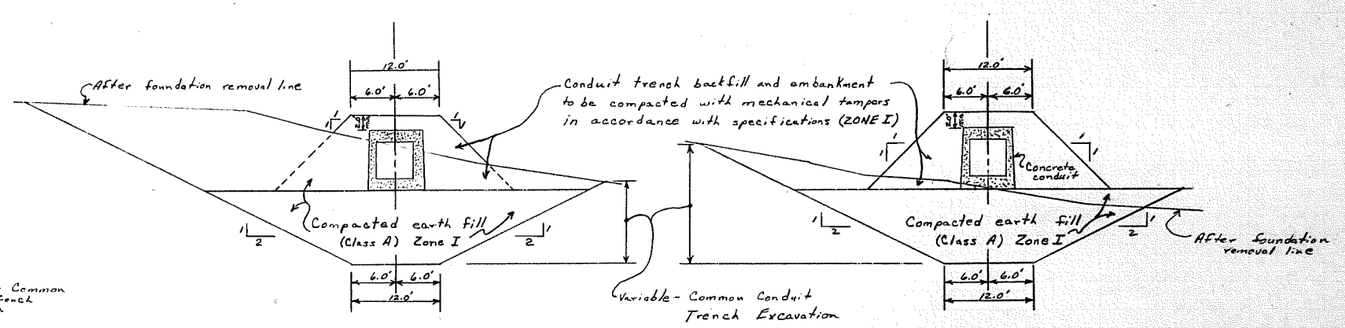
Designed L.M.S.	9-71	Approved by	
Drawn		Title	
Traced		Title	
Checked R.D.S.	10-73	Sheet No. 12 of 40	Drawing No. 5,E-29,772



JUNCTION - PIPE AND CUTOFF TRENCH
STATION 18+00 ℄ DAM = STATION 8+40 ℄ PRIN. SPWY.
Not to scale



Scale: 1" = 5'



Scale: 1" = 10'

Scale: 1" = 10'

DIAGRAMS OF CONDUIT TRENCH - EXCAVATION, BACKFILL AND EMBANKMENT

AS BUILT
NOV 15 1978

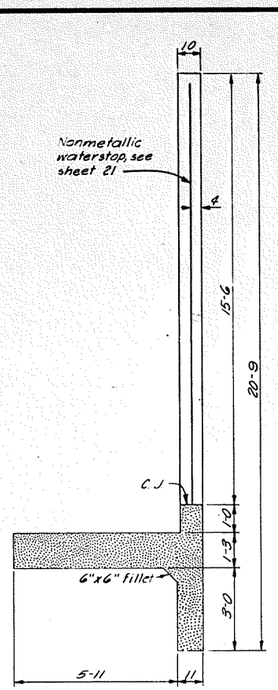
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

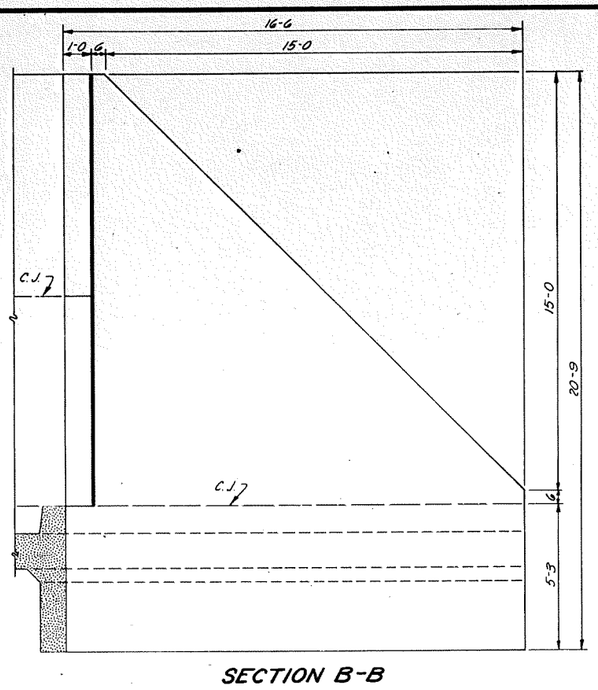
	Date		
Designed		Approved by	
Drawn R. BIRD	11/75	Title	
Traced		Title	
Checked		Sheet No. 12A of 40	Drawing No. 5,E-29,772

SCS-313 C (9-64)

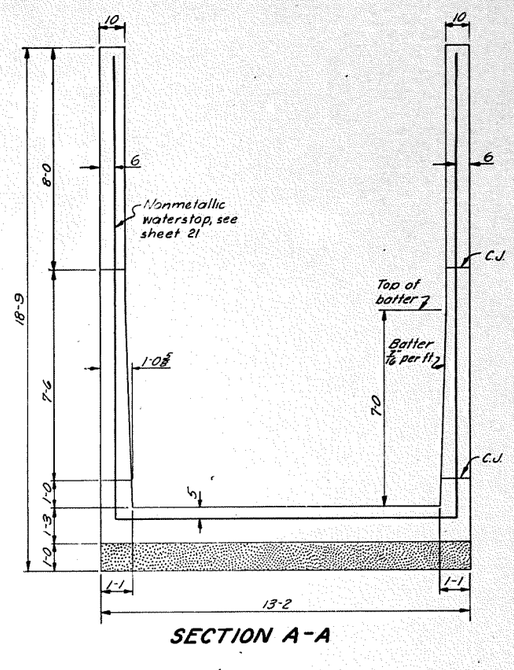
U.S. GOVERNMENT PRINTING OFFICE : 1964 O—746-944



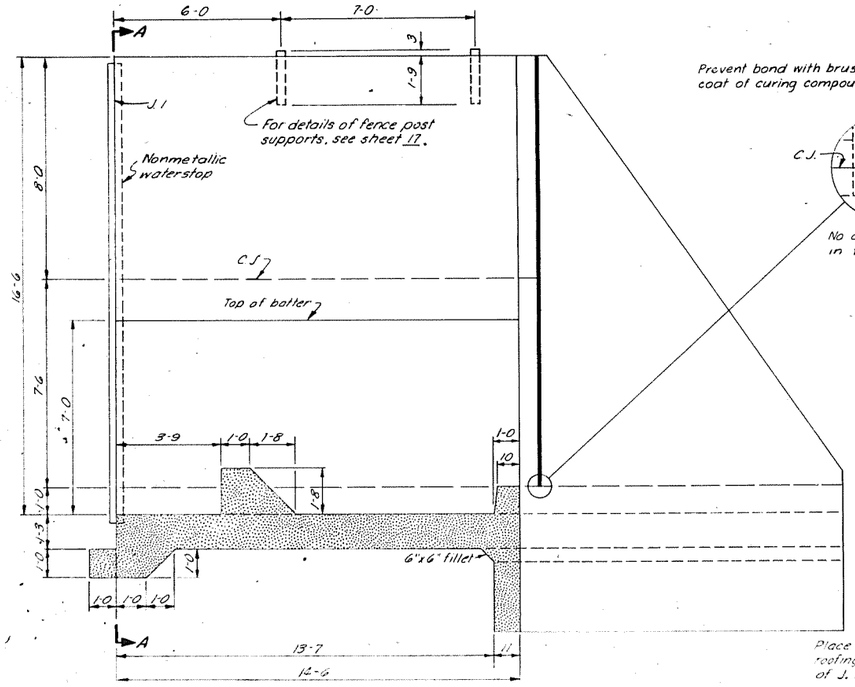
SECTION C-C



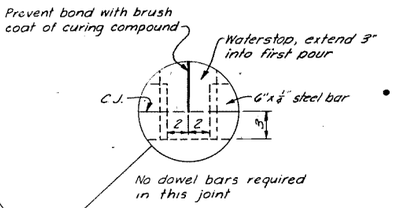
SECTION B-B

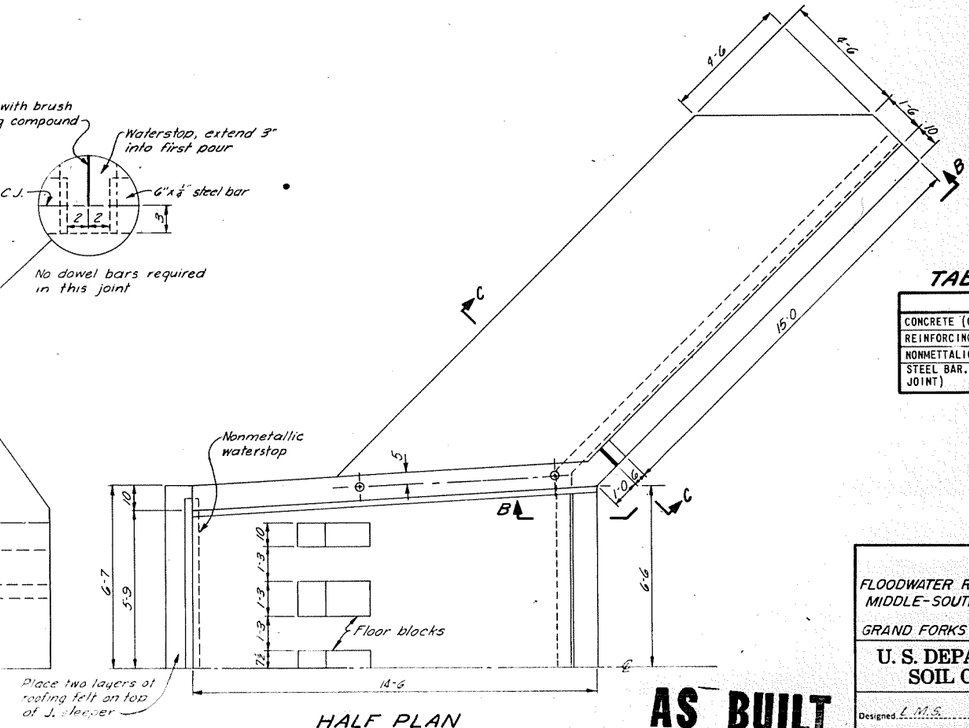


SECTION A-A



SECTION ON CENTERLINE





HALF PLAN

NOTES:

1. C.J. = CONSTRUCTION JOINT.
2. J.= JOINT.
3. FOR DETAILS OF WATERSTOP AND DOWEL BARS. SEE SHEET 21.
4. FOR DETAILS OF PLATE CONSTRUCTION JOINT. SEE SHEET 19.

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	52.9
REINFORCING STEEL	LB.	7,168.0
NONMETTALIC WATERSTOP	LIN.FT.	77-6
STEEL BAR, 6" X 1/4" (CONSTRUCTION JOINT)	LIN.FT.	92-0

0 1 2 3 4
Scale in feet

AS BUILT
NOV 15 1978

SAF OUTLET

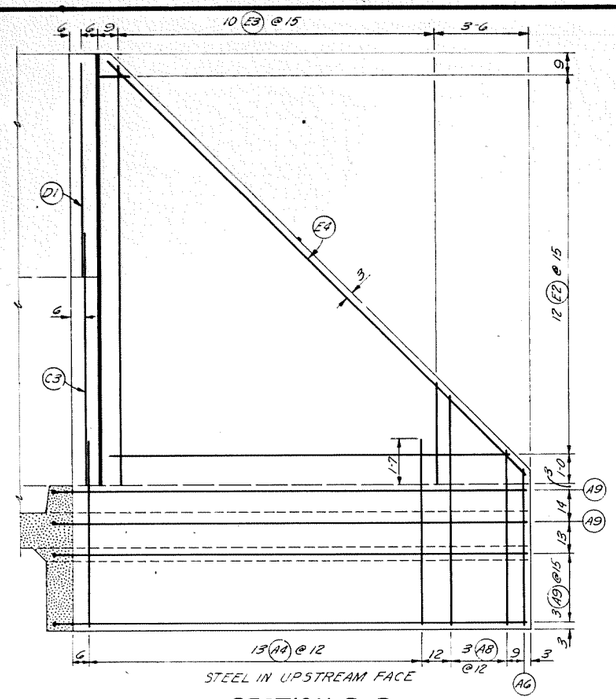
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

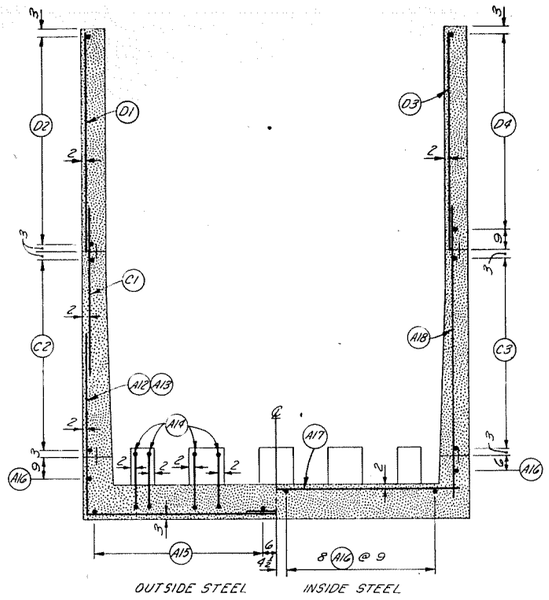
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

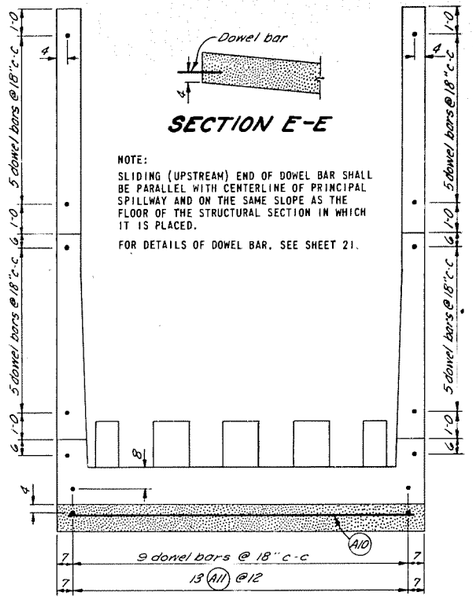
	Date		
Designed L.M.S.	10-71	Approved by	
Drawn M.R.H.	3-71	Title	
Traced		Title	
Checked E.J.S.	10-71	Sheet No 12 of 37 sheets	Drawing No. 5,E-29,772



SECTION B-B



SECTION D-D

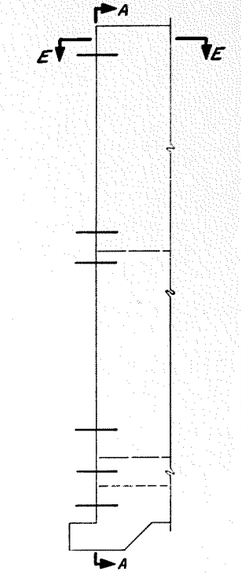


SECTION E-E

NOTE:
SLIDING (UPSTREAM) END OF DOWEL BAR SHALL BE PARALLEL WITH CENTERLINE OF PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH IT IS PLACED.

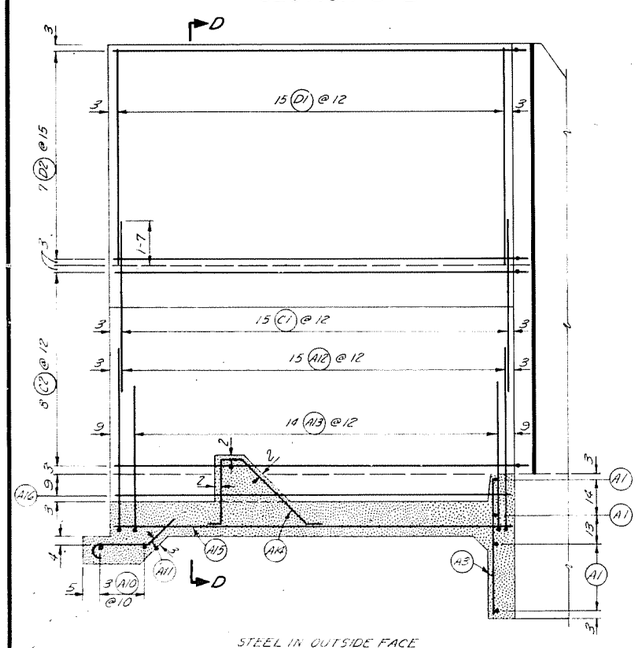
FOR DETAILS OF DOWEL BAR, SEE SHEET 21.

SECTION A-A

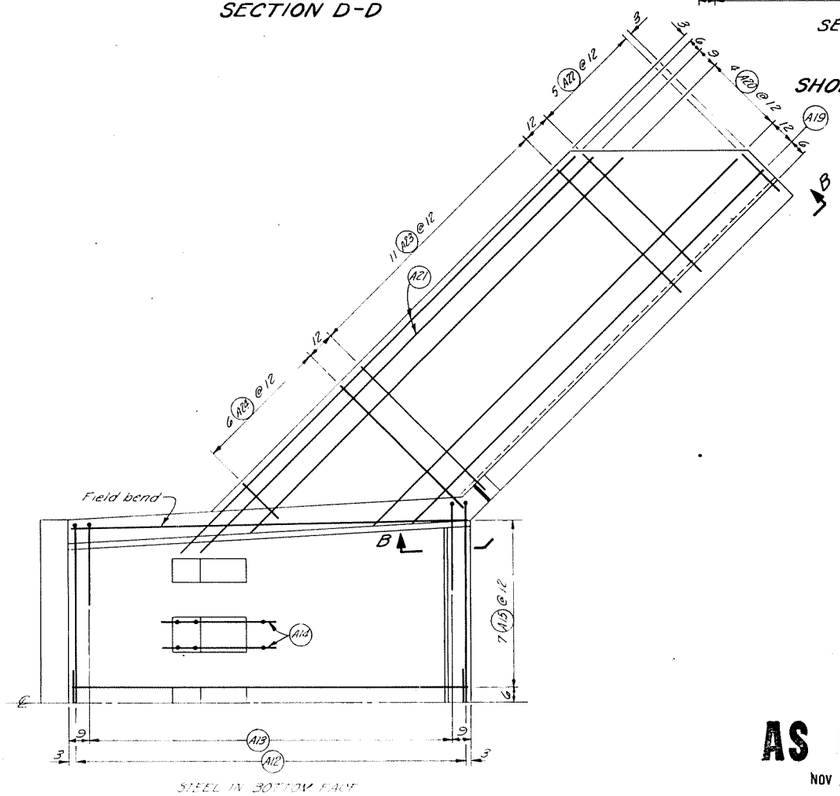


PARTIAL SIDEWALL ELEVATION

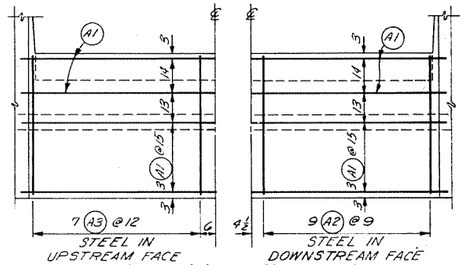
DETAILS OF JOINT I
SHOWING LOCATION OF DOWEL BARS



SECTION ON CENTERLINE



HALF PLAN



TOEWALL ELEVATION

0 1 2 3 4
Scale in feet

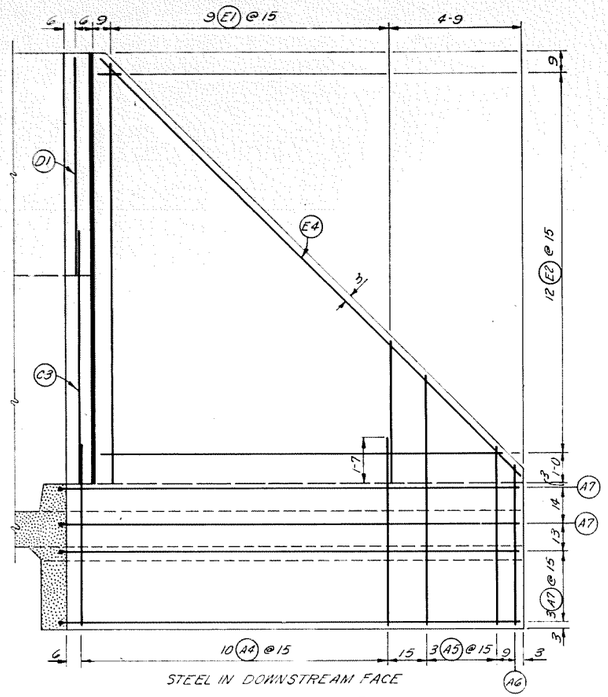
SAF OUTLET

AS BUILT
NOV 15 1978

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

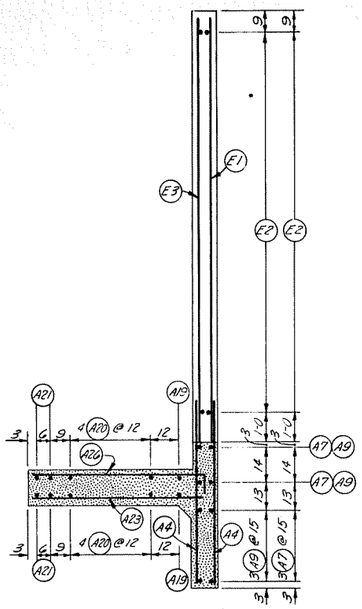
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 10-71	Approved by	
Drawn R.P.H.	12-71	Title	
Traced		Title	
Checked L.M.S.		Sheet No 14 of 170	Drawing No 5, E-29, 772

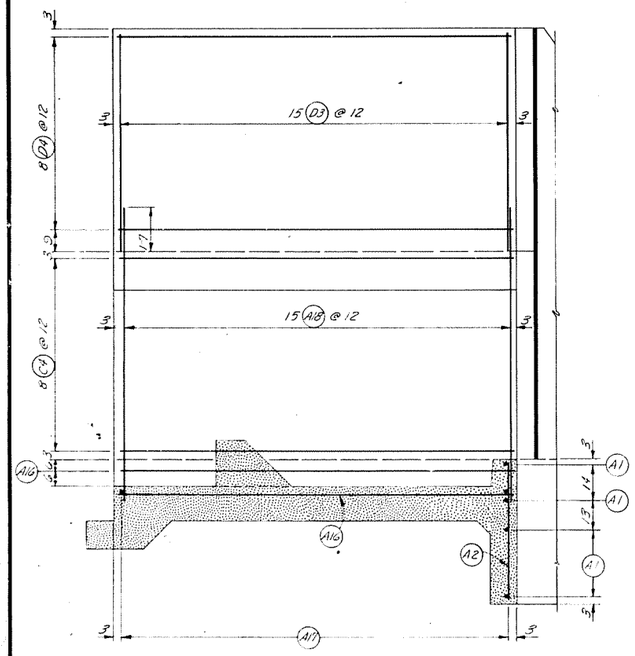


STEEL IN DOWNSTREAM FACE

SECTION B-B

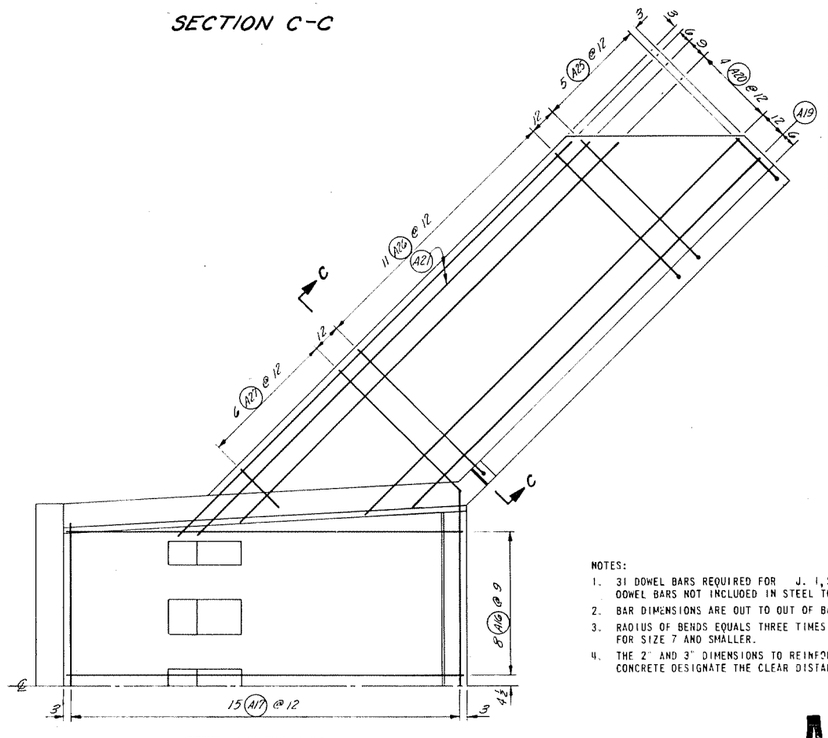


SECTION C-C



STEEL IN INSIDE FACE

SECTION ON CENTERLINE



STEEL IN TOP FACE

HALF PLAN

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)	
4	985-0	658.0	
5	4,311-5	4,497.0	
6	195-0	293.0	
7	841-6	~~1,720.0~~	1,916.0
TOTAL WEIGHT		~~7,168.0~~	7,364.0

BAR BENDS

TYPE 1 TYPE 19 TYPE 21 TYPE 24 TYPE 25

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	D	E	F
A1	5	10	13-6	135-0	1					
A2	7	18	4-10	87-0	1					
A3	5	14	4-10	67-8	1					
A4	5	46	7-0	322-0	1					
A5	5	2 SETS OF 3 BARS	6-6 TO 9-0 ± 1-3 INCR.	46-6	1					
A6	5	4	5-9	23-0	1					
A7	5	10	18-0	180-0	19	1-9	16-3			
A8	5	2 SETS OF 3 BARS	6-6 TO 8-6 ± 1-0 INCR.	45-0	1					
A9	5	10	18-3	182-6	19	1-9	16-6			
A10	5	3	12-9	38-3	1					
A11	5	13	3-9	48-9	24		SEE BAR BENDS			
A12	7	30	14-9	442-6	21	6-6	8-3			
A13	7	28	8-3	231-0	21	3-0	5-3			
A14	5	15	7-3	108-9	25	0-6	2-3	0-8	3-3	0-7
A15	4	14	14-3	199-6	1					
A16	5	20	14-3	285-0	1					
A17	6	1 SET OF 15 BARS	11-10 TO 14-2 ± 2" INCR.	195-0	1					
A18	5	30	10-6	315-0	1					
A19	5	4	17-9	71-0	1					
A20	4	16	19-3	308-0	1					
A21	7	4	20-3	81-0	1					
A22	4	2 SETS OF 5 BARS	2-0 TO 6-0 ± 1-0 INCR.	40-0	1					
A23	4	22	6-3	137-6	1					
A24	4	2 SETS OF 6 BARS	2-0 TO 6-2 ± 10" INCR.	49-0	1					
A25	4	2 SETS OF 5 BARS	2-9 TO 6-9 ± 1-0 INCR.	47-6	21	0-9	2-0 TO 6-0 ± 1-0 INCR.			
A26	4	22	7-0	154-0	21	0-9	6-3			
A27	4	2 SETS OF 6 BARS	2-3 TO 6-0 ± 9" INCR.	49-6	1					
C1	5	30	6-3	187-6	1					
C2	5	16	15-0	240-0	19	0-9	14-3			
C3	5	4	9-0	36-0	1					
C4	5	16	14-3	228-0	1					
D1	5	34	7-9	263-6	1					
D2	5	14	15-0	210-0	19	0-9	14-3			
D3	5	30	7-9	232-6	1					
D4	5	16	14-3	228-0	1					
E1	5	2 SETS OF 9 BARS	5-0 TO 15-0 1-3 INCR.	180-0	1					
E2	5	4 SETS OF 12 BARS	0-9 TO 14-5 ± 1-4 INCR.	366-0	1					
E3	5	2 SETS OF 10 BARS	3-9 TO 15-0 ± 1-3 INCR.	187-6	1					
E4	5	4	21-0	84-0	1					

Note: * the quantity in A-21's should be 8. these additional 4 bars were replaced with 6-B-20's for a total of 96' (with overlap) totaling an additional 196# of steel

NOTES:

1. 31 DOWEL BARS REQUIRED FOR J. I, SEE SHEET 14 FOR DETAILS. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR FOR SIZE 7 AND SMALLER.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.

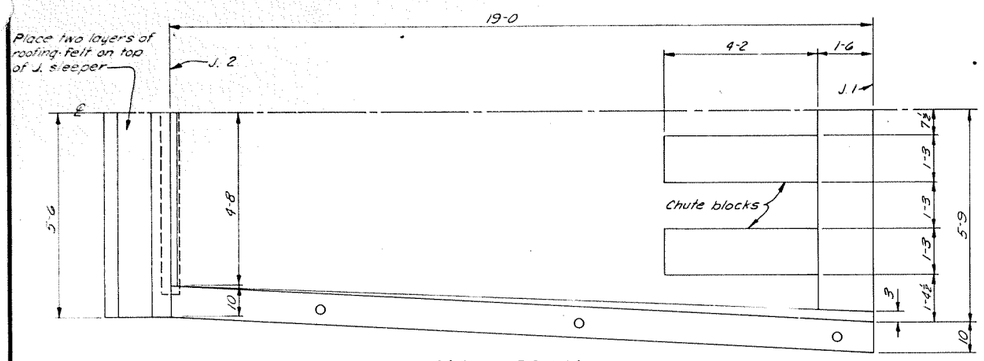
0 1 2 3 4
Scale in feet

AS BUILT
NOV 15 1978

SAF OUTLET
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

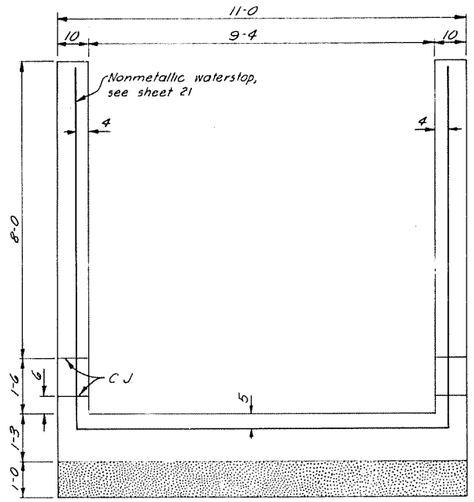
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S.	11-71	Approved by	
Drawn R.E.H.	2-72	Title	
Traced		Title	
Checked L.M.S.	2-72	Sheet No. 15 of 45	Drawing No. 5,E-29,772



HALF PLAN

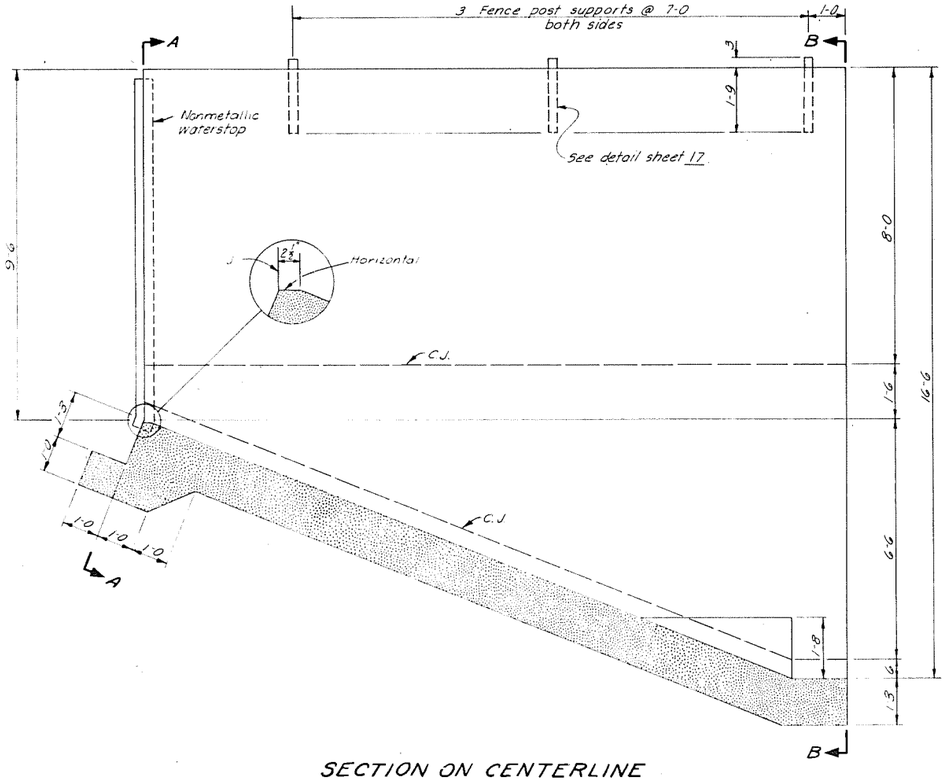
STRUCTURE SYMMETRICAL ABOUT ℄



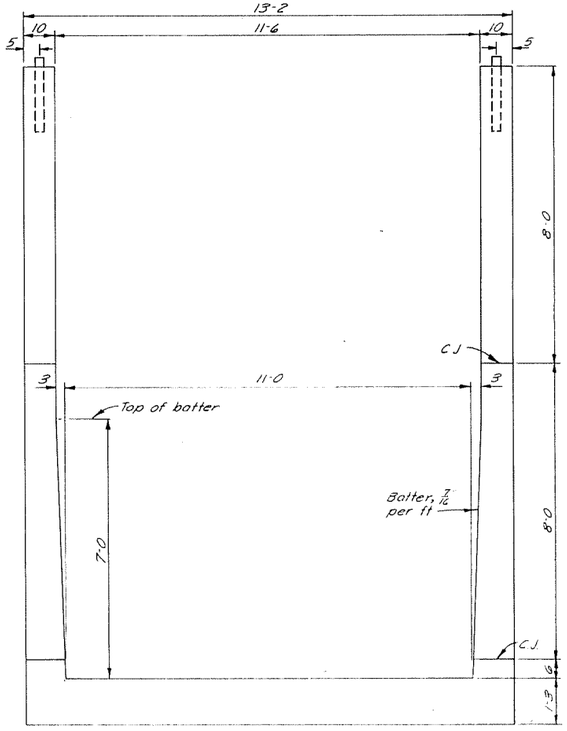
SECTION A-A

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	29.2
REINFORCING STEEL	LB.	5,250
NONMETALLIC	LIN.FT.	19-10
STEEL BAR, 6" x 1/4" (CONSTRUCTION JOINT)	LIN.FT.	79-0



SECTION ON CENTERLINE



SECTION B-B

NOTES:

1. J. = JOINT.
2. C.J. = CONSTRUCTION JOINT.
3. FOR DETAILS OF WATERSTOP AND DOWEL BARS, SEE SHEET 21.
4. FOR DETAILS OF PLATE CONSTRUCTION JOINT, SEE SHEET 19.

0 1 2 3 4

Scale in feet

AS BUILT

NOV 15 1978

DETAILS OF CHUTE (J. 1 – J. 2)

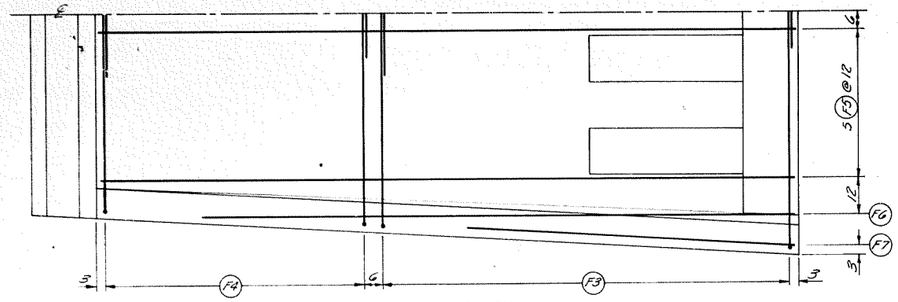
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed H.R.H.	10-7	Approved by	
Drawn H.R.H.	10-7	Title	
Traced		Title	
Checked		Sheet No.	Drawing No. 5,E-29,772

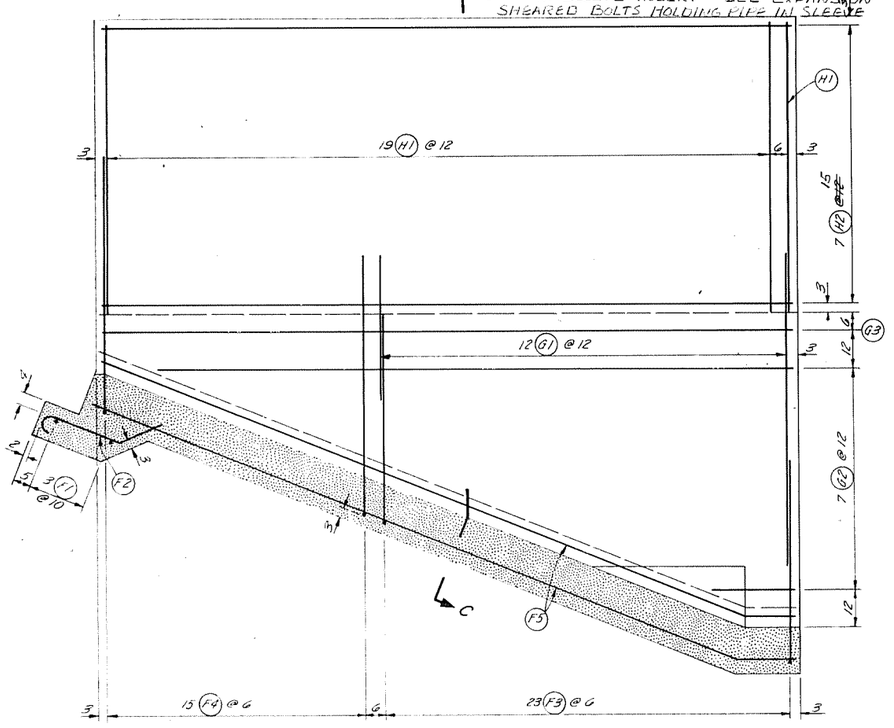


STEEL IN BOTTOM FACE

HALF PLAN

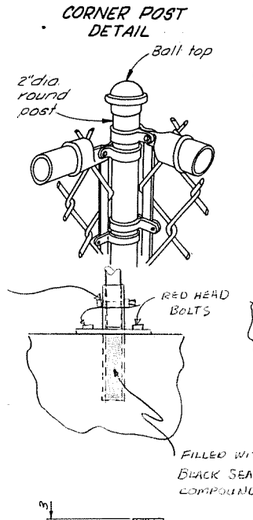
FABRICATED 2½ GALVANIZED SLEEVE INSERT FOR POST WELDED ON GALVANIZED PLATE FASTENED TO WALL WITH RED HEAD BOLTS

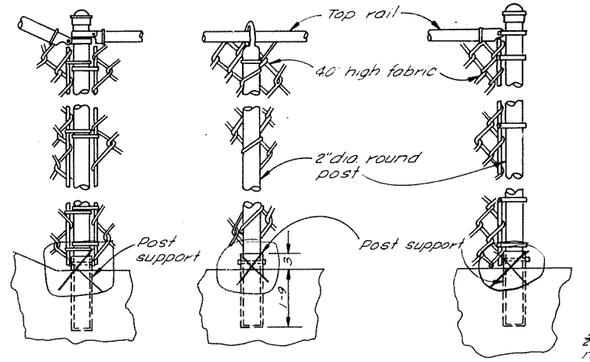
NOTE: MODIFIED BECAUSE OF ICE IN SLEEVE INSERT ICE EXPANSION SHEARED BOLTS HOLDING PIPE IN SLEEVE



STEEL IN OUTSIDE FACE

SECTION ON CENTERLINE

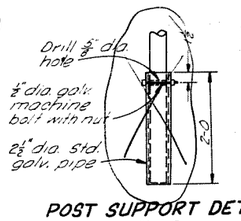




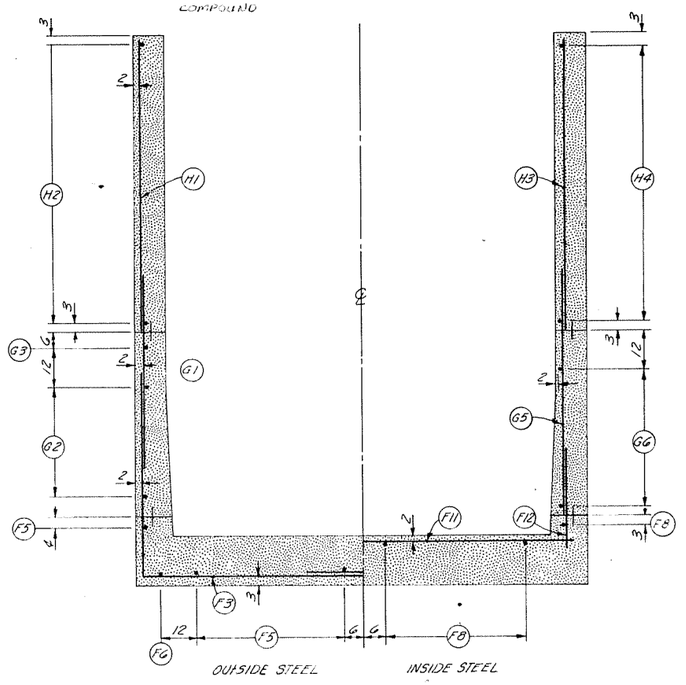
DETAILS OF CHAIN LINK FENCE

NOTES:

1. POST SUPPORTS ARE 2 1/2" DIA. STANDARD GALV. PIPE 2.0' LONG. SUPPORTS WILL BE EMBEDDED 21" IN CONCRETE. EMBEDDED ENDS SHALL BE CAPPED TO PREVENT CONCRETE FROM ENTERING PIPE.
2. FENCE POSTS SHALL BE BOLTED TO POST SUPPORTS WITH 0.5" DIA. GALV. MACHINE BOLTS 3" LONG.
3. FABRIC SHALL BE 9 GAUGE. GALVANIZED. 4.0' HIGH.
4. POSTS SHALL BE 2" DIA., GALVANIZED.
5. FABRIC TO BE INSTALLED TOWARDS OUTSIDE FACE OF CONCRETE WALL WITH POST ON THE INSIDE.



POST SUPPORT DETAIL
N.T.S.



SECTION C-C

TABLE OF QUANTITIES FOR CHAIN LINK FENCE

ITEM	UNIT	QUANTITY
4.0' HIGH, 9 GAUGE FABRIC AND HARDWARE	LIN.FT.	112.0
2" DIA. O.D. STEEL POSTS, GALV.	EACH	18.0
2 1/2" DIA. I.S. STD. GALV. PIPE AS PER DETAIL	EACH	18.0

0 1 2 3 4
Scale in feet

DETAILS OF CHUTE (J. 1 – J. 2)

AS BUILT
NOV 15 1978

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.R.M. Date 10-77	Approved by
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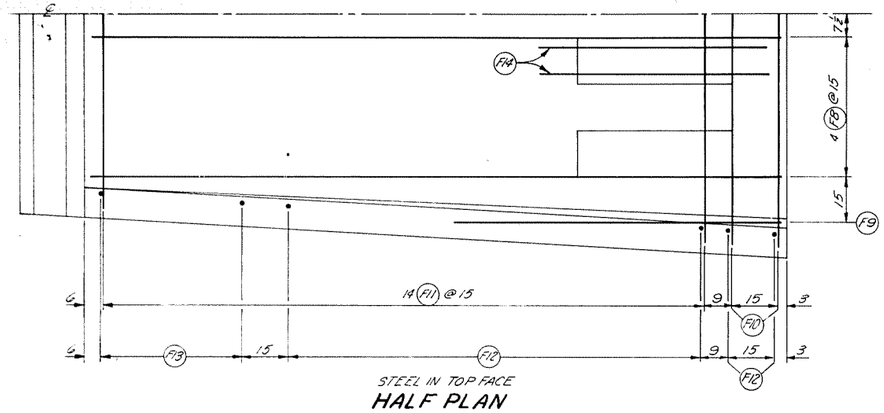
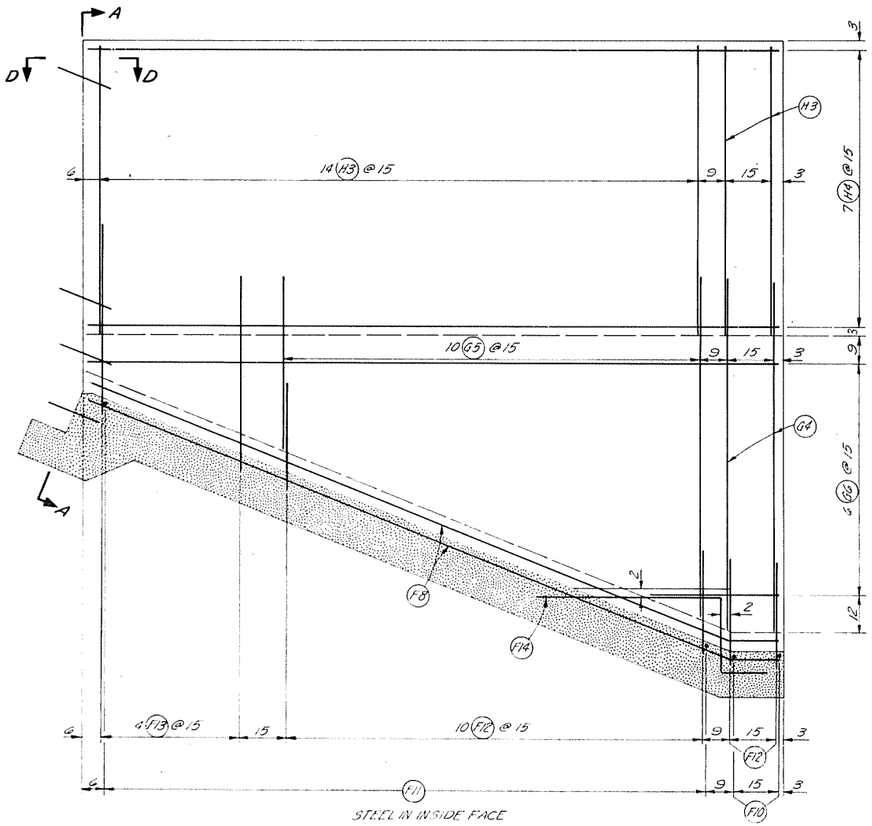
Traced	Title
Checked	Sheet No. of / Drawing No. 5,E-29,772



STEEL IN TOP FACE

HALF PLAN



STEEL IN INSIDE FACE

SECTION ON CENTERLINE

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	466-0	311.3
5	1,156-6	1,206.2
6	894-4	1,343.3
7	1,169-0	2,389.4
TOTAL WEIGHT		5,250.2

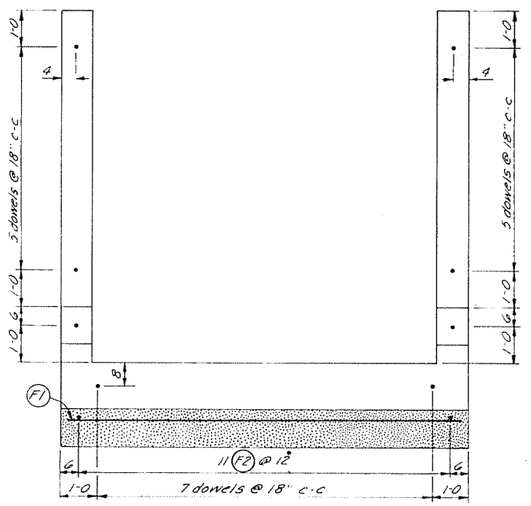
NOTES:

1. 19 DOWEL BARS REQUIRED FOR J. 2. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUAL THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSION TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.

BAR BENDS

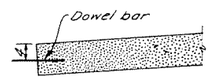
STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
F1	5	3	10-9	32-3	1				
F2	5	11	3-9	41-3	24		SEE BAR BENDS		
F3	7	46	13-0	598-0	21	5-6	7-6		
F4	7	30	14-0	420-0	21	7-0	7-0		
F5	4	12	20-3	243-0	23	1-6	18-9	0-7	1-5
F6	4	2	17-0	34-0	23	1-6	16-9	0-7	1-5
F7	4	2	9-3	18-6	23	1-6	7-9	0-7	1-5
F8	6	10	20-0	200-0	23	1-3	18-9	0-7	1-5
F9	6	2	9-3	18-6	23	1-3	8-0	0-7	1-5
F10	6	2	12-6	25-0	1				
F11	6	1 SET OF 14 BARS	10-4 TO 12-6 ± 2" INCR.	159-10	1				
F12	6	24	3-0	72-0	1				
F13	6	8	5-3	42-0	1				
F14	6	8	8-3	66-0	31		SEE BAR BENDS		
G1	7	2 SETS OF 12 BARS	4-0 TO 8-7 ± 5" INCR.	151-0	1				
G2	4	2 SETS OF 7 BARS	2-0 TO 17-0 ± 2-6 INCR.	133-0	1				
G3	4	2	18-9	37-6	1				
G4	6	4	9-9	39-0	1				
G5	6	2 SETS OF 10 BARS	4-9 TO 9-3 ± 6" INCR.	140-0	1				
G6	6	2 SETS OF 6 BARS	3-6 TO 18-6 ± 3-0 INCR.	132-0	1				
H1	5	40	7-9	310-0	1				
H2	5	14	18-9	262-6	1				
H3	5	32	7-9	248-0	1				
H4	5	14	18-9	262-6	1				



SECTION A-A

DETAILS OF JOINT 2



SECTION D-D

NOTE:

SLIDING (UPSTREAM) END OF DOWEL BAR SHALL BE PARALLEL WITH CENTERLINE OF PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH IT IS PLACED.

FOR DETAIL OF DOWEL BAR, SEE SHEET 21.

AS BUILT

NOV 15 1978

0 1 2 3 4

Scale in feet

DETAILS OF CHUTE (J. 1 – J. 2)

DAM 4

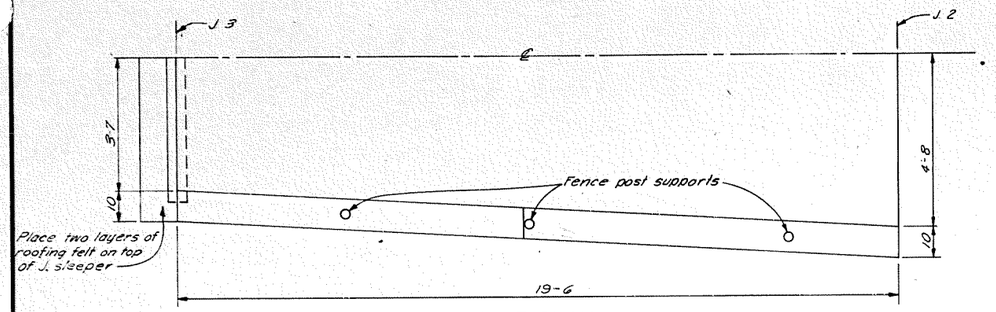
FLOODWATER RETARDING & RECREATION STRUCTURE

MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

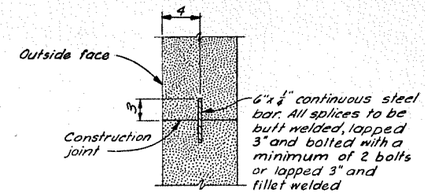
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed H.R.H.	10-71	Approved by	
Drawn H.R.H.	12-71	Title	
Traced		Title	
Checked P.D.S.	1-74	Sheet No. 2 of 22	Drawing No. 5,E-29,772



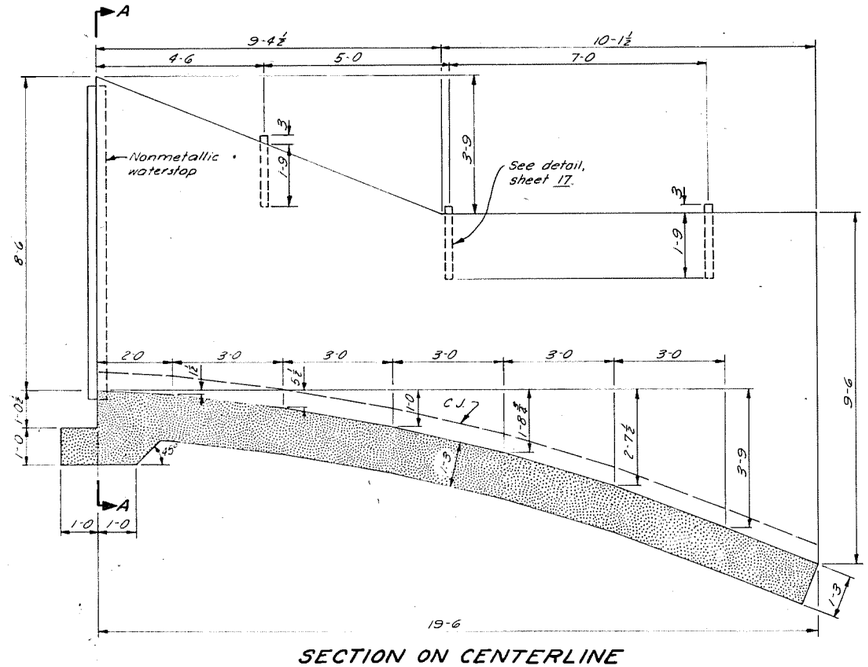
HALF PLAN

STRUCTURE SYMMETRICAL ABOUT ℄

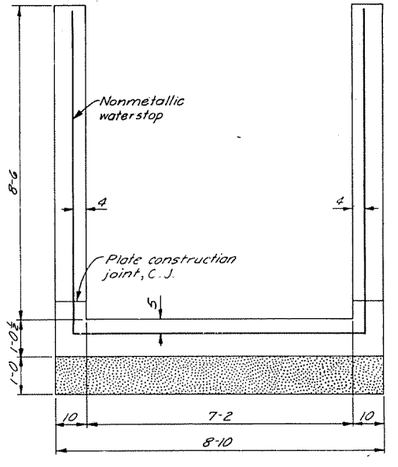


DETAILS OF PLATE CONSTRUCTION JOINT (OUTLET TO JOINT 3)

(Not to scale)



SECTION ON CENTERLINE



SECTION A-A

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	16.6
REINFORCING STEEL	LB.	3032
NONMETALLIC WATERSTOP	LIN.FT.	25-8
STEEL BAR. 6" X 1/4" (CONSTRUCTION JOINT)	LIN.FT.	40-0

NOTES:

1. J. = JOINT.
2. C.J. = CONSTRUCTION JOINT.
3. FOR DETAILS OF WATERSTOP AND DOWEL BARS. SEE SHEET 21.

AS BUILT

NOV 15 1978

0 1 2 3 4

Scale in feet

DETAILS OF CHUTE (J2 – J3)

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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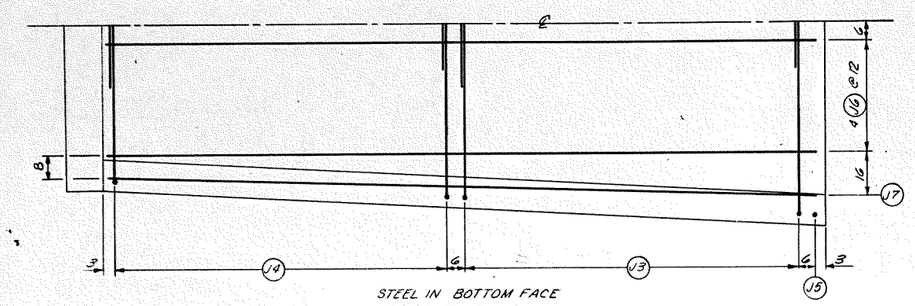
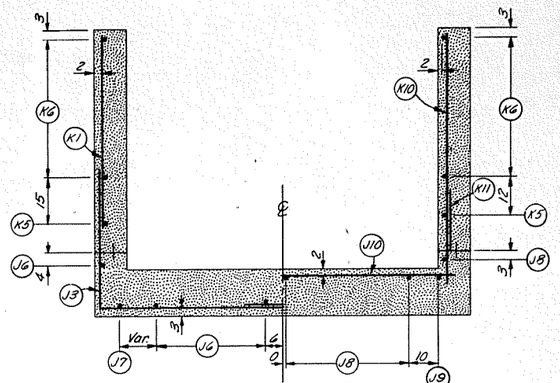
Drawn H.R.H.	12-71	Title	
Traced		Title	
Checked P.D.S.	1-74	Sheet No 19 of 40	Drawing No. 5.E-29,772



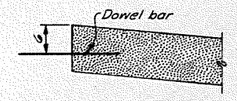
STEEL IN BOTTOM FACE

HALF PLAN



OUTSIDE FACE INSIDE FACE

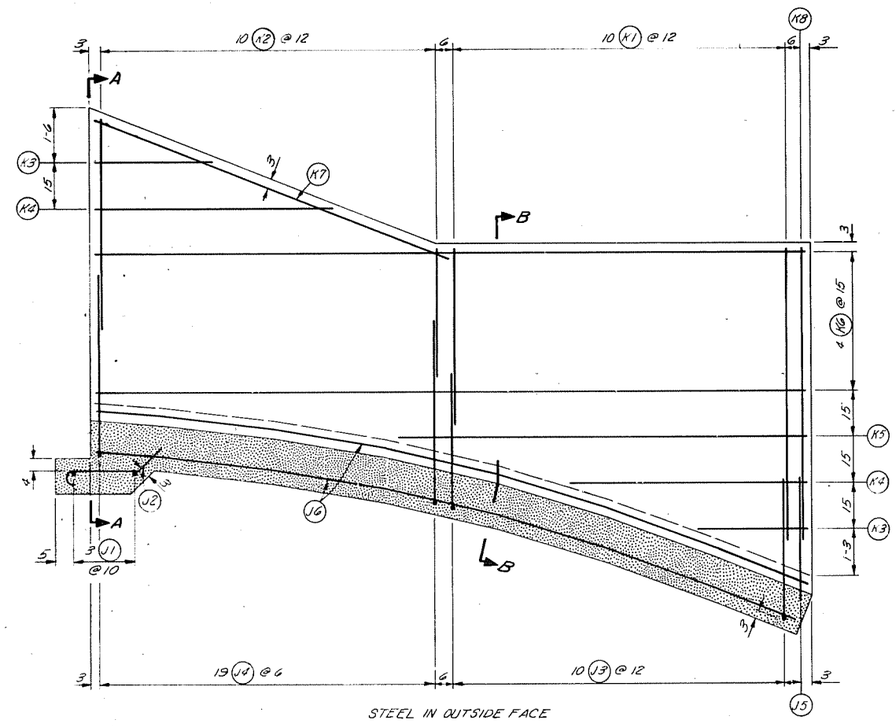
SECTION B-B



SECTION C-C
(Not to scale)

NOTE:
SLIDING (UPSTREAM) END OF DOWEL BAR SHALL BE PARALLED WITH THE CENTERLINE OF THE PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH IT IS PLACED.

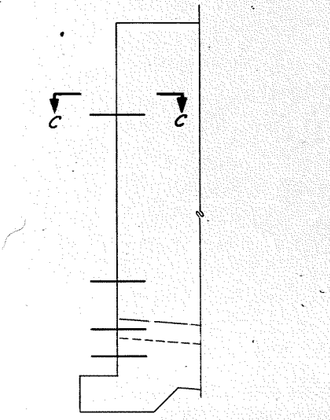
FOR DETAIL OF DOWEL BAR, SEE SHEET 21.



STEEL IN OUTSIDE FACE

SECTION ON CENTERLINE

SECTION A-A



PARTIAL SIDEWALL ELEVATION

DETAILS OF JOINT 3

0 1 2 3 4
Scale in feet

DETAILS OF CHUTE (J2 – J3)

AS BUILT

NOV 15 1978

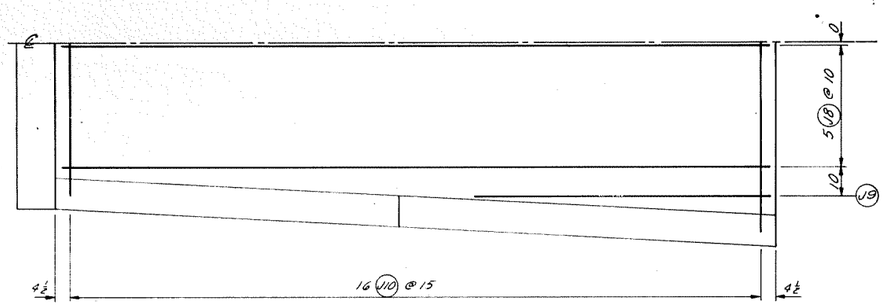
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S.	11-71	Approved by	
Drawn		Title	
Traced		Title	
Checked D.D.S.	10-73	Sheet No. 20 of 40	Drawing No. 5,E-29,772



STEEL IN TOP FACE

HALF PLAN

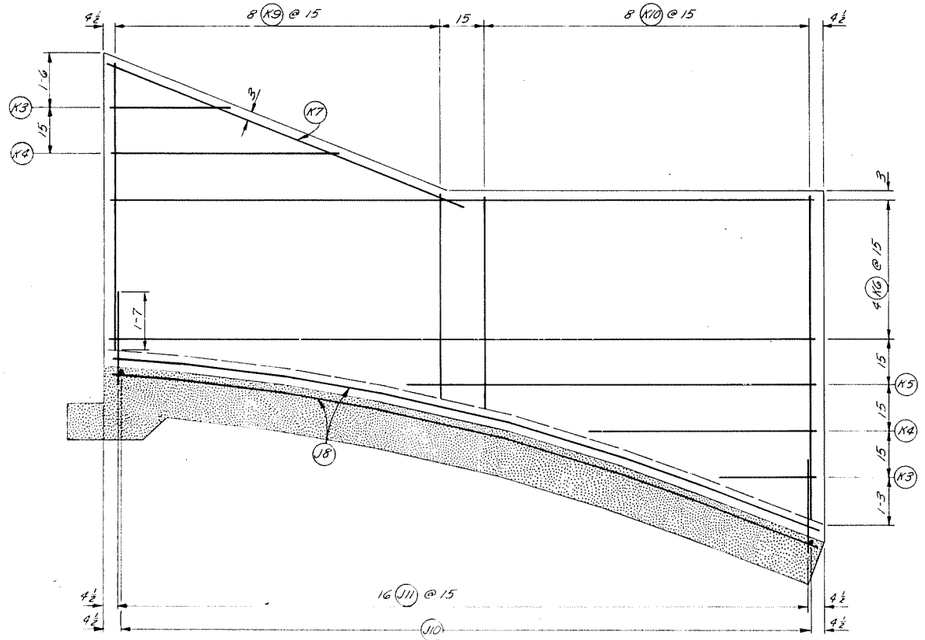
STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	195-0	130
5	1,334-10	1,392
6	148-0	222
7	630-0	1,288
TOTAL WEIGHT		3,032

BAR BENDS

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C
J1	5	3	8-6	25-6	1		
J2	5	9	3-9	33-9	24	SEE BAR BENDS	
J3	7	20	10-3	205-0	21	3-9	6-6
J4	7	38	11-0	418-0	21	5-0	6-0
J5	7	2	3-6	7-0	1		
J6	4	10	19-6	195-0	FIELD BEND		
J7	5	2	19-6	39-0	FIELD BEND		
J8	5	11	19-6	214-6	FIELD BEND		
J9	5	2	8-0	16-0	FIELD BEND		
J10	6	1 SET OF 16 BARS	8-0 TO 10-6 : 2" INCR.	148-0	1		
J11	5	32	2-6	80-0	1		
K1	5	2 SETS OF 10 BARS	5-0 TO 8-0 : 4" INCR.	130-0	1		
K2	5	2 SETS OF 10 BARS	3-6 TO 5-9 : 3" INCR.	92-6	1		
K3	5	8	3-0	24-0	1		
K4	5	8	6-3	50-0	1		
K5	5	4	11-0	44-0	1		
K6	5	16	19-3	308-0	1		
K7	5	4	10-3	41-0	1		
K8	5	2	8-0	16-0	1		
K9	5	2 SETS OF 8 BARS	5-5 TO 7-9 : 4" INCR.	105-4	1		
K10	5	2 SETS OF 8 BARS	5-9 TO 8-8 : 5" INCR.	115-4	1		

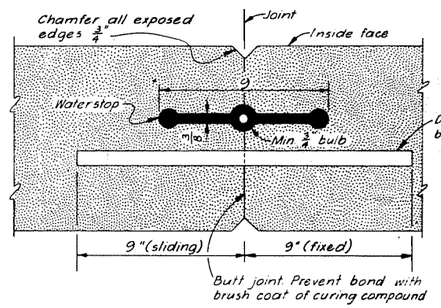


STEEL IN INSIDE FACE

SECTION ON CENTERLINE

NOTES:

1. DOWEL BARS SHALL BE 3/4" DIA. SMOOTH STEEL BARS COATED ON SLIDING END TO PREVENT BOND. COATING SHALL BE OIL, ASPHALT, OR OTHER METHOD ACCEPTED BY THE ENGINEER.
2. NONMETALLIC WATERSTOP SHALL BE CLASS II, TYPE O, SIZE 20 WITH MIN. 3/4" INSIDE DIAMETER BULB.
3. DOWEL BARS ARE TO BE PLACED PARALLEL TO THE CENTERLINE OF THE PRINCIPAL SPILLWAY AND ON THE SAME SLOPE AS THE FLOOR OF THE STRUCTURAL SECTION IN WHICH THE SLIDING (UPSTREAM) END WILL BE LOCATED.



DETAIL OF JOINTS 1, 2 & 3
(DOWEL BAR AND WATERSTOP)

Not to scale

0 1 2 3 4
Scale in feet

NOTES:

1. 18 DOWEL BARS REQUIRED FOR J. 3, SEE SHEET 20 FOR DETAILS. DOWEL BARS ARE NOT INCLUDED IN THE STEEL TOTALS.
2. EAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.

AS BUILT

NOV 15 1978

DETAILS OF CHUTE (J2 – J3)

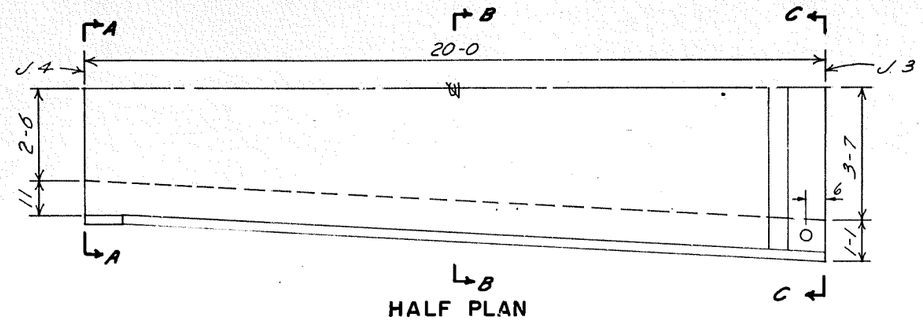
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

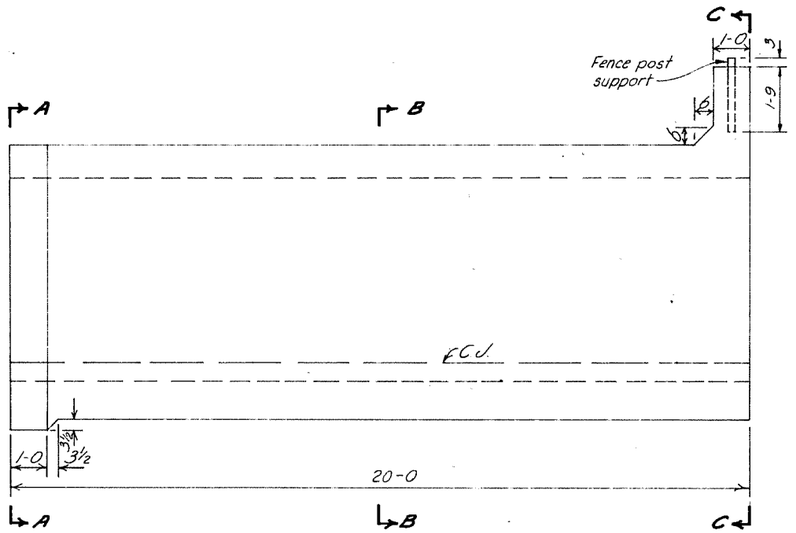
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

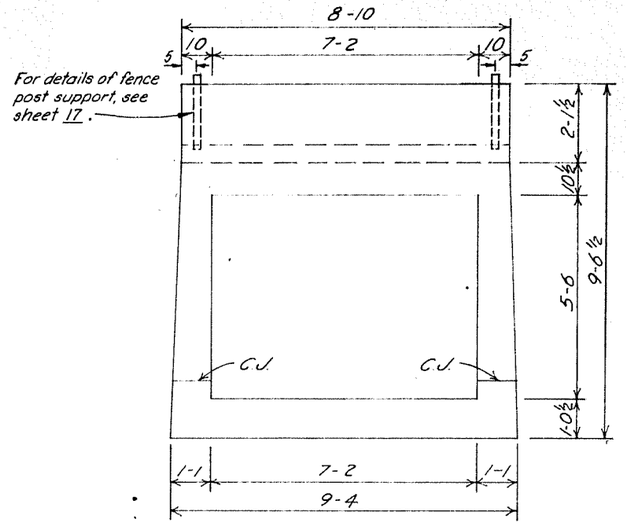
	Date		
Designed L.M.S.	11-71	Approved by	
Drawn H.R.H.	12-71	Title	
Traced		Title	
Checked R.D.S.	1-74	Sheet No. 21 of 30	Drawing No. 5,E-29,772



HALF PLAN

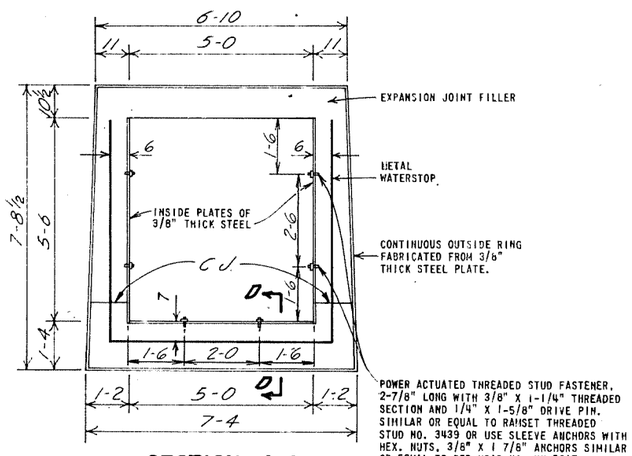


SIDEWALL ELEVATION

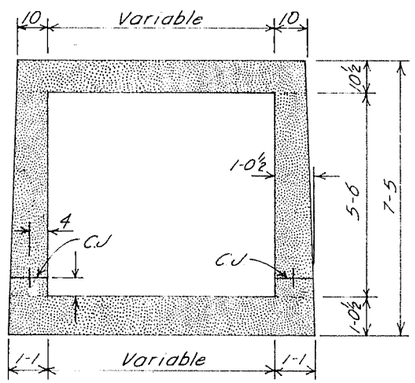


SECTION C-C

NOTES:
1. J.=JOINT.
2. C.J. = CONSTRUCTION JOINT.
3. FOR DETAILS OF SECTION D-D, SEE SHEET 24.
4. FOR DETAILS OF PLATE CONSTRUCTION JOINT, SEE SHEET 24.



SECTION A-A



SECTION B-B

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	20.0
REINFORCING STEEL	LB.	2,775
METAL WATERSTOP	LIN.FT.	18-2
STEEL BAR, 6" X 1/4", CONSTRUCTION JOINT	LIN.FT.	40-0

0 1 2 3 4
Scale in Feet

AS BUILT
NOV 15 1978

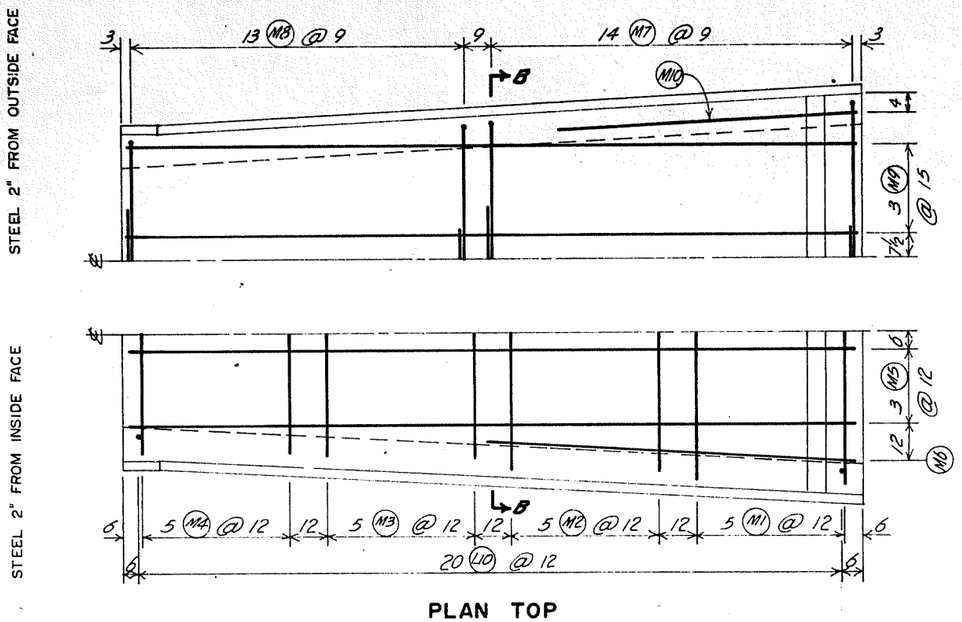
DETAILS OF TRANSITION

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

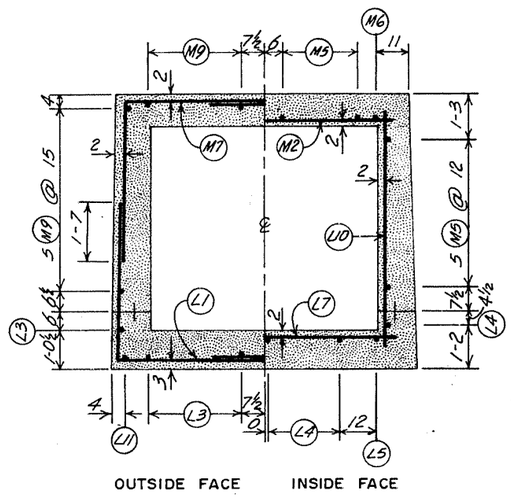
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	L. M. S.	Date 10/71	Approved by
Drawn	D. L. J.	12/71	Title
Traced			Title
Checked	C. E. M.	12/71	Sheet No. 22 of 40 — Drawing No. 5,E-29,772

SCS-ENG-313 Rev. 4-69

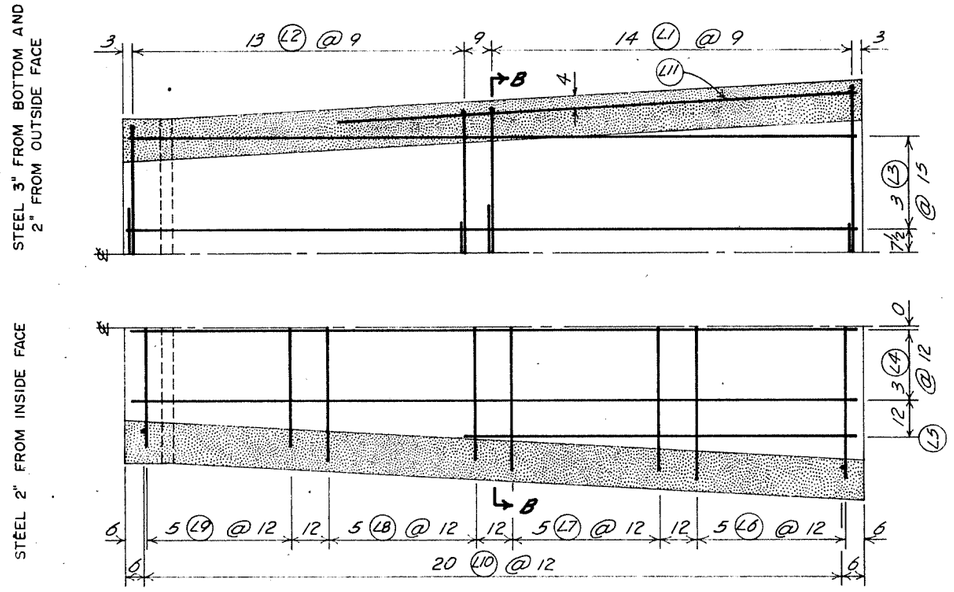


PLAN TOP



OUTSIDE FACE INSIDE FACE

SECTION B-B



PLAN FLOOR

0 1 2 3 4

Scale in Feet

AS BUILT

NOV 15 1978

DETAILS OF TRANSITION

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

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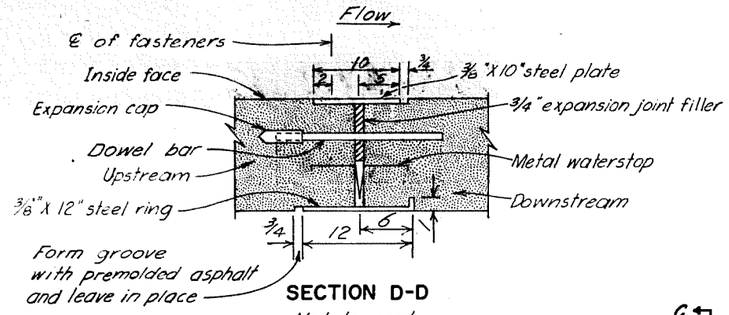
Designed	L. M. S.	10/71	Approved by	
Drawn	D. L. J.	12/71	Title	
Traced			Title	
Checked	C. E. M.	12/71	Sheet No. 23 of 40	Drawing No. 5-E-29,772

SCS-313 (9-64)

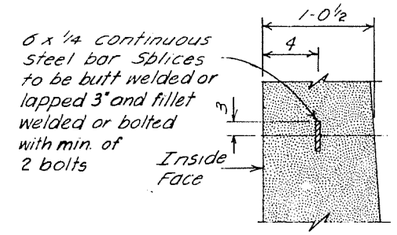
Note: Dowel bars shall be ¾" diameter X 18" long smooth steel bars coated on sliding end to prevent bond. Coating shall be oil, asphalt or other method accepted by the engineer.



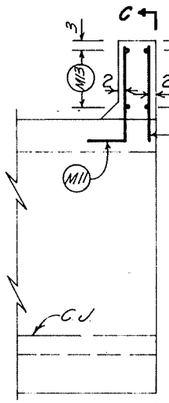
SECTION D-D
Not to scale

STEEL TOTALS

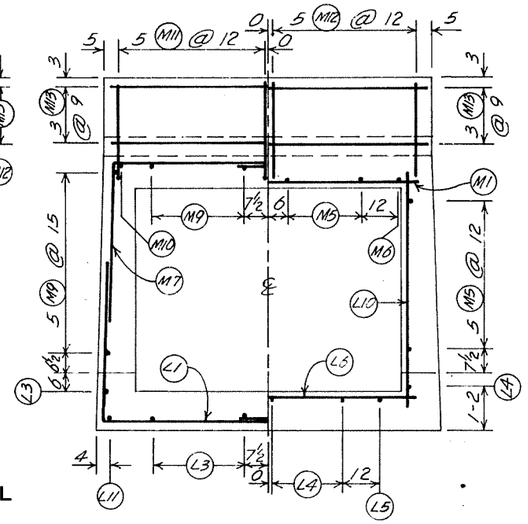
SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	569-0	380
5	1810-3	1,888
6	148-9	223
7	138-9	284
TOTAL WEIGHT		2,775



DETAILS OF PLATE CONSTRUCTION JOINT
J. 3 TO J. 4
Not to scale

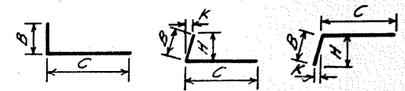


PARTIAL SIDEWALL ELEVATION



OUTSIDE FACE INSIDE FACE
SECTION C-C

BAR BENDS

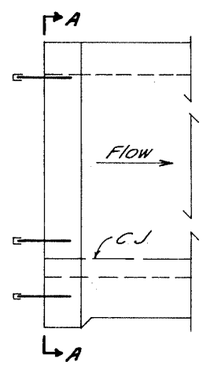


STEEL SCHEDULE

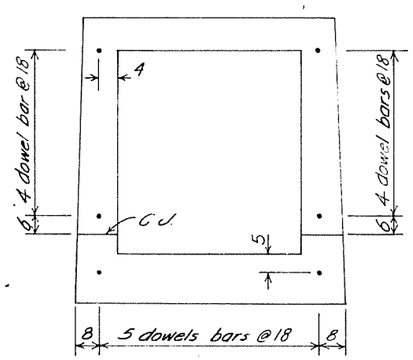
MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
L1	5	28	9-6	266-0	22	4-3	5-3	4-3	0-1 3/4
L2	5	26	9-0	234-0	22	4-3	4-9	4-3	0-1 3/4
L3	4	8	19-9	158-0	1				
L4	5	7	19-9	138-3	1				
L5	5	2	11-0	22-0	1				
L6	6	5	8-3	41-3	1				
L7	6	5	7-9	38-9	1				
L8	6	5	7-3	36-3	1				
L9	6	5	6-6	32-6	1				
L10	5	40	6-6	260-0	1				
L11	4	2	14-0	28-0	1				
M1	7	5	7-9	38-9	1				
M2	7	5	7-3	36-3	1				
M3	7	5	6-9	33-9	1				
M4	7	5	6-0	30-0	1				
M5	5	16	19-9	316-0	1				
M6	5	2	10-0	20-0	1				
M7	5	28	9-6	266-0	23	4-4	5-2	4-4	0-1 3/4
M8	5	26	9-0	234-0	23	4-4	4-8	4-4	0-1 3/4
M9	4	16	19-9	316-0	1				
M10	4	2	8-0	16-0	1				
M11	5	9	3-6	31-6	21	1-0	2-6		
M12	5	9	2-6	22-6	1				
M13	4	6	8-6	51-0	1				

NOTES:
1. 13 DOWEL BARS REQUIRED FOR J. 4. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. J. = JOINT.
6. C.J. = CONSTRUCTION JOINT.

DETAILS OF REINFORCING STEEL AT JOINT NO.3

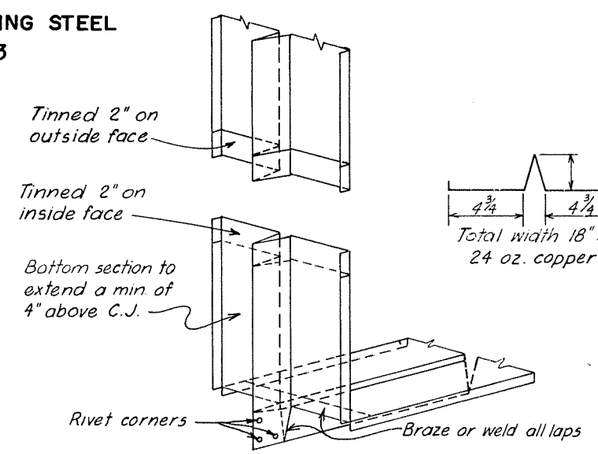


PARTIAL SIDEWALL ELEVATION

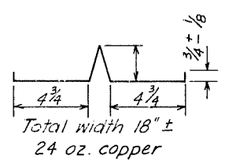


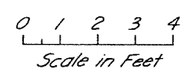
SECTION A-A

DETAILS OF JOINT NO. 4
SHOWING LOCATION OF DOWEL BARS



DETAIL OF METAL WATERSTOP
(J. 4)
Not to scale





AS BUILT
NOV 15 1978

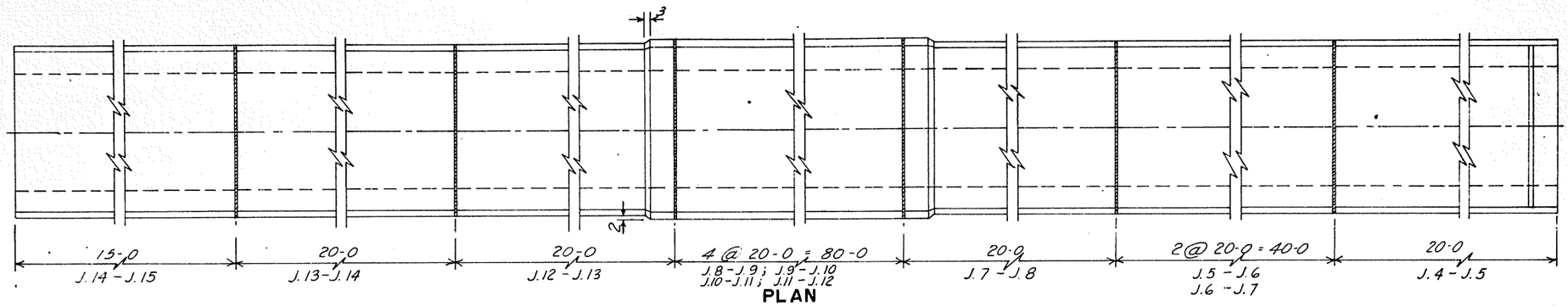
DETAILS OF TRANSITION

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE - SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

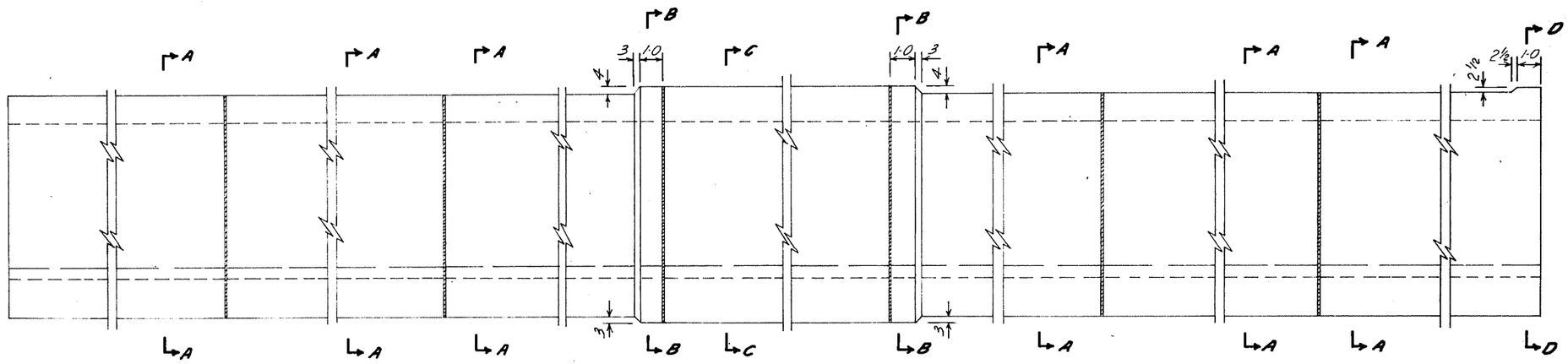
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	L.M.S.	10/71	Approved by	
Drawn	D.L.J.	12/71	Title	
Traced			Title	
Checked	C.E.M.	12/71	Sheet No. 24 of 40	Drawing No. 5,E-29,772

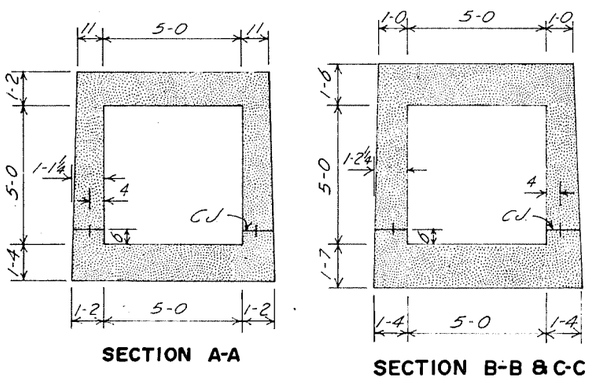
SCS-313 (9-64)



PLAN

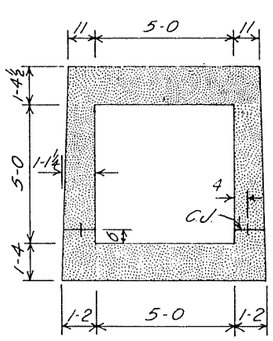


SIDEWALL ELEVATION

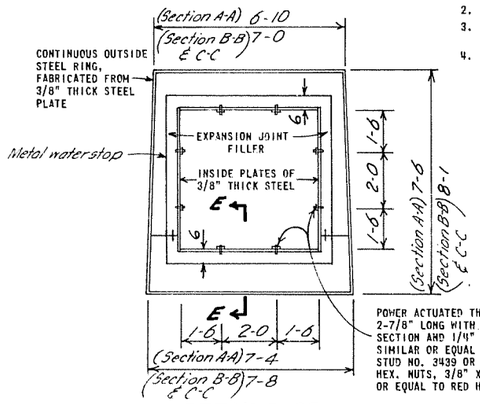


SECTION A-A

SECTION B-B & C-C



SECTION D-D



POWER ACTUATED THREADED STUD FASTENER, 2-7/8" LONG WITH 3/8" X 1-1/4" THREADED SECTION AND 1/4" X 1-5/8" DRIVE PIN. SIMILAR OR EQUAL TO RAMSET THREADED STUD NO. 3439 OR USE SLEEVE ANCHORS WITH HEX. NUTS, 3/8" X 1 7/8" ANCHORS SIMILAR OR EQUAL TO RED HEAD NO. HN-3817.

DETAILS OF JOINTS 5 THROUGH 15

NOTES:
1. C.J. = CONSTRUCTION JOINT.
2. J. = JOINT.
3. FOR DETAILS OF SECTION E-E, SEE SHEET 27.
4. FOR DETAILS OF CONSTRUCTION JOINT, SEE SHEET 27. AND 28.

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	242.5
REINFORCING STEEL	LB.	29,875
METAL WATERSTOP	LIN.FT.	264-0
STEEL BAR, 6" X 1/4" (CONSTRUCTION JOINT)	LIN.FT.	430-0
3/8" X 10" STEEL PLATE, EXPANSION JOINT (INSIDE)	LIN.FT.	220-0
STEEL PLATE, PER DETAIL, EXPANSION JOINT (OUTSIDE)	LIN.FT.	329-2

0 1 2 3 4
Scale in Feet

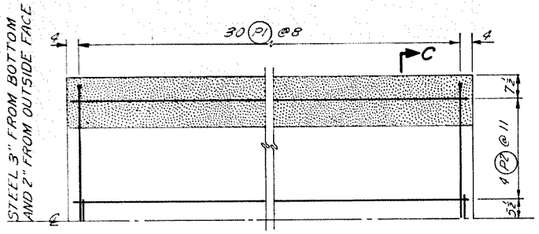
AS BUILT
NOV 15 1978

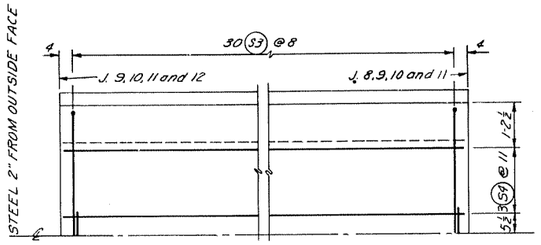
DETAILS OF CONDUIT

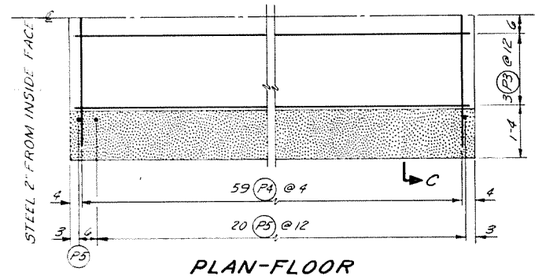
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

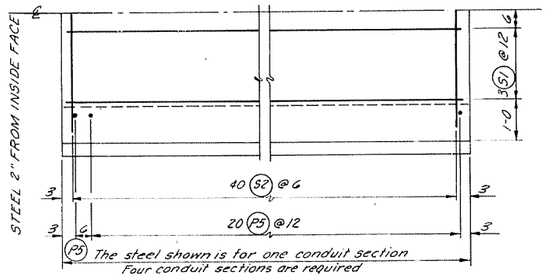
Designed L.M.S. & C.E.M.	Date 9/71	Approved by	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked		Sheet No. 25 of 40	Drawing No. 5-E-29.772





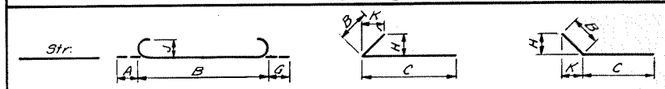


PLAN-FLOOR



PLAN-TOP

BAR BENDS

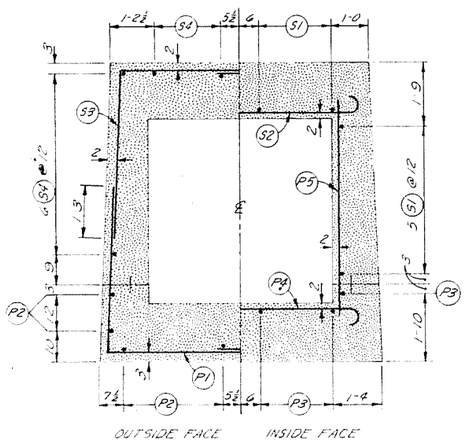


STEEL SCHEDULE

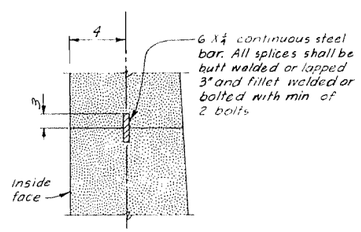
MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	A	B	C	G	H	J	K
P1	4	240	8-9	2100-0	22		4-4 1/2	4-4 1/2		4-4 1/2		0-1 3/4
P2	4	48	19-9	948-0	1							
P3	6	32	19-9	632-0	1							
P4	6	236	7-6	1770-0	27	0-8	6-2		0-8		0-6	
P5	6	168	6-6	1092-0	1							
S1	6	64	19-9	1264-0	1							
S2	7	160	7-9	1240-0	27	0-10	6-1		0-10		0-7	
S3	4	240	8-6	2040-0	23		4-6	4-0		4-6		0-1 3/4
S4	4	72	19-9	1422-0	1							

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	6,510-0	4,349
6	4,758-0	7,147
7	1,240-0	2,535
TOTAL WEIGHT		14,031



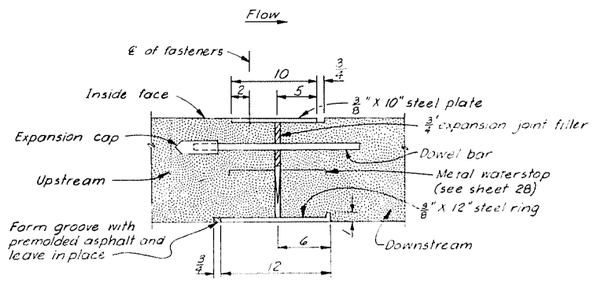
SECTION C-C



DETAILS OF PLATE CONSTRUCTION JOINT
J.5 - J.15
(Not to scale)

NOTE:

DOWEL BARS SHALL BE 3/4" DIA. X 18" LONG SMOOTH STEEL BARS COATED ON UPSTREAM END TO PREVENT BOND. COATING SHALL BE OIL, ASPHALT, OR OTHER METHOD APPROVED BY THE ENGINEER.



SECTION E-E
(Not to scale)

NOTES:

1. 9' DOWEL BARS REQUIRED FOR J. 9, 10, 11, AND 12. DOWEL BARS NOT INCLUDED IN STEEL TOTALS. SEE SHEET 28 FOR DETAILS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. BAR MARKS (P4) AND (S2) NEAREST CUT TO CLEAR WATERSTOP.
6. SEE SHEET 25 FOR LOCATION OF SECTIONS.
7. SEE SHEET 28 FOR DETAIL OF METAL WATERSTOP.

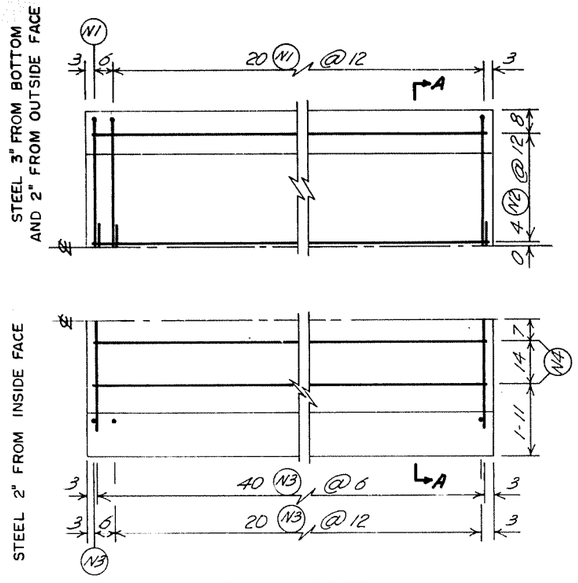
AS BUILT
NOV 15 1978
0 1 2 3 4
Scale in feet

DETAILS OF CONDUIT (J. 8-J.12)

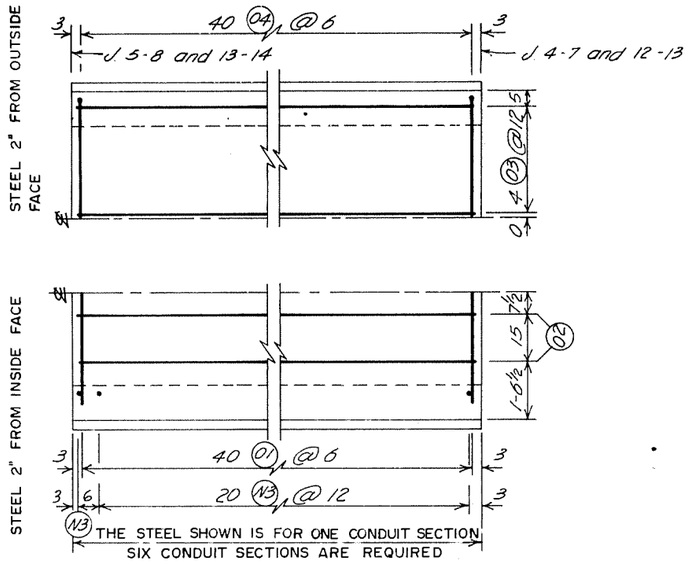
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	Approved by.	
Designed L.M.S., C.E.M.	9-71	Title	
Drawn E.L.J.	11-71	Title	
Traced		Sheet No. 27 of 28	Drawing No. 5, E-29, 772
Checked			

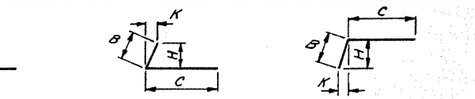


PLAN FLOOR



PLAN TOP

BAR BENDS



STEEL SCHEDULE

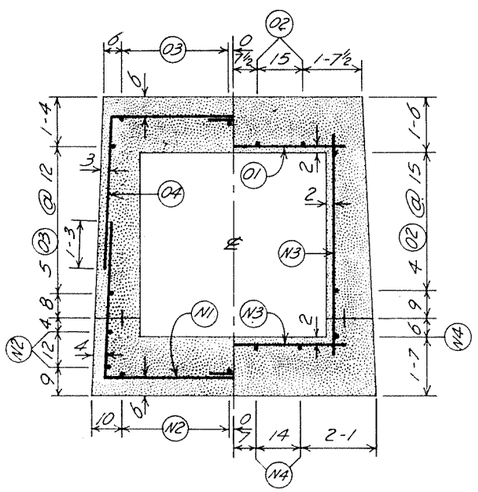
MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
N1	4	252	8-6	2142-0	22	4-3	4-3	4-3	0-1 3/4
N2	4	66	19-9	1303-6	1				
N3	5	492	6-0	2952-0	1				
N4	6	36	19-9	711-0	1				
01	5	240	6-0	1440-0	1				
02	6	72	19-9	1422-0	1				
03	4	102	19-9	2014-6	1				
04	4	480	8-3	3960-0	23	4-1 1/2	4-1 1/2	4-1 1/2	0-1 3/4

STEEL TOTALS

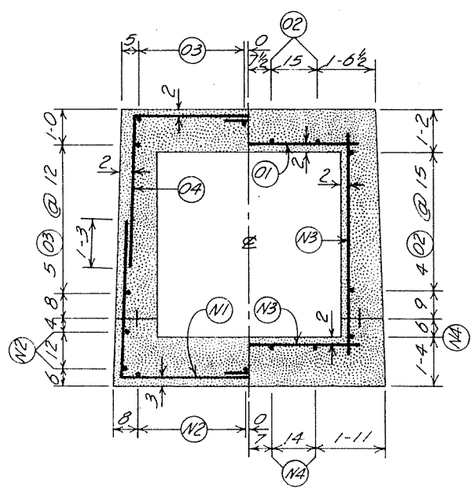
SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	9,420-0	6,293
5	4,392-0	4,581
6	2,133-0	3,204
TOTAL WEIGHT		14,078

NOTES:

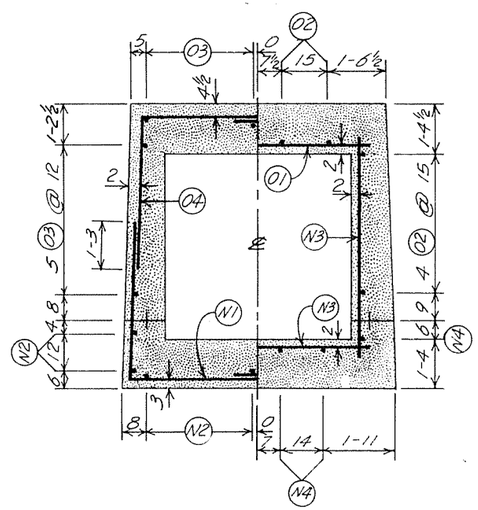
1. 96 DOWEL BARS REQUIRED FOR J. 5 - 8 AND 13-14. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. BAR MARKS (N3) AND (01) NEAREST JOINTS SHALL BE CUT TO CLEAR WATERSTOP.
6. SEE SHEET 25 FOR LOCATION OF SECTIONS B-B AND D-D.



SECTION B-B



SECTION A-A



SECTION D-D

AS BUILT

NOV 15 1978

0 1 2 3 4

Scale in Feet

DETAILS OF CONDUIT (J 4-8, 12-14)

DAM 4

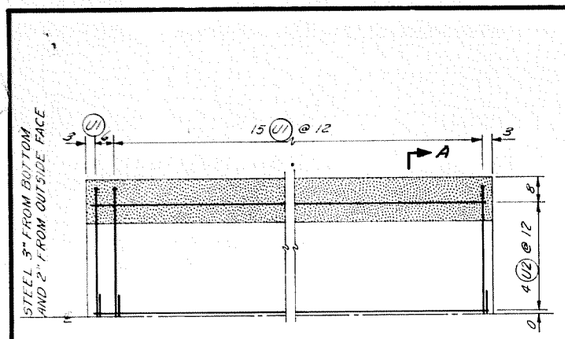
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

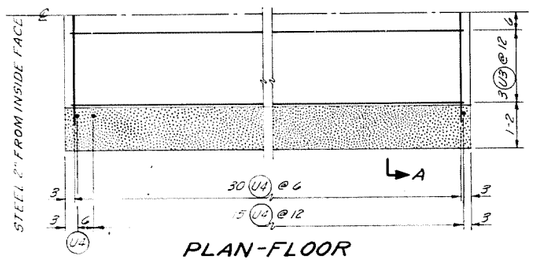
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

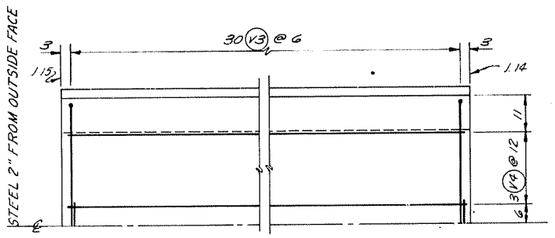
Designed L.M.S. & C.E.M.	Date 9/71	Approved by	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked		Sheet No. 26 of 40	Drawing No. 5,E-29,772

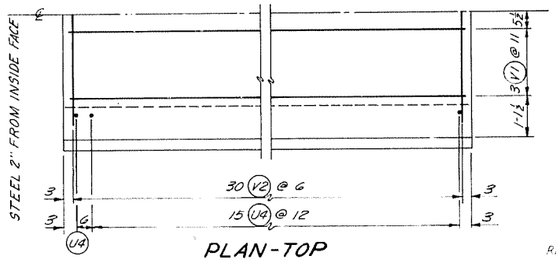
SCS-ENG-313 Rev. 4-69





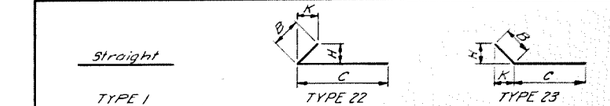
PLAN-FLOOR





PLAN-TOP

BAR BENDS

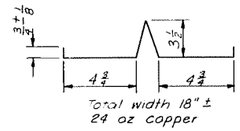


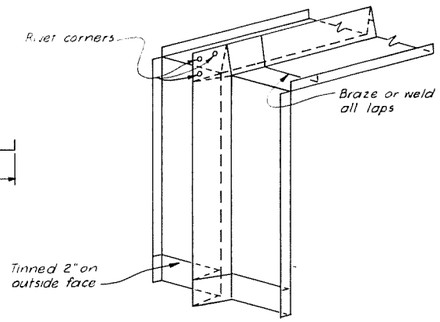
STEEL SCHEDULE

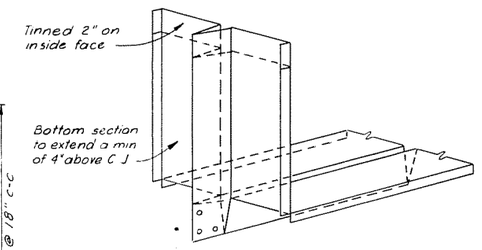
MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C	H	K
U1	4	32	8-6	272-0	22	4-3	4-3	4-3	0-1 3/4
U2	4	11	14-9	162-3	1				
U3	6	8	14-9	118-0	1				
U4	5	62	6-0	372-0	1				
V1	5	14	14-9	206-6	1				
V2	5	30	6-0	180-0	1				
V3	4	60	8-3	495-0	23	4-1 1/2	4-1 1/2	4-1 1/2	0-1 3/4
V4	4	18	14-9	265-6	1				

STEEL TOTALS

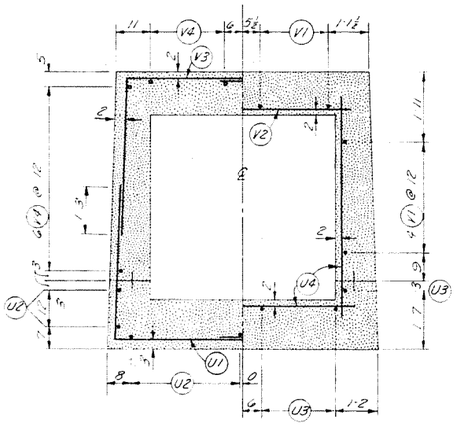
SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	1,194-9	798
5	758-6	791
6	118-0	177
TOTAL WEIGHT		1,766



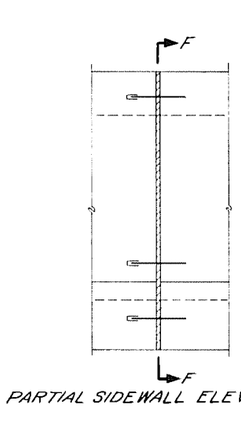




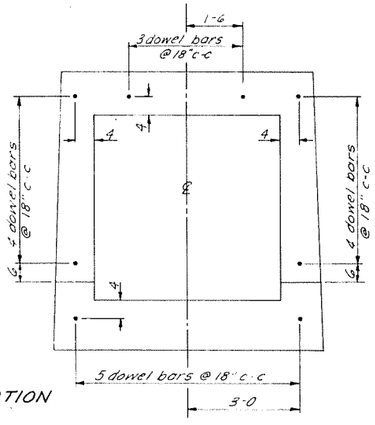
DETAIL OF METAL WATERSTOP
J. 5 THRU J. 15
Not to scale



SECTION A-A



PARTIAL SIDEWALL ELEVATION



SECTION F-F

DETAILS OF JOINTS 5 THRU 15
SHOWING LOCATION OF DOWEL BARS

NOTES:

1. 16 DOWEL BARS REQUIRED FOR J. 15. DOWEL BARS NOT INCLUDED IN STEEL TOTALS.
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR.
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR.
4. THE 2" AND 3" DIMENSIONS TO REINFORCING BARS FROM FACE OF CONCRETE DESIGNATE THE CLEAR DISTANCE.
5. BAR MARKS (U4) AND (V2) NEAREST JOINTS SHALL BE CUT TO CLEAR WATERSTOP.
6. SEE SHEET 25 FOR LOCATION OF SECTIONS.

AS BUILT
NOV 15 1978

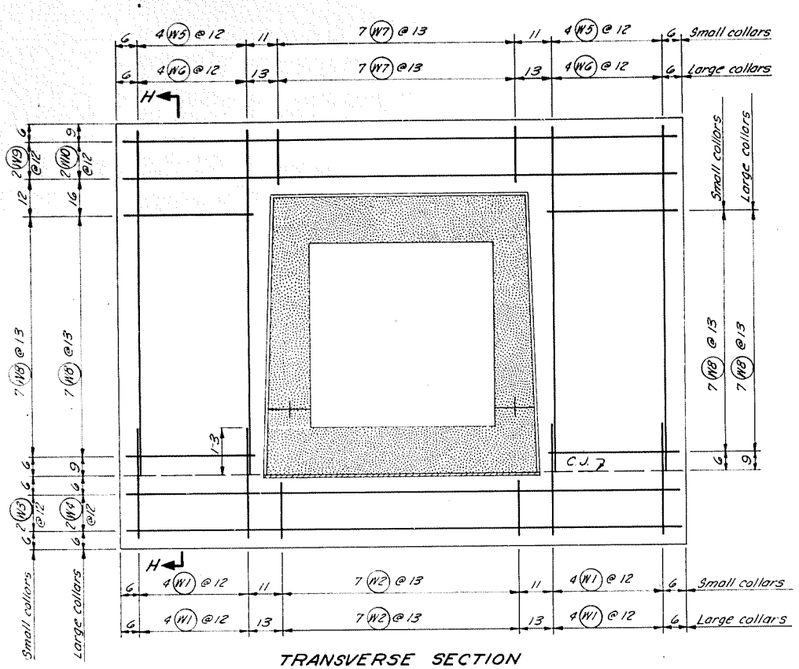
0 1 2 3 4
Scale in feet

DETAILS OF CONDUIT (J. 14 - J. 15)

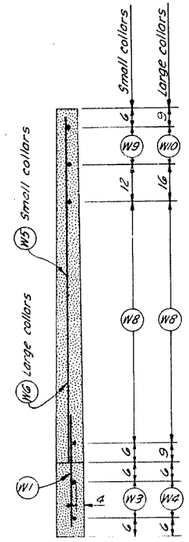
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S., C.E.M.	Date 9-71	Approved by	
Drawn C.L.J.	11-71	Title	
Traced		Title	
Checked		Sheet No. 29 of 30	Drawing No. 5,E-29,772

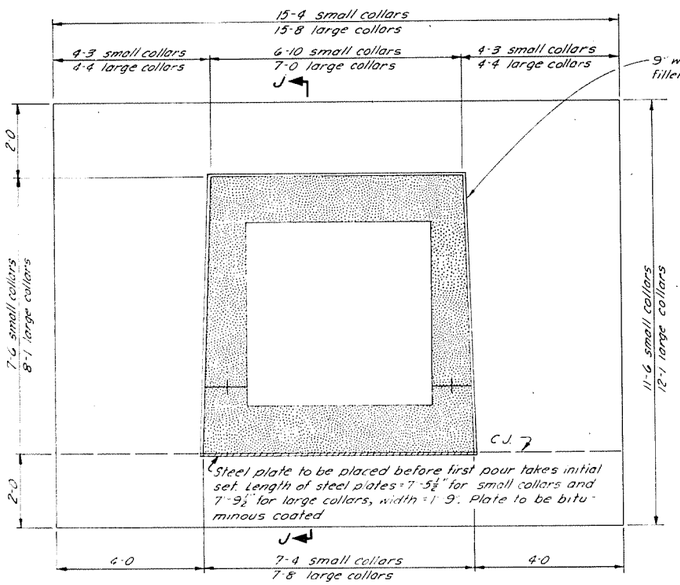


TRANSVERSE SECTION

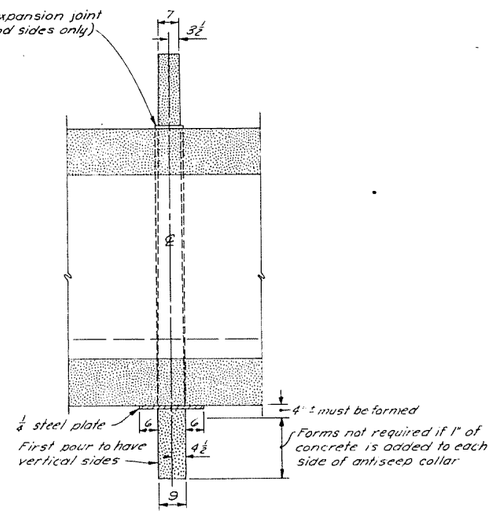


SECTION H-H

REINFORCING STEEL DETAILS OF ANTISEEP COLLARS



ELEVATION OF ANTISEEP COLLARS



SECTION J-J

BAR BENDS

Straight

TYPE 1

STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE
W1	4	56	3-0	168-0	1
W2	4	49	1-6	73-6	1
W3	4	6	14-9	88-6	1
W4	4	8	15-0	120-0	1
W5	4	24	9-3	222-0	1
W6	4	32	9-9	312-0	1
W7	4	49	1-6	73-6	1
W8	4	98	3-6	343-0	1
W9	4	6	14-9	88-6	1
W10	4	8	15-0	120-0	1

STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	1,609-0	1,075

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD	22.5
REINFORCING STEEL	LB.	1,075
1/4" X 1'-9" STEEL PLATE	LIN.FT.	53'-6 1/2"

NOTES:

1. C.J. = CONSTRUCTION JOINT
2. SMALL COLLARS USED FROM JOINTS 6 TO 7 AND 12 TO 15
3. LARGE COLLARS USED FROM JOINTS 8 TO 12.

AS BUILT

NOV 15 1978

0 1 2 3 4

Scale in feet

DETAILS OF ANTISEEP COLLARS

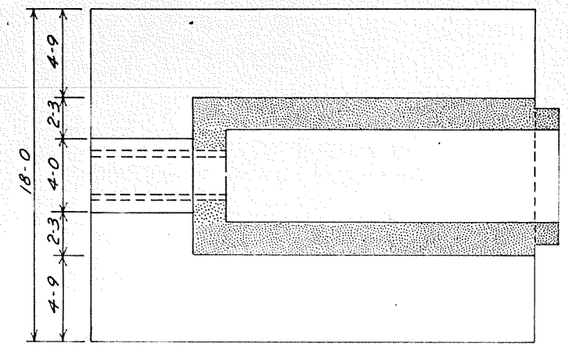
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

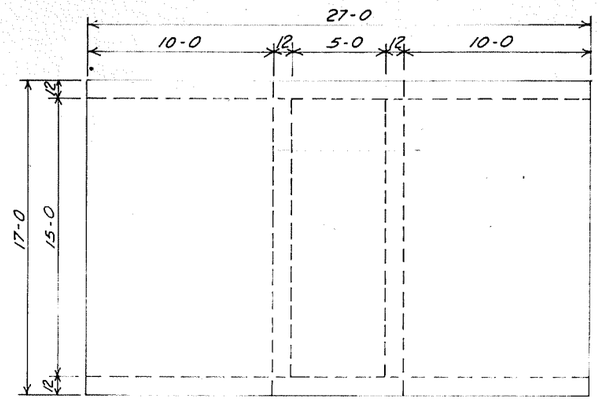
GRAND FORKS COUNTY — NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

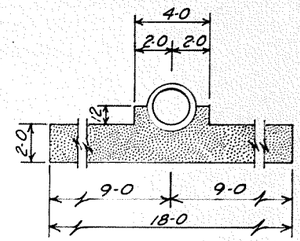
Designed C.E.M.	Date 12-71	Approved by	
Drawn		Title	
Traced		Title	
Checked L.M.S.	1-72	Sheet No. 29 of 30	Drawing No. 5-E-29,772



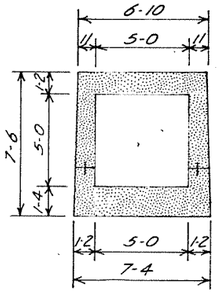
SECTION B-B



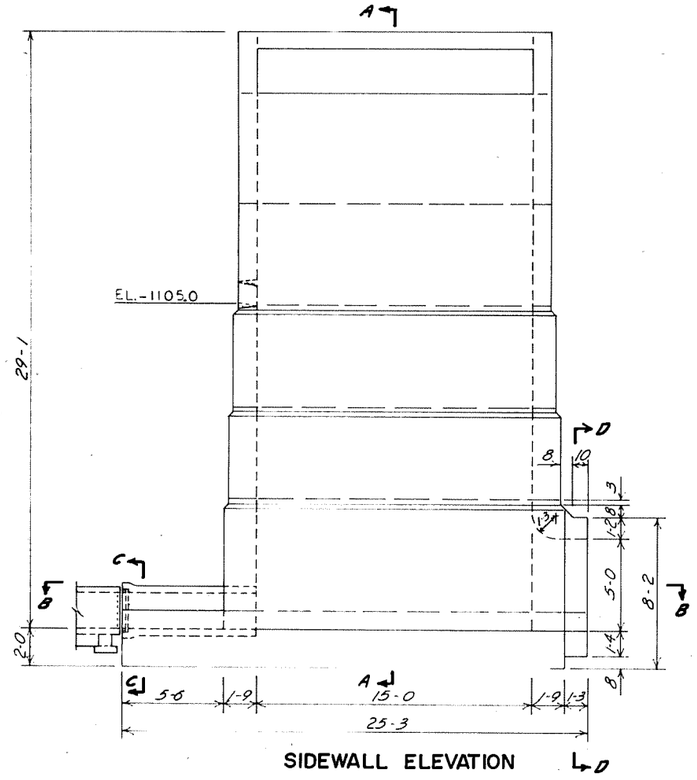
TOP PLAN



SECTION C-C



SECTION D-D



SIDEWALL ELEVATION

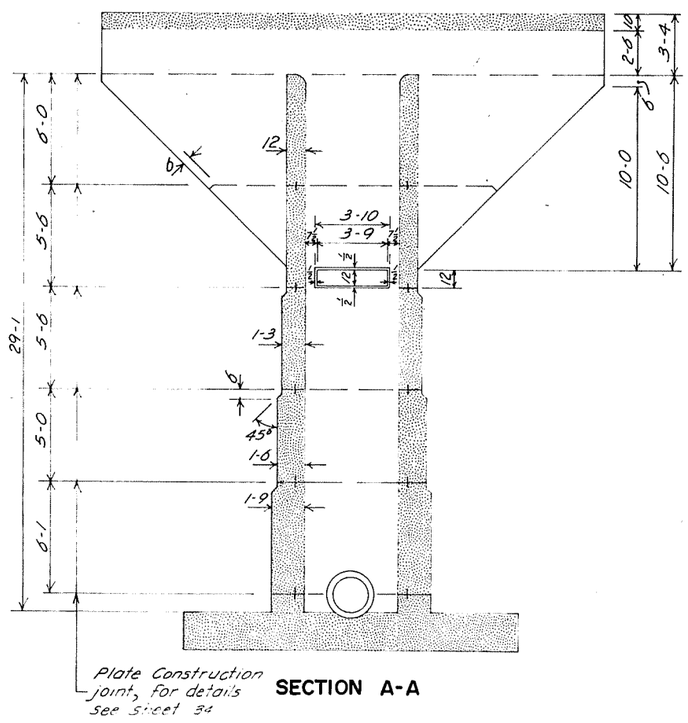


Plate Construction joint, for details see sheet 34

SECTION A-A

TABLE OF QUANTITIES

ITEM	UNIT	QUANTITY
CONCRETE (CLASS 4000)	CU.YD.	122.8
STEEL	LB.	23,304
1/4" X 6" STEEL PLATE	LIN.FT.	306

AS BUILT

NOV 15 1978

0 1 2 3 4

Scale in Feet

DETAILS OF R/C INLET

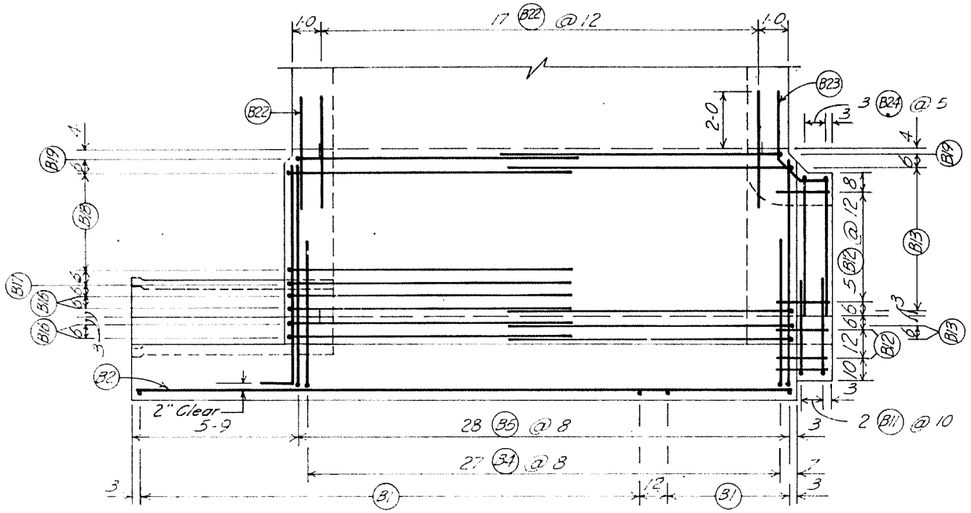
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

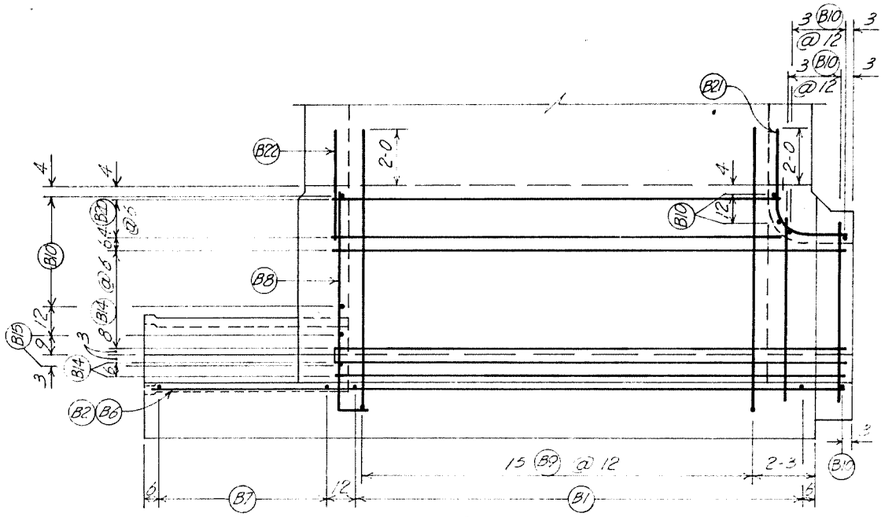
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed E.V.P. L.M.S.	Date 8/71 8/71	Approved by	
Drawn D.L.J.	10/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No. 30 of 20	Drawing No. 5,E-29,772



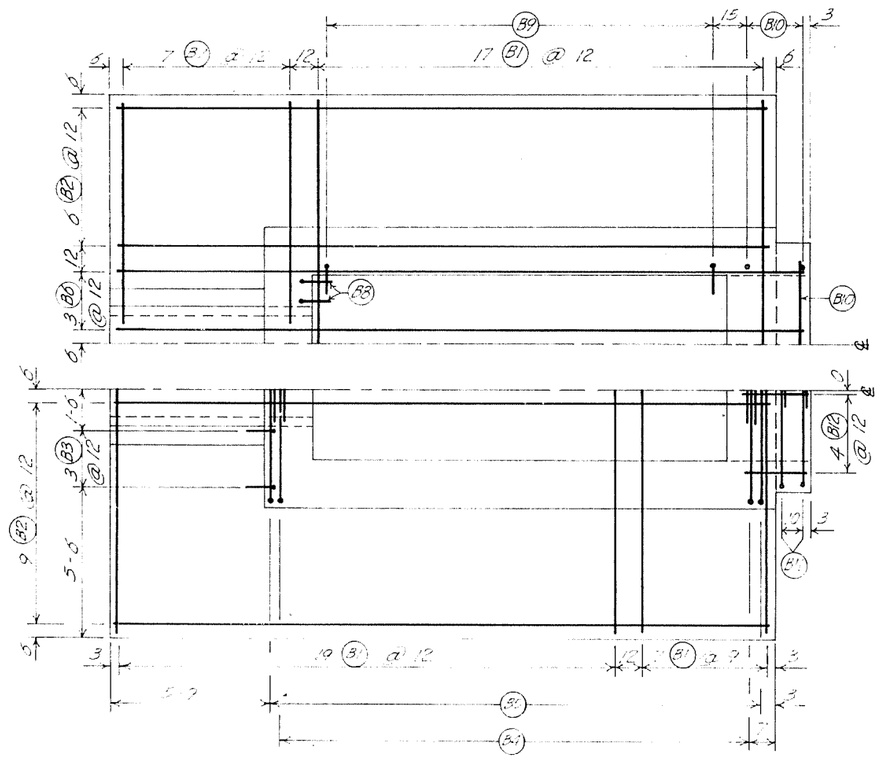
STEEL 2" FROM OUTSIDE FACE
AND 3" FROM BOTTOM OF FOOTING

SIDEWALL ELEVATION



STEEL 2" FROM INSIDE FACE
AND 2" FROM TOP OF FOOTING

SIDEWALL ELEVATION

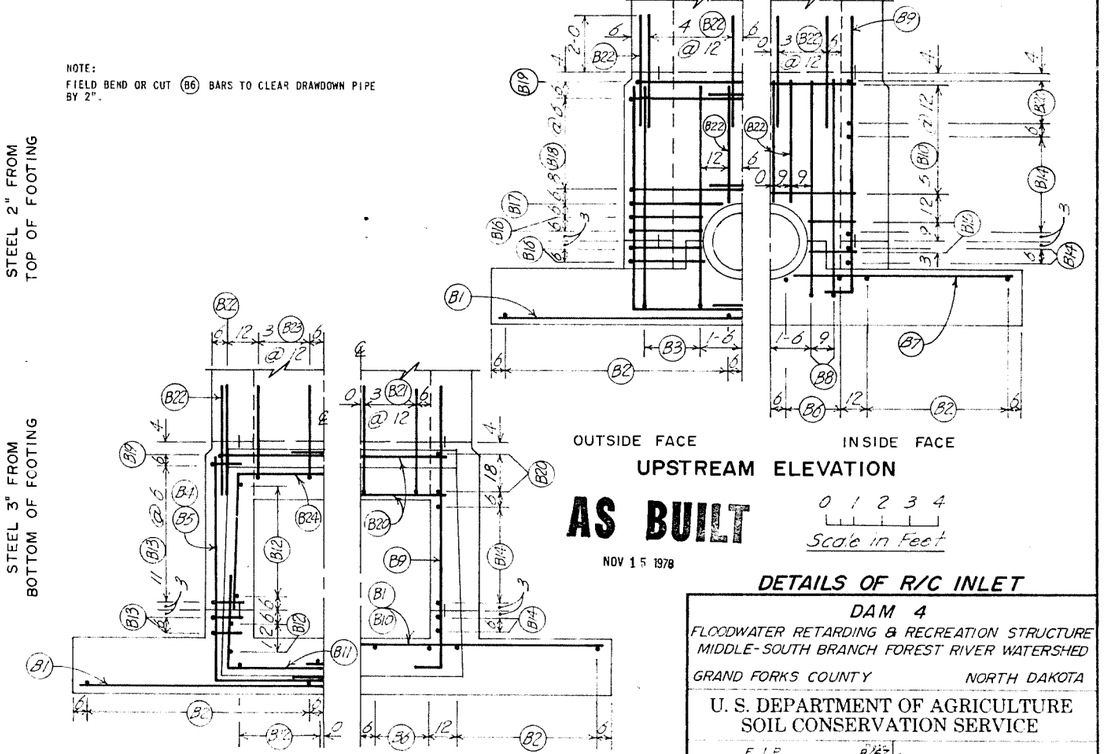


PLAN. FOOTING

NOTE:
FIELD BEND OR CUT B6 BARS TO CLEAR DRAWDOWN PIPE BY 2".

STEEL 2" FROM TOP OF FOOTING

STEEL 3" FROM BOTTOM OF FOOTING



UPSTREAM ELEVATION

DOWNSTREAM ELEVATION

AS BUILT

NOV 15 1978

0 1 2 3 4
Scale in Feet

DETAILS OF R/C INLET

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

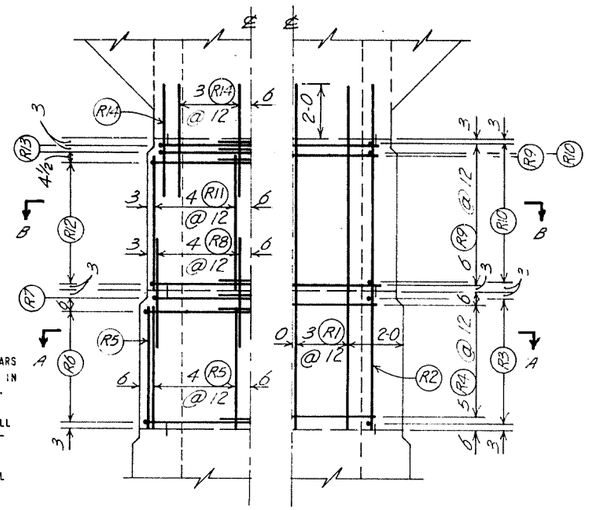
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGNED	E.I.P.	8/71	Approved
DRAWN	E.M.S.	8/71	Title
TRACED	D.L.	10/71	
CHECKED	C.E.H.	10/71	31/40 5,E-29,772

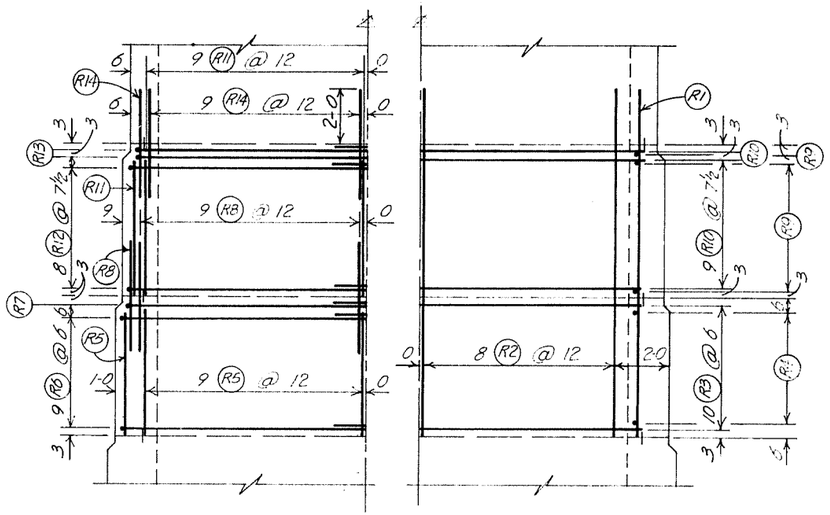
SCS-31719-64

NOTES:

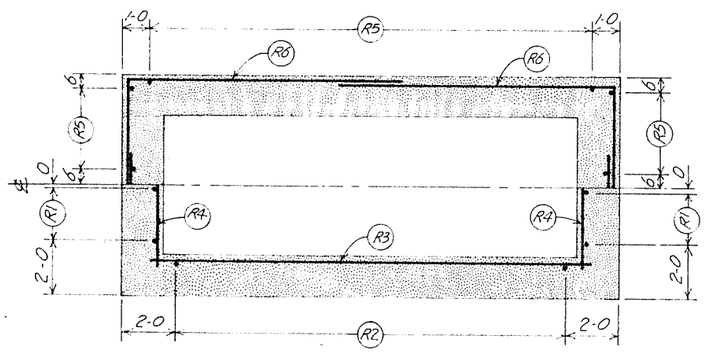
1. ELIMINATE THE 4 (R14) BARS IN THE UPSTREAM ENDWALL IN THE AREA OF THE ORIFICE.
2. MARK (R1) BARS PASSING THROUGH THE ORIFICE SHALL BE CUT 2" BELOW THE CONSTRUCTION JOINT.
3. THE STEEL PLATE IN THE CONSTRUCTION JOINT SHALL BE CUT 2" FROM THE EDGE OF THE ORIFICE.
4. MARK (R1) BARS PASSING ALONG SIDE ORIFICE SHALL BE MOVED TO CLEAR ORIFICE BY 2".
5. SEE SHEET 34 FOR ADDITIONAL STEEL REQUIREMENTS AT ORIFICE.



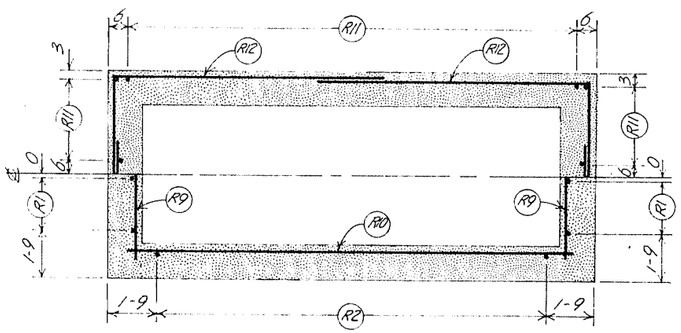
ENDWALL ELEVATION



SIDEWALL ELEVATION



SECTION A-A



SECTION B-B

AS BUILT

NOV 15 1978

0 1 2 3 4
Scale in Feet

DETAILS OF R/C INLET

DAM 4

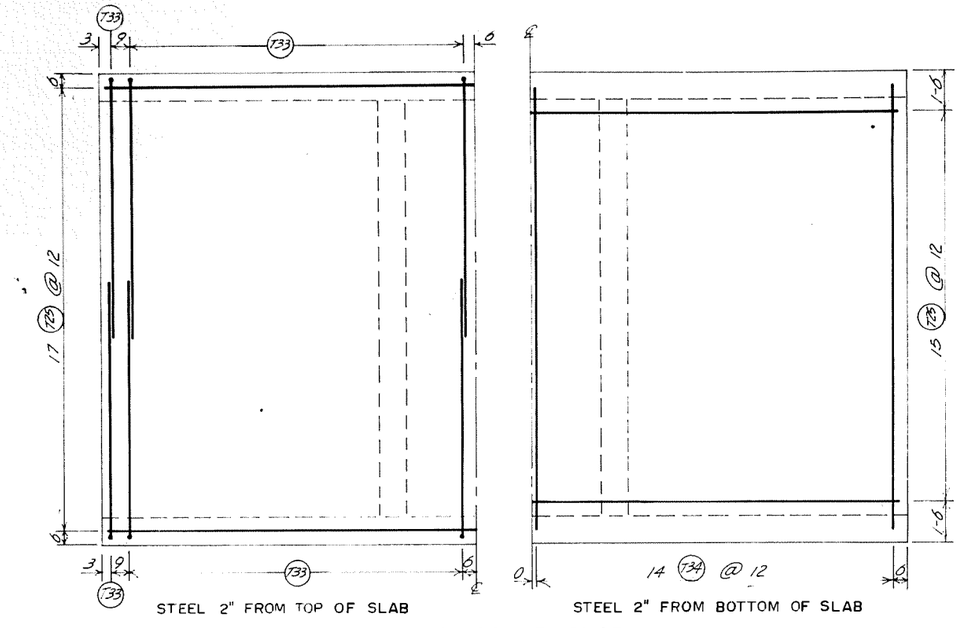
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

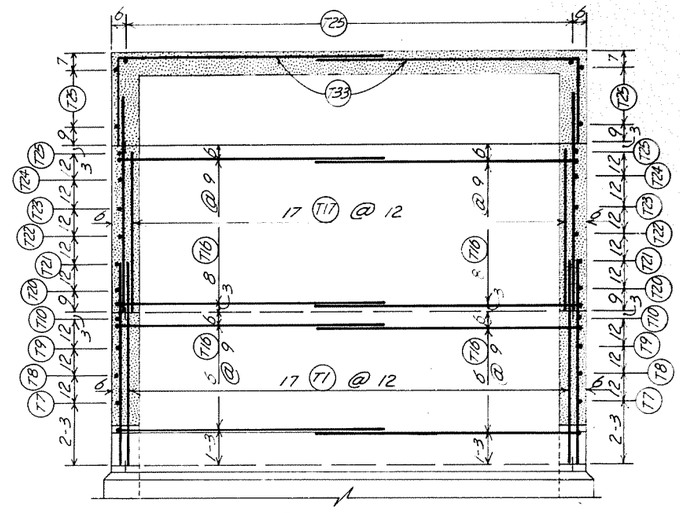
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	E.J.P. L.M.S.	8/67 8/71	Approved by	
Drawn	D.L.J.	10/71	Title	
Traced			Title	
Checked	C.E.M.	10/71	Sheet No. 32 of 40	Drawing No. 5,E-29,772

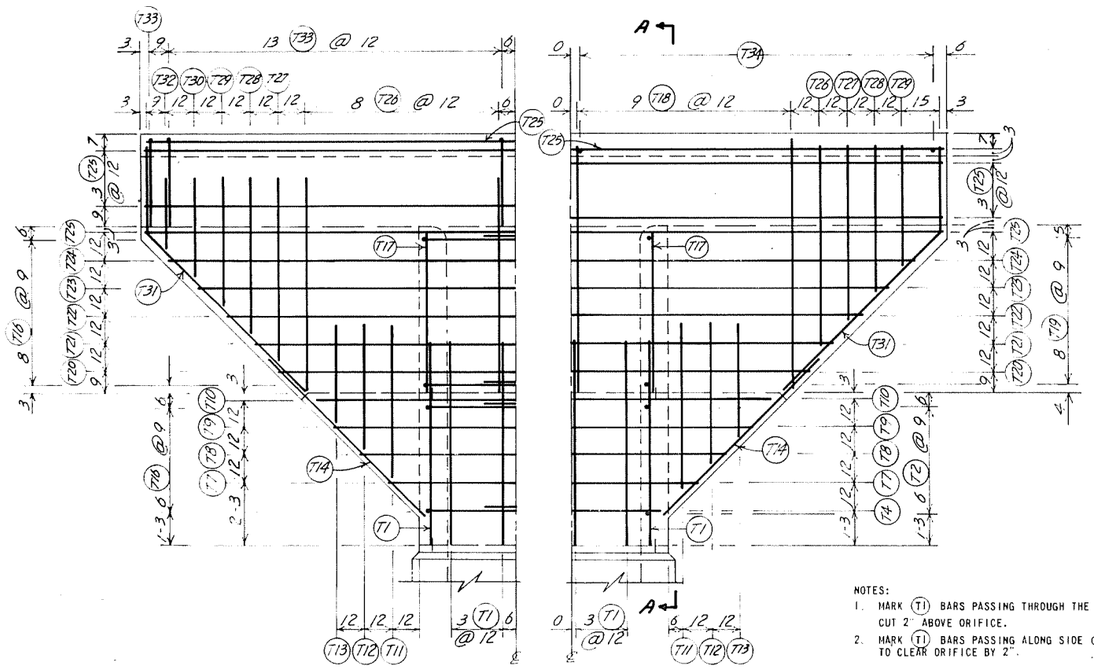
SCS-212-19-441



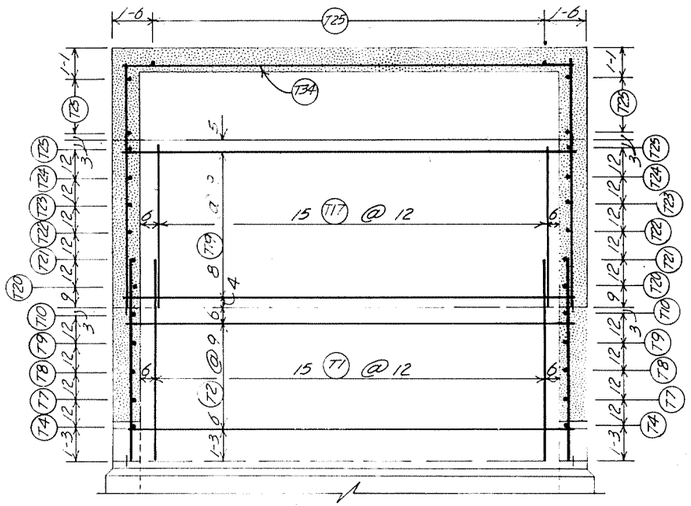
PLAN COVER SLAB



SECTION A-A



ENDWALL ELEVATION



SECTION A-A

NOTES:
1. MARK (T1) BARS PASSING THROUGH THE ORIFICE SHALL BE FIELD CUT 2" ABOVE ORIFICE.
2. MARK (T1) BARS PASSING ALONG SIDE OF THE ORIFICE SHALL BE MOVED TO CLEAR ORIFICE BY 2".

0 1 2 3 4
SCALE IN FEET

AS BUILT
NOV 15 1978

DETAILS OF R/C INLET

DAM 4

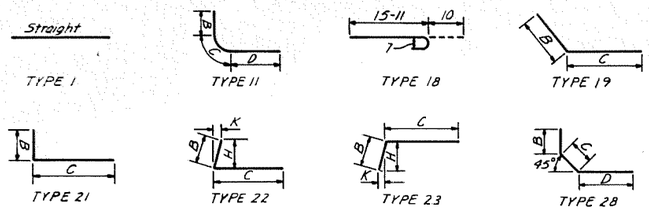
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date 8-77	Approved by	
Drawn		Title	
Traced		Title	
Checked		Sheet No 33 of	Drawing No. 5,E-29,772

BAR BENDS

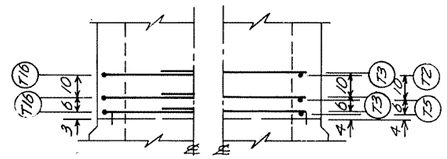


STEEL SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	A	B	C	D	E	F	H	K
B1	6	43	17-6	752-6	1								
B2	6	30	23-6	705-0	1								
B3	6	6	9-0	54-0	21		1-0	8-0					
B4	7	54	10-6	567-0	21		5-3	5-3					
B5	7	56	13-3	742-0	21		5-3	8-0					
B6	6	6	24-9	148-6	1								
B7	6	14	8-0	112-0	1								
B8	7	4	8-9	35-0	21		1-0	7-9					
B9	6	30	11-0	330-0	21		1-0	10-0					
B10	6	17	6-0	102-0	1								
B11	4	4	7-6	30-0	22		3-4 1/2	4-1 1/2				3-4 1/2	0-1 1/2
B12	4	21	1-9	36-9	1								
B13	7	26	11-3	292-6	21		1-0	10-3					
B14	7	20	18-3	365-0	1								
B15	6	4	1-9	7-0	1								
B16	7	8	13-0	104-0	21		2-9	10-3					
B17	7	2	13-9	27-6	21		3-6	10-3					
B18	7	16	15-6	248-0	21		5-3	10-3					
B19	7	4	15-0	60-0	21		5-0	10-0					
B20	7	8	16-0	128-0	1								
B21	6	5	6-0	30-0	11		2-10	1-7	1-7			RADIUS = 12"	
B22	6	52	4-0	208-0	1								
B23	6	6	4-3	25-6	28		2-4	1-2	0-9				
B24	4	6	9-0	54-0	23		5-0	4-0					
R1	6	10	12-6	125-0	1								
R2	6	30	12-6	375-0	1								
R3	7	20	16-0	320-0	1								
R4	6	10	6-0	60-0	1								
R5	6	50	4-6	225-0	1								
R6	7	36	15-0	540-0	21		5-0	10-0					
R7	7	4	14-6	58-0	21		4-9	9-9					
R8	6	50	4-0	200-0	1								
R9	6	14	6-0	84-0	1								
R10	7	20	16-0	320-0	1								
R11	6	50	5-0	250-0	1								
R12	7	32	14-6	464-0	21		4-9	9-9					
R13	7	8	14-0	112-0	21		4-6	9-6					
R14	6	42	4-0	168-0	1								
T1	5	86	7-3	623-6	1								
T2	7	14	16-0	224-0	1								
T3	5	4	6-0	24-0	1								
T4	5	2	7-0	14-0	1								
T5	7	4	16-9	67-0	18								
T6	NONE												
T7	5	4	9-0	36-0	1								
T8	5	4	11-0	44-0	1								
T9	5	4	13-0	52-0	1								
T10	5	4	14-6	58-0	1								
T11	5	8	5-6	44-0	1								
T12	5	8	4-6	36-0	1								
T13	5	8	3-6	28-0	1								
T14	5	8	8-0	64-0	1								
T15	7	4	10-9	43-0	21		1-3	9-6					
T16	7	64	14-0	896-0	21		4-6	9-6					
T17	5	64	5-9	368-0	1								
T18	5	34	9-0	306-0	1								
T19	7	16	16-0	256-0	1								
T20	5	4	17-0	68-0	1								
T21	5	4	19-0	76-0	1								
T22	5	4	21-0	84-0	1								
T23	5	4	23-0	92-0	1								
T24	5	4	25-0	100-0	1								
T25	5	48	26-6	1272-0	1								
T26	5	36	7-9	279-0	1								
T27	5	8	6-9	54-0	1								
T28	5	8	5-9	46-0	1								
T29	5	8	4-9	38-0	1								
T30	5	4	3-9	15-0	1								
T31	5	8	11-3	90-0	19		3-3	8-0					
T32	5	4	4-0	16-0	19		1-0	3-0					
T33	5	56	12-6	700-0	21		3-2	9-4					
T34	5	27	16-0	432-0	1								

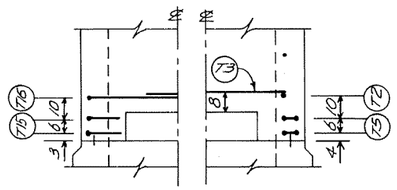
STEEL TOTALS

SIZE	LENGTH(FT.)	WEIGHT(LB.)
4	120-9	81.0
5	5,059-6	5,277.0
6	3,961-6	5,050.0
7	5,869-0	11,996.0
TOTAL		23,304.0



STEEL 2" FROM OUTSIDE FACE — STEEL 2" FROM INSIDE FACE

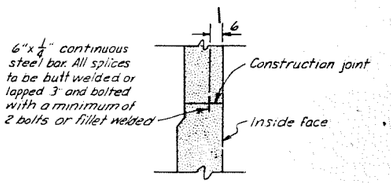
DOWNSTREAM ENDWALL



STEEL 2" FROM OUTSIDE FACE — STEEL 2" FROM INSIDE FACE

UPSTREAM ENDWALL

ADDITIONAL STEEL REQUIRED AROUND ORIFICE



0 1 2 3 4
Scale in Feet

AS BUILT
NOV 15 1978

DETAILS OF R/C INLET

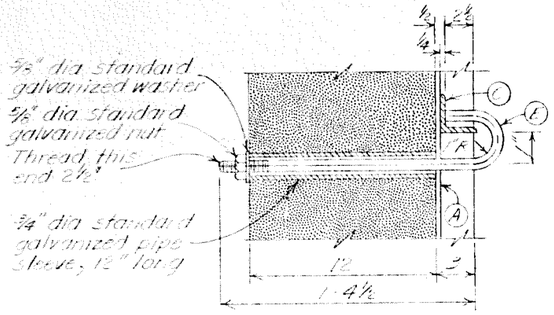
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

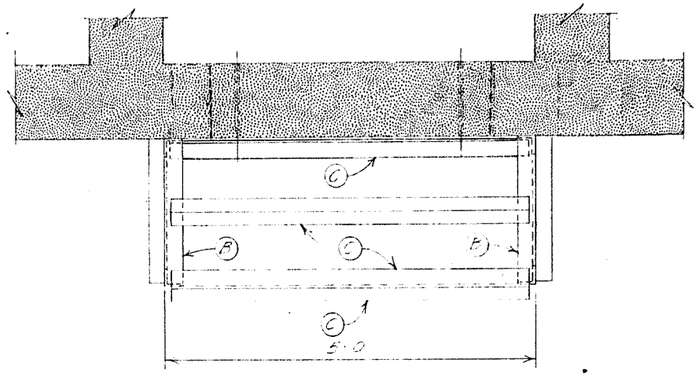
GRAND FORKS COUNTY ..... NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed E.V.P.	Date 8/77	Approved by	
Drawn D.E.L.		Title	
Traced		Title	
Checked C.E.M.		Sheet No. 34 of 70	Drawing No. 5,E-29,772



DETAIL OF ANCHOR BOLT



PLAN

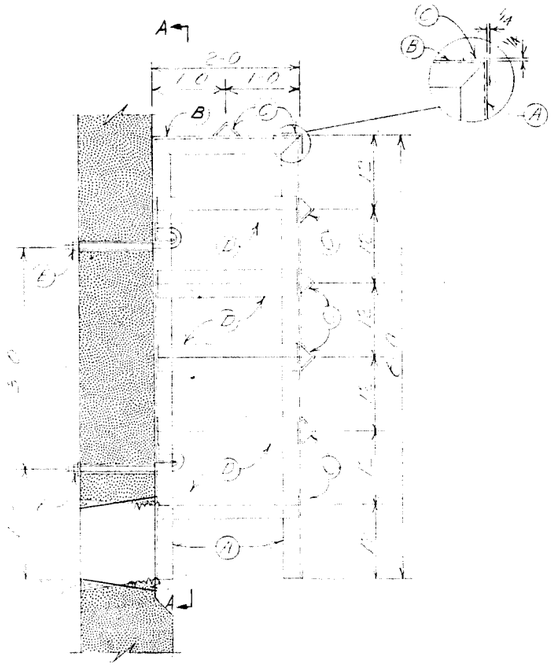
NOTES:

1. CLIP ENDS OF MEMBERS (A) AND (B) AS SHOWN.
2. ALL STRUCTURAL STEEL MEMBERS (WITH EXCEPTION OF GALVANIZED MEMBERS) TO BE PAINTED IN ACCORDANCE WITH SPECIFICATIONS.
3. ALL STRUCTURAL STEEL ANGLES TO BE SECURELY WELDED AT ALL JUNCTIONS.

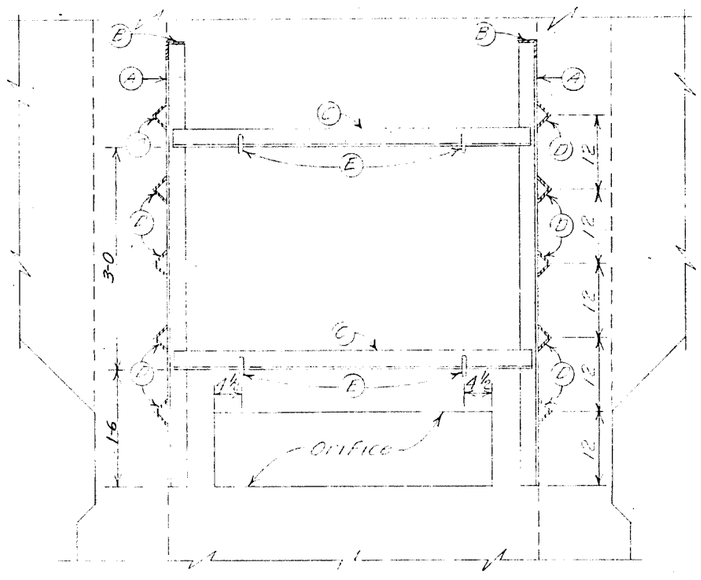
MATERIAL LIST

MARK	ITEM	QUANTITY
A	ANGLE 3" X 3" X 1/4", 6-0 LONG	4
B	ANGLE 3" X 3" X 1/4", 2-0 LONG	2
C	ANGLE 3" X 3" X 1/4", 4-11 LONG	9
D	ANGLE 3" X 3" X 1/4", 1-11 LONG	10
E	5/8" DIA. GALV. ROD (SEE DETAIL)	4

WEIGHT = 447 LB.

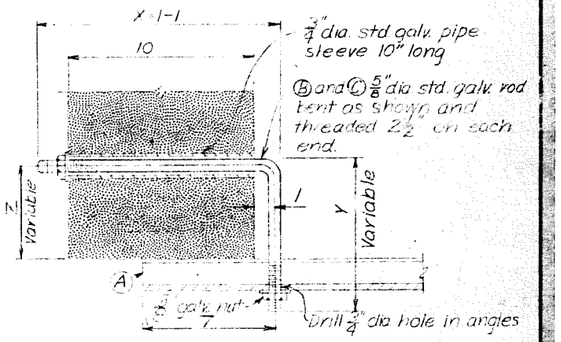


SIDE ELEVATION



SECTION A-A

DETAILS OF ORIFICE TRASH RACK



DETAIL OF ANCHORAGE FOR ANGLES
DRAWDOWN INLET TRASH RACK
(Not to scale)

TABLE OF QUANTITIES FOR TRASH RACK
ON DRAWDOWN INLET STRUCTURE

MARK	ITEM	X	Y	Z	QUANTITY
A	ANGLE 2 1/2" X 2 1/2" X 1/4", 4-6 LONG				6
B	5/8" GALVANIZED ROD	1-1	8	5	8
C	5/8" GALVANIZED ROD	1-1	1-3	12	4

WEIGHT OF ANGLES - STEEL 111 LB.

AS BUILT

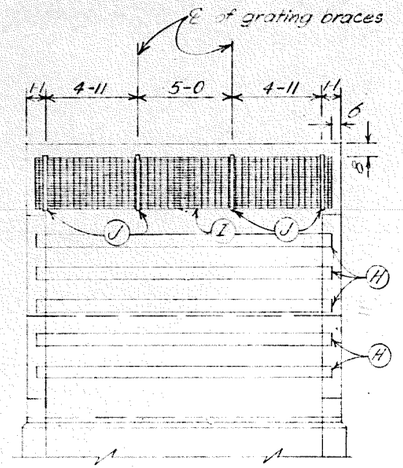
NOV 15 1978

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE - SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

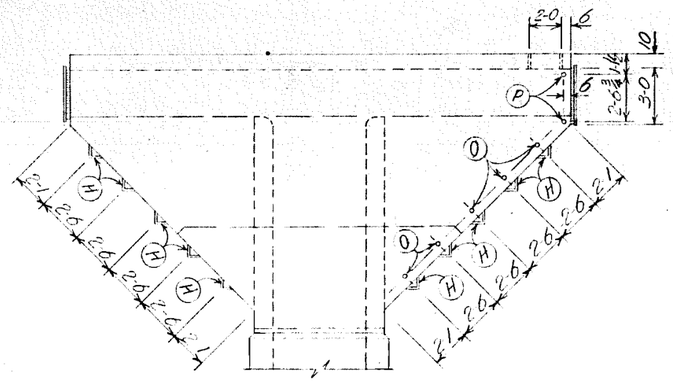
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S. & H.R.H.	Date 12/71	Approved By	
Drawn D.L.J.	12/71	Title	
Traced		Title	
Checked		Sheet No. 36 of 40	Drawing No. 5,E-29,772

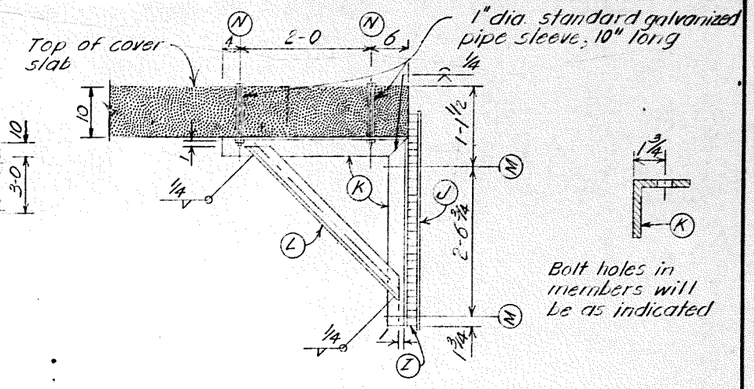
SCS-ENG-313 Rev. 4-69



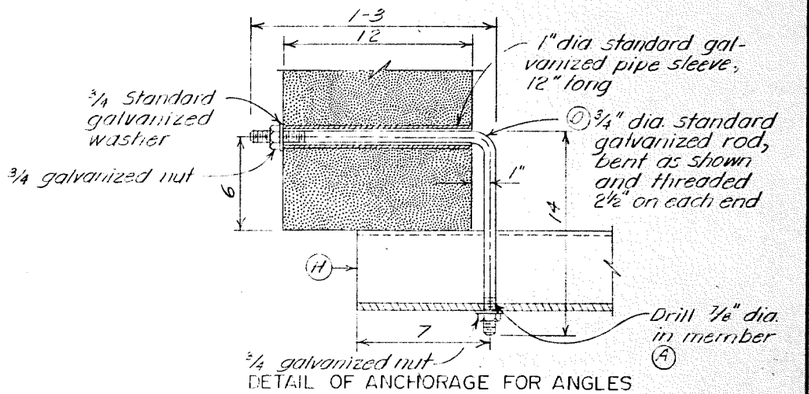
FRONT VIEW OF TRASH RACK



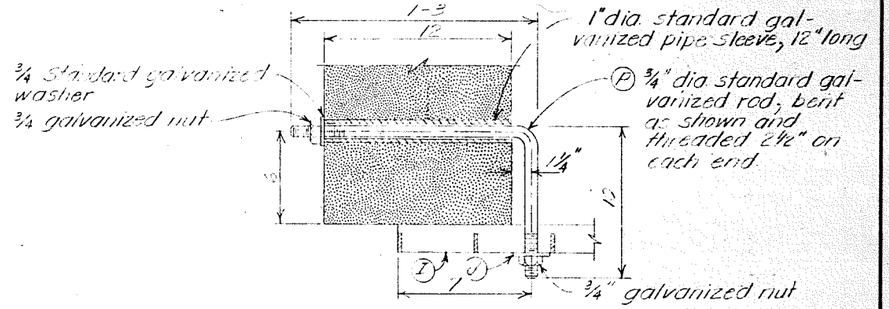
END VIEW OF TRASH RACK



DETAIL OF GRATING BRACE



DETAIL OF ANCHORAGE FOR ANGLES

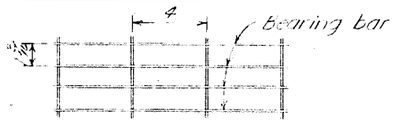


DETAIL OF ANCHORAGE FOR GRATING

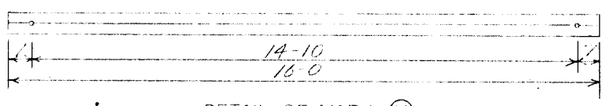
MATERIAL LIST

MARK	ITEM	QUANTITY
H	ANGLES 8" X 8" X 1/2", 16-0 LONG	10
I	GRATING: 16-0 LONG X 2-11 13/16 WIDE WITH 1 3/4" X 3/16" BEARING BARS	2
J	BAR 2" X 1/4" X 3-0	8
K	ANGLE 3" X 3" X 1/4", 2-10 LONG	8
L	ANGLE 3" X 3" X 1/4", 3-3 LONG	4
M	3/4" DIA. GALV. BOLT WITH NUT AND WASHER, 3 1/2" LONG	8
N	3/4" DIA. GALV. BOLT, 12" LONG WITH NUT AND WASHER AND WITH 1" DIA. STANDARD GALV. PIPE SLEEVE, 10" LONG AS PER DETAIL	6
O	3/4" DIA. GALV. ROD AS PER DETAIL WITH 1" DIA. STANDARD GALV. PIPE SLEEVE, 12" LONG AS PER DETAIL	20
P	3/4" DIA. GALV. ROD AS PER DETAIL WITH 1" DIA. STANDARD GALV. PIPE SLEEVE, 12" LONG AS PER DETAIL	8

WEIGHT OF ANGLES = 4,224 LB.
WEIGHT OF GRATING = 1,286 LB.



DETAIL OF GRATING SHOWING BEARING BAR SPACING



DETAIL OF MARK (H)

NOTES:
1. CLIP ENDS OF MEMBERS (K) AND (L) AS SHOWN.
2. GRATING BRACE ASSEMBLY 13 TO BE WELDED FORMING A FRAME AS SHOWN. EIGHT HOLES MUST BE DRILLED TO ATTACH FRAME TO COVER SLAB AND GRATING TO FRAME.
3. ALL STRUCTURAL STEEL MEMBERS (WITH EXCEPTION OF GALVANIZED MEMBERS) TO BE PAINTED IN ACCORDANCE WITH SPECIFICATIONS.
4. THE NUTS ON THE 3/4" GALVANIZED RODS SHOULD BE DRAWN UP CAREFULLY TO AVOID STRESSING THE RODS.

AS BUILT

NOV 15 1978

DETAILS FOR HIGH STAGE TRASH RACK

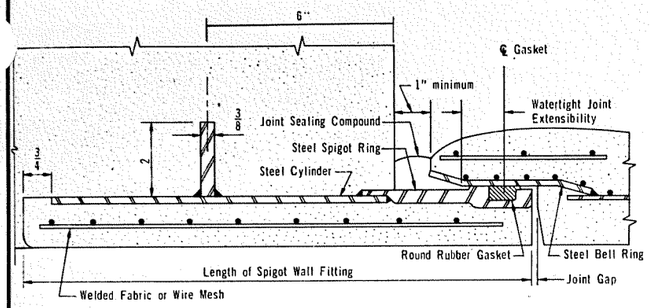
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE - SOUTH BRANCH FOREST RIVER WATERSHED

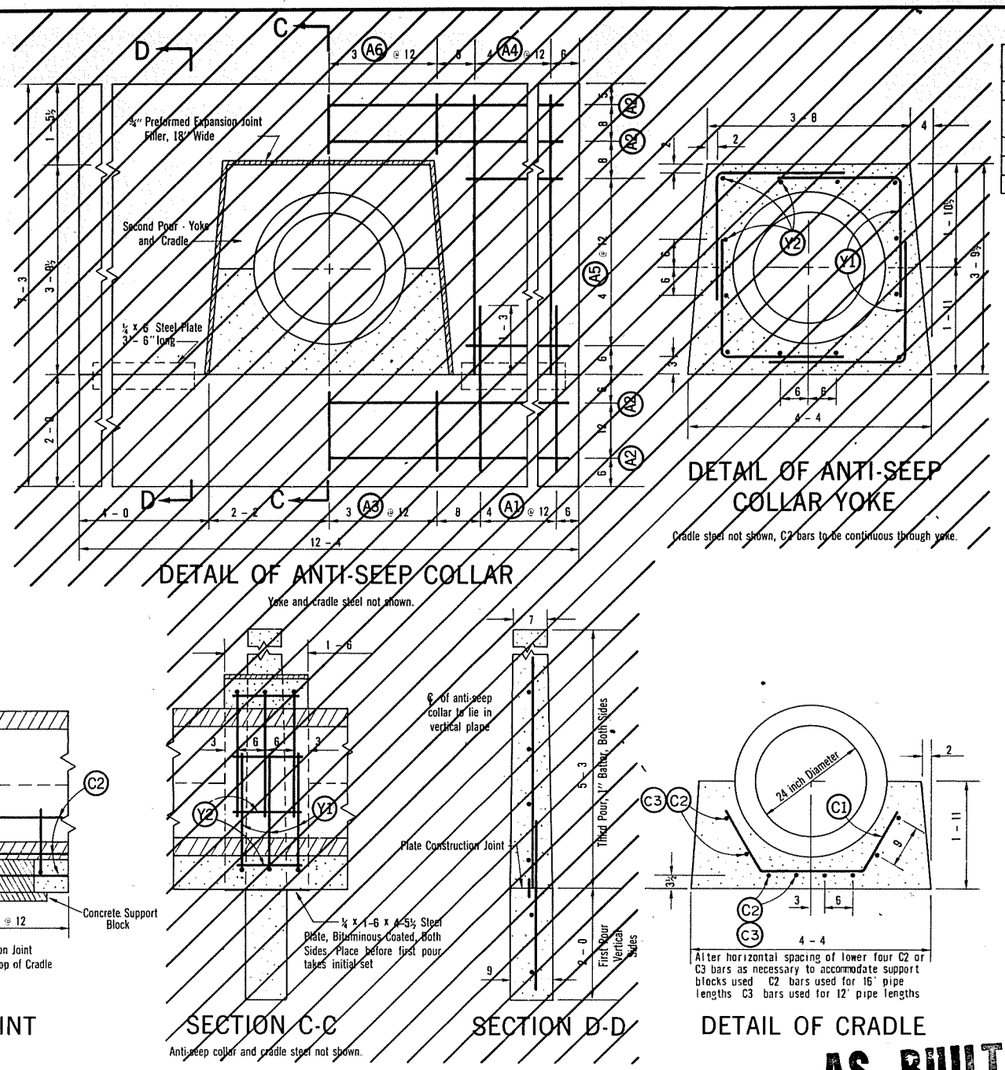
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	L.M.S. & H.R.H.	12/71	Approved by	
Drawn	D.L.J.	12/71	Title	
Traced			Title	
Checked	R.D.S.	1/74	Sheet No. 35 of 40	Drawing No. 5,E-29,772



DETAIL A



DETAIL OF ANTI-SEEP COLLAR

Yoke and cradle steel not shown.

DETAIL OF ANTI-SEEP COLLAR YOKE

Cradle steel not shown, C2 bars to be continuous through yoke.

DETAIL OF SPIGOT WALL FITTING

DETAIL OF PIPE JOINT

SECTION C-C

Anti-seep collar and cradle steel not shown.

SECTION D-D

DETAIL OF CRADLE

After horizontal spacing of lower four C2 or C3 bars as necessary to accommodate support blocks used C2 bars used for 16' pipe lengths C3 bars used for 12' pipe lengths

BAR TYPES

SUGGESTED SUPPORT BLOCKS

Sufficient blocks shall be provided to support the pipe to the required line and grade. The Contractor shall determine the number and size of blocks required. Wedges may be used as an alternate.

DETAIL B

STEEL SCHEDULE

Cradle

Mark	Size	Total Quantity	Length	Type		Total Length
C_1	4	44	4 - 4	7		190-8
C_2	6	16	15 - 6	1		248-0
C_3	6	8	11 - 6	1		92-0

QUANTITIES

Concrete	Cu. Yds.
Anti-Seep Collar including Yoke	2.123
Each Additional to Cradle	4.2
Total	6.3
Cradle	
** Per Lineal Foot of Cradle	0.1923
Total	8.5
Steel	**Pounds**
Anti-Seep Collar including Yoke	398
Cradle	638

Concrete quantities are based on an outside diameter of pipe of 32 inches.
Steel quantities do not change with outside diameter of pipe.
* This quantity is given by
2.123 - 8.0001515 $(D_f + 32)$ $(D_f - 32)$ cu. yds.
** This quantity is given by
0.1923 - 0.0001010 $(D_f + 32)$ $(D_f - 32)$ cu. yds.
D_f = outside diameter of pipe furnished, inches.

JOINT REQUIREMENTS

Length of Pipe Section	Minimun Joint Length	Minimum Joint Limiting Angle	
feet	inches	radians	degrees
16	2.75	0.0066	0°23'
12	2.75	0.0066	0°23'
8	2.75	0.0066	0°23'

For pipe length other than shown, joint requirements will be determined by the Engineer.

Where pipes of different length are connected, adjoining pipes shall meet the requirements of the longer pipe.

Prior to delivery of pipe, the pipe joint detail proposed for use shall be submitted to the Engineer for approval.

STRENGTH REQUIREMENTS

Inside Diameter of Pipe	Internal Load	External Load	
	Hydrostatic Pressure	Minimum 3-Edge Bearing Strength in Pounds per Lineal Foot of Pipe	
		Applicable Standard Specification	
		AWWA C-301	AWWA C-300
	Head of Water	Load to produce 0.001 inch crack one foot long	Load to produce 0.01 inch crack one foot long
inches	feet		
24	40	2,850	3,800

The outside diameter of pipe assumed in design is 32 inches. Where the pine furnished has an outside diameter greater than assumed in design, the three-edge bearing strength of the pipe furnished must not be less than the specified three-edge bearing strength multiplied by the ratio of the outside diameter of the pipe furnished to the outside diameter assumed in design.

AS BUILT
NOV 15 1978

STANDARD CONDUIT DETAILS

FOR
REINFORCED CONCRETE PRESSURE PIPE
PRINCIPAL SPILLWAY

STANDARD DWG. NO. ES-5024-CE

DATE 2-70 REV. 3-72 | SHEET 1 OF 1

Joint length equals watertight joint extensibility plus joint gap

The pipe shall be drawn together so that the maximum joint gap does not exceed 3/8 inch for pipe laid on a straight line. For cambered pipe or pipe laid on a curved line, the joint gap at the closest point shall not exceed 3/8 inch.

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
L.M.S.	9-73	Title
Drawn		Title
Traced		Sheet No. 37 of 40
Checked		Drawing No. 5E-29,772

MATERIALS LIST FOR GATE & GATE LIFTING MECHANISM

ITEM		UNIT	QUANTITY
3" DIA. STD. GALV. PIPE WITH UNIONS & COUPLINGS		UNIT	2-0
GATE STEM 1½" DIA.	BRONZE	LIN. FT.	5-6
	CARBON STEEL	LIN. FT.	47-6
STEM COUPLING		EACH	3
STEM SLEEVES		EACH	3
24" DIA. HAND WHEEL LIFT (EQUAL TO ARMCO HB-24) WITH BRONZE LIFT NUT		EACH	1
24" DIA. CAST IRON SLIDE GATE, RISING STEM, SPIGOT BACK AND BRONZE SEATS. (ARMCO MOD. SD-10 OR EQUAL)		EACH	1

QUANTITIES FOR LIFT STRUCTURE, INLET STRUCTURE & ANCHOR BLOCKS

CLASS 4000 CONCRETE ~~167~~ 30 Yds. 10.5
REINFORCING STEEL ~~535~~ Lbs. 665

NOTES:

1. Provide one 24" dia. cast iron Slide Gate, rising stem, spigot back and bronze seats (Armco Model SD-10 or equal). Operate by rotating hand wheel according to manufacturers specifications.
2. Fill Gate Stem Housing with 10W-30 or equal cylinder oil.
3. Trash Rack to be painted in accordance with specifications.
4. All bolts and nuts to be galvanized.
5. Length of the Gate Stem is measured from the center of the bore to the base of the hand wheel lift.
6. The inside of the inlet will be formed with steel forms which will be left in place upon completion.

PLAN OF INLET
NOT TO SCALE

SECTION E-E THROUGH GATE

SECTION C-C
Scale: 1½" = 1'-0"

SECTION D-D
NTS

SECTION ON ℄ OF LIFT STRUCTURE
Scale ½" = 1'-0"

STEM COUPLING
(For 1½" dia. gate stem) Not to scale

DETAIL OF BASE ANGLE FOR HANDWHEEL LIFT
N.T.S.

INSET "B" OIL SEAL
NTS

STEM SLEEVE
(For pipe housing)
N.T.S.

SECTION A-A
Showing bolt location
NTS.

INSET "A"
NTS

OIL FILLER WEATHER SEAL

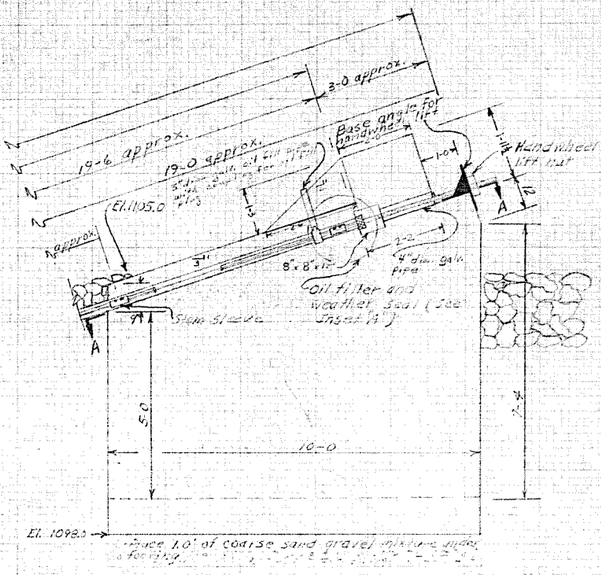
AS BUILT
NOV 15 1978

DETAILS OF DRAWDOWN DAM —

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	L.W.S., S.E.M.	Date 12/77	Approved by
Drawn	J.A.D.	9/78	Title
Traced			Title
Checked	R.D.S.	Sheet No. 38 of 40	Drawing No. 5,E-29,772



SECTION ON ℄ OF LIFT STRUCTURE

0 1/4 1/2 3/4 1

AS BUILT

NOV 15 1978

Revised Nov, 1978

DETAILS OF DRAWDOWN

DAM 4

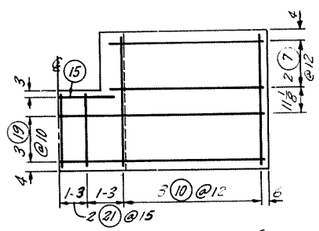
FLOODWATER RETARDING & RECREATION STRUCTURE

MIDDLE SOUTH BRANCH FOREST RIVER WATERSHED

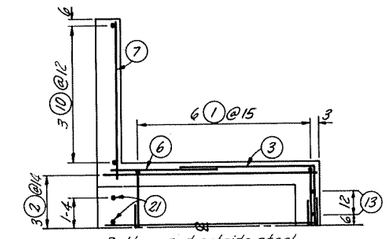
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

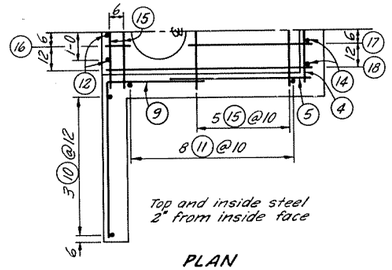
	Date		
Designed		Approved by	
Drawn	R.H.B. 11/78	Title	
Traced		Title	
Checked		Sheet No. 36A of 40	Drawing No. SE-29,112



Steel 2" from downstream face

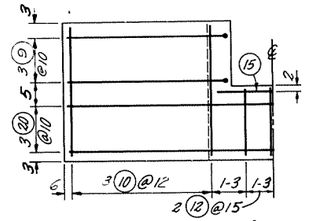


Bottom and outside steel
2" from outside face



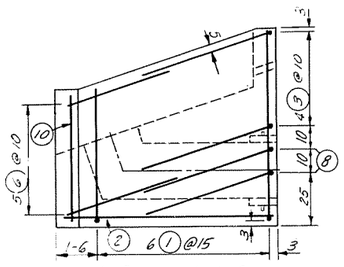
Top and inside steel
2" from inside face

PLAN

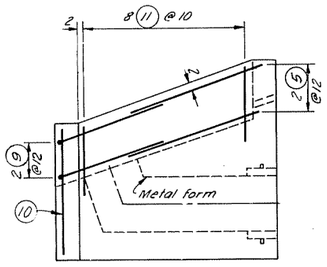


Steel 2" from upstream face

WINGWALLS

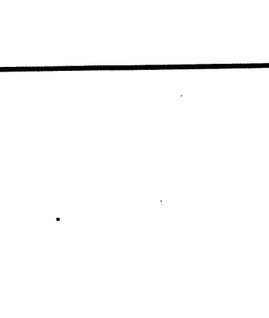


Steel 2" from outside face



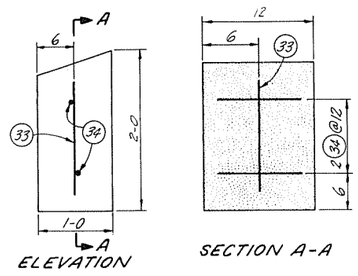
Steel 2" from inside face

SIDEWALL ELEVATION

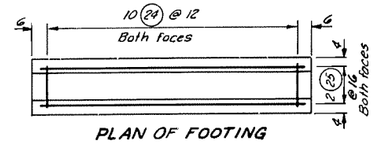


DOWNSTREAM END VIEW

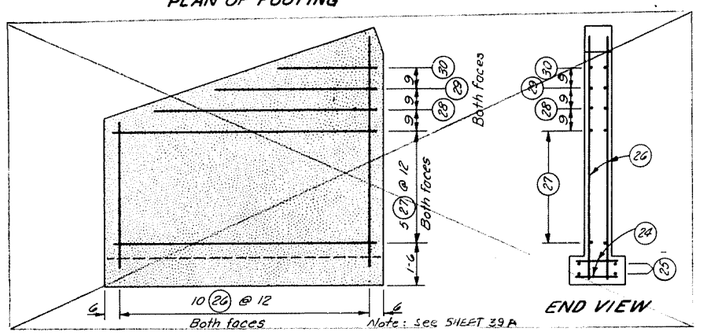
DETAILS OF DRAWDOWN INLET



DETAILS OF ANCHOR BLOCK



PLAN OF FOOTING



SECTION ON ℄

DETAILS OF LIFT STRUCTURE

BAR SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C
1	4	2 SETS OF 6 BARS	7'-0" TO 9'-1" - 5" INCR.	96-6	21	3-11 TO 6-0 - 5' INCR.	3-1
2	4	5	7-6	37-6	1		
3	4	8	8-0	64-0	21	4-11	3-1
4	4	2	4-3	8-6	1		
5	4	4	5-0	20-0	1		
6	4	10	4-3	42-6	1		
7	4	4	3-0	12-0	1		
8	4	4	6-0	24-0	21	4-11	1-1
9	4	4	6-10	27-4	21	2-10	4-9
10	4	12	3-9	45-0	1		
11	4	16	1-9	28-0	1		
12	4	3	2-3	6-9	1		
13	4	4	2-9	11-0	1		
14	4	4	1-9	7-0	1		
15	4	7	4-6	31-6	1		
16	4	2	0-9	1-6	1		
17	4	2	4-9	9-6	1		
18	4	2	8-0	16-0	1		
19	4	3	9-6	28-6	1		
20	4	3	9-6	28-6	1		
21	4	3	2-6	7-6	1		
24	4	20	[illegible]	30-0	1		
25	4	4	[illegible]	38-0	1		
26	4	2 SETS OF 10 BARS	5'-3" - 8'-3" - 4" INCR.	135-0	1		
27	4	10	9-6	95-0	1		
28	4	2	8-0	16-0	1		
29	4	2	5-9	11-6	1		
30	4	2	3-6	7-0	1		
33	4	2	1-6	3-0	1		
34	4	4	0-8	2-8	1		

Note: See page 39A

BAR TOTALS

SIZE	LENGTH(FT.)	LBS.
4	595	
	TOTAL	595

Note: See page 39A

NOTES:
1. FOR BAR TYPE DETAILS, SEE SHEET 34
2. BAR DIMENSIONS ARE OUT TO OUT OF BAR
3. RADIUS OF BENDS EQUALS THREE TIMES THE DIAMETER OF THE BAR

AS BUILT
NOV 15 1978

ADAPTED FROM:
STRUCTURE NO. 9 (LEFT)
SHEET 2 OF 38
DITCH CREEK WATERSHED
SAN FOR SOIL CONSERVATION SERVICE

DETAILS OF DRAWDOWN

DAM 4

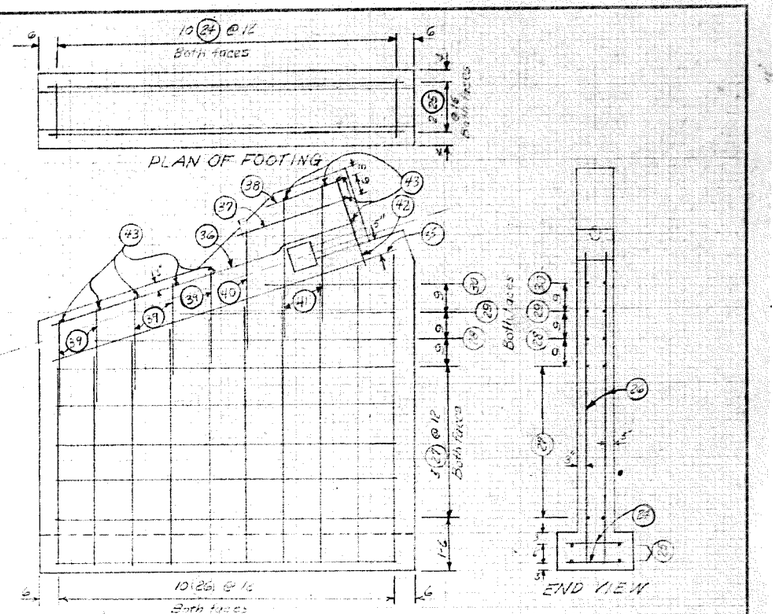
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed L.M.S., C.E.M.	12-71	Approved by	
Drawn D.L.J.	5-68	Title	
Traced		Title	
Checked		Sheet No. 39	Drawing No. 5,E-29,772

Not to scale



DETAILS OF LIFT STRUCTURE

BAR SCHEDULE

MARK	SIZE	QUANTITY	LENGTH	TOTAL LENGTH	TYPE	B	C
1	4	2 SETS OF 6 BARS	7'-0" TO 9'-1" ± 5" INCR.	96-6	21	3-11 TO 6-0 ± 5" INCR.	3-1
2	4	5	7-6	37-6	1		
3	4	8	8-0	64-0	21	4-11	3-1
4	4	2	4-3	8-6	1		
5	4	4	5-0	20-0	1		
6	4	10	4-3	42-6	1		
7	4	4	3-0	12-0	1		
8	4	4	6-0	24-0	21	4-11	1-1
9	4	4	6-10	27-4	21	2-10	4-9
10	4	12	3-9	45-0	1		
11	4	16	1-9	28-0	1		
12	4	3	2-3	6-9	1		
13	4	4	2-9	11-0	1		
14	4	4	1-9	7-0	1		
15	4	7	4-6	31-6	1		
16	4	2	0-9	1-6	1		
17	4	2	4-9	9-6	1		
18	4	2	8-0	16-0	1		
19	4	3	9-6	28-6	1		
20	4	3	9-6	28-6	1		
21	4	3	2-6	7-6	1		
24	4	20	1-5	30-0	1		
25	4	4	9-6	38-0	1		
26	4	2 SETS OF 10 BARS	5'-3" - 8'-3" @ 4" INCR.	135-0	1		
27	4	10	9-6	95-0	1		
28	4	2	8-0	16-0	1		
29	4	2	5-9	11-6	1		
30	4	2	3-6	7-0	1		
33	4	2	1-6	3-0	1		
34	4	4	0-8	2-8	1		
35	4	2	9-8	19-4	1		
36	4	2	8-6	17-0	1		
37	4	2	3-0	6-0	1		
38	4	2	2-0	4-0	1		
39	4	10	2-6	25-0	1		
40	4	2	3-3	6-6	1		
41	4	4	3-9	15-0	1		
42	4	2	2-4	4-8	1		
43	4	10	0-8	6-8	1		

BAR TOTALS

SIZE	LENGTH (FT)	LBS
4	995.5	665
TOTAL		665

AS BUILT

NOV 15 1978

Revised: Nov. 1976

DETAILS OF DRAWDOWN

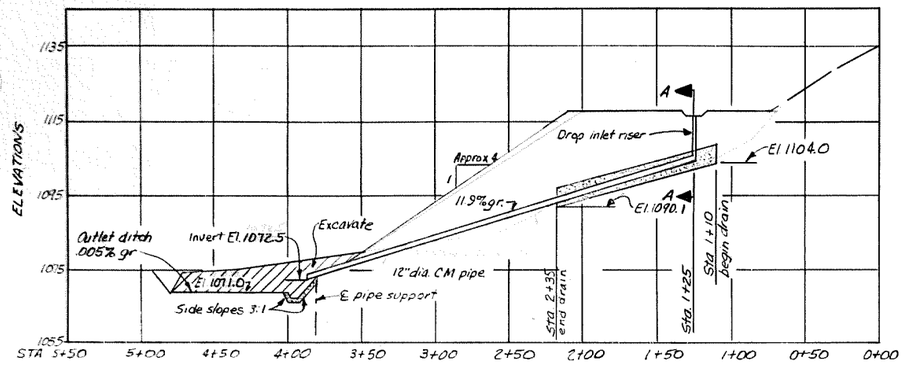
DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

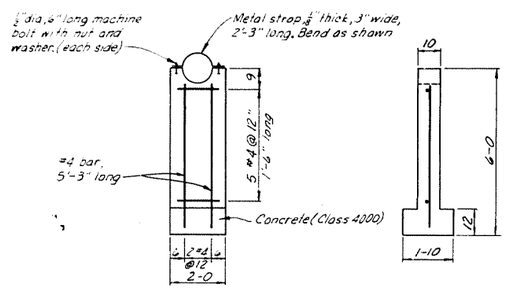
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Date	Approved by
Designed	Title
Drawn R.A.S. 4-76	
Traced	Title
Checked	Sheet No. 394 of 40 — Drawing No. 5-F-29 772

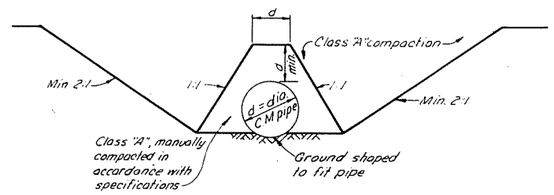


PROFILE ALONG ℄ OF C.M. PIPE DRAIN

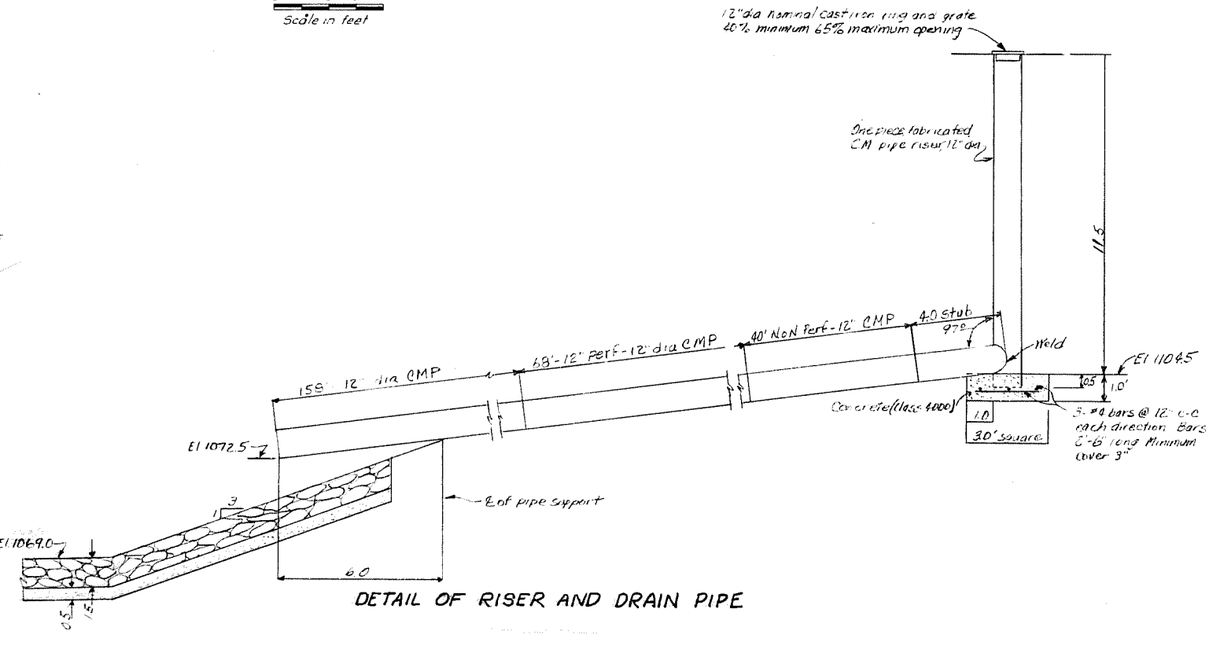


DETAIL OF CONCRETE PIPE SUPPORT

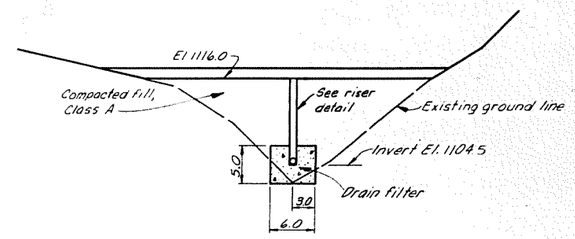
0 1 2 3 4
Scale in feet



TYPICAL DIAGRAM OF BACKFILL FOR C.M. PIPE



DETAIL OF RISER AND DRAIN PIPE



SECTION A-A

0 2 4 6 8 10
Scale in feet

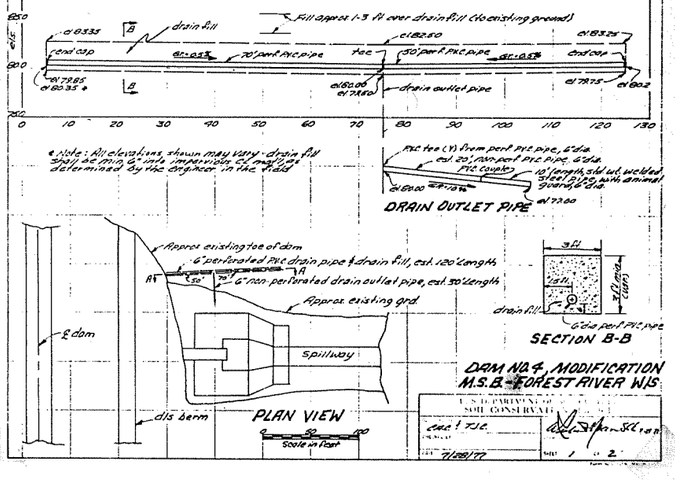
TABLE OF QUANTITIES

QUANTITY	ITEM	UNIT	QUANTITY
8,280.6	EARTH FILL (CLASS A)	CU.YD.	6,484
138.9	DRAIN FILL	CU.YD.	100
1.	12" DIA., C.M. RISER AS PER DETAIL. 0.064" WALL THICKNESS. ASBESTOS-TREATED. ASPHALT-COATED	EACH	1
198.	12" DIA., C.M. PIPE. 0.064" WALL THICKNESS. ASBESTOS-TREATED. ASPHALT COATED	LIN.FT.	198
68.	12" DIA., PERFORATED C.M. PIPE. 0.064" WALL THICKNESS. ASBESTOS-TREATED. ASPHALT COATED	LIN.FT.	68
0.8	CONCRETE. CLASS 4000	CU.YD.	0.8
22.	STEEL REINFORCEMENT	LB.	22
33.8	ROCK RIPRAP WITH BEDDING	CU.YD.	34
1.	12" DIA. NOMINAL CAST IRON RING AND GRATE. 40% MINIMUM. 65% MAXIMUM OPENING	EACH	1

SEE SHEET NO. 7

A BUTMENT DRAIN

SECTION A-A - (Section A-A looking south)



DAM NO 4, MODIFICATION
M.S.B. FOREST RIVER W.S.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

exec. by SCS
7/28/78
Sheet 1 of 2

NOTES:

1. LIMITS OF DRAIN FILTER WILL BE AS SHOWN UNLESS DIRECTED OTHERWISE BY THE ENGINEER.
2. FOR GRADATION OF FILTER MATERIAL, SEE SHEET 11.
3. CONSTRUCT PLUNGE POOL AS SHOWN WITH 2.0' BOTTOM WIDTH, 6.0' BOTTOM LENGTH, AND 3:1 SIDE SLOPES UNLESS DIRECTED OTHERWISE BY ENGINEER. PROVIDE 1.0' THICK ROCK RIPRAP PLUS 0.5' BEDDING MATERIAL. RIPRAP SIDES TO EL. 1073.5.
4. PERFORATED C.M. PIPE TO BE INSTALLED WITH PERFORATIONS TOWARD THE TOP.
5. ALL NUTS, BOLTS, AND WASHERS WILL BE GALVANIZED.

AS BUILT

NOV 15 1978

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY — NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date	
Designed L.M.S	1-74	Approved by
Drawn L.M.S	1-74	Title
Traced		Title
Checked R.D.S	1-74	Sheet No. 40 of 40

Drawing No. 5,E-29,772

STRUCTURE DATA

Class of Structure B

Drainage Area (total) 26,560 Ac. 41.5 Sq.Mi.

(uncontrolled) 26,560 Ac. 41.5 Sq.Mi.

Time of Concentration 12.5 Hours

Soil Cover Complex Number 75 For A.M.C. II

Sediment Capacity Available 221.2 Ac.Ft. below Elev. 1089

Total Sediment Capacity Available 221.2 Ac.Ft.

Capacity Equivalents (Vol.) 0.10 In.

Retarding Capacity Provided 5440 Ac.Ft.

Capacity Equivalents (Vol.) 2.46 In. 2/

Water Supply Provided 1964 Ac.Ft.-Identify Uses (Recreation)

Principal Spillway:

Maximum Capacity (low stage) 60 c.f.s.

Maximum Capacity (high stage) 840 c.f.s.

10 Day Drawdown Elev. 1116.2

Emergency Spillway:

Percent Chance Use 1 % Storm Duration 6 hr.

Type Veg. "n" Value Used 0.40

Emergency Spillway Hydrograph for Class B Structures

Rainfall 6.2 in.

Runoff 3.45 in.

Peak Inflow 6764 c.f.s.

Maximum Discharge - Emergency Spillway 3350 c.f.s.

Maximum Water Surface Elev. 1125.84

Velocity of Flow (Ve) 7.11 f.p.s.

Supplementary Data and Special Design Features:

1/ Principal spillway flood routing is based on D.A. = 32.9 mi.^{2} 8.6 mi.^{2} are defined as potholes.

2/ Based on full D.A. of 41.5 mi.^{2}

Freeboard Hydrograph for Class B Structures

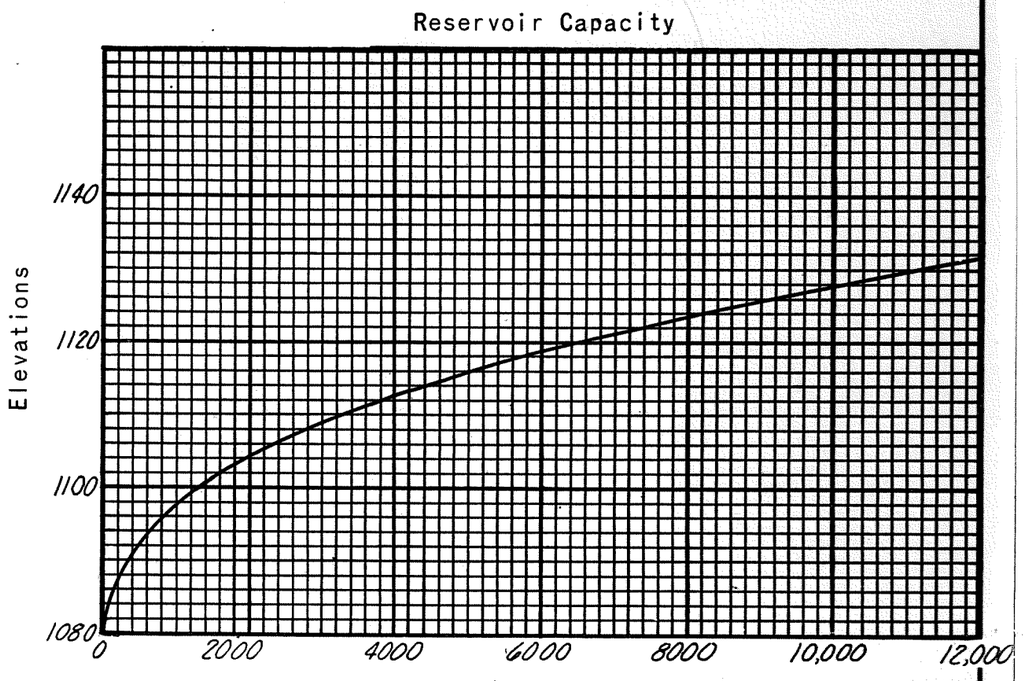
Rainfall 11.2 in.

Runoff 8.0 in.

Peak Inflow 15,520 c.f.s.

Maximum Discharge - Emergency Spillway 12,900 c.f.s.

Maximum Water Surface Elev. 1129.01



Supplementary Data and Special Design Features:

AS BUILT

NOV 15 1978

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE

MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

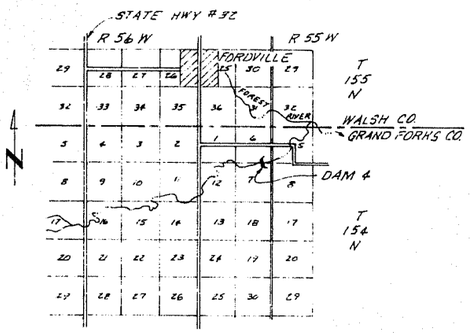
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

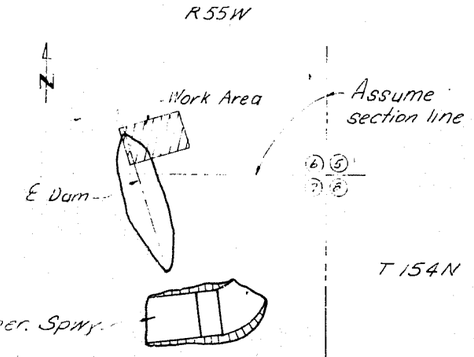
Designed L. M. S.	Date 7-71	Approved by	
Drawn		Title	
Traced		Title	
Checked C. E. M.	9-71	Sheet No 1 of 1	Drawing No. 5,E-29,772-E

FORDVILLE DAM

929 - 59



LOCATION MAP



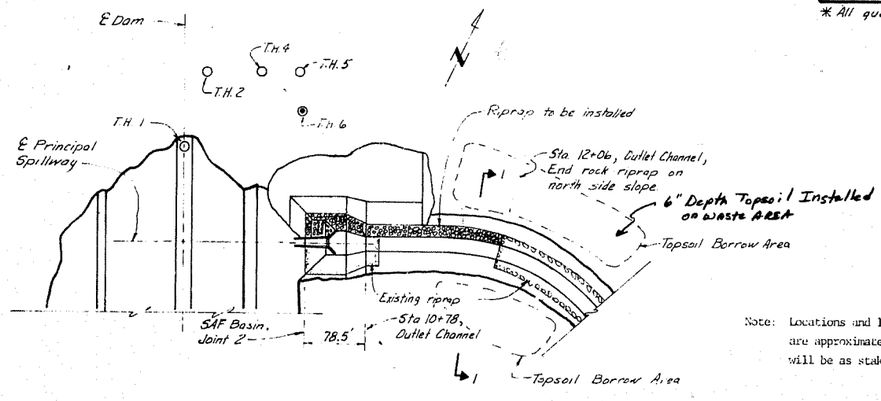
PLAN VIEW OF DAM SITE

660 0 660 1320

Scale in feet

NOTE:

1. For soils legend and symbols, see Standard Drawing S.R.-10,000.47.
2. TS = topsoil
3. WL indicates groundwater on July 24, 1979. Variation is expected.
4. Rock riprap is 1.5 ft. thick plus 0.5 ft. thick bedding (measured vertically).



PLAN VIEW OF NORTH ABUTMENT

100 50 0 100 200

(Scale in feet)

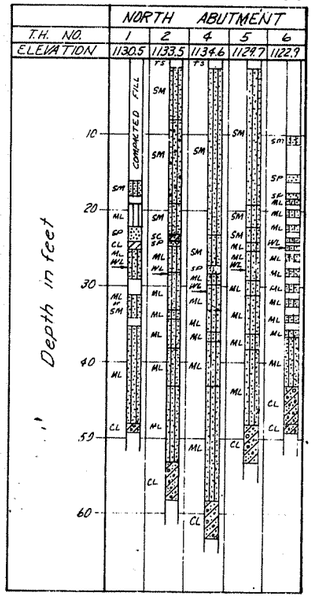
Note: Locations and limits of topsoil borrow areas are approximate. Exact locations and limits will be as staked by the engineer.

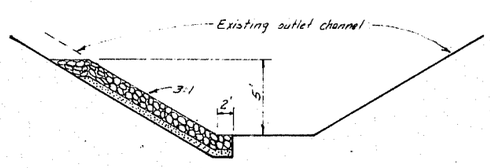
TABLE OF QUANTITIES *

ITEM	UNIT	QUANTITY	As Built QUANTITY
MOBILIZATION	LUMP SUM		Lump Sum
REMOVAL OF WATER	LUMP SUM		Lump Sum
EXCAVATION, COMMON: SLIDE AREA	CU.YD.	6,540	7,049.0
SHAPING ABOVE SCARP	CU.YD.	1,126	1,258.9
ROCK FILL	CU.YD.	4,216	3,781
SALVAGING AND SPREADING TOPSOIL, 6" DEPTH	SQ.YD.	1,213	3,022
ROCK RIPRAP WITH BEDDING	CU.YD.	336	385.9
SEEDING (INCLUDES FERTILIZING AND MULCHING)	ACRES	2.4	3.8
FINE FILTER	CU.YD.	292	230.6
COARSE FILTER	CU.YD.	36	36
DRAIN FILL	CU YD.	1,677	1,424.0
SALVAGING AND SPREADING TOPSOIL, 12" DEPTH	SQ.YD.	2,135	3,085.1

* All quantities are estimated

LOG OF SOIL BORINGS





SECTION 1-1
OUTLET CHANNEL SHOWING RIPRAP
(Not to scale)

near Fordville

Repairs to Fordville Dam

Sec 7A - 154 - 55

Construction Starting Date	10-9-79
Construction Completion Date	11-6-79
Project Engineer.	Larry Kuseske, Roger Thompson
Project Inspector:	Gerald Saltness

929-59

AS-BUILT

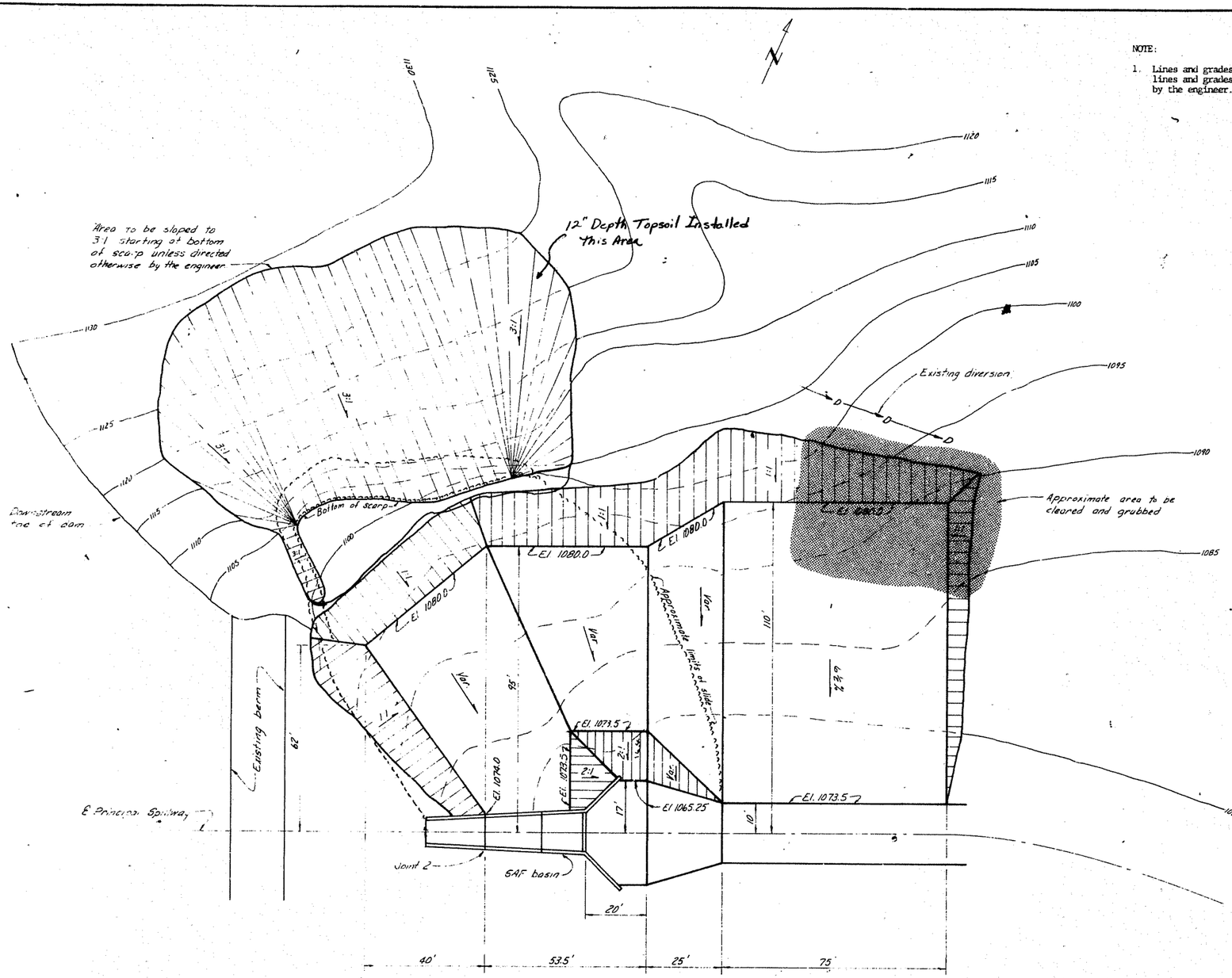
NORTH ABUTMENT REPAIR

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY, NORTH DAKOTA

134

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed JEN Date 8-79
Drawn
Traced
Checked Roger L. Thompson 7/79
Approved by Marion L. Thorne
Title STATE Conservation Engineer
William J. Owen
Title Acting Head Eng. Staff
Sheet No. 1 of 3
Drawing No. 08-79-008



PLAN VIEW OF EXCAVATION

20 10 0 20
Scale in feet

NOTE:

1. Lines and grades are approximate. Exact lines and grades will be as determined by the engineer.

AS-BUILT

NORTH ABUTMENT REPAIR

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY, NORTH DAKOTA

135

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

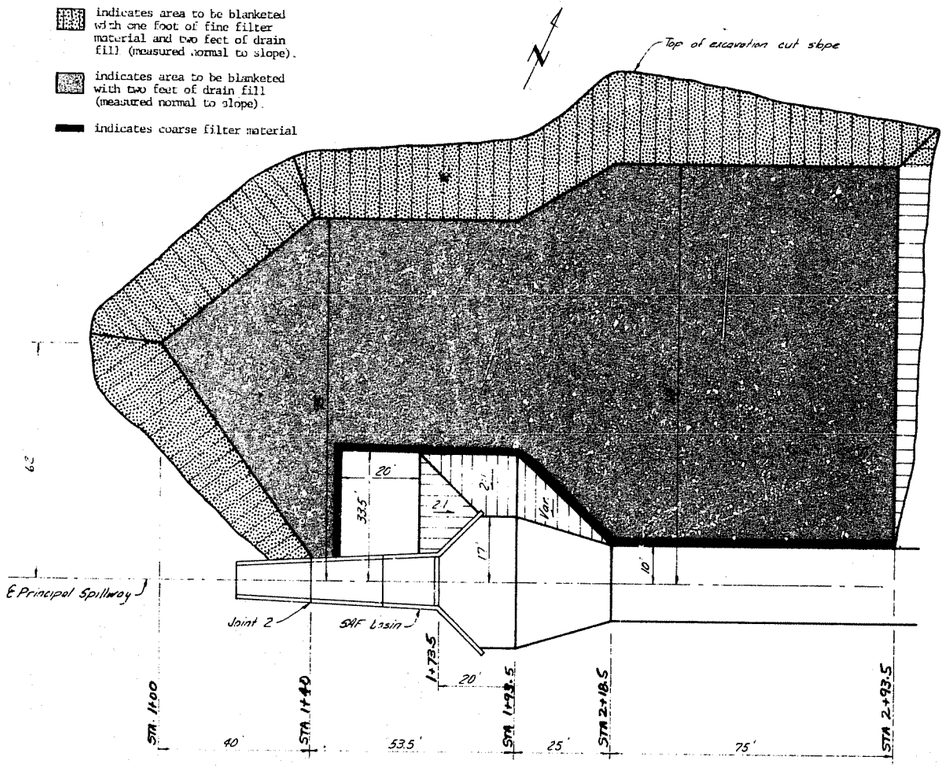
Designed JEN	Date 8-79	Approved by	
Drawn		Title	
Traced		Title	
Checked Arnold Sands	9-79	Sheet No. 2 of 3	Drawing No. 08-79-008

NOTE:

indicates area to be blanketed with one foot of fine filter material and two feet of drain fill (measured normal to slope).

indicates area to be blanketed with two feet of drain fill (measured normal to slope).

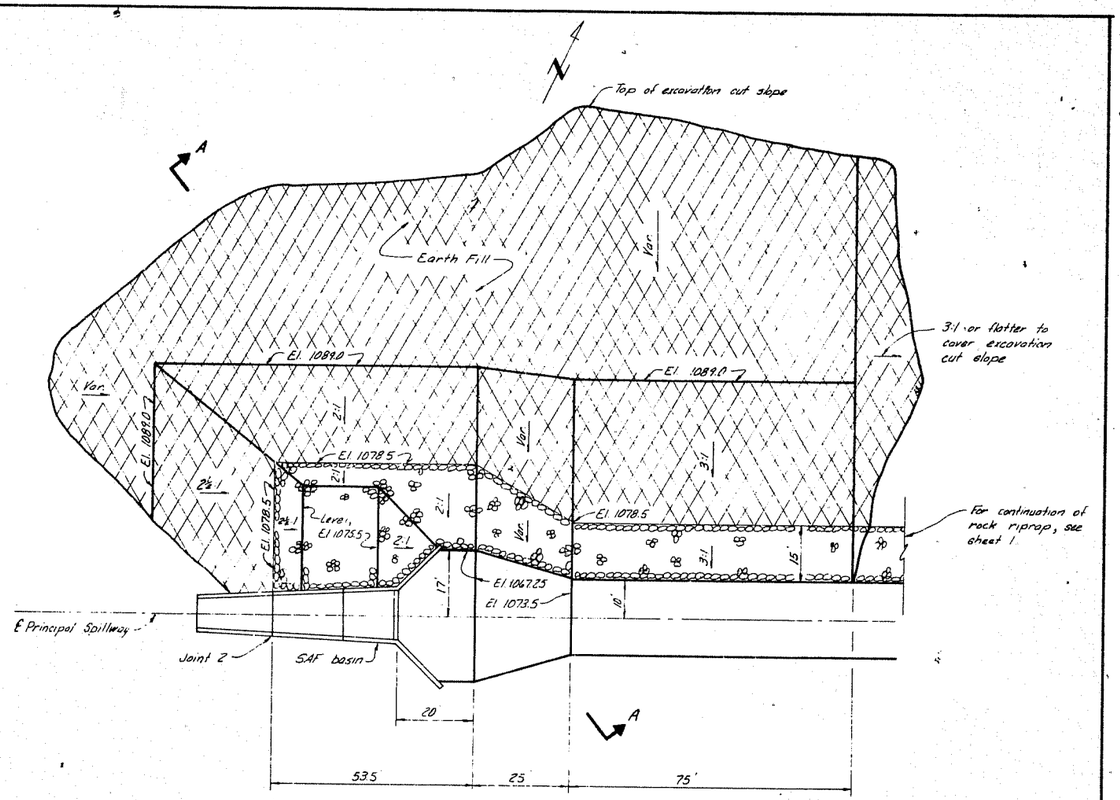
indicates coarse filter material



PLAN VIEW SHOWING LIMITS OF FILTER MATERIAL AND DRAIN FILL

20 10 0 20

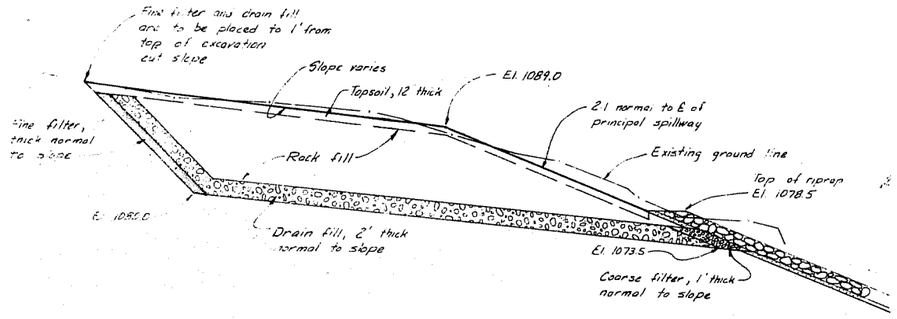
Scale in feet



PLAN VIEW SHOWING LIMITS OF ROCK RIPRAP AND EARTH FILL

20 10 0 40

Scale in feet



SECTION A-A

10 5 0 10

Scale in feet

NOTE:

1. Lines and grades are approximate. Exact lines and grades will be as determined by the engineer.
2. Rock riprap is 1.5 ft. thick plus 0.5 ft. thick bedding (measured vertically).

FILTER & DRAIN FILL GRADATION*

FINE FILTER		DRAIN FILL		COARSE FILTER	
SIEVE SIZE	PERCENT PASSING	SIEVE SIZE	PERCENT PASSING	SIEVE SIZE	PERCENT PASSING
3/8"	100	3/4"	100	2"	100
#4	95-100	½"	90-100	1½"	90-100
#8	80-100	3/8"	40-75	1"	30-60
#16	50-85	#4	5-25	3/4"	0-30
#30	25-60	#8	0-10	½"	0-10
#50	10-30	#16	0-5		
#100	2-10				
#200	0-5				

*FINES PASSING #200 SIEVE MUST BE NON-PLASTIC

Rev. 9-21-79

AS-BUILT

NORTH ABUTMENT REPAIR

DAM 4

FLOODWATER RETARDING & RECREATION STRUCTURE

MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED

GRAND FORKS COUNTY, NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed JEN	8-79	Approved by	
Drawn		Title	
Traced		Title	
Checked Ronald Sands	8-79	Sheet No. 3 of 3	Drawing No. 08-79-008

13

LEGEND

SYMBOLS

UNCONSOLIDATED MATERIAL

gravel	sand	silt	clay	cobbles, boulders
gravel, sandy	sand, gravelly	silt, gravelly	clay, gravelly	peat
gravel, silty	sand, silty	silt, sandy	clay, sandy	gypsiferous *
gravel, clayey	sand, clayey	silt, clayey	clay, silty	calcareous *
gravel, sand, silt	sand, silt, clay	organic silt	organic clay	

* to be added to Standard Symbol when significant amounts of dispersed gypsum or calcified zones are present in the section.

CONSOLIDATED MATERIAL

Sedimentary Rocks

shale	sandstone	limestone	chalk	coal
calcareous shale	calcareous sandstone	cherty limestone	marl	gypsum
sandy shale	shaley sandstone	sandy limestone	chert	conglomerate
siltstone	breccia	dolomite		

Metamorphic Rocks

quartzite	slate	
gneiss	schist	
marble	soapstone, talc, serpentine	

Igneous Rocks

intrusive	extrusive
pyroclastic	

Undifferentiated

Other Symbols

○ hole logged only

◉ hole sampled

pit or trench

ABBREVIATIONS

aq	aquifer	fri	friable
cav.	cavities	lam	laminated
℄	centerline	mas	massive
con	concretions	TD	total depth
US	undisturbed samples	v.	very
DS	disturbed samples	w/	with
dip	dipping	wea	weathered
frac	fractured	WL	(date) groundwater level on a specified date

TEST HOLE NUMBERING SYSTEM

Centerline of dam	1 - 99
Borrow area	101 - 199
Emergency spillway	201 - 299
Centerline of outlet structure	301 - 399
Stream channel	401 - 499
Relief wells	501 - 599
	601 - 699
	701 - 799

UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOLS

GW Well graded gravels; gravel-sand mixtures
GP Poorly graded gravels
GM Silty gravels; gravel-sand-silt mixtures
GC Clayey gravels; gravel-sand-clay mixtures
SW Well graded sands; sand-gravel mixtures
SP Poorly graded sands
SM Silty sand
SC Clayey sands; sand-clay mixtures
ML Silts; silty, v. fine sands; sandy or clayey silts
CL Clays of low plasticity to medium plasticity; silty, sandy or gravelly clays
CH Clays of high plasticity; fat clays
MH Elastic silts; micaceous or diatomaceous silts
OL Organic silts and organic silty clays of low plasticity
OH Organic clays or silts of medium to high plasticity

137

Revised 2/63

IDENTIFICATION SYMBOLS FOR SOIL AND ROCK MATERIALS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

COMPILED	CHECKED	DATE	DRAWING NO.
		12/58	5,R-10,000.47

APPENDIX C

Boring Logs

Date Started: 6/16/20	**DRILLING LOG**		Hole Number: FD2020-11
Date Finished: 6/17/20	Gannett Fleming		Sheet: 1 of 4
Soil Drilling: 113.8 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 113.8 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442165.4 ft
No. of Undist. Samples: 1	Driller: Jared Zak		E Coordinate: 2637221.7 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1130.2 ft
GROUNDWATER OBSERVATIONS At 63.2 ft after 17 Hrs Elev. 1067.0 ft after 17 Hrs	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	2-4-3-3-3	0.8	32		0.0'-19.5': Clayey SAND (SC) (EMBANKMENT). Gravel is angular to subangular, fine, max. particle size: 1"; Sand is medium to coarse, subangular to rounded; Fines: low plasticity. Dry to Slightly Moist, no HCl reaction, Color varies from dark grayish brown (10yr 4/2) to olive brown (2.5y 4/4). gravel consists of angular shale (pierre fm.)	P.P. = Too disturbed to measure
2.5 - 5.0	S-2	2-4-4-8-12	1.3	52		3.0' : Sandy silt	P.P. = Too disturbed to measure
5.0 - 7.5	S-3	5-12-13-13-14	1.3	52			P.P. = 0.0 tsf
7.5 - 10.0	S-4	4-6-18-29-29	1.8	72			P.P. = 2.5 tsf
10.0 - 12.5	S-5	5-12-16-18-18	1.7	68			P.P. = 1.3 tsf
12.5 - 15.0	S-6	7-8-9-13-17	1.8	72		12': Silty sand, moist	P.P. = >4.5 tsf
15.0 - 17.5	S-7	5-11-13-18-18	2.0	80		15': Silty sand with clay	P.P. = 2.6 tsf
17.5 - 20.0	S-8	10-11-12-5-7	1.8	72		17': 1" shale clast	P.P. = 1.7 tsf
						El. 1110.7	
20.0 - 22.5	S-9	2-8-6-8-9	1.8	72		19.5'-62.0': Sandy Lean CLAY (CL) (EMBANKMENT). Gravel is angular to subrounded, fine, max. particle size: 1.5"; Sand is medium to coarse, subangular to rounded; Fines: medium plasticity. Slightly Moist, no HCl reaction, Color is olive brown (2.5y 4/3). gravel consist of angular to subrounded fine grained sedimentary and coarse grained igneous clasts.	P.P. = 3.7 tsf
22.5 - 25.0	S-10	5-8-9-12-13	1.7	68		22.5': Higher sand content	P.P. = 2.6 tsf

Purpose: Sample embankment and foundation soils. Install piezometers.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 113.8'.
Termination: Refusal at 113.8' (54 blows/3")
Abandonment: Install two vibrating wire piezometers in sand-socks cement grouted in place at 56' (S/N: 2021598, Zero reading: 2976.8hz, 24.0° C) and 101' (S/N: 2021594, Zeo Reading: 2971.3hz, 27.5°C).
Additional Remarks: Drilled on crest of dam, immediately downstream of guiderail.

Log Checked By: E.J. Barben, 11/11/20

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-11
Driller: Jared Zak	Gannett Fleming	Sheet: 2 of 4
Inspector: M. Mussey		Elev. Top of Hole: +1130.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-11	4-7-9-9-13	1.5	60			P.P. = 1.5 tsf
27.5 - 30.0	S-12	4-5-8-12-15	1.0	40		27.5': Iron staining	P.P. = 4.0 tsf
30.0 - 32.5	S-13	5-9-15-19-20	1.7	68		30': Silty sand and gravel, rounded clasts	P.P. = >4.5 tsf
32.5 - 35.0	S-14	11-14-12-14-20	0.6	24		32.5': 1.5" angular rock clasts, light gray/white	P.P. = 4.0 tsf
35.0 - 37.5	S-15	5-6-11-12-14	2.0	80			P.P. = 3.5 tsf
37.5 - 38.5	U-1		1.0	100			38.5': Shelby tube refusal
38.5 - 40.0	S-16	8-11-15	1.1	73			P.P. = 2.5 tsf
40.0 - 42.5	S-17	5-4-4-25-28	2.0	80			P.P. = >4.5 tsf
42.5 - 45.0	S-18	5-18-18-20-23	1.5	60		42': Silty clay with gravel	P.P. = 2.2 tsf
45.0 - 47.5	S-19	6-12-13-22-23	2.0	80			P.P. = 3.3 tsf
47.5 - 50.0	S-20	11-12-19-20-22	2.2	88		47.5': 0.75" angular shale clast	P.P. = 3.0 tsf
50.0 - 52.5	S-21	5-8-15-15-13	1.3	52			P.P. = 2.7 tsf
52.5 - 55.0	S-22	6-8-10-11-13	2.0	80		52': Gravel, max size 2.0", subrounded, coarse grained igneous	P.P. = 2.5 tsf
55.0 - 57.5	S-23	2-4-6-11-13	1.8	72		56': Slightly moist	P.P. = 4.5 tsf
57.5 - 60.0	S-24	7-7-7-9-13	2.3	92			P.P. = 1.5 tsf

Agency: Interstate Drilling Services, Inc.	DRILLING LOG	Hole Number: FD2020-11
Driller: Jared Zak		Sheet: 3 of 4
Inspector: M. Mussey	Gannett Fleming	Elev. Top of Hole: +1130.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
60.0 - 62.5	S-25	3-5-7-13-9	1.8	72		El. 1068.2	P.P. = 1.7 tsf
62.5 - 65.0	S-26	8-11-12-12-15	2.0	80		62.0'-113.8': Silty CLAY (cl) (OUTWASH/ALLUVIUM) with coarse sand, layers of silt (ml) and silty sand (sm). Gravel is subangular to subrounded, fine, maximum particle size: 1"; Sand is fine to coarse, subangular to rounded; Fines are medium plasticity; dry to wet, no HCL reaction. Color varies from very dark greenish gray (10Y 3/1) to very dark gray (5Y 3/1), gravel consist of angular to subrounded fine grained sedimentary clasts.	P.P. = >4.5 tsf
65.0 - 67.5	S-27	3-7-10-11-17	2.0	80		62.0-62.5': Well graded sand with gravel, wet, some fines, rounded subangular, very dark gray 62.5'-68.0': Silty clay, low sand, moist, rounded gravel, very dark greenish gray	P.P. = 2.5 tsf
67.5 - 70.0	S-28	10-11-13-22-23	2.5	100		67.5'-70.0': Laboratory classified as silty, clayey SAND (SC-SM) 68.0'-71.8': Well graded sand, loose, medium to fine, wet, dark gray	P.P. = 0.0 tsf
70.0 - 72.5	S-30	2-3-7-11-13	2.5	100			P.P. = 3.0 tsf
72.5 - 75.0	S-31	7-8-11-17-18	1.6	64			P.P. = 2.4 tsf
75.0 - 77.5	S-32	5-10-11-18-34	1.6	64		71.8'-80.0': Silty clay, stiff, moist, some sand and gravel	P.P. = >4.5 tsf
77.5 - 80.0	S-33	15-26-17-24-36	2.3	92		77.5'-78.7: Coarser sands 78': Wet 78.4': Higher gravel content	P.P. = >4.5 tsf
80.0 - 82.5	S-34	11-16-15-20-30	2.5	100		80.0'-81.0': Well graded sand and gravel, wet, very dark greenish gray 80.0'-86.5': Silty clay	P.P. = >4.5 tsf
82.5 - 85.0	S-35	15-18-24-28-39	2.5	100		82.5'-85.0': Laboratory classified as sandy SILT (ML)	P.P. = 3.0 tsf
85.0 - 87.5	S-36	5-26-28-37-56	2.5	100		86.5'-87.5': Dense silty sand, dark gray, slight moist	P.P. = >4.5 tsf
87.5 - 90.0	S-37	12-15-19-19-24	2.3	92		87.5-97.5': Silty clay, stiff, some gravel and coarse sand, subrounded, moist to wet, dark gray 88.0'-88.3': Fine sand and silt	P.P. = >4.5 tsf
90.0 - 92.5	S-38	2-4-11-18-22	2.5	100			P.P. = 3.0 tsf
92.5 - 95.0	S-39	6-9-12-19-23	2.3	92			P.P. = 3.6 tsf

Agency: Interstate Drilling Services, Inc.	DRILLING LOG	Hole Number: FD2020-11
Driller: Jared Zak		Sheet: 4 of 4
Inspector: M. Mussey	Gannett Fleming	Elev. Top of Hole: +1130.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
95.0 - 97.5	S-40	5-7-14-17-29	2.4	96		95.1': Wet	P.P. = 3.4 tsf
97.5 - 99.5	S-41	26-36-46-53	1.4	70		97.5'-102.0': Silt, dense some sand and gravel, angular to subrounded, moist, friable shale clasts, very dark greenish gray	P.P. = >4.5 tsf Shelby tube sample attempt at 97.5', would not advance. Resume spoon sampling.
99.5 - 100.0							99.5': Advance augers
100.0 - 102.5	S-42	13-29-30-24-30	1.8	72		100.0'-102.5': Laboratory classified as clayey SAND (SC)	P.P. = >4.5 tsf
102.5 - 105.0	S-43	8-19-30-25-32	2.4	96		102.0'-109.3': Silty clay, stiff, some coarse subangular sand and gravel, dark gray	P.P. = 4.0 tsf
105.0 - 107.5	S-44	4-5-13-19-25	2.0	80		104.5'-107.0': Increased gravel	P.P. = 3.0 tsf
107.5 - 110.0	S-45	25-66-27-51-48	2.2	88		107.0'-107.3': Fine sand, moist, wet 109.3'-110.0': Well graded dense sand and gravel	P.P. = 3.3 tsf
110.0 - 112.5	S-46	10-10-10-21-24	2.5	100		110.0'-111.0': Silty clay with gravel, finer with depth, wet 111.0'-112.4': Well graded sand, medium, low fines, wet	P.P. = 0.0 tsf
112.5 - 113.8	S-47	11-41-54/0.3	1.2	92		112.4-113.8': Silty clay, stiff, some gravel El. 1016.4	P.P. = >4.5 tsf

Bottom of Borehole at 113.8 feet.

Date Started: 6/22/20	**DRILLING LOG**		Hole Number: FD2020-212
Date Finished: 6/22/20			Sheet: 1 of 2
Soil Drilling: 45.0 ft	Gannett Fleming		Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 45.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 441284.9 ft
No. of Undist. Samples: 0	Driller: Dave Tokar		E Coordinate: 2637425.2 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1123.8 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 5.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	6-4-12-26-52	1.3	52		0.0'-8.0': Clayey SAND (SC) (SOIL CEMENT). Sand is fine to coarse; Fines: low plasticity. Olive brown (2.5Y 4/3), Dry, no HCl reaction, Gravel roadway and subgrade top 1.0' 1.0'-2.5': Sand and rounded gravel	P.P. = 2.7 tsf
2.5 - 5.0	S-2	28-32-16-26-47	2.1	84		2.5'-8.0' Dense cement matrix 2.5': Dry	P.P. = Too disturbed to measure
5.0 - 7.5	S-3	11-12-11-8-7	1.6	64			P.P. = Too disturbed to measure
7.5 - 10.0	S-4	8-8-7-6-18	1.9	76		7.5'-8.0': medium sand and fines, wet El. 1115.8 8.0'-10.0': Sandy Lean CLAY (CL). Fines: medium plasticity. Olive brown (2.5Y 4/3), organic odor, no HCl reaction El. 1113.8	P.P. = 2.8 tsf
10.0 - 12.5	S-5	8-13-26-31-44	1.9	76		10.0'-17.0': Silty SAND (SM). Sand is medium; Fines: medium plasticity. Brown (10YR 3/2), organic odor, Moist to Wet, no HCl reaction 10.0'-12.5': Clayey sand and gravel, moist	P.P. = >4.5 tsf
12.5 - 15.0	S-6	11-11-12-11-13	1.8	72			P.P. = 0.4 tsf
15.0 - 17.5	S-7	12-10-6-8-5	1.8	72		El. 1106.8	P.P. = 0.2 tsf
17.5 - 20.0	S-8	1-1-1-3-4	2.5	100		17.0'-45.0': Clayey SILT (ml) (LACUSTRINE). Fines: medium plasticity. Very dark greenish gray (5GY 3/1), Wet to Very Moist, no HCl reaction, Tan & gray laminations	P.P. = 0.3 tsf
20.0 - 22.5	S-9	2-3-4-5-5	2.5	100			P.P. = 0.0 tsf
22.5 - 25.0	S-10	1-1-1-2-3	2.5	100		22.5': Slow dilatency	P.P. = 0.0 tsf

Purpose: Sample auxiliary spillway soils, use result to establish SITES parameters.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 45.0'.
Termination: 45.0' below ground surface
Abandonment: Cement grout backfill.
Additional Remarks: Drilled in auxiliary spillway through soil-cement barrier.

Log Checked By: E.J. Barben, 11/11/20

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-212
Driller: Dave Tokar	Gannett Fleming	Sheet: 2 of 2
Inspector: M. Mussey		Elev. Top of Hole: +1123.8 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-11	1-1-1-2-3	2.5	100			P.P. = 0.0 tsf
27.5 - 30.0	S-12	2-3-4-6-6	2.5	100			P.P. = 0.0 tsf
30.0 - 32.5	S-13	1-1-2-2-3	2.5	100			P.P. = 0.0 tsf
32.5 - 35.0	S-14	1-1-2-3-4	2.3	92			P.P. = 0.0 tsf
35.0 - 37.5	S-15	1-1-1-4-4	2.4	96			P.P. = 0.0 tsf
37.5 - 40.0	S-16	1-1-1-2-2	2.4	96			P.P. = 0.0 tsf 37.5': Shelby tube attempt, no recovery. Resample using split-spoon.
40.0 - 42.5	S-17	2-3-4-6-6	2.5	100			P.P. = 0.0 tsf
42.5 - 45.0	S-18	2-2-2-3-3	2.4	96		El. 1078.8	P.P. = 0.0 tsf

Bottom of Borehole at 45.0 feet.

Date Started: 6/22/20	**DRILLING LOG**		Hole Number: FD2020-213
Date Finished: 6/22/20	Gannett Fleming		Sheet: 1 of 2
Soil Drilling: 45.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 45.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 441291.7 ft
No. of Undist. Samples: 1	Driller: Dave Tokar		E Coordinate: 2637462.5 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1123.7 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	1-2-3-5-10	1.9	76		0.0'-15.5': Silty SAND (SM). Gravel is subrounded, max. particle size: 1.0"; Sand is fine to coarse; Fines: low plasticity. Olive brown (2.5Y 4/3), Dry to Wet, no HCl reaction, Loose to medium dense, iron oxide staining at 9.0'	P.P. = 3.3 tsf
2.5 - 5.0	S-2	8-9-10-8-9	2.3	92		0.0'-0.5': Topsoil	P.P. = too disturbed to measure
5.0 - 7.5	S-3	6-7-7-6-7	1.5	60			P.P. = too disturbed to measure
7.5 - 10.0	S-4	3-4-5-5-4	2.9	100			P.P. = 0.0 tsf
						9.0': Iron staining	
10.0 - 12.5	S-5	5-6-6-7-9	1.3	52			P.P. = 0.2 tsf
12.5 - 15.0	S-6	4-5-6-7-9	1.8	72		12.5'-15.5': clayey sand, moist	P.P. = 0.0 tsf
						El. 1108.2	
15.0 - 17.5	S-7	5-4-4-3-2	2.5	100		15.5'-45.0': SILT (ML) (GLACIOLACUSTRINE). Fines: medium plasticity. Very dark greenish gray (5GY 3/1), no HCl reaction, Very soft, tan & gray laminations	P.P. = 0.0 tsf
17.5 - 20.0	S-8	1-2-2-3-5	2.4	96		17.5': Wet	P.P. = 0.0 tsf
20.0 - 22.3	U-1		2.3	100			20.0': Pushed shelby tube.
22.3 - 22.5							22.3'-22.5': Advanced augers
22.5 - 25.0	S-9	1-1-2-2-2	2.2	88			P.P. = 0.0 tsf

Purpose: Sample auxiliary spillway soils, use result to establish SITES parameters.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 45.0'.
Termination: 45.0' below ground surface
Abandonment: Cement grout backfill.
Additional Remarks: Drilled in auxiliuary spillway. Boring moved 190' SSE of surveyed and staked location. New location is the same distance from roadway and stake was moved to new location.

Log Checked By: E.J. Barben, 11/11/20

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-213
Driller: Dave Tokar	Gannett Fleming	Sheet: 2 of 2
Inspector: M. Mussey		Elev. Top of Hole: +1123.7 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-10	1-1-2-2-3	2.3	92			P.P. = 0.0 tsf
27.5 - 30.0	S-11	1-2-2-3-4	2.4	96			P.P. = 0.0 tsf
30.0 - 32.5	S-12	1-2-3-5-5	2.5	100			P.P. = 0.0 tsf
32.5 - 35.0	S-13	1-1-2-3-5	2.3	92			P.P. = 0.0 tsf
35.0 - 37.5	S-14	1-1-3-3-5	2.5	100			P.P. = 0.0 tsf
37.5 - 40.0	S-15	1-2-2-2-3	2.4	96			P.P. = 0.0 tsf
40.0 - 42.5	S-16	2-2-4-5-5	2.5	100			P.P. = 0.0 tsf
42.5 - 45.0	S-17	2-2-3-3-5	2.5	100		El. 1078.7	P.P. = 0.0 tsf

Bottom of Borehole at 45.0 feet.

Date Started: 6/22/20	**DRILLING LOG**		Hole Number: FD2020-214
Date Finished: 6/22/02	Gannett Fleming		Sheet: 1 of 2
Soil Drilling: 45.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 45.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 441515.2 ft
No. of Undist. Samples: 1	Driller: Dave Tokar		E Coordinate: 2637685.0 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1124.1 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	4-4-6-7-9	2.3	92		0.0'-21.7': Silty SAND (SM). fine to medium; Fines: low plasticity. Olive brown (2.5Y 4/3), Dry to Wet, no HCl reaction 0.0-1.5': Topsoil, dark brown/black	P.P. = 2.3 tsf
2.5 - 5.0	S-2	6-7-8-8-9	1.8	72			P.P. = 0.8 tsf
5.0 - 7.5	S-3	3-4-5-6-7	1.8	72		5.0': 1" subangular gravel	P.P. = too disturbed to measure
7.5 - 10.0	S-4	3-4-4-6-7	1.4	56		7.5': Moist, iron staining 8.0'-18.0': Iron oxide staining	P.P. = 0.0 tsf
10.0 - 12.5	S-5	6-7-6-6-4	1.8	72		11.5'-14.0': Fine sand and silt, light gray	P.P. = 0.0 tsf
12.5 - 15.0	S-6	6-6-7-6-7	1.6	64			P.P. = 0.3 tsf
15.0 - 17.5	S-7	5-5-5-6-7	2.0	80			P.P. = 1.6 tsf
17.5 - 20.0	S-8	4-5-5-6-5	1.8	72		17.5': Wet, iron staining	P.P. = 0.0 tsf
20.0 - 22.5	S-9	2-4-4-5-3	1.8	72		El. 1102.4	P.P. = 2.0 tsf
22.5 - 25.0	S-10	1-1-1-2-3	2.4	96		21.7'-45.0': Clayey SILT (ml) (GLACIOLACUSTRINE). very soft; Fines: medium plasticity. Very dark greenish gray (5GY 3/1), Wet, no HCl reaction, Tan & gray laminations	P.P. = 0.0 tsf

Purpose: Sample auxiliary spillway soils, use result to establish SITES parameters.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 45.0'.
Termination: 45.0' below ground surface
Abandonment: Cement grout backfill.
Additional Remarks:

Log Checked By: E.J. Barben, 11/11/20

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-214
Driller: Dave Tokar	Gannett Fleming	Sheet: 2 of 2
Inspector: M. Mussey		Elev. Top of Hole: +1124.1 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-11	1-1-1-2-1	2.4	96			P.P. = 0.0 tsf
27.5 - 30.0	S-12	1-1-1-3-5	2.5	100			P.P. = 0.0 tsf
30.0 - 32.5	S-13	2-3-5-5-6	2.3	92			P.P. = 0.0 tsf
32.5 - 35.0	S-14	1-2-2-5-6	2.5	100			P.P. = 0.0 tsf
35.0 - 37.5	S-15	1-2-3-3-5	2.4	96			P.P. = 0.0 tsf
37.5 - 40.0	S-16	2-3-3-5-5	2.5	100			P.P. = 0.0 tsf
40.0 - 42.4	U-1		2.4	100			40.0': Pushed shelby tube
42.4 - 42.5							42.4'-42.5': Advanced augers
42.5 - 45.0	S-17	1-2-3-3-5	2.5	100		El. 1079.1	

Bottom of Borehole at 45.0 feet.

Date Started: 6/18/20	**DRILLING LOG**		Hole Number: FD2020-608
Date Finished: 6/18/20	Gannett Fleming		Sheet: 1 of 3
Soil Drilling: 85.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 85.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442187.8 ft
No. of Undist. Samples: 2	Driller: Jared Zak		E Coordinate: 2637296.7 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1101.5 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	2-5-6-8-10	1.6	64		0.0'-8.5': Clayey SAND (SC) (EMBANKMENT). Sand is medium to coarse, subangular to rounded; Fines: low plasticity. Very dark grayish brown (10YR 3/2), Slightly Moist, no HCl reaction 0.0-0.75': Topsoil	P.P. = 1.5 tsf
2.5 - 5.0	S-2	5-7-12-14-16	2.1	84			P.P. = 1.3 tsf
5.0 - 7.5	S-3	9-10-13-15-18	2.1	84			P.P. = 0.0 tsf
7.5 - 10.0	S-4	5-7-8-10-10	2.2	88		El. 1093.0 8.5'-17.5': Silty Clayey SAND (SC-SM) (EMBANKMENT). Sand is fine to medium, subangular to rounded; Fines: medium plasticity. Dark greenish brown (2.5Y 4/2), Moist to Very Moist, no HCl reaction	P.P. = 1.3 tsf
10.0 - 11.0	U-1		0.9	90			10.0': Pushed shelby tube
11.0 - 12.5	S-5	17-15-19	1.0	67			P.P. = 0.0 tsf
12.5 - 15.0	S-6	10-12-14-16-19	2.3	92			P.P. = 0.2 tsf
15.0 - 17.5	S-7	5-10-17-17-19	2.1	84			P.P. = 4.0 tsf
17.5 - 20.0	S-8	14-21-24-28-24	2.2	88		El. 1084.0 17.5'-21.0': Poorly graded SAND (sp) (EMBANKMENT) with low fines and gravel. Gravel is subrounded, maximum particle size: 0.75"; Sand is medium to coarse, subangular to rounded; dense, no HCL reaction, olive brown (2.5Y 4/3).	P.P. = 2.0 tsf
20.0 - 22.5	S-9	9-10-16-18-19	2.1	84		El. 1080.5 21.0'-23.4': Silty CLAY (cl) (EMBANKMENT), with some sand. Sand is medium, subangular to rounded; Fines are medium plasticity, moist, no HCL reaction, very dark gray (2.5Y 3/1).	P.P. = 0.5 tsf
22.5 - 25.0	S-10	4-5-6-7-6	2.2	88		El. 1078.1 23.4'-30.0': Clayey SAND (SC)	P.P. = 0.0 tsf

Purpose: Sample embankment and foundation soils. Install piezometers.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 85.0'.
Termination: ~1015.0' elevation.
Abandonment: Install two vibrating wire piezometers in sand-socks cement grouted in place at 26' (S/N: 2021599, zero reading: 2984.1hz, 26.7°C) and 82' (S/N: 2021596, zero reading: 2968.7hz, 26.8°C).
Additional Remarks: Drilled 6.5' up embankment, 0.9' lower elevation from staked/surveyed location.

Log Checked By: E.J. Barben, 11/11/20

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-608
Driller: Jared Zak	Gannett Fleming	Sheet: 2 of 3
Inspector: M. Mussey		Elev. Top of Hole: +1101.5 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
						(OUTWASH/ALLUVIUM). Sand is coarse; Fines: low plasticity. Greenish black (5BG 2.5/1), Wet, no HCl reaction, Organic odor	
25.0 - 27.5	S-11	2-3-4-4-3	1.5	60		26.5': Wet	P.P. = 0.0 tsf
27.5 - 30.0	U-2		0.0	0		El. 1071.5	27.5': Shelby tube attempt, no recovery. Advance augers to 30'.
30.0 - 32.5	S-12	2-3-5-6-3	1.8	72		30.0'-32.0': Poorly graded Sand (sp) (Alluvium/Outwash) with some fines. Sand is coarse, loose, wet, organics odor, no HCl reaction, greenish black (5BG 2.5/1) El. 1069.5	P.P. = 0.0 tsf
32.5 - 35.0	S-13	3-4-5-9-9	2.2	88		32.0'-85.0': Sandy SILT (ML) (OUTWASH/ALLUVIUM). Gravel is subangular to subrounded, fine, max. particle size: 1"; Sand is fine to coarse, subangular to rounded; Fines: medium plasticity. Very dark greenish gray (10Y 3/1), Moist to Wet, no HCl reaction	P.P. = 1.7 tsf
35.0 - 37.5	S-14	2-5-7-9-10	2.2	88		32.5': Silt and clay, some coarse sand, dark gray, very moist to wet	P.P. = 2.4 tsf
37.5 - 40.0	S-15	5-6-7-10-10	2.3	92			P.P. = 2.0 tsf
40.0 - 42.5	S-16	3-5-6-10-11	2.3	92		40.0': Stiff silty clay, white, moist	P.P. = 1.6 tsf
42.5 - 45.0	S-17	4-5-7-10-10	2.2	88		44.0': Clay, less coarse sand, moist	P.P. = 1.7 tsf
45.0 - 47.5	S-18	3-8-6-7-8	2.2	88			P.P. = 4.2 tsf
47.5 - 50.0	S-19	5-6-7-19-21	1.9	76			P.P. = >4.5 tsf
50.0 - 52.5	S-20	7-11-11-17-18	2.2	88			P.P. = >4.5 tsf
52.5 - 55.0	S-21	7-8-10-14-16	2.1	84			P.P. = >4.5 tsf
55.0 - 57.0	U-3		1.8	90		55.0': Silty clay at bottom of Shelby tube sample, wet	55': Pushed shelby tube.
57.0 - 57.5							57': Advanced augers.
57.5 - 60.0	S-22	6-8-11-13-19	2.5	100		57.5': Stiff silty clay, moist	P.P. = 3.9 tsf

Agency: Interstate Drilling Services, Inc.	DRILLING LOG	Hole Number: FD2020-608
Driller: Jared Zak		Sheet: 3 of 3
Inspector: M. Mussey	Gannett Fleming	Elev. Top of Hole: +1101.5 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
60.0 - 62.5	S-23	7-8-15-19-22	2.5	100		59.9': 1" piece of gravel 60.5-60.7': Higher gravel content, wet	P.P. = >4.5 tsf
62.5 - 65.0	S-24	14-22-26-32-41	2.3	92		62.5': Very stiff clay, slightly moist coarse sand, fine gravel	P.P. = >4.5 tsf
65.0 - 67.5	S-25	7-19-27-33-38	2.4	96			P.P. = >4.5 tsf
67.5 - 70.0	S-26	13-14-29-33-48	2.4	96		67.5': Moist	P.P. = >4.5 tsf
70.0 - 72.5	S-27	11-15-31-41-56	2.5	100		70.6'-70.8': Fine sand and clay, wet	P.P. = >4.5 tsf
72.5 - 75.0	S-28	17-22-25-36-48	2.5	100			P.P. = >4.5 tsf
75.0 - 77.5	S-29	11-11-14-26-34	2.2	88			P.P. = >4.5 tsf
77.5 - 80.0	S-30	11-17-22-35-31	2.4	96			P.P. = >4.5 tsf
80.0 - 82.5	S-31	8-12-12-24-25	2.0	80		81.'-82.0': Higher sand content, still medium plasticity, wet	P.P. = >4.5 tsf
82.5 - 85.0	S-32	8-14-19-36-14	2.3	92		83.7': Gravel 94.0': Coarse sand and gravel, layers of clayey sand (sc) El. 1016.5	P.P. = >4.5 tsf

Bottom of Borehole at 85.0 feet.

Date Started: 6/19/20	**DRILLING LOG**		Hole Number: FD2020-609
Date Finished: 6/19/20	Gannett Fleming		Sheet: 1 of 3
Soil Drilling: 67.5 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 67.5 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442206.2 ft
No. of Undist. Samples: 1	Driller: Jared Zak		E Coordinate: 2637358.6 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1083.2 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	1-3-4-6-3	1.7	68		0.0'-2.5': Poorly graded SAND (sp) with some fines. Sand is medium to coarse, subangular to rounded; Fines are low plasticity, dry, loose, no HCl reaction. 0.0'-0.5': Topsoil; reddish brown silty sand, some fines. High organic content. El. 1080.7	P.P. = 2.6 tsf
2.5 - 5.0	S-2	4-6-7-8-9	2.1	84		2.5'-7.5': Silty CLAY (cl), with some sand. Sand is fine to medium, subangular to rounded; Fines are medium plasticity, moist to wet, no HCL reaction, organic odor and particles, very dark greenish gray (10Y 3/1).	P.P. = 3.0 tsf
5.0 - 7.5	S-3	3-5-6-7-7	2.2	88		El. 1075.7	P.P. = 2.0 tsf
7.5 - 10.0	S-4	1-2-2-2-2	2.2	88		7.5'-12.5': Lean CLAY with sand (CL). Sand is medium to coarse; Very dark brown (N 3/), no HCl reaction	P.P. = 0.0 tsf
10.0 - 12.5	S-5	1-1-2-2-3	1.8	72		El. 1070.7	P.P. = 0.0 tsf
12.5 - 15.0	S-6	2-3-4-6-7	2.3	92		12.5'-67.5': Sandy SILT (ML) (OUTWASH/ALLUVIUM). Gravel is subangular to subrounded, fine, max. particle size: 1.5"; Sand is medium to coarse, subangular to rounded; Fines: medium plasticity. Very dark greenish gray (10Y 3/1), Moist to Wet, no HCl reaction	P.P. = 2.5 tsf
15.0 - 17.5	S-7	3-7-7-11-13	1.8	72			P.P. = 3.6 tsf
17.5 - 20.0	S-8	5-6-7-8-10	2.3	92			P.P. = 2.1 tsf
20.0 - 22.5	S-9	2-3-5-6-6	2.1	84		20.0'-22.5': Silty clay, moist	P.P. = 1.2 tsf
22.5 - 25.0	S-10	3-3-6-6-8	2.1	84		22.0': 1" gravel, fine subangular	P.P. = 2.5 tsf

Purpose: Sample foundaton material beyond downstream embankment toe. Install piezometers.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 67.5'.
Termination: ~1015.0' elevation.
Abandonment: Install two vibrating wire piezometers in sand-socks cement grouted in place at 12' (S/N: 2021600, zero reading: 2976.3hz, 21.7°C) and 57.5' (S/N: 2021597, zero reading: 2984.4hz, 21.9°C)
Additional Remarks:

Log Checked By: E.J. Barben, 11/11/20

Agency: Interstate Drilling Services, Inc.	DRILLING LOG	Hole Number: FD2020-609
Driller: Jared Zak		Sheet: 2 of 3
Inspector: M. Mussey	Gannett Fleming	Elev. Top of Hole: +1083.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.0	S-11	3-3-10-11-50/0.5"	1.5	75			P.P. = 1.8 tsf
27.0 - 27.5						27.0': Large grain igneous gravel; fractured while sampling	27': Advanced augers
27.5 - 30.0	S-12	3-5-5-7-10	2.5	100			P.P. = 2.1 tsf
30.0 - 32.0	U-1		2.0	100		30.0'-32.0': Fine sand and silt at bottom of undistributed sample, wet	
32.0 - 32.5							32'-32.5': Advanced augers
32.5 - 35.0	S-13	9-11-13-19-22	2.2	88		32.5'-32.7': Higher fine sand	P.P. = >4.5 tsf
35.0 - 37.5	S-14	14-26-19-22-25	1.8	72			P.P. = >4.5 tsf
37.5 - 40.0	S-15	7-14-17-22-25	2.3	92		37.5'-40.0': Slightly moist	P.P. = >4.5 tsf
40.0 - 42.5	S-16	9-14-17-26-17	2.2	88			P.P. = 3.1 tsf
42.5 - 45.0	S-17	17-12-15-17-24	2.3	92		42.0': Gravel, subangular, 3/8", granite 43.0': Angular shale gravel (0.5")	P.P. = 4.5 tsf
45.0 - 47.5	S-18	8-10-16-18-28	2.5	100			P.P. = >4.5 tsf
47.5 - 50.0	S-19	9-11-13-23-34	2.5	100			P.P. = >4.5 tsf
50.0 - 52.5	S-20	10-12-15-28-28	2.5	100		49.5': Gravel, 1" subrounded, fine, white	P.P. = >4.5 tsf
52.5 - 55.0	S-21	14-15-30-10-24	2.3	92		52.0': Coarse sand, subrounded to round, with fines	P.P. = >4.5 tsf
55.0 - 57.4	S-22	5-10-15-24-50/4"	1.9	79			P.P. = >4.5 tsf
57.5 - 60.0	S-23	14-14-14-27-36	2.3	92		57.4': Gravel >1.5", fine, white, fresh fracture; difficult to auger 57.5'-57.9': Fine sand with fines, wet	P.P. = >4.5 tsf

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-609
Driller: Jared Zak		Sheet: 3 of 3
Inspector: M. Mussey	Gannett Fleming	Elev. Top of Hole: +1083.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
						59.6'-59.8': Fresh shale, freshley fractured >1.5"	
60.0 - 62.5	S-24	10-12-14-28-44	2.0	80		59.8'-62.5': Stiff silty clay, some coarse sand	P.P. = >4.5 tsf
62.5 - 64.7	S-25	14-35-38-100/8"	1.8	82		62.5'-63.0': Fine sand, wet 63.0'-63.2: Moist sand and fines	P.P. = >4.5 tsf
64.7 - 65.0							P.P. = >4.5 tsf
65.0 - 67.5	S-26	8-14-17-22-59	1.9	76		El. 1015.7	

Bottom of Borehole at 67.5 feet.

APPENDIX D

Piezometer Construction Logs and Data

Project No.:	**PIEZOMETER CONSTRUCTION LOG**		**Hole Number:** FD2020-11
Date Started: 6/16/20	Gannett Fleming		Piezo. ID: FD2020-11S & FD2020-11D
Date Finished: 6/17/20			Line & Station:
Elev. Top of Hole: +1130.2 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 113.8 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442165.4 ft
Borehole Diameter: 7.0 "	Driller: Jared Zak		E Coordinate: 2637221.7 ft
Logged By: M. Mussey			

Strata		Piezometer Construction		
Description	USCS	Piezometer Materials	Piezometer Construction Details	Elev.
			Protective Casing — Stick Up: 3.0 ft; Diameter: 8 in; Material: Steel	1133.2
0.0'-19.5': Clayey SAND (SC)			0.0'-113.8': Grout Backfill	1130.2
El. 1110.7				
19.5'-62.0': Sandy Lean CLAY (CL)				
			56.0': VW Transducer Tip, Geokon Model 4500S embedded within sand-filled sock	1074.2
El. 1068.2				
62.0'-113.8': Silty CLAY (cl)				
			101.0': VW Transducer Tip, Geokon Model 4500S embedded within sand-filled sock	1029.2
El. 1016.4				
			113.8': Bottom of Borehole	1016.4

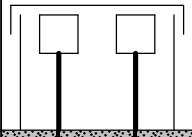
Remarks: Two vibrating wire piezometers embedded in sand socks, cement grouted in place at 56' (S/N: 2021598; zero reading: 2976.8hz, 24°C) and 101' (S/N: 2021594; zero reading: 2971.3hz, 27.5°C)

Project No.:	**PIEZOMETER CONSTRUCTION LOG**		Hole Number: FD2020-608
Date Started: 6/18/20	Gannett Fleming		Piezo. ID: FD2020-608S & FD2020-608D
Date Finished: 6/18/20			Line & Station:
Elev. Top of Hole: +1101.5 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 85.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442187.8 ft
Borehole Diameter: 7.0 "	Driller: Jared Zak		E Coordinate: 2637296.7 ft
Logged By: M. Mussey			

Strata		Piezometer Construction		
Description	USCS	Piezometer Materials	Piezometer Construction Details	Elev.
			Protective Casing — Stick Up: 3.0 ft; Diameter: 8 in; Material: Steel	1104.5
0.0'-8.5': Clayey SAND (SC)			0.0'-85.0': Grout Backfill	1101.5
El. 1093.0				
8.5'-17.5': Silty Clayey SAND (SC-SM)				
El. 1084.0				
17.5'-21.0': Poorly Graded SAND (sp)				
El. 1080.5				
21.0'-23.4': Silty CLAY with sand (ml)				
El. 1078.1				
23.4'-30.0': Clayey SAND (SC)			26.0': VW Transducer Tip, Geokon Model 4500S embedded within sand-filled sock	1075.5
El. 1071.5				
30.0'-32.0': Poorly Graded SAND (sp)				
El. 1069.5				
32.0'-85.0': Sandy SILT (ML)				
El. 1016.5			82.0': VW Transducer Tip, Geokon Model 4500S embedded within sand-filled sock	1019.5
			85.0': Bottom of Borehole	1016.5

Remarks: Two vibrating wire piezometers embedded in sand socks, cement grouted in place at 26' (S/N: 2021599; zero reading: 2968.7hz, 26.8°C) and 82' (S/N: 2021596; zero reading 2984.1hz, 26.7°C)

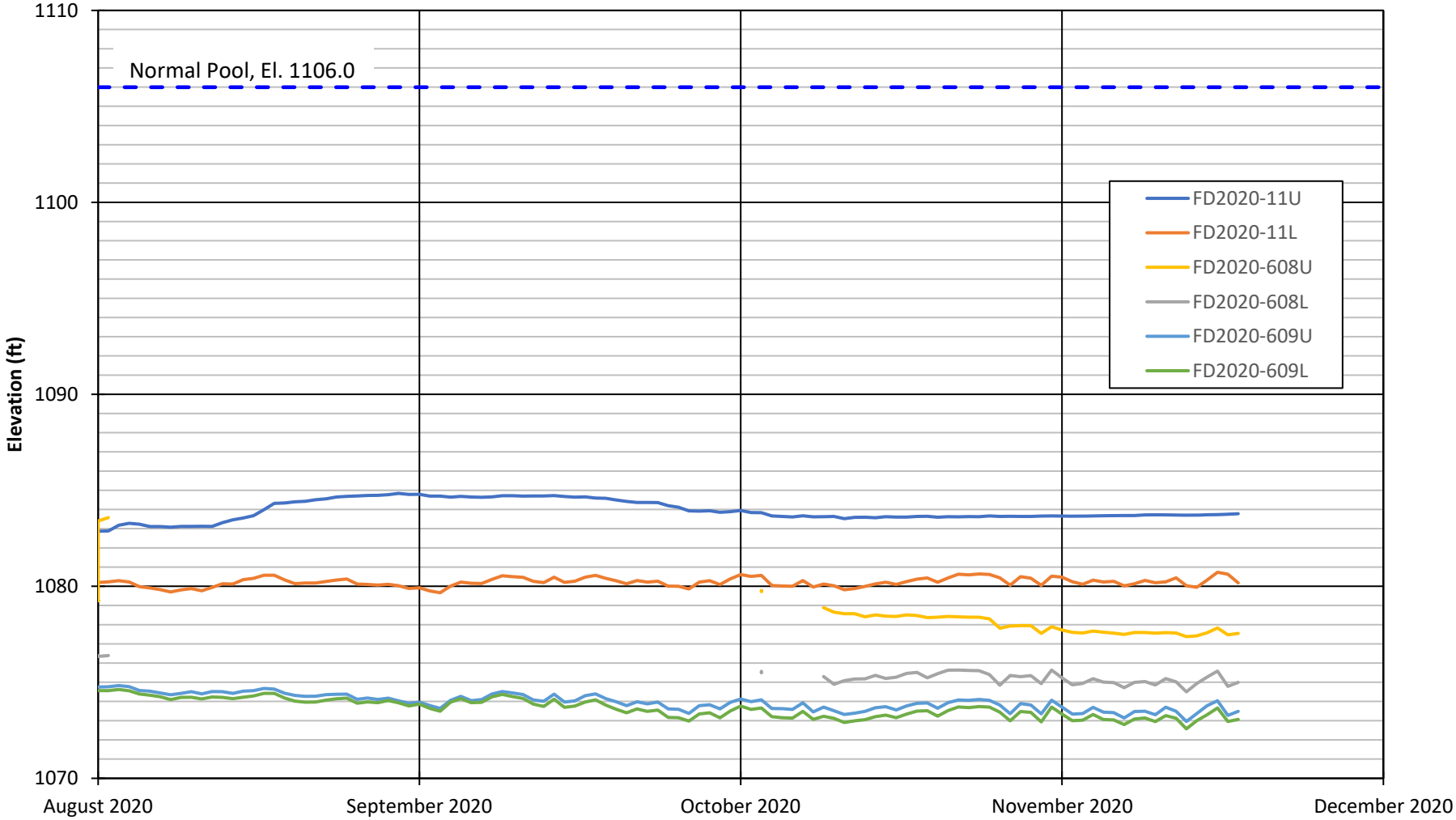
Project No.:	**PIEZOMETER CONSTRUCTION LOG**		Hole Number: FD2020-609
Date Started: 6/19/20	Gannett Fleming		Piezo. ID: FD2020-609S & FD2020-609D
Date Finished: 6/19/20			Line & Station:
Elev. Top of Hole: +1083.2 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 67.5 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442206.2 ft
Borehole Diameter: 7.0 "	Driller: Jared Zak		E Coordinate: 2637358.6 ft
Logged By: M. Mussey			



Strata		Piezometer Construction		
Description	USCS	Piezometer Materials	Piezometer Construction Details	Elev.
			Protective Casing — Stick Up: 3.0 ft; Diameter: 8 in; Material: Steel	1086.2
0.0'-2.5': Poorly Graded SAND with silt (sp) El. 1080.7			0.0'-67.5': Grout Backfill	1083.2
2.5'-7.5': Silty CLAY with sand (cl) El. 1075.7				
7.5'-12.5': Lean CLAY with sand (CL) El. 1070.7			12.0': VW Transducer Tip, Geokon Model 4500S embedded within sand-filled sock	1071.2
12.5'-67.5': Sandy SILT (ML)				
			57.5': VW Transducer Tip, Geokon Model 4500S embedded within sand-filled sock	1025.7
El. 1015.7				
			67.5': Bottom of Borehole	1015.7

Remarks: Two vibrating wire piezometers embedded in sand socks, cement grouted in place at 12' (S/N: 2021600; zero reading: 2984.4 hz, 21.9°C) and 57.5' (S/N: 2021597; zero reading: 2976.3 hz, 21.7°C)

Fordville Dam
Piezometer Data



Notes:

1) Pool data is not available. A "normal pool" elevation equal to the invert of the 1st stage of the principal spillway is shown on the plot for reference. Pool reported at El. 1105.97 on 6/16/20 during site survey.

2) Data loggers installed on August 1, 2020.

3) Data for FD2020-608U/L is unavailable between 8/1/20 and 10/10/20 due to a battery issue.

APPENDIX E

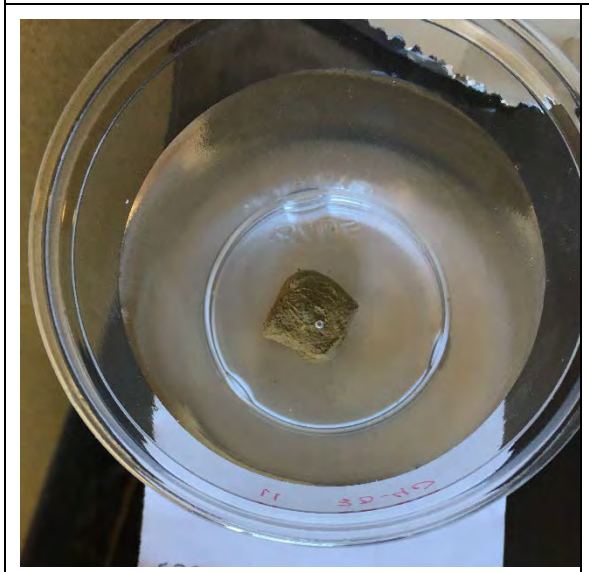
Field Crumb Dispersion Tests

FIELD CRUMB DISPERSION TEST RESULTS

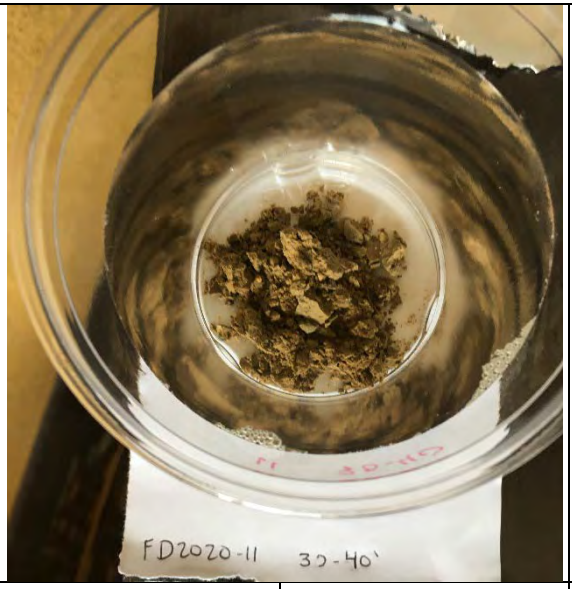
(ASTM D 6572)

	Stratum	Boring	Stratum Depth (ft)		Sample Depth (ft)		Grade			
			Top	Bottom	Top	Bottom	2 min	1 hr	6 hr	Avg.
Dam	Embankment	FD2020-11	0	62	30	40	1	1	1	1
		FD2020-608	0	30	15	17.5	1	1	1	
		FD2020-609	0	12.5	2.5	7.5	1	1	1	
	Outwash	FD2020-11	62	114	71.8	80	1	1	1	2
					102	109.3	1	2	2	
		FD2020-608	30	85	40	42.5	2	2	2	
					77.5	80	2	2	2	
		FD2020-609	12.5	67.5	20	30	1	1	1	
					63.2	67.5	1	1	1	
Auxiliary Spillway	Till	FD2020-212	0	17	8	10	1	1	1	1
	Silt/Clay (glaciolacustrine)	FD2020-212	17	45	25	32.5	2	2	2	1
		FD2020-213	15.5	45	15.5	25	1	1	1	
					40	45	1	1	1	
		FD2020-214	21.5	45	21.7	30	1	1	1	
					30	40	2	2	2	

FD2020-11 30'-40' Embankment



Time = 2 min | Grade = 1

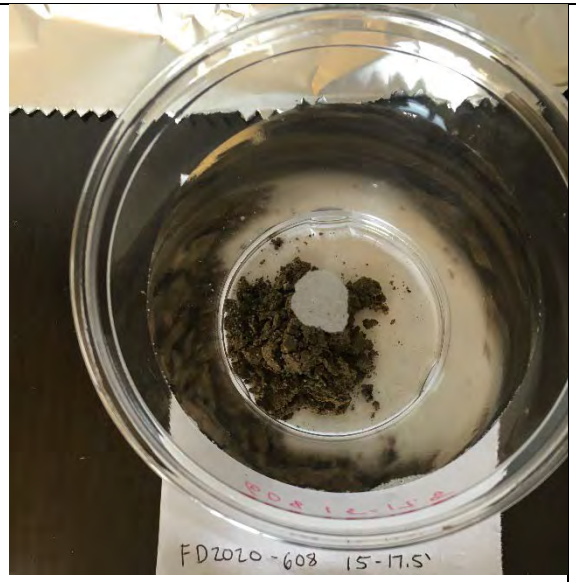


Time = 1 hour | Grade = 1

Time = 6 hours | Grade = 1

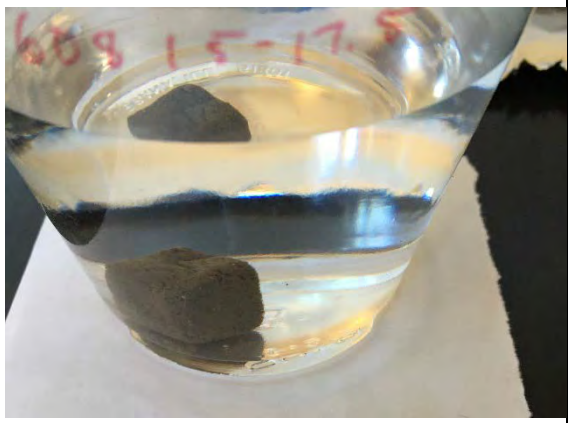
FD2020-608 15'-17.5' Embankment

Time = 2 min	Grade = 1



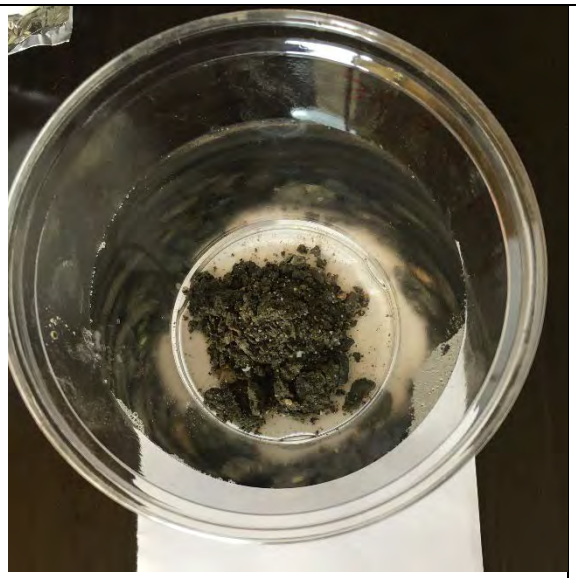
Time = 1 hour	Grade = 1

Time = 6 hours	Grade = 1



FD2020-609 2.5'-7.5' Embankment

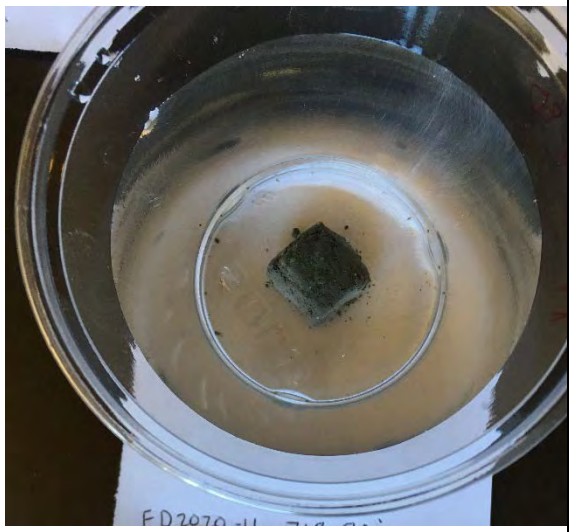
Time = 2 min	Grade = 1



Time = 1 hour	Grade = 1

Time = 6 hours	Grade = 1

FD2020-11 71.8'-80' Outwash



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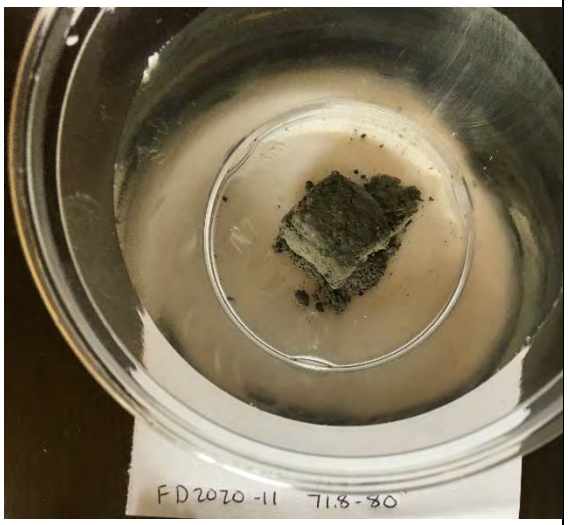
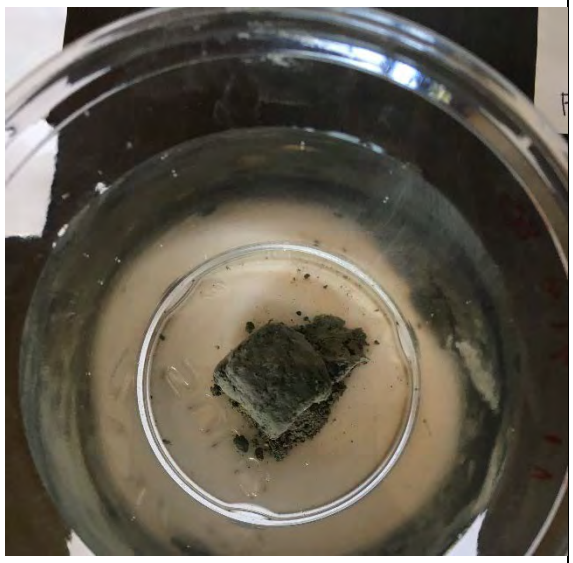
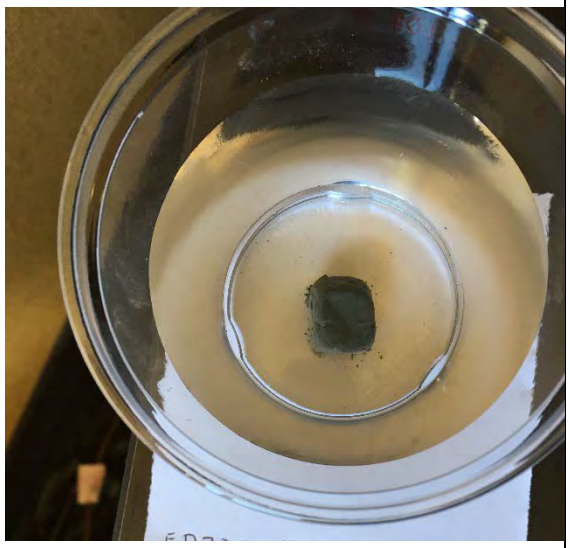


Time = 1 hour	Grade = 1



Time = 6 hours	Grade = 1

FD2020-11 102'-109.3' Outwash



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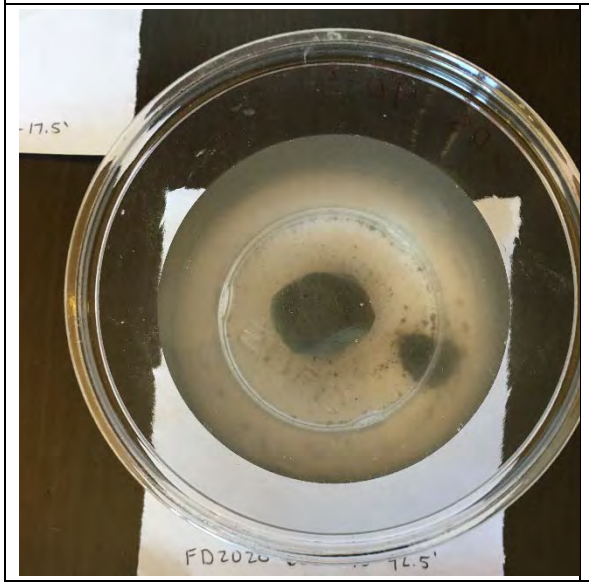
Time = 1 hour	Grade = 2

Time = 6 hours	Grade = 2

FD2020-608 40'-42.5' Outwash



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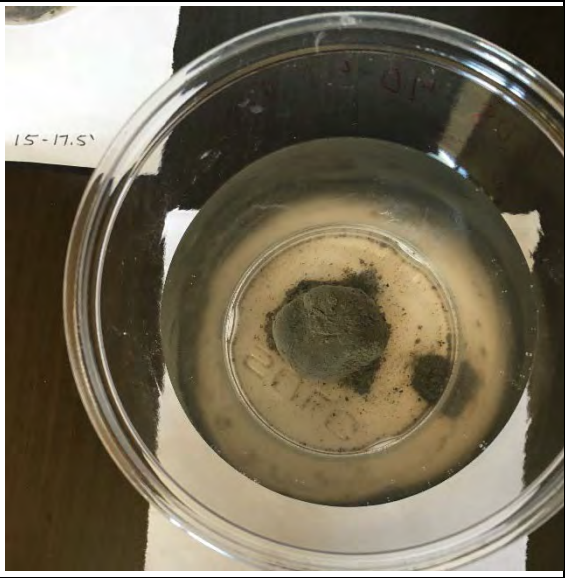
Time = 1 hour	Grade = 2



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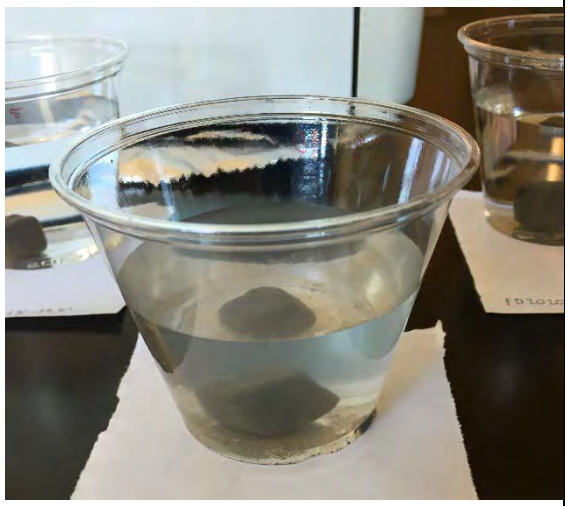
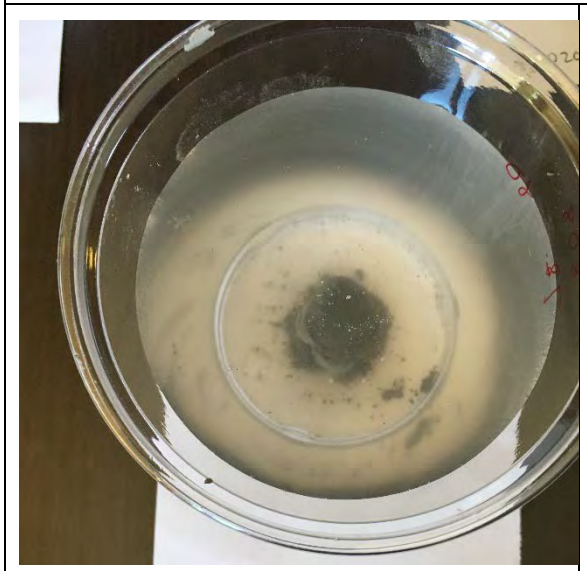


FD2020-608 77.5'-80' Outwash



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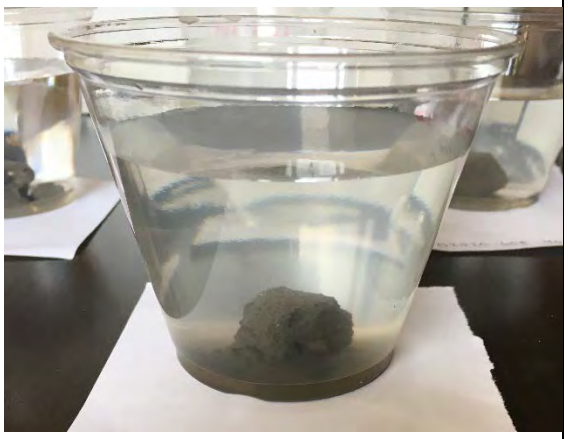
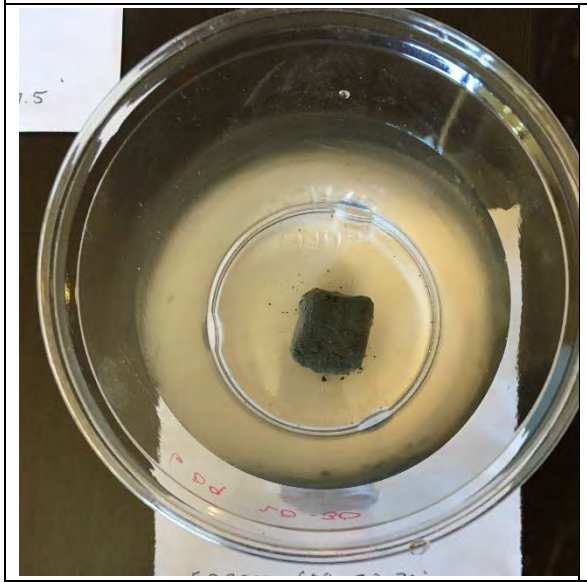
Time = 1 hour	Grade = 2

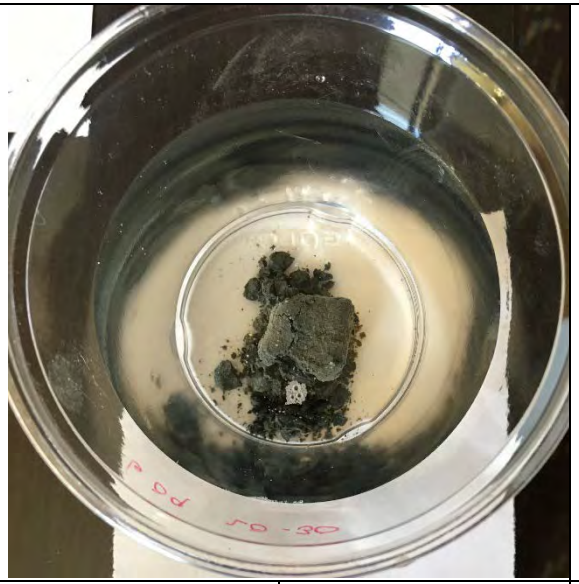
Time = 6 hours	Grade = 2



FD2020-609 20'-30' Outwash



Time = 2 min | Grade = 1



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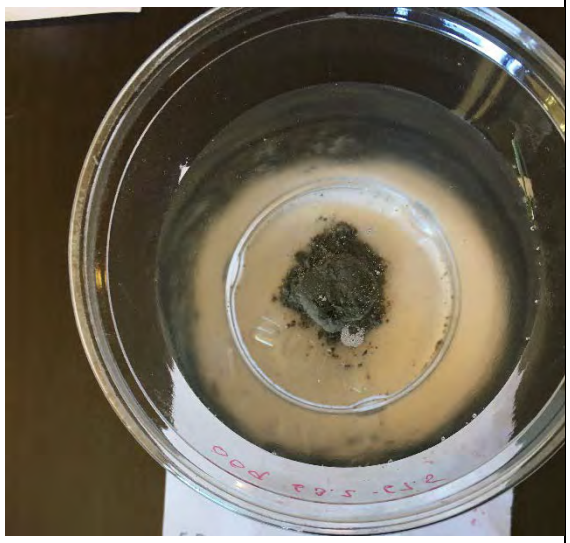
Time = 6 hours | Grade = 1

FD2020-609 63.2'-67.5' Outwash



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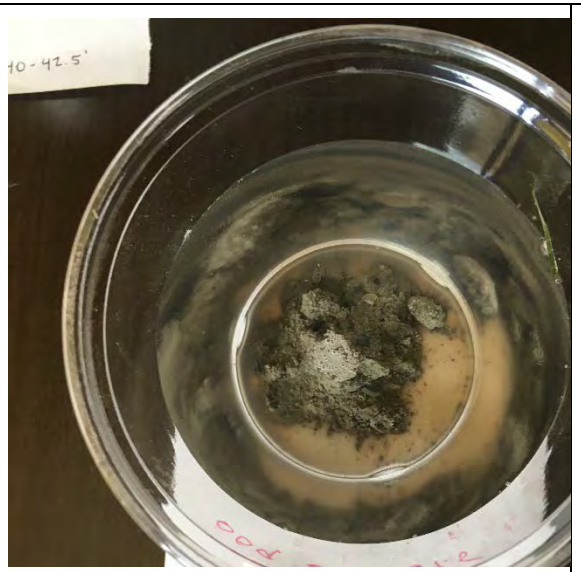

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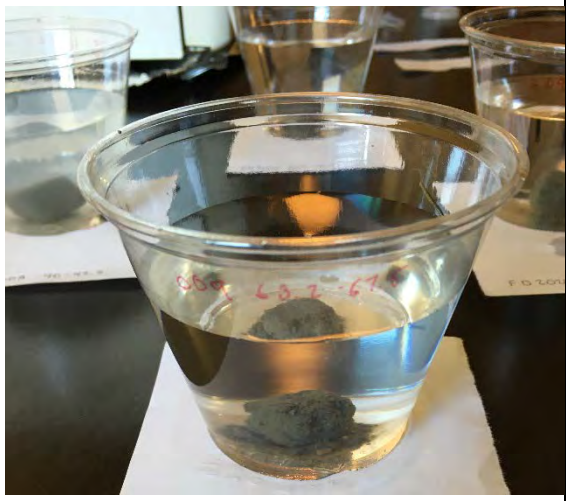
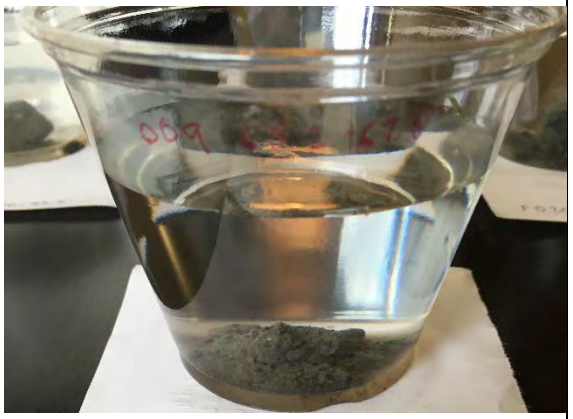
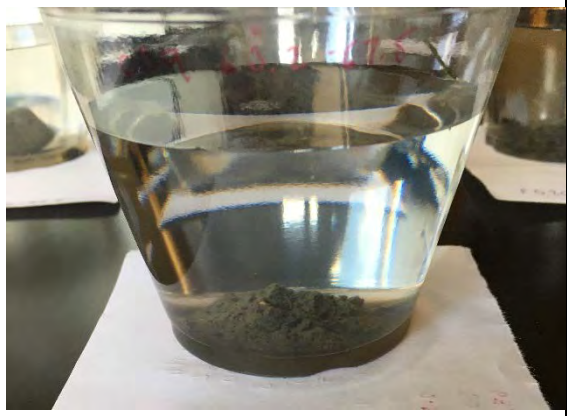
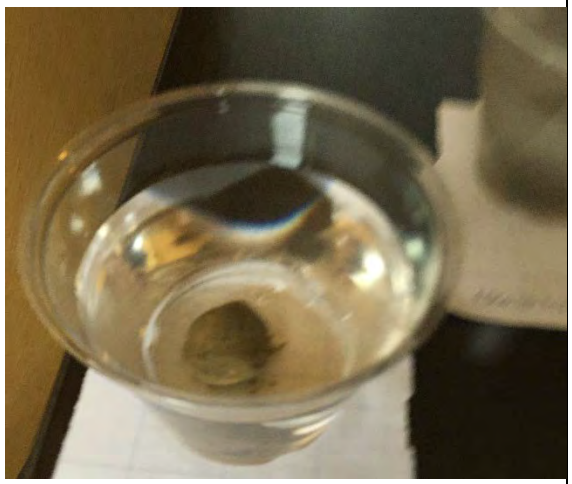






FD2020-212 8.0'-10.0' Till



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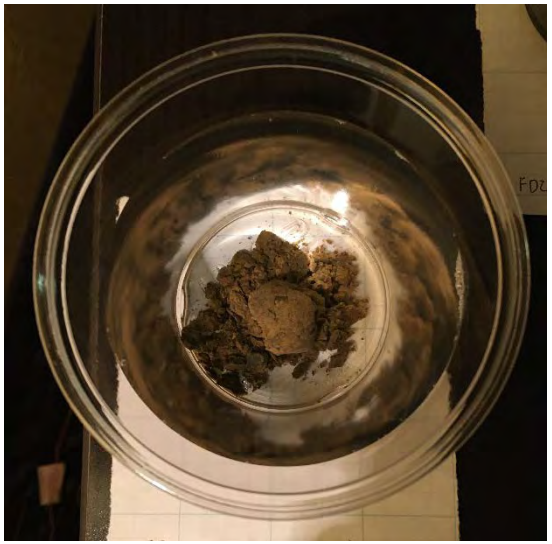
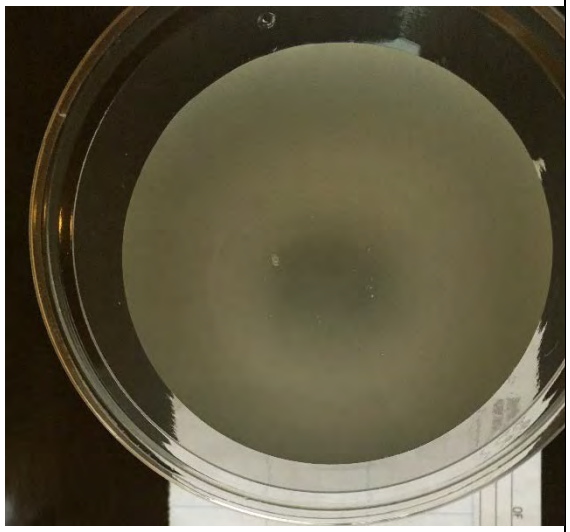
Time = 1 hour | Grade = 1



Time = 6 hours | Grade = 1

FD2020-212 25.0'-32.5' Glaciolacustrine



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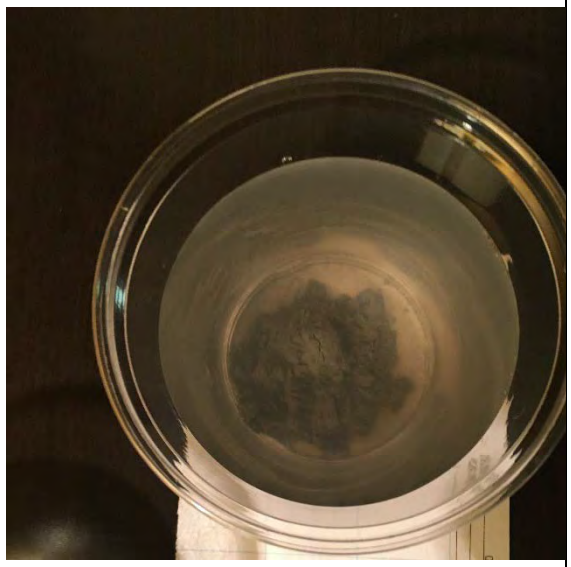
Time = 1 hour	Grade = 2



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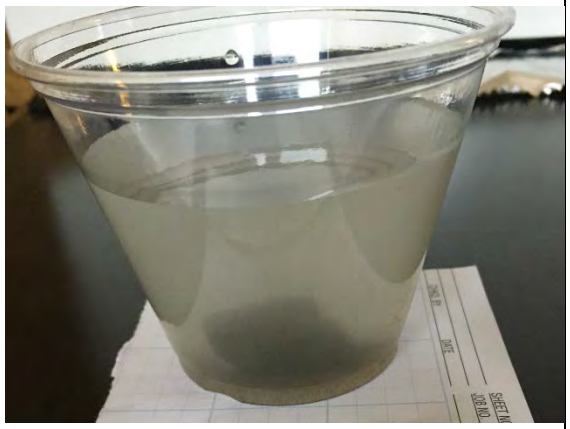

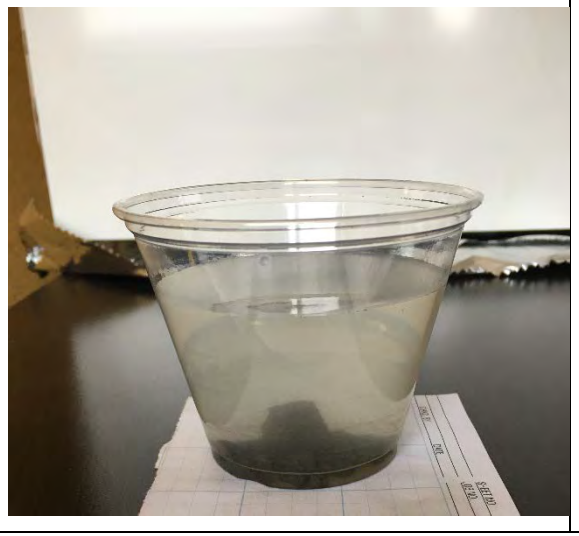

FD2020-213 15.5'-25.0' Glaciolacustrine

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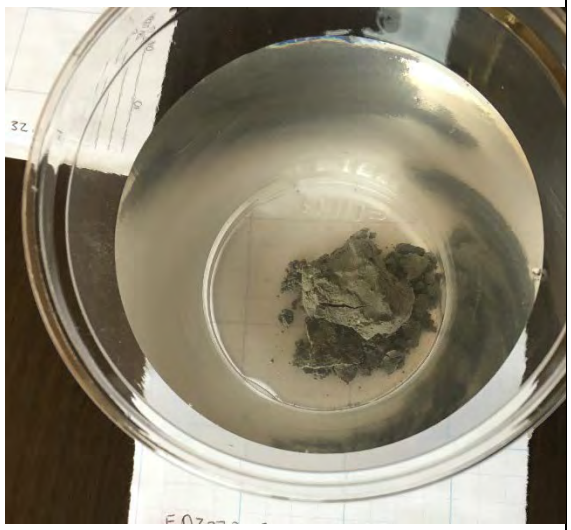
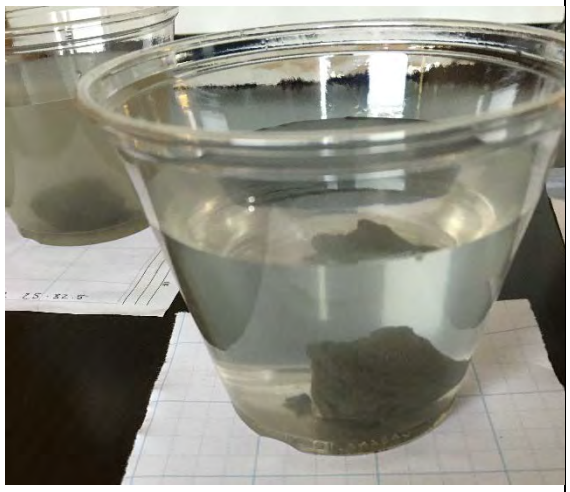
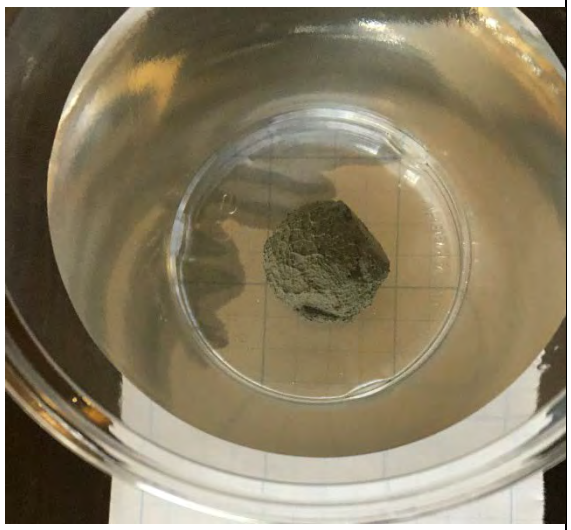


Time = 1 hour	Grade = 1

Time = 6 hours	Grade = 1



FD2020-213 40.0'-45.0' Glaciolacustrine



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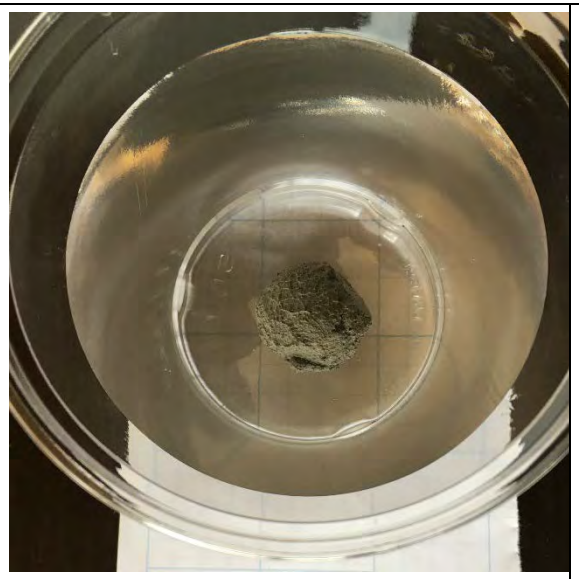
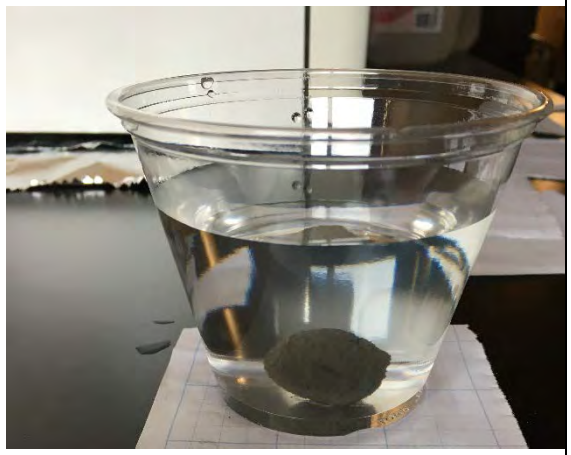
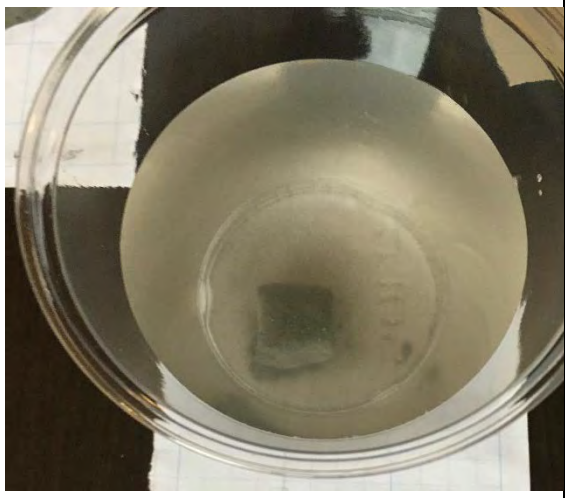


Time = 1 hour	Grade = 1

Time = 6 hours	Grade = 1



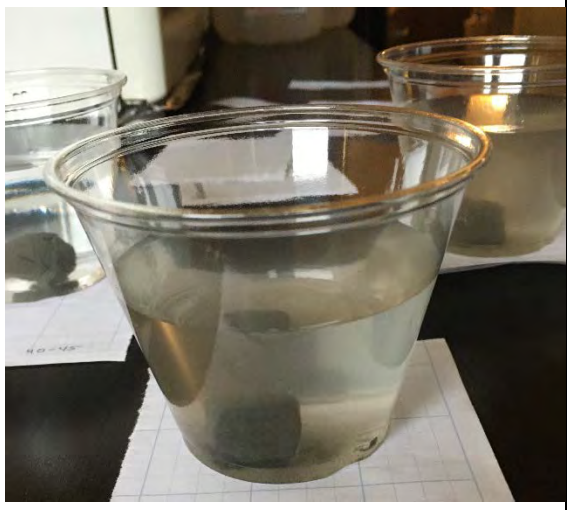
FD2020-214 21.7'-30.0' Glaciolacustrine

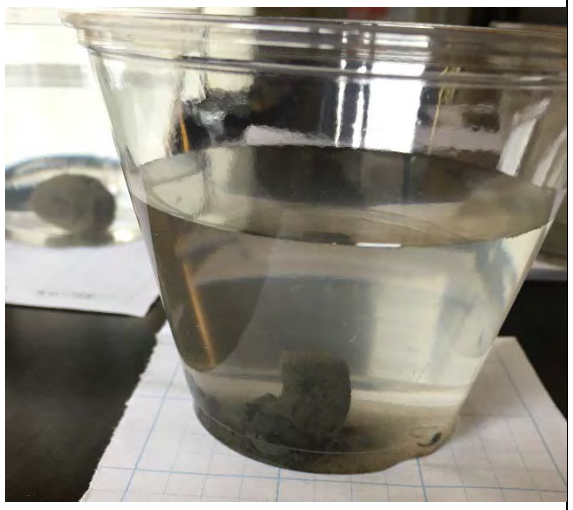


Time = 2 min	Grade = 1

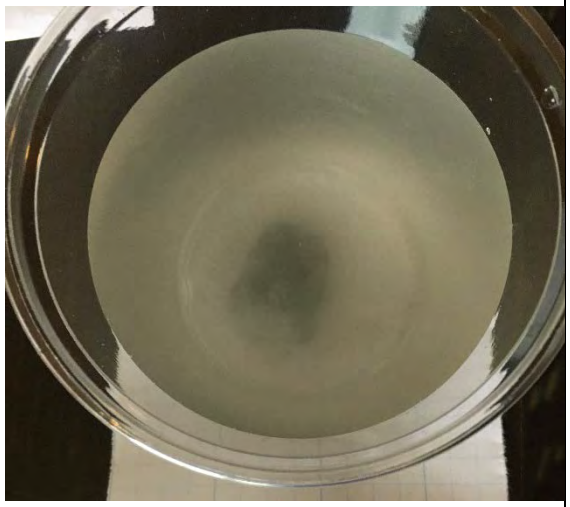
Time = 1 hour	Grade = 1

Time = 6 hours	Grade = 1

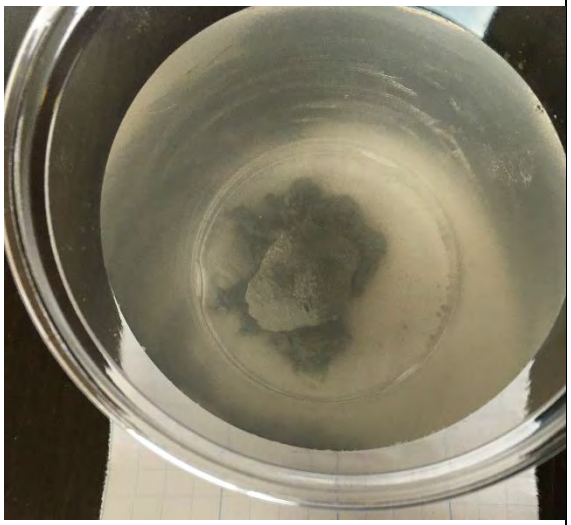




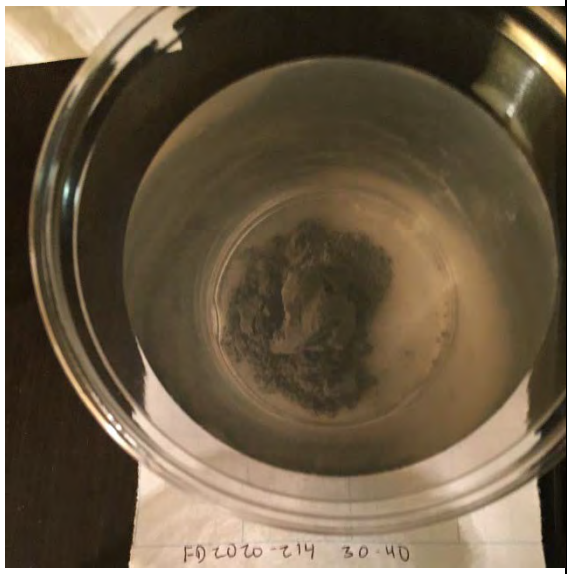
FD2020-214 30.0'-40.0' Glaciolacustrine



Time = 2 min	Grade = 2



Time = 1 hour	Grade = 2



Time = 6 hours	Grade = 2

APPENDIX F

Laboratory Test Reports

Gannett Fleming

Fordville Dam
Summary of Laboratory Soil Test Results

EJB, 9/2020
TNK, 12/2020

Test Boring Number	Sample Number	Sample Depth	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	% Gravel	% Sand	% Silt	% Clay	LL (%)	PL (%)	Plasticity Index	Natural Moisture (%)	Specific Gravity (dim.)	Dry Unit Weight (pcf)	Moist Unit Weight (pcf)	Crumb Dispersion Grade
FD2020-11	S-6 & S-7	12.5 - 17.5	1117.7	Zone II	SC	Clayey SAND	0.0	65.7	21.1	13.2	29	19	10	17.8	2.82			1
FD2020-11	U1	37.5 - 38.5	1092.7	Zone I	CL	Sandy lean CLAY	0.0	35.0	40.1	24.8	39	19	20	14.0	2.79	119.9	136.7	2
FD2020-11	S-22 & S-23	52.5 - 57.5	1077.7	Zone I	CL	Sandy lean CLAY	1.5	33.6	37.5	27.4	40	19	21	16.4				1
FD2020-11	S-26	62.5 - 65.0	1067.7	Embankment Foundation														1
FD2020-11	S-28	67.5 - 70.0	1062.7	Embankment Foundation	SC-SM	Silty, clayey SAND	0.2	80.0	12.9	6.9	24	20	4	29.6				
FD2020-11	S-31	72.5 - 75.0	1057.7	Embankment Foundation														1
FD2020-11	S-35	82.5 - 85.0	1047.7	Embankment Foundation	ML	Sandy SILT	2.9	45.3	29.1	22.7	32	24	8	27.5				1
FD2020-11	S-42	100.0 - 102.5	1030.2	Embankment Foundation	SC	Clayey SAND	6.9	56.9	31.0	5.1	32	22	10	24.1				
FD2020-212	S-1 & S-2	0.0 - 5.0	1123.8	ASW Foundation	SC	Clayey SAND	10.2	68.3	14.6	6.9	45	22	23	14.7				1
FD2020-212	S-4	7.5 - 10.0	1116.3	ASW Foundation	CL	Sandy lean CLAY	5.6	41.6	39.7	13.2	40	22	18	19.1				
FD2020-212	S-5 & S-6	10.0 - 15.0	1113.8	ASW Foundation	SM	Silty SAND	5.7	78.3	7.8	8.2	32	26	6	17.7				
FD2020-213	S-2 & S-3	2.5 - 7.5	1121.2	ASW Foundation	SM	Silty SAND	5.8	74.7	12.6	7.0	31	25	6	11.3				
FD2020-213	U-1	20.0 - 22.3	1103.7	ASW Foundation	ML	SILT	0.0	2.4	77.9	19.7	33	30	3	40.7		81.0	114.0	
FD2020-214	S-3 & S-4	5.0 - 10.0	1119.1	ASW Foundation	SM	Silty SAND	0.0	81.6	7.0	11.4	43	28	15	18.7				
FD2020-608	S-1 & S-2	0.0 - 5.0	1101.5	Zone II	SC	Clayey SAND	0.7	82.0	8.7	8.6	38	22	16	16.3	2.66			
FD2020-608	U-1	10.0 - 11.0	1091.5	Zone II	SC-SM	Silty, clayey SAND	0.0	69.9	18.5	11.7	27	21	6	22.6	2.65	91.7	112.4	2
FD2020-608	S-11	25.0 - 27.5	1076.5	Embankment Foundation	SC	Clayey SAND	0.0	73.1	15.9	11.0	29	18	11	27.0				
FD2020-608	S-13	32.5 - 35.0	1069.0	Embankment Foundation														1
FD2020-608	U-2	55.0 - 57.0	1046.5	Embankment Foundation	ML	Sandy SILT	0.0	34.0	42.6	23.5	34	31	3	25.7	2.48	96.6	121.4	
FD2020-609	S-2	2.5 - 5.0	1080.7	Embankment Foundation														1
FD2020-609	S-5	10.0 - 12.5	1073.2	Embankment Foundation	CL	Lean CLAY with sand	0.0	28.6	63.5	8.0	39	24	15	34.4				
FD2020-609	U-1	30.0 - 32.0	1053.2	Embankment Foundation	ML	Sandy SILT	0.0	49.9	37.5	12.6	39	26	13	47.7	2.66	81.0	119.6	2

PERMEABILITY

Test Boring Number	Sample Number	Sample Depth (ft)	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	Permeability (cm/s)
FD2020-608	S-1 to S-7	0 - 17.5	1101.5	Zone II	SM	Silty SAND	6.50E-06
FD2020-11	S-10 to S-20	22.2 - 50.0	1108	Zone I	CL	Sand lean CLAY	7.70E-08
FD2020-608	U-2	55 - 57.0	1046.5	Foundation	ML	Sandy SILT	2.20E-08
FD2020-609	U-1	30 - 32	1053.2	Foundation	ML	Sandy SILT	3.50E-06

CU TRIAXIAL SHEAR

Test Boring Number	Sample Number	Sample Depth (ft)	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	Moisture (%)	Dry Unit Weight (pcf)	Moist Unit Weight (pcf)	Total Stress Cohesion* (psf)	Total Stress Friction Angle* (°)	Effective Stress Cohesion* (psf)	Effective Stress Friction Angle* (°)
FD2020-11	S-10 to S-20	22.5 - 50.0	1108.0	Zone I	CL	Sandy lean CLAY	21.0	109.8	132.9	701.3	25.4	529.9	34.4
							21.0	110.2	133.3				
							21.0	110.1	133.2				
FD2020-608	U-2	55.0 - 57.0	1046.5	Foundation	ML	Sandy SILT	26.6	90.9	115.1	159.8	22.0	230.4	32.3
							25.8	92.9	116.9				
							24.7	97.4	121.5				
FD2020-609	U-1	30.0 - 32.0	1053.2	Foundation	ML	Sandy SILT	26.6	96.9	122.7	463.7	19.5	0.0	35.5
							28.9	90.2	116.3				
							23.7	99.3	122.8				

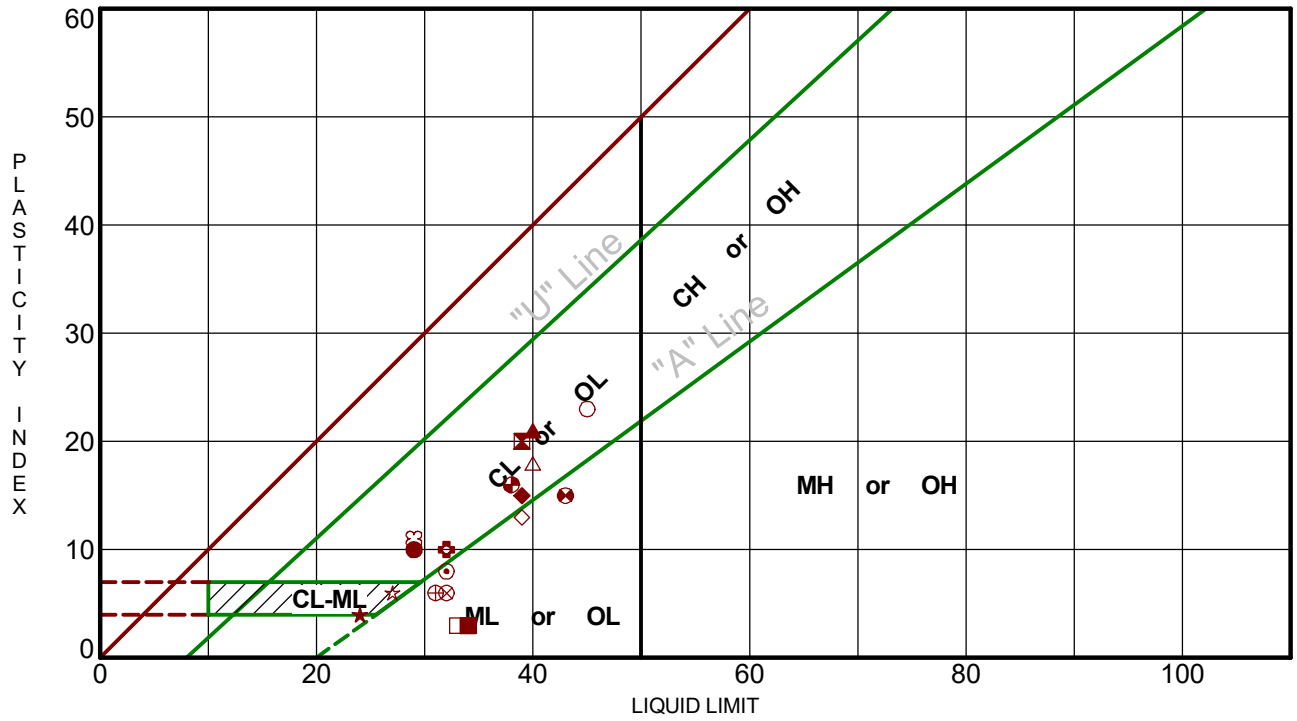
DIRECT SHEAR

Test Boring Number	Sample Number	Sample Depth (ft)	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	Moisture (%)	Dry Unit Weight (pcf)	Moist Unit Weight (pcf)	Effective Stress Cohesion* (psi)	Effective Stress Friction Angle* (deg)
							Remolded				
FD2020-608	S-1 to S-7	0.0 - 17.5	1101.5	Zone II	SM	Silty SAND	21	100	121	0.63	37

*Strength parameters may not match laboratory test report sheets because engineering judgment was utilized to evaluate the results for each material to develop recommended shear strength parameters.

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID		Depth	LL	PL	PI	Fines	USCS	Description
●	FD2020-11	12.5 - 17.5	29	19	10	34.3	SC	CLAYEY SAND
⊠	FD2020-11	37.5 - 38.5	39	19	20	65.0	CL	SANDY LEAN CLAY
▲	FD2020-11	52.5 - 57.5	40	19	21	64.9	CL	SANDY LEAN CLAY
★	FD2020-11	67.5 - 70	24	20	4	19.8	SC-SM	SILTY, CLAYEY SAND
⊙	FD2020-11	82.5 - 85	32	24	8	51.8	ML	SANDY SILT
✿	FD2020-11	100 - 102.5	32	22	10	36.2	SC	CLAYEY SAND
○	FD2020-212	0 - 5	45	22	23	21.5	SC	CLAYEY SAND
△	FD2020-212	7.5 - 10	40	22	18	52.9	CL	SANDY LEAN CLAY
⊗	FD2020-212	10 - 15	32	26	6	16.0	SM	SILTY SAND
⊕	FD2020-213	2.5 - 7.5	31	25	6	19.5	SM	SILTY SAND
□	FD2020-213	20 - 22.3	33	30	3	97.6	ML	SILT
⊛	FD2020-214	5 - 10	43	28	15	18.4	SM	SILTY SAND
◕	FD2020-608	0 - 5	38	22	16	17.3	SC	CLAYEY SAND
☆	FD2020-608	10 - 11	27	21	6	30.1	SC-SM	SILTY, CLAYEY SAND
❀	FD2020-608	25 - 27.5	29	18	11	26.9	SC	CLAYEY SAND
■	FD2020-608	55 - 57	34	31	3	66.0	ML	SANDY SILT
◆	FD2020-609	10 - 12.5	39	24	15	71.4	CL	LEAN CLAY with SAND
◇	FD2020-609	30 - 32	39	26	13	50.1	ML	SANDY SILT

PROJECT: Fordville Dam

PROJECT NUMBER: M5205037

SITE: 43rd Street NE
Fordville, ND

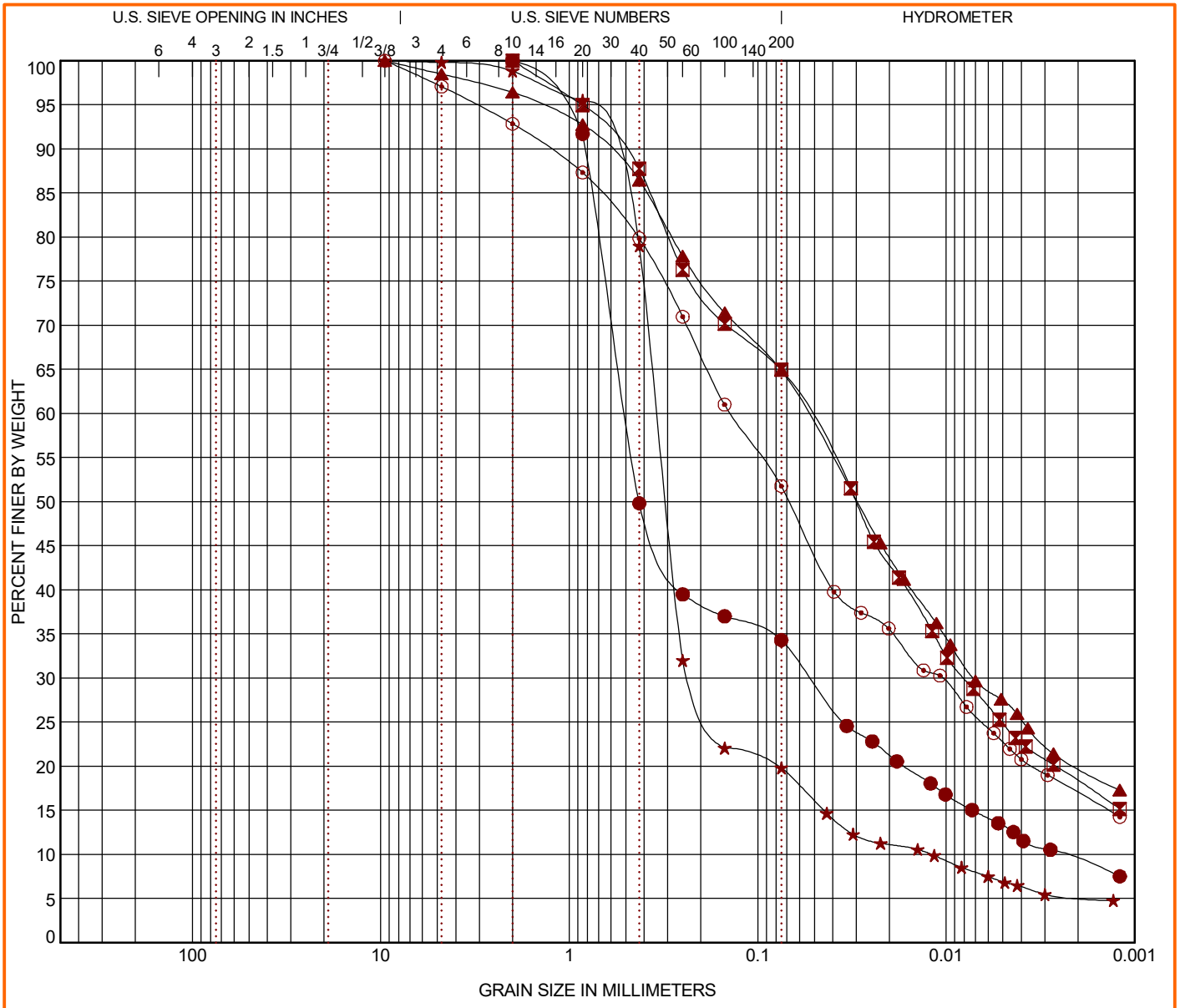
Terracon
1555 N 42nd St, Unit B
Grand Forks, ND

CLIENT: Gannett Fleming, Inc.
Greenwood Village, CO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. ATTERBERG LIMITS M5205037 FORDVILLE DAM.GPJ TERRACON_DATATEMPLATE.GDT 11/23/20

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-11	12.5 - 17.5	CLAYEY SAND (SC)	17.8	29	19	10	2.28	208.53
FD2020-11	37.5 - 38.5	SANDY LEAN CLAY (CL)	14.0	39	19	20		
FD2020-11	52.5 - 57.5	SANDY LEAN CLAY (CL)	16.4	40	19	21		
FD2020-11	67.5 - 70	SILTY, CLAYEY SAND (SC-SM)	29.6	24	20	4	12.39	28.65
FD2020-11	82.5 - 85	SANDY SILT (ML)	27.5	32	24	8		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-11	12.5 - 17.5	2	0.503	0.053	0.002	0.0	0.0	65.7	21.1		13.2
FD2020-11	37.5 - 38.5	2	0.055	0.008		0.0	0.0	35.0	40.1		24.8
FD2020-11	52.5 - 57.5	9.5	0.055	0.007		0.0	1.5	33.6	37.5		27.4
FD2020-11	67.5 - 70	9.5	0.343	0.226	0.012	0.0	0.2	80.0	12.9		6.9
FD2020-11	82.5 - 85	9.5	0.139	0.011		0.0	2.9	45.3	29.1		22.7

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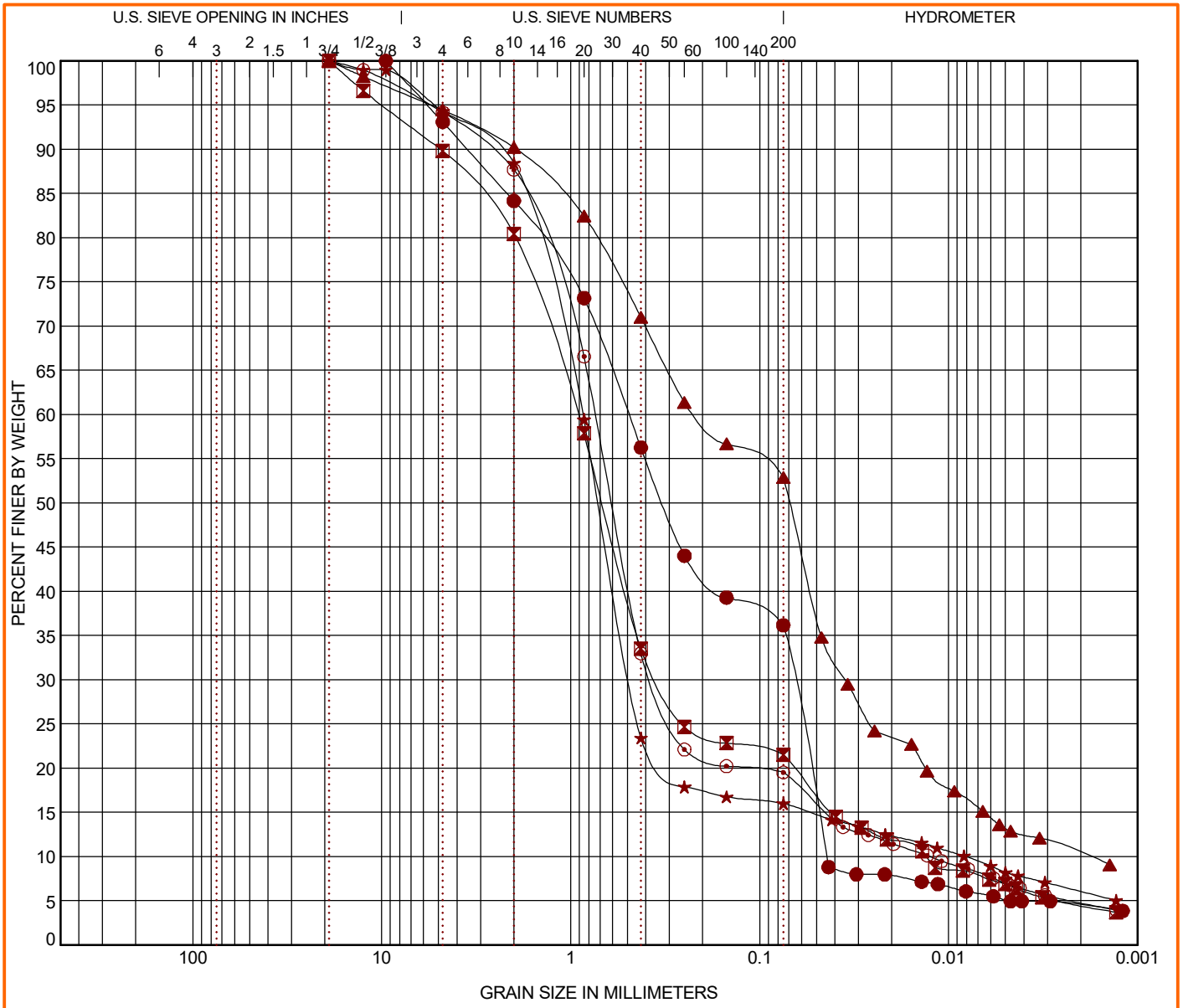
LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 M5205037 FORDVILLE DAM.GPJ TERRACON_DATATEMPLATE.GDT 11/23/20

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID		Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
●	FD2020-11	100 - 102.5	CLAYEY SAND (SC)	24.1	32	22	10	0.20	11.19
⊠	FD2020-212	0 - 5	CLAYEY SAND (SC)	14.7	45	22	23	9.83	70.27
▲	FD2020-212	7.5 - 10	SANDY LEAN CLAY (CL)	19.1	40	22	18	3.16	118.28
★	FD2020-212	10 - 15	SILTY SAND (SM)	17.7	32	26	6	33.10	106.22
⊙	FD2020-213	2.5 - 7.5	SILTY SAND (SM)	11.3	31	25	6	14.52	59.22

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	FD2020-11	100 - 102.5	9.5	0.495	0.066	0.044	0.0	6.9	56.9	31.0		5.1
⊠	FD2020-212	0 - 5	19	0.921	0.345	0.013	0.0	10.2	68.3	14.6		6.9
▲	FD2020-212	7.5 - 10	19	0.215	0.035	0.002	0.0	5.6	41.6	39.7		13.2
★	FD2020-212	10 - 15	19	0.864	0.482	0.008	0.0	5.7	78.3	7.8		8.2
⊙	FD2020-213	2.5 - 7.5	19	0.742	0.368	0.013	0.0	5.8	74.7	12.6		7.0

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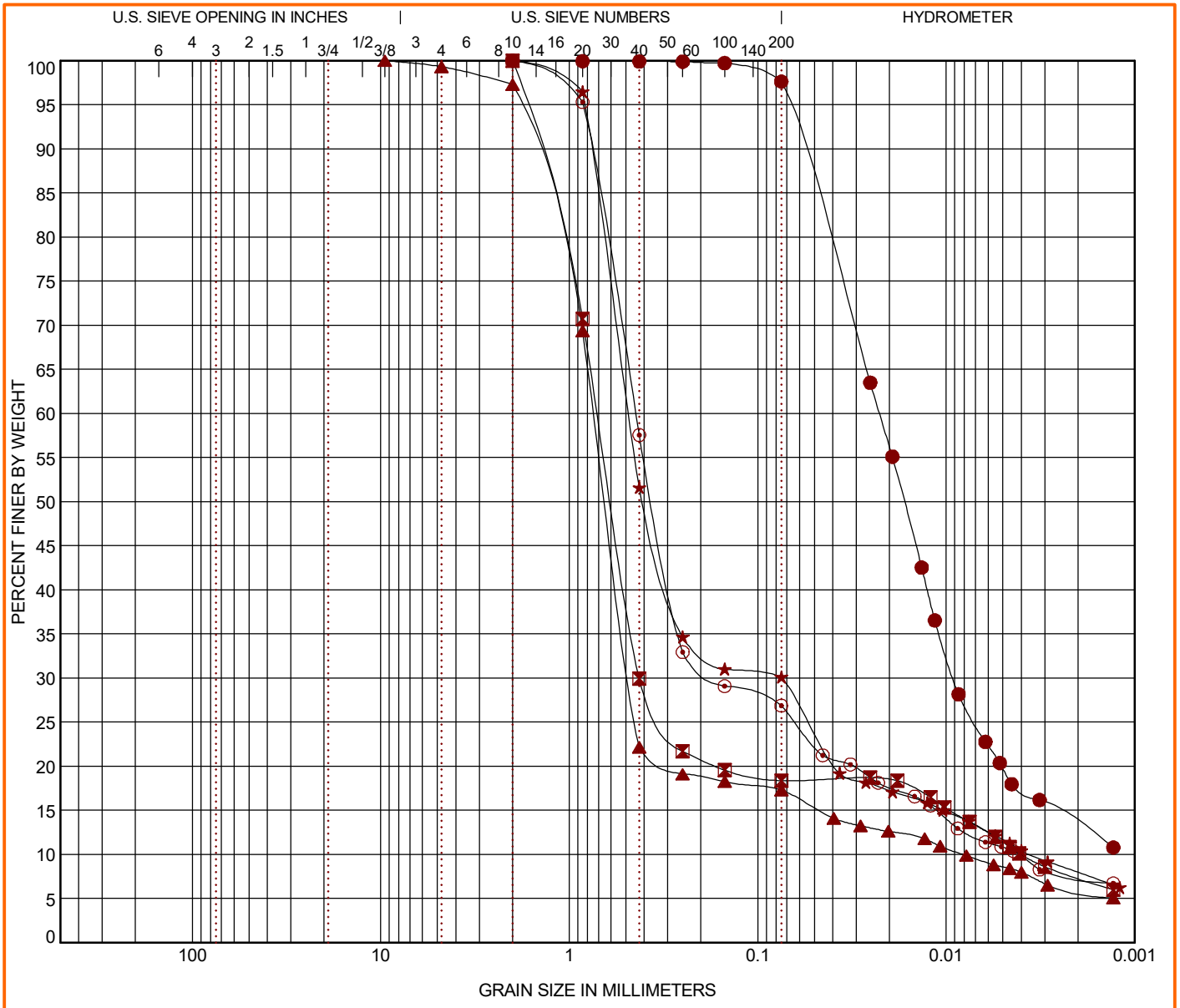
ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-213	20 - 22.3	SILT (ML)	40.7	33	30	3		
FD2020-214	5 - 10	SILTY SAND (SM)	18.7	43	28	15	63.85	176.90
FD2020-608	0 - 5	CLAYEY SAND (SC)	16.3	38	22	16	37.92	91.55
FD2020-608	10 - 11	SILTY, CLAYEY SAND (SC-SM)	22.6	27	21	6	3.20	135.21
FD2020-608	25 - 27.5	CLAYEY SAND (SC)	27.0	29	18	11	15.51	106.76

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-213	20 - 22.3	2	0.023	0.009		0.0	0.0	2.4	77.9		19.7
FD2020-214	5 - 10	2	0.708	0.426	0.004	0.0	0.0	81.6	7.0		11.4
FD2020-608	0 - 5	9.5	0.741	0.477	0.008	0.0	0.7	82.0	8.7		8.6
FD2020-608	10 - 11	2	0.484	0.074	0.004	0.0	0.0	69.9	18.5		11.7
FD2020-608	25 - 27.5	2	0.444	0.169	0.004	0.0	0.0	73.1	16.1		10.8

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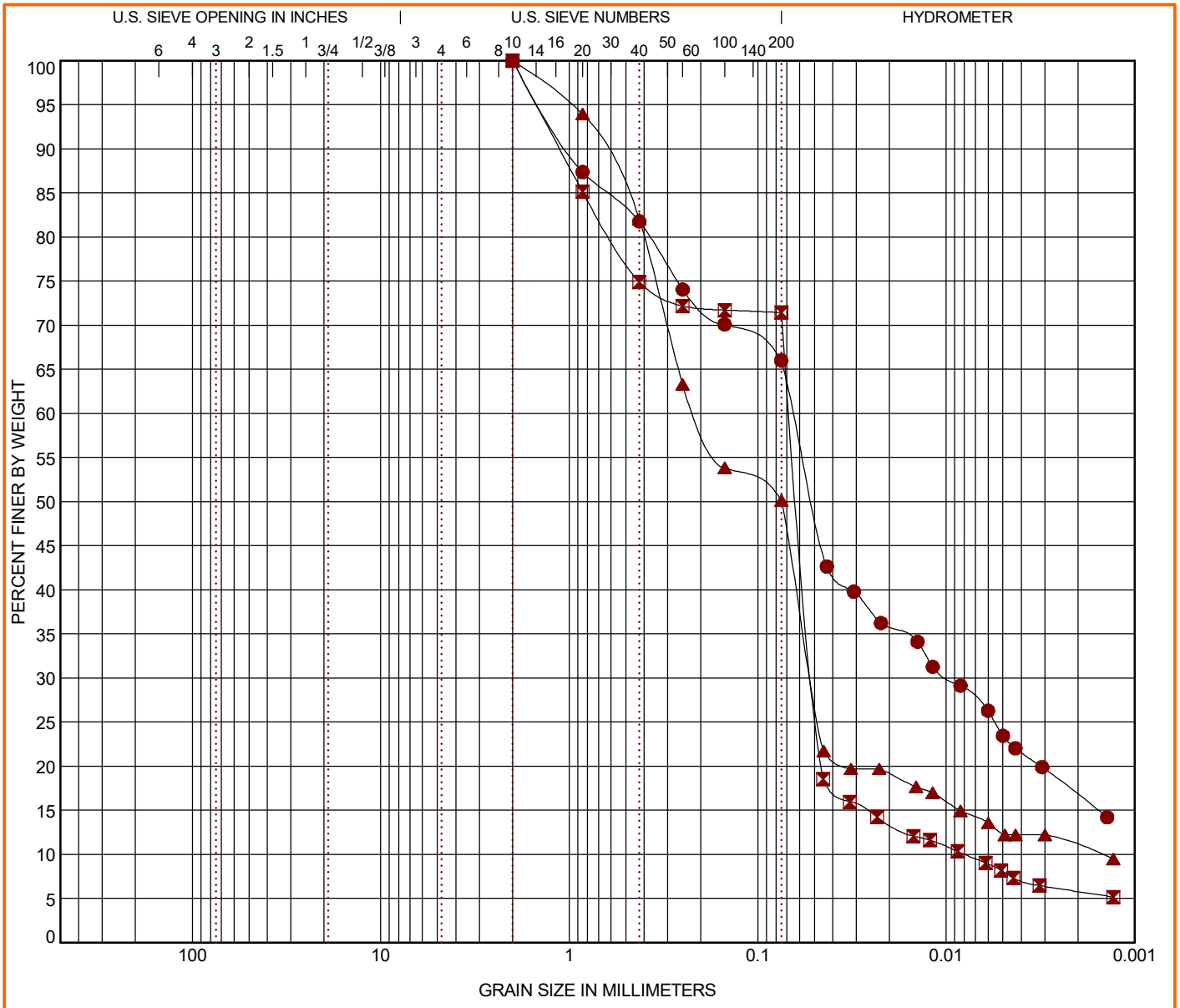
GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-608	55 - 57	SANDY SILT (ML)	25.7	34	31	3		
FD2020-609	10 - 12.5	LEAN CLAY with SAND (CL)	34.4	39	24	15	4.72	8.45
FD2020-609	30 - 32	SANDY SILT (ML)	47.3	39	26	13	8.56	138.34

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-608	55 - 57	2	0.065	0.01		0.0	0.0	34.0	42.6		23.5
FD2020-609	10 - 12.5	2	0.067	0.05	0.008	0.0	0.0	28.6	63.4		8.1
FD2020-609	30 - 32	2	0.209	0.052	0.002	0.0	0.0	49.9	37.8		12.4

PROJECT: Fordville Dam

PROJECT NUMBER: M5205037

SITE: 43rd Street NE
Fordville, ND

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND

CLIENT: Gannett Fleming, Inc.
Greenwood Village, CO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 M5205037 FORDVILLE DAM.GPJ TERRACON_DATATEMPLATE.GDT 11/23/20

Specific Gravity Testing

Boring No.	FD2020-11	FD2020-11	FD2020-608	FD2020-608	FD2020-608	FD2020-609
Depth, ft.	12.5-17.5	37.5-38.5	0-5.0	10.0-11.0	55.0-57.0	30-32.0
Specific Gravity	2.82	2.79	2.66	2.65	2.48	2.66

Unit Weight

Boring No.	FD2020-11	FD2020-213	FD2020-608	FD2020-608	FD2020-609
Depth, ft.	37.5-38.5	20.0-22.3	10.0-11.0	55.0-57.0	30-32.0
Dry Density, pcf	119.9	81.0	97.1	96.6	81.0
Water Content, %	14.0	40.7	22.6	25.7	47.3

CRUMB TEST D6572

FORDVILLE DAM

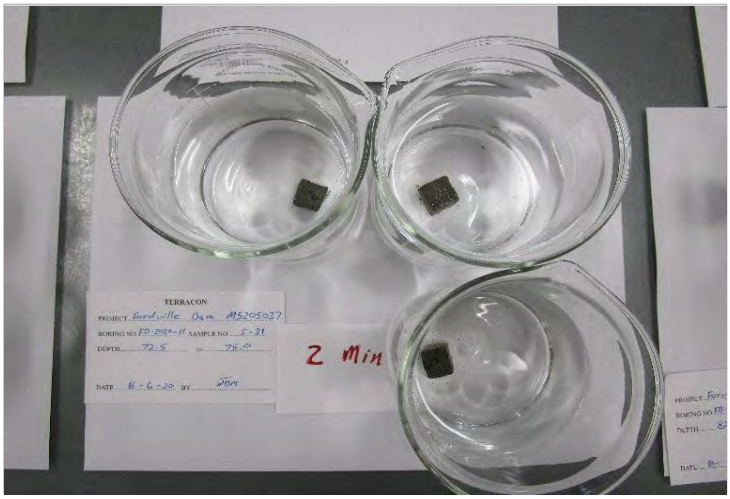
M5205037

FD-2020-11 S-31 72.5 - 75.0 feet

2 MIN

GRADE: 1

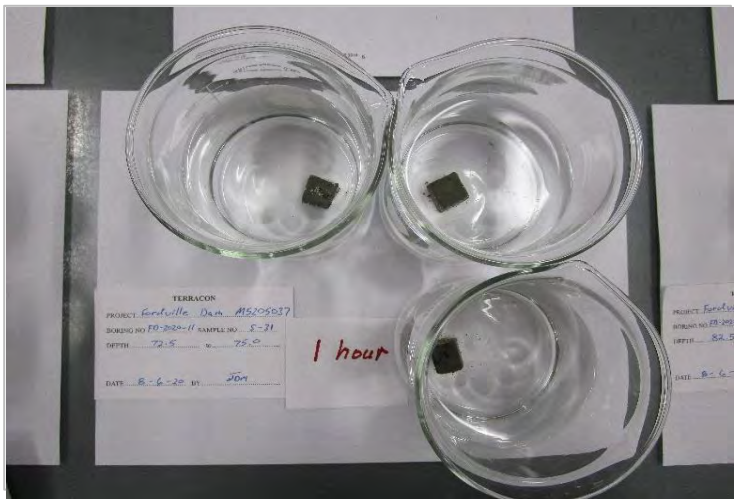
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 1

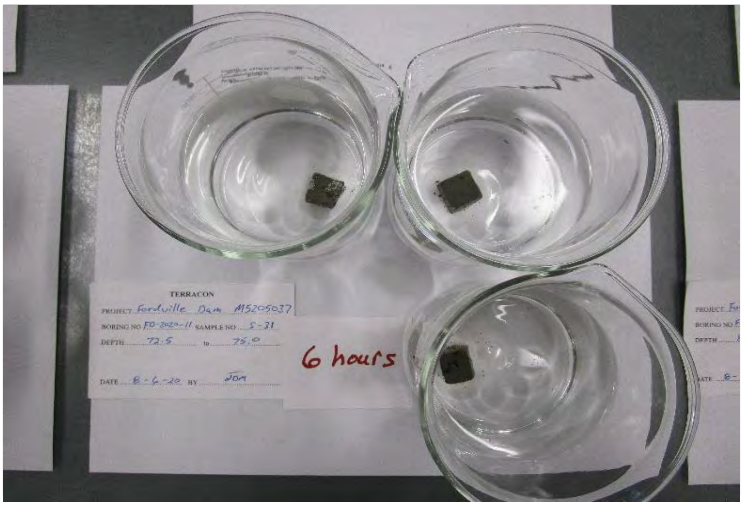
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

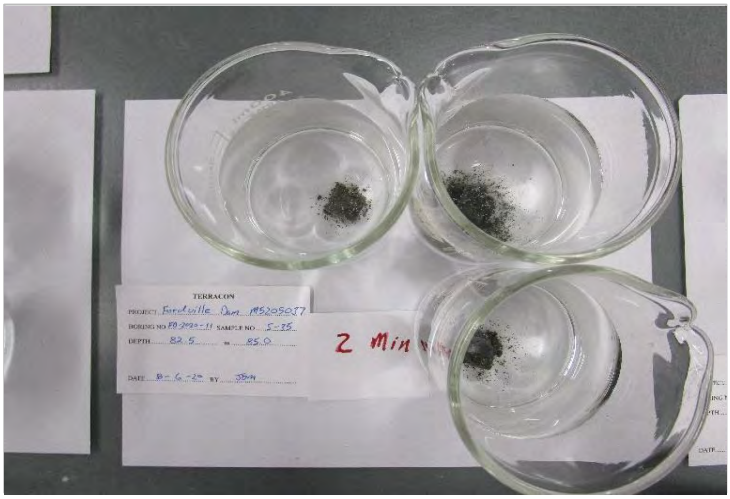
M5205037

FD-2020-11 S-35 82.5 - 85.0 feet

2 MIN

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



1 HOUR

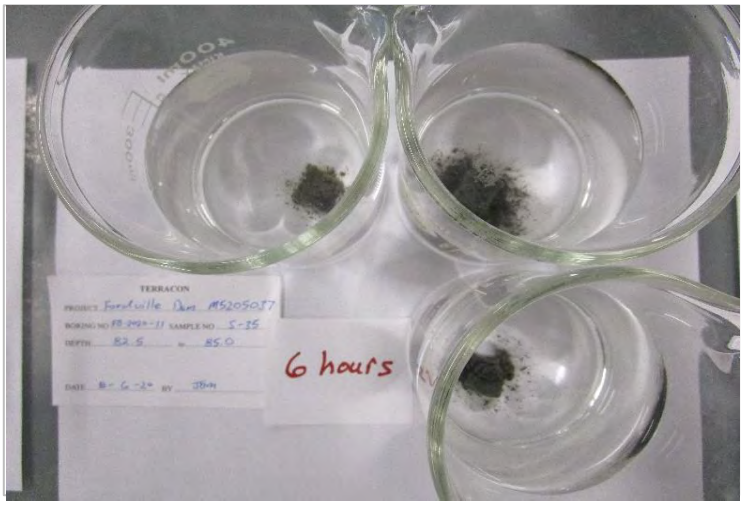
GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE

6 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

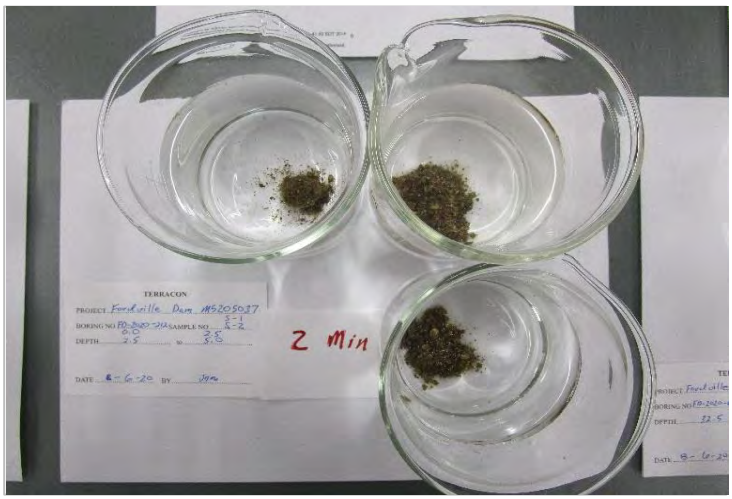
M5205037

FD-2020-212 S-1 & S-2 0.0 - 2.5 & 2.5 - 5.0 feet

2 MIN

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



1 HOUR

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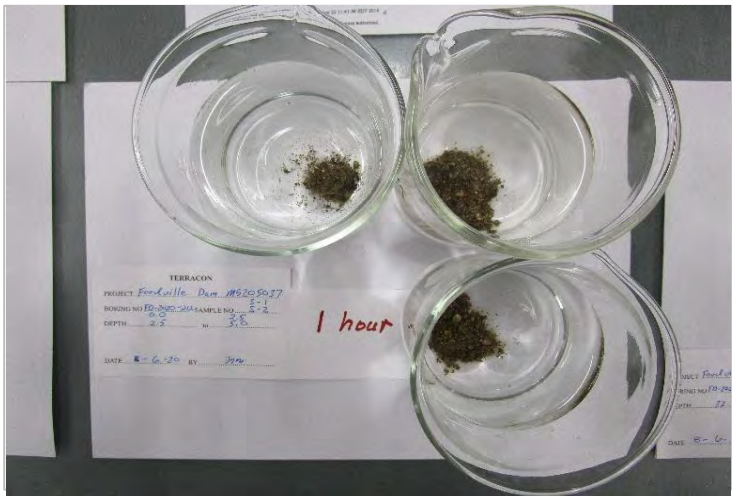
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE

Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

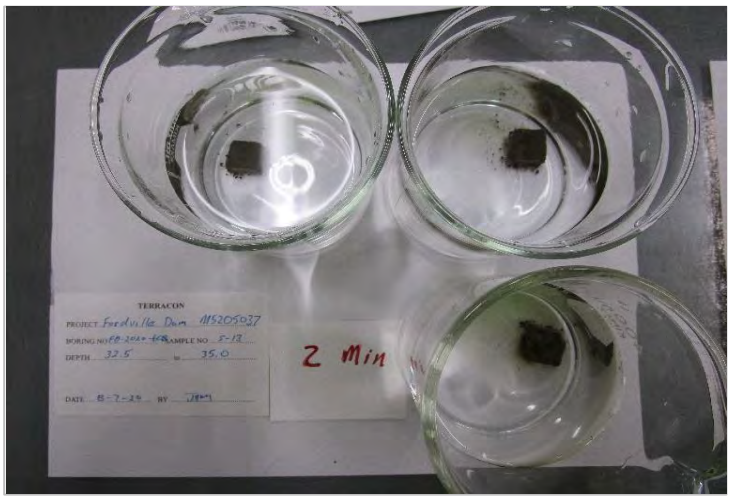
M5205037

FD-2020-608 S-13 32.5 - 35.0 feet

2 MIN

GRADE: 1

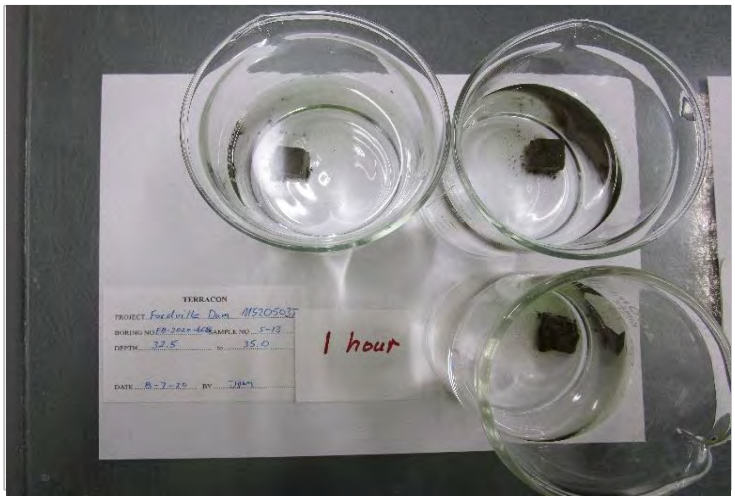
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 1

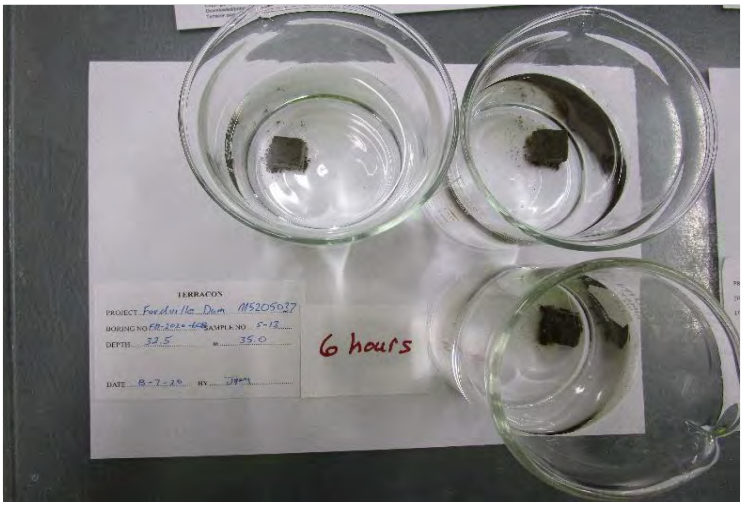
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

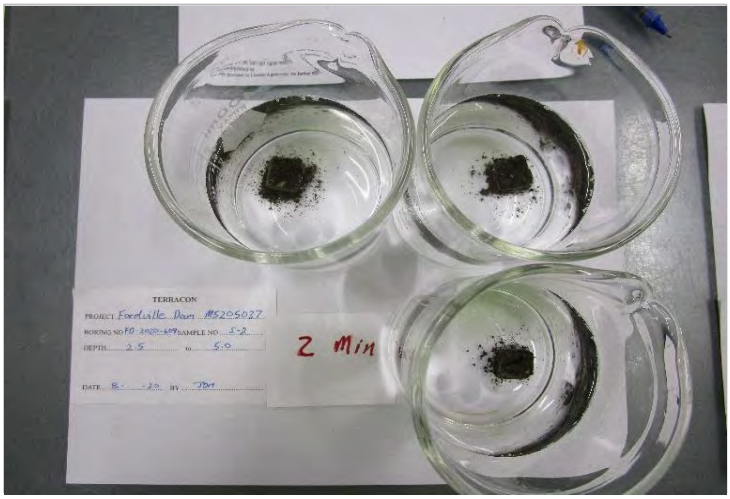
M5205037

FD2020-609 S-2 2.5 - 5.0 feet

2 MIN

GRADE: 1

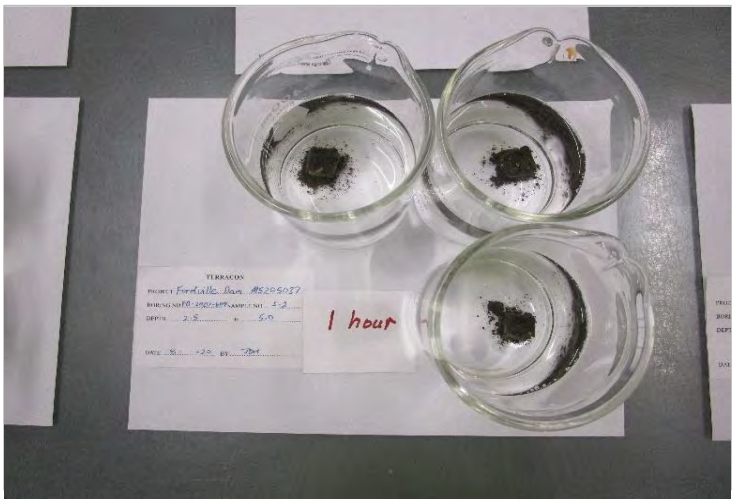
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE

Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

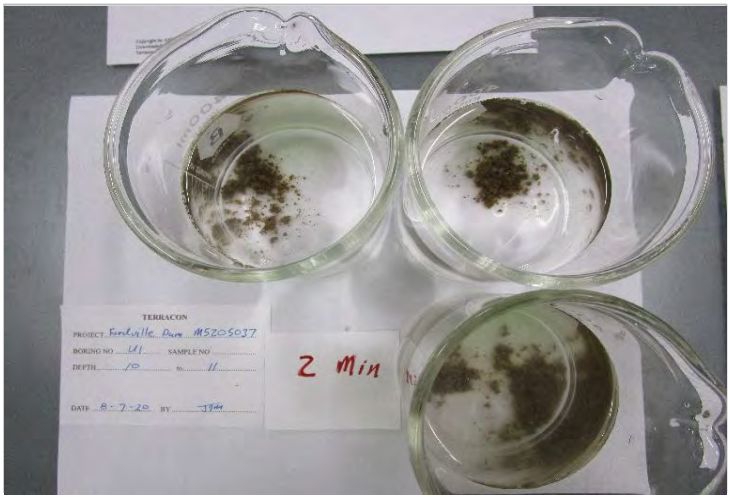
M5205037

FD2020-608 U1 10 - 11 feet

2 MIN

GRADE: 2

DISPERSIVE CLASSIFICATION: INTERMEDIATE



1 HOUR

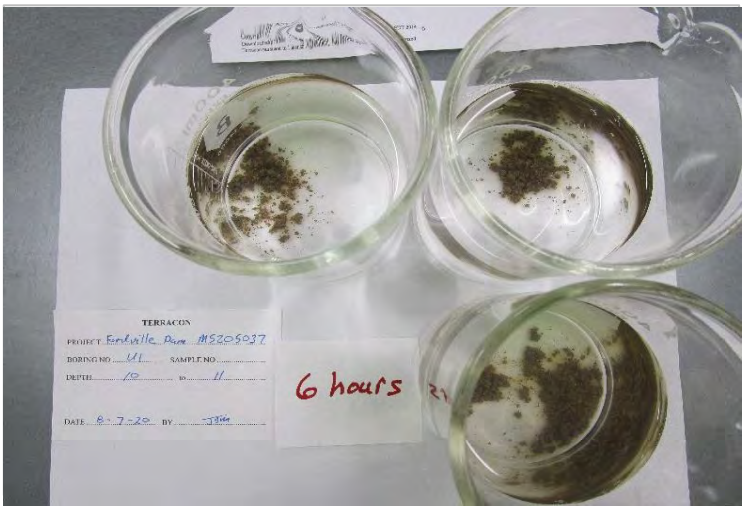
GRADE: 2

DISPERSIVE CLASSIFICATION: INTERMEDIATE

6 HOUR

GRADE: 2

DISPERSIVE CLASSIFICATION: INTERMEDIATE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

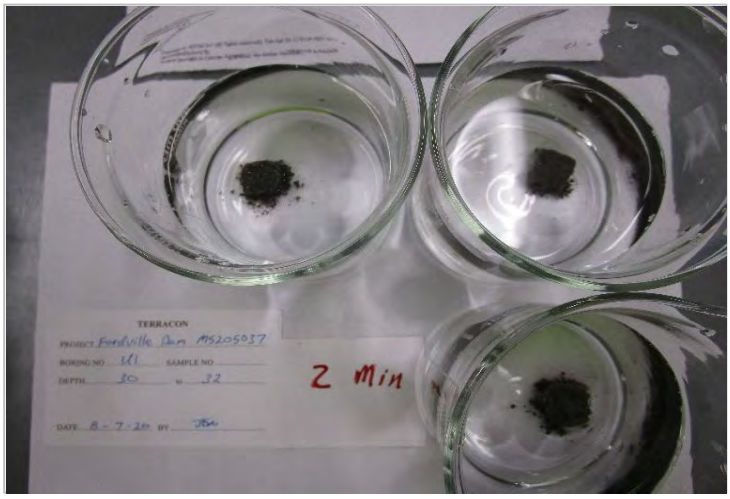
M5205037

FD2020-609 U1 30 - 32 feet

2 MIN

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 2

DISPERSIVE CLASSIFICATION: INTERMEDIATE

6 HOUR

GRADE: 2

DISPERSIVE CLASSIFICATION: INTERMEDIATE

Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

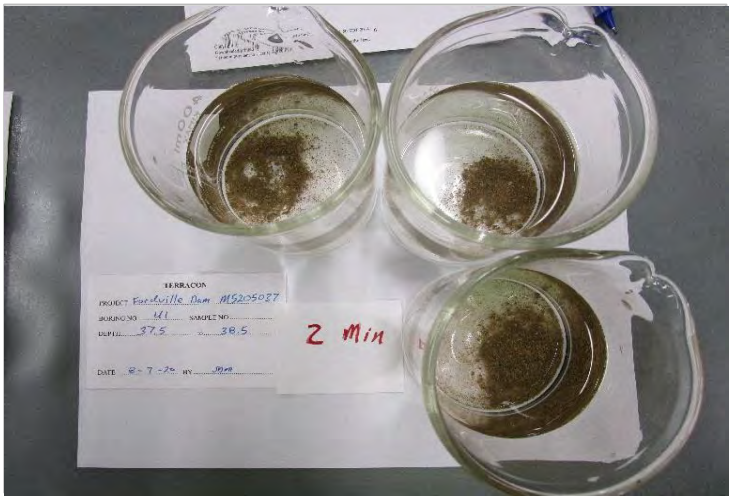
M5205037

FD2020-11 U1 37.5 - 38.5 feet

2 MIN

GRADE: 2

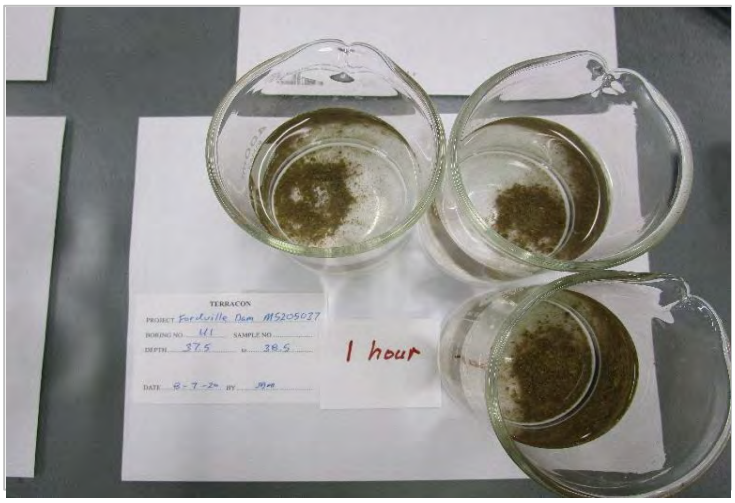
DISPERSIVE CLASSIFICATION: INTERMEDIATE



1 HOUR

GRADE: 2

DISPERSIVE CLASSIFICATION: INTERMEDIATE



6 HOUR

GRADE: 2

DISPERSIVE CLASSIFICATION: INTERMEDIATE

Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

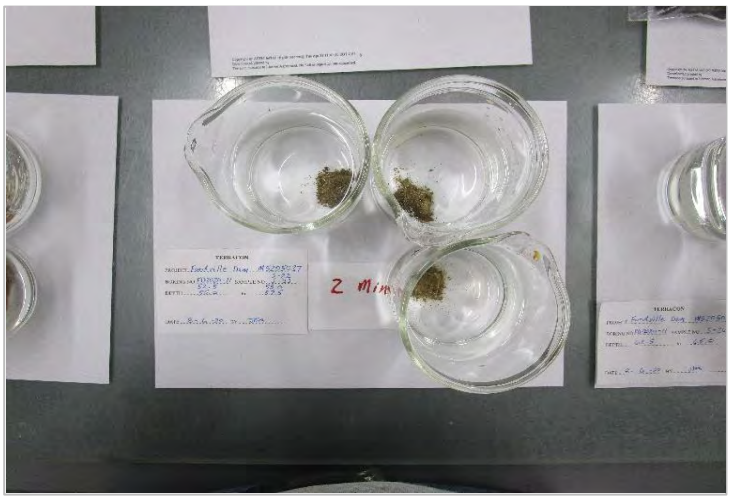
M5205037

FD-2020-11 S-22 & S-23 52.5 - 55.0 & 55.0 - 57.5 feet

2 MIN

GRADE: 1

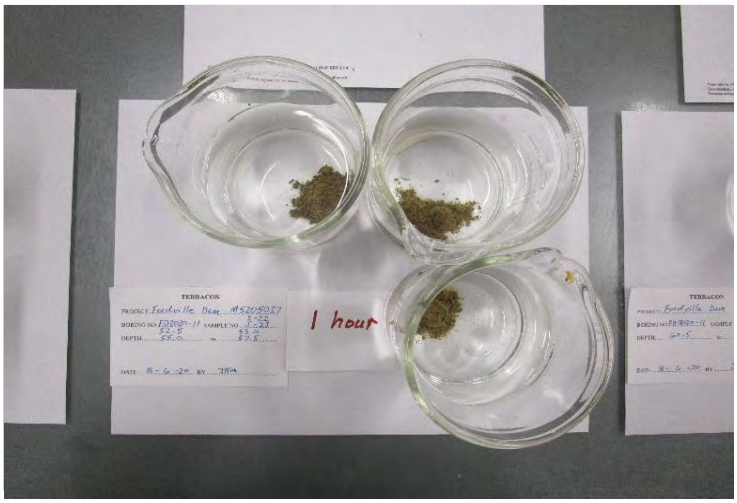
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



1 HOUR

GRADE: 1

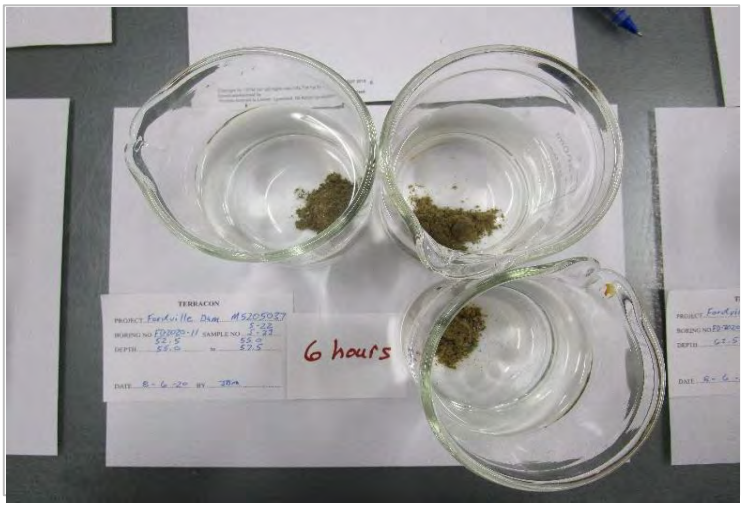
DISPERSIVE CLASSIFICATION: NONDISPERSIVE



6 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

CRUMB TEST D6572

FORDVILLE DAM

M5205037

FD-2020-11 S-26 62.5 - 65.0 feet

2 MIN

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE

1 HOUR

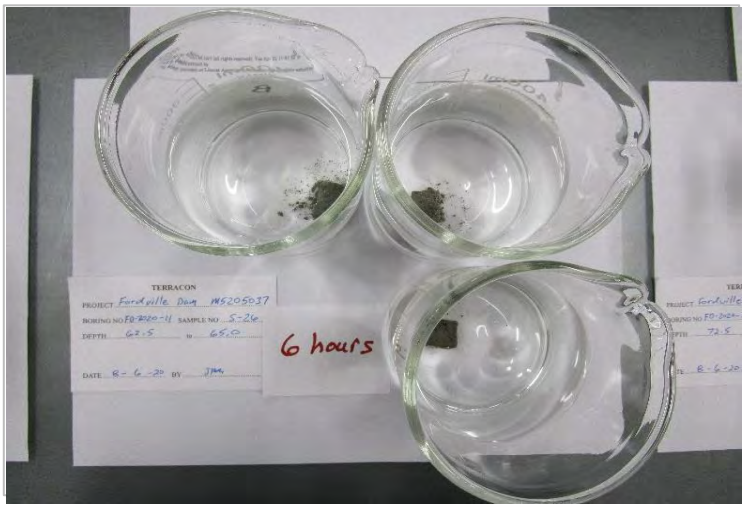
GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE

6 HOUR

GRADE: 1

DISPERSIVE CLASSIFICATION: NONDISPERSIVE



Grade 1 - Nondispersive

Grade 2 - Intermediate

Grade 3 - Dispersive

Grade 4 - Highly Dispersive

Terracon

Terracon

Hydraulic Conductivity using a Flexible Wall Permeameter ASTM D-5084-97 "C"

Project:	Fordville Dam	Sample No.:	FD2020-609 S-10 to S-20 22.5'-50.0'
Project No.:	M5205037	Tracking No.:	
Date Sampled :		Location :	
		File Name:	
Soil Type :	Sandy Lean Clay		
Proctor Results :	115.0 pcf	Molded @ :	99.8 % compact
	15.0 %		15.0 % M.C.

Initial Sample Parameters						Moisture	Content
Wet Wt Soil (g)	152.00	Soil Diameter(in)	1.404	Soil Height (in)	2.825	Pan No.:	76
Dry Wt Soil (g)	132.17		1.404		2.832	Wet Soil & pan	162.26
Sample Area(cm^2)	9.993		1.405		2.830	Dry Soil & pan	154.20
Sample Area (in^2)	1.549	Average (in)	1.404	Average(in)	2.829	Pan Wt.	100.47
Density (pcf)	114.8					M.C.	15.0
Assumed Sp.G.	2.72		Void Ratio	0.478			
Vol Wet (cc)	71.81	Vol. Solids Vs(cc)	48.59	Porosity n (%)	32	Saturation (%)	0.8541267

Final Sample Parameters						Moisture	Content
Wet Wt. (g)		Diameter (in)		Height (in)		Pan No.:	
Dry Wt. (g)						Wet Soil & pan	
Area (cm^2)						Dry Soil & pan	
Area (in^2)		Average (in)		Average(in)		Pan Wt.	
Density (pcf)						M.C. (%)	
				Ave Temp (C°)	20	Saturation (%)	

Panel No.:	2	Chamber No.:	T-2	Hydraulic Gradient		19.6	
Cell Press.(psi)	62.0	Back Press.(psi)	57.0	Tail Press. (psi)	55.0	B Coefficient	0.95

Date	Time(min.)	Elapsed Time	Head (h1)	Tail (h2)	Total Head	k (cm / s)	dt / dh
7-Nov	1150		1.13	8.86	180.32		
	1241	51	1.19	8.80	179.71	7.8E-08	1.00
	1241		1.19	8.80	179.71		
	1312	31	1.22	8.77	179.41	6.5E-08	1.00
	1312		1.22	8.77	179.41		
	1400	48	1.28	8.71	178.79	8.4E-08	1.00
	1400		1.28	8.71	178.79		
	1429	29	1.32	8.68	178.44	8.1E-08	0.75

Terracon

Hydraulic Conductivity using a Flexible Wall Permeameter ASTM D-5084-97 "C"

Project:	Fordville Dam	Sample No.:	FD2020-608 U-2 55'-57'
Project No.:	M5205037	Tracking No.:	
Date Sampled :		Location :	
		File Name:	
Soil Type :	Sandy Silt - gray		
Proctor Results :	pcf	Molded @ :	% compact
	%		26.6 % M.C.

Initial Sample Parameters						Moisture	Content
Wet Wt Soil (g)	123.05	Soil Diameter(in)	1.375	Soil Height (in)	2.767	Pan No.:	67
Dry Wt Soil (g)	97.23		1.377		2.767	Wet Soil & pan	59.40
Sample Area(cm^2)	9.599		1.377		2.769	Dry Soil & pan	49.46
Sample Area (in^2)	1.488	Average (in)	1.376	Average(in)	2.768	Pan Wt.	12.03
Density (pcf)	89.9					M.C.	26.6
Assumed Sp.G.	2.72		Void Ratio	0.888			
Vol Wet (cc)	67.48	Vol. Solids Vs(cc)	35.75	Porosity n (%)	47	Saturation (%)	0.8137561

Final Sample Parameters						Moisture	Content
Wet Wt. (g)		Diameter (in)		Height (in)		Pan No.:	
Dry Wt. (g)						Wet Soil & pan	
Area (cm^2)						Dry Soil & pan	
Area (in^2)		Average (in)		Average(in)		Pan Wt.	
Density (pcf)						M.C. (%)	
				Ave Temp (C°)	20	Saturation (%)	

Panel No.:	2	Chamber No.:	T-4	Hydraulic Gradient		20.0	
Cell Press.(psi)	52.0	Back Press.(psi)	47.0	Tail Press. (psi)	45.0	B Coefficient	0.95

Date	Time(min.)	Elapsed Time	Head (h1)	Tail (h2)	Total Head	k (cm / s)	dt / dh
29-Oct	758		2.18	7.71	169.10		
	833	35	2.19	7.70	169.00	2.1E-08	1.00
	833		2.19	7.70	169.00		
	900	27	2.20	7.69	168.90	2.7E-08	1.00
	900		2.20	7.69	168.90		
	933	33	2.21	7.68	168.80	2.2E-08	1.00
	933		2.21	7.68	168.80		
	1010	37	2.22	7.67	168.70	2.0E-08	1.00

Terracon

Hydraulic Conductivity using a Flexible Wall Permeameter ASTM D-5084-97 "C"

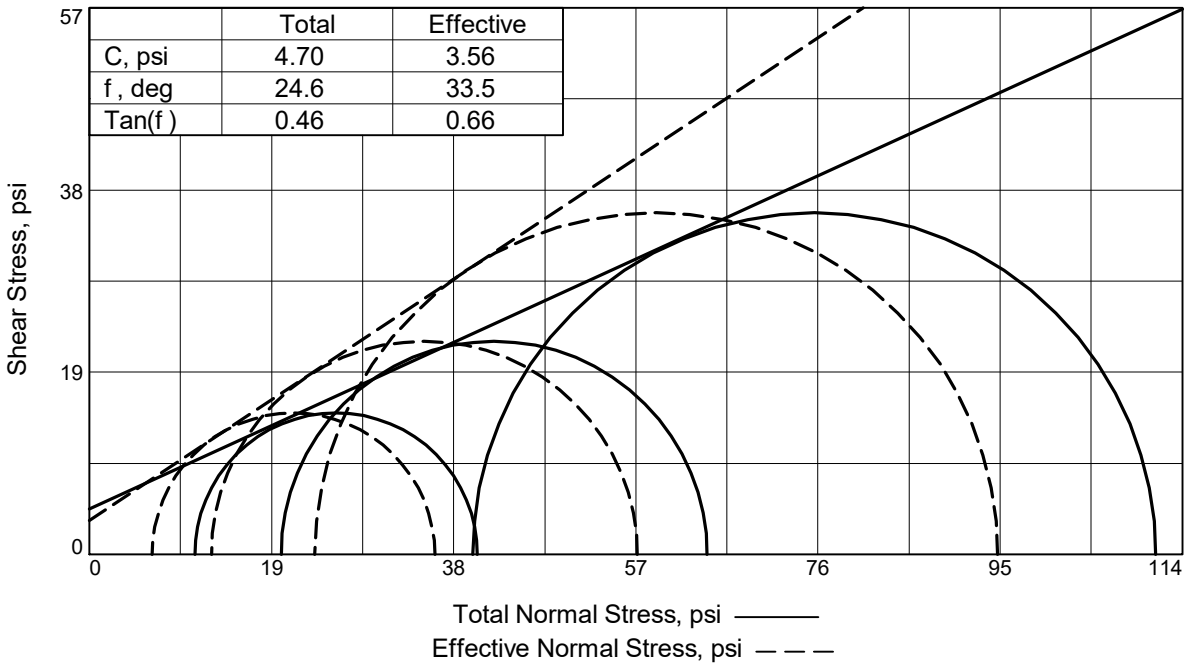
Project:	Fordville Dam	Sample No.:	FD2020-609 U-1 30'-32'
Project No.:	M5205037	Tracking No.:	
Date Sampled :		Location :	
		File Name:	
Soil Type :	Sandy Silt - gray		
Proctor Results :	pcf	Molded @ :	% compact
	%		26.6 % M.C.

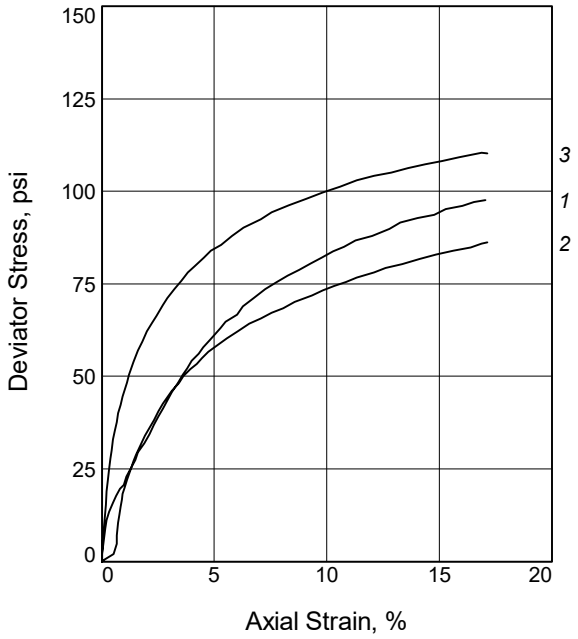
Initial Sample Parameters						Moisture	Content
Wet Wt Soil (g)	1068.71	Soil Diameter(in)	2.761	Soil Height (in)	5.555	Pan No.:	6
Dry Wt Soil (g)	844.36		2.766		5.540	Wet Soil & pan	55.61
Sample Area(cm^2)	38.478		2.740		5.550	Dry Soil & pan	46.47
Sample Area (in^2)	5.964	Average (in)	2.756	Average(in)	5.548	Pan Wt.	12.07
Density (pcf)	97.1					M.C.	26.6
Assumed Sp.G.	2.72		Void Ratio	0.747			
Vol Wet (cc)	542.26	Vol. Solids Vs(cc)	310.43	Porosity n (%)	43	Saturation (%)	0.9677203

Final Sample Parameters						Moisture	Content
Wet Wt. (g)		Diameter (in)		Height (in)		Pan No.:	
Dry Wt. (g)						Wet Soil & pan	
Area (cm^2)						Dry Soil & pan	
Area (in^2)		Average (in)		Average(in)		Pan Wt.	
Density (pcf)						M.C. (%)	
				Ave Temp (C°)	20	Saturation (%)	

Panel No.:	2	Chamber No.:	T-4	Hydraulic Gradient		10.0
Cell Press.(psi)	52.0	Back Press.(psi)	47.0	Tail Press. (psi)	45.0	B Coefficient 0.95

Date	Time(min.)	Elapsed Time	Head (h1)	Tail (h2)	Total Head	k (cm / s)	dt / dh
11-Jul	842		1.00	8.96	181.50		
	902	20	2.83	7.13	162.83	3.2E-06	1.00
	902		2.83	7.13	162.83		
	903	1	2.93	7.03	161.81	3.8E-06	1.00
	903		2.93	7.03	161.81		
	904	1	3.03	6.93	160.79	3.8E-06	1.00
	904		3.03	6.93	160.79		
	906	2	3.20	6.76	159.06	3.2E-06	1.00
					Average:	**3.5E-06 cm/s**	





Sample No.		1	2	3
Initial	Water Content, %	15.0	15.0	15.0
	Dry Density, pcf	115.5	115.9	115.9
	Saturation, %	88.2	89.2	89.0
	Void Ratio	0.4594	0.4539	0.4549
	Diameter, in.	1.403	1.400	1.400
	Height, in.	2.820	2.800	2.790
At Test	Water Content, %	17.0	17.4	16.9
	Dry Density, pcf	115.4	114.7	115.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.4600	0.4694	0.4570
	Diameter, in.	1.405	1.414	1.407
	Height, in.	2.814	2.776	2.767
Strain rate, in./min.		0.000	0.000	0.000
Back Pressure, psi		56.0	55.0	47.0
Cell Pressure, psi		67.0	75.0	87.0
Fail. Stress, psi		29.5	44.4	71.2
Excess Pore Pr., psi		4.5	7.3	16.5
Ult. Stress, psi				
Excess Pore Pr., psi				
$\bar{s}_1$ Failure, psi		36.0	57.2	94.8
$\bar{s}_3$ Failure, psi		6.5	12.7	23.5

Type of Test:
CU with Pore Pressures
Sample Type: Remolded
Description: Sandy Lean Clay

Assumed Specific Gravity= 2.7
Remarks: Remolded Specimens

Client: Gannett Fleming, Inc.

Project: Fordville Dam

Source of Sample: FD2020-11 **Depth:** 22.5-50.0 ft
Sample Number: S-10 to S-20
Proj. No.: M5205037 **Date Sampled:** N/A

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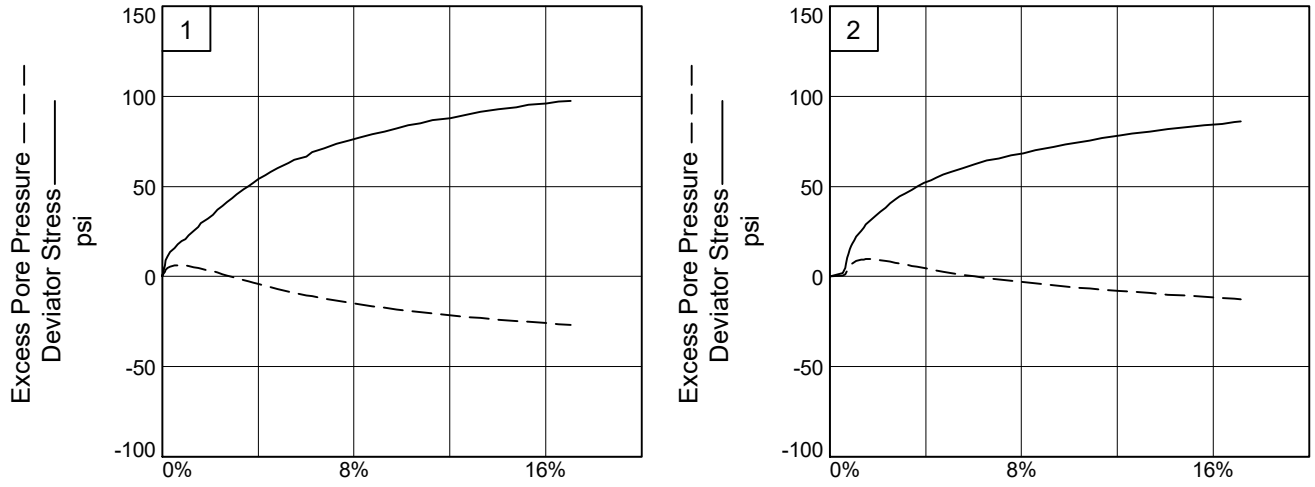

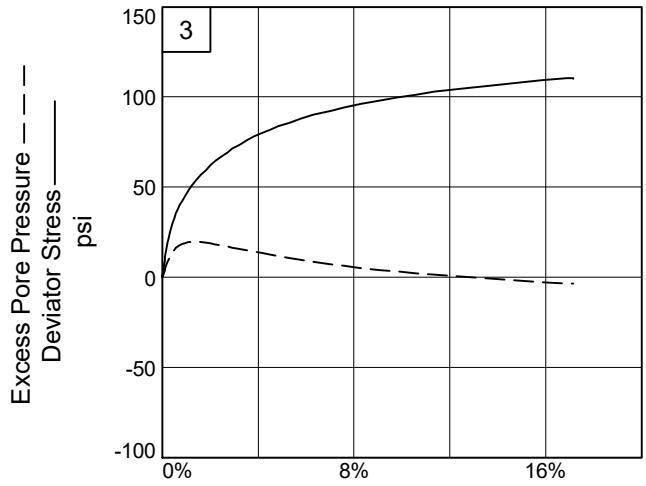

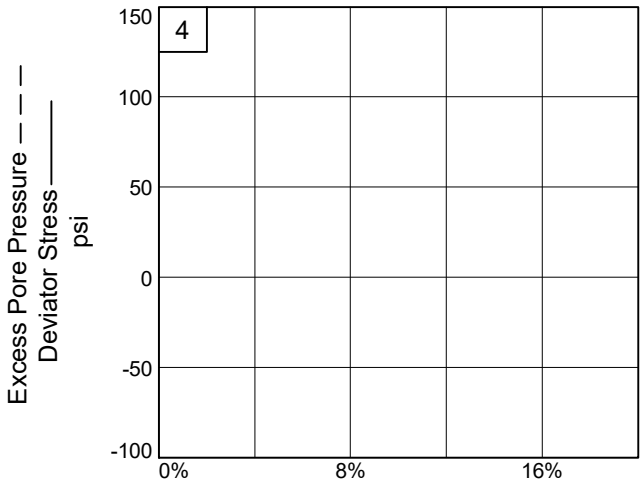

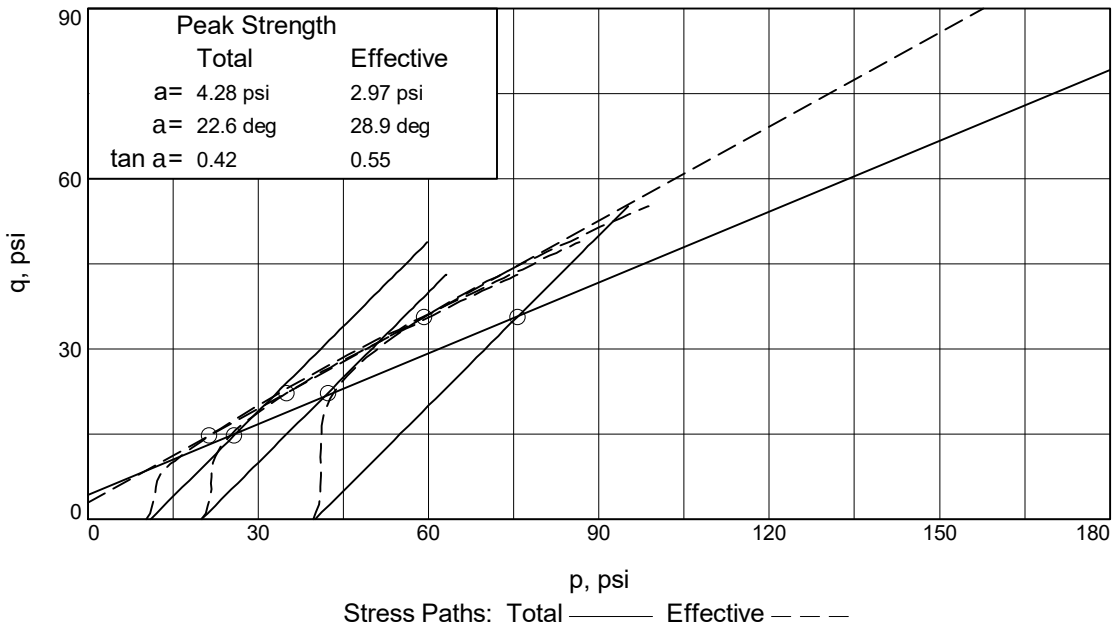

Client: Gannett Fleming, Inc.
Project: Fordville Dam
Source of Sample: FD2020-11 **Depth:** 22.5-50.0 ft **Sample Number:** S-10 to S-20
Project No.: M5205037

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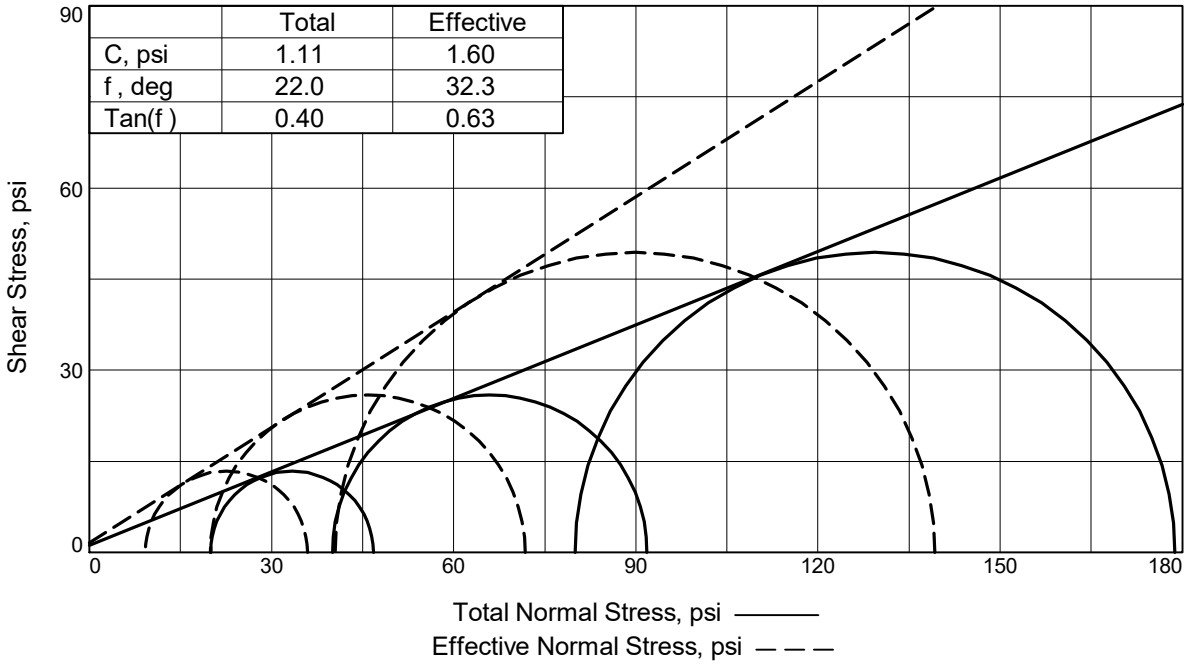

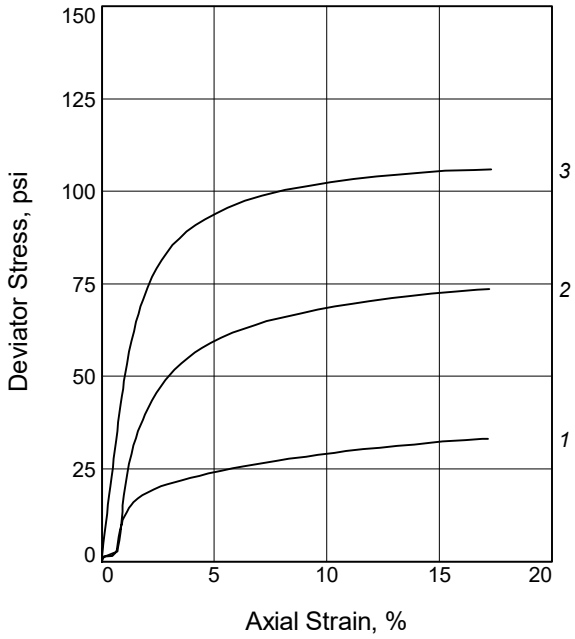

Sample No.		1	2	3
Initial	Water Content, %	26.6	25.8	24.7
	Dry Density, pcf	90.9	92.9	97.4
	Saturation, %	93.7	96.1	103.8
	Void Ratio	0.7031	0.6664	0.5897
	Diameter, in.	1.376	1.371	1.329
	Height, in.	2.740	2.750	2.740
At Test	Water Content, %	26.7	26.0	24.7
	Dry Density, pcf	93.2	94.2	96.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6614	0.6439	0.6117
	Diameter, in.	1.366	1.370	1.350
	Height, in.	2.714	2.717	2.693
Strain rate, in./min.		0.000	0.000	0.000
Back Pressure, psi		42	40	15
Cell Pressure, psi		62	80	95
Fail. Stress, psi		27	52	99
Excess Pore Pr., psi		11	20	40
Ult. Stress, psi				
Excess Pore Pr., psi				
$\bar{s}_1$ Failure, psi		36	72	139
$\bar{s}_3$ Failure, psi		9	20	40

Type of Test:
CU with Pore Pressures
Sample Type: Tube
Description: Sandy Silt

Specific Gravity= 2.48
Remarks: Three Specimen Series

Client: Gannett Fleming, Inc.

Project: Fordville Dam

Source of Sample: FD2020-608 **Depth:** 55.0-57.0 ft
Sample Number: U-2
Proj. No.: M5205037 **Date Sampled:** N/A

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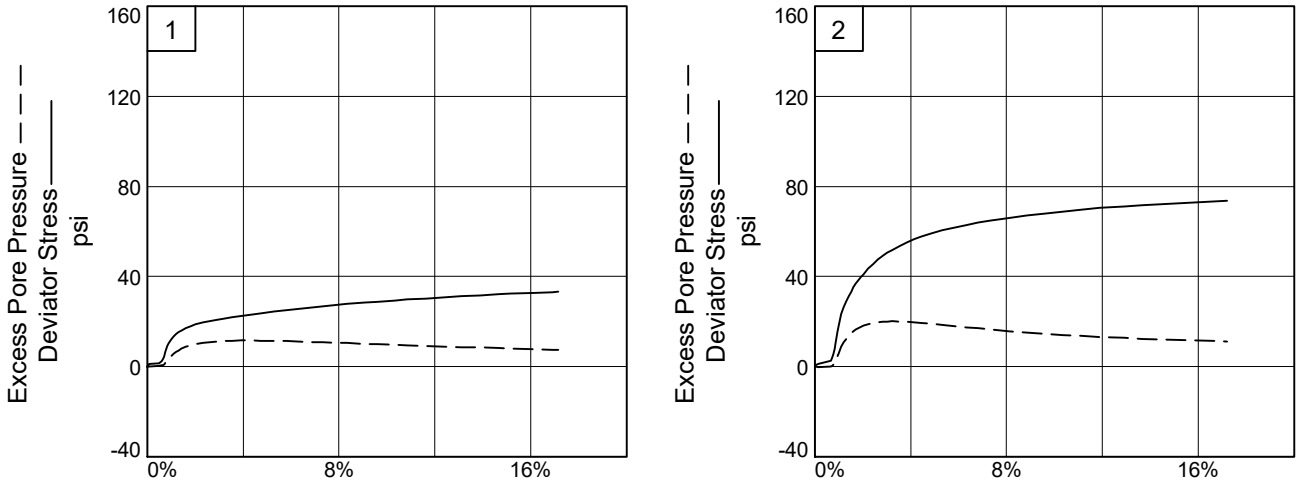
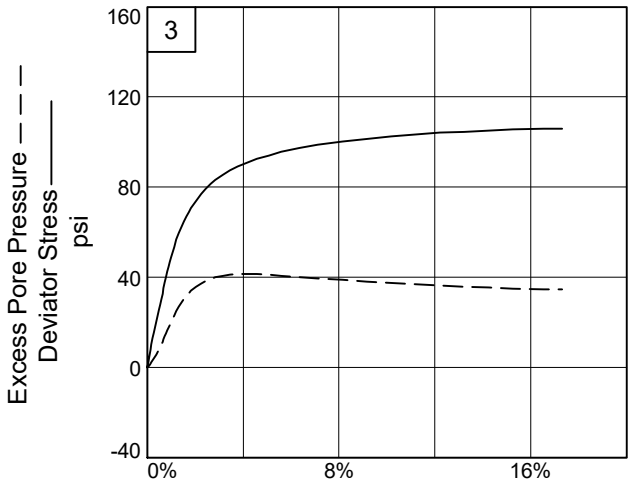
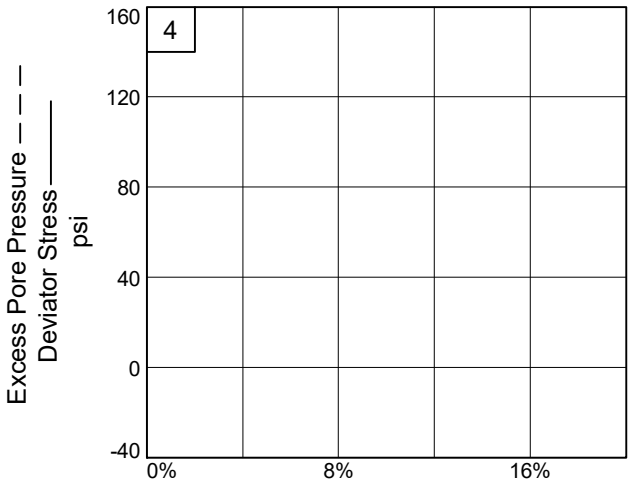
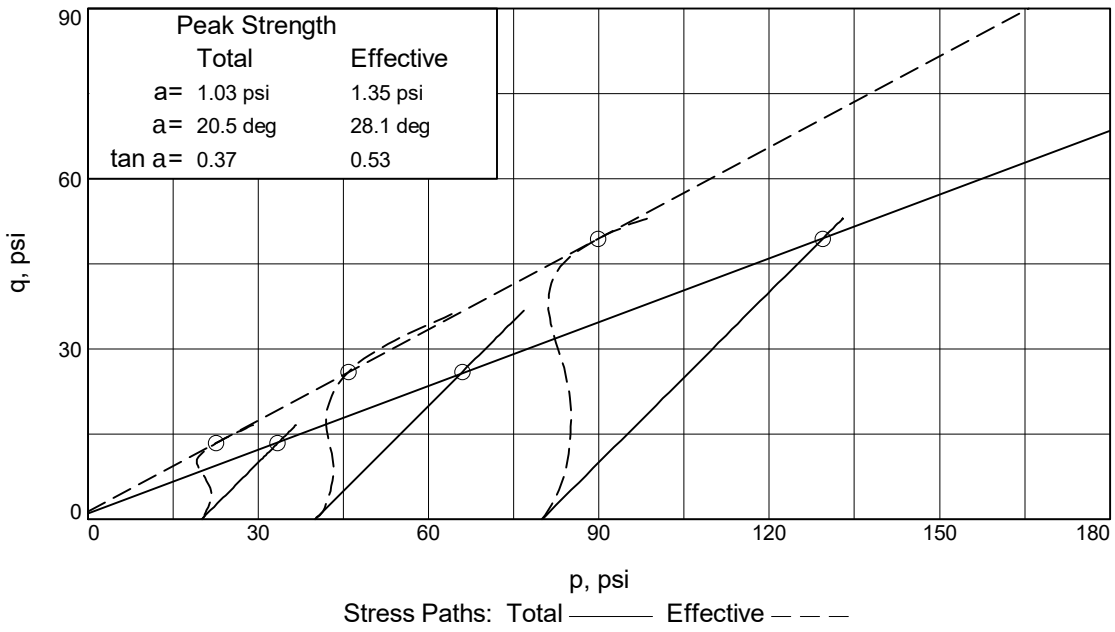


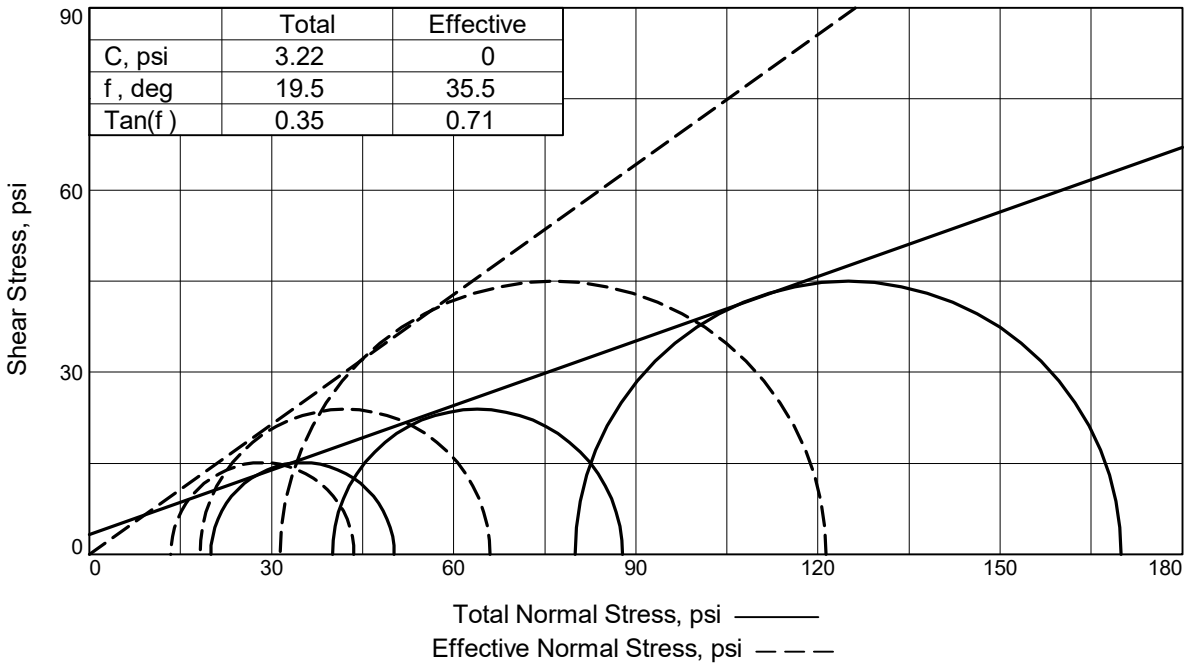


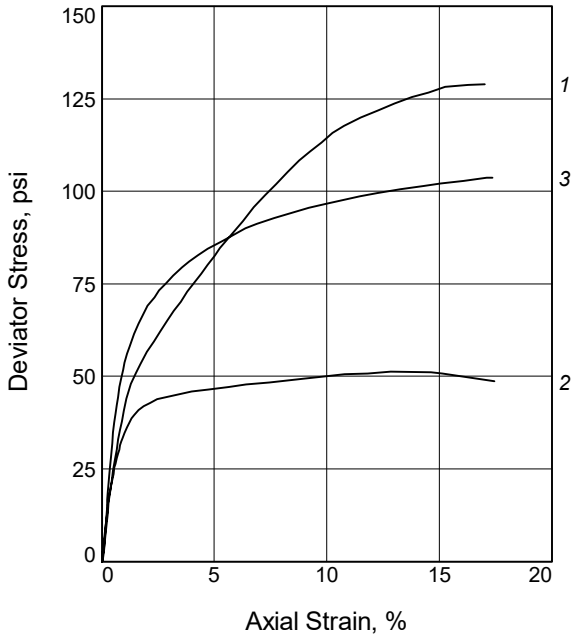




Client: Gannett Fleming, Inc.
Project: Fordville Dam
Source of Sample: FD2020-608 **Depth:** 55.0-57.0 ft **Sample Number:** U-2
Project No.: M5205037

Terracon Consultants, Inc.





Sample No.		1	2	3
Initial	Water Content, %	26.6	28.9	23.7
	Dry Density, pcf	96.9	90.2	99.3
	Saturation, %	99.0	91.5	93.9
	Void Ratio	0.7139	0.8419	0.6720
	Diameter, in.	2.760	2.830	2.850
	Height, in.	5.549	5.410	5.470
At Test	Water Content, %	28.6	35.9	23.3
	Dry Density, pcf	94.3	85.0	102.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.7618	0.9537	0.6209
	Diameter, in.	2.812	2.954	2.835
	Height, in.	5.496	5.267	5.361
Strain rate, in./min.		0.001	0.001	0.001
Back Pressure, psi		47	45	15
Cell Pressure, psi		67	85	95
Fail. Stress, psi		30	48	90
Excess Pore Pr., psi		7	22	49
Ult. Stress, psi				
Excess Pore Pr., psi				
$\bar{s}_1$ Failure, psi		44	66	121
$\bar{s}_3$ Failure, psi		13	18	31

Type of Test:
CU with Pore Pressures
Sample Type: Tube
Description: Sandy Silt

Specific Gravity= 2.66
Remarks: Three Specimen Series

Client: Gannett Fleming, Inc.

Project: Fordville Dam

Source of Sample: FD2020-609 **Depth:** 30.0-32.0 ft
Sample Number: U-1
Proj. No.: M5205037 **Date Sampled:** N/A

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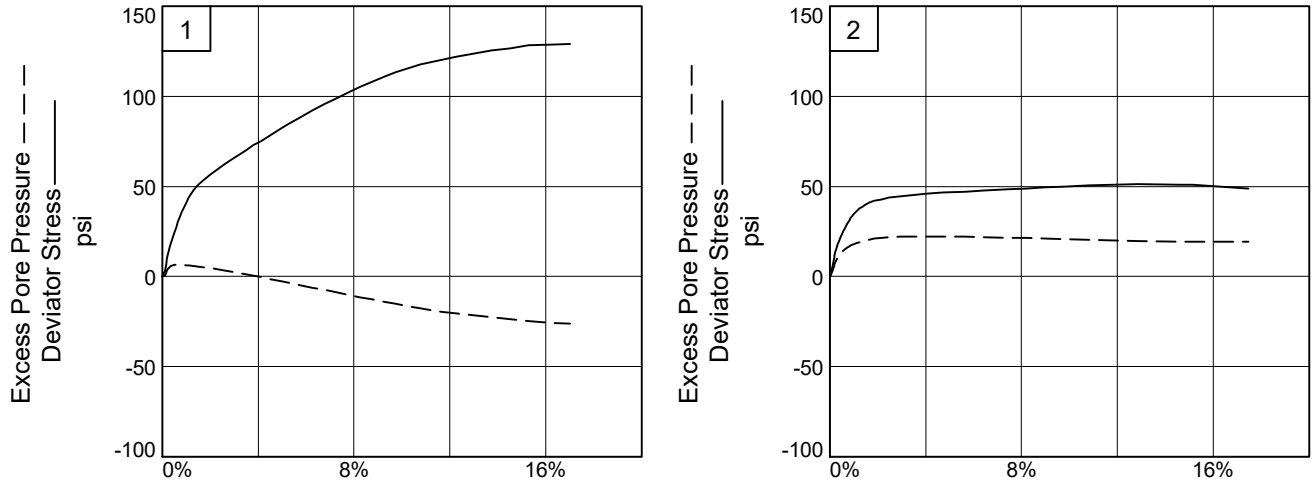
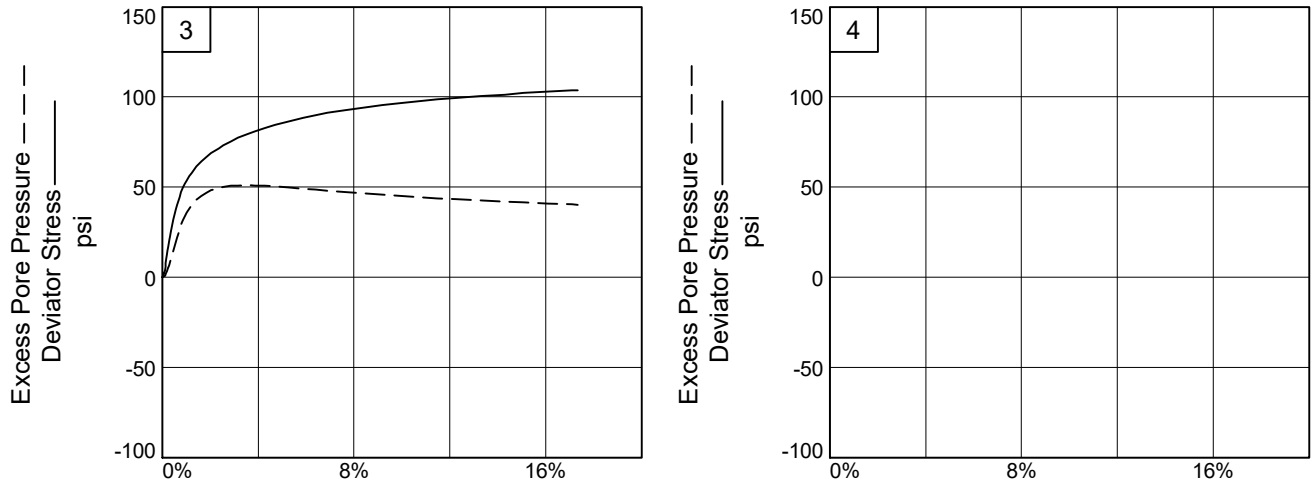
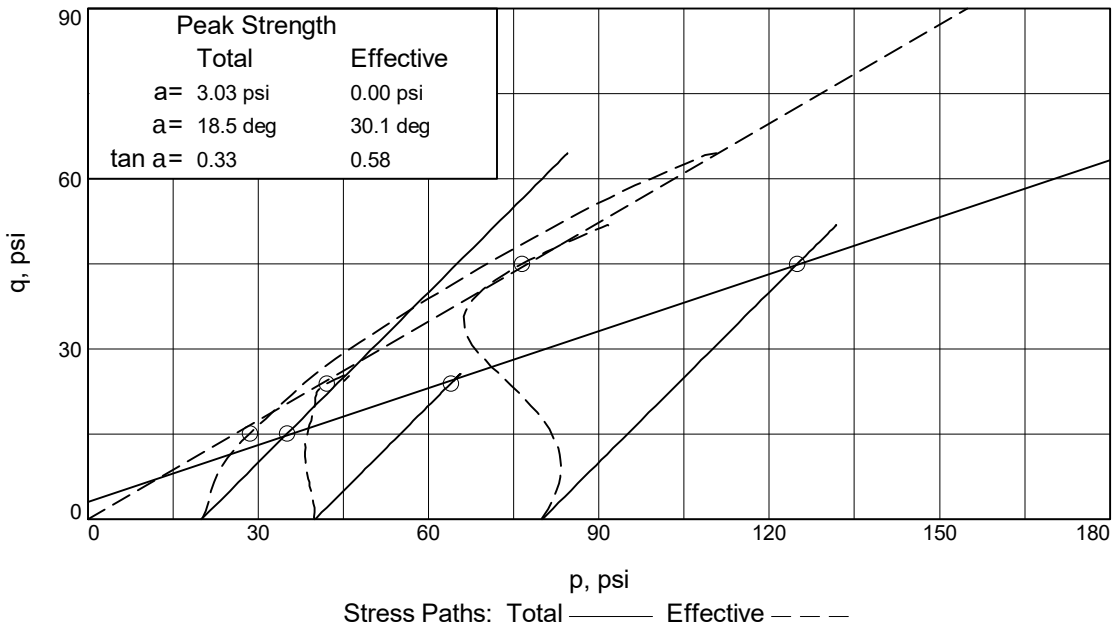
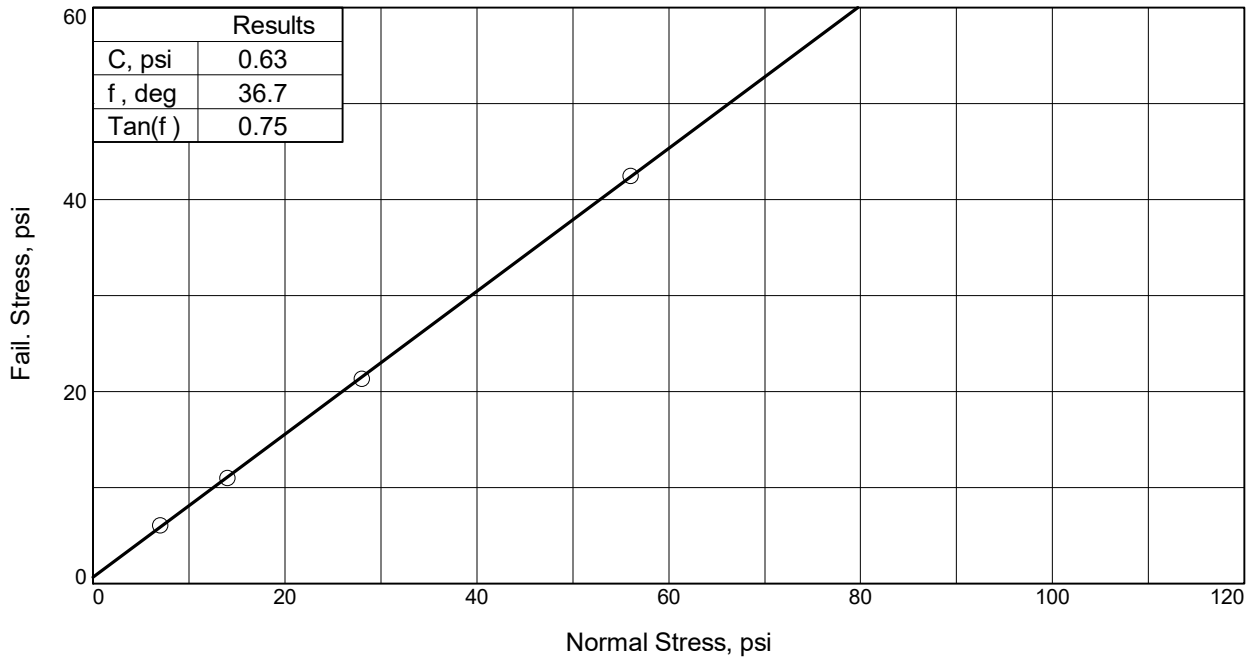


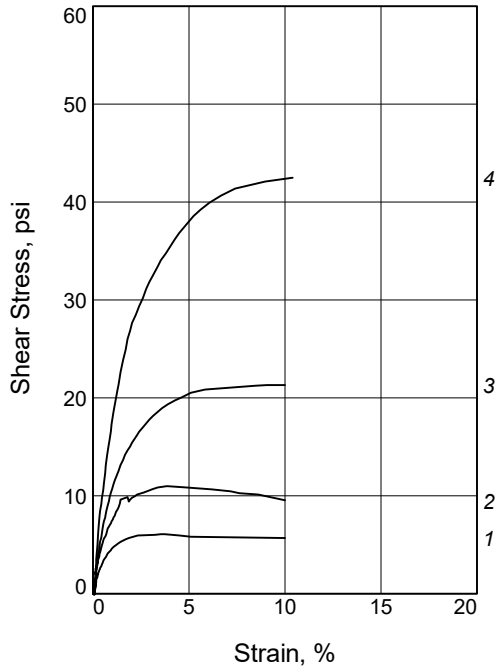




Client: Gannett Fleming, Inc.
Project: Fordville Dam
Source of Sample: FD2020-609 **Depth:** 30.0-32.0 ft **Sample Number:** U-1
Project No.: M5205037

Terracon Consultants, Inc.





Sample No.		1	2	3	4
Initial	Water Content, %	21.0	21.0	21.0	21.0
	Dry Density, pcf	100.0	100.0	100.0	100.0
	Saturation, %	84.7	84.5	84.8	84.7
	Void Ratio	0.6598	0.6607	0.6601	0.6599
	Diameter, in.	2.500	2.500	2.500	2.500
	Height, in.	1.000	1.000	1.000	1.000
At Test	Water Content, %	23.3	21.6	21.2	19.9
	Dry Density, pcf	103.2	105.8	107.0	109.2
	Saturation, %	101.4	100.7	102.5	101.5
	Void Ratio	0.6097	0.5697	0.5512	0.5213
	Diameter, in.	2.500	2.500	2.500	2.500
	Height, in.	0.970	0.945	0.934	0.916
Normal Stress, psi		7.00	14.00	28.00	56.00
Fail. Stress, psi		6.04	10.97	21.31	42.45
Strain, %		3.6	3.8	10.0	10.4
Ult. Stress, psi					
Strain, %					
Strain rate, in./min.		0.002	0.002	0.002	0.002

Sample Type: Remolded
Description: Silty Sand

Specific Gravity= 2.66
Remarks: 4-point series. Specimens remolded to approximately 100 pcf at 21 % moisture.

Client: Gannett Fleming, Inc.

Project: Fordville Dam

Source of Sample: FD2020-608 **Depth:** 0.0-17.5 ft
Sample Number: S1-S7
Proj. No.: M5205037 **Date Sampled:** N/A

DIRECT SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN

APPENDIX G

Calculations

GEOTECHNICAL ENGINEERING REPORT
MIDDLE SOUTH BRANCH FOREST RIVER DAM NO. 4 (Fordville Dam)
GRAND FORKS COUNTY, NORTH DAKOTA

APPENDIX G

CALCULATIONS

TABLE OF CONTENTS

1. SITES Analysis Parameters G-1
2. Filter Compatibility Analyses
   a. Drain Fill Aggregate for Existing Site Soils G-23
   b. Zone I versus Zone II G-45
3. Shear Strength Calculations G-58
4. Embankment Seepage and Slope Stability Modeling
   a. Inputs and Assumptions G-89
   b. Steady-State Seepage at Normal Pool G-126
   c. Downstream Slope Stability at Normal Pool G-144
   d. Steady-State Seepage at Maximum Flood Pool G-152
   e. Downstream Slope Stability at Maximum Flood Pool G-170
   f. Rapid Drawdown Slope Stability G-179

Gannett Fleming

By: EJB Date: Aug 2020
Chkd by: CRB Date: Aug 2020

Title: Geotechnical Parameters for SITES Analysis

Project: Fordville Dam
GF Job #: 066441

Purpose: Determine the Headcut Erodibility Index, K_h, for overburden (soil) stratigraphy, and parameters needed for SITES model.

References:
1. NRCS. 2001. NEH Chapter 52. Field Procedures Guide for the Headcut Erodibility Index.
2. Gannett Fleming. 2020. Fordville Dam boring logs.
3. Bowles, J.E. 1996. Foundation Analysis and Design, 5th ed.
4. Terracon. 2020. Fordville Dam Laboratory Testing Results.
5. Hvorslev, M.J. 1962. Subsurface Exploration and Sampling for Civil Engineering Purposes. Table 6, page 120.

Calculation:

From Ref. 1:

Headcut Erodibility, $K_h = M_s \times K_b \times K_d \times J_s$

Where: M_s = material strength number of the earth material
K_b = block or particle size number
K_d = discontinuity or interparticle bond shear strength number
J_s = relative ground structure number

The subsurface exploration at Fordville Dam encountered four distinct soil layers. Strata depths listed below are from boring logs (Ref. 2). Laboratory classifications from discrete zones within logged strata are applied to entire stratum.

Soil Cement:
FD2020-212: 0.0' - 8.0', laboratory classified as clayey SAND (SC)

Clay:
FD2020-212: 8.0' - 10.0', laboratory classified as sandy lean CLAY (CL)

Silty Sand:
FD2020-212: 10.0' - 17.0', laboratory classified as silty SAND (SM)
FD2020-213: 0.0' - 15.5', laboratory classified as silty SAND (SM)
FD2020-214: 0.0' - 21.7', laboratory classified as silty SAND (SM)

Silt:
FD2020-212: 17.0' - 45.0', field classified as clayey SILT (ml)
FD2020-213: 15.5' - 45.0', laboratory classified as SILT (ML)
FD2020-214: 21.7' - 45.0', field classified as clayey SILT (ml)

Determine soil strength parameter, M_s:

Use Ref. 1, Table 52-2 and 53-3 to determine M_s. Use Table 52-2 when soils have PI less than 10 and Table 52-3 when soils have PI greater than 10. Use Ref. 5 to correlate split-spoon sampler blow counts (summations or 2nd and 3rd 6-inch intervals) to relative density for soils; correlate relative soil density to M_s. Sampler blow counts are not corrected for overburden. Uncorrected blow counts are considered appropriate for this analysis as they are typically more conservative when correlating to soil strength for head cut erodibility. The energy correction is negligble due to the use of an auto hammer.

Soil Cement:

Boring	Depth (ft)	Sampler Blows (bpf)				
		Min.	Avg.	Max.	Density Description	USCS
212	0.0 - 7.5	16	29	48	very stiff	SC

Using Ref. 1, Table 52-3, (Soil Cement PI = 23). M_s ranges from 0.2 greater than 0.45 for very stiff soils. Average sampler blows per foot is 29 which correlates to approximately M_s = 0.45.

For Soil Cement use $M_{s_SoilCement} := 0.45$

Clay:

Boring	Depth (ft)	Sampler Blows (bpf)				
		Min.	Avg.	Max.	Density Description	USCS
212	7.5 - 10.0	15	15	15	stiff	CL

Clay was encountered in one discrete location within the spillway borings and therefore only one split-spoon sample is available .

Using Ref. 1 Table 52-3, (Clay PI = 18). SPT blow count of 15 bpf is the transition between stiff ($0.10 < M_s < 0.20$) and very stiff ($0.20 < M_s < 0.45$).

For Clay, use $M_{s_Clay} := 0.20$

Silty Sand:

Boring	Depth (ft)	Sampler Blows (bpf)				
		Min.	Avg.	Max.	Density Description	USCS
212	10.0 - 17.0	16	26	39	medium dense to dense	SM
213	0.0 - 15.5	5	12	19	loose to medium dense	SM
214	0.0 - 21.7	8	11	15	stiff	SM

PI for silty sands were found to be 6, 6, and 15 for samples from Borings 212, 213, and 214 respectively. Using Table 52-2, M_s ranges from 0.02 and 0.20 for loose to dense soils encountered in borings 212 and 213. Per Table 52-3, M_s ranges from 0.10 to 0.20 for stiff soils.

For Silty Sand, use $M_{s_SiltySand} := 0.1$

Glaciolacustrine:

Boring	Depth (ft)	Sampler Blows (bpf)				
		Min.	Avg.	Max.	Density Description	USCS
212	17.0 - 45.0	2	4	7	very loose to loose	ml
213	15.5 - 45.0	3	4	8	very loose to loose	ML
214	21.7 - 45.0	2	4	8	very loose to loose	ml

Using Ref. 1, Table 52-2, (Glaciolacustrine PI = 3). M_s ranges from less than 0.02 to 0.05.

For Glaciolacustrine, use $M_{s_Lacustrine} := 0.02$

Determine block size, K_b:

Block size is most applicable for rock material. Ref. 1 section 628.5203.b.2 recommends K_b = 1.0 for intact cohesive soils and gravels, which are not descriptive of the onsite soils (silts and sands). Sample worksheets in Ref. 1 Appendix B doesn't provide an option to determin K_b for soils. Therefore, use K_b = 1.0 for conservatism.

$K_b := 1.0$

Determine discontinuity or interparticle bond shear strength number, K_d:

According to Ref. 1, K_d is approximately equal to tan ϕ'_r where ϕ'_r is the residual friction angle of the soil. Because residual shear testing was not completed, utilize empirical relationships from Ref. 1 to determine ϕ'_r.

Atterberg limit testing on spillway soils per Ref. 4 yielded liquid limits and clay contents depicted below. Per Ref. 4, clay particles are less than 0.005 mm.

Layer	USCS	% clay	LL
Soil Cement	SC	6.9	45
Clay	CL	13.2	40
Silty Sand	SM	8.2	32
Silty Sand	SM	7	31
Glaciolacustrine	ML	19.7	33
Silty Sand	SM	11.4	43

$LL_{SoilCement} := 45$

$LL_{Clay} := 40$

$LL_{SiltySand} := 31$ (conservative)

$LL_{Lacustrine} := 33$

Eq. 52-7, for ≤ 20% clay,

$\phi_{r_52.7} := 169.58 \cdot LL_{SoilCement}^{-0.4925} = 26.012$

$\phi_{r_52.7} := 169.58 \cdot LL_{Clay}^{-0.4925} = 27.565$

$\phi_{r_52.7} := 169.58 \cdot LL_{SiltySand}^{-0.4925} = 31.252$

Use results of equation 52-10.

$K_{d_SoilCement} := \tan(\phi_{r_52.7} \cdot deg) = 0.488$

$K_{d_Clay} := \tan(\phi_{r_52.7} \cdot deg) = 0.522$

$K_{d_SiltySand} := \tan(\phi_{r_52.7} \cdot deg) = 0.607$

$\phi_{r_52.7} := 169.58 \cdot LL_{Lacustrine}^{-0.4925} = 30.304$ $K_{d_Lacustrine} := \tan(\phi_{r_52.7} \cdot deg) = 0.584$

For Glaciolacustrine, the residual shear strength per Eq. 52-7 seems high, especially with the low PI. Based on previous experience with residual strengths of lacustrine silt assume ϕ_r=18 degrees. This is reasonable for a minimum residual shear strength for sandy silt material.

$K_{d_Lacustrine} := \tan(18 \cdot deg) = 0.325$

Determine relative ground structure number, J_s:

According to Section 628.5203.d, J_s equals 1.0 for intact soil material (without structure).

$J_s := 1.0$

Computation of Headcut Index:

$K_{h_SoilCement} := M_{s_SoilCement} \cdot K_b \cdot K_{d_SoilCement} \cdot J_s = 0.22$

$K_{h_Clay} := M_{s_Clay} \cdot K_b \cdot K_{d_Clay} \cdot J_s = 0.10$

$K_{h_SiltySand} := M_{s_SiltySand} \cdot K_b \cdot K_{d_SiltySand} \cdot J_s = 0.061$

$K_{h_Lacustrine} := M_{s_Lacustrine} \cdot K_b \cdot K_{d_Lacustrine} \cdot J_s = 0.0065$

Estimate dry unit weight of soil:

Unit weight test results are unavailable for spillway soils. Use applicable lab testing data (Ref. 4) and Ref. 3 to estimate unit weight for soil materials. Note that soil cement is granular per USCS and was only considered to be cohesive in determining M_s per Ref. 1. Use moisture content per Ref. 4 to determine dry unit weight.

$$\gamma_{dry} = \frac{\gamma_{wet}}{1 + w\%}$$

Layer	Density Description (per Ref. 5)	γ_m range (pcf) (per Ref. 3)	Design γ_m (pcf)	Design γ_d (pcf)
Soil Cement	dense	108 - 140	120	105
Clay	stiff	110 - 130	120	101
Silty Sand	loose to dense	90 - 140	115	100
Glaciolacustrine	very loose to loose	70 - 114	105	75

Determine representative particle diameter and plasticity index:

The representative particle diameter, D_{75}, and PI are other SITES parameter that needs to be established for input into the model. Use Ref. 4 for all soil materials. See Summary Table below.

Summary Tables for Fordville Dam Soil Overburden Parameters

Table 1. Summary of Soil Parameters by Stratum

Strata	Dry Unit Weight (pcf)	% Clay	Kh	D75 (mm)	PI
Soil Cement	105	7	0.22	1.5	23
Clay	101	13	0.1	0.52	18
Silty Sand	100	9	0.061	1	9
Glaciolacustrine	75	20	0.0065	0.033	3

Table 2. Thickness of Strata within Each Borehole

Strata	FD2020-212			FD2020-213			FD2020-214		
	Depth (ft)		Thickness (ft)	Depth (ft)		Thickness (ft)	Depth (ft)		Thickness (ft)
Soil Cement	0	8	8	Not encountered			Not encountered		
Clay	8	10	2	Not encountered			Not encountered		
Silty Sand	10	17	7	0	15.5	15.5	0	21.7	21.7
Glaciolacustrine	17	45	28	15.5	45	29.5	21.7	45	23.3

Ref. 1 (excerpts)

Calc By: EJB, 8/20
Checked By: CRB, 8/20

628.5203 Field procedure for evaluating constituent parameters

(a) Material strength number (M_s)

(1) Field identification

The material strength number is determined separately for cohesionless soil (table 52–2), cohesive soil (table 52–3), and rock (table 52–4). Standard definitions are relied on for distinction between these various materials. The values of the parameters are based on field identification tests, or, alternatively, rigorous standard testing. Scales of relative density, consistency, and hardness are correlated with ranges in strength. The relative density scales for cohesionless soil, cohesive soil, and rock are as used by Korhonen et al. (1971), Jennings et al. (1973), and GSL (1977), respectively.

The material strength number for cohesionless soils in table 52–2 are correlated with values for in situ deformation modulus (ASTM D 1194, Standard Test Method for Bearing Capacity of Soil for Static Load and Spread Footings), using Kirsten's (1988) unpublished data.

Table 52–2 Material strength number, M_s, for cohesionless soil 1/

Relative density	Field identification tests	SPT 2/ 5/ (blows/0.3 m) 4/ 5/	In situ deformation modulus (IDM) (MPa) 5/	M_s 3/
Very loose	Particles loosely packed. High percentage of voids. Very easily dislodged by hand. Matrix crumbles easily when scraped with point of geologic pick. Raveling often occurs on excavated faces.	< 5	< 0.005	< 0.02
Loose	Particles loosely packed. Some resistance to being dislodged by hand. Large number of voids. Matrix shows low resistance to penetration by point of geologic pick.	5 - 10	0.005 - 0.01	0.02 - 0.05
Medium dense	Particles closely packed. Difficult to dislodge individual particles by hand. Voids less apparent. Matrix has considerable resistance to penetration by point of geologic pick.	10 - 30	0.01 - 0.03	0.05 - 0.10
Dense	Particles very closely packed and occasionally very weakly cemented. Cannot dislodge individual particles by hand. The mass has very high resistance to penetration by point of geologic pick. Requires many blows of geologic pick to dislodge particles.	30 - 50	0.03 - 0.08	0.10 - 0.20
Very dense	Particles very densely packed and usually cemented together. Mass has high resistance to repeated blows of geologic pick. Requires power tools for excavation.	> 50	0.08 - 0.2	0.20 - 0.45

1/ Cohesionless soil is a material with a plasticity index (PI) less than or equal to 10. Use table 52–3 for cohesive soils.
2/ Standard Penetration Test, SPT (ASTM D 1586) used for most sandy-type cohesionless soils. In situ deformation modulus (IDM) (ASTM D 1194) used for most gravel-type soils and coarse detritus.
3/ M_s of a cohesionless soil is approximately determined from results of IDM testing by the following relationship:

$$M_s = 1.7\ (IDM)^{0.832} \text{ for IDM in MPa}$$

4/ Cohesionless soils in which blow counts are greater than 50 or IDM is greater than 200 kPa to be taken as rock, for which the hardness may be obtained from table 52–4.
5/ Correlation between SPT and IDM should be used as a guide only as results may vary in different geologic areas. Lab strength tests are recommended on soil materials to support SPT or field assessment tests.

Scales for consistency of cohesive soil (table 52–3) and hardness of rock material (table 52–4) are based on GSL (1977). These ranges are correlated with values for unconfined compressive strength as determined by ASTM D 2166 Standard Test Method for Unconfined Compressive Strength for Cohesive Soil and ASTM D 2938 Standard Test Method for Unconfined Compressive Strength of Rock Core Specimens, respectively. Field identification tests given in tables 52–3 and 52–4 are from GSL (1977), International Society for Rock Mechanics (ISRM 1981), and USDA (1978). Material strength numbers given in tables 52–3 and 52–4 represent rounded off products of uniaxial compressive strengths and coefficients of relative density. Penetrometer blow count data (ASTM D 1586, Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils) given in tables 52–2 and 52–3 are derived from Lambe and Whitman (1969).

Table 52–3 Material strength number, M_s, for cohesive soil

Consistency	Field identification tests	SPT (blows/0.3 m)	Unconfined compressive strength (UCS) (kPa)	M_s
Very soft	Exudes between fingers when squeezed in hand.	< 2	< 40	< 0.02
Soft	Easily molded with fingers. Point of geologic pick easily pushed into shaft of handle.	2 - 4	40 - 80	0.02 - 0.05
Firm	Penetrated several centimeters by thumb with moderate pressure. Molded by fingers with some pressure.	4 - 8	80 - 150	0.05 - 0.10
Stiff	Indented by thumb with great effort. Point of geologic pick can be pushed in up to 1 centimeter. Very difficult to mold with fingers. Just penetrated with hand spade.	8 - 15	150 - 300	0.10 - 0.20
Very stiff	Indented only by thumbnail. Slight indentation by pushing point of geologic pick. Requires hand pick for excavation.	15 - 30	300 - 625	0.20 - 0.45

Notes:
1. Cohesive soil is material with a plasticity index (PI) greater than 10. Use table 52–2 for cohesionless soils.
2. 1 kPa equals 1 kN/m^2.
3. Vane shear strength (ASTM D 2573, field; ASTM D 4648, lab) also may be used for unconfined compressive strength (ASTM D 2166).
4. Cohesive soils in which blow counts are greater than 30 or strengths greater than 625 kPa are to be taken as rock, for which the hardness can be obtained from table 52–4.
5. Cohesive soils must be evaluated for hardness in the saturated condition.
6. M_s of a cohesive soil also can be determined as the product of unconfined compressive strength (in MPa) times its coefficient of relative density. For most cohesive soils, M_s is approximately determined by:

$$M_s = 0.78\ (UCS)^{1.09} \text{ for UCS} \leq 10 \text{ MPa, and } M_s = \text{UCS for UCS} > 10 \text{ MPa.}$$

7. Correlation between SPT and UCS should only be used as a guide, as results may vary in geologic areas. Lab strength tests are recommended on soil materials to support SPT or field assessment tests. Vane shear strength values also are applicable in the lower strength ranges.

(2) Other identification methods

Other methods for determining hardness include:

- ASTM D 5873 Test Method for Determining Hardness of Rock by the Rebound Hammer Method—Used for rock categories that have hardnesses varying between very soft and very hard.
- The pocket penetrometer—Used for most soils with strength less than 2.00 MPa.

(b) Block/particle size number (K_b)

The term K_b represents the mean size of individual material units as determined by the spacing of discontinuities in a rock mass, or it is a function of particle diameter of cohesionless granular soils, including detritus and boulder formations. The number can be calculated by a variety of approaches.

(1) Rock and rock-like materials

For rock and rock-like materials, the primary method to calculate K_b is:

$$K_b = \frac{RQD}{J_n} \qquad [52–2]$$

where:
RQD = rock quality designation
J_n = joint set number

RQD, a standard parameter in drill core logging, can be determined from drill cores according to methods in Deere and Deere (1988) and ASTM D 6032, Standard Test Method for Determining RQD of Rock Core, or from a joint count per cubic meter of rock mass, as defined in Barton et al. (1974). RQD represents the sum of the length of core pieces greater than 0.1 meter divided by the total core run length (generally 1.5 meters), expressed in percent (Deere and Miller 1966 or Deere and Deere 1988).

The term, J_n, is the joint set number, table 52–5. The joint set number is a scale factor representing the effect of different individual discontinuity spacings relative to the average discontinuity spacing. The factor accounts for the shape of the material units or, alternatively, the relative occurrence of different joint sets.

Depending on the type of data available, RQD also can be determined in alternative ways, as summarized below, and for which 5 is less than or equal to RQD less than or equal to 100.

$$RQD = \left(115 - 3.3J_C\right) \qquad [52–3]$$

$$RQD = \left(105 - \frac{10}{D}\right) \qquad [52–4]$$

$$RQD = \left[105 - \frac{10}{\left(J_X J_Y J_Z\right)^{0.33}}\right] \qquad [52–5]$$

where:
J_c = joint count number representing the number of joints per cubic meter

$$J_c \cong \left(\frac{3}{D}\right) + 3 \quad \text{(as given in table 52–6)}$$

where:
D = mean block diameter, in meters

Mean block size is taken as the cube root of the product of the average spacings of joint sets, J_x, J_y, J_z, measured in three mutually perpendicular directions, x, y, z, as explained in Appendix 52A, The Fixed Line Survey, such that:

$$D = \left(J_x J_y J_z\right)^{0.33}, \text{ for } D \geq 0.10\ m \qquad [52–6]$$

Table 52–5 Joint set number, J_n

Intact; no or few joints	1.00
One joint set	1.22
One joint set plus random	1.50
Two joint sets	1.83
Two joint sets plus random	2.24
Three joint sets	2.73
Three joint sets plus random	3.34
Four joint sets	4.09
More than four joint sets	5.00

(2) Cohesive soils and coarse detritus, gravels, and boulders

For intact, cohesive soils and coarse detritus, gravels, and boulder formations for which D > 0.1 meter, $K_b = 1$. For strongly cemented materials that lack discontinuities, RQD = 100 and $J_n = 1$. If soil joints occur within the soil mass, use equation 52–3 to obtain RQD and apply the applicable value for J_n to obtain K_b by equation 52–2.

Whether material units erode as individual constituent particles or by blocks of material depends on the occurrence of discontinuities within the mass. In rock formations, only discontinuities that effectively break the mass into discrete blocks are to be considered.

(3) Identification of joint set spacing

Joint set spacing (J_x, J_y, J_z) is the average spacing of joints within a given set, expressed in meters. The fixed line survey method (appendix 52A) can be used to determine joint spacing.

Bedding plane partings form a systematic joint set. Although a different set of terms for bedding plane partings has been used for years in classic field geology, the recommendation is to use one set of terms common to both bedding plane partings and high angle joint sets. Descriptive terms should be consistent with the usage in table 52–7.

(4) Identification of particle size

Mean diameter (D_{50}) of granular soil materials is determined by the visual-manual procedures given in ASTM D 2488.

(c) Discontinuity/interparticle bond shear strength number

The discontinuity/interparticle bond shear strength number (K_d) is represented as:

$$k_d = \frac{J_r}{J_a} \qquad [52–7]$$

where:
J_r = joint roughness number
J_a = joint alteration number

J_r represents the degree of roughness of opposing faces of a rock discontinuity (table 52–8), and J_a the degree of alteration of the materials that form the faces (table 52–9).

(1) Discontinuity strength

The shear strength of a rock discontinuity is directly proportional to the degree of roughness of the opposing faces and inversely proportional to the degree of alteration. Joint roughness affects the shear strength

Table 52–6 Joint count number, J_c, from RQD 1/ 2/

No. joints per cubic meter (J_c)	Rock quality designation (RQD)	No. joints per cubic meter (J_c)	Rock quality designation (RQD)
33	5	18	55
32	10	17	60
30	15	15	65
29	20	14	70
27	25	12	75
26	30	11	80
24	35	9	85
23	40	8	90
21	45	6	95
20	50	5	100

1/ RQD ≅ 115 - 3.3 J_c; or
2/ For blocks with mean diameters, D ≥ 0.10 meter, J_c ≅ (3/D) + 3

Table 52–7 Spacing categories for joint sets

Joint set spacing categories		Spacing (meters)
Bedding plane partings	High angle joints	
Massive/unstratified	Extremely wide	> 6.000
Very thick-bedded	Very wide	2.000 - 6.000
Thick-bedded	Wide	0.600 - 2.000
Medium-bedded	Mod. wide	0.200 - 0.600
Thin-bedded	Mod. close	0.060 - 0.200
Very thin-bedded	Close	0.020 - 0.060
Laminated	Very close	0.006 - 0.020
Thinly laminated	Shattered	0.002 - 0.006
Fissile	Fissured	< 0.002

of a discontinuity particularly in cases of undisplaced and interlocked features, such as unfilled (open) joints. The relative influence of wall roughness on shear strength declines as aperture width or infilling thickness increases.

Values for J_r and J_a apply primarily to the joint set or discontinuity in the rock mass most likely to fail. Experience in stratified sedimentary rocks indicates this joint set is typically bedding plane partings, if parting spacing is significantly smaller than the spacing of major high-angle joint sets. If bedding plane partings classify as very thick bedded or unstratified, the joint set closest to being perpendicular to streamflow tends to be most adverse.

(2) Interparticle bond shear strength

If the material under consideration occurs as a soil mass or as gouge in the apertures of rock discontinuities, the interparticle bond shear strength number, K_d, is represented by the quotient J_r/J_a, that, in turn, is approximately equal to tan ϕ'_r, where ϕ'_r is the residual (minimum) friction angle. The residual friction angle can be estimated according to a relationship with soil index properties (Stark and Eid, 1994).

Figure 52–1 presents a correlation of drained residual friction angle (ϕ'_r) and liquid limit (LL) for shear tests conducted on cohesive clays at an effective normal stress of 100 kPa, a value considered typical of near surface materials. The data form three distinct curves according to three ranges of clay size fraction:

For ≤ 20% clay, $\phi'_r = 169.58\ (LL)^{-0.4925}$ [52–7]

For 25 – 45% clay, $\phi'_r = 329.56\ (LL)^{-0.7100}$ [52–8]

For ≥ 50 % clay, $\phi'_r = 234.73\ (LL)^{-0.6655}$ [52–9]

The interparticle bond shear strength number (K_d) of a cohesive soil is predicted by a rational correlation between soil index properties and residual shear strength by the following method (Moore, 2001).

Table 52–8 Joint roughness number, J_r

Joint separation	Joint roughness condition (intermediate scale; small scale)	J_r 1/
Joints are tight or become closed during hydraulic flow	Discontinuous joints; stepped	4.0
	Rough/irregular; undulating (e.g., tension joints, rough sheeting joints, rough bedding)	3.0
	Smooth; undulating (e.g., smooth sheeting, nonplanar foliation and bedding)	2.0
	Slickensided; undulating	1.5
	Rough/irregular; planar	1.5
	Smooth; planar (e.g., planar sheeting joints, planar foliation and bedding)	1.0
	Slickensided; planar	0.5
Joints are open and remain open during hydraulic flow 2/	Joints are either open or contain relatively soft gouge of sufficient thickness to prevent wall contact during hydraulic flow	1.0
	Joints contain swelling clays	1.0

1/ For intact, cohesive material $J_r = 3.0$.
2/ Consider joints open when aperture width exceeds amplitude of asperities (intermediate scale roughness) of joint faces.

1. Determine the liquid limit by ASTM D 4318, Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, and report the result to the nearest one percent.
2. Determine clay content (the percent finer than 0.002 mm) by ASTM D 422, Standard Test Method for Particle-Size Analysis of Soils, and report the result to the nearest five percent.
3. Use the clay content value to select the appropriate equation (52–7, 52–8, or 52–9) to predict effective residual friction angle, ϕ'_r, and report the result to the nearest one-tenth degree.

Typical ranges of friction angles for various materials are provided in table 52–9. If the residual friction angle calculated by this method differs significantly from these values, consider conducting laboratory or in situ standard test methods, such as:

- ASTM D 3080, Direct Shear Test of Soils Under Consolidated Drained Conditions
- ASTM D 6467, Torsional Ring Shear Test to Determine Drained Residual Shear strength of Cohesive Soils

Once the friction angle is determined, the interparticle bond shear strength number, K_d, is determined by

$$K_d \cong \tan \phi'_r \qquad [52\text{-}10]$$

Table 52–9 Joint alteration number, J_a

Field identification of gouge (infilling)	J_a for aperture width < 1.0 mm 1/	J_a for aperture width 1.0 - 5.0 mm 2/	J_a for aperture width ≥ 5.0 mm 3/	Typical ϕ'_r °
Joint tightly healed with hard, nonsoftening, impermeable mineral filling, e.g., quartz, calcite, or epidote.	0.75	1.0	1.5	- - -
Clean, open joint with fresh or discolored (unweathered) walls only; no infilling.	1.0	1.5	2.0	- - -
Discolored to disintegrated joint walls; infilling is sand or gravel with < 15% cohesionless fines in matrix; with or without disintegrated or crushed rock fragments.	2.0	4.0	6.0	(25 – 30)
Discolored to disintegrated joint walls; cohesionless, nonswelling, low to nonplastic fines in matrix; with or without disintegrated or crushed rock fragments.	3.0 4/	6.0 4/	10.0 4/	(15 – 24)
Disintegrated to decomposed joint walls; nonswelling, lean clay or clay matrix, or low friction clays, such as chlorite, talc, mica, serpentine, gypsum, graphite, kaolinite, or other sheet silicates; with or without disintegrated or crushed rock fragments.	4.0 4/	8.0 4/ 5/	13.0 4/ 5/	(10 – 14)
Disintegrated to decomposed joint walls; fat clay, swelling clay, such as montmorillonite, or clay matrix, with or without disintegrated or crushed rock fragments.	5.0 4/	10.0 4/ 5/	18.0 4/ 5/	(6 – 9)

1/ Joint walls effectively in contact.
2/ Joint walls come into contact after approximately 100 mm shear.
3/ Joint walls do not come into contact at all upon shear. Use this column to determine J_a for intact, cohesive granular materials, for which $J_r = 3.0$. Alternatively, $\tan \phi'_r$ can be substituted for the quotient J_r/J_a where ϕ'_r is the equivalent residual (minimum) friction angle.
4/ Values added to Barton et al. (1974) data.
5/ Also applies when disintegrated or crushed rock fragments occur in clay matrix without wall contact.

joint sets, the dip angle and the dip direction of the closer spaced set relative to the direction of spillway flow. In this methodology, soil material is considered intact (without structure), in which case $J_s = 1$.

To calculate the effective dip (q), the apparent dip of the bedrock is first determined by using the following relationship, expressing horizontal angles in degrees azimuth and vertical angles in degrees:

$$\tan a = (\tan b)(\sin c) \qquad [52–11]$$

where:
- a = apparent dip of discontinuity
- b = true dip of discontinuity
- c = (strike of discontinuity) – (spillway flow direction)

Effective dip is defined as the apparent dip of the discontinuity adjusted for the slope of the spillway channel, α. Dip direction is measured perpendicular to the strike. If the absolute value of the dip direction (expressed in degrees azimuth) minus the spillway flow direction (expressed in degrees azimuth) is less than 90 degrees (including 0°; i.e., north) or greater than 270 degrees, the dip direction is considered to be with the direction of spillway flow; otherwise, it is considered against the flow.

If the spillway flow direction is with the apparent dip

$$q = a - \alpha \qquad [52–12]$$

If spillway flow direction is against the apparent dip

$$q = a + \alpha \qquad [52–13]$$

Use the calculated value of effective dip to determine J_s from table 52–12.

The ratio of joint spacing, r, reflects the relative shape of the material unit. It is the quotient of the average spacing of the two most dominant high angle joint sets. Select a value for r nearest to 1:1, 1:2, 1:4, or 1:8. For values of r less than 1:8, J_s is taken as r = 1:8.

Table 52–12 Relative ground structure number, J_s

Dip direction 1/ of least favorable joint set (degrees)	Effective dip angle of least favorable joint set 2/ (degrees)	Ratio of joint spacing, r			
		1:1	1:2	1:4	1:8
With flow:					
180/0	90	1.00	1.00	1.00	1.00
0	85	0.72	0.67	0.62	0.56
0	80	0.63	0.57	0.50	0.45
0	70	0.52	0.45	0.41	0.38
0	60	0.49	0.44	0.41	0.37
0	50	0.49	0.46	0.43	0.40
0	40	0.53	0.49	0.46	0.44
0	30	0.63	0.59	0.55	0.53
0	20	0.84	0.77	0.71	0.68
0	10	1.22	1.10	0.99	0.93
0	5	1.33	1.20	1.09	1.03
0/180	0	1.00	1.00	1.00	1.00
Against flow:					
180	5	0.72	0.81	0.86	0.90
180	10	0.63	0.70	0.76	0.81
180	20	0.52	0.57	0.63	0.67
180	30	0.49	0.53	0.57	0.59
180	40	0.49	0.52	0.54	0.56
180	50	0.53	0.56	0.58	0.60
180	60	0.63	0.67	0.71	0.73
180	70	0.84	0.91	0.97	1.01
180	80	1.22	1.32	1.40	1.46
180	85	1.33	1.39	1.45	1.50
180/0	90	1.00	1.00	1.00	1.00

1/ Use dip direction of least favorable joint set with respect to direction of spillway flow.
2/ Using the true dip angle (of least favorable joint set in vertical plane containing direction of streamflow), make corrections for apparent dip and the slope of stream channel to obtain effective dip using formulas 52–8, 52–9, and 52–10.
Note: For granular materials, $J_s = 1.00$.
For values of r less than 1:8, take J_s as for r = 1:8.

Ref. 2

Calc By: EJB, 8/20
Checked By: CRB, 8/20

Date Started: 6/22/20	**DRILLING LOG**		Hole Number: FD2020-212
Date Finished: 6/22/20	Gannett Fleming		Sheet: 1 of 2
Soil Drilling: 45.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 45.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 441284.9 ft
No. of Undist. Samples: 0	Driller: Dave Tokar		E Coordinate: 2637425.2 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1123.8 ft
GROUNDWATER OBSERVATIONS	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 5.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	6-4-12-26-52	1.3	52		0.0'-8.0': Poorly Graded SAND with (sp). Sand is fine to coarse; Fines: low plasticity. Olive brown (2.5Y 4/3), Dry, no HCl reaction, Gravel roadway and subgrade top 1.0' 1.0'-2.5': sand, rounded gravel 2.0'-5.5': Brown moist to fine sand, some fines, dry, dense, enable gray clasts, cement <0.75 (2.5Y 4/3) 2.5'-8.0' Dense cement matrix/granules from 2.5'-8.0' (earthern cement barrier) 2.5': dry **Lab classified as SC**	P.P. = 2.7 tsf
2.5 - 5.0	S-2	28-32-16-26-47	2.1	84			P.P. = Pocket penetrometer - Too disturbed to measure tsf
5.0 - 7.5	S-3	11-12-11-8-7	1.6	64		5.0'-7.5': moist sand, brown with gray clayey sand cement, no HCl reaction	P.P. = Too disturbed to measure tsf
7.5 - 10.0	S-4	8-8-7-6-18	1.9	76		7.5'-8.0': medium sand and fines, wet El. 1115.8 8.0'-10.0': Silty CLAY with gravel (cl). Fines: medium plasticity. Olive brown (2.5Y 4/3), organic odor, no HCl reaction **Lab classified as CL** El. 1113.8	P.P. = 2.8 tsf
10.0 - 12.5	S-5	8-13-26-31-44	1.9	76		10.0'-17.0': Clayey SAND with gravel (sc). Sand is medium; Fines: medium plasticity. Brown (10YR 3/2), organic odor, Moist to Wet, no HCl reaction 10.0'-12.5': clayey sand and gravel, moist 12.5': Clayey sand, medium brown, loose, moist 10YR 3/2 **Lab classified as SM**	P.P. = >4.5 tsf
12.5 - 15.0	S-6	11-11-12-11-13	1.8	72			P.P. = 0.4 tsf
15.0 - 17.5	S-7	12-10-6-8-5	1.8	72		15.0'-17.0': medium sand and clay with fines, wet 15.5': wet El. 1106.8	P.P. = 0.2 tsf
17.5 - 20.0	S-8	1-1-1-3-4	2.5	100		17.0'-45.0': Clayey SILT (ml). Fines: medium plasticity. Very dark greenish gray (5GY 3/1), Wet to Very Moist, no HCl reaction, (Glaciolacustrine) tan/gray laminations 17.0': very soft silty clay, gray, wet homogeneous, highly plastic gray/tan laminated	P.P. = 0.3 tsf
20.0 - 22.5	S-9	2-3-4-5-5	2.5	100			P.P. = 0.0 tsf
22.5 - 25.0	S-10	1-1-1-2-3	2.5	100		22.5': Dilatency (slow)	P.P. = 0.0 tsf

Purpose: Sample auxiliary spillway material and foundation soils.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 45.0'.
Termination: 45.0' below ground surface
Abandonment: Cement grout.
Additional Remarks: Drilled in gravel roadway, over portion of earthen-cement barrier.

DRAFT

Log Checked By: ,

Calc By: EJB, 8/20
Checked By: CRB, 8/20

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-212
Driller: Dave Tokar		Sheet: 2 of 2
Inspector: M. Mussey	Gannett Fleming	Elev. Top of Hole: +1123.8 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-11	1-1-1-2-3	2.5	100			P.P. = 0.0 tsf
27.5 - 30.0	S-12	2-3-4-6-6	2.5	100			P.P. = 0.0 tsf
30.0 - 32.5	S-13	1-1-2-2-3	2.5	100			P.P. = 0.0 tsf
32.5 - 35.0	S-14	1-1-2-3-4	2.3	92			P.P. = 0.0 tsf
35.0 - 37.5	S-15	1-1-1-4-4	2.4	96			P.P. = 0.0 tsf
37.5 - 40.0	S-16	1-1-1-2-2	2.4	96		37.5': undisturbed sample attempt, no recovery	P.P. = 0.0 tsf
40.0 - 42.5	S-17	2-3-4-6-6	2.5	100			P.P. = 0.0 tsf
42.5 - 45.0	S-18	2-2-2-3-3	2.4	96		El. 1078.8	P.P. = 0.0 tsf

Bottom of Borehole at 45.0 feet.

DRAFT

Calc By: EJB, 8/20
Checked By: CRB, 8/20

Date Started: 6/22/20	**DRILLING LOG**		Hole Number: FD2020-213
Date Finished: 6/22/20	Gannett Fleming		Sheet: 1 of 2
Soil Drilling: 45.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 45.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 441291.7 ft
No. of Undist. Samples: 1	Driller: Dave Tokar		E Coordinate: 2637462.5 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1123.7 ft
GROUNDWATER OBSERVATIONS	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	1-2-3-5-10	1.9	76		0.0'-15.5': Poorly Graded SAND with clay and gravel (sp). Gravel is subrounded, max. particle size: 1.0"; Sand is fine to coarse; Fines: low plasticity. Olive brown (2.5Y 4/3), Dry to Wet, no HCl reaction, loose to medium dense, iron oxide staining at 9.0'	P.P. = 3.3 tsf
2.5 - 5.0	S-2	8-9-10-8-9	2.3	92		0.'-0.5': Topsoil medium fine sand, some gravel, organics red brown to dark brown/black, dry to moist, loose **Lab classified as SM**	P.P. = Pocket penetrometer - Too disturbed to measure tsf
5.0 - 7.5	S-3	6-7-7-6-7	1.5	60			P.P. = Too disturbed to measure tsf
7.5 - 10.0	S-4	3-4-5-5-4	2.9	100		7.5': layered sand, medium, loose, slightly moist gravel, max. particle size 1", igneous subrounded, no HCl reaction 9.0': iron staining	P.P. = 0.0 tsf
10.0 - 12.5	S-5	5-6-6-7-9	1.3	52			P.P. = 0.2 tsf
12.5 - 15.0	S-6	4-5-6-7-9	1.8	72		12.5'-15.5': clayey sand, moist sand, loose, black finer grained and layers, moist, 1" gravel subrounded	P.P. = 0.0 tsf
15.0 - 17.5	S-7	5-4-4-3-2	2.5	100		El. 1108.2 15.5'-45.0': Clayey SILT (ml). Fines: medium plasticity. Very dark greenish gray (5GY 3/1), no HCl reaction, (Glaciolacustrine), very soft, tan/gray laminations	P.P. = 0.0 tsf
17.5 - 20.0	S-8	1-2-2-3-5	2.4	96		15.5': silty clay/clayey silt, gray, very soft, gray/tan banding fine layering 17.5': wet **Lab classified as ML**	P.P. = 0.0 tsf
20.0 - 22.3	U-1		2.3	100		20.0'-22.3': U-1: 2.3' recovery	
22.5 - 25.0	S-9	1-1-2-2-2	2.2	88			P.P. = 0.0 tsf

Purpose: Sample auxiliary spillway material and foundation soils.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 45.0'.
Termination: 45.0' below ground surface
Abandonment: Cement grout.
Additional Remarks: Boring advanced 190' SSE of surveyed and staked location. New location same distance from roadway and stake was moved to new location.

DRAFT

Log Checked By: ,

Calc By: EJB, 8/20
Checked By: CRB, 8/20

Agency: Interstate Drilling Services, Inc.	DRILLING LOG	Hole Number: FD2020-213
Driller: Dave Tokar		Sheet: 2 of 2
Inspector: M. Mussey	Gannett Fleming	Elev. Top of Hole: +1123.7 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-10	1-1-2-2-3	2.3	92			P.P. = 0.0 tsf
27.5 - 30.0	S-11	1-2-2-3-4	2.4	96			P.P. = 0.0 tsf
30.0 - 32.5	S-12	1-2-3-5-5	2.5	100		30.0': clayey silt/silty clay, wet	P.P. = 0.0 tsf
32.5 - 35.0	S-13	1-1-2-3-5	2.3	92			P.P. = 0.0 tsf
35.0 - 37.5	S-14	1-1-3-3-5	2.5	100			P.P. = 0.0 tsf
37.5 - 40.0	S-15	1-2-2-2-3	2.4	96			P.P. = 0.0 tsf
40.0 - 42.5	S-16	2-2-4-5-5	2.5	100			P.P. = 0.0 tsf
42.5 - 45.0	S-17	2-2-3-3-5	2.5	100		El. 1078.7	P.P. = 0.0 tsf

Bottom of Borehole at 45.0 feet.

DRAFT

Calc By: EJB, 8/20
Checked By: CRB, 8/20

Date Started: 6/22/20	**DRILLING LOG**		Hole Number: FD2020-214
Date Finished: 6/22/02	Gannett Fleming		Sheet: 1 of 2
Soil Drilling: 45.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 45.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 441515.2 ft
No. of Undist. Samples: 1	Driller: Dave Tokar		E Coordinate: 2637685.0 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1124.1 ft
GROUNDWATER OBSERVATIONS	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	4-4-6-7-9	2.3	92		0.0'-21.7': Poorly Graded SAND with silt and gravel (sp). fine to medium; Fines: low plasticity. Olive brown (2.5Y 4/3), Dry to Wet, no HCl reaction, loose 0.0-1.5': Topsoil, dark brown/black 1.5': Brown, medium fine sand, low fines, loose, dry, slighlty moist **Lab classified as SM**	P.P. = 2.3 tsf
2.5 - 5.0	S-2	6-7-8-8-9	1.8	72			P.P. = 0.8 tsf
5.0 - 7.5	S-3	3-4-5-6-7	1.8	72		5.0': gravel 1" subangular	P.P. = Pocket penetrometer - Too disturbed to measure tsf
7.5 - 10.0	S-4	3-4-4-6-7	1.4	56		7.5': moist, iron staining 8.0'-18.0': Iron oxide staining	P.P. = 0.0 tsf
10.0 - 12.5	S-5	6-7-6-6-4	1.8	72			P.P. = 0.0 tsf
12.5 - 15.0	S-6	6-6-7-6-7	1.6	64		11.5'-14.0': fine sand and silt, light gray, slightly dense, slightly moist	P.P. = 0.3 tsf
15.0 - 17.5	S-7	5-5-5-6-7	2.0	80		14.0': medium sand, loose, tan to brown, loose, moist to moist	P.P. = 1.6 tsf
17.5 - 20.0	S-8	4-5-5-6-5	1.8	72		17.5': wet, iron staining	P.P. = 0.0 tsf
20.0 - 22.5	S-9	2-4-4-5-3	1.8	72		El. 1102.4	P.P. = 2.0 tsf
22.5 - 25.0	S-10	1-1-1-2-3	2.4	96		21.7'-45.0': Clayey SILT (ml). very soft; Fines: medium plasticity. Very dark greenish gray (5GY 3/1), Wet, no HCl reaction, (Glaciolacustrine) tan/gray laminations	P.P. = 0.0 tsf

Purpose: Sample auxiliary spillway material and foundation soils.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 45.0'.
Termination: 45.0' below ground surface
Abandonment: Cement grout.
Additional Remarks:

DRAFT

Log Checked By: ,

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-214
Driller: Dave Tokar	Gannett Fleming	Sheet: 2 of 2
Inspector: M. Mussey		Elev. Top of Hole: +1124.1 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
						21.7': clayey silt and silty clay, very soft, wet, gray laminated	
25.0 - 27.5	S-11	1-1-1-2-1	2.4	96			P.P. = 0.0 tsf
27.5 - 30.0	S-12	1-1-1-3-5	2.5	100			P.P. = 0.0 tsf
30.0 - 32.5	S-13	2-3-5-5-6	2.3	92		30.0': clayey silt and silty clay, soft, gray/tan laminated, wet	P.P. = 0.0 tsf
32.5 - 35.0	S-14	1-2-2-5-6	2.5	100			P.P. = 0.0 tsf
35.0 - 37.5	S-15	1-2-3-3-5	2.4	96			P.P. = 0.0 tsf
37.5 - 40.0	S-16	2-3-3-5-5	2.5	100			P.P. = 0.0 tsf
40.0 - 42.4	U-1		2.4	100		40.0'-42.4': U-1	
42.5 - 45.0	S-17	1-2-3-3-5	2.5	100		El. 1079.1	

Bottom of Borehole at 45.0 feet.

DRAFT

Ref. 3

TABLE 3-4
Empirical values for ϕ, D_r, and unit weight of granular soils based on the SPT at about 6 m depth and normally consolidated [approximately, $\phi = 28° + 15°D_r$ (±2°)]

Description	Very loose	Loose	Medium	Dense	Very dense
Relative density D_r	0	0.15	0.35	0.65	0.85
SPT N'_{70}: fine	1–2	3–6	7–15	16–30	?
medium	2–3	4–7	8–20	21–40	> 40
coarse	3–6	5–9	10–25	26–45	> 45
ϕ: fine	26–28	28–30	30–34	33–38	
medium	27–28	30–32	32–36	36–42	< 50
coarse	28–30	30–34	33–40	40–50	
γ_{wet}, pcf	70 - 102	90 - 114	108 - 127	108 - 140	127 - 146
γ_{wet}, kN/m^3	11–16*	14–18	17–20	17–22	20–23

* Excavated soil or material dumped from a truck has a unit weight of 11 to 14 kN/m^3 and must be quite dense to weigh much over 21 kN/m^3. No existing soil has a D_r = 0.00 nor a value of 1.00. Common ranges are from 0.3 to 0.7.

$$\gamma_{dry} = \frac{\gamma_{wet}}{1+w}$$

Table 3-3 Empirical values for q_u* and consistency of cohesive soils based on the standard penetration number.

Consistency	Very soft	Soft	Medium	Stiff	Very stiff	Hard
q_u, ksf = $2S_u$	0	0.5	1.0	2.0	4.0	8.0
(kPa)		(25)	(50)	(100)	(200)	(400)
N, standard penetration resistance	0	2	4	8	16	32
γ_{sat}, pcf		100–120	110–130		120–140	
(kN/m^3)		(16–19)	(17–20)		(19–22)	

* These values should be used as a guide only. Local cohesive samples should be tested, and the relationship between N and the unconfined compressive strength q_u established as $q_u = KN$.

S_u = Shear strength (undrained)

$S_u = q_u/2$

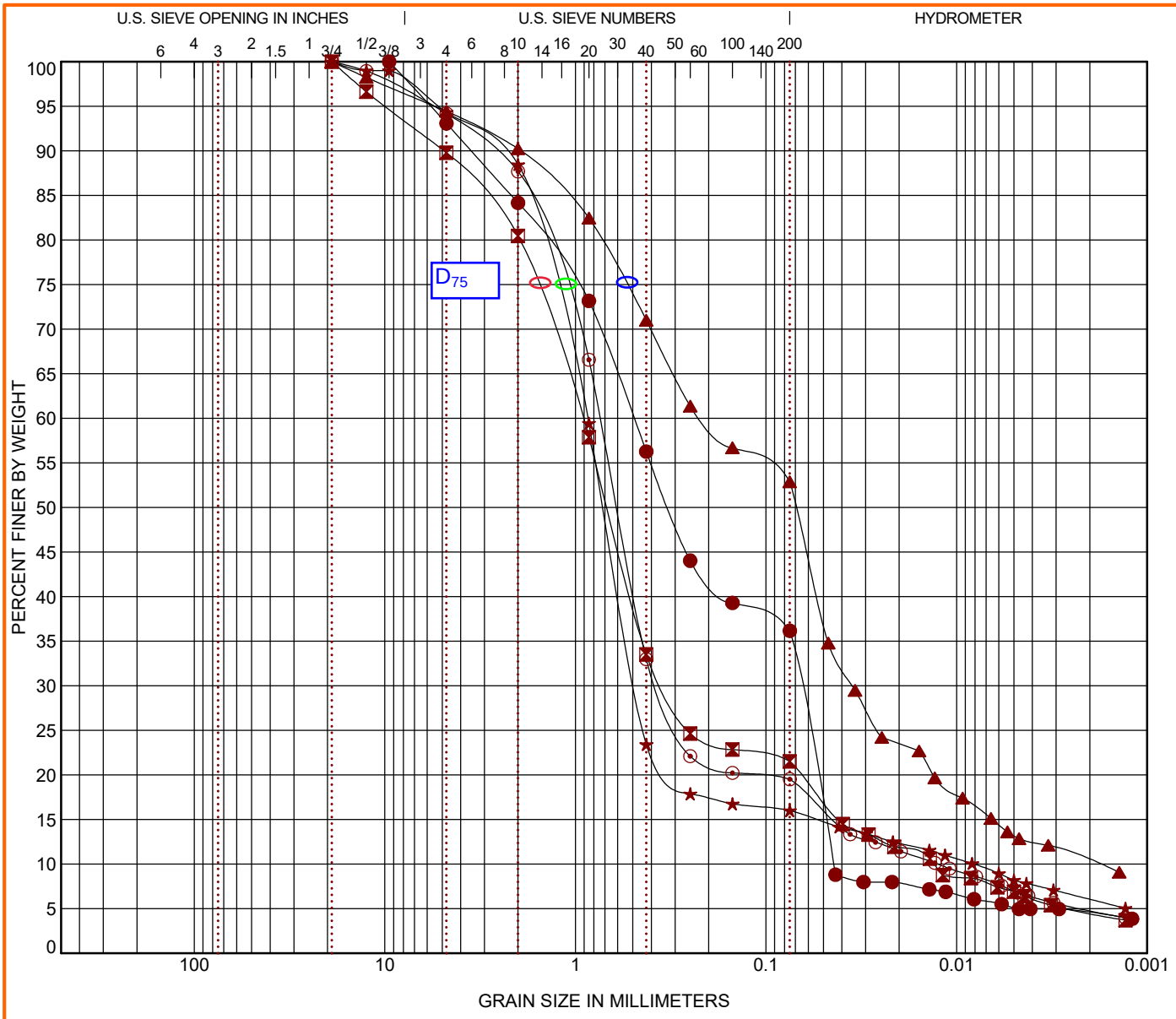
estimated foundation base. Sometimes the borings are extended to bedrock; how-

Ref. 4

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

Calc By: EJB, 8/20
Checked By: CRB, 8/20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-11	100 - 102.5	CLAYEY SAND (SC)	24.1	32	22	10	0.20	11.19
FD2020-212	0 - 5	CLAYEY SAND (SC)	14.7	45	22	23	9.83	70.27
FD2020-212	7.5 - 10	SANDY LEAN CLAY (CL)	19.1	40	22	18	3.16	118.28
FD2020-212	10 - 15	SILTY SAND (SM)	17.7	32	26	6	33.10	106.22
FD2020-213	2.5 - 7.5	SILTY SAND (SM)	11.3	31	25	6	14.52	59.22

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-11	100 - 102.5	9.5	0.495	0.066	0.044	0.0	6.9	56.9	31.0		5.1
FD2020-212	0 - 5	19	0.921	0.345	0.013	0.0	10.2	68.3	14.6		6.9
FD2020-212	7.5 - 10	19	0.215	0.035	0.002	0.0	5.6	41.6	39.7		13.2
FD2020-212	10 - 15	19	0.864	0.482	0.008	0.0	5.7	78.3	7.8		8.2
FD2020-213	2.5 - 7.5	19	0.742	0.368	0.013	0.0	5.8	74.7	12.6		7.0

PROJECT: Fordville Dam

PROJECT NUMBER: M5205037

SITE: 43rd Street NE
Fordville, ND

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND

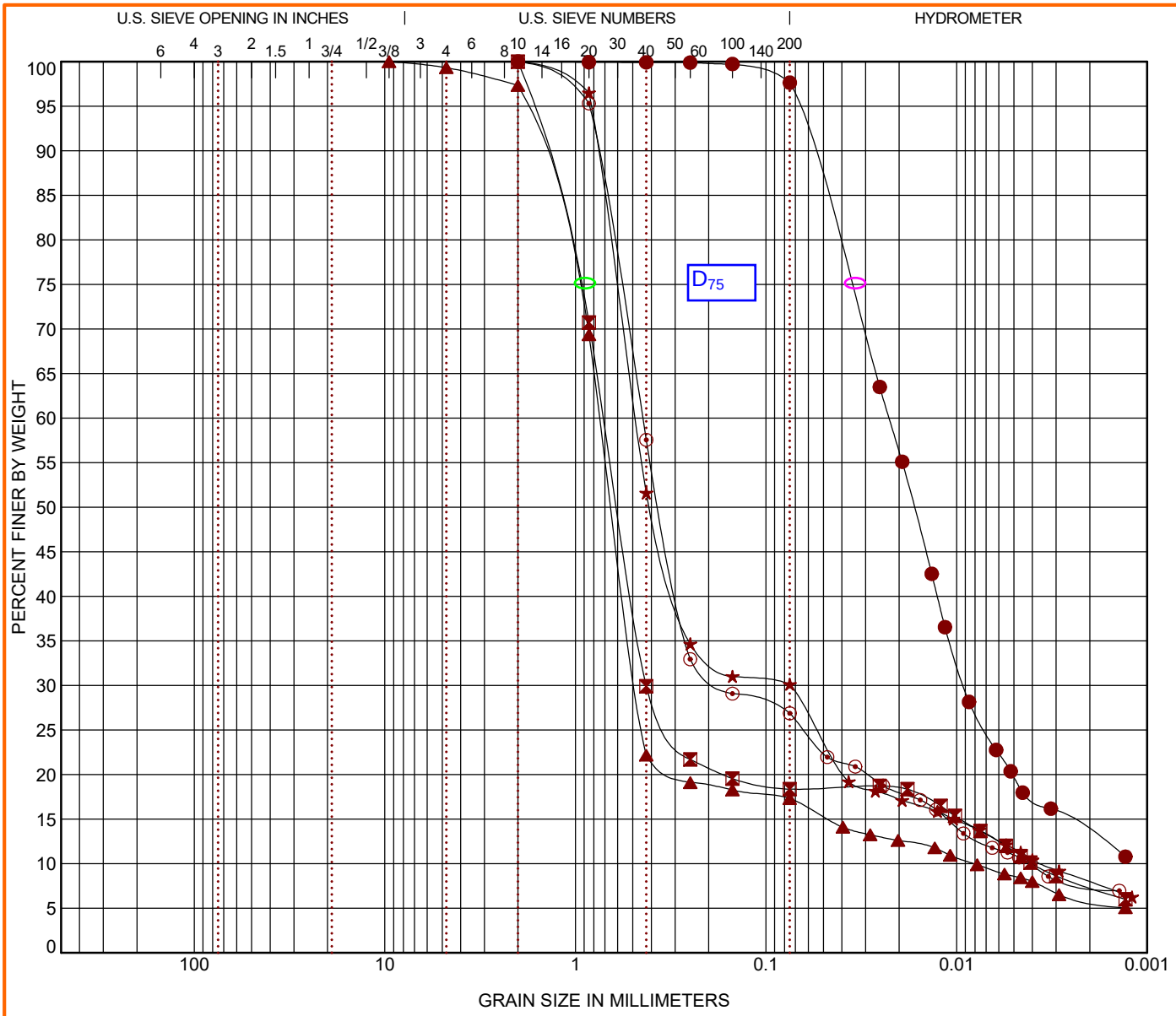
CLIENT: Gannett Fleming, Inc.
Greenwood Village, CO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 M5205037 FORDVILLE DAM.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

Calc By: EJB, 8/20
Checked By: CRB, 8/20



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-213	20 - 22	SILT (ML)	40.7	33	30	3		
FD2020-214	1.5	SILTY SAND (SM)		43	28	15	63.85	176.90
FD2020-608	0 - 5	SILTY SAND (SM)	16.3	38	40	NP	37.92	91.55
FD2020-608	10 - 11	SILTY, CLAYEY SAND (SC-SM)	22.6	27	21	6	3.20	135.21
FD2020-608	25 - 27.5	CLAYEY SAND (SC)	27.0	29	18	11	15.45	106.36

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-213	20 - 22	2	0.023	0.009		0.0	0.0	2.4	77.9		19.7
FD2020-214	1.5	2	0.708	0.426	0.004	0.0	0.0	81.6	7.0		11.4
FD2020-608	0 - 5	9.5	0.741	0.477	0.008	0.0	0.7	82.0	8.7		8.6
FD2020-608	10 - 11	2	0.484	0.074	0.004	0.0	0.0	69.9	18.5		11.7
FD2020-608	25 - 27.5	2	0.444	0.169	0.004	0.0	0.0	73.1	15.9		11.0

PROJECT: Fordville Dam

PROJECT NUMBER: M5205037

SITE: 43rd Street NE
Fordville, ND

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND

CLIENT: Gannett Fleming, Inc.
Greenwood Village, CO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 M5205037 FORDVILLE DAM.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

Ref. 5

Calc By: EJB, 8/20
Checked By: CRB, 8/20

Hvorslev & Jull 1965 → Subsurface Exploration for Civil Engineering

data only provide a rough, not always dependable indication of the consistency or relative density of the soil, and that the penetration resistance depends on many other factors discussed below in groups pertaining to equipment, procedure, and soil conditions.

TABLE 6 - SOME PROPOSED CORRELATIONS OF PENETRATION RESISTANCE AND SOIL PROPERTIES

Extreme caution should be exercised in using any table of correlations outside the areas or for other conditions than those for which the correlations have been established; even then large deviations from such correlations have been reported. The penetration resistance depends not only on dimensions of the equipment and the consistency or relative density of the soil, but it may also vary with the method of operation, depth below ground surface, and other factors not yet fully investigated.

AUTHOR	H. A. MOHR		TERZAGHI AND PECK		NEW YORK CITY CODE		NEW ENGLAND DIV., C.E.	
SAMPLER	1-in. Extra Heavy Pipe 1.315-in. OD, 0.957-in. ID		Raymond - Fig. 178 2.0-in. OD, 1.375-in. ID		2.50-in. OD		3.00-in. OD	
HAMMER	140 lb ±, 30-in. ± Fall		140 lb, 30-in. Fall		300 lb, 18-in. Fall		300 lb, 18-in. Fall	
SOIL	Designation	Blows/Ft.	Designation	Blows/Ft.	Designation	Blows/Ft.	Designation	Blows/Ft.
SAND and SILT — Rel. Density	Loose	Less 9	Very loose	Less 4	Loose	0 - 15	Very loose	Less 8
			Loose	4 - 10			Loose	8 - 16
	Firm	9 - 13	Medium	10 - 30	Compact	16 - 50	Medium	16 - 55
	Hard	14 - 49	Dense	30 - 50			Compact	55 - 110
	Hardpan	Over 50	Very dense	Over 50	Very compact	Over 50	Very compact	Over 110
CLAY — Consistency	Soft	Less 5	Very soft	Less 2	Very soft	0 - 2	Very soft	Less 8
			Soft	2 - 4	Soft	3 - 10	Soft	8 - 16
	Medium	5 - 10	Medium	4 - 8			Medium stiff	16 - 55
			Stiff	8 - 15	Stiff	11 - 30	Stiff to Medium hard	55 - 110
	Hard	11 - 30	Very stiff	15 - 30				
			Hard	Over 30	Hard	Over 30	Very hard	Over 110

Gannett Fleming

Excellence Delivered As Promised

Title: Filter Compatibility of Site Soils

Project: Fordville Dam, Grand Forks County, ND
Project No.: 66441
Objective: The existing embankment drain is located approximately 90 feet downstream of the dam centerline and consists of a single coarse aggregate material. Gradation limits specified in the record drawings indicate the drain fill is a mixture of approximately half gravel and half coarse to medium sand.

By inspection, this material does not meet the state-of-the-practice drain fill gradation criteria for seepage control/conveyance (existing drain fill is too coarse and too broadly graded). Determine acceptable aggregate for use as drain fill at Fordville Dam.

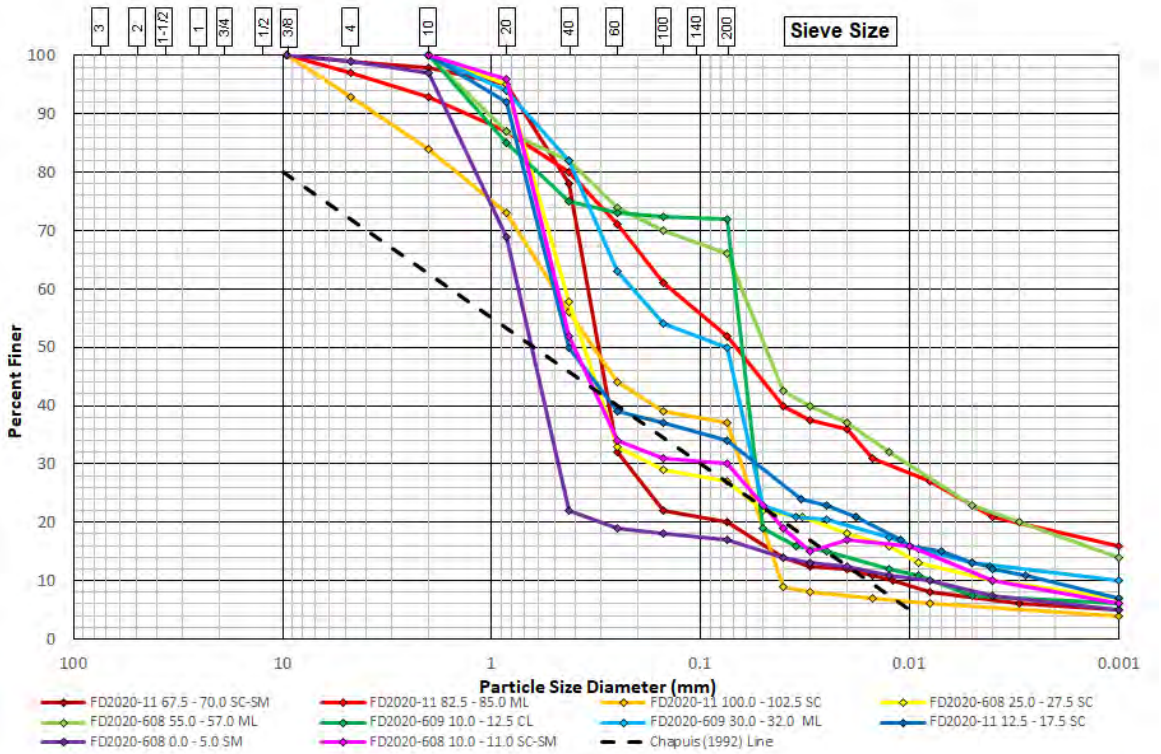
References:

1. NRCS Part 633, Chapter 26, Appendix 26A, Aug 2017.
2. Terracon. 2020. Laboratory Testing Reports.
3. ASTM C33 / C33M. Standard Specification for Concrete Aggregates
4. North Dakota Department of Transportation. Standard Specifications for Road and Bridge Construction. Oct 2014.
5. Gannett Fleming. Derivation of D_{60} Control Points for Filter Compatibility Analysis. Nov. 2020
6. U.S. Department of the Interior. Soil Conservation Service. 1978. Middle-South Branch Forest River Watershed Dam 4 (Fordville Dam). "As-Built" Drawings.

Methodology: Use NRCS design criteria to determine a gradation band of suitable drain material. This material will be required to act primarily as a drain, but also as a filter to prevent piping. The computed band will be compared with readily available aggregates. Three soil samples will be considered in this analysis - FD2020-609 10.0'-12.5', FD2020-608 55.0'-57.0', FD2020-608 10.0'-11.0'. Each of these soils represents a different Soil Category per Ref. 1 and may require a slightly different soil gradation.

Step 1: Plot the gradation curves. This analysis considers laboratory classified samples identified as Zone II embankment and foundation soils below the embankment. Zone I embankment and auxiliary spillway soils were not considered in this analysis as these soils are not in proximity of the existing foundation drain nor near the embankment toe where a hypothetical drain would be installed if a dam rehabilitation program is required.

Figure 1. Zone II Embankment and Foundation Gradations



Step 2: Determine if base soils have particles larger than the No. 4 sieve and determine if base soils are gap-graded or potentially internally unstable.

Four of the base soils contain a small fraction of gravel, up to 7% per the laboratory gradations. Based on the laboratory gradation curves, there appears to be some indication of gap-graded soils, particularly between the #60 and #200 sieve. The sample from FD2020-609 10'-12' shows a gap-graded curve and will be regraded on the #40 sieve which is at the inflection point of the curve.

Internally unstable soils are generally characterized by a gradation curve flatter than 25% as defined by Chapuis (1992). Per Ref. 1, a line with a 25% slope, i.e., a "Chapuis Line" is plotted on Figure 1. By inspection, the laboratory gradations included in this analysis do not appear to be internally unstable.

Step 3: Prepare adjusted gradation curve for base soils that have particles larger than the No. 4 sieve.

a) Obtain a correction factor by dividing 100% by the percent passing the No. 4 sieve. Then multiply the correction factor by the original % passing gradations.

For example, gradation for FD2020-608 0.0'-5.0':

$$\%_{passing4sieve} := 99$$

$$Correction_{factor} := \frac{100}{\%_{passing4sieve}}$$

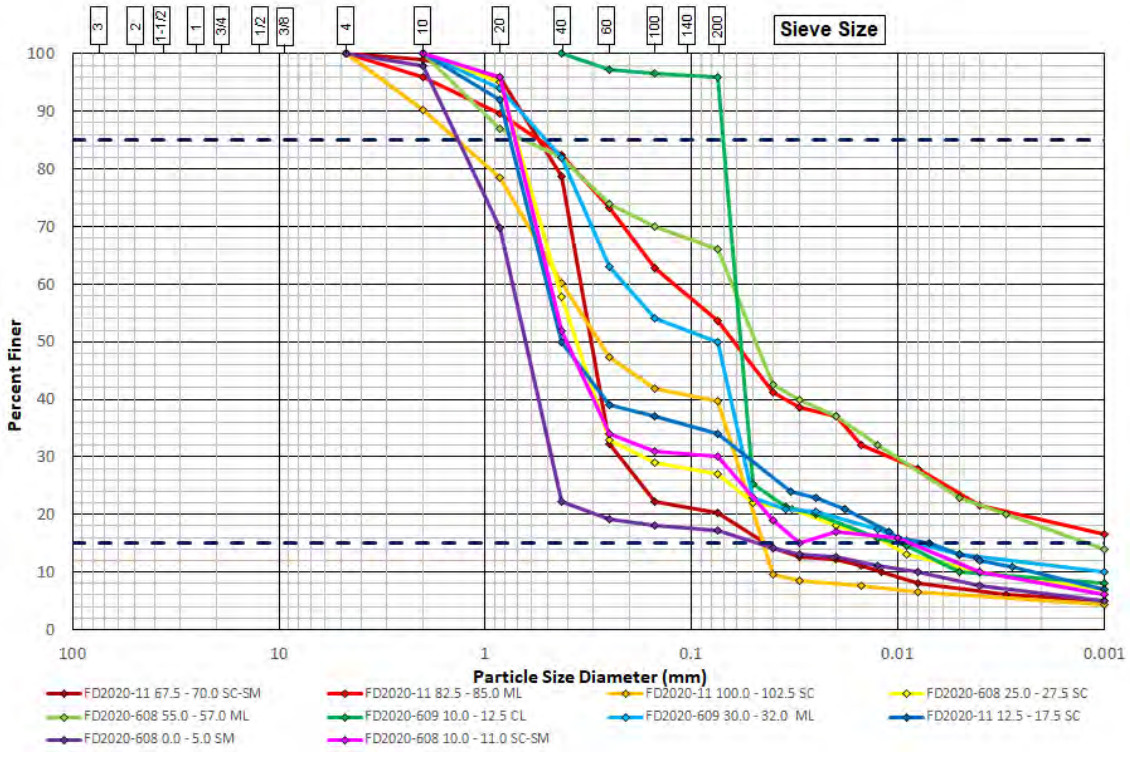
$$Sieve := \begin{pmatrix} \text{"No. 4"} \\ \text{"No. 10"} \\ \text{"No. 20"} \\ \text{"No. 40"} \\ \text{"No. 60"} \\ \text{"No. 100"} \\ \text{"No. 200"} \end{pmatrix} \qquad FD2020_608 := \begin{pmatrix} 99 \\ 97 \\ 69 \\ 22 \\ 19 \\ 18 \\ 17 \end{pmatrix}$$

Adjusted Gradations
FD2020-608 0.0'-5.0':

$$FD2020_608_{adj} := FD2020_608 \cdot Correction_{factor}$$

$$Sieve = \begin{pmatrix} \text{"No. 4"} \\ \text{"No. 10"} \\ \text{"No. 20"} \\ \text{"No. 40"} \\ \text{"No. 60"} \\ \text{"No. 100"} \\ \text{"No. 200"} \end{pmatrix} \qquad FD2020_608_{adj} = \begin{pmatrix} 100 \\ 98 \\ 70 \\ 22 \\ 19 \\ 18 \\ 17 \end{pmatrix}$$

Figure 2. Regraded Zone II Embankment and Foundation Soils



Step 4: Place the base soil in a Category determined by the percent passing the No. 200 sieve from the regraded gradation curve data according to Ref. 1 Table 26-1.

Table 26–1 Base soil categories

Base soil category	Percent finer than No. 200 sieve (0.075 mm) (after regrading where applicable)	Base soil description
1	> 85	Fine silt and clays
2	40–85	Sands, silts, clays, and silty sands
3	15–39	Silty and clayey sands and gravels
4	< 15	Sands and gravels

One soil is Category 1, four soils are Category 2, and five soils are Category 3.

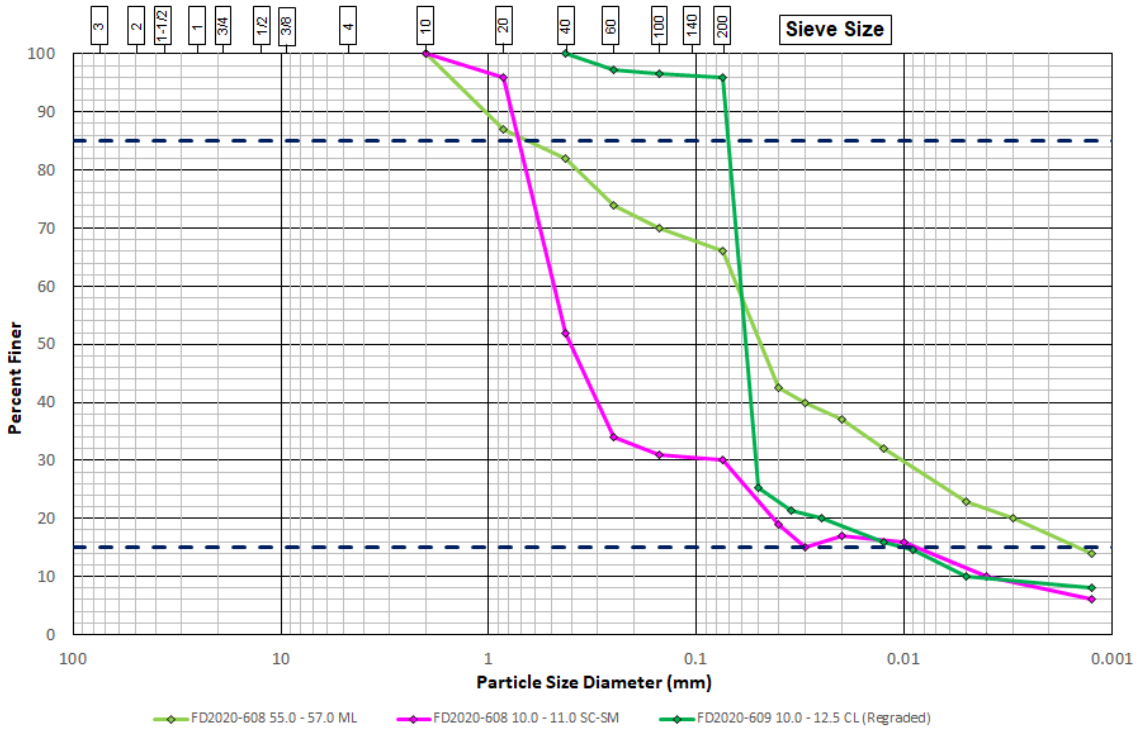
No Zone II embankment soils or foundation soils directly below the embankment were determined to be dispersive per crumb testing.

The analysis moving forward will consider:

- FD2020-609 10.0'-12.5', Category 1, the finest laboratory classified soil representing the embankment foundation after regrading.
- FD2020-608 55.0'-57.0', Category 2, the finest non-Category 1 soil representing the embankment foundation after regrading.
- FD2020-608 10.0'-11.0', Category 3, representing the Zone II embankment soils, particularly in proximity to the existing foundation drain.

See Figure 3 for the gradation curves for these soils. Note that only FD2020-609 was regraded per criteria in Ref. 1.

Figure 3. Regraded Curves for Select Samples



Step 5: To satisfy filtration requirements, determine the maximum allowable D_{15} size for the filter/drain in accordance with Ref. 1 Table 26-2.

Table 26–2 Filtering criteria

Base soil category	Filtering—maximum D_{15}
1	The maximum D_{15} should be $\le 9 \times d_{85}$ of the base soil, but not less than 0.2 mm, unless the soils are dispersive. Dispersive soils in category 1 require a filter with a maximum D_{15} that is ≤ 6.5 times the d_{85} of the base soil size, but not less than 0.2 mm.
2	The maximum D_{15} should be ≤ 0.7 mm unless soil is dispersive, in which case the maximum D_{15} should be < 0.5 mm.
3	The maximum D_{15} should be: $\le \left(\frac{40-A}{40-15}\right)\left[(4 \times d_{85}) - 0.7\text{ mm}^*\right] + 0.7\text{ mm}^*$ A = percent passing No. 200 sieve after regrading (when $4 \times d_{85}$ is less than 0.7 mm*, use 0.7 mm*).
4	The maximum D_{15} should be $\le 4 \times d_{85}$ of base soil after regrading.

* If fines are dispersive, use 0.5 mm rather than 0.7 mm.

For FD2020-609 10.0'-12.5':

$d_{85_1} := 0.07\text{mm}$ $D_{15_max1} := \text{if}\left(9d_{85_1} \le 0.2\text{mm}, 0.2\text{mm}, 9 \cdot d_{85_1}\right) = 0.63 \cdot \text{mm}$

For FD2020-608 55.0'-57.0': $D_{15_max2} := 0.7\text{mm}$

For FD2020-608 10.0'-11.0': $A_3 := 30.0$ $d_{85_3} := 0.715\text{mm}$

$$D_{15_max3} := \left(\frac{40 - A_3}{40 - 15}\right) \cdot \left[\left(4 \cdot d_{85_3}\right) - 0.7\text{mm}\right] + 0.7\text{mm} = 1.564 \cdot \text{mm}$$

Step 6: Establish a minimum D_{15} as the greater of:

- 0.1 mm
- a fifth of the maximum D_{15} size established in step 5
- In some cases, this minimum D_{15} size may be too fine for adequate permeability, and the preliminary design band may need to be narrowed at this step by shifting the minimum D_{15} to be slightly coarser.

For FD2020-609 10.0'-12.5': $D_{15_min1} := \text{if}\left(\frac{D_{15_max1}}{5} \le 0.1\text{mm}, 0.1\text{mm}, \frac{D_{15_max1}}{5}\right) = 0.13 \cdot \text{mm}$

For FD2020-608 55.0'-57.0': $D_{15_min2} := \text{if}\left(\frac{D_{15_max2}}{5} \le 0.1\text{mm}, 0.1\text{mm}, \frac{D_{15_max2}}{5}\right) = 0.14 \cdot \text{mm}$

For FD2020-608 10.0'-11.0': $D_{15_min3} := \text{if}\left(\frac{D_{15_max3}}{5} \le 0.1\text{mm}, 0.1\text{mm}, \frac{D_{15_max3}}{5}\right) = 0.31 \cdot \text{mm}$

Step 7: Establish the minimum and maximum D_{60} sizes of the filter band. Preliminarily assume $C_U = 6$ and band width of 5 per recommendations in Ref. 1.

For FD2020-609 10.0'-12.5': $D_{60_min1} := D_{15_max1} = 0.63 \cdot mm$ $D_{60_max1} := 5 \cdot D_{60_min1} = 3.15 \cdot mm$

For FD2020-608 55.0'-57.0': $D_{60_min2} := D_{15_max2} = 0.7 \cdot mm$ $D_{60_max2} := 5 \cdot D_{60_min2} = 3.5 \cdot mm$

For FD2020-608 10.0'-11.0': $D_{60_min3} := D_{15_max3} = 1.564 \cdot mm$ $D_{60_max3} := 5 \cdot D_{60_min3} = 7.82 \cdot mm$

Step 8: Establish the maximum particle size and maximum percentage passing No. 200 sieve.

For FD2020-609 10.0'-12.5': $D_{100_max1} := 2in = 50.8 \cdot mm$ $D_{5_min1} := 0.075mm$

For FD2020-608 55.0'-57.0': $D_{100_max2} := 2in = 50.8 \cdot mm$ $D_{5_min2} := 0.075mm$

For FD2020-608 10.0'-11.0': $D_{100_max3} := 2in = 50.8 \cdot mm$ $D_{5_min3} := 0.075mm$

Step 9: Check segregation potential, determine minimum D_{10} and maximum D_{90}.

Table 26–3 Segregation criteria

Base soil category	If D_{10} is: (mm)	Then, maximum D_{90} is: (mm)
ALL categories	< 0.5	20
	0.5-1.0	25
	1.0-2.0	30
	2.0-5.0	40
	5.0-10	50
	> 10	60

For FD2020-609 10.0'-12.5': $D_{10_min1} := \frac{D_{15_min1}}{1.2} = 0.1 \cdot mm$ $D_{90_max1} := 20mm$

For FD2020-608 55.0'-57.0': $D_{10_min2} := \frac{D_{15_min2}}{1.2} = 0.1 \cdot mm$ $D_{90_max2} := 20mm$

For FD2020-608 10.0'-11.0': $D_{10_min3} := \frac{D_{15_min3}}{1.2} = 0.3 \cdot mm$ $D_{90_max3} := 20mm$

Establish Filter Criteria for FD2020-609 10.0'-12.5':

Preliminary Control Points:

$$Fine_{CP_1} := \begin{pmatrix} D_{60_min1} \\ D_{15_min1} \\ D_{5_min1} \end{pmatrix} \qquad Fine_{CP_1} = \begin{pmatrix} 0.63 \\ 0.13 \\ 0.08 \end{pmatrix} \cdot mm$$

$$Coarse_{CP_1} := \begin{pmatrix} D_{100_max1} \\ D_{90_max1} \\ D_{60_max1} \\ D_{15_max1} \end{pmatrix} \qquad Coarse_{CP_1} = \begin{pmatrix} 50.8 \\ 20.0 \\ 3.2 \\ 0.6 \end{pmatrix} \cdot mm$$

The control points of the FD2020-609 10.0'-12.5' base soil are presented in Figure 4. Per Ref. 1, the control points can be somewhat modified by revising previous assumptions, e.g., the assumed $C_u = 6$ can be revised such that filter C_u is less than 6, but greater than 2 such that a commercially available aggregate will fit within the control points. However, the minimum and maximum D_{15} are the critical control points and manipulation of these points is not generally recommended.

Two commercially available aggregates (ASTM C33 fine aggregate and ND DOT fine aggregate) and the existing drain fill gradation are plotted on Figure 5 for comparison with the computed control points.

Per Figure 5, ND DOT Fine Aggregate is suitable for use as a filter materials. It is also important to note that the existing drain fill is not compatible with the sample from FD2020-609 10.0'-12.5'.

Figure 4. Preliminary Design Filter Gradation Criteria based on FD2020-609 10.0'-12.5'

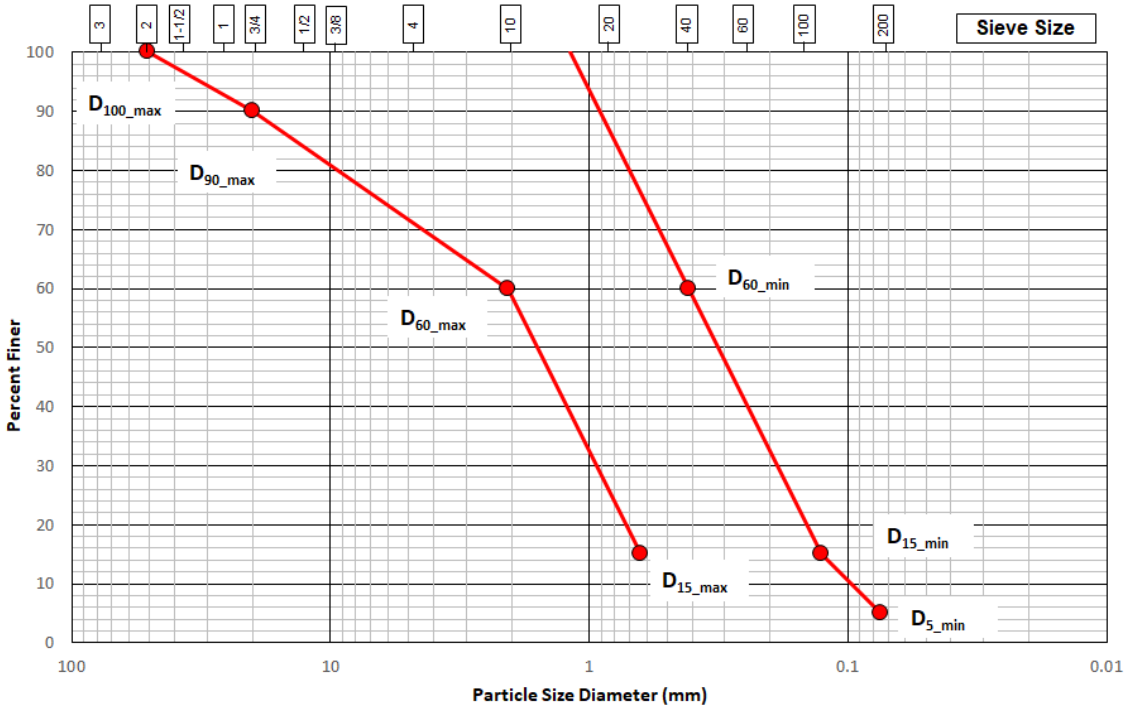
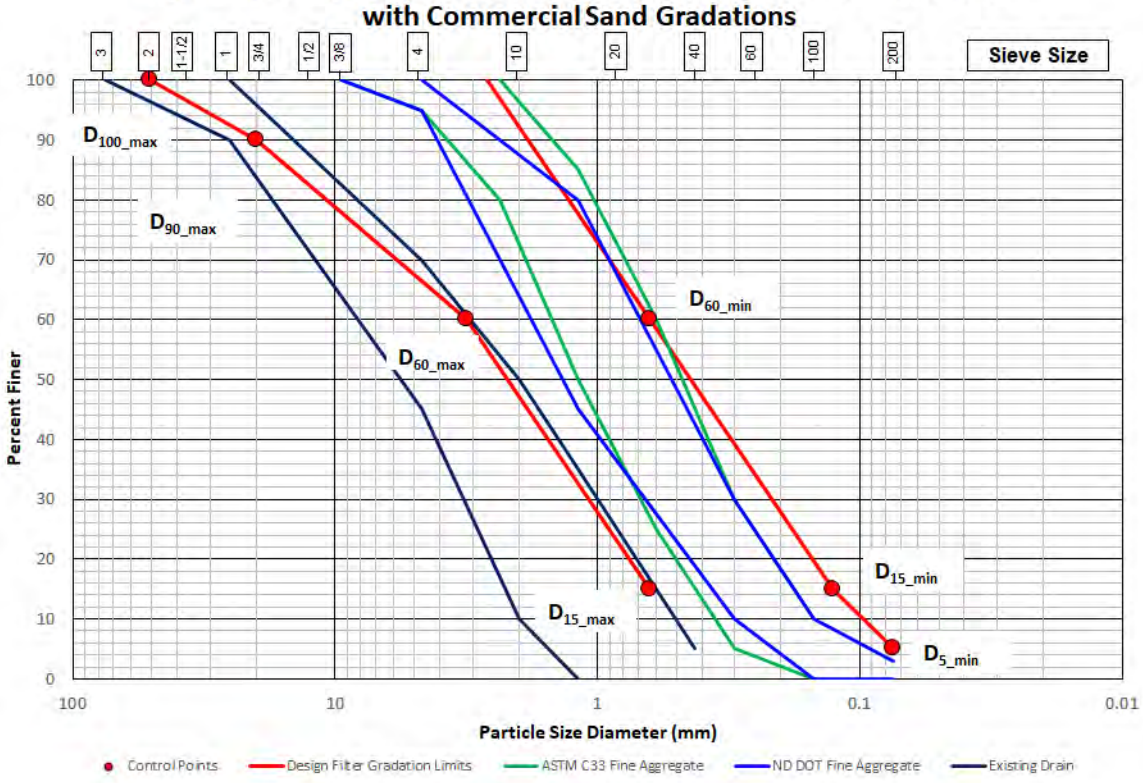


Figure 5. Design Filter Gradation Criteria per FD2020-609 10.0'-12.5' with Commercial Sand Gradations



Establish Filter Criteria for FD2020-608 55.0'-57.0':

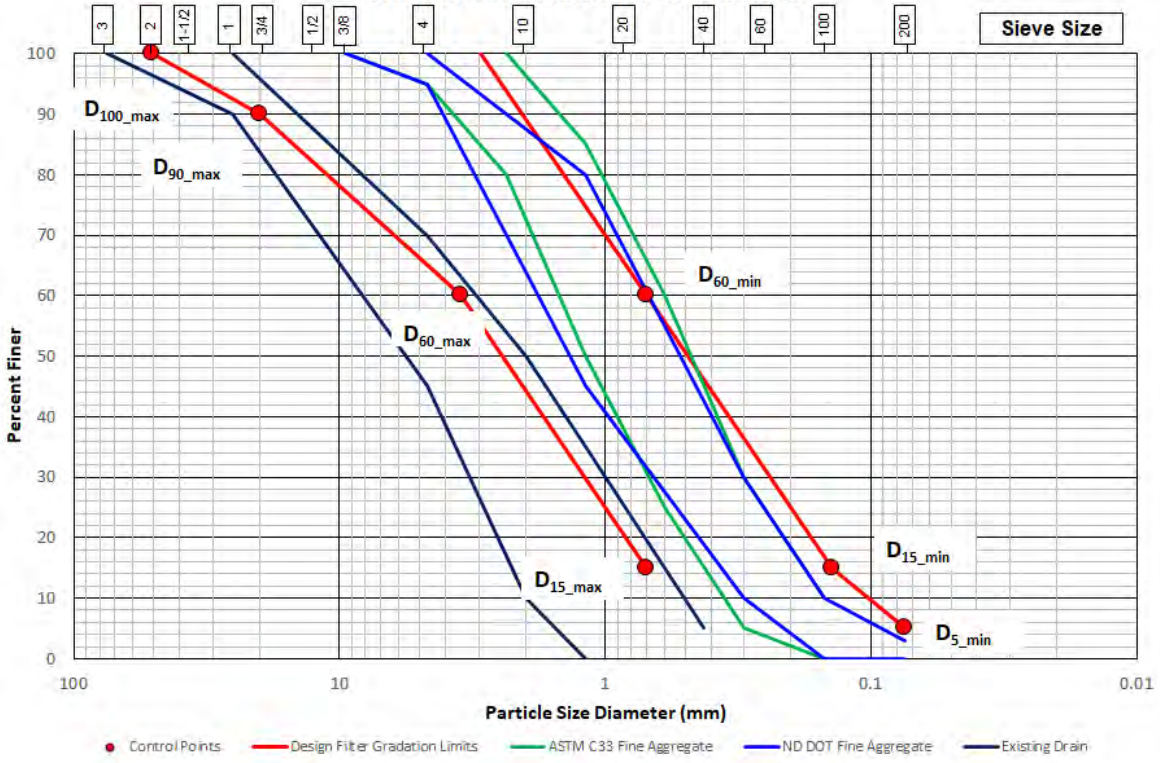
Preliminary Control Points:

$$Fine_{CP_2} := \begin{pmatrix} D_{60_min2} \\ D_{15_min2} \\ D_{5_min2} \end{pmatrix} \qquad Fine_{CP_2} = \begin{pmatrix} 0.7 \\ 0.14 \\ 0.08 \end{pmatrix} \cdot mm$$

$$Coarse_{CP_2} := \begin{pmatrix} D_{100_max2} \\ D_{90_max2} \\ D_{60_max2} \\ D_{15_max2} \end{pmatrix} \qquad Coarse_{CP_2} = \begin{pmatrix} 50.8 \\ 20.0 \\ 3.5 \\ 0.7 \end{pmatrix} \cdot mm$$

Preliminary control points for sample FD2020-608 55.0'-57.0' are plotted in Figure 6 along with commercially available fine aggregates (ASTM C33 and ND DOT) and the existing Fordville Dam drain fill. ND DOT fine aggregate is suitable for use as a filter material whereas the existing drain fill is not compatible. The curve can be manipulated by adjusting the assumed Cu of the filter gradation band to 4.0. By making this adjustment, both ASTM C33 and ND DOT filter aggregate are both within the control points, see Figure 7.

Figure 6. Design Filter Gradation Criteria per FD2020-608 55.0'-57.0' with Commercial Sand Gradations



Adjust D_{60min} and D_{60max} control points based on a Cu = 4.0 instead of 6.0. Use the relationship of D_{15} and D_{10} per Ref. 1 Step 9 to determine the a new D_{60}. The 1.2 factor used in Step 9 becomes 1.15 for a Cu = 4.0 (see Ref. 5).

$$D_{10_max2} := \frac{D_{15_max2}}{1.15} = 0.609 \cdot mm \qquad D_{60_max2_adj} := D_{10_max2} \cdot 4.0 = 2.4 \cdot mm$$

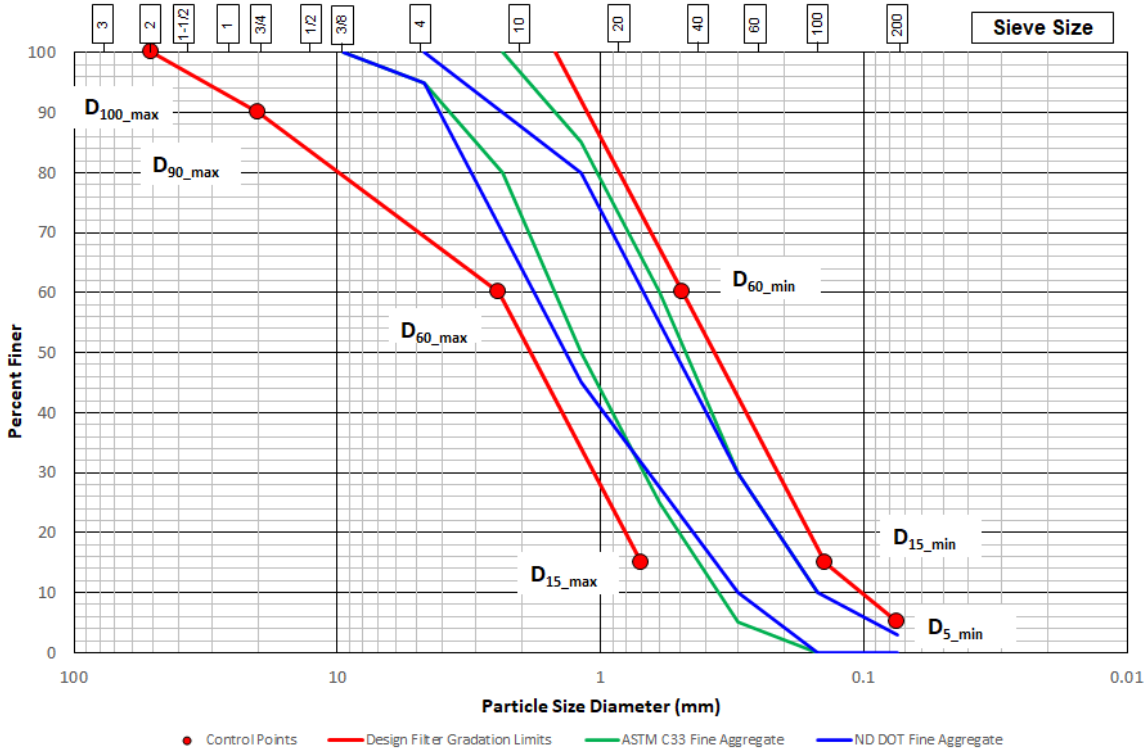
$$D_{10_min2_adj} := \frac{D_{15_min2}}{1.15} = 0.122 \cdot mm \qquad D_{60_min2_adj} := D_{10_min2_adj} \cdot 4.0 = 0.49 \cdot mm$$

The revised Control Points are then:

$$Fine_{CP_2_adj} := \begin{pmatrix} D_{60_min2_adj} \\ D_{15_min2} \\ D_{5_min2} \end{pmatrix} \qquad Fine_{CP_2_adj} = \begin{pmatrix} 0.49 \\ 0.14 \\ 0.08 \end{pmatrix} \cdot mm$$

$$Coarse_{CP_2_adj} := \begin{pmatrix} D_{100_max2} \\ D_{90_max2} \\ D_{60_max2_adj} \\ D_{15_max2} \end{pmatrix} \qquad Coarse_{CP_2_adj} = \begin{pmatrix} 50.8 \\ 20.0 \\ 2.4 \\ 0.7 \end{pmatrix} \cdot mm$$

Figure 7. Revised Filter Gradation Criteria per FD2020-608 55.0'-57.0' with Commercial Sand Gradations



Establish Filter Criteria for FD2020-608 10.0'- 11.0':

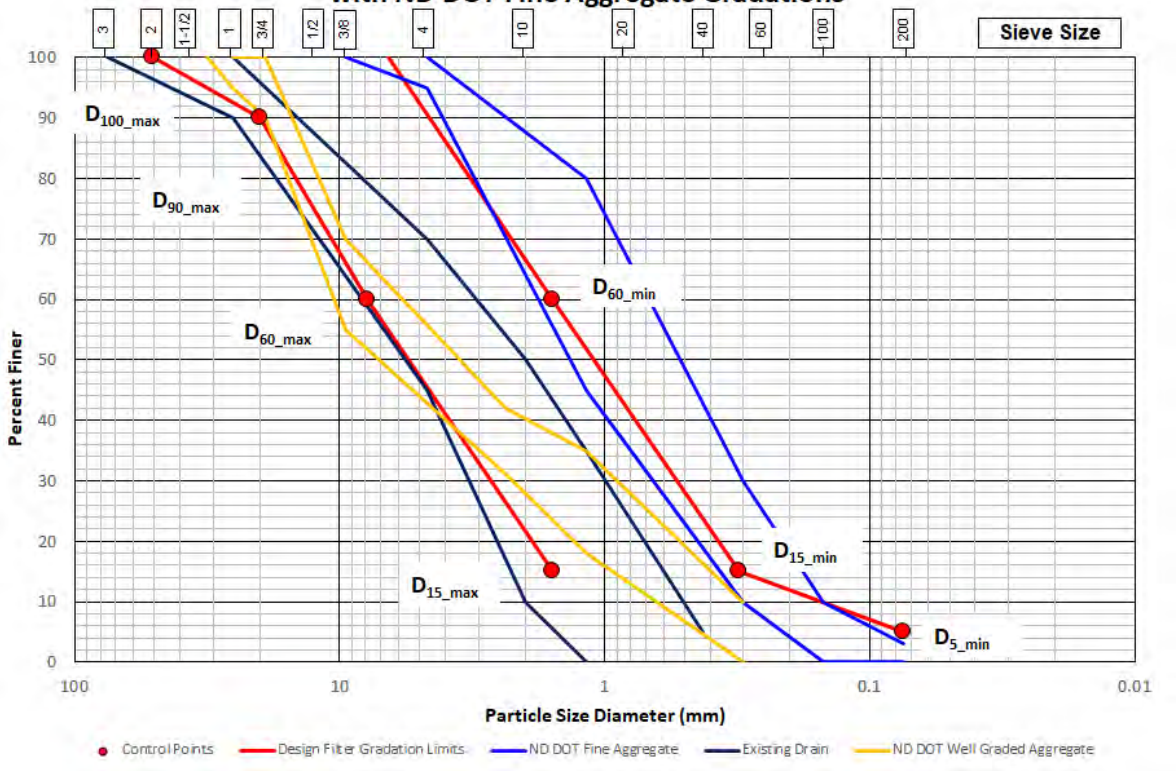
Preliminary Control Points:

$$Fine_{CP_3} := \begin{pmatrix} D_{60_min3} \\ D_{15_min3} \\ D_{5_min3} \end{pmatrix} \qquad Fine_{CP_3} = \begin{pmatrix} 1.56 \\ 0.31 \\ 0.08 \end{pmatrix} \cdot mm$$

$$Coarse_{CP_3} := \begin{pmatrix} D_{100_max3} \\ D_{90_max3} \\ D_{60_max3} \\ D_{15_max3} \end{pmatrix} \qquad Coarse_{CP_3} = \begin{pmatrix} 50.8 \\ 20.0 \\ 7.8 \\ 1.6 \end{pmatrix} \cdot mm$$

Control points for filter criteria based on FD2020-608 10.0'-11.0' are plotted in Figure 8 along with gradations for ND DOT Fine Aggregate (i.e., concrete sand), ND DOT Well Graded Aggregate, and the existing drain fill. ASTM C33 Fine Aggregate is not plotted due to its similarity to ND DOT Fine Aggregate and to reduce clutter on Figure 8. Figure 8 indicates that the existing filter material, per the gradation on the As-Built Drawings, fits reasonably well within the control points - there is some incompatibility at the D_{15max} control point, but this could change if the gradation of the actual drain fill could be proven to to closert to the finer limits of the specified gradation shown on the As-Built drawings. Also per Figure 8, concrete sand is not within the allowable filter band of the FD2020-608 10.0'-11.0' gradation. For this scenario, concrete sand would still meet filtration requirements, but lacks the capacity to act as a drain. ND DOT Well Graded Aggregate is also plotted because it represents the commercially specified aggregate that closest fits the allowable filter band.

Figure 8. Design Filter Gradation Criteria per FD2020-608 10.0'-11.0' with ND DOT Fine Aggregate Gradations



Conclusion:
The existing drain fill is not compatible with the foundation soil, however if a drain fill aggregate would be required for future dam rehabilitation work, ND DOT fine aggregate is compatible.

ND DOT fine aggregate is adequate to filter soils representing the Zone II shell, but lacks the drainage capacity to adequately convey collected seepage. The existing drain fill compares reasonably well with the design filter band for the Zone II soils, but does not meet state-of-the-practice criteria. If a drain fill aggregate would be required for future dam rehabilitation work, a custom aggragate gradation would need to be produced.

Ref. 2

GRAIN SIZE DISTRIBUTION

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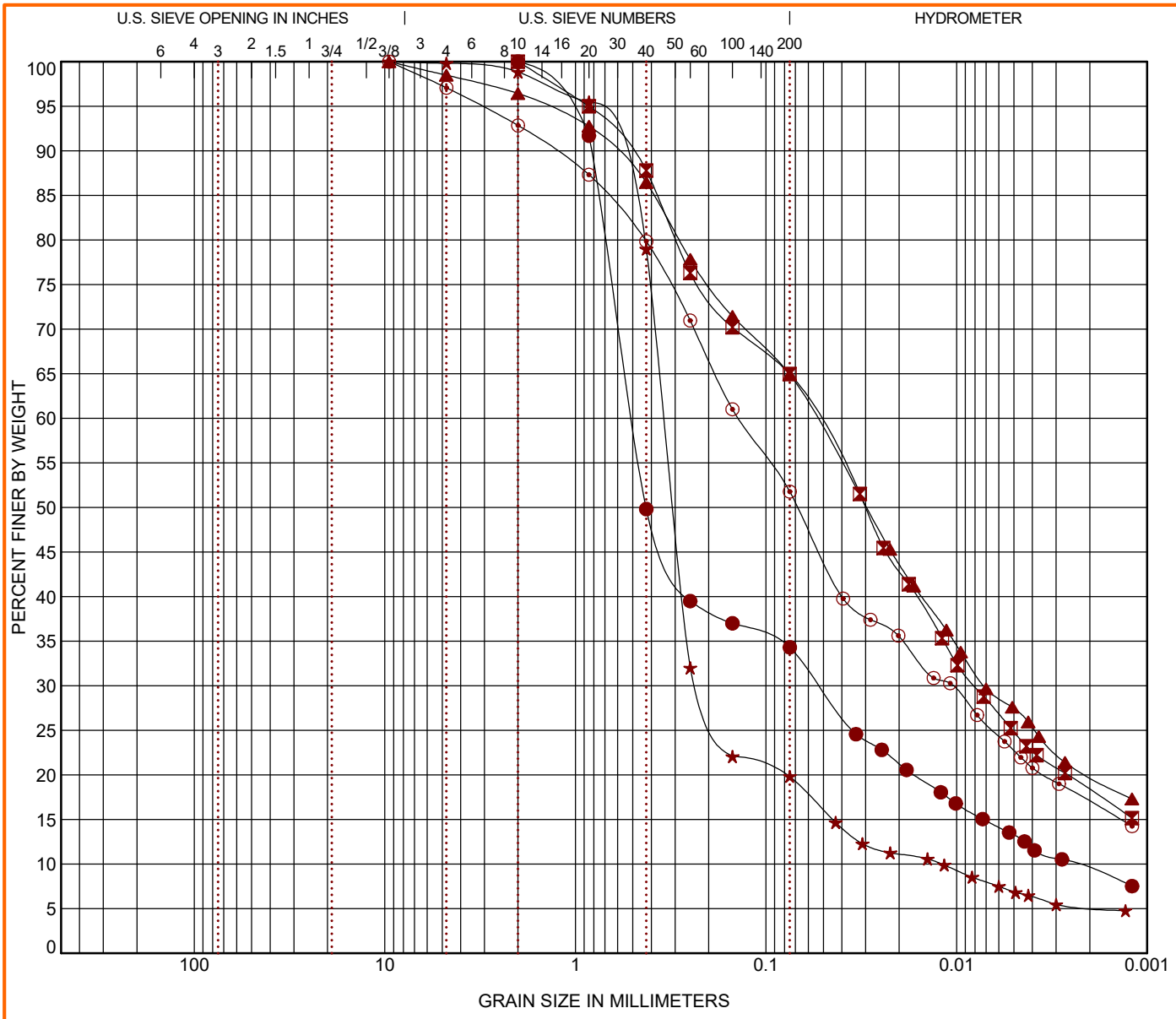

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-11	12.5 - 17.5	CLAYEY SAND (SC)	17.8	29	19	10	2.28	208.53
FD2020-11	37.5 - 39.5	SANDY LEAN CLAY (CL)	14.0	39	19	20		
FD2020-11	52.5 - 57.5	SANDY LEAN CLAY (CL)	16.4	40	19	21		
FD2020-11	67.5 - 70	SILTY, CLAYEY SAND (SC-SM)	29.6	24	20	4	12.39	28.65
FD2020-11	82.5 - 85	SANDY SILT (ML)	27.5	32	24	8		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-11	12.5 - 17.5	2	0.503	0.053	0.002	0.0	0.0	65.7	21.1		13.2
FD2020-11	37.5 - 39.5	2	0.055	0.008		0.0	0.0	35.0	40.1		24.8
FD2020-11	52.5 - 57.5	9.5	0.055	0.007		0.0	1.5	33.6	37.5		27.4
FD2020-11	67.5 - 70	9.5	0.343	0.226	0.012	0.0	0.2	80.0	12.9		6.9
FD2020-11	82.5 - 85	9.5	0.139	0.011		0.0	2.9	45.3	29.1		22.7

PROJECT: Fordville Dam

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Fordville, ND

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND

CLIENT: Gannett Fleming, Inc.
Greenwood Village, CO

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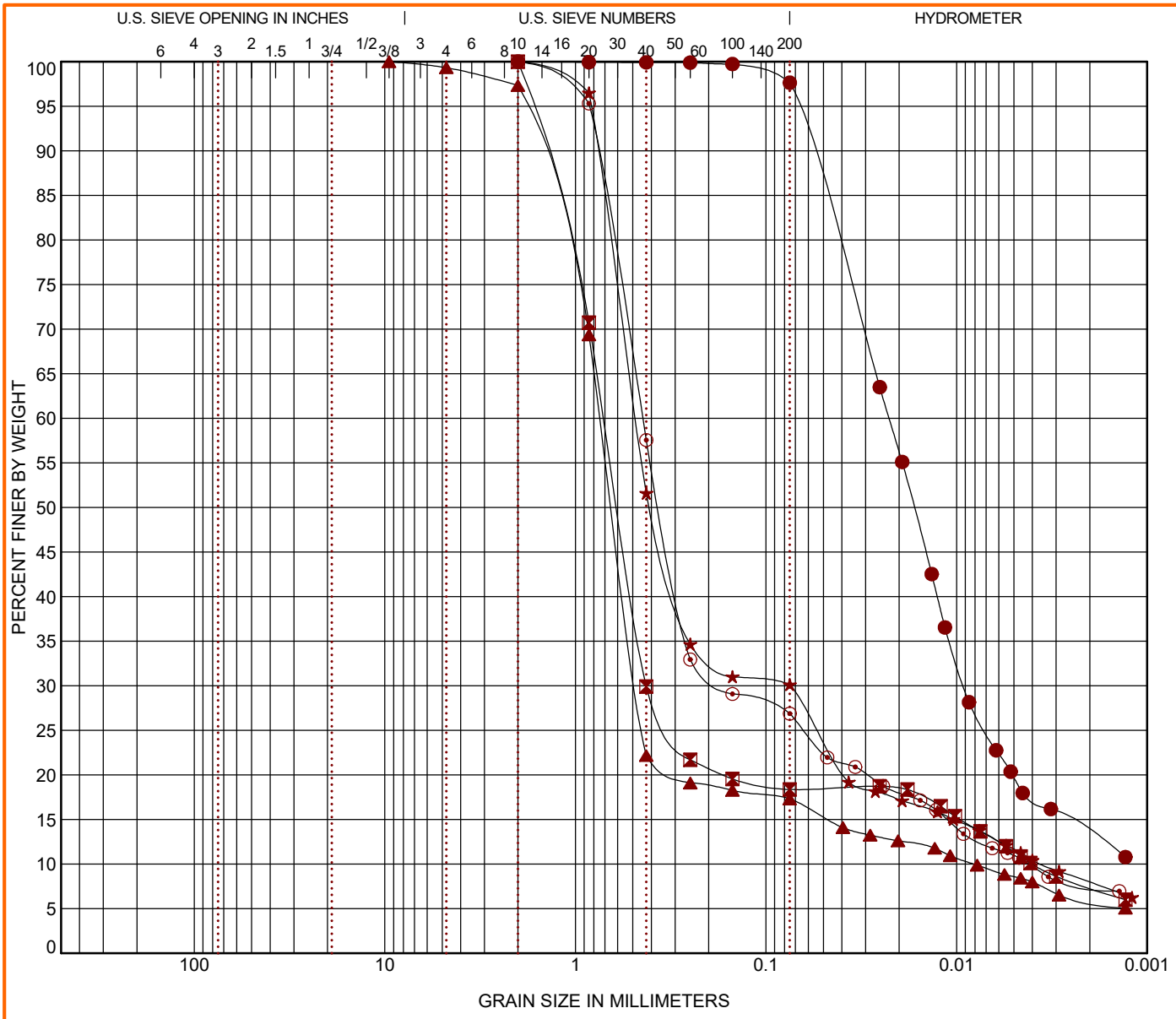

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-213	20 - 22	SILT (ML)	40.7	33	30	3		
FD2020-214	1.5	SILTY SAND (SM)		43	28	15	63.85	176.90
FD2020-608	0 - 5	SILTY SAND (SM)	16.3	38	40	NP	37.92	91.55
FD2020-608	10 - 11	SILTY, CLAYEY SAND (SC-SM)	22.6	27	21	6	3.20	135.21
FD2020-608	25 - 27.5	CLAYEY SAND (SC)	27.0	29	18	11	15.45	106.36

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-213	20 - 22	2	0.023	0.009		0.0	0.0	2.4	77.9		19.7
FD2020-214	1.5	2	0.708	0.426	0.004	0.0	0.0	81.6	7.0		11.4
FD2020-608	0 - 5	9.5	0.741	0.477	0.008	0.0	0.7	82.0	8.7		8.6
FD2020-608	10 - 11	2	0.484	0.074	0.004	0.0	0.0	69.9	18.5		11.7
FD2020-608	25 - 27.5	2	0.444	0.169	0.004	0.0	0.0	73.1	15.9		11.0

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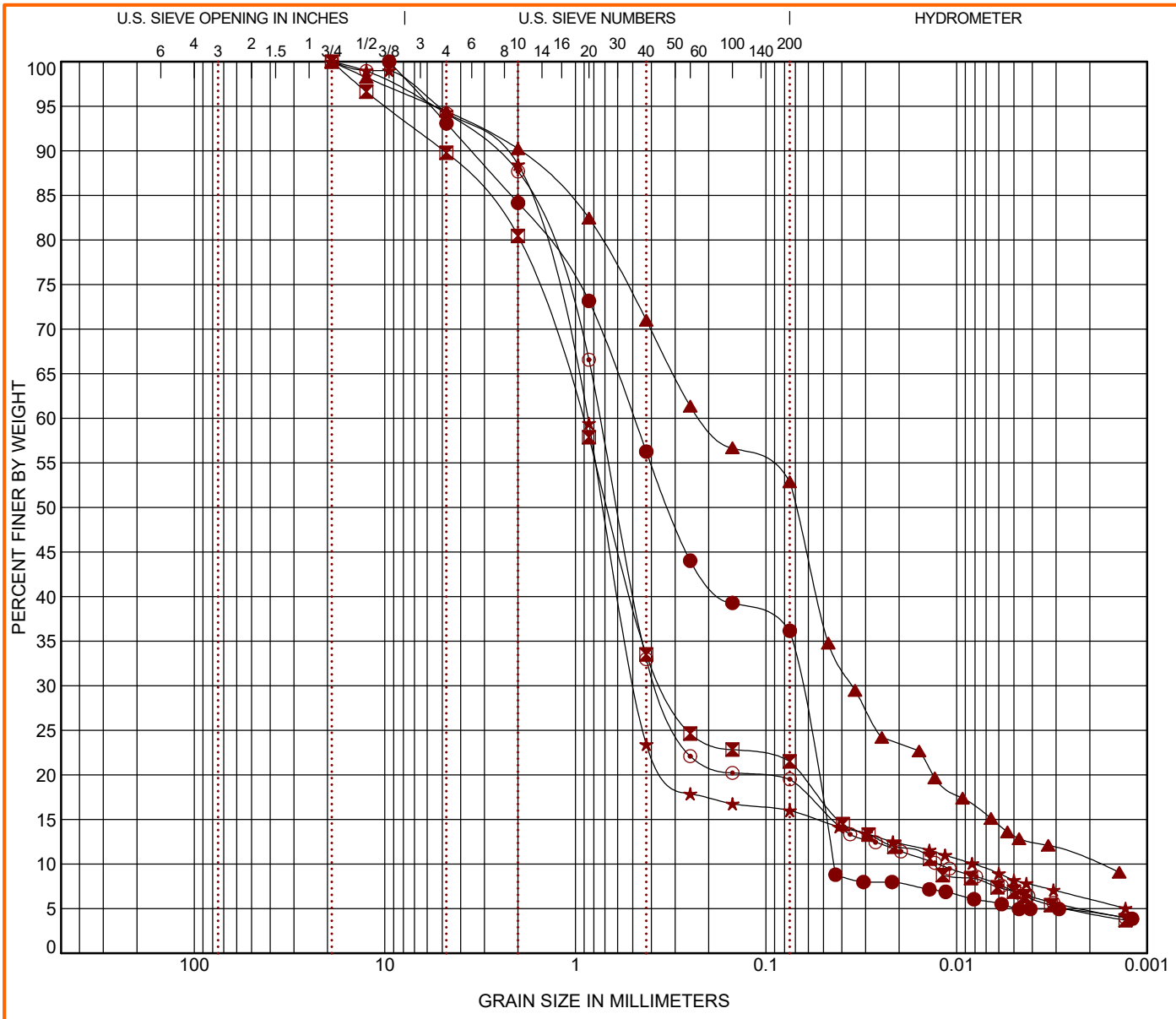

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-11	100 - 102.5	CLAYEY SAND (SC)	24.1	32	22	10	0.20	11.19
FD2020-212	0 - 5	CLAYEY SAND (SC)	14.7	45	22	23	9.83	70.27
FD2020-212	7.5 - 10	SANDY LEAN CLAY (CL)	19.1	40	22	18	3.16	118.28
FD2020-212	10 - 15	SILTY SAND (SM)	17.7	32	26	6	33.10	106.22
FD2020-213	2.5 - 7.5	SILTY SAND (SM)	11.3	31	25	6	14.52	59.22

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-11	100 - 102.5	9.5	0.495	0.066	0.044	0.0	6.9	56.9	31.0		5.1
FD2020-212	0 - 5	19	0.921	0.345	0.013	0.0	10.2	68.3	14.6		6.9
FD2020-212	7.5 - 10	19	0.215	0.035	0.002	0.0	5.6	41.6	39.7		13.2
FD2020-212	10 - 15	19	0.864	0.482	0.008	0.0	5.7	78.3	7.8		8.2
FD2020-213	2.5 - 7.5	19	0.742	0.368	0.013	0.0	5.8	74.7	12.6		7.0

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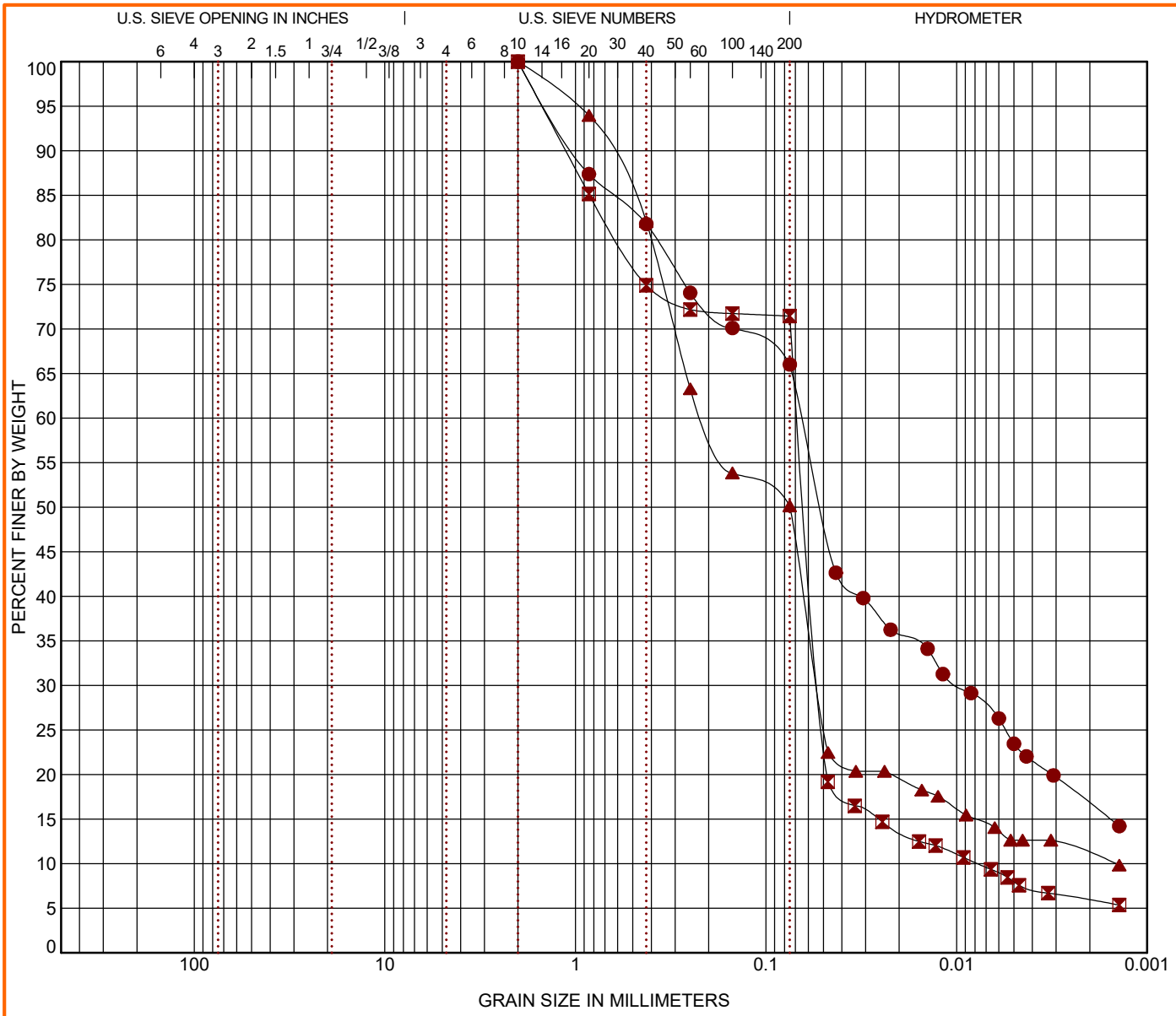

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-608	55 - 57	SANDY SILT (ML)	25.7	34	31	3		
FD2020-609	10 - 12.5	LEAN CLAY with SAND (CL)	34.4	39	24	15	5.18	8.77
FD2020-609	30 - 32	SANDY SILT (ML)	47.7	39	26	13	9.34	142.25

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-608	55 - 57	2	0.065	0.01		0.0	0.0	34.0	42.6		23.5
FD2020-609	10 - 12.5	2	0.068	0.052	0.008	0.0	0.0	28.6	63.5		8.0
FD2020-609	30 - 32	2	0.209	0.054	0.001	0.0	0.0	49.9	37.5		12.6

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aggregate to obtain a desired grading, provided that the gradings are not otherwise restricted by the project specifier and the nominal maximum size indicated by the size number is not exceeded,

4.3.3.2 The class designation (see 11.1 and Table 3),

4.3.3.3 Whether the restriction on reactive materials in 11.2 applies,

4.3.3.4 In the case of the sulfate soundness test (see Table 3), which salt is to be used. If none is stated, either sodium sulfate or magnesium sulfate shall be used, and

4.3.4 The person responsible for selecting the concrete proportions if other than the concrete producer.

4.3.5 Any exceptions or additions to this specification (see Note 1).

FINE AGGREGATE

5. General Characteristics

5.1 Fine aggregate shall consist of natural sand, manufactured sand, or a combination thereof.

6. Grading

6.1 *Sieve Analysis*—Fine aggregate, except as provided in 6.2 and 6.3 shall be graded within the following limits:

Sieve (Specification E 11)	Percent Passing
9.5-mm (⅜-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10

NOTE 2—Concrete with fine aggregate gradings near the minimums for percent passing the 300 µm (No.50) and 150 µm (No.100) sometimes have difficulties with workability, pumping or excessive bleeding. The addition of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

6.2 The fine aggregate shall have not more than 45 % passing any sieve and retained on the next consecutive sieve of those shown in 6.1, and its fineness modulus shall be not less than 2.3 nor more than 3.1.

6.3 Fine aggregate failing to meet these grading requirements shall meet the requirements of this section provided that the supplier can demonstrate to the purchaser or specifier that concrete of the class specified, made with fine aggregate under consideration, will have relevant properties (see Note 4) at least equal to those of concrete made with the same ingredients, with the exception that the reference fine aggregate shall be selected from a source having an acceptable performance record in similar concrete construction.

NOTE 3—Fine aggregate that conforms to the grading requirements of a specification, prepared by another organization such as a state transportation agency, which is in general use in the area, should be considered as having a satisfactory service record with regard to those concrete properties affected by grading.

NOTE 4—Relevant properties are those properties of the concrete that are important to the particular application being considered. STP 169C[8] provides a discussion of important concrete properties.

6.4 For continuing shipments of fine aggregate from a given source, the fineness modulus shall not vary more than 0.20 from the base fineness modulus. The base fineness modulus shall be that value that is typical of the source. The purchaser or specifier has the authority to approve a change in the base fineness modulus.

NOTE 5—The base fineness modulus should be determined from previous tests, or if no previous tests exist, from the average of the fineness modulus values for the first ten samples (or all preceding samples if less than ten) on the order. The proportioning of a concrete mixture may be dependent on the base fineness modulus of the fine aggregate to be used. Therefore, when it appears that the base fineness modulus is considerably different from the value used in the concrete mixture, a suitable adjustment in the mixture may be necessary.

7. Deleterious Substances

7.1 The amount of deleterious substances in fine aggregate shall not exceed the limits prescribed in Table 1.

7.2 *Organic Impurities*:

7.2.1 Fine aggregate shall be free of injurious amounts of organic impurities. Except as herein provided, aggregates subjected to the test for organic impurities and producing a color darker than the standard shall be rejected.

7.2.2 Use of a fine aggregate failing in the test is not prohibited, provided that the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.

7.2.3 Use of a fine aggregate failing in the test is not prohibited, provided that, when tested for the effect of organic impurities on strength of mortar, the relative strength at 7 days, calculated in accordance with Test Method C 87, is not less than 95 %.

7.3 Fine aggregate for use in concrete that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground shall not contain any materials that are deleteriously reactive with the alkalies in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, use of the fine aggregate is not prohibited when used with a cement containing less than 0.60 % alkalies calculated as sodium oxide equivalent ($Na_2O + 0.658K_2O$) or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction. (See Appendix X1.)

8. Soundness

8.1 Except as provided in 8.2 and 8.3, fine aggregate subjected to five cycles of the soundness test shall have a weighted average loss not greater than 10 % when sodium sulfate is used or 15 % when magnesium sulfate is used.

8.2 Fine aggregate failing to meet the requirements of 8.1 shall be regarded as meeting the requirements of this section provided that the supplier demonstrates to the purchaser or

[8] *Significance of Tests and Properties of Concrete and Concrete Making Materials, STP 169C*, ASTM, 1994.

Calc By: EJB, Nov. 2020
Checked By: TNK, Dec. 2020

Ref. 4

of the ND T 71 test result in a relative strength less than 95 percent, do not use the fine aggregate.

Table 802-04 Fine Aggregate Gradation	
Sieve Size	**Percent Passing**
3/8 Inch	100
No. 4	95 – 100
No. 16	45 – 80
No. 50	10 – 30
No. 100	0 – 10
No. 200	0 – 3.0

Table 802-05 Miscellaneous Fine Aggregate Properties		
Test	**Method**	**Requirement**
Soundness (sodium sulfate)	AASHTO T 104	10% max.
Lightweight pieces in Aggregate	ND T 113	2% max.

4. **Well Graded Aggregate.**
Use a well graded aggregate that meets the gradation in Table 802-06 and the properties specified in Table 802-02 and 802-05.

When testing material properties specified in Table 802-02 and Table 802-05, divide aggregate samples into course and fine aggregate on the No. 4 sieve.

Table 802-06 Well Graded Gradation	
Sieve Size	**Percent Passing**
1-1/4 inch	100
1 inch	95 – 100
3/4 inch	90 – 100
3/8 inch	55 – 70
No. 8	31 – 42
No. 16	18 – 35
No. 50	0.0 – 10
No. 200	0.0 – 3.0

D. **Water.**
Provide water as specified in Section 812, “Water.”

The water content of the mixed concrete includes the quantity of mixing water

Calc By: EJB, Nov. 2020
Checked By: TNK, Dec. 2020

Gannett Fleming

Excellence Delivered As Promised

Title: Derivation of D_{60} control points for filter/drain compatibility analysis.

Project:
Job #:

Objective: Determine D_{60min} and D_{60max} for CU = 4.5 to adjust filter/drain gradation limits for NRCS Filter Drain Design.

References:
5.1. NRCS Part 633 National Engineering Handbook, Chapter 26, 2017.
5.2. McCook, D. "Filter Design - A Step by Step Approach." ASDSO Webinar. 2010.

Purpose: The filter/drain design criteria presented in Ref. 1 assumes an initial coefficient of uniformity, CU, of 6. However, filter bands may be adjusted to a steeper configuration with CU values less than 6 if needed, for instance to determine the practicality of a readily available aggregate. Ref. 1 states that assuming a CU less than 6 is acceptable provided the CU remains greater than 2 and the other filter and permeability criteria are satisfied.

An adjustment to the initial assumption of CU = 6 must be made to verify that AASHTO No. 8 Coarse Aggregate is compatible with ASTM C-33 Fine Aggregate (i.e., concrete sand) for purposes of designing a dual aggregate filter.

Calculation: Assume that CU = 4

The coefficient of uniformity is defined as the ratio of % passing the 60 sieve to % passing the 10 sieve.

$$CU = \frac{D_{60}}{D_{10}} = 4.0$$

Because the grain size distribution is log based, $\log(D_{60}) - \log(D_{10}) = \log(4.0) = 0.602$

By definition, the slope of a line is: $\frac{\Delta y}{\Delta x} = \frac{60 - 10}{\log(D_{60}) - \log(D_{10})} \quad \frac{50}{\log(4.0)} = 83$

Therefore, $\frac{\Delta y}{\Delta \log(x)} = 83$ or, rearranging: $\Delta \log(x) = \frac{\Delta y}{83}$

Assuming a constant slope, for the relationship between D_{60} and D_{15}:

$$\log(D_{60}) - \log(D_{15}) = \frac{60 - 15}{83} = 0.542$$

Raise both sides to the power of 10 to eliminate the logs:

$$\frac{D_{60}}{D_{15}} = 10^{0.542} = 3.483 \qquad \text{Thus,} \quad D_{60} = 3.483 \text{ x } D_{15}$$

(This is for both minimum and maximum boundaries)

When completing Step 9 in Ref. 1, $D_{10max} = \frac{D_{15max}}{1.2}$ The 1.2 factor is based on Cu=6.

To find the appropriate conversion factor, CF, for a desired Cu. Using a Cu of 4.0 as presented above:

$$\frac{D_{60}}{D_{15}} \cdot CF = \frac{D_{60}}{D_{10}} \quad \text{----->} \quad 3.483 \cdot CF = 4.0 \quad \text{----->} \quad CF = 1.15$$

Or, simplified into one equation:

$$Cu := 6 \qquad Conversion_Factor := \frac{Cu}{10^{\left[\frac{(60-15)}{\frac{(60-10)}{\log(Cu)}}\right]}} = 1.196 \qquad \text{say 1.2}$$

$$Cu := 4.0 \qquad Conversion_Factor := \frac{Cu}{10^{\left[\frac{(60-15)}{\frac{(60-10)}{\log(Cu)}}\right]}} = 1.149 \qquad \text{say 1.15}$$

The revised D_{60} then is computed by dividing the D_{15} by 1.15 instead of 1.2 per Ref. 2:

$D_{15max} := 0.7mm$

$D_{10max} := \frac{D_{15max}}{1.15} = 0.61 \cdot mm$

Using the newly assumed Cu = 4.0, compute the revised D_{60} max:

$D_{60max} := 4.0 \cdot D_{10max} = 2.43 \cdot mm$

Compute the revised D_{60} min by using the filter band width of 5:

$D_{60min} := \frac{D_{60max}}{5} = 0.49 \cdot mm$

McCook, D.K. "Filter Design - A Step by Step Approach" [illegible]
2/18/10, Supplemental Materials.

Ref. 5.2

Appendix 1

Derivation of location of Minimum and Maximum D_{60} control points

Two requirements are stated for a filter band to prevent possible gap-graded filters. The coefficient of uniformity, CU, is set initially at no flatter than 6. The width of the filter band is set at 5.

The definition of the coefficient of uniformity CU is the ratio $D_{60} \div D_{10}$, Then if $D_{60} \div D_{10} = 6$,

$$\log_{10}(D_{60}) - \log_{10}(D_{10}) = \log_{10}(6) = 0.7782$$

The equation for the slope of a line is given as follows, for the line between D_{60} and D_{10}.

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{50}{\text{Log}_{10} D_{60} - \text{Log}_{10} D_{10}}$$ Substituting then,

$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{50}{0.7782} = 64.25486$$

In general then, $\frac{\Delta y}{\Delta \text{Log} x} = 64.25486$

Then for the relationship between D_{60} and D_{15}, rearranging the equation

$$\text{Log}D_{60} - \text{Log}D_{15} = \frac{45}{64.25486} = 0.700336$$ Then,

$$\frac{D_{60}}{D_{15}} = 10^{0.700336} \cong 5$$

Because the ratio of the Minimum and Maximum D_{sizes} is 5, and because the ratio of the D_{60} to the D_{15} size is 5, then it is obvious that the Minimum D_{60} size is equal to the Maximum D_{15} size, as follows:

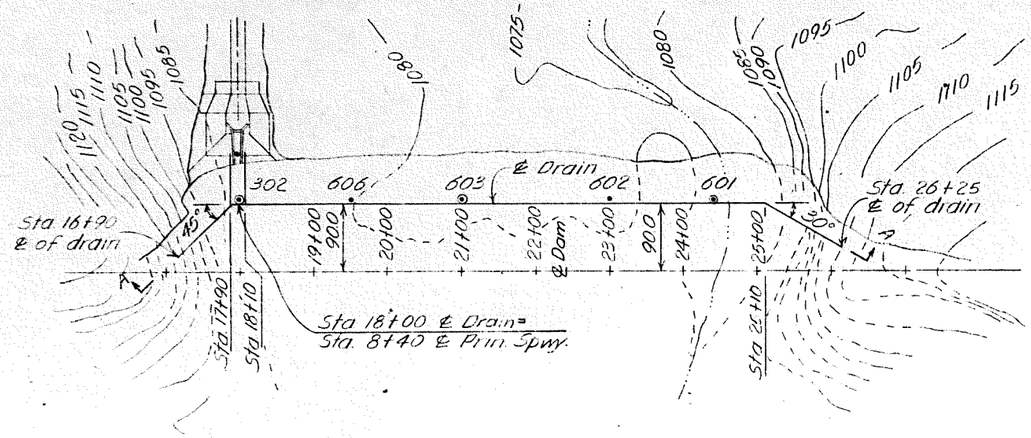
D_{60} Max = 5 * D_{15} Max D_{60} Max also = 5 * D_{60} Min

Therefore, 5 * D_{15} Max = 5 * D_{60} Min

and, D_{15} Max = D_{60} Min

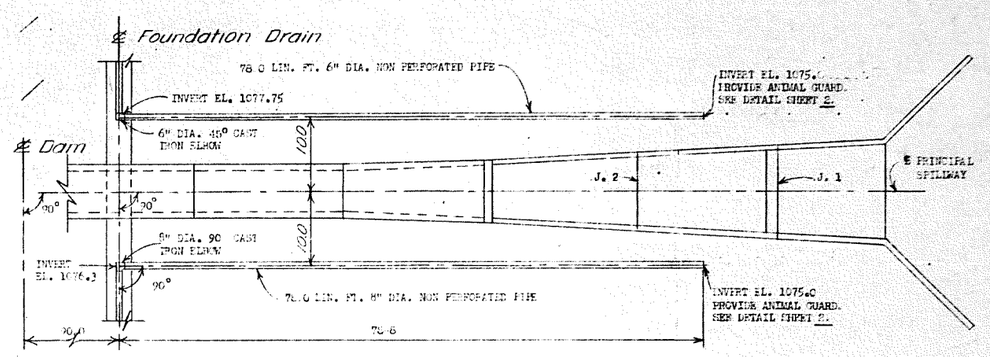
Calc By: EJB, Nov. 2020
Checked By: TNK, Dec. 2020

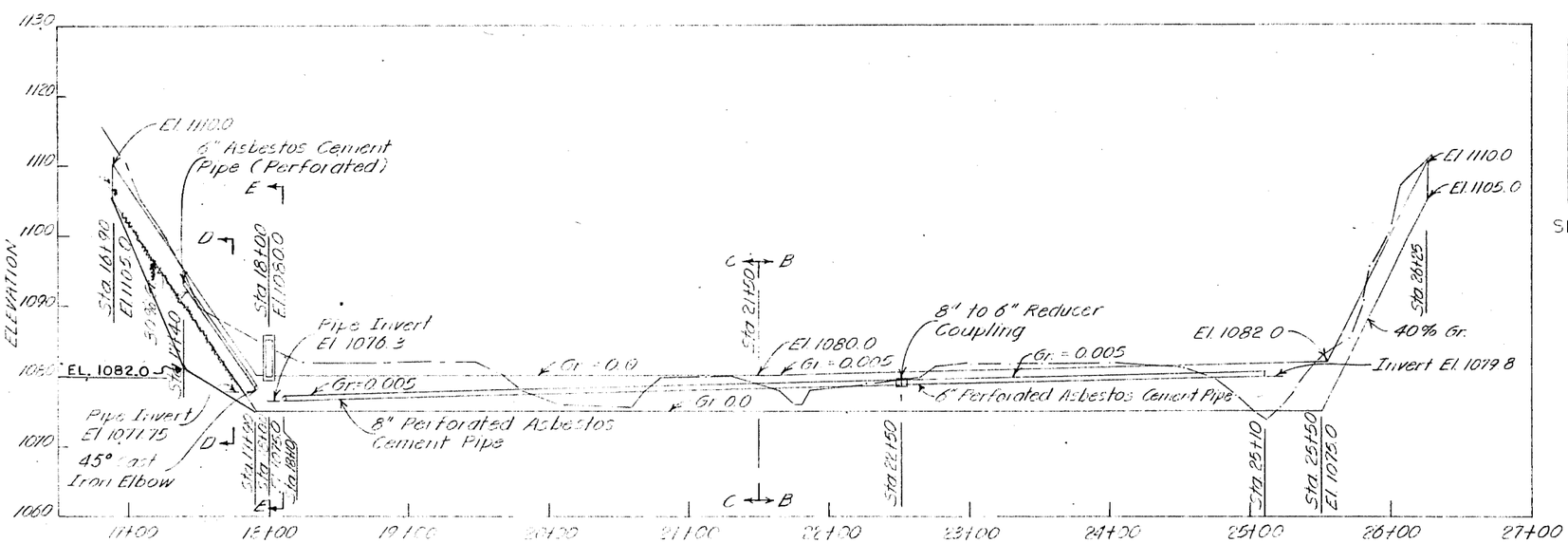
Ref. 6



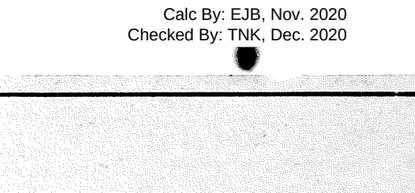
PLAN OF BASE OF DAM SHOWING FOUNDATION DRAIN

100 50 0 100 200 300
Scale in Feet

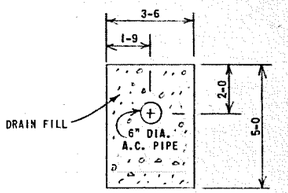




SECTION A-A
PROFILE ALONG ℄ OF TRANSVERSE FOUNDATION DRAIN



SECTION B-B SECTION C-C



SECTION D-D

AS BUILT
NOV 15 1978

NOTES:
1. PROVIDE ANIMAL GUARD AT OUTLET END OF OUTLET PIPES. FOR DETAILS OF ANIMAL GUARDS, SEE SHEET 2.
2. PLUG UPPER END OF PIPES WITH 6" OF CONCRETE OR PREFABRICATED CAP.
3. THE DEPTH OF FILL OVER THE DRAIN PIPE SHALL BE AT LEAST 2' BEFORE PASSING HEAVY EQUIPMENT OVER THE PIPE.
4. WHERE THE TRANSVERSE DRAIN TRENCH IS ABOVE THE GROUND LINE, PLACE COMPACTED EARTH FILL TO ELEVATION AT TOP OF DRAIN AND EXCAVATE DRAIN IN COMPACTED FILL.
5. STA. 17+90 THRU STA. 25+10 OF THE DRAIN CENTERLINE COINCIDE WITH STA. 17+90 THRU 25+10 OF THE DAM CENTERLINE.
6. PLACE TWO LAYERS OF ROOFING FELT UNDER THE PRINCIPAL SPILLWAY CONDUIT AT ITS INTERSECTION WITH THE FOUNDATION DRAIN.
7. DRAIN PIPE WILL OUTLET THROUGH RIPRAP. PLACE RIPRAP AROUND OUTLET AS DIRECTED BY ENGINEER.

DRAIN FILL GRADATION

SIEVE SIZE	PERCENT PASSING
3"	100
1"	90 - 100
#4	45 - 70
#10	10 - 50
#16	0 - 35
#40	5

QUANTITIES

ITEM	UNIT	QUANTITY
DRAIN FILL MATERIAL	CU.YD.	660
8" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	440
8" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
6" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	310
6" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
8" DIA. 90° CAST IRON ELBOW	EACH	1
6" DIA. 45° CAST IRON ELBOW	EACH	1
8" TO 6" DIA. REDUCER COUPLING	EACH	1

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	L.M.S.	9/71	Approved by	
Drawn	D.L.J.	12/71	Title	
Traced			Title	
Checked	C.E.M.	12/71	Sheet No. 11 of 40	Drawing No. 5-E-29,772

SCS-ENG-11-B Rev. 7-69

Gannett Fleming

Excellence Delivered As Promised

Title: Compatibility of Embankment Soils

Project: Fordville Dam, Grand Forks County, ND
Project No.: 66441
Objective: The existing Fordville Dam embankment consists of a clay core (Zone I) with a sandy shell (Zone II). Check compatibility to determine if Zone II is adequate to act as a filter/drain for Zone I. Also consider foundation material sampled in the immediate vicinity of the Zone I material based on the limits provided by the As-Built Drawings (Ref. 4).

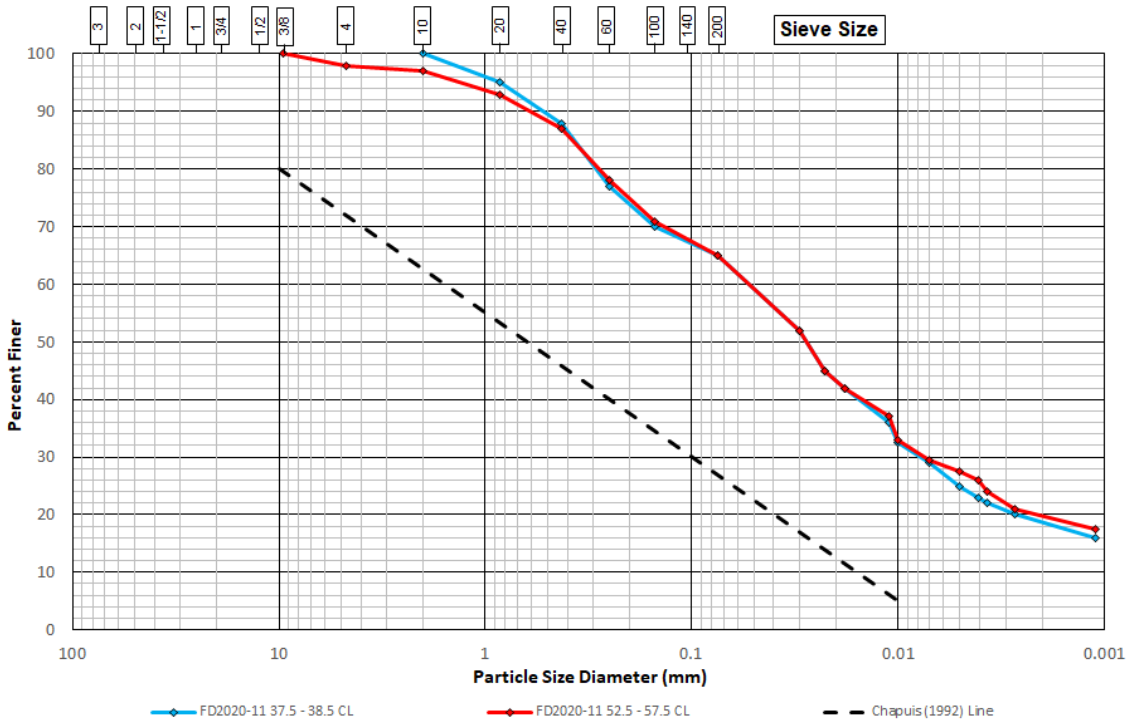
References:

1. NRCS Part 633, Chapter 26, Appendix 26A, Aug 2017.
2. Terracon. 2020. Laboratory Testing Reports.
3. Gannett Fleming. Derivation of D_{60} Control Points for Filter Compatibility Analysis. Nov. 2020
4. U.S. Department of the Interior. Soil Conservation Service. 1978. Middle-South Branch Forest River Watershed Dam 4 (Fordville Dam). "As-Built" Drawings.

Methodology: Use NRCS design criteria to determine a gradation band of suitable filter/drain material. This material will be required to act primarily as a drain, but also as a filter to prevent piping. The computed band will be compared with gradations obtained from Zone II material.

Step 1: Plot the gradation curves. This analysis considers both of the laboratory classified samples identified as Zone I embankment material.

Figure 1. Zone I Embankment



Step 2: Determine if base soils have particles larger than the No. 4 sieve and determine if base soils are gap-graded or potentially internally unstable.

FD2020-11 52.5'-57.5' contains a small fraction of gravel, approximately 3% per the laboratory gradation. The FD2020-11 37.5'-38.5' sample has no gravel and does not need to be regraded.

Internally unstable soils are generally characterized by a gradation curve flatter than 25% as defined by Chapuis (1992). Per Ref. 1, a line with a 25% slope, i.e., a "Chapuis Line" is plotted on Figure 1. By inspection, the laboratory gradations included in this analysis do not appear to be internally unstable.

Step 3: Prepare adjusted gradation curve for base soils that have particles larger than the No. 4 sieve.

a) Obtain a correction factor by dividing 100% by the percent passing the No. 4 sieve. Then multiply the correction factor by the original % passing gradations.

For example, gradation for FD2020-11 52.5'-57.5':

$$\%_{passing4sieve} := 99$$

$$Correction_{factor} := \frac{100}{\%_{passing4sieve}}$$

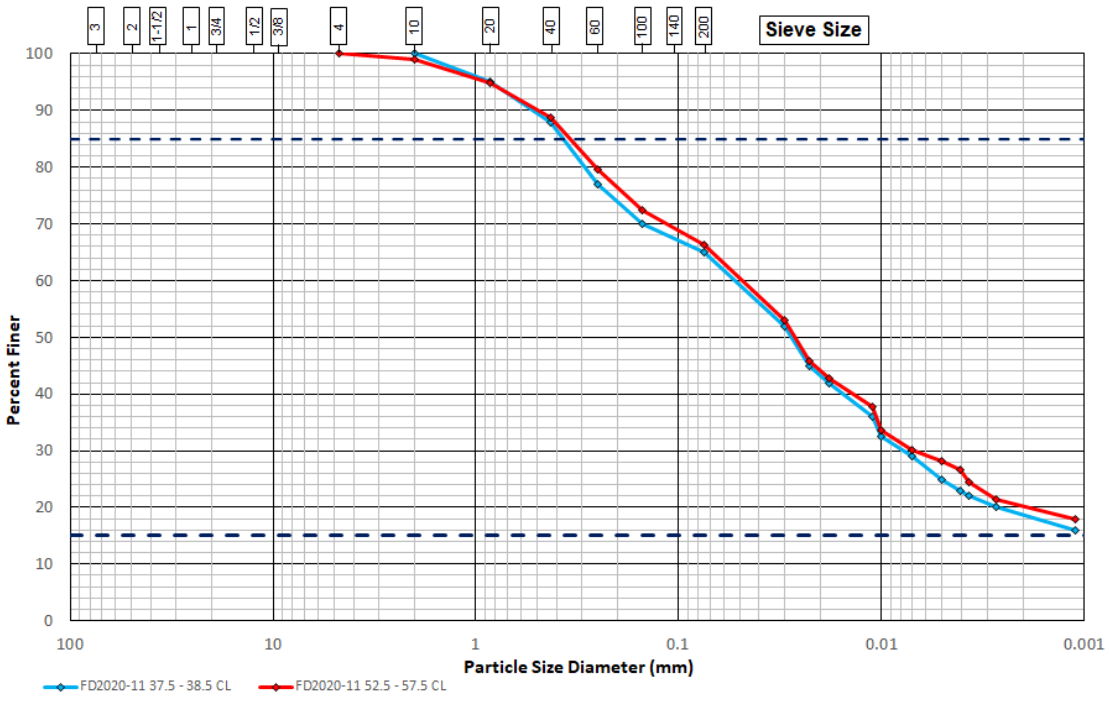
$$Sieve := \begin{pmatrix} \text{"No. 4"} \\ \text{"No. 10"} \\ \text{"No. 20"} \\ \text{"No. 40"} \\ \text{"No. 60"} \\ \text{"No. 100"} \\ \text{"No. 200"} \end{pmatrix} \qquad FD2020_11 := \begin{pmatrix} 98 \\ 97 \\ 93 \\ 87 \\ 78 \\ 71 \\ 65 \end{pmatrix} = \begin{pmatrix} 98 \\ 97 \\ 93 \\ 87 \\ 78 \\ 71 \\ 65 \end{pmatrix}$$

Adjusted Gradations
FD2020-11 52.5'-57.5' CL:

$$FD2020_11_{adj} := FD2020_11 \cdot Correction_{factor}$$

$$Sieve = \begin{pmatrix} \text{"No. 4"} \\ \text{"No. 10"} \\ \text{"No. 20"} \\ \text{"No. 40"} \\ \text{"No. 60"} \\ \text{"No. 100"} \\ \text{"No. 200"} \end{pmatrix} \qquad FD2020_11_{adj} = \begin{pmatrix} 99 \\ 98 \\ 94 \\ 88 \\ 79 \\ 72 \\ 66 \end{pmatrix}$$

Figure 2. Regraded Zone I Embankment



Step 4: Place the base soil in a Category determined by the percent passing the No. 200 sieve from the regraded gradation curve data according to Ref. 1 Table 26-1.

Table 26–1 Base soil categories

Base soil category	Percent finer than No. 200 sieve (0.075 mm) (after regrading where applicable)	Base soil description
1	> 85	Fine silt and clays
2	40–85	Sands, silts, clays, and silty sands
3	15–39	Silty and clayey sands and gravels
4	< 15	Sands and gravels

Both Zone I soils are Category 2.

Step 5: To satisfy filtration requirements, determine the maximum allowable D_{15} size for the filter/drain in accordance with Ref. 1 Table 26-2.

Table 26–2 Filtering criteria

Base soil category	Filtering—maximum D_{15}
1	The maximum D_{15} should be $\le 9 \times d_{85}$ of the base soil, but not less than 0.2 mm, unless the soils are dispersive. Dispersive soils in category 1 require a filter with a maximum D_{15} that is ≤ 6.5 times the d_{85} of the base soil size, but not less than 0.2 mm.
2	The maximum D_{15} should be ≤ 0.7 mm unless soil is dispersive, in which case the maximum D_{15} should be < 0.5 mm.
3	The maximum D_{15} should be: $\le \left(\frac{40-A}{40-15}\right)\left[(4 \times d_{85}) - 0.7\ \text{mm}^*\right] + 0.7\ \text{mm}^*$ A = percent passing No. 200 sieve after regrading (when $4 \times d_{85}$ is less than 0.7 mm*, use 0.7 mm*).
4	The maximum D_{15} should be $\le 4 \times d_{85}$ of base soil after regrading.

* If fines are dispersive, use 0.5 mm rather than 0.7 mm.

Zone I soils are not dispersive, therefore use $D_{15_max} := 0.7mm$

Step 6: Establish a minimum D_{15} as the greater of:

- 0.1 mm
- a fifth of the maximum D_{15} size established in step 5
- In some cases, this minimum D_{15} size may be too fine for adequate permeability, and the preliminary design band may need to be narrowed at this step by shifting the minimum D_{15} to be slightly coarser.

$$D_{15_min} := \text{if}\left(\frac{D_{15_max}}{5} \le 0.1mm, 0.1mm, \frac{D_{15_max}}{5}\right) = 0.14 \cdot mm$$

Step 7: Establish the minimum and maximum D_{60} sizes of the filter band. Preliminarily assume $C_U = 6$ and band width of 5 per recommendations in Ref. 1.

$D_{60_min} := D_{15_max} = 0.7 \cdot mm$ $D_{60_max} := 5 \cdot D_{60_min} = 3.5 \cdot mm$

Step 8: Establish the maximum particle size and maximum percentage passing No. 200 sieve.

$D_{100_max} := 2in = 50.8 \cdot mm$ $D_{5_min} := 0.075mm$

Step 9: Check segregation potential, determine minimum D_{10} and maximum D_{90}.

Table 26–3 Segregation criteria

Base soil category	If D_{10} is: (mm)	Then, maximum D_{90} is: (mm)
ALL categories	< 0.5	20
	0.5-1.0	25
	1.0-2.0	30
	2.0-5.0	40
	5.0-10	50
	> 10	60

$D_{10_min} := \frac{D_{15_min}}{1.2} = 0.1 \cdot mm$ $D_{90_max} := 20mm$

Establish Filter Criteria for Zone I Soils:

Preliminary Control Points:

$$Fine_{CP} := \begin{pmatrix} D_{60_min} \\ D_{15_min} \\ D_{5_min} \end{pmatrix} \qquad Fine_{CP} = \begin{pmatrix} 0.7 \\ 0.14 \\ 0.08 \end{pmatrix} \cdot mm$$

$$Coarse_{CP} := \begin{pmatrix} D_{100_max} \\ D_{90_max} \\ D_{60_max} \\ D_{15_max} \end{pmatrix} \qquad Coarse_{CP} = \begin{pmatrix} 50.8 \\ 20.0 \\ 3.5 \\ 0.7 \end{pmatrix} \cdot mm$$

The control points of Zone I soils are presented in Figure 3. Per Ref. 1, the control points can be somewhat modified by revising previous assumptions, e.g., the assumed $C_u = 6$ can be revised such

that filter C_u is less than 6, but greater than 2 such that a commercially available aggregate will fit within the control points. However, the minimum and maximum D_{15} are the critical control points and manipulation of these points is not generally recommended.

Figure 3. Preliminary Design Filter Gradation Criteria for Zone I Soils

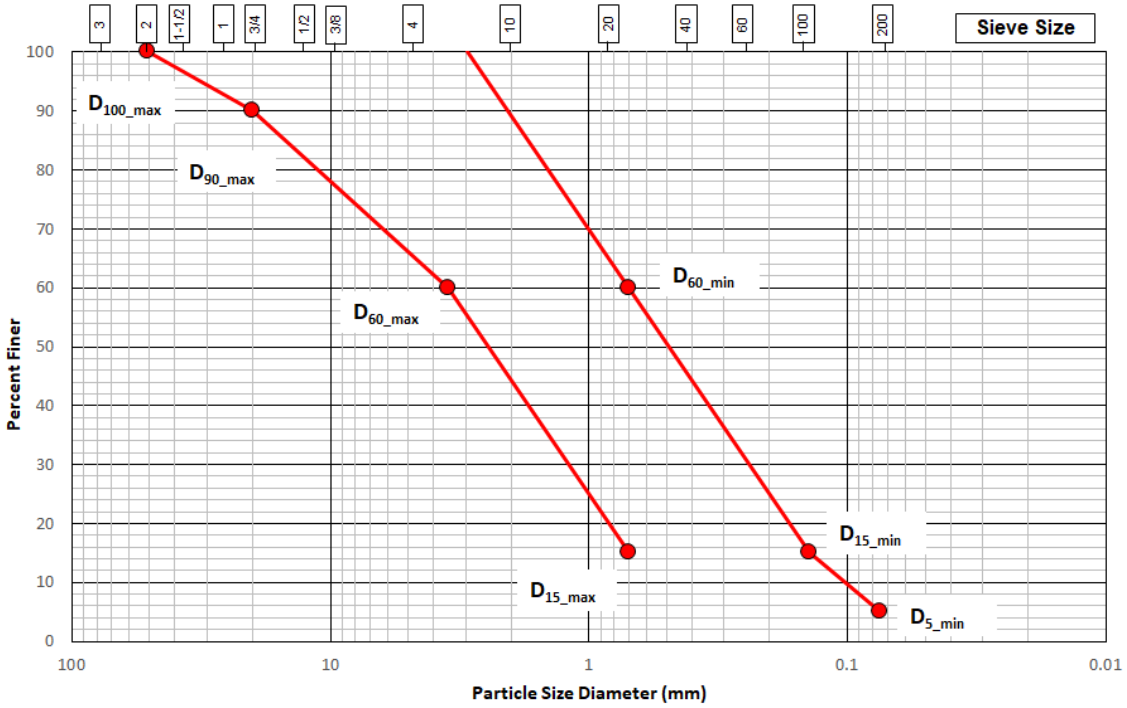
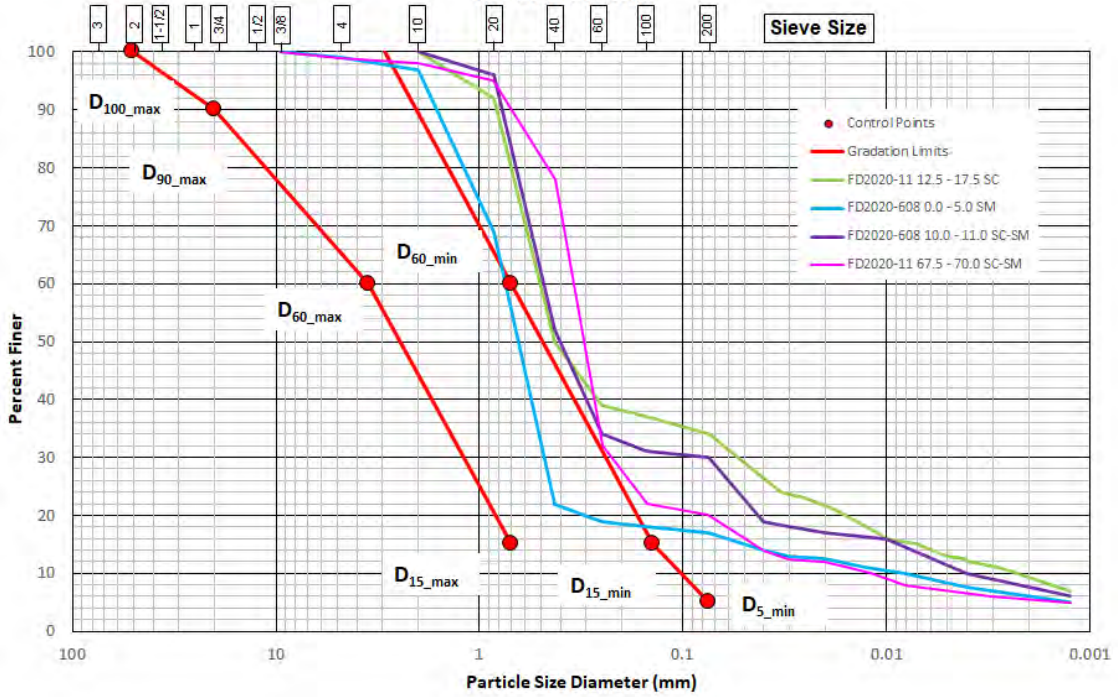


Figure 4 shows the design filter range for Zone I soils compared with Zone II soils and encountered foundation soils immediately adjacent to Zone I (e.g., FD2020-11 67.5-70'). Per Figure 4, the existing Zone I soils do not appear to be compatible with Zone II soils. However, if the Cu is assumed equal to 2 (rather than 6), the gradations fit better within the design gradation band (See Figure 5).

Figure 4. Preliminary Design Filter Gradation Criteria for Zone I Soils



Adjust D_{60min} and D_{60max} control points based on a Cu = 2.0 instead of 6.0. Use the relationship of D_{15} and D_{10} per Ref. 1 Step 9 to determine the a new D_{60}. The 1.2 factor used in Step 9 becomes 1.07 for a Cu = 2.0 (see Ref. 3).

$$D_{10_max} := \frac{D_{15_max}}{1.07} = 0.654 \cdot mm \qquad D_{60_max_adj} := D_{10_max} \cdot 2.0 = 1.3 \cdot mm$$

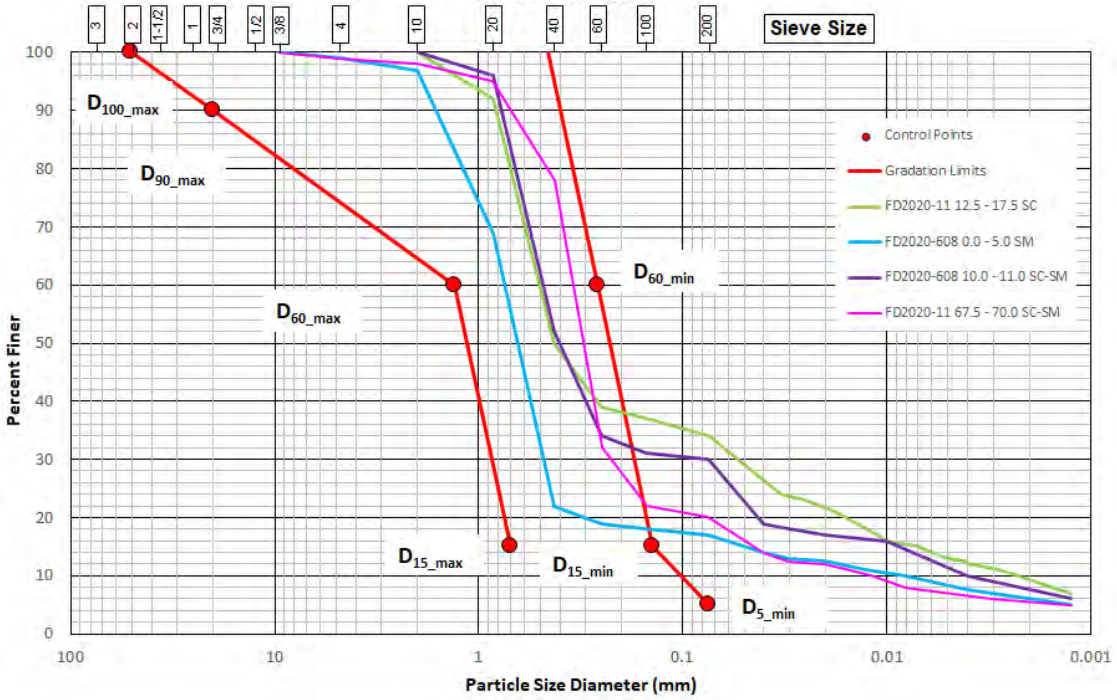
$$D_{10_min_adj} := \frac{D_{15_min}}{1.07} = 0.131 \cdot mm \qquad D_{60_min_adj} := D_{10_min_adj} \cdot 2.0 = 0.26 \cdot mm$$

The revised Control Points are then:

$$Fine_{CP_adj} := \begin{pmatrix} D_{60_min_adj} \\ D_{15_min} \\ D_{5_min} \end{pmatrix} \qquad Fine_{CP_adj} = \begin{pmatrix} 0.26 \\ 0.14 \\ 0.08 \end{pmatrix} \cdot mm$$

$$Coarse_{CP_adj} := \begin{pmatrix} D_{100_max} \\ D_{90_max} \\ D_{60_max_adj} \\ D_{15_max} \end{pmatrix} \qquad Coarse_{CP_adj} = \begin{pmatrix} 50.8 \\ 20.0 \\ 1.3 \\ 0.7 \end{pmatrix} \cdot mm$$

Figure 5. Revised Design Filter Gradation Criteria for Zone I Soils



Based on the revised control points with Cu assumed to be equal to 2.0, the +38% finer fraction is entirely within the design filter band. From a filtration standpoint, Zone II and the adjacent foundation material represented by FD2020-11 67.5'-70.0 SC-SM are compatible. However, Zone II does not have sufficient drainage capacity to convey water from the Zone I core - which is not necessarily a dam safety concern because the clay core is supposed to retain water, not convey water.

Conclusion:

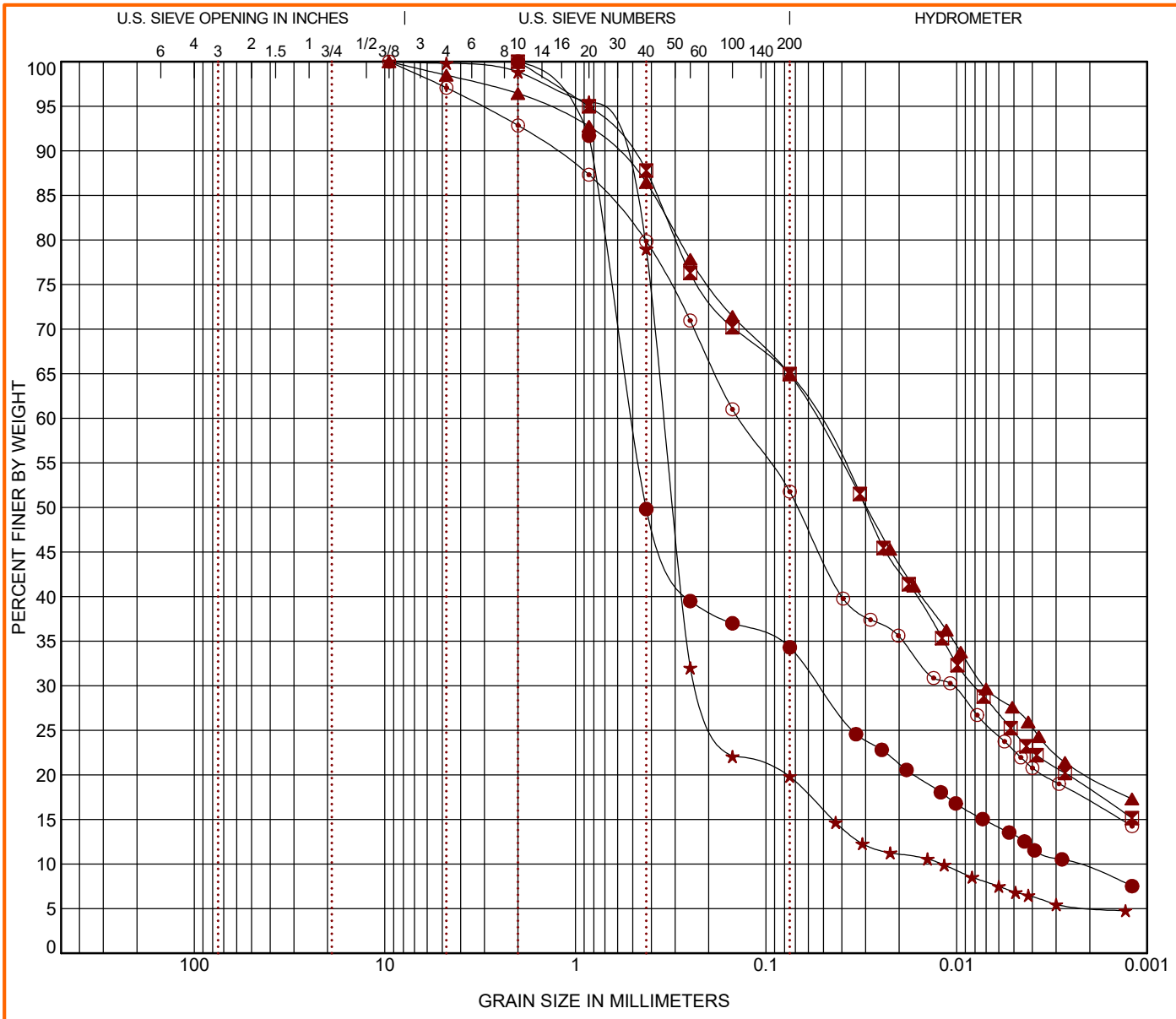
The Zone I core material is compatible with Zone II and foundation soils (e.g., FD2020-11 67.5'-70.0') with regards to filtration and therefore not susceptible to piping/suffusion into the these adjacent materials.

Ref. 2

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

Calc By: EJB, Nov. 2020
Checked By: TNK, Dec. 2020



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
FD2020-11	12.5 - 17.5	Zone II CLAYEY SAND (SC)	17.8	29	19	10	2.28	208.53
FD2020-11	37.5 - 39.5	Zone I SANDY LEAN CLAY (CL)	14.0	39	19	20		
FD2020-11	52.5 - 57.5	Zone I SANDY LEAN CLAY (CL)	16.4	40	19	21		
FD2020-11	67.5 - 70	Foundation SILTY, CLAYEY SAND (SC-SM)	29.6	24	20	4	12.39	28.65
FD2020-11	82.5 - 85	SANDY SILT (ML)	27.5	32	24	8		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
FD2020-11	12.5 - 17.5	2	0.503	0.053	0.002	0.0	0.0	65.7	21.1		13.2
FD2020-11	37.5 - 39.5	2	0.055	0.008		0.0	0.0	35.0	40.1		24.8
FD2020-11	52.5 - 57.5	9.5	0.055	0.007		0.0	1.5	33.6	37.5		27.4
FD2020-11	67.5 - 70	9.5	0.343	0.226	0.012	0.0	0.2	80.0	12.9		6.9
FD2020-11	82.5 - 85	9.5	0.139	0.011		0.0	2.9	45.3	29.1		22.7

PROJECT: Fordville Dam

PROJECT NUMBER: M5205037

SITE: 43rd Street NE
Fordville, ND

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND

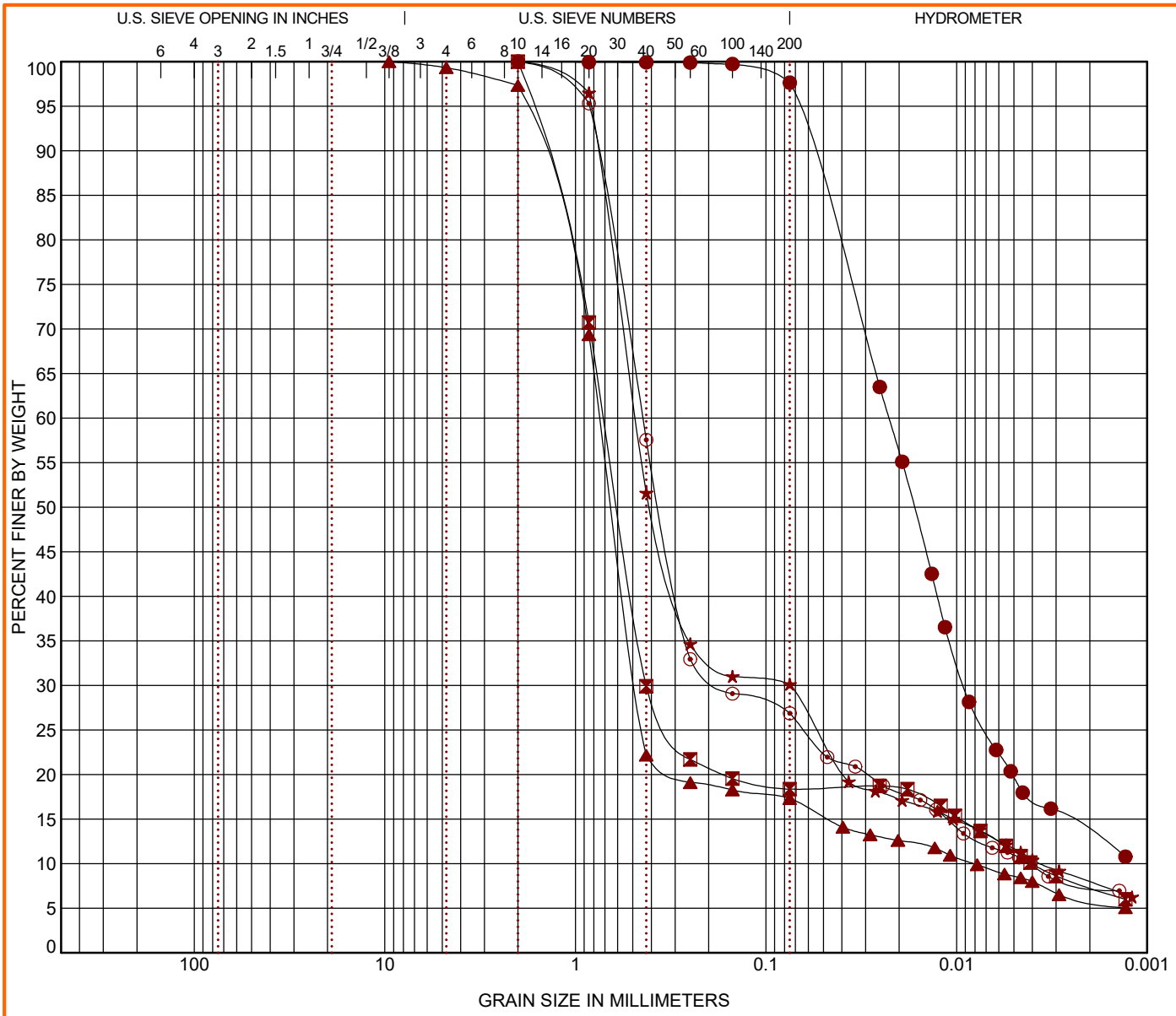
CLIENT: Gannett Fleming, Inc.
Greenwood Village, CO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 M5205037 FORDVILLE DAM.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136

Calc By: EJB, Nov. 2020
Checked By: TNK, Dec. 2020



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Boring ID		Depth	USCS Classification		WC (%)	LL	PL	PI	Cc	Cu
●	FD2020-213	20 - 22	SILT (ML)		40.7	33	30	3		
⊠	FD2020-214	1.5	SILTY SAND (SM)			43	28	15	63.85	176.90
▲	FD2020-608	0 - 5	Zone II	SILTY SAND (SM)	16.3	38	40	NP	37.92	91.55
★	FD2020-608	10 - 11	Zone II	SILTY, CLAYEY SAND (SC-SM)	22.6	27	21	6	3.20	135.21
⊙	FD2020-608	25 - 27.5	CLAYEY SAND (SC)		27.0	29	18	11	15.45	106.36

Boring ID		Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Cobbles	%Gravel	%Sand	%Silt	%Fines	%Clay
●	FD2020-213	20 - 22	2	0.023	0.009		0.0	0.0	2.4	77.9		19.7
⊠	FD2020-214	1.5	2	0.708	0.426	0.004	0.0	0.0	81.6	7.0		11.4
▲	FD2020-608	0 - 5	9.5	0.741	0.477	0.008	0.0	0.7	82.0	8.7		8.6
★	FD2020-608	10 - 11	2	0.484	0.074	0.004	0.0	0.0	69.9	18.5		11.7
⊙	FD2020-608	25 - 27.5	2	0.444	0.169	0.004	0.0	0.0	73.1	15.9		11.0

PROJECT: Fordville Dam

SITE: 43rd Street NE
Fordville, ND

Terracon
1555 N 42nd St, Unit B
Grand Forks, ND

PROJECT NUMBER: M5205037

CLIENT: Gannett Fleming, Inc.
Greenwood Village, CO

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 M5205037 FORDVILLE DAM.GPJ TERRACON_DATATEMPLATE.GDT 8/25/20

REF. 3

Calc By: EJB, Nov. 2020
Checked By: TNK, Dec. 2020

Gannett Fleming

Excellence Delivered As Promised

Title: Derivation of D_{60} control points for filter/drain compatibility analysis.

Project:
Job #:

Objective: Determine D_{60min} and D_{60max} for CU = 4.5 to adjust filter/drain gradation limits for NRCS Filter Drain Design.

References:
1. NRCS Part 633 National Engineering Handbook, Chapter 26, 2017.
2. McCook, D. "Filter Design - A Step by Step Approach." ASDSO Webinar. 2010.

Purpose: The filter/drain design criteria presented in Ref. 1 assumes an initial coefficient of uniformity, CU, of 6. However, filter bands may be adjusted to a steeper configuration with CU values less than 6 if needed, for instance to determine the practicality of a readily available aggregate. Ref. 1 states that assuming a CU less than 6 is acceptable provided the CU remains greater than 2 and the other filter and permeability criteria are satisfied.

An adjustment to the initial assumption of CU = 6 must be made to verify that AASHTO No. 8 Coarse Aggregate is compatible with ASTM C-33 Fine Aggregate (i.e., concrete sand) for purposes of designing a dual aggregate filter.

Calculation: Assume that CU = 2

The coefficient of uniformity is defined as the ratio of % passing the 60 sieve to % passing the 10 sieve.

$$CU = \frac{D_{60}}{D_{10}} = 2.0$$

Because the grain size distribution is log based, $\log(D_{60}) - \log(D_{10}) = \log(2.0) = 0.301$

By definition, the slope of a line is: $\frac{\Delta y}{\Delta x} = \frac{60 - 10}{\log(D_{60}) - \log(D_{10})} \quad \frac{50}{\log(2.0)} = 166$

Therefore, $\frac{\Delta y}{\Delta \log(x)} = 166$ or, rearranging: $\Delta \log(x) = \frac{\Delta y}{166}$

Assuming a constant slope, for the relationship between D_{60} and D_{15}:

$$\log(D_{60}) - \log(D_{15}) = \frac{60 - 15}{166} = 0.271$$

Raise both sides to the power of 10 to eliminate the logs:

$$\frac{D_{60}}{D_{15}} = 10^{0.271} = 1.866 \qquad \text{Thus,} \quad D_{60} = 1.866 \times D_{15}$$

(This is for both minimum and maximum boundaries)

When completing Step 9 in Ref. 1, $D_{10max} = \frac{D_{15max}}{1.2}$ The 1.2 factor is based on Cu=6.

To find the appropriate conversion factor, CF, for a desired Cu. Using a Cu of 4.0 as presented above:

$$\frac{D_{60}}{D_{15}} \cdot CF = \frac{D_{60}}{D_{10}} \quad \text{----->} \quad 1.866 \cdot CF = 2.0 \quad \text{----->} \quad CF = 1.07$$

Or, simplified into one equation:

$Cu := 6$ $\qquad$ $Conversion_Factor := \frac{Cu}{10^{\left[\frac{(60-15)}{\frac{(60-10)}{\log(Cu)}}\right]}} = 1.196$ $\qquad$ say 1.2

$Cu =: 2.0$ $\qquad$ $Conversion_Factor := \frac{Cu}{10^{\left[\frac{(60-15)}{\frac{(60-10)}{\log(Cu)}}\right]}} = 1.072$ $\qquad$ say 1.07

The revised D_{60} then is computed by dividing the D_{15} by 1.07 instead of 1.2 per Ref. 2:

$D_{15max} := 0.7mm$

$D_{10max} := \frac{D_{15max}}{1.07} = 0.65 \cdot mm$

Using the newly assumed Cu = 2.0, compute the revised D_{60} max:

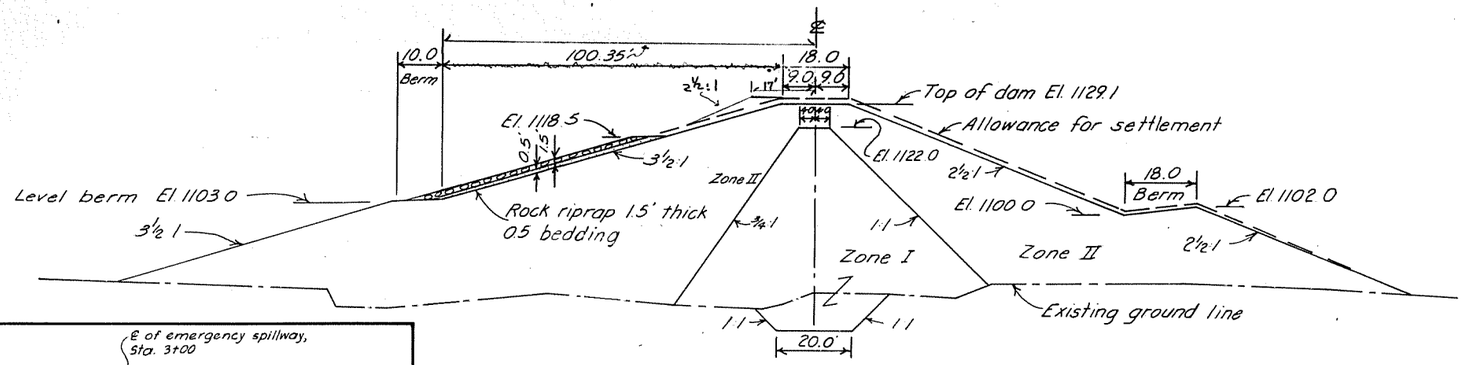
$D_{60max} =: 2.0 \cdot D_{10max} = 1.31mm$

Compute the revised D_{60} min by using the filter band width of 5:

$$D_{60min} := \frac{D_{60max}}{5} = 0.26mm$$

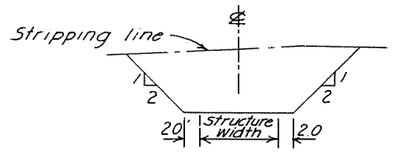
Calc By: EJB, Nov. 2020
Checked By: TNK, Dec. 2020

Ref. 4

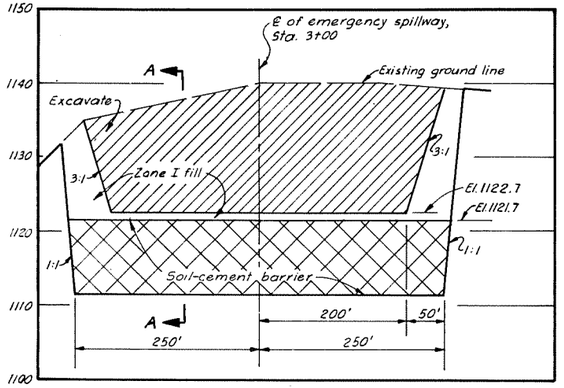


STATION 24+50
MAXIMUM CROSS SECTION OF DAM

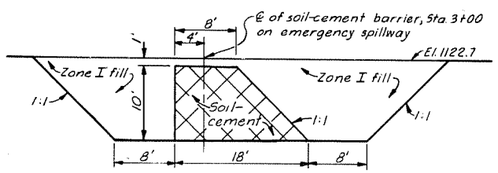
20 0 20 40
Scale in feet



TYPICAL SECTION - STRUCTURE EXCAVATION
BOX CONDUIT AND SAF

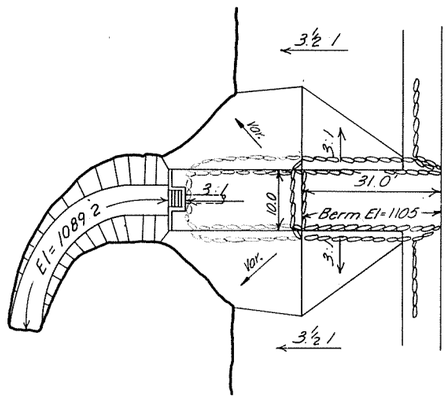


PROFILE ALONG ℄ OF SOIL-CEMENT BARRIER

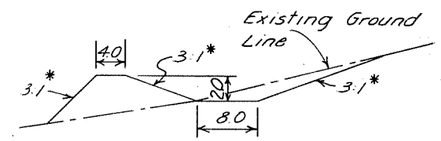


SECTION A-A

DETAILS OF SOIL-CEMENT BARRIER



PLAN VIEW OF UPSTREAM
LOCAL BERM AT RISER



TYPICAL CROSS-SECTION OF DIVERSION

* SIDE SLOPES WILL BE AS SHOWN UNLESS DIRECTED OTHERWISE BY THE ENGINEER.

EMBANKMENT MATERIAL SOURCES AND PLACEMENT REQUIREMENT

SOURCE OF MATERIAL				PLACEMENT AND MOISTURE DENSITY REQUIREMENT							
LOCATION	APPROX. DEPTH (FT.) FROM	APPROX. DEPTH (FT.) TO	UNIFIED SOIL CLASSIFICATION	DEPTH OF LIFT	MAX. SIZE ROCK FRAGMENTS	FILL MATRIX SIZE TESTED	COMPACTION CLASS	REFERENCE TEST METHOD	REQ'D. (%) COMPACTION	ALLOWABLE MOISTURE RANGE FROM OPTIMUM(%)	FILL LOCATION
BORROW C	1	18	CL	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE I
EMERGENCY SPILLWAY	3	23	SM & SP	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
BORROW B	3	13	SM	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
EMERGENCY SPILLWAY	0	5	SC	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II

LABORATORY TEST INFORMATION ON TYPICAL MATERIALS

UNIFIED SOIL CLASSIFICATION	TEST HOLE 111 CL	TEST HOLE 201 SM	TEST HOLE 102 SC	TEST HOLE 109 CL
REFERENCE TEST METHOD	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698
MAXIMUM DRY DENSITY	106.0 P.C.F.	103.0 P.C.F.	98.0 P.C.F.	91.0 P.C.F.
OPTIMUM MOISTURE	18.0%	20.0%	21.5%	25.0%
DESCRIPTION	GLACIAL TILL	DELTA SEDIMENTS	DELTA SEDIMENTS	DELTA SEDIMENTS

NOTES:
1. LABORATORY TEST DATA ON THE SOIL INVESTIGATION IS AVAILABLE AT THE SCS WATERSHED OFFICE IN GRAFTON, NORTH DAKOTA.
2. FOR SOIL LEGEND AND SYMBOLS, SEE STANDARD DRAWING NO. 5-R-10.000-47.
3. MORE PLASTIC MATERIAL EXCAVATED FROM EMERGENCY SPILLWAY AND BORROW B IS TO BE SELECTIVELY PLACED ADJACENT TO THE UPSTREAM PORTION OF ZONE I. IN THE COMPACTED EARTH BARRIER AND ADJACENT TO THE SOIL-CEMENT BARRIER.
4. DO NOT BORROW CLOSER THAN 100' FROM BASE OF DAM UNLESS DIRECTED OTHERWISE BY THE ENGINEER IN THE FIELD.

AS BUILT
NOV 15 1978

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No. 10 of 40	Drawing No. 5,E-29,772

SCS-312-10-A41

Gannett Fleming

Calc By: EJB, Nov 2020
Calc Check By: TNK, Dec 2020

Title: Shear Strength Calculation
Project: Fordville Dam
GF Job #: 066441

Purpose: Determine shear strength parameters of samples site soils for use in slope stability analysis.

References:
1. Terracon. 2020. Laboratory testing results for Fordville Dam

Assumptions:
1. Neglect apparent cohesion for effective stress parameters.

Calculation:
Mohr circles are replotted in Microsoft excel using data from Ref. 1. Failure is determined to occur at the maximum principal stress ratio. See attached plots for total and effective Mohr circles for individual strata. Mohr circles are plotted in units of psi to check against Ref. 1. Parameters are presented in the summary table below with units of psf for easier input into slope stability software. Friction angles are rounded to the nearest whole degree.

Shear stress parameters for Embankment Zone II are determined from direct shear testing and therefore only effective stress parameters are computed. Direct shear testing was conducted because the classification of the soil was too coarse to procure a sufficient triaxial shear specimen.

Stratum	Total Stress Parameters		Effective Stress Parameters	
	c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)
Embankment Zone I	576	25	0	33
Embankment Zone II	n/a	n/a	0	37
Foundation	317	21	0	32

Remarks: The effective cohesion values of 3.7 psi for the Zone I embankment and 2 psi for the foundation soil as determined in the attached analyses is neglected for conservatism. If the failure envelope for the Zone I embankment Mohr circles is forced through the origin, a friction angle of 38° can be drawn. However, a friction angle of 38° is not typical of a CL material thus 33° with neglected cohesion is recommend for use in the stability analysis for Zone I. Similarly, the failure envelope for the foundation Mohr circles is forced through the origin, a friction angle of 36° can be drawn, which is a little higher than typical for a ML material. Thus, a friction angle of 32° with neglected cohesion is recommend for use in the stability analysis for the Foundation soil.

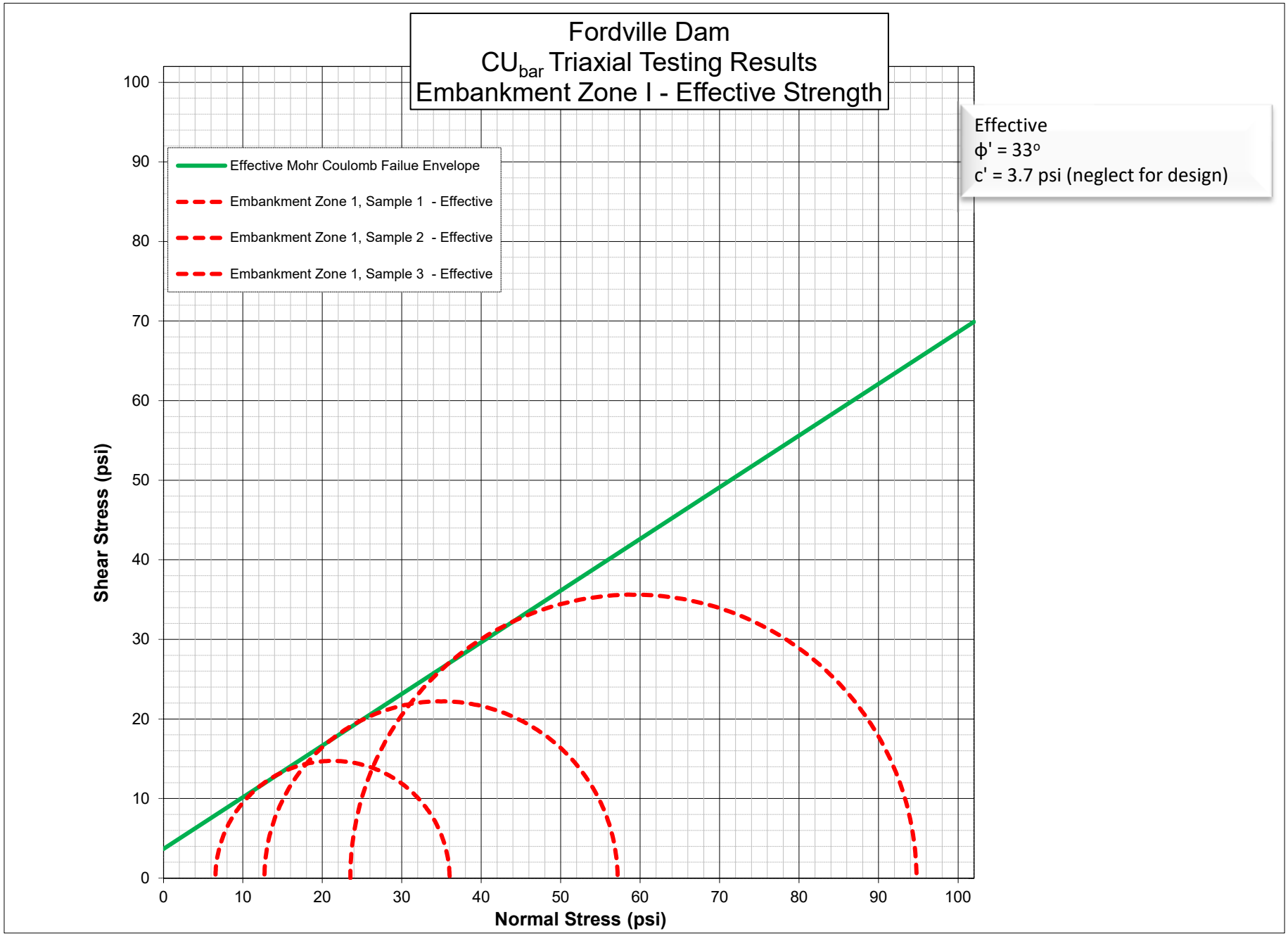
Gannett Fleming

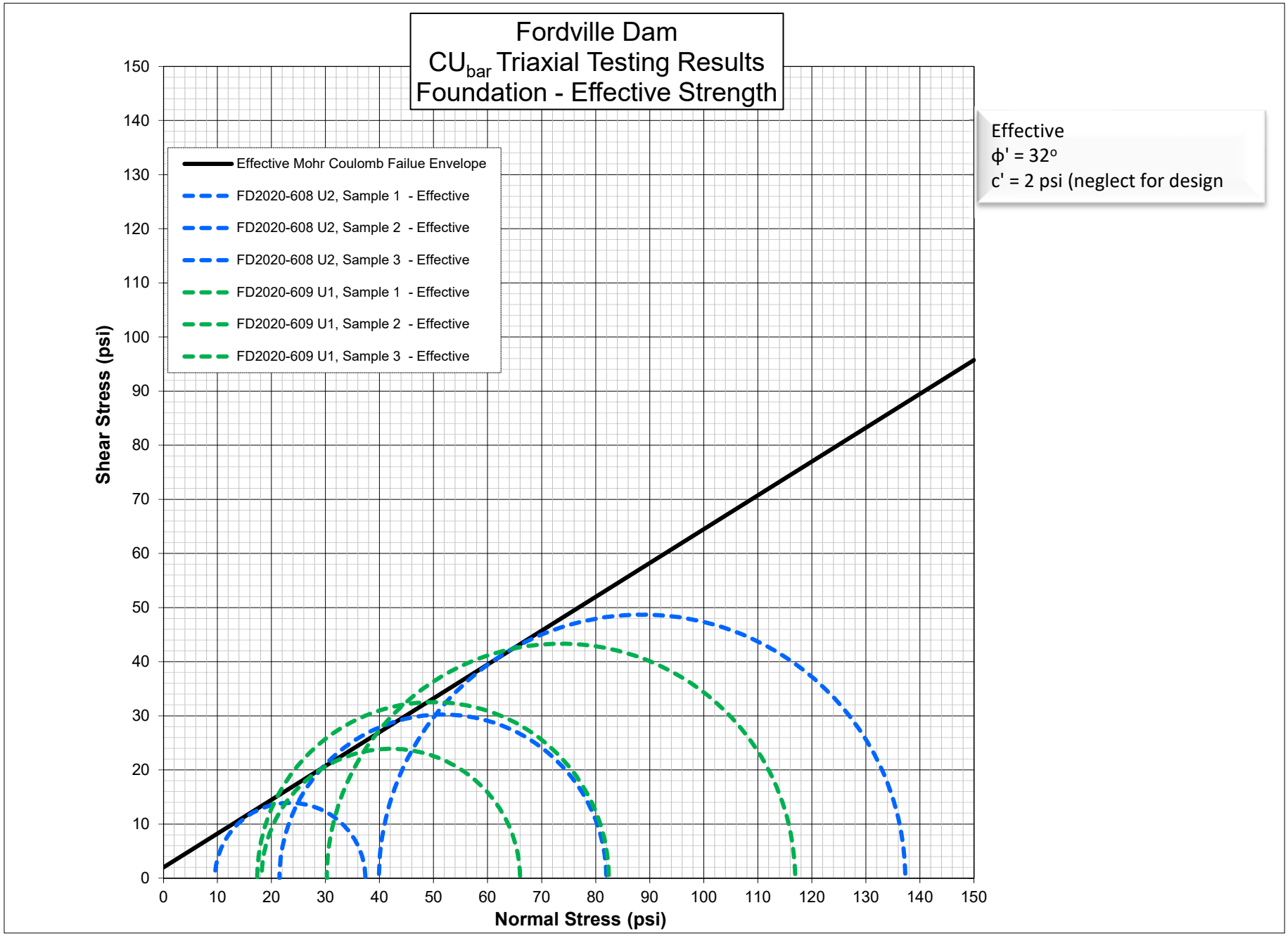
Fordville Dam
Triaxial Shear Strength Testing Results
CU_{bar} Testing

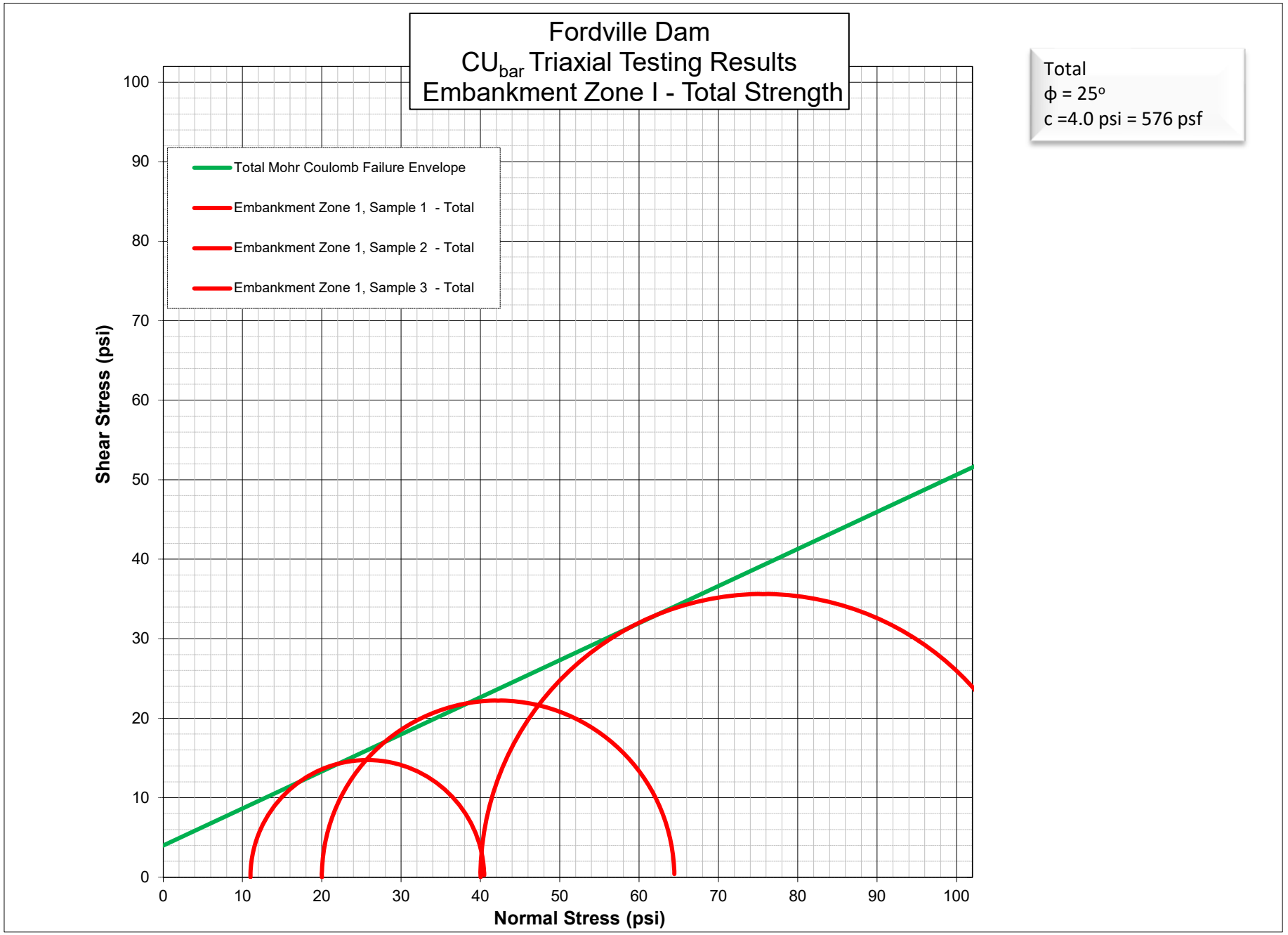
By: EJB, 11/20
Ckd By: TNK, 12/20

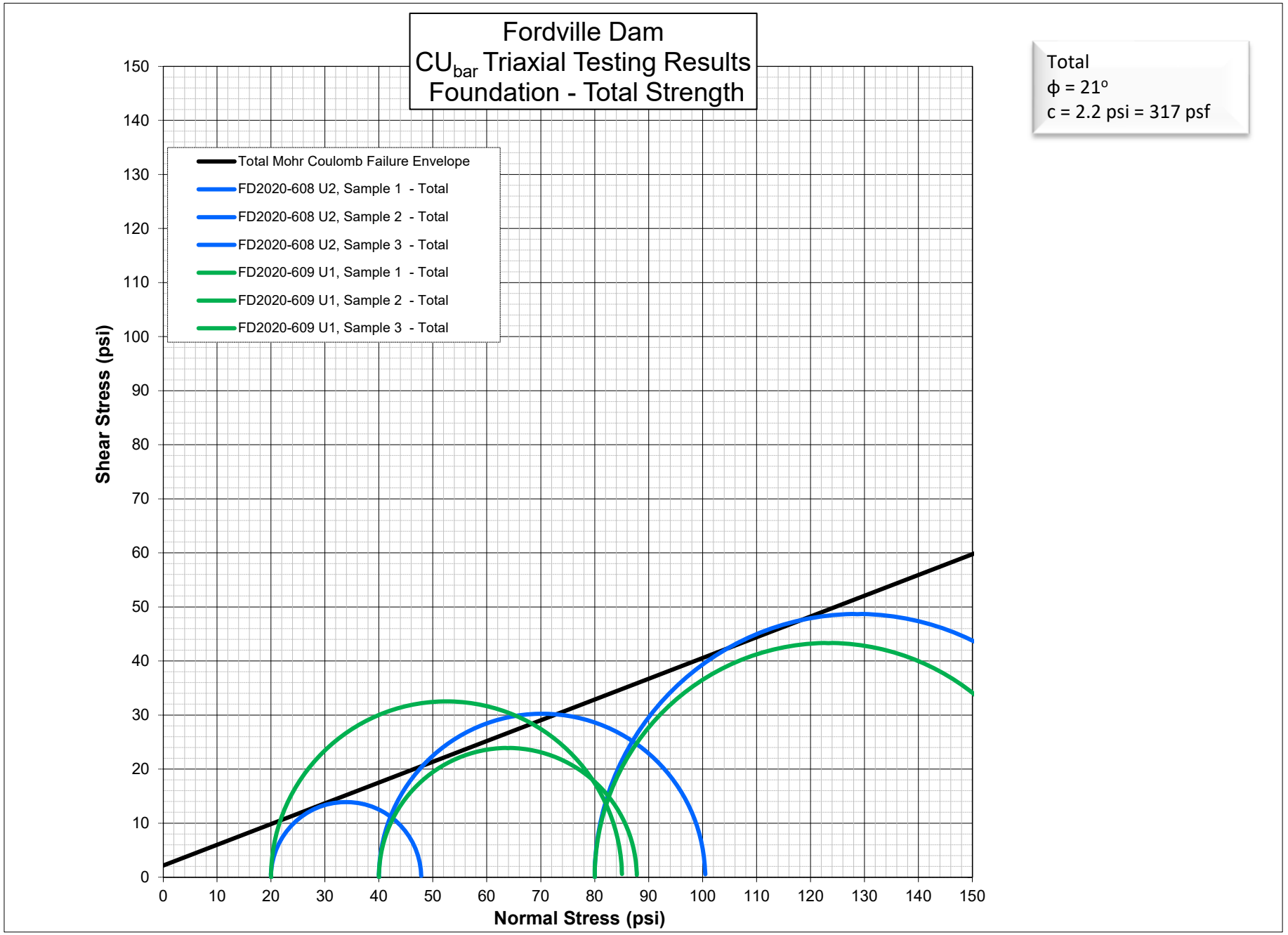
Boring	Sample	Sample Type	Depth (ft)	USCS	Stratum	Specimen ID	Consolidation Effective Confining Stress (ksf)	Consolidation Effective Confining Stress (psi)	Failure Stress or Deviator Stress (ksf)	Failure Stress or Deviator Stress (psi)	Pore Pressure at Failure Reading (ksf)	Pore Pressure at Failure Reading (psi)	ΔPore Pressure (psi)	Total σ_3 (psi)	Total σ_1 (psi)	Effective σ'_3 (psi)	Effective σ'_1 (psi)
FD2020-11	S-10 to S-20	Remold	22.5 - 50.0	CL	Zone I (Embankment)	1	1.58	11.0	4.24	29.5	0.64	4.45	4.45	11.0	40.5	6.6	36.0
						2	2.88	20.0	6.40	44.4	1.05	7.28	7.28	20.0	64.4	12.7	57.2
						3	5.76	40.0	10.26	71.2	2.37	16.5	16.48	40.0	111.2	23.5	94.8
FD2020-608	U-2	Undisturbed	55.0 - 57.0	ML	Foundation	1	2.88	20.0	4.01	27.8	1.50	10.5	10.5	20.0	47.8	9.6	37.4
						2	5.76	40.0	8.71	60.5	2.67	18.5	18.5	40.0	100.5	21.5	82.0
						3	11.52	80.0	14.02	97.4	5.77	40.1	40.1	80.0	177.4	39.9	137.3
FD2020-609	U-1	Undisturbed	30.0 - 32.0	ML	Foundation	1	2.88	20.0	9.37	65.0	0.38	2.62	2.62	20.0	85.0	17.4	82.4
						2	5.76	40.0	6.88	47.8	3.14	21.8	21.8	40.0	87.8	18.2	66.0
						3	11.52	80.0	12.48	86.6	7.16	49.8	49.8	80.0	166.6	30.3	116.9

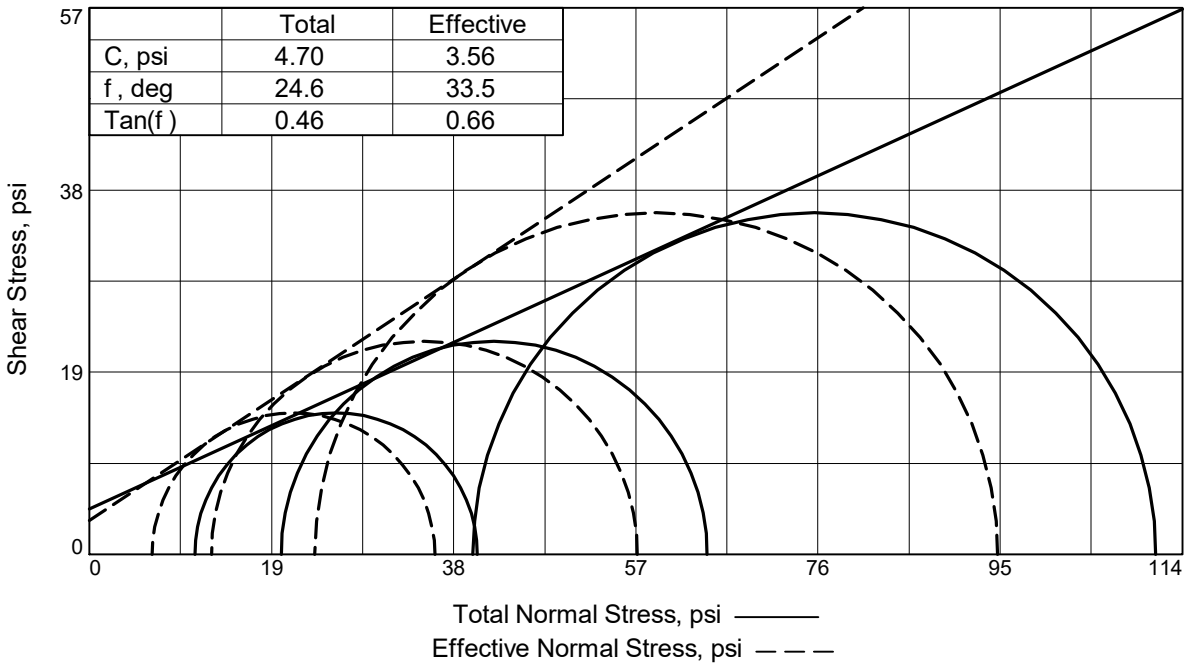
This table summarizes the failure conditions of the CU triaxial shear strength test specimens. Failure Stresses in this table are taken at Maximum Principal Stress Ratio.

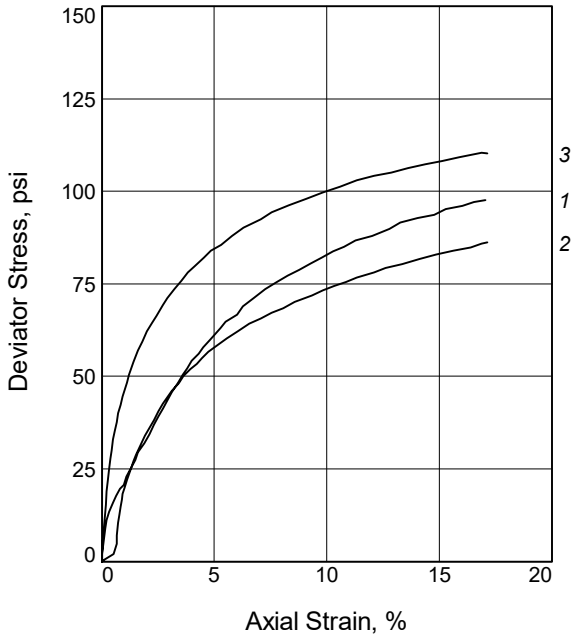

Fordville Dam
CU$_{bar}$ Triaxial Testing Results
Embankment Zone I - Effective Strength
Effective Mohr Coulomb Failue Envelope
Embankment Zone 1, Sample 1 - Effective
Embankment Zone 1, Sample 2 - Effective
Embankment Zone 1, Sample 3 - Effective
Effective
ϕ' = 33°
c' = 3.7 psi (neglect for design)
Shear Stress (psi)
Normal Stress (psi)
0
10
20
30
40
50
60
70
80
90
100


Fordville Dam
CU$_{bar}$ Triaxial Testing Results
Foundation - Effective Strength
Effective Mohr Coulomb Failue Envelope
FD2020-608 U2, Sample 1 - Effective
FD2020-608 U2, Sample 2 - Effective
FD2020-608 U2, Sample 3 - Effective
FD2020-609 U1, Sample 1 - Effective
FD2020-609 U1, Sample 2 - Effective
FD2020-609 U1, Sample 3 - Effective
Effective
ϕ' = 32°
c' = 2 psi (neglect for design
Shear Stress (psi)
Normal Stress (psi)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150


Fordville Dam
CU$_{bar}$ Triaxial Testing Results
Embankment Zone I - Total Strength
Total
ϕ = 25°
c =4.0 psi = 576 psf
Total Mohr Coulomb Failure Envelope
Embankment Zone 1, Sample 1 - Total
Embankment Zone 1, Sample 2 - Total
Embankment Zone 1, Sample 3 - Total
Shear Stress (psi)
Normal Stress (psi)
0
10
20
30
40
50
60
70
80
90
100


Fordville Dam
CU$_{bar}$ Triaxial Testing Results
Foundation - Total Strength
Total Mohr Coulomb Failure Envelope
FD2020-608 U2, Sample 1 - Total
FD2020-608 U2, Sample 2 - Total
FD2020-608 U2, Sample 3 - Total
FD2020-609 U1, Sample 1 - Total
FD2020-609 U1, Sample 2 - Total
FD2020-609 U1, Sample 3 - Total
Shear Stress (psi)
Normal Stress (psi)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
Total
ϕ = 21°
c = 2.2 psi = 317 psf





Sample No.		1	2	3
Initial	Water Content, %	15.0	15.0	15.0
	Dry Density, pcf	115.5	115.9	115.9
	Saturation, %	88.2	89.2	89.0
	Void Ratio	0.4594	0.4539	0.4549
	Diameter, in.	1.403	1.400	1.400
	Height, in.	2.820	2.800	2.790
At Test	Water Content, %	17.0	17.4	16.9
	Dry Density, pcf	115.4	114.7	115.7
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.4600	0.4694	0.4570
	Diameter, in.	1.405	1.414	1.407
	Height, in.	2.814	2.776	2.767
Strain rate, in./min.		0.000	0.000	0.000
Back Pressure, psi		56.0	55.0	47.0
Cell Pressure, psi		67.0	75.0	87.0
Fail. Stress, psi		29.5	44.4	71.2
Excess Pore Pr., psi		4.5	7.3	16.5
Ult. Stress, psi				
Excess Pore Pr., psi				
$\bar{s}_1$ Failure, psi		36.0	57.2	94.8
$\bar{s}_3$ Failure, psi		6.5	12.7	23.5

Type of Test:
CU with Pore Pressures
Sample Type: Remolded
Description: Sandy Lean Clay

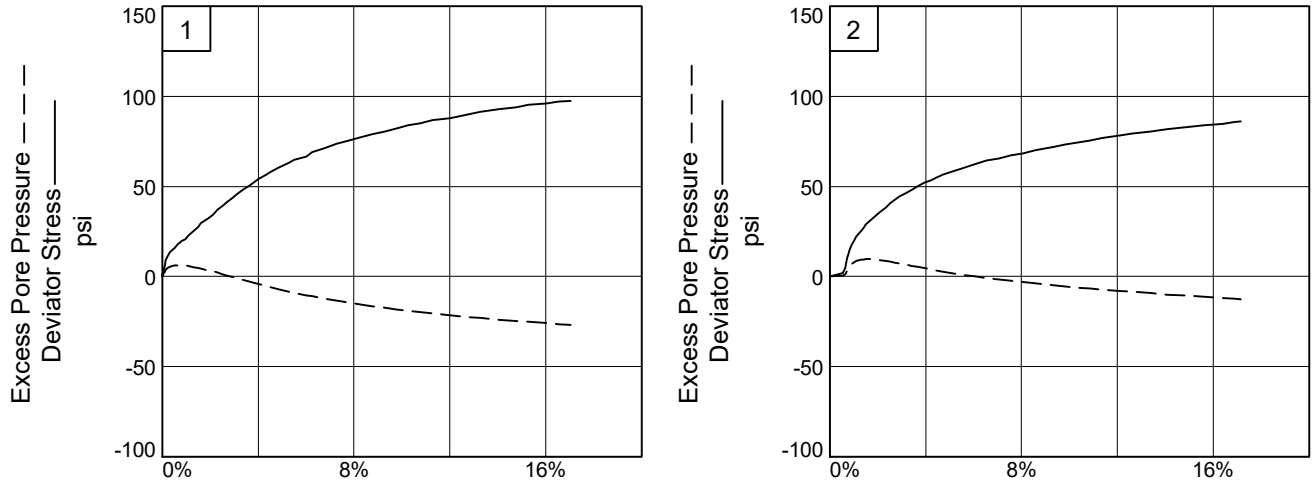
Assumed Specific Gravity= 2.7
Remarks: Remolded Specimens

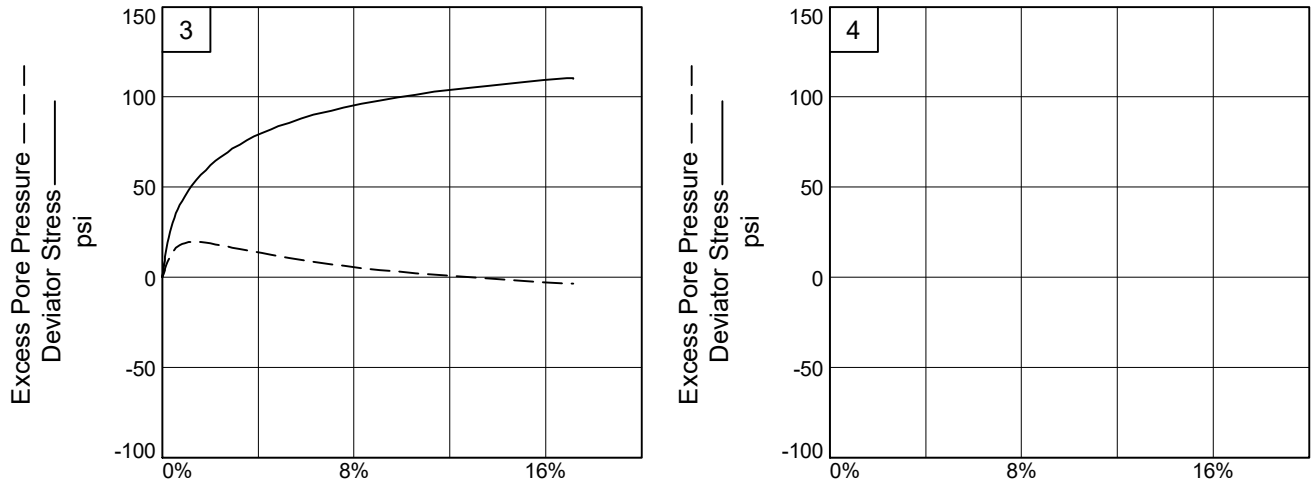
Client: Gannett Fleming, Inc.

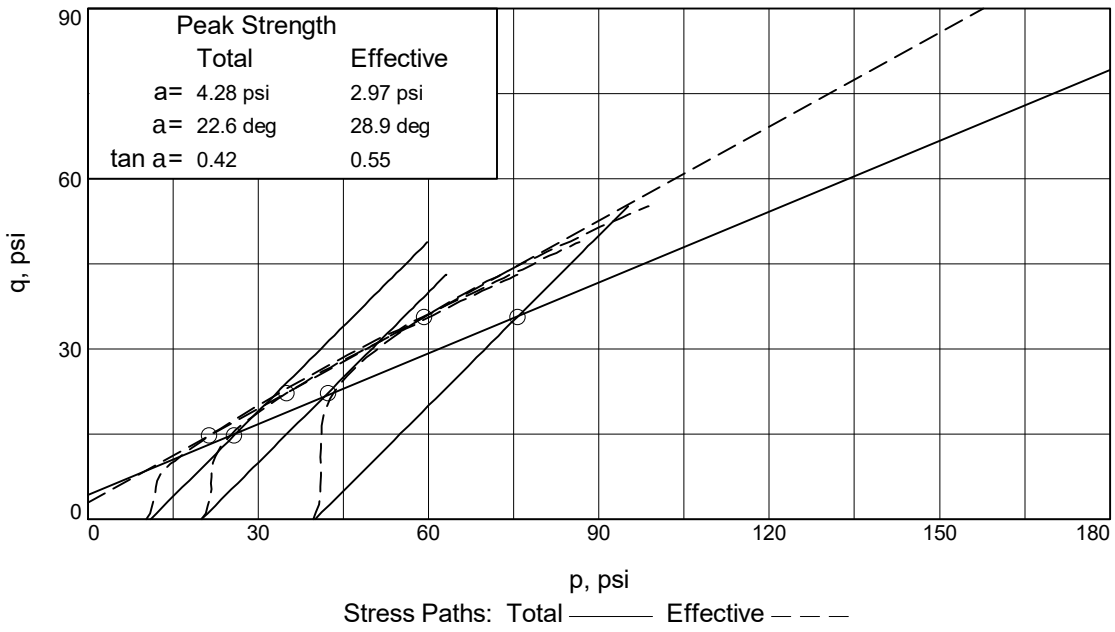
Project: Fordville Dam

Source of Sample: FD2020-11 **Depth:** 22.5-50.0 ft
Sample Number: S-10 to S-20
Proj. No.: M5205037 **Date Sampled:** N/A

TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN







Client: Gannett Fleming, Inc.
Project: Fordville Dam
Source of Sample: FD2020-11 **Depth:** 22.5-50.0 ft **Sample Number:** S-10 to S-20
Project No.: M5205037

Terracon Consultants, Inc.

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

11/20/2020
10:26 AM

Date: N/A
Client: Gannett Fleming, Inc.
Project: Fordville Dam
Project No.: M5205037
Location: FD2020-11
Depth: 22.5-50.0 ft **Sample Number:** S-10 to S-20
Description: Sandy Lean Clay
Remarks: Remolded Specimens
Type of Sample: Remolded
Assumed Specific Gravity=2.7 **LL=** **PL=** **PI=**
Test Method: ASTM D 4767 Method B

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	115.000			202.000
Moisture content: Dry soil+tare, gms.	100.000			179.530
Moisture content: Tare, gms.	0.000			47.640
Moisture, %	15.0	17.0	17.0	17.0
Moist specimen weight, gms.	152.00			
Diameter, in.	1.403	1.405	1.405	
Area, in.²	1.546	1.550	1.550	
Height, in.	2.820	2.813	2.814	
Net decrease in height, in.		0.007	-0.001	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	132.8	135.1	135.1	
Dry density, pcf	115.5	115.4	115.4	
Void ratio	0.4594	0.4600	0.4600	
Saturation, %	88.2	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 67.00 psi
Consolidation back pressure = 56.00 psi
Consolidation effective confining stress = 11.00 psi
Strain rate, in./min. = 0.000
Fail. Stress = 29.47 psi **at reading no.** 13

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.1037	2.613	0.0	0.0	0.00	10.26	10.26	1.00	56.74	10.26	0.00
1	0.1044	5.835	3.2	0.0	2.08	9.85	11.93	1.21	57.15	10.89	1.04
2	0.1066	12.282	9.7	0.1	6.23	8.42	14.65	1.74	58.58	11.53	3.12
3	0.1080	16.428	13.8	0.2	8.90	7.37	16.27	2.21	59.63	11.82	4.45
4	0.1101	19.989	17.4	0.2	11.19	6.29	17.48	2.78	60.71	11.89	5.59
5	0.1129	23.604	21.0	0.3	13.50	5.41	18.91	3.50	61.59	12.16	6.75
6	0.1178	27.234	24.6	0.5	15.81	4.78	20.58	4.31	62.22	12.68	7.90
7	0.1221	30.436	27.8	0.7	17.83	4.66	22.50	4.83	62.34	13.58	8.92
8	0.1263	33.316	30.7	0.8	19.65	4.74	24.39	5.15	62.26	14.57	9.83
9	0.1312	34.884	32.3	1.0	20.62	4.98	25.60	5.14	62.02	15.29	10.31
10	0.1348	38.686	36.1	1.1	23.02	5.22	28.24	5.41	61.78	16.73	11.51
11	0.1404	42.172	39.6	1.3	25.19	5.73	30.92	5.40	61.27	18.33	12.60
12	0.1460	45.857	43.2	1.5	27.48	6.28	33.76	5.37	60.72	20.02	13.74
13	0.1489	49.035	46.4	1.6	29.47	6.55	36.02	5.50	60.45	21.28	14.74
14	0.1573	53.135	50.5	1.9	31.98	7.50	39.47	5.26	59.50	23.49	15.99
15	0.1630	57.058	54.4	2.1	34.39	8.18	42.57	5.20	58.82	25.38	17.19
16	0.1686	61.166	58.6	2.3	36.91	8.88	45.79	5.15	58.12	27.34	18.45
17	0.1742	64.799	62.2	2.5	39.12	9.61	48.73	5.07	57.39	29.17	19.56
18	0.1799	68.428	65.8	2.7	41.31	10.36	51.68	4.99	56.64	31.02	20.66
19	0.1855	72.086	69.5	2.9	43.52	11.10	54.62	4.92	55.90	32.86	21.76
20	0.1912	75.772	73.2	3.1	45.74	11.86	57.59	4.86	55.14	34.73	22.87
21	0.1996	80.240	77.6	3.4	48.38	12.98	61.36	4.73	54.02	37.17	24.19
22	0.2053	83.590	81.0	3.6	50.36	13.70	64.06	4.68	53.30	38.88	25.18
23	0.2109	86.598	84.0	3.8	52.12	14.43	66.55	4.61	52.57	40.49	26.06
24	0.2166	90.068	87.5	4.0	54.16	15.14	69.30	4.58	51.86	42.22	27.08
25	0.2250	93.480	90.9	4.3	56.10	16.15	72.25	4.47	50.85	44.20	28.05
26	0.2307	96.654	94.0	4.5	57.94	16.85	74.79	4.44	50.15	45.82	28.97
27	0.2391	100.334	97.7	4.8	60.02	17.83	77.85	4.37	49.17	47.84	30.01
28	0.2518	105.771	103.2	5.3	63.05	19.25	82.30	4.28	47.75	50.77	31.53
29	0.2589	108.745	106.1	5.5	64.70	19.96	84.66	4.24	47.04	52.31	32.35
30	0.2730	112.603	110.0	6.0	66.70	21.41	88.11	4.12	45.59	54.76	33.35
31	0.2800	116.691	114.1	6.3	68.99	22.02	91.02	4.13	44.98	56.52	34.50
32	0.2941	121.069	118.5	6.8	71.26	23.28	94.54	4.06	43.72	58.91	35.63
33	0.3082	125.473	122.9	7.3	73.51	24.45	97.96	4.01	42.55	61.21	36.75
34	0.3223	129.510	126.9	7.8	75.51	25.51	101.02	3.96	41.49	63.26	37.76
35	0.3364	133.119	130.5	8.3	77.24	26.53	103.77	3.91	40.47	65.15	38.62
36	0.3505	136.592	134.0	8.8	78.86	27.50	106.36	3.87	39.50	66.93	39.43
37	0.3646	140.173	137.6	9.3	80.53	28.36	108.89	3.84	38.64	68.63	40.26
38	0.3787	143.526	140.9	9.8	82.03	29.21	111.24	3.81	37.79	70.23	41.02
39	0.3928	147.318	144.7	10.3	83.77	30.02	113.79	3.79	36.98	71.91	41.89
40	0.4069	150.361	147.7	10.8	85.06	30.77	115.83	3.76	36.23	73.30	42.53
41	0.4210	154.114	151.5	11.3	86.73	31.48	118.20	3.76	35.52	74.84	43.36
42	0.4422	157.653	155.0	12.0	88.00	32.50	120.50	3.71	34.50	76.50	44.00
43	0.4633	162.254	159.6	12.8	89.84	33.41	123.25	3.69	33.59	78.33	44.92
44	0.4774	166.230	163.6	13.3	91.55	34.00	125.55	3.69	33.00	79.78	45.77
45	0.4986	169.940	167.3	14.0	92.81	34.84	127.65	3.66	32.16	81.25	46.41
46	0.5197	173.078	170.5	14.8	93.72	35.63	129.35	3.63	31.37	82.49	46.86

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
47	0.5338	176.690	174.1	15.3	95.15	36.12	131.27	3.63	30.88	83.69	47.57
48	0.5550	179.988	177.4	16.0	96.09	36.85	132.94	3.61	30.15	84.90	48.04
49	0.5691	182.900	180.3	16.5	97.08	37.34	134.42	3.60	29.66	85.88	48.54
50	0.5832	184.869	182.3	17.0	97.55	37.78	135.34	3.58	29.22	86.56	48.78

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	115.000			237.460
Moisture content: Dry soil+tare, gms.	100.000			214.730
Moisture content: Tare, gms.	0.000			83.990
Moisture, %	15.0	17.4	17.4	17.4
Moist specimen weight, gms.	150.85			
Diameter, in.	1.400	1.408	1.414	
Area, in.²	1.539	1.557	1.569	
Height, in.	2.800	2.798	2.776	
Net decrease in height, in.		0.002	0.022	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	133.3	134.7	134.7	
Dry density, pcf	115.9	114.7	114.7	
Void ratio	0.4539	0.4694	0.4694	
Saturation, %	89.2	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 75.00 psi

Consolidation back pressure = 55.00 psi

Consolidation effective confining stress = 20.00 psi

Strain rate, in./min. = 0.000

Fail. Stress = 44.44 psi **at reading no.** 21

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.1113	3.690	0.0	0.0	0.00	20.04	20.04	1.00	54.96	20.04	0.00
1	0.1120	3.920	0.2	0.0	0.15	20.00	20.15	1.01	55.00	20.08	0.07
2	0.1260	6.987	3.3	0.5	2.09	19.64	21.73	1.11	55.36	20.68	1.05
3	0.1295	11.176	7.5	0.7	4.74	18.72	23.46	1.25	56.28	21.09	2.37
4	0.1302	14.715	11.0	0.7	6.98	17.96	24.94	1.39	57.04	21.45	3.49
5	0.1316	20.380	16.7	0.7	10.56	16.51	27.07	1.64	58.49	21.79	5.28
6	0.1330	23.709	20.0	0.8	12.66	15.29	27.95	1.83	59.71	21.62	6.33
7	0.1344	27.251	23.6	0.8	14.89	14.27	29.16	2.04	60.73	21.72	7.44
8	0.1358	30.095	26.4	0.9	16.68	13.46	30.14	2.24	61.54	21.80	8.34
9	0.1372	32.603	28.9	0.9	18.25	12.80	31.05	2.43	62.20	21.92	9.13
10	0.1393	35.202	31.5	1.0	19.88	12.06	31.93	2.65	62.94	22.00	9.94
11	0.1421	38.802	35.1	1.1	22.13	11.36	33.48	2.95	63.64	22.42	11.06
12	0.1477	44.275	40.6	1.3	25.52	10.62	36.14	3.40	64.38	23.38	12.76
13	0.1505	46.934	43.2	1.4	27.17	10.45	37.62	3.60	64.55	24.03	13.58
14	0.1533	49.585	45.9	1.5	28.80	10.34	39.14	3.79	64.66	24.74	14.40
15	0.1589	53.906	50.2	1.7	31.45	10.36	41.81	4.04	64.64	26.08	15.73
16	0.1645	58.023	54.3	1.9	33.96	10.57	44.53	4.21	64.43	27.55	16.98
17	0.1701	61.586	57.9	2.1	36.11	10.89	47.00	4.32	64.11	28.94	18.06

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
18	0.1757	64.970	61.3	2.3	38.14	11.29	49.43	4.38	63.71	30.36	19.07
19	0.1813	69.080	65.4	2.5	40.62	11.80	52.41	4.44	63.20	32.11	20.31
20	0.1869	72.573	68.9	2.7	42.70	12.26	54.95	4.48	62.74	33.61	21.35
21	0.1925	75.530	71.8	2.9	44.44	12.72	57.16	4.49	62.28	34.94	22.22
22	0.1981	78.280	74.6	3.1	46.04	13.24	59.28	4.48	61.76	36.26	23.02
23	0.2065	82.100	78.4	3.4	48.25	14.09	62.34	4.43	60.91	38.21	24.13
24	0.2121	85.166	81.5	3.6	50.03	14.55	64.58	4.44	60.45	39.56	25.02
25	0.2205	88.649	85.0	3.9	52.01	15.29	67.30	4.40	59.71	41.30	26.00
26	0.2289	91.235	87.5	4.2	53.42	16.05	69.47	4.33	58.95	42.76	26.71
27	0.2345	93.872	90.2	4.4	54.92	16.55	71.47	4.32	58.45	44.01	27.46
28	0.2429	96.895	93.2	4.7	56.58	17.23	73.81	4.28	57.77	45.52	28.29
29	0.2513	99.458	95.8	5.0	57.95	17.90	75.85	4.24	57.10	46.88	28.97
30	0.2653	103.745	100.1	5.5	60.22	18.98	79.20	4.17	56.02	49.09	30.11
31	0.2793	107.648	104.0	6.1	62.24	19.90	82.13	4.13	55.10	51.01	31.12
32	0.2933	111.576	107.9	6.6	64.24	20.87	85.11	4.08	54.13	52.99	32.12
33	0.3073	114.465	110.8	7.1	65.61	21.66	87.27	4.03	53.34	54.47	32.80
34	0.3213	117.853	114.2	7.6	67.25	22.44	89.68	4.00	52.56	56.06	33.62
35	0.3353	120.438	116.7	8.1	68.39	23.21	91.60	3.95	51.79	57.41	34.20
36	0.3493	124.044	120.4	8.6	70.12	23.92	94.04	3.93	51.08	58.98	35.06
37	0.3703	128.150	124.5	9.3	71.91	24.93	96.84	3.88	50.07	60.89	35.96
38	0.3843	131.070	127.4	9.8	73.19	25.52	98.71	3.87	49.48	62.11	36.59
39	0.3983	134.035	130.3	10.3	74.47	26.16	100.63	3.85	48.84	63.40	37.24
40	0.4123	136.592	132.9	10.8	75.51	26.66	102.17	3.83	48.34	64.42	37.75
41	0.4262	139.610	135.9	11.3	76.79	27.22	104.01	3.82	47.78	65.61	38.39
42	0.4472	143.107	139.4	12.1	78.09	28.04	106.13	3.79	46.96	67.08	39.04
43	0.4612	145.985	142.3	12.6	79.24	28.54	107.79	3.78	46.46	68.16	39.62
44	0.4822	149.339	145.6	13.4	80.41	29.25	109.66	3.75	45.75	69.46	40.21
45	0.5032	153.026	149.3	14.1	81.73	29.98	111.70	3.73	45.02	70.84	40.86
46	0.5242	156.497	152.8	14.9	82.89	30.67	113.56	3.70	44.33	72.11	41.45
47	0.5452	159.998	156.3	15.6	84.04	31.32	115.36	3.68	43.68	73.34	42.02
48	0.5662	162.757	159.1	16.4	84.75	31.94	116.69	3.65	43.06	74.31	42.38
49	0.5802	165.737	162.0	16.9	85.82	32.36	118.18	3.65	42.64	75.27	42.91
50	0.5872	167.014	163.3	17.1	86.23	32.55	118.78	3.65	42.45	75.67	43.12
51	0.5874	166.843	163.2	17.1	86.14	32.55	118.69	3.65	42.45	75.62	43.07

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	115.000			194.010
Moisture content: Dry soil+tare, gms.	100.000			172.000
Moisture content: Tare, gms.	0.000			41.950
Moisture, %	15.0	16.9	16.9	16.9
Moist specimen weight, gms.	150.20			
Diameter, in.	1.400	1.402	1.407	
Area, in.²	1.539	1.544	1.554	
Height, in.	2.790	2.785	2.767	
Net decrease in height, in.		0.005	0.018	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	133.2	135.3	135.3	
Dry density, pcf	115.9	115.7	115.7	
Void ratio	0.4549	0.4570	0.4570	
Saturation, %	89.0	100.0	100.0	

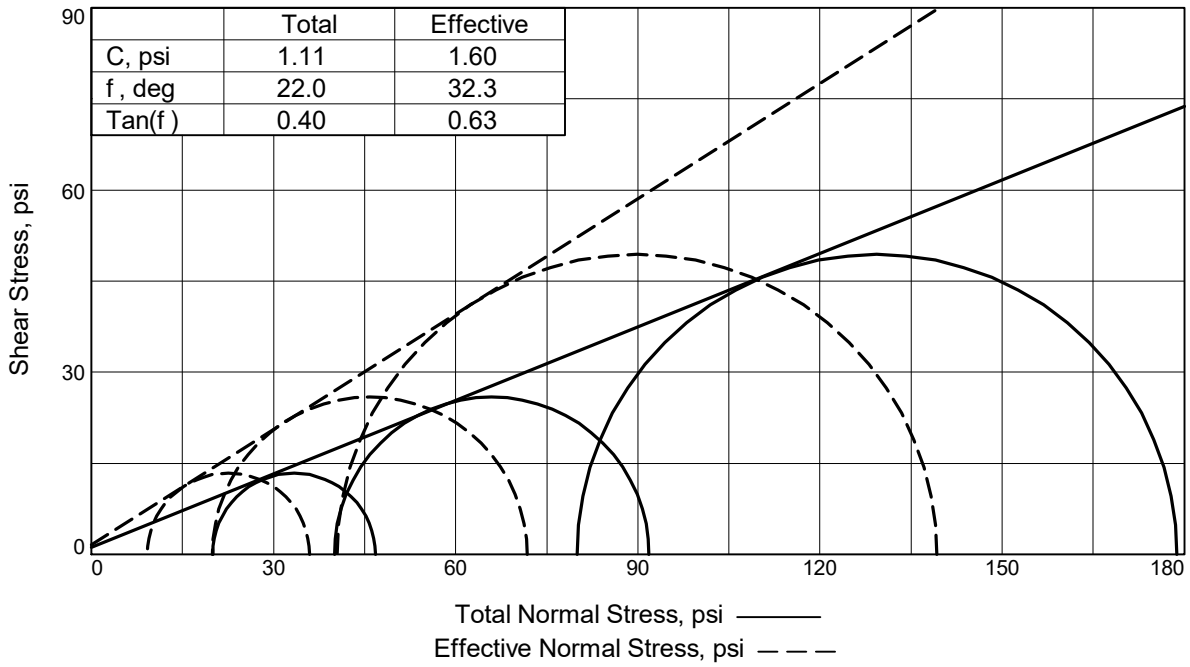
Test Readings for Specimen No. 3

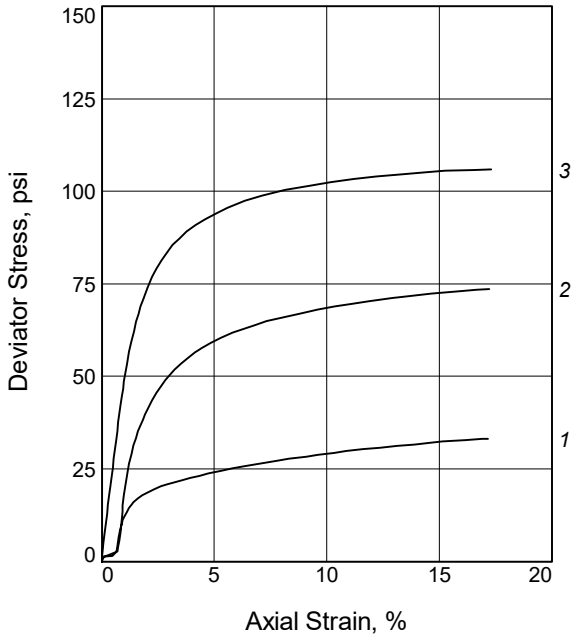
Consolidation cell pressure = 87.00 psi
Consolidation back pressure = 47.00 psi
Consolidation effective confining stress = 40.00 psi
Strain rate, in./min. = 0.000
Fail. Stress = 71.24 psi **at reading no.** 26

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.1457	2.944	0.0	0.0	0.00	39.64	39.64	1.00	47.36	39.64	0.00
1	0.1464	6.621	3.7	0.0	2.37	38.93	41.30	1.06	48.07	40.11	1.18
2	0.1471	11.142	8.2	0.1	5.27	38.09	43.36	1.14	48.91	40.72	2.64
3	0.1485	17.428	14.5	0.1	9.31	36.23	45.54	1.26	50.77	40.89	4.65
4	0.1492	20.758	17.8	0.1	11.45	35.23	46.67	1.32	51.77	40.95	5.72
5	0.1506	26.904	24.0	0.2	15.39	33.34	48.73	1.46	53.66	41.03	7.69
6	0.1520	32.528	29.6	0.2	18.99	31.56	50.55	1.60	55.44	41.05	9.49
7	0.1534	37.088	34.1	0.3	21.91	29.96	51.86	1.73	57.04	40.91	10.95
8	0.1548	42.005	39.1	0.3	25.05	28.48	53.53	1.88	58.52	41.00	12.52
9	0.1562	46.164	43.2	0.4	27.70	27.21	54.91	2.02	59.79	41.06	13.85
10	0.1575	49.953	47.0	0.4	30.11	26.07	56.19	2.15	60.93	41.13	15.06
11	0.1596	54.451	51.5	0.5	32.97	24.71	57.68	2.33	62.29	41.20	16.49
12	0.1617	58.352	55.4	0.6	35.44	23.66	59.10	2.50	63.34	41.38	17.72
13	0.1638	61.775	58.8	0.7	37.60	22.84	60.44	2.65	64.16	41.64	18.80
14	0.1659	65.604	62.7	0.7	40.02	22.18	62.20	2.80	64.82	42.19	20.01
15	0.1687	69.329	66.4	0.8	42.35	21.48	63.83	2.97	65.52	42.66	21.18
16	0.1715	72.920	70.0	0.9	44.60	21.03	65.63	3.12	65.97	43.33	22.30
17	0.1764	79.081	76.1	1.1	48.44	20.54	68.98	3.36	66.46	44.76	24.22
18	0.1792	82.319	79.4	1.2	50.45	20.42	70.87	3.47	66.58	45.64	25.22
19	0.1848	87.833	84.9	1.4	53.84	20.42	74.26	3.64	66.58	47.34	26.92
20	0.1903	92.928	90.0	1.6	56.96	20.56	77.52	3.77	66.44	49.04	28.48
21	0.1959	96.958	94.0	1.8	59.39	20.89	80.27	3.84	66.11	50.58	29.69
22	0.2015	101.518	98.6	2.0	62.14	21.31	83.45	3.92	65.69	52.38	31.07
23	0.2071	105.394	102.4	2.2	64.45	21.74	86.19	3.97	65.26	53.96	32.22
24	0.2127	108.739	105.8	2.4	66.42	22.23	88.65	3.99	64.77	55.44	33.21
25	0.2210	113.733	110.8	2.7	69.34	23.02	92.36	4.01	63.98	57.69	34.67

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
26	0.2266	117.012	114.1	2.9	71.24	23.52	94.76	4.03	63.48	59.14	35.62
27	0.2350	121.019	118.1	3.2	73.51	24.34	97.85	4.02	62.66	61.09	36.76
28	0.2434	125.141	122.2	3.5	75.84	25.09	100.94	4.02	61.91	63.01	37.92
29	0.2517	129.041	126.1	3.8	78.02	25.88	103.90	4.01	61.12	64.89	39.01
30	0.2601	132.463	129.5	4.1	79.88	26.65	106.53	4.00	60.35	66.59	39.94
31	0.2713	136.592	133.6	4.5	82.08	27.67	109.75	3.97	59.33	68.71	41.04
32	0.2796	140.056	137.1	4.8	83.94	28.31	112.25	3.97	58.69	70.28	41.97
33	0.2922	143.342	140.4	5.3	85.54	29.36	114.90	3.91	57.64	72.13	42.77
34	0.3061	148.048	145.1	5.8	87.94	30.49	118.43	3.88	56.51	74.46	43.97
35	0.3201	152.483	149.5	6.3	90.14	31.44	121.58	3.87	55.56	76.51	45.07
36	0.3410	157.570	154.6	7.1	92.46	32.87	125.33	3.81	54.13	79.10	46.23
37	0.3550	161.431	158.5	7.6	94.25	33.68	127.94	3.80	53.32	80.81	47.13
38	0.3759	166.027	163.1	8.3	96.19	34.90	131.09	3.76	52.10	82.99	48.10
39	0.3968	170.410	167.5	9.1	97.96	35.99	133.96	3.72	51.01	84.98	48.98
40	0.4177	174.893	171.9	9.8	99.75	36.93	136.68	3.70	50.07	86.81	49.87
41	0.4387	178.901	176.0	10.6	101.22	37.83	139.04	3.68	49.17	88.43	50.61
42	0.4596	183.512	180.6	11.3	102.99	38.66	141.65	3.66	48.34	90.15	51.50
43	0.4805	187.063	184.1	12.1	104.12	39.47	143.59	3.64	47.53	91.53	52.06
44	0.5015	190.269	187.3	12.9	105.02	40.16	145.19	3.61	46.84	92.67	52.51
45	0.5224	194.221	191.3	13.6	106.31	40.87	147.17	3.60	46.13	94.02	53.15
46	0.5433	197.768	194.8	14.4	107.33	41.50	148.83	3.59	45.50	95.17	53.67
47	0.5642	201.114	198.2	15.1	108.21	42.12	150.33	3.57	44.88	96.22	54.10
48	0.5852	204.763	201.8	15.9	109.22	42.70	151.92	3.56	44.30	97.31	54.61
49	0.6131	209.332	206.4	16.9	110.35	43.49	153.84	3.54	43.51	98.67	55.18
50	0.6200	209.858	206.9	17.1	110.30	43.64	153.94	3.53	43.36	98.79	55.15
51	0.6201	209.642	206.7	17.1	110.18	43.63	153.81	3.53	43.37	98.72	55.09





Sample No.		1	2	3
Initial	Water Content, %	26.6	25.8	24.7
	Dry Density, pcf	90.9	92.9	97.4
	Saturation, %	93.7	96.1	103.8
	Void Ratio	0.7031	0.6664	0.5897
	Diameter, in.	1.376	1.371	1.329
	Height, in.	2.740	2.750	2.740
At Test	Water Content, %	26.7	26.0	24.7
	Dry Density, pcf	93.2	94.2	96.1
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6614	0.6439	0.6117
	Diameter, in.	1.366	1.370	1.350
	Height, in.	2.714	2.717	2.693
Strain rate, in./min.		0.000	0.000	0.000
Back Pressure, psi		42	40	15
Cell Pressure, psi		62	80	95
Fail. Stress, psi		27	52	99
Excess Pore Pr., psi		11	20	40
Ult. Stress, psi				
Excess Pore Pr., psi				
$\bar{s}_1$ Failure, psi		36	72	139
$\bar{s}_3$ Failure, psi		9	20	40

Type of Test:
CU with Pore Pressures
Sample Type: Tube
Description: Sandy Silt

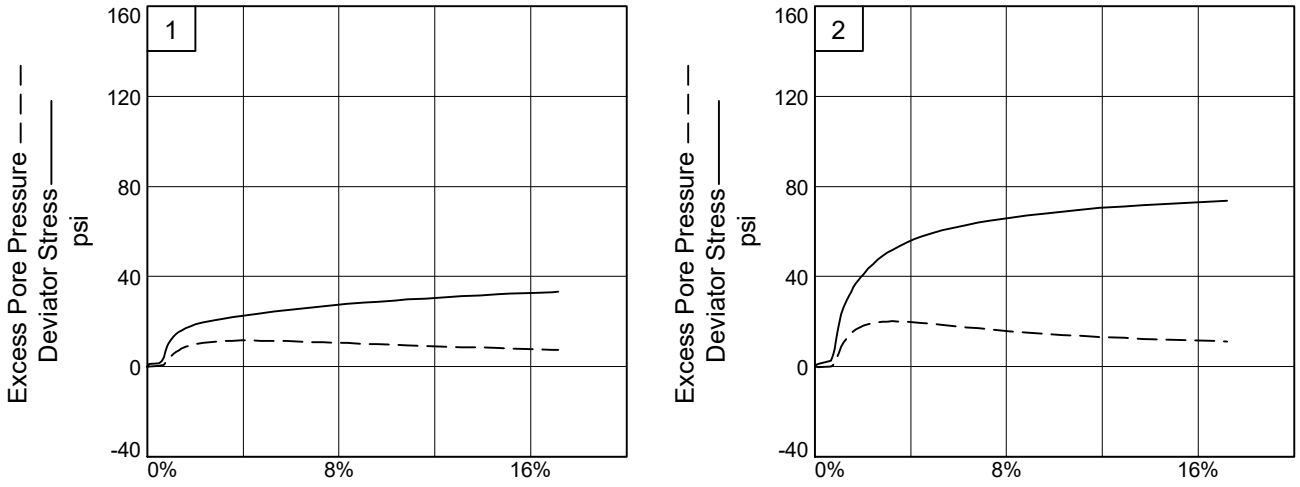
Specific Gravity= 2.48
Remarks: Three Specimen Series

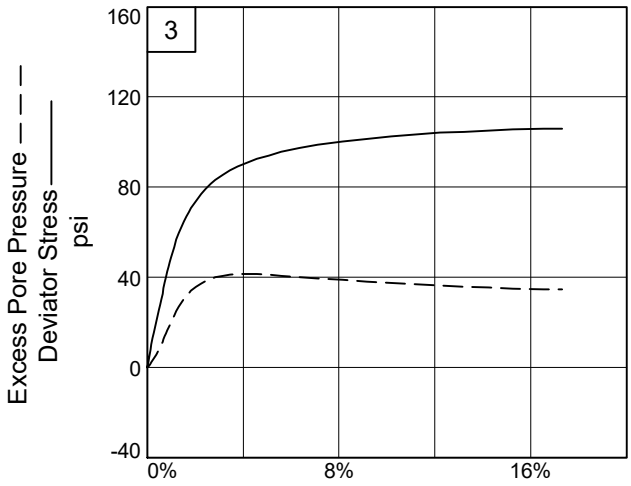
Client: Gannett Fleming, Inc.

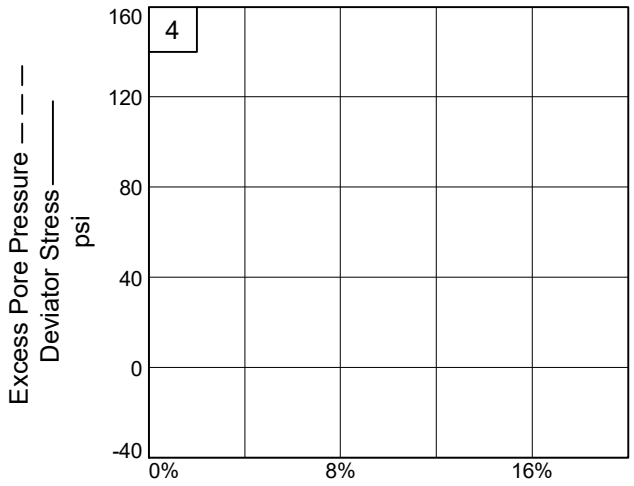
Project: Fordville Dam

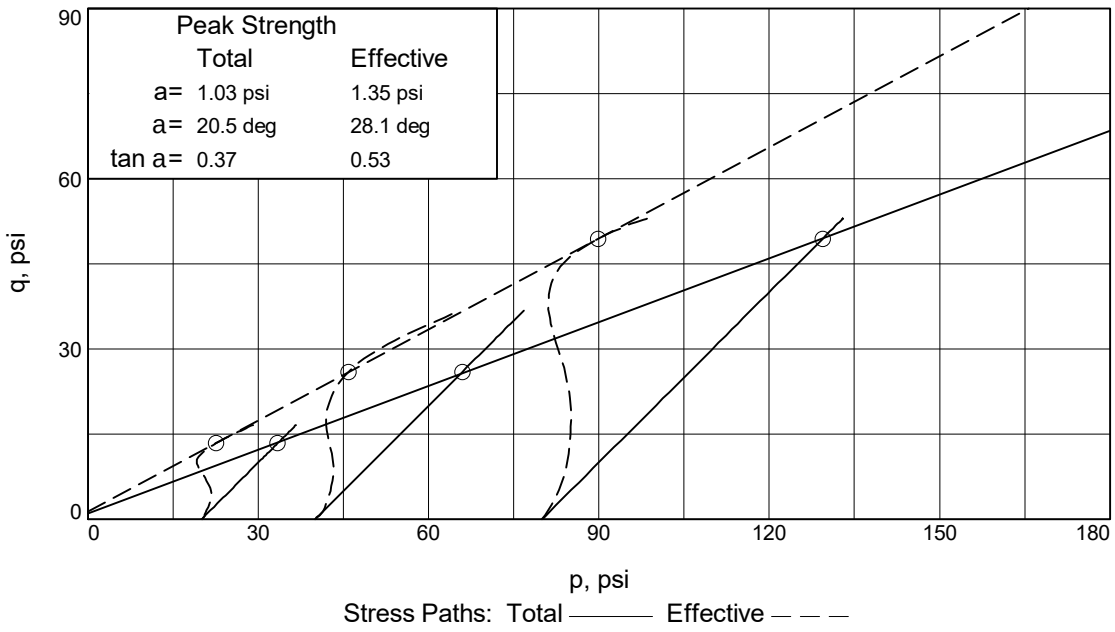
Source of Sample: FD2020-608 **Depth:** 55.0-57.0 ft
Sample Number: U-2
Proj. No.: M5205037 **Date Sampled:** N/A

TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN









Client: Gannett Fleming, Inc.
Project: Fordville Dam
Source of Sample: FD2020-608 **Depth:** 55.0-57.0 ft **Sample Number:** U-2
Project No.: M5205037

Terracon Consultants, Inc.

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

11/20/2020
10:56 AM

Date: N/A
Client: Gannett Fleming, Inc.
Project: Fordville Dam
Project No.: M5205037
Location: FD2020-608
Depth: 55.0-57.0 ft **Sample Number:** U-2
Description: Sandy Silt
Remarks: Three Specimen Series
Type of Sample: Tube
Specific Gravity=2.48 **LL=** **PL=** **PI=**
Test Method: ASTM D 4767 Method B

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	59.400			164.900
Moisture content: Dry soil+tare, gms.	49.460			139.030
Moisture content: Tare, gms.	12.030			42.030
Moisture, %	26.6	26.7	26.7	26.7
Moist specimen weight, gms.	123.05			
Diameter, in.	1.376	1.362	1.366	
Area, in.²	1.487	1.456	1.465	
Height, in.	2.740	2.730	2.714	
Net decrease in height, in.		0.010	0.016	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	115.0	118.0	118.0	
Dry density, pcf	90.9	93.2	93.2	
Void ratio	0.7031	0.6614	0.6614	
Saturation, %	93.7	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 62.00 psi
Consolidation back pressure = 42.00 psi
Consolidation effective confining stress = 20.00 psi
Strain rate, in./min. = 0.000
Fail. Stress = 26.74 psi **at reading no.** 34

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.3767	2.773	0.0	0.0	0.00	20.12	20.12	1.00	41.88	20.12	0.00
1	0.3774	3.154	0.4	0.0	0.26	20.04	20.30	1.01	41.96	20.17	0.13
2	0.3788	4.703	1.9	0.1	1.32	19.94	21.26	1.07	42.06	20.60	0.66
3	0.3897	5.076	2.3	0.5	1.56	19.70	21.27	1.08	42.30	20.48	0.78
4	0.3931	6.385	3.6	0.6	2.45	19.49	21.94	1.13	42.51	20.72	1.23
5	0.3945	7.400	4.6	0.7	3.14	19.31	22.45	1.16	42.69	20.88	1.57
6	0.3959	9.119	6.3	0.7	4.30	19.02	23.32	1.23	42.98	21.17	2.15
7	0.3966	10.941	8.2	0.7	5.54	18.67	24.20	1.30	43.33	21.44	2.77
8	0.3973	12.578	9.8	0.8	6.64	18.29	24.94	1.36	43.71	21.61	3.32
9	0.3979	13.958	11.2	0.8	7.58	17.93	25.51	1.42	44.07	21.72	3.79
10	0.3986	15.194	12.4	0.8	8.41	17.55	25.96	1.48	44.45	21.75	4.21
11	0.3993	16.190	13.4	0.8	9.08	17.19	26.27	1.53	44.81	21.73	4.54
12	0.4007	17.834	15.1	0.9	10.19	16.52	26.72	1.62	45.48	21.62	5.10
13	0.4021	19.230	16.5	0.9	11.13	15.91	27.04	1.70	46.09	21.47	5.57
14	0.4034	20.437	17.7	1.0	11.94	15.33	27.27	1.78	46.67	21.30	5.97
15	0.4069	22.796	20.0	1.1	13.52	14.13	27.65	1.96	47.87	20.89	6.76
16	0.4096	24.351	21.6	1.2	14.55	13.36	27.91	2.09	48.64	20.64	7.28
17	0.4123	25.537	22.8	1.3	15.34	12.69	28.03	2.21	49.31	20.36	7.67
18	0.4151	26.581	23.8	1.4	16.03	12.11	28.14	2.32	49.89	20.12	8.01
19	0.4206	28.208	25.4	1.6	17.09	11.21	28.29	2.52	50.79	19.75	8.54
20	0.4260	29.587	26.8	1.8	17.98	10.54	28.51	2.71	51.46	19.52	8.99
21	0.4315	30.701	27.9	2.0	18.68	10.02	28.70	2.87	51.98	19.36	9.34
22	0.4397	32.052	29.3	2.3	19.53	9.43	28.95	3.07	52.57	19.19	9.76
23	0.4480	33.270	30.5	2.6	20.28	9.04	29.32	3.24	52.96	19.18	10.14
24	0.4562	34.259	31.5	2.9	20.87	8.76	29.63	3.38	53.24	19.20	10.43
25	0.4644	35.217	32.4	3.2	21.44	8.60	30.03	3.49	53.40	19.32	10.72
26	0.4726	36.158	33.4	3.5	21.99	8.47	30.46	3.60	53.53	19.46	10.99
27	0.4836	37.262	34.5	3.9	22.62	8.40	31.03	3.69	53.60	19.71	11.31
28	0.4945	38.279	35.5	4.3	23.19	8.41	31.60	3.76	53.59	20.00	11.60
29	0.5055	39.319	36.5	4.7	23.77	8.45	32.22	3.81	53.55	20.33	11.88
30	0.5206	40.595	37.8	5.3	24.46	8.55	33.01	3.86	53.45	20.78	12.23
31	0.5343	41.816	39.0	5.8	25.11	8.68	33.79	3.89	53.32	21.24	12.56
32	0.5480	42.922	40.1	6.3	25.68	8.82	34.50	3.91	53.18	21.66	12.84
33	0.5617	43.921	41.1	6.8	26.18	9.00	35.18	3.91	53.00	22.09	13.09
34	0.5754	45.036	42.3	7.3	26.74	9.19	35.93	3.91	52.81	22.56	13.37
35	0.5891	46.155	43.4	7.8	27.30	9.38	36.68	3.91	52.62	23.03	13.65
36	0.6028	47.221	44.4	8.3	27.82	9.55	37.37	3.91	52.45	23.46	13.91
37	0.6233	48.478	45.7	9.1	28.37	9.86	38.23	3.88	52.14	24.05	14.19
38	0.6370	49.422	46.6	9.6	28.80	10.04	38.83	3.87	51.96	24.44	14.40
39	0.6576	50.700	47.9	10.3	29.34	10.34	39.68	3.84	51.66	25.01	14.67
40	0.6713	51.729	49.0	10.9	29.80	10.52	40.32	3.83	51.48	25.42	14.90
41	0.6918	52.988	50.2	11.6	30.31	10.79	41.10	3.81	51.21	25.94	15.15
42	0.7124	54.242	51.5	12.4	30.80	11.05	41.85	3.79	50.95	26.45	15.40
43	0.7329	55.401	52.6	13.1	31.22	11.31	42.53	3.76	50.69	26.92	15.61
44	0.7535	56.547	53.8	13.9	31.62	11.54	43.16	3.74	50.46	27.35	15.81
45	0.7740	57.756	55.0	14.6	32.05	11.80	43.85	3.72	50.20	27.82	16.02
46	0.7877	58.873	56.1	15.1	32.50	11.95	44.45	3.72	50.05	28.20	16.25

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
47	0.8151	60.125	57.4	16.2	32.83	12.21	45.05	3.69	49.79	28.63	16.42
48	0.8357	61.177	58.4	16.9	33.13	12.43	45.57	3.66	49.57	29.00	16.57
49	0.8425	61.487	58.7	17.2	33.21	12.48	45.69	3.66	49.52	29.09	16.60

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	57.890			165.960
Moisture content: Dry soil+tare, gms.	48.520			140.410
Moisture content: Tare, gms.	12.230			42.010
Moisture, %	25.8	26.0	26.0	26.0
Moist specimen weight, gms.	124.57			
Diameter, in.	1.371	1.362	1.370	
Area, in.²	1.476	1.458	1.474	
Height, in.	2.750	2.747	2.717	
Net decrease in height, in.		0.003	0.030	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	116.9	118.6	118.6	
Dry density, pcf	92.9	94.2	94.2	
Void ratio	0.6664	0.6439	0.6439	
Saturation, %	96.1	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 80.00 psi

Consolidation back pressure = 40.00 psi

Consolidation effective confining stress = 40.00 psi

Strain rate, in./min. = 0.000

Fail. Stress = 51.85 psi **at reading no.** 28

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.2869	2.735	0.0	0.0	0.00	40.03	40.03	1.00	39.97	40.03	0.00
1	0.2875	3.574	0.8	0.0	0.57	40.05	40.62	1.01	39.95	40.33	0.28
2	0.2903	4.637	1.9	0.1	1.29	40.16	41.45	1.03	39.84	40.80	0.64
3	0.3054	6.653	3.9	0.7	2.64	40.01	42.65	1.07	39.99	41.33	1.32
4	0.3068	8.658	5.9	0.7	3.99	39.67	43.65	1.10	40.33	41.66	1.99
5	0.3082	11.173	8.4	0.8	5.68	39.12	44.80	1.15	40.88	41.96	2.84
6	0.3095	14.774	12.0	0.8	8.10	38.30	46.40	1.21	41.70	42.35	4.05
7	0.3102	17.453	14.7	0.9	9.90	37.71	47.61	1.26	42.29	42.66	4.95
8	0.3109	20.218	17.5	0.9	11.76	37.01	48.77	1.32	42.99	42.89	5.88
9	0.3116	22.826	20.1	0.9	13.51	36.33	49.83	1.37	43.67	43.08	6.75
10	0.3123	25.258	22.5	0.9	15.14	35.61	50.75	1.43	44.39	43.18	7.57
11	0.3130	27.479	24.7	1.0	16.63	34.93	51.56	1.48	45.07	43.24	8.31
12	0.3137	29.509	26.8	1.0	17.98	34.25	52.24	1.53	45.75	43.25	8.99
13	0.3171	37.426	34.7	1.1	23.27	31.26	54.53	1.74	48.74	42.89	11.64
14	0.3198	42.214	39.5	1.2	26.46	29.27	55.73	1.90	50.73	42.50	13.23
15	0.3226	46.119	43.4	1.3	29.04	27.70	56.74	2.05	52.30	42.22	14.52
16	0.3253	49.585	46.8	1.4	31.33	26.35	57.69	2.19	53.65	42.02	15.67
17	0.3281	52.665	49.9	1.5	33.36	25.26	58.62	2.32	54.74	41.94	16.68
18	0.3308	55.446	52.7	1.6	35.18	24.35	59.53	2.44	55.65	41.94	17.59

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
19	0.3336	58.016	55.3	1.7	36.86	23.58	60.43	2.56	56.42	42.00	18.43
20	0.3363	60.317	57.6	1.8	38.35	22.91	61.27	2.67	57.09	42.09	19.18
21	0.3391	62.516	59.8	1.9	39.78	22.36	62.14	2.78	57.64	42.25	19.89
22	0.3418	64.578	61.8	2.0	41.11	21.89	62.99	2.88	58.11	42.44	20.55
23	0.3473	68.291	65.6	2.2	43.48	21.16	64.65	3.05	58.84	42.90	21.74
24	0.3528	71.528	68.8	2.4	45.54	20.63	66.17	3.21	59.37	43.40	22.77
25	0.3583	74.474	71.7	2.6	47.39	20.29	67.68	3.34	59.71	43.98	23.69
26	0.3638	77.180	74.4	2.8	49.07	20.08	69.15	3.44	59.92	44.61	24.54
27	0.3693	79.516	76.8	3.0	50.51	19.96	70.47	3.53	60.04	45.22	25.25
28	0.3748	81.722	79.0	3.2	51.85	19.90	71.75	3.61	60.10	45.83	25.93
29	0.3831	84.604	81.9	3.5	53.57	19.97	73.54	3.68	60.03	46.76	26.79
30	0.3913	87.252	84.5	3.8	55.13	20.12	75.25	3.74	59.88	47.68	27.57
31	0.3995	89.613	86.9	4.1	56.49	20.36	76.86	3.77	59.64	48.61	28.25
32	0.4078	91.779	89.0	4.5	57.72	20.60	78.32	3.80	59.40	49.46	28.86
33	0.4188	94.265	91.5	4.9	59.08	21.02	80.10	3.81	58.98	50.56	29.54
34	0.4312	96.876	94.1	5.3	60.47	21.49	81.97	3.81	58.51	51.73	30.24
35	0.4449	99.468	96.7	5.8	61.81	22.02	83.83	3.81	57.98	52.92	30.90
36	0.4586	101.793	99.1	6.3	62.95	22.54	85.50	3.79	57.46	54.02	31.48
37	0.4724	103.893	101.2	6.8	63.94	23.02	86.96	3.78	56.98	54.99	31.97
38	0.4861	105.921	103.2	7.3	64.87	23.49	88.35	3.76	56.51	55.92	32.43
39	0.5067	108.630	105.9	8.1	66.03	24.18	90.21	3.73	55.82	57.19	33.01
40	0.5273	111.236	108.5	8.9	67.09	24.79	91.88	3.71	55.21	58.34	33.55
41	0.5480	113.592	110.9	9.6	67.98	25.38	93.36	3.68	54.62	59.37	33.99
42	0.5686	116.003	113.3	10.4	68.87	25.91	94.78	3.66	54.09	60.35	34.44
43	0.5892	118.285	115.6	11.1	69.67	26.36	96.03	3.64	53.64	61.20	34.83
44	0.6098	120.462	117.7	11.9	70.37	26.76	97.14	3.63	53.24	61.95	35.19
45	0.6373	123.049	120.3	12.9	71.09	27.26	98.36	3.61	52.74	62.81	35.55
46	0.6579	125.154	122.4	13.7	71.71	27.61	99.31	3.60	52.39	63.46	35.85
47	0.6854	127.693	125.0	14.7	72.34	28.00	100.34	3.58	52.00	64.17	36.17
48	0.7129	130.034	127.3	15.7	72.82	28.34	101.16	3.57	51.66	64.75	36.41
49	0.7403	132.501	129.8	16.7	73.34	28.62	101.96	3.56	51.38	65.29	36.67
50	0.7544	133.654	130.9	17.2	73.53	28.75	102.29	3.56	51.25	65.52	36.77

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	75.140			167.000
Moisture content: Dry soil+tare, gms.	62.680			143.380
Moisture content: Tare, gms.	12.200			47.620
Moisture, %	24.7	24.7	24.7	24.7
Moist specimen weight, gms.	121.15			
Diameter, in.	1.329	1.339	1.350	
Area, in.²	1.387	1.409	1.431	
Height, in.	2.740	2.735	2.693	
Net decrease in height, in.		0.005	0.042	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	121.4	119.8	119.8	
Dry density, pcf	97.4	96.1	96.1	
Void ratio	0.5897	0.6117	0.6117	
Saturation, %	103.8	100.0	100.0	

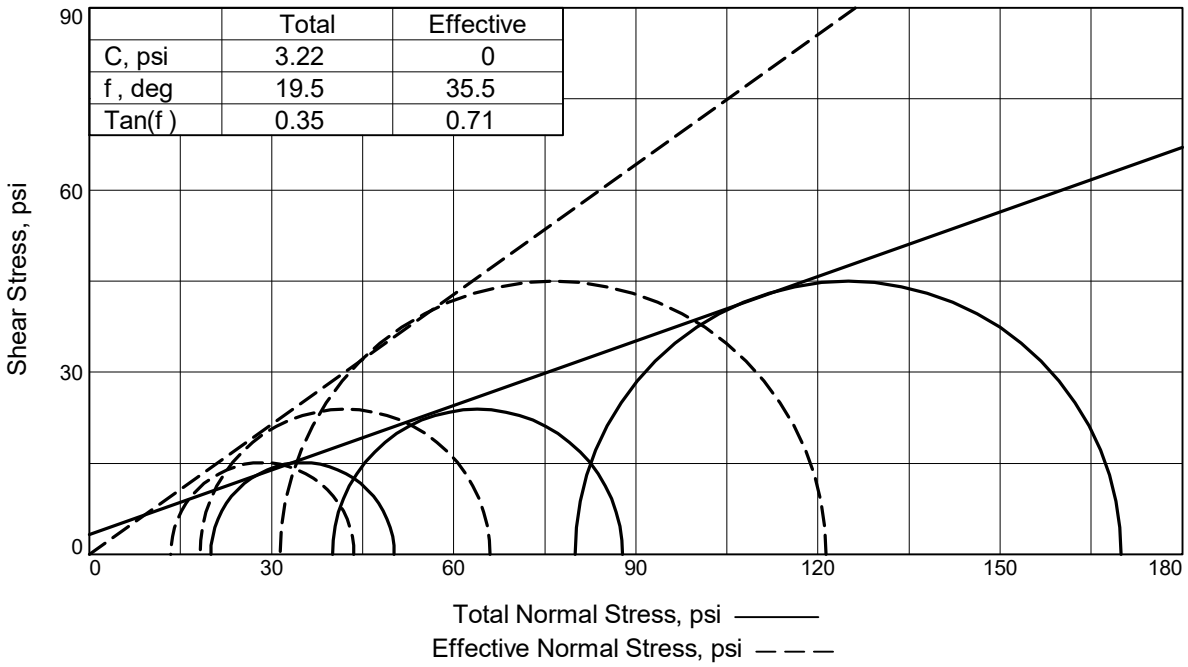
Test Readings for Specimen No. 3

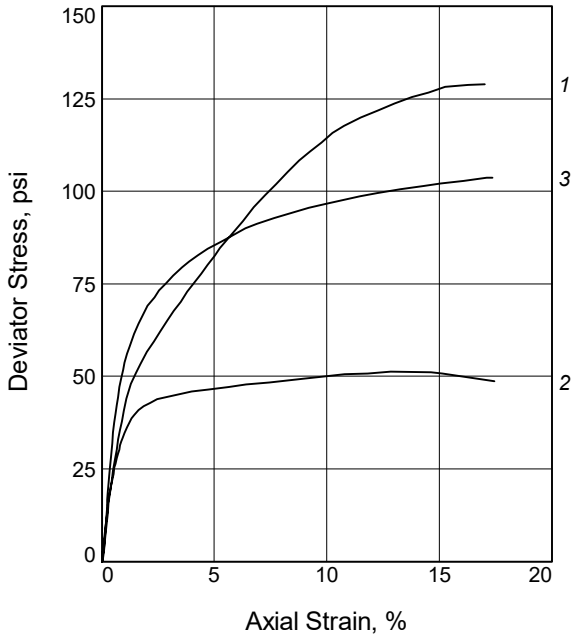
Consolidation cell pressure = 95.00 psi
Consolidation back pressure = 15.00 psi
Consolidation effective confining stress = 80.00 psi
Strain rate, in./min. = 0.000
Fail. Stress = 98.77 psi **at reading no.** 42

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.2358	2.952	0.0	0.0	0.00	79.93	79.93	1.00	15.07	79.93	0.00
1	0.2365	5.030	2.1	0.0	1.45	79.72	81.17	1.02	15.28	80.44	0.73
2	0.2378	9.953	7.0	0.1	4.89	79.16	84.05	1.06	15.84	81.61	2.44
3	0.2392	14.140	11.2	0.1	7.81	78.48	86.29	1.10	16.52	82.38	3.90
4	0.2406	17.719	14.8	0.2	10.30	77.76	88.07	1.13	17.24	82.91	5.15
5	0.2419	21.482	18.5	0.2	12.92	76.97	89.89	1.17	18.03	83.43	6.46
6	0.2433	25.039	22.1	0.3	15.39	76.12	91.52	1.20	18.88	83.82	7.70
7	0.2447	28.690	25.7	0.3	17.93	75.21	93.14	1.24	19.79	84.17	8.96
8	0.2460	32.288	29.3	0.4	20.42	74.24	94.66	1.28	20.76	84.45	10.21
9	0.2474	35.865	32.9	0.4	22.90	73.21	96.11	1.31	21.79	84.66	11.45
10	0.2488	39.477	36.5	0.5	25.40	72.11	97.52	1.35	22.89	84.82	12.70
11	0.2502	42.889	39.9	0.5	27.76	71.02	98.78	1.39	23.98	84.90	13.88
12	0.2515	46.424	43.5	0.6	30.20	69.88	100.08	1.43	25.12	84.98	15.10
13	0.2529	50.020	47.1	0.6	32.68	68.70	101.38	1.48	26.30	85.04	16.34
14	0.2543	53.625	50.7	0.7	35.17	67.49	102.66	1.52	27.51	85.07	17.58
15	0.2556	57.284	54.3	0.7	37.69	66.24	103.93	1.57	28.76	85.08	18.84
16	0.2570	60.830	57.9	0.8	40.13	64.97	105.10	1.62	30.03	85.03	20.06
17	0.2584	64.285	61.3	0.8	42.50	63.67	106.18	1.67	31.33	84.93	21.25
18	0.2598	67.445	64.5	0.9	44.67	62.43	107.09	1.72	32.57	84.76	22.33
19	0.2611	70.387	67.4	0.9	46.68	61.20	107.89	1.76	33.80	84.55	23.34
20	0.2625	73.355	70.4	1.0	48.71	60.01	108.73	1.81	34.99	84.37	24.36
21	0.2659	80.264	77.3	1.1	53.42	57.12	110.55	1.94	37.88	83.84	26.71
22	0.2687	85.006	82.1	1.2	56.64	55.00	111.64	2.03	40.00	83.32	28.32
23	0.2714	89.324	86.4	1.3	59.56	53.09	112.65	2.12	41.91	82.87	29.78
24	0.2741	93.156	90.2	1.4	62.14	51.37	113.51	2.21	43.63	82.44	31.07
25	0.2769	96.956	94.0	1.5	64.69	49.77	114.46	2.30	45.23	82.11	32.35

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
26	0.2796	100.301	97.3	1.6	66.93	48.34	115.26	2.38	46.66	81.80	33.46
27	0.2824	103.216	100.3	1.7	68.86	47.11	115.96	2.46	47.89	81.54	34.43
28	0.2851	106.056	103.1	1.8	70.73	45.99	116.73	2.54	49.01	81.36	35.37
29	0.2906	110.932	108.0	2.0	73.93	44.15	118.07	2.67	50.85	81.11	36.96
30	0.2961	115.369	112.4	2.2	76.80	42.71	119.52	2.80	52.29	81.11	38.40
31	0.3015	119.052	116.1	2.4	79.16	41.60	120.75	2.90	53.40	81.18	39.58
32	0.3070	122.493	119.5	2.6	81.33	40.74	122.07	3.00	54.26	81.41	40.67
33	0.3125	125.387	122.4	2.8	83.13	40.08	123.20	3.07	54.92	81.64	41.56
34	0.3207	129.224	126.3	3.2	85.46	39.37	124.83	3.17	55.63	82.10	42.73
35	0.3289	132.393	129.4	3.5	87.33	39.00	126.33	3.24	56.00	82.66	43.67
36	0.3372	135.445	132.5	3.8	89.11	38.67	127.78	3.30	56.33	83.22	44.55
37	0.3481	138.665	135.7	4.2	90.89	38.61	129.50	3.35	56.39	84.05	45.44
38	0.3591	141.550	138.6	4.6	92.42	38.70	131.13	3.39	56.30	84.92	46.21
39	0.3728	144.736	141.8	5.1	94.04	38.93	132.98	3.42	56.07	85.96	47.02
40	0.3865	147.889	144.9	5.6	95.62	39.32	134.94	3.43	55.68	87.13	47.81
41	0.4070	151.768	148.8	6.4	97.39	39.90	137.28	3.44	55.10	88.59	48.69
42	0.4276	155.116	152.2	7.1	98.77	40.48	139.24	3.44	54.52	89.86	49.38
43	0.4550	159.199	156.2	8.1	100.31	41.17	141.48	3.44	53.83	91.32	50.15
44	0.4824	162.627	159.7	9.2	101.37	41.89	143.26	3.42	53.11	92.58	50.69
45	0.5098	166.146	163.2	10.2	102.44	42.54	144.98	3.41	52.46	93.76	51.22
46	0.5372	169.534	166.6	11.2	103.39	43.16	146.54	3.40	51.84	94.85	51.69
47	0.5646	172.620	169.7	12.2	104.10	43.71	147.80	3.38	51.29	95.75	52.05
48	0.5920	175.443	172.5	13.2	104.60	44.17	148.77	3.37	50.83	96.47	52.30
49	0.6194	178.264	175.3	14.2	105.06	44.63	149.69	3.35	50.37	97.16	52.53
50	0.6468	181.221	178.3	15.3	105.57	45.01	150.58	3.35	49.99	97.80	52.78
51	0.6811	184.365	181.4	16.5	105.82	45.35	151.17	3.33	49.65	98.26	52.91
52	0.7016	186.198	183.2	17.3	105.91	45.52	151.43	3.33	49.48	98.47	52.96
53	0.7017	186.062	183.1	17.3	105.83	45.53	151.36	3.32	49.47	98.45	52.91





Sample No.		1	2	3
Initial	Water Content, %	26.6	28.9	23.7
	Dry Density, pcf	96.9	90.2	99.3
	Saturation, %	99.0	91.5	93.9
	Void Ratio	0.7139	0.8419	0.6720
	Diameter, in.	2.760	2.830	2.850
	Height, in.	5.549	5.410	5.470
At Test	Water Content, %	28.6	35.9	23.3
	Dry Density, pcf	94.3	85.0	102.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.7618	0.9537	0.6209
	Diameter, in.	2.812	2.954	2.835
	Height, in.	5.496	5.267	5.361
Strain rate, in./min.		0.001	0.001	0.001
Back Pressure, psi		47	45	15
Cell Pressure, psi		67	85	95
Fail. Stress, psi		30	48	90
Excess Pore Pr., psi		7	22	49
Ult. Stress, psi				
Excess Pore Pr., psi				
$\bar{s}_1$ Failure, psi		44	66	121
$\bar{s}_3$ Failure, psi		13	18	31

Type of Test:
CU with Pore Pressures
Sample Type: Tube
Description: Sandy Silt

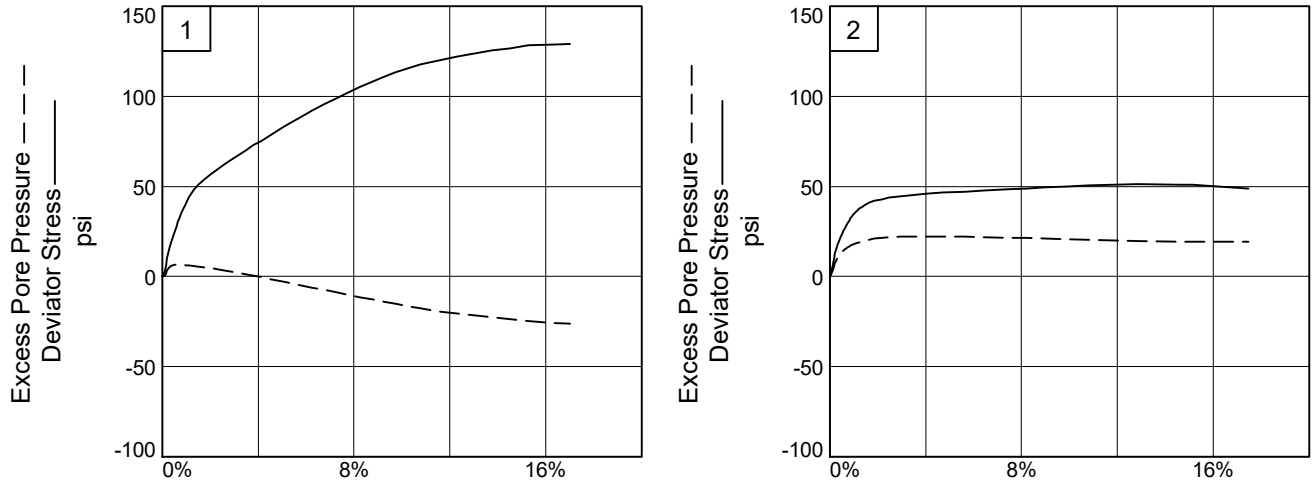
Specific Gravity= 2.66
Remarks: Three Specimen Series

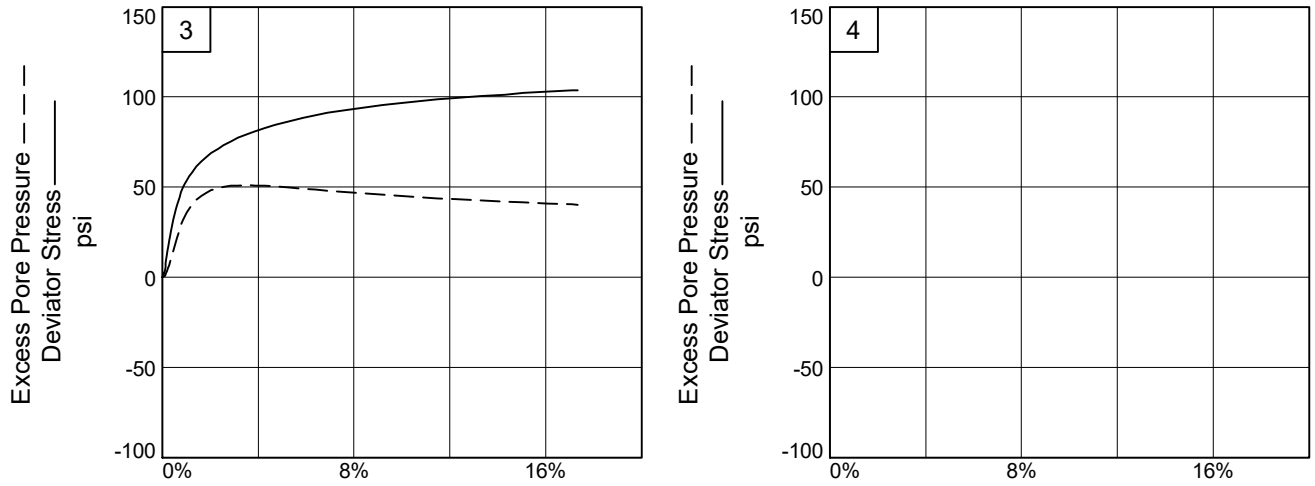
Client: Gannett Fleming, Inc.

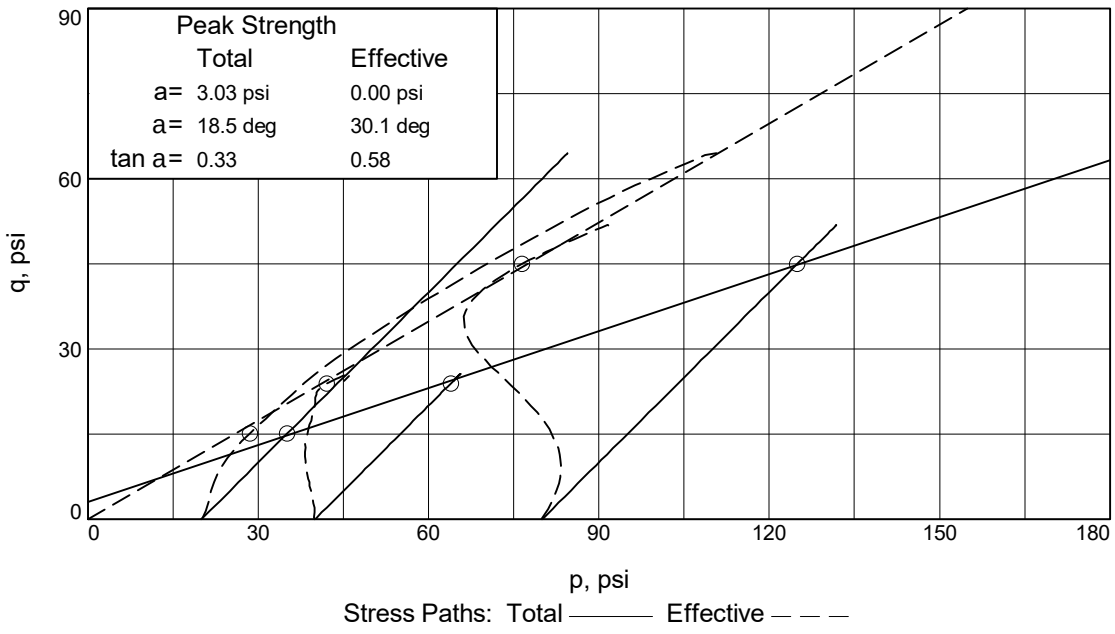
Project: Fordville Dam

Source of Sample: FD2020-609 **Depth:** 30.0-32.0 ft
Sample Number: U-1
Proj. No.: M5205037 **Date Sampled:** N/A

TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN







Client: Gannett Fleming, Inc.
Project: Fordville Dam
Source of Sample: FD2020-609 **Depth:** 30.0-32.0 ft **Sample Number:** U-1
Project No.: M5205037

Terracon Consultants, Inc.

TRIAXIAL COMPRESSION TEST 11/20/2020

CU with Pore Pressures 11:19 AM

Date: N/A
Client: Gannett Fleming, Inc.
Project: Fordville Dam
Project No.: M5205037
Location: FD2020-609
Depth: 30.0-32.0 ft **Sample Number:** U-1
Description: Sandy Silt
Remarks: Three Specimen Series
Type of Sample: Tube
Specific Gravity=2.66 **LL=** **PL=** **PI=**
Test Method: ASTM D 4767 Method B

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	55.610			1151.490
Moisture content: Dry soil+tare, gms.	46.470			920.410
Moisture content: Tare, gms.	12.070			113.500
Moisture, %	26.6	28.6	28.6	28.6
Moist specimen weight, gms.	1068.71			
Diameter, in.	2.760	2.805	2.812	
Area, in.²	5.983	6.180	6.209	
Height, in.	5.549	5.522	5.496	
Net decrease in height, in.		0.027	0.026	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	122.6	121.3	121.3	
Dry density, pcf	96.9	94.3	94.3	
Void ratio	0.7139	0.7618	0.7618	
Saturation, %	99.0	100.0	100.0	

Test Readings for Specimen No. 1

Consolidation cell pressure = 67.00 psi
Consolidation back pressure = 47.00 psi
Consolidation effective confining stress = 20.00 psi
Strain rate, in./min. = 0.001
Fail. Stress = 30.21 psi **at reading no.** 11

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.1339	2.721	0.0	0.0	0.00	19.99	19.99	1.00	47.01	19.99	0.00
1	0.1356	4.931	2.2	0.0	0.36	19.95	20.31	1.02	47.05	20.13	0.18
2	0.1398	20.532	17.8	0.1	2.87	19.32	22.19	1.15	47.68	20.75	1.43
3	0.1425	43.915	41.2	0.2	6.62	17.95	24.57	1.37	49.05	21.26	3.31
4	0.1453	65.059	62.3	0.2	10.02	16.67	26.69	1.60	50.33	21.68	5.01
5	0.1480	84.104	81.4	0.3	13.07	15.65	28.73	1.84	51.35	22.19	6.54
6	0.1508	101.057	98.3	0.3	15.79	14.88	30.67	2.06	52.12	22.77	7.89
7	0.1535	116.002	113.3	0.4	18.18	14.32	32.50	2.27	52.68	23.41	9.09
8	0.1576	136.969	134.2	0.4	21.53	13.78	35.31	2.56	53.22	24.54	10.76
9	0.1618	155.674	153.0	0.5	24.51	13.53	38.03	2.81	53.47	25.78	12.25
10	0.1659	173.966	171.2	0.6	27.42	13.39	40.81	3.05	53.61	27.10	13.71
11	0.1700	191.534	188.8	0.7	30.21	13.37	43.58	3.26	53.63	28.48	15.10
12	0.1741	208.889	206.2	0.7	32.96	13.44	46.40	3.45	53.56	29.92	16.48
13	0.1783	224.868	222.1	0.8	35.49	13.54	49.03	3.62	53.46	31.29	17.74
14	0.1824	239.756	237.0	0.9	37.84	13.64	51.47	3.77	53.36	32.55	18.92
15	0.1879	258.374	255.7	1.0	40.77	13.77	54.54	3.96	53.23	34.16	20.38
16	0.1948	278.979	276.3	1.1	44.00	13.93	57.93	4.16	53.07	35.93	22.00
17	0.2058	304.324	301.6	1.3	47.94	14.13	62.07	4.39	52.87	38.10	23.97
18	0.2168	324.198	321.5	1.5	50.99	14.39	65.39	4.54	52.61	39.89	25.50
19	0.2278	340.377	337.7	1.7	53.45	14.74	68.19	4.63	52.26	41.46	26.72
20	0.2443	361.399	358.7	2.0	56.60	15.33	71.93	4.69	51.67	43.63	28.30
21	0.2608	380.823	378.1	2.3	59.49	15.98	75.46	4.72	51.02	45.72	29.74
22	0.2773	399.696	397.0	2.6	62.26	16.70	78.97	4.73	50.30	47.84	31.13
23	0.2938	418.665	415.9	2.9	65.04	17.38	82.42	4.74	49.62	49.90	32.52
24	0.3103	437.348	434.6	3.2	67.75	18.14	85.89	4.74	48.86	52.01	33.87
25	0.3268	454.190	451.5	3.5	70.16	18.85	89.01	4.72	48.15	53.93	35.08
26	0.3433	472.826	470.1	3.8	72.82	19.63	92.45	4.71	47.37	56.04	36.41
27	0.3598	489.921	487.2	4.1	75.24	20.37	95.61	4.69	46.63	57.99	37.62
28	0.3763	507.289	504.6	4.4	77.68	21.16	98.83	4.67	45.84	59.99	38.84
29	0.3928	524.653	521.9	4.7	80.10	21.94	102.04	4.65	45.06	61.99	40.05
30	0.4093	542.370	539.6	5.0	82.55	22.73	105.29	4.63	44.27	64.01	41.28
31	0.4231	557.400	554.7	5.3	84.63	23.42	108.05	4.61	43.58	65.74	42.32
32	0.4506	584.920	582.2	5.8	88.36	24.74	113.10	4.57	42.26	68.92	44.18
33	0.4781	611.746	609.0	6.3	91.94	26.07	118.01	4.53	40.93	72.04	45.97
34	0.5056	639.731	637.0	6.8	95.65	27.43	123.08	4.49	39.57	75.25	47.83
35	0.5331	665.678	663.0	7.3	99.01	28.85	127.87	4.43	38.15	78.36	49.51
36	0.5606	688.626	685.9	7.8	101.89	30.13	132.02	4.38	36.87	81.07	50.94
37	0.5881	714.991	712.3	8.3	105.23	31.45	136.68	4.35	35.55	84.07	52.61
38	0.6156	739.459	736.7	8.8	108.25	32.73	140.98	4.31	34.27	86.85	54.13
39	0.6431	761.155	758.4	9.3	110.83	34.03	144.86	4.26	32.97	89.45	55.41
40	0.6706	781.933	779.2	9.8	113.24	35.24	148.48	4.21	31.76	91.86	56.62
41	0.6981	803.216	800.5	10.3	115.68	36.44	152.12	4.17	30.56	94.28	57.84
42	0.7256	821.230	818.5	10.8	117.63	37.60	155.23	4.13	29.40	96.42	58.81
43	0.7669	844.671	841.9	11.5	119.98	39.22	159.19	4.06	27.78	99.21	59.99
44	0.8081	865.442	862.7	12.3	121.89	40.56	162.45	4.01	26.44	101.51	60.95
45	0.8494	885.665	882.9	13.0	123.68	41.64	165.32	3.97	25.36	103.48	61.84
46	0.8907	905.826	903.1	13.8	125.42	42.69	168.10	3.94	24.31	105.39	62.71

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
47	0.9319	922.850	920.1	14.5	126.67	43.67	170.34	3.90	23.33	107.01	63.33
48	0.9732	942.578	939.9	15.3	128.25	44.58	172.83	3.88	22.42	108.70	64.12
49	1.0282	957.626	954.9	16.3	128.76	45.62	174.38	3.82	21.38	110.00	64.38
50	1.0691	967.795	965.1	17.0	128.98	46.26	175.24	3.79	20.74	110.75	64.49

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	54.980			1109.040
Moisture content: Dry soil+tare, gms.	45.460			846.250
Moisture content: Tare, gms.	12.570			113.270
Moisture, %	28.9	35.9	35.9	35.9
Moist specimen weight, gms.	1038.44			
Diameter, in.	2.830	2.925	2.954	
Area, in.²	6.290	6.722	6.853	
Height, in.	5.410	5.370	5.267	
Net decrease in height, in.		0.040	0.103	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	116.3	115.5	115.5	
Dry density, pcf	90.2	85.0	85.0	
Void ratio	0.8419	0.9537	0.9537	
Saturation, %	91.5	100.0	100.0	

Test Readings for Specimen No. 2

Consolidation cell pressure = 85.00 psi

Consolidation back pressure = 45.00 psi

Consolidation effective confining stress = 40.00 psi

Strain rate, in./min. = 0.001

Fail. Stress = 47.80 psi **at reading no.** 40

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.0786	4.296	0.0	0.0	0.00	39.95	39.95	1.00	45.05	39.95	0.00
1	0.0799	9.373	5.1	0.0	0.74	39.44	40.18	1.02	45.56	39.81	0.37
2	0.0813	20.673	16.4	0.1	2.39	38.69	41.08	1.06	46.31	39.89	1.19
3	0.0826	31.948	27.7	0.1	4.03	37.85	41.88	1.11	47.15	39.87	2.02
4	0.0840	42.669	38.4	0.1	5.59	36.87	42.46	1.15	48.13	39.67	2.80
5	0.0853	54.082	49.8	0.1	7.26	35.88	43.14	1.20	49.12	39.51	3.63
6	0.0867	66.150	61.9	0.2	9.01	34.91	43.92	1.26	50.09	39.41	4.51
7	0.0880	75.543	71.2	0.2	10.38	33.99	44.37	1.31	51.01	39.18	5.19
8	0.0894	84.551	80.3	0.2	11.69	33.15	44.84	1.35	51.85	39.00	5.84
9	0.0907	94.679	90.4	0.2	13.16	32.38	45.53	1.41	52.62	38.96	6.58
10	0.0921	102.215	97.9	0.3	14.25	31.61	45.86	1.45	53.39	38.74	7.13
11	0.0934	109.955	105.7	0.3	15.37	30.92	46.29	1.50	54.08	38.61	7.69
12	0.0948	117.991	113.7	0.3	16.54	30.27	46.81	1.55	54.73	38.54	8.27
13	0.0961	126.164	121.9	0.3	17.72	29.62	47.34	1.60	55.38	38.48	8.86
14	0.0989	138.383	134.1	0.4	19.49	28.53	48.02	1.68	56.47	38.27	9.75
15	0.1002	145.484	141.2	0.4	20.52	28.05	48.57	1.73	56.95	38.31	10.26
16	0.1029	156.086	151.8	0.5	22.05	27.18	49.22	1.81	57.82	38.20	11.02
17	0.1056	167.582	163.3	0.5	23.70	26.35	50.05	1.90	58.65	38.20	11.85

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
18	0.1083	178.524	174.2	0.6	25.28	25.66	50.94	1.99	59.34	38.30	12.64
19	0.1110	186.944	182.6	0.6	26.49	25.02	51.51	2.06	59.98	38.26	13.24
20	0.1137	196.883	192.6	0.7	27.91	24.45	52.36	2.14	60.55	38.40	13.96
21	0.1164	205.559	201.3	0.7	29.16	23.96	53.12	2.22	61.04	38.54	14.58
22	0.1191	213.311	209.0	0.8	30.26	23.50	53.77	2.29	61.50	38.64	15.13
23	0.1218	220.801	216.5	0.8	31.33	23.10	54.43	2.36	61.90	38.76	15.67
24	0.1245	228.366	224.1	0.9	32.41	22.73	55.14	2.43	62.27	38.94	16.21
25	0.1273	234.938	230.6	0.9	33.34	22.38	55.72	2.49	62.62	39.05	16.67
26	0.1313	243.937	239.6	1.0	34.62	21.97	56.59	2.58	63.03	39.28	17.31
27	0.1381	255.283	251.0	1.1	36.21	21.30	57.51	2.70	63.70	39.40	18.11
28	0.1435	265.678	261.4	1.2	37.67	20.87	58.54	2.81	64.13	39.70	18.84
29	0.1489	272.658	268.4	1.3	38.64	20.47	59.11	2.89	64.53	39.79	19.32
30	0.1543	279.400	275.1	1.4	39.57	20.10	59.67	2.97	64.90	39.89	19.78
31	0.1651	289.377	285.1	1.6	40.92	19.50	60.42	3.10	65.50	39.96	20.46
32	0.1759	297.432	293.1	1.8	41.98	19.08	61.06	3.20	65.92	40.07	20.99
33	0.1922	304.566	300.3	2.2	42.87	18.59	61.46	3.31	66.41	40.02	21.44
34	0.2084	312.664	308.4	2.5	43.89	18.29	62.17	3.40	66.71	40.23	21.94
35	0.2354	318.958	314.7	3.0	44.55	17.97	62.52	3.48	67.03	40.25	22.27
36	0.2625	325.269	321.0	3.5	45.20	17.85	63.05	3.53	67.15	40.45	22.60
37	0.2895	332.028	327.7	4.0	45.91	17.83	63.74	3.57	67.17	40.79	22.95
38	0.3274	338.923	334.6	4.7	46.52	17.87	64.40	3.60	67.13	41.14	23.26
39	0.3761	346.201	341.9	5.6	47.07	17.98	65.05	3.62	67.02	41.51	23.54
40	0.4167	354.357	350.1	6.4	47.80	18.19	65.99	3.63	66.81	42.09	23.90
41	0.4707	362.838	358.5	7.4	48.42	18.51	66.93	3.62	66.49	42.72	24.21
42	0.5113	369.275	365.0	8.2	48.88	18.72	67.60	3.61	66.28	43.16	24.44
43	0.5519	376.084	371.8	9.0	49.38	18.98	68.35	3.60	66.02	43.66	24.69
44	0.5924	382.967	378.7	9.8	49.86	19.22	69.08	3.59	65.78	44.15	24.93
45	0.6465	392.606	388.3	10.8	50.55	19.59	70.14	3.58	65.41	44.86	25.28
46	0.7006	399.323	395.0	11.8	50.83	19.93	70.77	3.55	65.07	45.35	25.42
47	0.7547	407.530	403.2	12.8	51.29	20.30	71.59	3.53	64.70	45.95	25.64
48	0.8494	414.219	409.9	14.6	51.06	20.68	71.74	3.47	64.32	46.21	25.53
49	0.8629	413.953	409.7	14.9	50.88	20.72	71.59	3.46	64.28	46.15	25.44
50	0.8764	415.014	410.7	15.1	50.85	20.80	71.65	3.45	64.20	46.22	25.43
51	0.9981	408.438	404.1	17.5	48.68	20.75	69.42	3.35	64.25	45.09	24.34

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	58.020			1221.780
Moisture content: Dry soil+tare, gms.	49.170			1012.120
Moisture content: Tare, gms.	11.880			113.980
Moisture, %	23.7	23.3	23.3	23.3
Moist specimen weight, gms.	1125.65			
Diameter, in.	2.850	2.811	2.835	
Area, in.²	6.379	6.204	6.310	
Height, in.	5.470	5.453	5.361	
Net decrease in height, in.		0.017	0.092	
Net decrease in water volume, cc.			0.000	
Wet density, pcf	122.9	126.4	126.4	
Dry density, pcf	99.3	102.4	102.4	
Void ratio	0.6720	0.6209	0.6209	
Saturation, %	93.9	100.0	100.0	

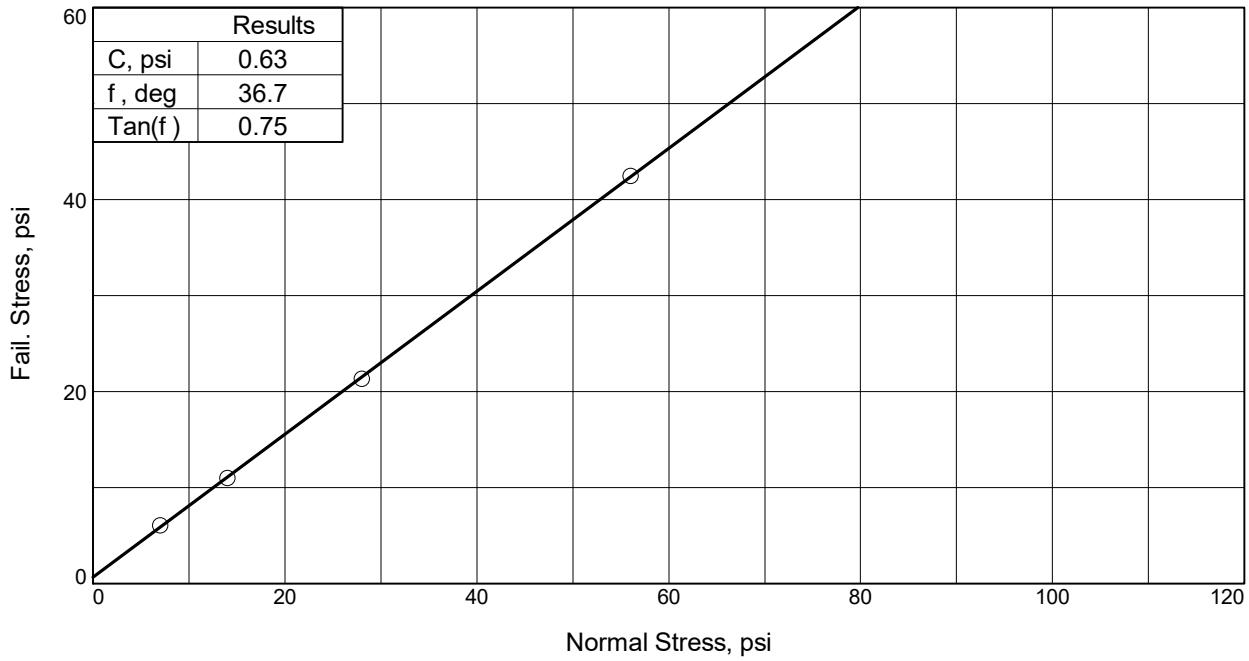
Test Readings for Specimen No. 3

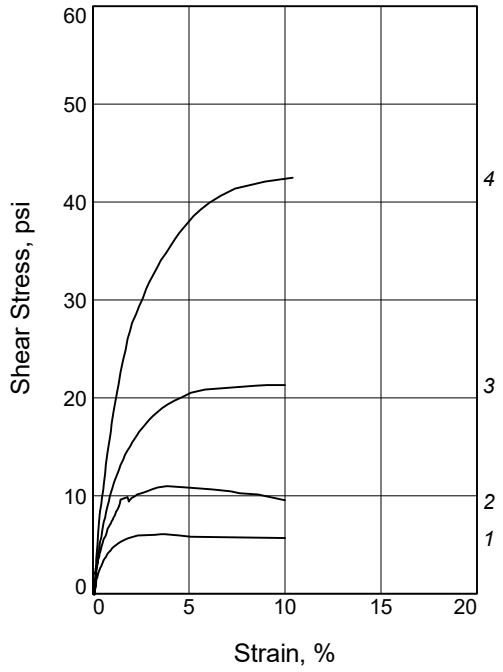
Consolidation cell pressure = 95.00 psi
Consolidation back pressure = 15.00 psi
Consolidation effective confining stress = 80.00 psi
Strain rate, in./min. = 0.001
Fail. Stress = 89.93 psi **at reading no.** 40

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.0781	4.126	0.0	0.0	0.00	79.92	79.92	1.00	15.08	79.92	0.00
1	0.0795	5.823	1.7	0.0	0.27	79.81	80.08	1.00	15.19	79.95	0.13
2	0.0836	27.285	23.2	0.1	3.67	79.20	82.86	1.05	15.80	81.03	1.83
3	0.0850	40.661	36.5	0.1	5.78	78.72	84.51	1.07	16.28	81.62	2.89
4	0.0863	53.864	49.7	0.2	7.87	78.14	86.01	1.10	16.86	82.08	3.93
5	0.0877	68.228	64.1	0.2	10.14	77.46	87.60	1.13	17.54	82.53	5.07
6	0.0891	83.578	79.5	0.2	12.56	76.64	89.21	1.16	18.36	82.92	6.28
7	0.0904	97.739	93.6	0.2	14.80	75.78	90.58	1.20	19.22	83.18	7.40
8	0.0918	110.362	106.2	0.3	16.79	74.82	91.61	1.22	20.18	83.22	8.40
9	0.0932	123.895	119.8	0.3	18.93	73.81	92.73	1.26	21.19	83.27	9.46
10	0.0945	136.128	132.0	0.3	20.85	72.74	93.59	1.29	22.26	83.17	10.43
11	0.0959	148.952	144.8	0.3	22.87	71.59	94.47	1.32	23.41	83.03	11.44
12	0.0973	161.935	157.8	0.4	24.92	70.43	95.35	1.35	24.57	82.89	12.46
13	0.1000	183.212	179.1	0.4	28.26	67.93	96.19	1.42	27.07	82.06	14.13
14	0.1027	206.123	202.0	0.5	31.86	65.37	97.23	1.49	29.63	81.30	15.93
15	0.1055	224.848	220.7	0.5	34.80	62.84	97.64	1.55	32.16	80.24	17.40
16	0.1082	242.843	238.7	0.6	37.62	60.36	97.98	1.62	34.64	79.17	18.81
17	0.1109	257.715	253.6	0.6	39.94	58.02	97.96	1.69	36.98	77.99	19.97
18	0.1137	272.469	268.3	0.7	42.24	55.82	98.06	1.76	39.18	76.94	21.12
19	0.1164	286.445	282.3	0.7	44.42	53.76	98.18	1.83	41.24	75.97	22.21
20	0.1205	304.063	299.9	0.8	47.15	50.90	98.05	1.93	44.10	74.47	23.58
21	0.1246	319.979	315.9	0.9	49.62	48.41	98.03	2.02	46.59	73.22	24.81
22	0.1287	334.533	330.4	0.9	51.86	46.17	98.04	2.12	48.83	72.10	25.93
23	0.1328	346.814	342.7	1.0	53.75	44.19	97.94	2.22	50.81	71.07	26.88
24	0.1383	362.080	358.0	1.1	56.09	41.92	98.00	2.34	53.08	69.96	28.04
25	0.1438	374.708	370.6	1.2	58.01	40.00	98.01	2.45	55.00	69.01	29.00

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
26	0.1547	397.358	393.2	1.4	61.42	36.96	98.38	2.66	58.04	67.67	30.71
27	0.1657	416.538	412.4	1.6	64.29	34.75	99.03	2.85	60.25	66.89	32.14
28	0.1766	432.319	428.2	1.8	66.61	33.06	99.67	3.01	61.94	66.36	33.30
29	0.1876	448.766	444.6	2.0	69.02	31.82	100.84	3.17	63.18	66.33	34.51
30	0.2040	465.707	461.6	2.3	71.43	30.50	101.93	3.34	64.50	66.22	35.71
31	0.2149	478.287	474.2	2.6	73.22	29.94	103.17	3.45	65.06	66.56	36.61
32	0.2313	492.228	488.1	2.9	75.14	29.40	104.54	3.56	65.60	66.97	37.57
33	0.2478	507.892	503.8	3.2	77.30	29.09	106.40	3.66	65.91	67.74	38.65
34	0.2696	524.111	520.0	3.6	79.46	28.98	108.44	3.74	66.02	68.71	39.73
35	0.2861	536.060	531.9	3.9	81.02	29.07	110.10	3.79	65.93	69.58	40.51
36	0.3080	549.972	545.8	4.3	82.79	29.27	112.06	3.83	65.73	70.66	41.40
37	0.3298	563.014	558.9	4.7	84.41	29.62	114.03	3.85	65.38	71.83	42.20
38	0.3654	581.820	577.7	5.4	86.64	30.25	116.89	3.86	64.75	73.57	43.32
39	0.3928	596.091	592.0	5.9	88.30	30.86	119.16	3.86	64.14	75.01	44.15
40	0.4201	610.313	606.2	6.4	89.93	31.42	121.36	3.86	63.58	76.39	44.97
41	0.4475	622.825	618.7	6.9	91.29	32.02	123.31	3.85	62.98	77.67	45.64
42	0.4885	638.098	634.0	7.7	92.77	32.84	125.62	3.82	62.16	79.23	46.39
43	0.5296	653.360	649.2	8.4	94.22	33.62	127.84	3.80	61.38	80.73	47.11
44	0.5706	667.614	663.5	9.2	95.48	34.35	129.83	3.78	60.65	82.09	47.74
45	0.6116	681.385	677.3	10.0	96.64	35.03	131.67	3.76	59.97	83.35	48.32
46	0.6527	694.365	690.2	10.7	97.66	35.64	133.30	3.74	59.36	84.47	48.83
47	0.6937	706.846	702.7	11.5	98.57	36.22	134.79	3.72	58.78	85.51	49.29
48	0.7348	719.908	715.8	12.2	99.54	36.79	136.33	3.71	58.21	86.56	49.77
49	0.7895	735.688	731.6	13.3	100.55	37.51	138.06	3.68	57.49	87.78	50.27
50	0.8442	750.354	746.2	14.3	101.36	38.15	139.51	3.66	56.85	88.83	50.68
51	0.8852	763.267	759.1	15.1	102.19	38.58	140.77	3.65	56.42	89.68	51.09
52	0.9399	777.484	773.4	16.1	102.85	39.11	141.96	3.63	55.89	90.53	51.43
53	0.9947	792.967	788.8	17.1	103.63	39.69	143.32	3.61	55.31	91.51	51.82
54	1.0082	795.051	790.9	17.3	103.59	39.84	143.43	3.60	55.16	91.64	51.80





Sample No.		1	2	3	4
Initial	Water Content, %	21.0	21.0	21.0	21.0
	Dry Density, pcf	100.0	100.0	100.0	100.0
	Saturation, %	84.7	84.5	84.8	84.7
	Void Ratio	0.6598	0.6607	0.6601	0.6599
	Diameter, in.	2.500	2.500	2.500	2.500
	Height, in.	1.000	1.000	1.000	1.000
At Test	Water Content, %	23.3	21.6	21.2	19.9
	Dry Density, pcf	103.2	105.8	107.0	109.2
	Saturation, %	101.4	100.7	102.5	101.5
	Void Ratio	0.6097	0.5697	0.5512	0.5213
	Diameter, in.	2.500	2.500	2.500	2.500
	Height, in.	0.970	0.945	0.934	0.916
Normal Stress, psi		7.00	14.00	28.00	56.00
Fail. Stress, psi		6.04	10.97	21.31	42.45
Strain, %		3.6	3.8	10.0	10.4
Ult. Stress, psi					
Strain, %					
Strain rate, in./min.		0.002	0.002	0.002	0.002

Sample Type: Remolded
Description: Silty Sand

Specific Gravity= 2.66
Remarks: 4-point series. Specimens remolded to approximately 100 pcf at 21 % moisture.

Client: Gannett Fleming, Inc.

Project: Fordville Dam

Source of Sample: FD2020-608 **Depth:** 0.0-17.5 ft
Sample Number: S1-S7
Proj. No.: M5205037 **Date Sampled:** N/A

DIRECT SHEAR TEST REPORT
Terracon Consultants, Inc.
Chattanooga, TN

Objective:

This narrative documents the assumptions and methodology used in the Fordville Dam embankment stability analysis to meet requirements of TR-60 (Ref. 1). Analyses performed include steady-state static stability and rapid drawdown. Seepage analyses were also performed to determine the corresponding pore pressures for the appropriate stability models.

References:

1. NRCS Technical Release 60. Earth Dams and Reservoirs. *(Selected Pages Attached)*
2. Houston Engineering. 2020. Fordville Dam Surface Topography.
3. Gannett Fleming. 2020. Fordville Dam Boring Logs. *(Selected Logs Attached*)
4. U.S. Department of the Interior. Soil Conservation Service. 1978. Middle-South Branch Forest River Watershed Dam 4 (Fordville Dam). "As-Built" Drawings. *(Selected Sheets Attached*)
5. Houston Engineering. 2020. PMF Headwater/Tailwater Elevations.
6. Gannett Fleming. 2020 Summary of Laboratory Test Results for Fordville Dam.
7. USBR. 1987. Design Standards No. 13 Embankment Dams. Chapter 8 Seepage Analysis and Control.
8. Gannett Fleming. 2020. Piezometer Data for Fordville Dam.
9. Gannett Fleming. 2020. Shear Strength Calculations for Fordville Dam.

GENERAL ASSUMPTIONS AND MODEL INPUTS

Purpose

The analyses completed in this scope of work include normal pool steady-state seepage, static stability, maximum surcharge pool static stability, and stability of the upstream slope during rapid drawdown conditions, in accordance with Ref. 1.

Geometry

The geometry of the model is developed from the site topography (Ref. 2) to establish the ground surface, subsurface boring logs (Ref. 3) to delimit differing materials, and As-Built drawings (Ref. 4) to fill in data gaps, such as fill placements, drain locations, and the upstream slope that below the normal pool. A few discrepancies were noted between the embankment geometry as shown on the As-Built drawings (Ref. 4) and site topography (Ref. 2). In particular, the dam crest is listed as 26 feet wide on the As-Built drawings but is shown as 30 feet wide on the site topography and the downstream bench is listed as 18 feet wide on the As-Built drawings but is shown as approximately 23 feet wide on the site topography. Therefore, the embankment slopes are modeled based on Ref. 2 rather than Ref. 4 to account for any changes that may have occurred since completion of original construction. Additionally, the centerline of the model is based on

the centerline of the existing roadway that cross the dam crest rather than the centerline shown on the As-Built drawings – note that the as-built drawings show an additional 8 foot of crest wide upstream of the dam centerline which was likely a change made during construction. The geometry of the model corresponds to Station 24+50 which is the approximate location of borings FD2020-11, FD2020-608, and FD2020-609 and the maximum height of fill.

Five different materials were modeled: Zone I (embankment core), Zone II (embankment shell) Drain Fill, sandy alluvium overburden, and alluvium/outwash overburden.

The model utilizes NAVD 88 as the reference datum, which is approximately 1.2 feet greater than NAVD 29, the reference datum presumably used in the as-built drawings. Therefore, referenced elevations from the as-built drawings utilized in the GeoStudio model are increased by 1.2 feet.

Seepage Modeling

General

SEEP/W models were developed for normal pool and raised pool (equal to the maximum pool elevation) conditions to develop the appropriate pore water conditions to meet Ref. 1 criteria, as applicable. The use of these SEEP/W models in conjunction with specific SLOPE/W stability models is presented herein.

Boundary Conditions

The boundary conditions (BC) used for seepage modeling, i.e., generation of pore pressures, are:

1. A total head BC equal to the respective pool elevation was used to model different reservoir pool conditions.
    a. Normal Pool is modeled at El. 1106.0, which is equal to the invert of the 1st Stage of the principal spillway.
    b. Flood Surcharge Pool is modeled at El. 1129.4 which is equal to maximum flood (i.e., probably maximum flood, PMF) hydrograph (Ref. 5).
2. A potential seepage face review BC was used on the downstream embankment slope for each of the modeled pool conditions. This is a conservative approach in which the program starts by solving the problem based on the upstream boundary conditions and then computes the pressure on the nodes that make up the potential seepage face, with the assumed requirement that water can't pond on the surface – it simply runs off. The program iterates through all nodes, preventing ponded water, until a solution is reached where the phreatic surface may be at the ground surface for some portion of the potential seepage face.
3. A total head BC for tailwater is used for each modeled pool condition.

a. The normal pool tailwater is modeled at El. 1075.0 ft. This boundary condition is located in the stream channel approximately 650 feet downstream of the dam centerline. The tailwater elevation is based on the site topography (Ref. 2) and assume a 1 ft deep stream flow.
b. The flood pool tailwater is modeled at El. 1086.2 ft, which was developed from the maximum flood hydrograph (Ref. 5)

A fifth boundary condition, a zero pressure head, $H_P = 0$, was considered during model calibration to represent the pipe within the foundation drain located approximately 90 ft downstream of the dam centerline. Typically, use of this BC is considered appropriate because the drain acts as a "sink" to convey seepage to an actively flowing outlet. However, omission of the BC at the foundation drain allows for the calibration model to achieve better agreement with the pore pressures measured by the vibrating wire piezometers.

Hydraulic Conductivity Input

Material Models – SEEP/W requires the selection of a model type for each material that is being used in the seepage analysis. In general, the "Saturated/Unsaturated" model was selected for all materials that exist near the ground surface or near the anticipated phreatic surface through the dam during normal and raised pool seepage conditions – for the purposes of this evaluation, all strata, except for the Outwash/Alluvium, was modeled as "Saturated/Unsaturated". The "Saturated Only" model was chosen for the Outwash/Alluvium which is always completely submerged below the phreatic surface during the analyses. The selected material model for each layer is shown on the output reports. A summary of the saturated hydraulic conductivity (k_{sat}) values is displayed in Table 1.

Table 1. Summary of Saturated Hydraulic Conductivity Parameters

Strata	Material Model	Permeability (ft/sec)	Permeability (cm/sec)	Data Source
Zone I (Core)	Saturated/Unsaturated	$2.5\text{x}10^{-9}$	$7.7\text{x}10^{-8}$	Ref. 5
Zone II (Shell)	Saturated/Unsaturated	$2.1\text{x}10^{-7}$	$6.5\text{x}10^{-6}$	Ref. 5
Drain Fill	Saturated/Unsaturated	$3.3\text{x}10^{-3}$	$1\text{x}10^{-1}$	See Note 1
Sandy Alluvium	Saturated/Unsaturated	$5.0\text{x}10^{-5}$	$1.5\text{x}10^{-3}$	See Note 2
Outwash/Alluvium	Saturated Only	$1.15\text{x}10^{-7}$	$3.5\text{x}10^{-6}$	See Note 3

Notes:

1) Per Ref. 6, the gradation of the existing drain fill indicates a poorly graded sand with gravel. A permeability of $1\text{x}10^{-6}$ cm/sec is reasonable for this material per Ref. 7, Table A-3.
2) The permeability of this material was not measured by field or laboratory methods. For modeling purposes, the permeability of this material was adjusted until modeled pore pressures were in relative agreement with observed field conditions.

3) Two permeability test were conduction on outwash/alluvium samples. Better agreement between the model and observed conditions is achieved when the lower permeability of $3.5x10^{-6}$ cm/sec is utilized.

Saturated Only Model – For this model type, a saturated hydraulic conductivity value is required. No function is required because the geomaterial is assumed to be continuously saturated. Inputs for saturated water content, equal to the material porosity, are also required.

Saturated/Unsaturated Model – A hydraulic conductivity function, i.e., k-function, must be input for each Saturated/Unsaturated material. The k-function defines the hydraulic conductivity as a function of negative pore water pressure. Each material k-function was generated by the software using the volumetric water content function, the saturated hydraulic conductivity (k_{sat}), and a residual volumetric water content (Θ_r), typically set to 10% of the porosity. All materials utilized a k-ratio of 1.

The volumetric water content function (water content versus negative pore water pressure) is generated by a subroutine within the software using the saturated water content, i.e., material porosity, and the general soil type (e.g., clay, silty sand, gravel, etc.). Porosity is estimated using the USCS material classifications provided in Ref. 6 and Ref. 7, Table A-8. Material porosities and selected volumetric water content function representative soil types are summarized in Table 2.

Table 2. Summary of Design Porosity Values

Strata	Representative Sample Material	Porosity
Zone I (Core)	Clay	0.33
Zone II (Shell)	Silty Sand	0.25
Drain Fill	Sand	0.30
Sandy Alluvium	Silty Sand	0.25
Outwash/Alluvium	n/a	0.35

Notes:

1) The Outwash/Alluvium utilizes the "Saturated Only" model which does not require a volumetric water content function and therefore a representative soil type was not assigned.

Piezometer Data Used to Calibrate the Model

Pore pressure data obtained from piezometers FD2020-11, FD2020-608, and FD2020-609, was utilized to calibrate the seepage model (i.e., confirm user inputs). The SEEP/W model under normal pool conditions yields pore pressures within five feet of the pore pressures measured (Ref. 8) in five of the six monitoring locations as summarized in Table 3.

Table 3. Comparison of Observed and Modeled Piezometric Heads

Piezometer	Observed in Field[1] (ft)	Modeled (ft)	Delta[2] (ft)
FD2020-11 Upper	1083.7	1081.5	-2.2
FD2020-11 Lower	1080.3	1088.4	8.1
FD2020-608 Upper	1077.8	1077.2	-0.6
FD2020-608 Lower	1075.2	1080.1	4.9
FD2020-609 Upper	1073.6	1076.7	3.1
FD2020-609 Lower	1073.2	1077.6	4.4

Notes:

1) Average observed head over a 30-day period from 10/21/20 to 11/19/20.
2) Negative delta value indicated modeled head in lower than field observed head.

SLOPE STABILITY MODELING

Pore Water Pressures

Static Stability at Normal Pool

Pore water pressures were developed using the SEEP/W model during steady-state normal pool conditions. The analysis is carried out for the downstream slope of the dam.

Static Stability at Flood Surcharge Pool

Pore water pressures were developed using the SEEP/W model during steady-state flood surcharge pool conditions. The analysis is carried out for the downstream slope of the dam.

Rapid Drawdown

Pore water pressures for this analysis were modeled using a manually-input single piezometric line equal to El. 1090.8 from the upstream-most boundary of the model to the Zone I core. This elevation is equal to the elevation of the drawdown inlet on the As-Built Drawings, El. 1089.6 (Ref. 4, Sheet 12) adjusted from NVGD29 to NAVD88 (+1.2 ft). The piezometric line is then drawn to closely match the piezometric surface from the normal pool stability model downstream of the Zone I core. This piezometric surface represents an instantaneous drawdown within the SLOPE/W model. The analysis is carried out for the upstream slope of the dam.

Shear Strength Parameters

General

Design shear strength parameters (Ref. 9) were calculated using lab testing results (Ref. 6) for the Zone I, Zone II and Outwash/Alluvium materials. The shear strength parameters for the existing drain fill and sandy alluvium overburden are based on typical values for course grained materials.

Due to the apparent coarseness of the Zone II shell as determined from field and laboratory characterization, this material was assumed to be free draining and strength parameters were determined from direct shear testing, thus precluding the ability to determine total stress parameters. Subsequent permeability testing yielded a permeability of 6.5×10^{-6} cm/sec indicating this material is not free draining. Therefore, in the absence to sufficient laboratory testing, the total stress parameters for the Zone II shell are conservatively assumed to be equal to the Zone I core for the rapid drawdown analysis – in theory the total stress shear strength of a sandy soil should be greater than the total stress shear strength of a clayey soil.

Static Stability at Normal Pool

The SLOPE/W model utilizes effective strength parameters as presented in Table 4.

Static Stability at Flood Surcharge Pool

The SLOPE/W model utilizes bilinear strength parameters, i.e., the lowest of the effective or the consolidated total stress failure envelope as required in Ref. 1. SLOPE/W requires the input of both effective and total stress parameters as well as the normal stress of the intersection of the two failure envelopes to perform a bilinear strength analysis. These parameters are presented in Table 4.

Rapid Drawdown

The SLOPE/W model utilizes bilinear strength parameters (previously defined) as required per Ref. 1 for the Zoned Embankment and Outwash/Alluvium strata as these materials are relatively low permeability and are expected to have limited drainage during a drawdown of the pool.

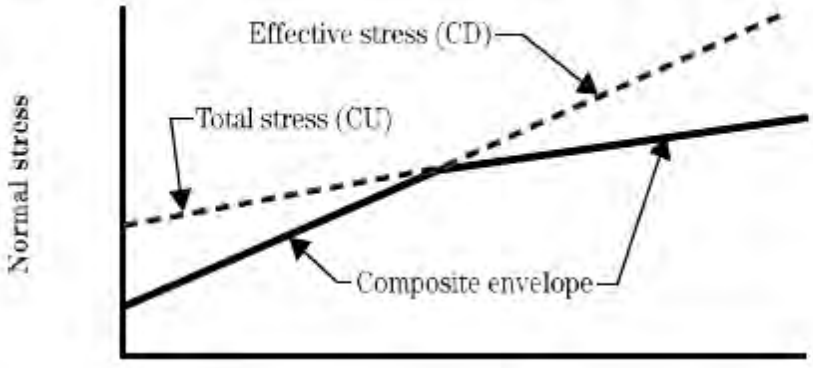
Table 4. SLOPE/W Soil and Rock Design Parameter Summary

Material	Unit Weight	Shear Strength Parameters				
		Effective Stress		Total Stress		Bilinear Stress
		Cohesion, c'	Friction Angle, ϕ'	Cohesion, c	Friction Angle, ϕ	Normal Stress[1], σN
	(pcf)	(psf)	(degrees)	(psf)	(degrees)	(psf)
Zone I (Core)	133	0	33	576	25	3146
Zone II (Shell)	121	0	37	See Note 2		2005
Drain Fill	110	0	36	0	36	-
Sandy Alluvium	110	0	34	0	34	-
Outwash/Alluvium	120	0	32	317	21	1315

Notes:

1) The normal stress, σ_N, is the normal stress coordinate of the intersection of the effective stress and total stress failure envelope (Ref. 1, Figure 5-2 is duplicated below) and is calculated with the equation: $\sigma_N = \frac{c - c'}{\tan\phi' - \tan\phi}$
2) Total stress parameters are estimated to be equal to Zone I as previously discussed.
3) The sandy alluvium overburden and drain fill are considered to be free draining and therefore effective stress parameters are utilized for the rapid drawdown model.

Figure 5–2: Mohr-Coulomb Envelope for Upstream Drawdown



ANALYSIS AND CONCLUSION

A summary of the embankment stability analyses performed during this scope of work is presented in Table 5.

- The evaluation indicates that the existing embankment meets TR-60 criteria (Ref. 1) for normal pool, steady-state seepage (FS = 2.3, required FS = 1.5).

- The evaluation indicates that the existing embankment meets TR-60 criteria (Ref. 1) for normal pool, steady-state seepage (FS = 1.7, required FS = 1.4).

- The evaluation indicates that the existing embankment does meet TR-60 criteria (Ref. 1) for stability of the upstream slope during rapid drawdown of the reservoir from normal pool (FS=2.1, required FS=1.2).

Table 5. Summary of Fordville Dam Embankment Stability Evaluation

Pool Condition	Pool Elevation	Seepage Conditions	PWP Conditions	Design Criteria	Slope	Stability Analysis	Shear Strength Parameters	Required Factor of Safety	Calculated Factor of Safety
Normal	1106.0	Steady State	From Normal Pool SEEP/W Analysis	TR-60	Downstream	Static	Effective Stress Strengths for All Materials	1.5	2.3
Flood Surcharge	1128.3	Steady-State	From Flood Surcharge Pool SEEP/W Analysis	TR-60	Downstream	Static	Bilinear Strengths for Embankment and non-free draining Foundation materials.	1.4	1.7
Rapid Drawdown	1090.8	Steady-State	Piezometric Surface Equal to Invert of Lowest Gated Outlet	TR-60	Upstream	Static	Bilinear Strengths for Embankment and non-free draining Foundation materials,	1.2	2.1

Ref. 1

Overall height of embankment, H, (ft)	Minimum top width (ft)		
	All dams	Single-purpose floodwater retarding	Multipurpose or other purposes
35<94.9	N/A	14	(H+35)/5
95.0+	N/A	16	26

Embankment Slope Stability

Analyze the stability of embankment slopes using generally accepted methods based on sound engineering principles. Document all aspects of the analyses performed. Documentation should include analysis program and methods used, input data, and tabular and graphical output. Document shear strength parameters used for each zone of the embankment and each soil type or horizon in the foundation and the basis for these parameters. Document piezometric assumptions included in the analyses and any other variables that will influence stability, along with the basis for the values. The stability analysis should incorporate zones of saturation and seepage pressures consistent with the results of the seepage analysis. Identify and incorporate features necessary to achieve required safety factors in the design.

The extent and intent of the site investigation, soil testing program, and analyses should be consistent. The level of investigation, testing, and analysis should be commensurate with the complexity of the site and structure, along with the consequences of failure. Minimum required static stability safety factors are summarized in figure 5–3 for each condition analyzed.

This TR does not address all potential situations that may arise in the embankment dam stability analysis. When using approaches outside the scope of this TR, document references for all analysis methods used. Include justification for the methodology used, the basis for material characterization and pore pressure assumptions, and comparison of the analysis results with analysis methods included in this technical release.

Consider the following guidance in analyzing slope stability for all conditions:

- Evaluate the overall stability of the embankment and foundation. Determine the stability of critical slip zones (zones that encompass a significant portion of the embankment, pass through major portions of the embankment and foundation, and zones that include the crest), and identify slip surfaces with the overall minimum factors of safety. Document the location of slip surfaces evaluated relative to the location of comparatively weaker materials and areas of high pore pressure, to assure the evaluation of zones that have a propensity to control stability.
- Use effective stress parameters for soils that will drain as rapidly as load is applied. These parameters apply for all conditions of stability analyzed for these soils.
- Limit the use of infinite slope equations and associated safety factors listed in figure 5–3 to the stability of near surface failure surfaces in the exterior slope of embankments with cohesionless soils, when the critical failure is wholly within soils of this character, and analysis of deeper failures would result in higher factors of safety. Infinite slope equations should model the predicted seepage pattern in the slope under analysis. Different equations apply for no seepage, horizontal seepage paths, and seepage paths parallel to the slope face. If shallow slope failure

could progress and affect deeper embankment zones, use the higher safety factors listed in figure 5–3. If cohesionless zones occur with other soil types in analysis of a cross section, use other methods to analyze circular arc or wedge-shaped surfaces that intersect the soil zones with cohesion to locate the minimum safety factor.

- Use residual effective stress parameters for modeling slope stability analyses involving fissured clays or shales if preexisting movements have occurred. Drained shear strength tests provide the basis for these parameters. Use residual parameters for designing against shallow slope failures in desiccated clay embankments with previous movement. Designers can use fully softened shear strength with conservative pore pressure assumptions to evaluate the potential for first time shallow slope failures in compacted high plasticity clay embankments.

Static Stability

Analyze embankment stability for each of the following conditions in the structure life that are appropriate to the site. Clearly document the reasons for not analyzing a condition. Document the source of all shear strength parameters used. When using a shear strength parameter determined from an empirical correlation, include correlations to field performance and document the justification for use of the empirically based value rather than site-specific sampling and testing. Include discussion on the sensitivity of the outcome of the analysis to the variability of the parameter. Stability analyses must identify and incorporate any lower strength materials that may control stability.

Stability During Construction

The construction sequence may control the configuration of the embankment and rate of construction when analysis predicts that embankment soil, foundation soils, or both will develop significant pore pressures during embankment construction. Evaluate site conditions, such as soft clay layers in the foundation that may require special designs. Consider flattened slopes and sequentially staged construction to achieve stable conditions. Factors determining the likelihood of this occurring include the overall height of the planned embankment, the speed of construction, the saturated consistency of foundation soils, and others. Perform appropriate shear tests to model placement conditions of embankment soils, as summarized in figure 5–3. Consider the highest likely placement water content of embankment soils in the shear-testing program. Alternatively, designers can use effective stress shear parameters to establish limits for pore pressure buildup during construction. The design should include procedures for monitoring pore pressures during construction to assure that actual pore pressures do not exceed limits established during design.

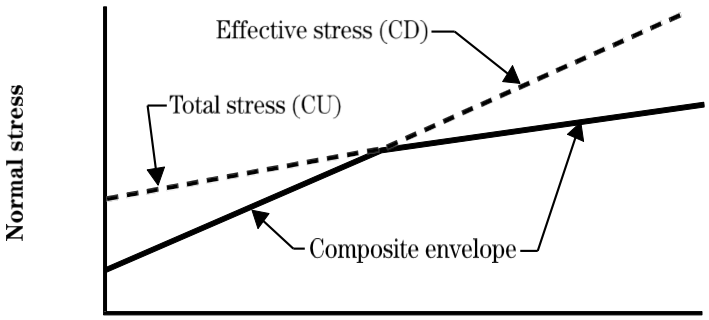
Construction stability analysis must include stability of excavation slopes that could have significant safety or construction consequences, such as excavation of existing embankment slopes during rehabilitation construction.

Rapid Drawdown

Analyze the stability of the upstream embankment slope for the condition created by a rapid drawdown of the water level in the reservoir from the normal full reservoir level from which a phreatic line is likely to develop to the elevation of the lowest gated outlet. If the potential exists for saturation of zones in the upstream slope during temporary flood retention storage above the permanent normal pool, consider the effect of drawdown back to the normal pool on that saturated portion of the embankment. Designers may use transient seepage analysis to estimate the short-term saturation of the portion of the embankment above permanent normal pool. Select shear strength parameters for the

analyses according to figure 5–3, as illustrated in figure 5–2.

Figure 5–2: Mohr-Coulomb Envelope for Upstream Drawdown



In cases where rapid drawdown slope stability is critical to embankment geometry or zoning, or for modifications to a previously constructed embankment, designers can also analyze rapid drawdown using procedures included in U.S. Army Corps of Engineers (USACE) Engineer Manual (EM) 1110-2-1902, Appendix G. Documentation should include the difference in analysis results between the methods and justification to use the selected results.

Steady Seepage

Analyze downstream slope stability of new or previously constructed dams under steady-state seepage conditions. Perform the analysis with the reservoir elevation at the highest normal pool level. Use shear parameters as listed in figure 5–3. Base the location of the steady-state phreatic surface on the highest normal reservoir pool elevation. Designers can develop the phreatic surface for the analyses using computer programs for seepage analysis, flow nets, or Casagrande procedures.

Existing embankments may not have achieved steady-state conditions. Thus, use the calculated long-term high-level steady-state seepage condition for both new and existing embankments. For existing embankments, compare the computed phreatic surface with field performance and field measurements, when available, to assure that the computed phreatic surface meets or exceeds that which has occurred over the life of the structure.

Include a separate foundation phreatic surface as appropriate at sites with limited foundation seepage cutoff, particularly in sites with confined seepage that results in uplift at the downstream toe.

If steady-state seepage stability is highly dependent on the success of internal drainage features to control the phreatic surface, check stability assuming partially functioning or plugged drainage systems.

For appropriate slopes, designers can use infinite slope equations and applicable safety factors listed in figure 5-3.

Flood Surcharge

Analyze downstream slope stability of new or previously constructed dams under flood detention conditions. Perform the analysis with the reservoir elevation at the freeboard hydrograph pool level. Use shear parameters as listed in figure 5–3.

Develop a phreatic surface resulting from the maximum reservoir elevation. Consider material properties and the potential for defects in the upper portion of the embankment when selecting the appropriate seepage analysis and evaluating seepage conditions that could develop. Also consider the potential for increase in pore pressures in the normally saturated portion of the foundation or embankment that may result from the higher reservoir loading. Evaluate a range of potential seepage conditions to determine the sensitivity of flood storage stability to potential seepage conditions.

If short term flood storage stability is highly dependent on the success of internal drainage features to control the phreatic surface, check stability assuming partially functioning or plugged drainage systems.

For appropriate slopes, designers can use infinite slope equations and applicable safety factors listed in figure 5-3.

Figure 5–3: Table of Static Slope Stability Criteria

Design condition	Primary assumption	Remarks	Applicable shear strength parameters	Minimum safety factor
1. Construction Stability (upstream or downstream slope)	Zones of the embankment or layers of the foundation expected to develop significant pore pressures during construction	Low-permeability embankment soils should be tested at water contents that are as wet as likely during construction (usually wet of optimum). Saturated low permeable foundation soils not expected to consolidate fully during construction. Existing dams with additional fill placed above saturated low-permeability zones.	Unconsolidated; Total stress consistent with preconstruction stress state	1.4 for failure surfaces extending into foundation layers 1.3 for embankments on stronger foundations where the failure surface is located entirely in the embankment
	Embankment zones and/or strata not expected to develop significant pore pressures during construction	Embankment zones, foundation strata, or both comprised of material with a permeability high enough to drain as rapidly as they are loaded	Effective stress	
2. Rapid drawdown (upstream slope)	Drawdown from the highest normal pool to the lowest gated outlet	Consider failure surfaces both within the embankment and extending into the foundation Low-permeability embankment and foundation soils that will have limited drainage during reservoir drawdown	Lowest of effective stress or consolidated; total stress; consistent with predrawdown consolidation stresses (See fig. 5-1)	1.2 1.1 for near surface (infinite slope) failure surfaces in cohesionless soils
		Embankment zones, foundation strata, or both comprised of material with a permeability high enough to drain as the reservoir is drawn down	Effective stress	
3. Steady seepage	Reservoir water surface at highest normal pool. Phreatic surface developed from the highest normal pool; typically the principal spillway crest	Consider failure surfaces within both the embankment and extending into the foundation. Foundation analysis may require separate phreatic surface evaluation, particularly in sites with confined seepage that results in uplift at the downstream toe.	Effective stress	1.5 1.3 for near surface (infinite slope) failure surfaces in cohesionless soils
4. Flood surcharge	Reservoir at freeboard hydrograph level. Steady seepage phreatic surface incorporating increased pore water pressure that may occur from flood detention and pore water pressure from short term seepage resulting from reservoir surface above the normal pool elevation	Consider failure surfaces within both the embankment and extending into the foundation. Embankment zones, foundation strata, or both comprised of material with a permeability high enough to drain rapidly with changes in reservoir elevation Low-permeability embankment and foundation soils that will have limited drainage as the increased reservoir load is applied	Effective stress Lowest of effective stress or consolidated; total stress (See fig. 5-1)	1.4 1.2 for near surface (infinite slope) failure surfaces in cohesionless soils

Figure 5–4: Shear Strength Parameters, Associated Tests, and Nomenclature

Shear strength parameter	Types of shear tests	NRCS notation	Other common abbreviation	Notes	American Standard for Testing Materials (ASTM) test standard
Total stress; unconsolidated[1]	Unconsolidated undrained triaxial	UU	Q		D2850
	Unconfined-compression	qu		Suitable for limited types of soils[2]	D2166
	Field vane shear			Limited to saturated low strength (Su<2 tsf) clays and silts. Field vane shear test results must be corrected for plasticity index to determine undrained strength	D2573
Total stress; consolidated [1]	Consolidated undrained triaxial	CU	R	ASTM standard for cohesive soils	D4767
Effective stress	Consolidated undrained triaxial with pore pressure measurements	$\overline{CU}$	R	Determine effective stress parameters by subtracting measured pore pressures from total stresses.	D4767
	Consolidated drained triaxial[3]	CD	S		D7181
	Direct shear			Strain rate must be limited to the extent required to allow drainage	D3080
Residual effective stress	Ring shear			Residual shear strength of cohesive materials containing preexisting shear surfaces	D6467
				Fully softened shear strength of cohesive materials without preexisting shear surfaces.	D7608
	Repeated direct shear			No ASTM standard for soils	

1. Using total stress parameters in the analyses model generates pore pressures (positive or negative) in laboratory specimens that simulate the pore pressures that will develop in the field soils during loading. Total stress parameters used in developing composite shear strength envelopes should not consider large negative pore pressures that may result from shear testing. Take the stress condition at failure to correspond to either maximum deviator stress or maximum principal effective stress ratio to define total stress parameters. Only use the stress conditions at a target axial strain to define failure when more limiting than other criteria.
2. The test for unconfined compressive strength (qu) applies only to cohesive materials that will retain strength without confining pressure and will not expel water during testing. This test does not apply to dry, crumbly, fissured, or non-cohesive soils or other soils that will not hold their shape without confinement. Some soils will exhibit higher strengths when tested using the unconsolidated undrained (UU) test. See ASTM D2166.
3. NRCS generally performs consolidated undrained with pore pressure measurements ($\overline{CU}$) tests rather than consolidated drained (CD) tests, as a more rapid strain rate with the CU test reduces the time required to complete the test. With appropriately performed tests, effective shear strength parameters obtained from CU *bar* tests should be equivalent to those from CD tests.

Dynamic Stability

Evaluate the effects of earthquake loading for all dams.

Analysis of dams for earthquake loading must address all potential failure modes. Distress of embankment dams from earthquake loading primarily manifests itself in deformation causing crest settlement, lateral spreading, cracking and differential displacements between the embankment or foundation and appurtenant structures.

Ref. 2

CP# 5
N 442913.77
E 2636965.88
ELEV. 1138.30

Location of GeoStudio Design Section

WING WALL

PRINCIPAL SPILLWAY RISER

NORMAL POOL ELEV. 1105.97

5' x 5' RECTANGULAR CONDUIT

TOP OF DAM ℄
ELEV. 1132.08

BORING FD2020-11
ELEV. 1130.16
(GROUND)

BORING FD2020-609
ELEV. 1102.[illegible]
(GROUND)

BORING FD2020-609
ELEV. 1083.16
(GROUND)

CP# 4
N 442219.02
E 2637169.78
ELEV. 1131.54

ROAD ℄

EXISTING GUARD RAIL

EXISTING GUARD RAIL

12" CMP
INV. 1073.70

CP# 3
N 441635.45
E 2637422.78
ELEV. 1135.06

BORING FD2020-214
ELEV. 1124.07
(GROUND)

12" CMP

CATCH BASIN
RIM ELEV. 1117.04

18" CMP
W INV. 1121.99
E INV. 1122.34

AUXILIARY SPILLWAY ℄

BORING FD2020-212
ELEV. 1123.85
(GROUND)

BORING FD2020-213
ELEV. 1123.67
(GROUND)

AUXILIARY SPILLWAY
CREST ELEV. 1124.20

CP# 2
N 441256.12
E 2637406.87
ELEV. 1123.93

G-104

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

N

100 0 100 200
Scale Feet

LEGEND

- MAJOR CONTOURS — 1360
- MINOR CONTOURS
- GROUND SURVEY LIMITS
- BATHYMETRIC SURVEY LIMITS
- SOIL BORING
- CONTROL POINT
- TOPO SURVEY POINT
- GRAVEL
- DRAINAGE DIRECTION

NOTE:
1. REFER TO SHEET B1 FOR GENERAL NOTES.

2. MAJOR CONTOUR INTERVAL IS 10 FEET AND MINOR CONTOUR INTERVAL IS 2 FEET

PRELIMINARY
NOT FOR CONSTRUCTION

No.	Revision	Date	By

FORDVILLE DAM
EXISTING CONDITIONS TOPOGRAPHY

HOUSTON engineering, Inc.

Drawn By	AJK,SMH
Checked By	PDL
Date	10-13-20
Scale	As Shown
Project No.	7135-0036
SHEET	B2

H:\JBN\7100\7135\7135_0036\CAD\Plans\Fordville Topo.dwg-EX_CONDITIONS_TOPO-10/13/2020 9:35 AM-(shanson)

Ref. 3

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Date Started: 6/16/20	**DRILLING LOG**		Hole Number: FD2020-11
Date Finished: 6/17/20	Gannett Fleming		Sheet: 1 of 4
Soil Drilling: 113.8 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 113.8 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442165.4 ft
No. of Undist. Samples: 1	Driller: Jared Zak		E Coordinate: 2637221.7 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1130.2 ft
GROUNDWATER OBSERVATIONS At 63.2 ft after 17 Hrs Elev. 1067.0 ft after 17 Hrs	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	2-4-3-3-3	0.8	32		0.0'-19.5': Clayey SAND (SC) (EMBANKMENT). Gravel is angular to subangular, fine, max. particle size: 1"; Sand is medium to coarse, subangular to rounded; Fines: low plasticity. Dry to Slightly Moist, no HCl reaction, Color varies from dark grayish brown (10yr 4/2) to olive brown (2.5y 4/4). gravel consists of angular shale (pierre fm.)	P.P. = Too disturbed to measure
2.5 - 5.0	S-2	2-4-4-8-12	1.3	52		3.0' : Sandy silt	P.P. = Too disturbed to measure
5.0 - 7.5	S-3	5-12-13-13-14	1.3	52			P.P. = 0.0 tsf
7.5 - 10.0	S-4	4-6-18-29-29	1.8	72			P.P. = 2.5 tsf
10.0 - 12.5	S-5	5-12-16-18-18	1.7	68			P.P. = 1.3 tsf
						12': Silty sand, moist	
12.5 - 15.0	S-6	7-8-9-13-17	1.8	72			P.P. = >4.5 tsf
15.0 - 17.5	S-7	5-11-13-18-18	2.0	80		15': Silty sand with clay	P.P. = 2.6 tsf
						17': 1" shale clast	
17.5 - 20.0	S-8	10-11-12-5-7	1.8	72			P.P. = 1.7 tsf
						El. 1110.7	
20.0 - 22.5	S-9	2-8-6-8-9	1.8	72		19.5'-62.0': Sandy Lean CLAY (CL) (EMBANKMENT). Gravel is angular to subrounded, fine, max. particle size: 1.5"; Sand is medium to coarse, subangular to rounded; Fines: medium plasticity. Slightly Moist, no HCl reaction, Color is olive brown (2.5y 4/3). gravel consist of angular to subrounded fine grained sedimentary and coarse grained igneous clasts.	P.P. = 3.7 tsf
22.5 - 25.0	S-10	5-8-9-12-13	1.7	68		22.5': Higher sand content	P.P. = 2.6 tsf

Purpose: Sample embankment and foundation soils. Install piezometers.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 113.8'.
Termination: Refusal at 113.8' (54 blows/3")
Abandonment: Install two vibrating wire piezometers in sand-socks cement grouted in place at 56' (S/N: 2021598, Zero reading: 2976.8hz, 24.0° C) and 101' (S/N: 2021594, Zeo Reading: 2971.3hz, 27.5°C).
Additional Remarks: Drilled on crest of dam, immediately downstream of guiderail.

Log Checked By: E.J. Barben, 11/11/20

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-11
Driller: Jared Zak	Gannett Fleming	Sheet: 2 of 4
Inspector: M. Mussey		Elev. Top of Hole: +1130.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-11	4-7-9-9-13	1.5	60			P.P. = 1.5 tsf
27.5 - 30.0	S-12	4-5-8-12-15	1.0	40		27.5': Iron staining	P.P. = 4.0 tsf
30.0 - 32.5	S-13	5-9-15-19-20	1.7	68		30': Silty sand and gravel, rounded clasts	P.P. = >4.5 tsf
32.5 - 35.0	S-14	11-14-12-14-20	0.6	24		32.5': 1.5" angular rock clasts, light gray/white	P.P. = 4.0 tsf
35.0 - 37.5	S-15	5-6-11-12-14	2.0	80			P.P. = 3.5 tsf
37.5 - 38.5	U-1		1.0	100			38.5': Shelby tube refusal
38.5 - 40.0	S-16	8-11-15	1.1	73			P.P. = 2.5 tsf
40.0 - 42.5	S-17	5-4-4-25-28	2.0	80			P.P. = >4.5 tsf
42.5 - 45.0	S-18	5-18-18-20-23	1.5	60		42': Silty clay with gravel	P.P. = 2.2 tsf
45.0 - 47.5	S-19	6-12-13-22-23	2.0	80			P.P. = 3.3 tsf
47.5 - 50.0	S-20	11-12-19-20-22	2.2	88		47.5': 0.75" angular shale clast	P.P. = 3.0 tsf
50.0 - 52.5	S-21	5-8-15-15-13	1.3	52			P.P. = 2.7 tsf
52.5 - 55.0	S-22	6-8-10-11-13	2.0	80		52': Gravel, max size 2.0", subrounded, coarse grained igneous	P.P. = 2.5 tsf
55.0 - 57.5	S-23	2-4-6-11-13	1.8	72		56': Slightly moist	P.P. = 4.5 tsf
57.5 - 60.0	S-24	7-7-7-9-13	2.3	92		G-106	P.P. = 1.5 tsf

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Date Started: 6/22/20	**DRILLING LOG**		Hole Number: FD2020-214
Date Finished: 6/22/02	Gannett Fleming		Sheet: 1 of 2
Soil Drilling: 45.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 45.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 441515.2 ft
No. of Undist. Samples: 1	Driller: Dave Tokar		E Coordinate: 2637685.0 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1124.1 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	4-4-6-7-9	2.3	92		0.0'-21.7': Silty SAND (SM). fine to medium; Fines: low plasticity. Olive brown (2.5Y 4/3), Dry to Wet, no HCl reaction 0.0-1.5': Topsoil, dark brown/black	P.P. = 2.3 tsf
2.5 - 5.0	S-2	6-7-8-8-9	1.8	72			P.P. = 0.8 tsf
5.0 - 7.5	S-3	3-4-5-6-7	1.8	72		5.0': 1" subangular gravel	P.P. = too disturbed to measure
7.5 - 10.0	S-4	3-4-4-6-7	1.4	56		7.5': Moist, iron staining 8.0'-18.0': Iron oxide staining	P.P. = 0.0 tsf
10.0 - 12.5	S-5	6-7-6-6-4	1.8	72			P.P. = 0.0 tsf
12.5 - 15.0	S-6	6-6-7-6-7	1.6	64		11.5'-14.0': Fine sand and silt, light gray	P.P. = 0.3 tsf
15.0 - 17.5	S-7	5-5-5-6-7	2.0	80			P.P. = 1.6 tsf
17.5 - 20.0	S-8	4-5-5-6-5	1.8	72		17.5': Wet, iron staining	P.P. = 0.0 tsf
20.0 - 22.5	S-9	2-4-4-5-3	1.8	72		El. 1102.4	P.P. = 2.0 tsf
22.5 - 25.0	S-10	1-1-1-2-3	2.4	96		21.7'-45.0': Clayey SILT (ml) (GLACIOLACUSTRINE). very soft; Fines: medium plasticity. Very dark greenish gray (5GY 3/1), Wet, no HCl reaction, Tan & gray laminations	P.P. = 0.0 tsf

Purpose: Sample auxiliary spillway soils, use result to establish SITES parameters.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 45.0'.
Termination: 45.0' below ground surface
Abandonment: Cement grout backfill.
Additional Remarks:

Log Checked By: E.J. Barben, 11/11/20

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-214
Driller: Dave Tokar	Gannett Fleming	Sheet: 2 of 2
Inspector: M. Mussey		Elev. Top of Hole: +1124.1 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.5	S-11	1-1-1-2-1	2.4	96			P.P. = 0.0 tsf
27.5 - 30.0	S-12	1-1-1-3-5	2.5	100			P.P. = 0.0 tsf
30.0 - 32.5	S-13	2-3-5-5-6	2.3	92			P.P. = 0.0 tsf
32.5 - 35.0	S-14	1-2-2-5-6	2.5	100			P.P. = 0.0 tsf
35.0 - 37.5	S-15	1-2-3-3-5	2.4	96			P.P. = 0.0 tsf
37.5 - 40.0	S-16	2-3-3-5-5	2.5	100			P.P. = 0.0 tsf
40.0 - 42.4	U-1		2.4	100			40.0': Pushed shelby tube
42.4 - 42.5							42.4'-42.5': Advanced augers
42.5 - 45.0	S-17	1-2-3-3-5	2.5	100		El. 1079.1	

Bottom of Borehole at 45.0 feet.

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Date Started: 6/18/20	**DRILLING LOG**		Hole Number: FD2020-608
Date Finished: 6/18/20	Gannett Fleming		Sheet: 1 of 3
Soil Drilling: 85.0 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 85.0 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442187.8 ft
No. of Undist. Samples: 2	Driller: Jared Zak		E Coordinate: 2637296.7 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1101.5 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	2-5-6-8-10	1.6	64		0.0'-8.5': Clayey SAND (SC) (EMBANKMENT). Sand is medium to coarse, subangular to rounded; Fines: low plasticity. Very dark grayish brown (10YR 3/2), Slightly Moist, no HCl reaction 0.0-0.75': Topsoil	P.P. = 1.5 tsf
2.5 - 5.0	S-2	5-7-12-14-16	2.1	84			P.P. = 1.3 tsf
5.0 - 7.5	S-3	9-10-13-15-18	2.1	84			P.P. = 0.0 tsf
7.5 - 10.0	S-4	5-7-8-10-10	2.2	88		El. 1093.0	P.P. = 1.3 tsf
10.0 - 11.0	U-1		0.9	90		8.5'-17.5': Silty Clayey SAND (SC-SM) (EMBANKMENT). Sand is fine to medium, subangular to rounded; Fines: medium plasticity. Dark greenish brown (2.5Y 4/2), Moist to Very Moist, no HCl reaction	10.0': Pushed shelby tube
11.0 - 12.5	S-5	17-15-19	1.0	67			P.P. = 0.0 tsf
12.5 - 15.0	S-6	10-12-14-16-19	2.3	92			P.P. = 0.2 tsf
15.0 - 17.5	S-7	5-10-17-17-19	2.1	84		El. 1084.0	P.P. = 4.0 tsf
17.5 - 20.0	S-8	14-21-24-28-24	2.2	88		17.5'-21.0': Poorly graded SAND (sp) (EMBANKMENT) with low fines and gravel. Gravel is subrounded, maximum particle size: 0.75"; Sand is medium to coarse, subangular to rounded; dense, no HCL reaction, olive brown (2.5Y 4/3).	P.P. = 2.0 tsf
20.0 - 22.5	S-9	9-10-16-18-19	2.1	84		El. 1080.5 21.0'-23.4': Silty CLAY (cl) (EMBANKMENT), with some sand. Sand is medium, subangular to rounded; Fines are medium plasticity, moist, no HCL reaction, very dark gray (2.5Y 3/1).	P.P. = 0.5 tsf
22.5 - 25.0	S-10	4-5-6-7-6	2.2	88		El. 1078.1 23.4'-30.0': Clayey SAND (SC)	P.P. = 0.0 tsf

Purpose: Sample embankment and foundation soils. Install piezometers.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 85.0'.
Termination: ~1015.0' elevation.
Abandonment: Install two vibrating wire piezometers in sand-socks cement grouted in place at 26' (S/N: 2021599, zero reading: 2984.1hz, 26.7°C) and 82' (S/N: 2021596, zero reading: 2968.7hz, 26.8°C).
Additional Remarks: Drilled 6.5' up embankment, 0.9' lower elevation from staked/surveyed location.

Log Checked By: E.J. Barben, 11/11/20

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-608
Driller: Jared Zak	Gannett Fleming	Sheet: 2 of 3
Inspector: M. Mussey		Elev. Top of Hole: +1101.5 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
						(OUTWASH/ALLUVIUM). Sand is coarse; Fines: low plasticity. Greenish black (5BG 2.5/1), Wet, no HCl reaction, Organic odor	
25.0 - 27.5	S-11	2-3-4-4-3	1.5	60		26.5': Wet	P.P. = 0.0 tsf
27.5 - 30.0	U-2		0.0	0		El. 1071.5	27.5': Shelby tube attempt, no recovery. Advance augers to 30'.
30.0 - 32.5	S-12	2-3-5-6-3	1.8	72		30.0'-32.0': Poorly graded Sand (sp) (Alluvium/Outwash) with some fines. Sand is coarse, loose, wet, organics odor, no HCl reaction, greenish black (5BG 2.5/1) El. 1069.5	P.P. = 0.0 tsf
32.5 - 35.0	S-13	3-4-5-9-9	2.2	88		32.0'-85.0': Sandy SILT (ML) (OUTWASH/ALLUVIUM). Gravel is subangular to subrounded, fine, max. particle size: 1"; Sand is fine to coarse, subangular to rounded; Fines: medium plasticity. Very dark greenish gray (10Y 3/1), Moist to Wet, no HCl reaction	P.P. = 1.7 tsf
35.0 - 37.5	S-14	2-5-7-9-10	2.2	88		32.5': Silt and clay, some coarse sand, dark gray, very moist to wet	P.P. = 2.4 tsf
37.5 - 40.0	S-15	5-6-7-10-10	2.3	92			P.P. = 2.0 tsf
40.0 - 42.5	S-16	3-5-6-10-11	2.3	92		40.0': Stiff silty clay, white, moist	P.P. = 1.6 tsf
42.5 - 45.0	S-17	4-5-7-10-10	2.2	88		44.0': Clay, less coarse sand, moist	P.P. = 1.7 tsf
45.0 - 47.5	S-18	3-8-6-7-8	2.2	88			P.P. = 4.2 tsf
47.5 - 50.0	S-19	5-6-7-19-21	1.9	76			P.P. = >4.5 tsf
50.0 - 52.5	S-20	7-11-11-17-18	2.2	88			P.P. = >4.5 tsf
52.5 - 55.0	S-21	7-8-10-14-16	2.1	84			P.P. = >4.5 tsf
55.0 - 57.0	U-3		1.8	90		55.0': Silty clay at bottom of Shelby tube sample, wet	55': Pushed shelby tube.
57.0 - 57.5							57': Advanced augers.
57.5 - 60.0	S-22	6-8-11-13-19	2.5	100		57.5': Stiff silty clay, moist	P.P. = 3.9 tsf

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-608
Driller: Jared Zak	Gannett Fleming	Sheet: 3 of 3
Inspector: M. Mussey		Elev. Top of Hole: +1101.5 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
60.0 - 62.5	S-23	7-8-15-19-22	2.5	100		59.9': 1" piece of gravel 60.5-60.7': Higher gravel content, wet	P.P. = >4.5 tsf
62.5 - 65.0	S-24	14-22-26-32-41	2.3	92		62.5': Very stiff clay, slightly moist coarse sand, fine gravel	P.P. = >4.5 tsf
65.0 - 67.5	S-25	7-19-27-33-38	2.4	96			P.P. = >4.5 tsf
67.5 - 70.0	S-26	13-14-29-33-48	2.4	96		67.5': Moist	P.P. = >4.5 tsf
70.0 - 72.5	S-27	11-15-31-41-56	2.5	100		70.6'-70.8': Fine sand and clay, wet	P.P. = >4.5 tsf
72.5 - 75.0	S-28	17-22-25-36-48	2.5	100			P.P. = >4.5 tsf
75.0 - 77.5	S-29	11-11-14-26-34	2.2	88			P.P. = >4.5 tsf
77.5 - 80.0	S-30	11-17-22-35-31	2.4	96			P.P. = >4.5 tsf
80.0 - 82.5	S-31	8-12-12-24-25	2.0	80		81.'-82.0': Higher sand content, still medium plasticity, wet	P.P. = >4.5 tsf
82.5 - 85.0	S-32	8-14-19-36-14	2.3	92		83.7': Gravel 94.0': Coarse sand and gravel, layers of clayey sand (sc) El. 1016.5	P.P. = >4.5 tsf

Bottom of Borehole at 85.0 feet.

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Date Started: 6/19/20	**DRILLING LOG**		Hole Number: FD2020-609
Date Finished: 6/19/20	Gannett Fleming		Sheet: 1 of 3
Soil Drilling: 67.5 ft			Line & Station:
Rock Sampling: 0.0 ft	Project: Fordville Dam		Offset:
Total Depth of Hole: 67.5 ft	Drilling Agency: Interstate Drilling Services, Inc.		N Coordinate: 442206.2 ft
No. of Undist. Samples: 1	Driller: Jared Zak		E Coordinate: 2637358.6 ft
Total Number of Core Boxes: 0	Bit Size and Type: N/A	Spoon Size: 2.0 " OD	Elev. Top of Hole: +1083.2 ft
GROUNDWATER OBSERVATIONS Not recorded	Casing Size: N/A	Hammer Wt.: 140 lb	Direction of Hole
	Hollow Stem Auger: 3.25 " ID x 7.0 " OD	Hammer Drop: 30.0 "	Vertical ☒ Inclined ☐
	Drilling Fluid: N/A	Hammer Type: Automatic	Degrees from Vertical ---
	Drill Rig: Dietrich 50 Track Rig		Logged By: M. Mussey

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
0.0 - 2.5	S-1	1-3-4-6-3	1.7	68		0.0'-2.5': Poorly graded SAND (sp) with some fines. Sand is medium to coarse, subangular to rounded; Fines are low plasticity, dry, loose, no HCl reaction. 0.0'-0.5': Topsoil; reddish brown silty sand, some fines. High organic content. El. 1080.7	P.P. = 2.6 tsf
2.5 - 5.0	S-2	4-6-7-8-9	2.1	84		2.5'-7.5': Silty CLAY (cl), with some sand. Sand is fine to medium, subangular to rounded; Fines are medium plasticity, moist to wet, no HCL reaction, organic odor and particles, very dark greenish gray (10Y 3/1).	P.P. = 3.0 tsf
5.0 - 7.5	S-3	3-5-6-7-7	2.2	88		El. 1075.7	P.P. = 2.0 tsf
7.5 - 10.0	S-4	1-2-2-2-2	2.2	88		7.5'-12.5': Lean CLAY with sand (CL). Sand is medium to coarse; Very dark brown (N 3/), no HCl reaction	P.P. = 0.0 tsf
10.0 - 12.5	S-5	1-1-2-2-3	1.8	72		El. 1070.7	P.P. = 0.0 tsf
12.5 - 15.0	S-6	2-3-4-6-7	2.3	92		12.5'-67.5': Sandy SILT (ML) (OUTWASH/ALLUVIUM). Gravel is subangular to subrounded, fine, max. particle size: 1.5"; Sand is medium to coarse, subangular to rounded; Fines: medium plasticity. Very dark greenish gray (10Y 3/1), Moist to Wet, no HCl reaction	P.P. = 2.5 tsf
15.0 - 17.5	S-7	3-7-7-11-13	1.8	72			P.P. = 3.6 tsf
17.5 - 20.0	S-8	5-6-7-8-10	2.3	92			P.P. = 2.1 tsf
20.0 - 22.5	S-9	2-3-5-6-6	2.1	84		20.0'-22.5': Silty clay, moist 22.0': 1" gravel, fine subangular	P.P. = 1.2 tsf
22.5 - 25.0	S-10	3-3-6-6-8	2.1	84			P.P. = 2.5 tsf

Purpose: Sample foundaton material beyond downstream embankment toe. Install piezometers.
Drilling Method: Continuous split spoon sampling using hollow stem auger, drilled to 67.5'.
Termination: ~1015.0' elevation.
Abandonment: Install two vibrating wire piezometers in sand-socks cement grouted in place at 12' (S/N: 2021600, zero reading: 2976.3hz, 21.7°C) and 57.5' (S/N: 2021597, zero reading: 2984.4hz, 21.9°C)
Additional Remarks:

Log Checked By: E.J. Barben, 11/11/20

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-609
Driller: Jared Zak	Gannett Fleming	Sheet: 2 of 3
Inspector: M. Mussey		Elev. Top of Hole: +1083.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
25.0 - 27.0	S-11	3-3-10-11-50/0.5"	1.5	75			P.P. = 1.8 tsf
27.0 - 27.5						27.0': Large grain igneous gravel; fractured while sampling	27': Advanced augers
27.5 - 30.0	S-12	3-5-5-7-10	2.5	100			P.P. = 2.1 tsf
30.0 - 32.0	U-1		2.0	100		30.0'-32.0': Fine sand and silt at bottom of undistributed sample, wet	
32.0 - 32.5							32'-32.5': Advanced augers
32.5 - 35.0	S-13	9-11-13-19-22	2.2	88		32.5'-32.7': Higher fine sand	P.P. = >4.5 tsf
35.0 - 37.5	S-14	14-26-19-22-25	1.8	72			P.P. = >4.5 tsf
37.5 - 40.0	S-15	7-14-17-22-25	2.3	92		37.5'-40.0': Slightly moist	P.P. = >4.5 tsf
40.0 - 42.5	S-16	9-14-17-26-17	2.2	88			P.P. = 3.1 tsf
42.5 - 45.0	S-17	17-12-15-17-24	2.3	92		42.0': Gravel, subangular, 3/8", granite 43.0': Angular shale gravel (0.5")	P.P. = 4.5 tsf
45.0 - 47.5	S-18	8-10-16-18-28	2.5	100			P.P. = >4.5 tsf
47.5 - 50.0	S-19	9-11-13-23-34	2.5	100			P.P. = >4.5 tsf
50.0 - 52.5	S-20	10-12-15-28-28	2.5	100		49.5': Gravel, 1" subrounded, fine, white	P.P. = >4.5 tsf
52.5 - 55.0	S-21	14-15-30-10-24	2.3	92		52.0': Coarse sand, subrounded to round, with fines	P.P. = >4.5 tsf
55.0 - 57.4	S-22	5-10-15-24-50/4"	1.9	79			P.P. = >4.5 tsf
57.5 - 60.0	S-23	14-14-14-27-36	2.3	92		57.4': Gravel >1.5", fine, white, fresh fracture; difficult to auger 57.5'-57.9': Fine sand with fines, wet	P.P. = >4.5 tsf

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

Agency: Interstate Drilling Services, Inc.	**DRILLING LOG**	Hole Number: FD2020-609
Driller: Jared Zak	Gannett Fleming	Sheet: 3 of 3
Inspector: M. Mussey		Elev. Top of Hole: +1083.2 ft

Fordville Dam

Depth (Ft.)	Sample No.	Blows or RQD (%)	Rec. (ft.)	Rec. (%)	USCS	Description Of Materials	Remarks
						59.6'-59.8': Fresh shale, freshley fractured >1.5"	
60.0 - 62.5	S-24	10-12-14-28-44	2.0	80		59.8'-62.5': Stiff silty clay, some coarse sand	P.P. = >4.5 tsf
62.5 - 64.7	S-25	14-35-38-100/8"	1.8	82		62.5'-63.0': Fine sand, wet 63.0'-63.2: Moist sand and fines	P.P. = >4.5 tsf
64.7 - 65.0							P.P. = >4.5 tsf
65.0 - 67.5	S-26	8-14-17-22-59	1.9	76		El. 1015.7	

Bottom of Borehole at 67.5 feet.

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

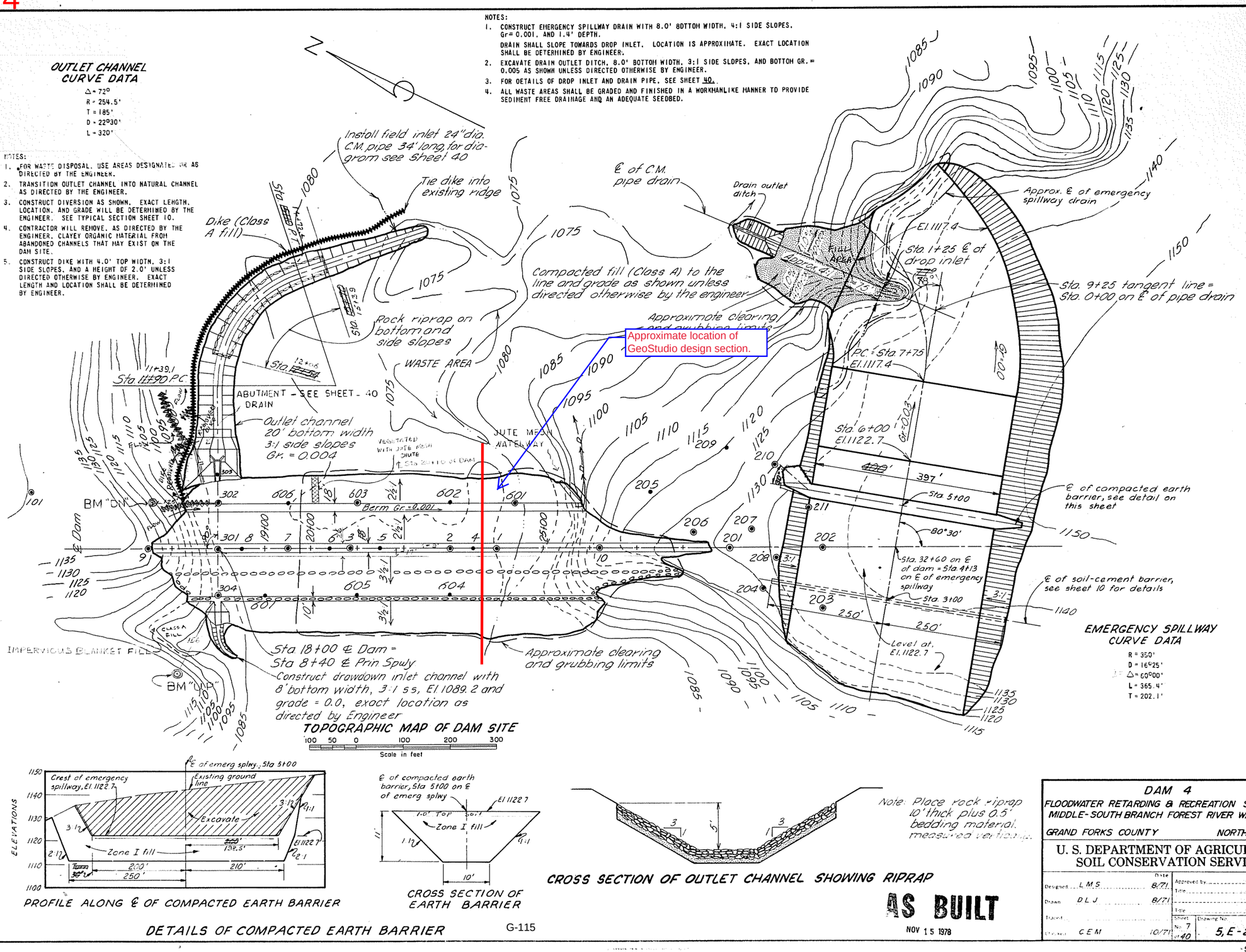
Ref. 4

OUTLET CHANNEL CURVE DATA

Δ = 72°
R = 254.5'
T = 185'
D = 22°30'
L = 320'

NOTES:
1. FOR WASTE DISPOSAL, USE AREAS DESIGNATED OR AS DIRECTED BY THE ENGINEER.
2. TRANSITION OUTLET CHANNEL INTO NATURAL CHANNEL AS DIRECTED BY THE ENGINEER.
3. CONSTRUCT DIVERSION AS SHOWN. EXACT LENGTH, LOCATION, AND GRADE WILL BE DETERMINED BY THE ENGINEER. SEE TYPICAL SECTION SHEET 10.
4. CONTRACTOR WILL REMOVE, AS DIRECTED BY THE ENGINEER, CLAYEY ORGANIC MATERIAL FROM ABANDONED CHANNELS THAT MAY EXIST ON THE DAM SITE.
5. CONSTRUCT DIKE WITH 4.0' TOP WIDTH, 3:1 SIDE SLOPES, AND A HEIGHT OF 2.0' UNLESS DIRECTED OTHERWISE BY ENGINEER. EXACT LENGTH AND LOCATION SHALL BE DETERMINED BY ENGINEER.

NOTES:
1. CONSTRUCT EMERGENCY SPILLWAY DRAIN WITH 8.0' BOTTOM WIDTH, 4:1 SIDE SLOPES, Gr= 0.001, AND 1.4' DEPTH.
   DRAIN SHALL SLOPE TOWARDS DROP INLET. LOCATION IS APPROXIMATE. EXACT LOCATION SHALL BE DETERMINED BY ENGINEER.
2. EXCAVATE DRAIN OUTLET DITCH, 8.0' BOTTOM WIDTH, 3:1 SIDE SLOPES, AND BOTTOM GR. = 0.005 AS SHOWN UNLESS DIRECTED OTHERWISE BY ENGINEER.
3. FOR DETAILS OF DROP INLET AND DRAIN PIPE, SEE SHEET NO.
4. ALL WASTE AREAS SHALL BE GRADED AND FINISHED IN A WORKMANLIKE MANNER TO PROVIDE SEDIMENT FREE DRAINAGE AND AN ADEQUATE SEEDBED.



TOPOGRAPHIC MAP OF DAM SITE

100 50 0 100 200 300
Scale in feet

EMERGENCY SPILLWAY CURVE DATA

R = 350'
D = 16°25'
Δ = 60°00'
L = 365.4'
T = 202.1'

PROFILE ALONG ℄ OF COMPACTED EARTH BARRIER

CROSS SECTION OF EARTH BARRIER

CROSS SECTION OF OUTLET CHANNEL SHOWING RIPRAP

Note: Place rock riprap 10" thick plus 0.5' bedding material, measured vertically.

DETAILS OF COMPACTED EARTH BARRIER

G-115

AS BUILT
NOV 15 1978

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

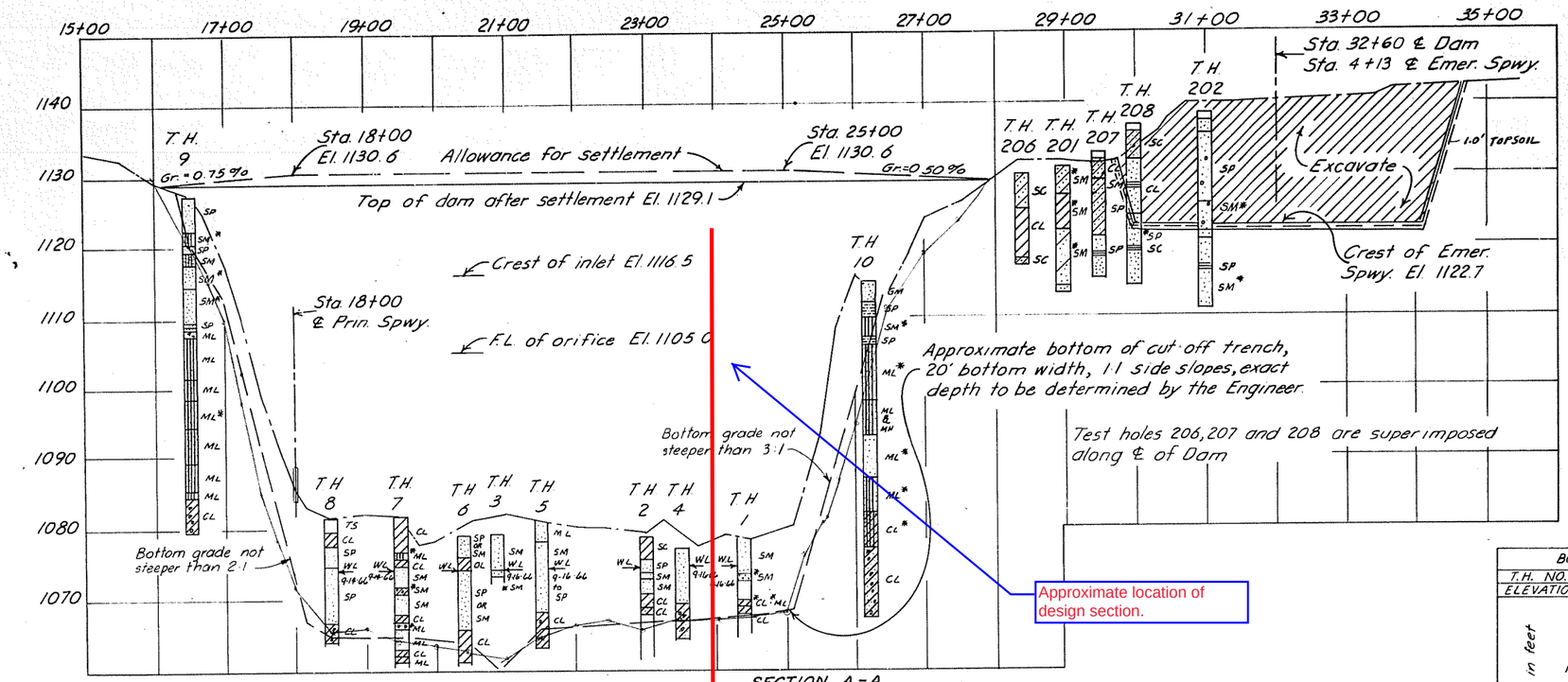
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date
Designed	L.M.S.	8/71
Drawn	D.L.J.	8/71
Traced		
Checked	C.E.M.	10/71

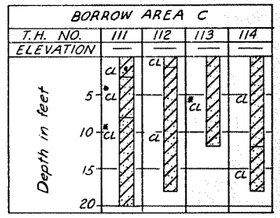
Approved by:
Title:
Sheet No. 7 of 40
Drawing No. 5, E-29,772

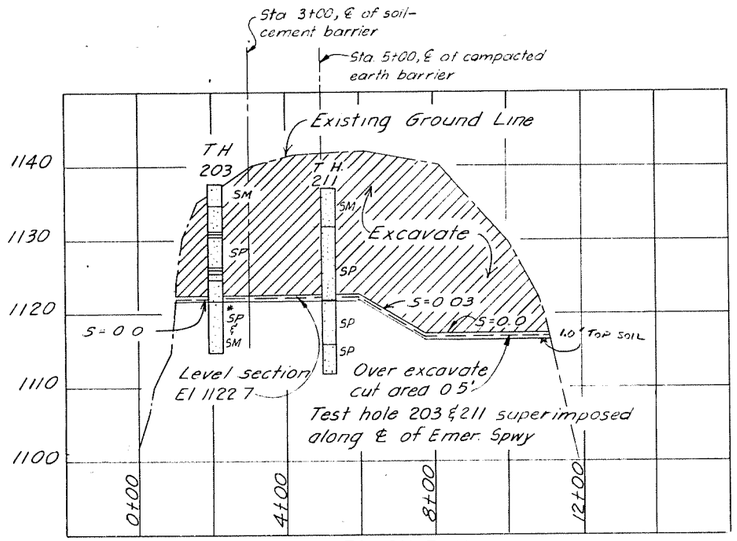
SCS-313 (9-64) - C

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020



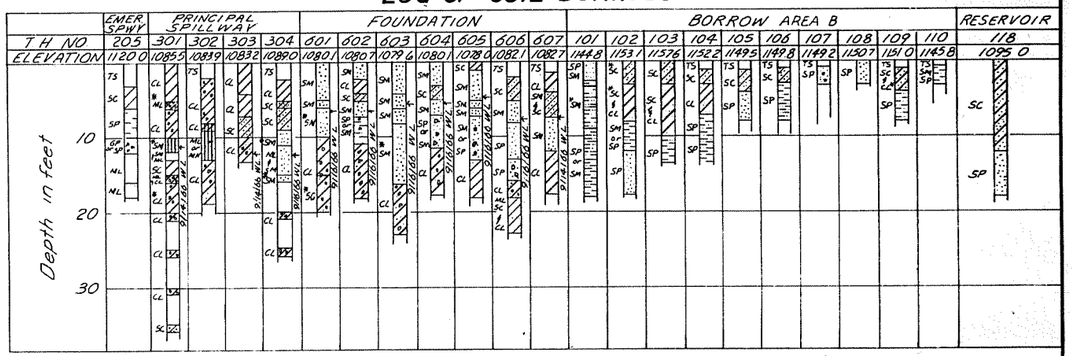
SECTION A-A
PROFILE ALONG ℄ OF DAM





SECTION B-B
PROFILE ALONG ℄ OF EMERGENCY SPILLWAY

LOG OF SOIL BORINGS



AS BUILT
NOV 15 1978

Notes
1. For soils legend and symbols, see standard drawing 5,R-10,000 47.
2. Soil Exploration date Sept 14, 1966
3. → indicates groundwater at time of exploration
4. The Unified Soil Classification symbols followed by an asterisk are based on laboratory classification. Those symbols without an asterisk are based on field classification and are subject to revision based on laboratory test
5. Over excavate cut area of Emergency Spillway 0.5': Backfill with select topsoil material
6. TS = topsoil

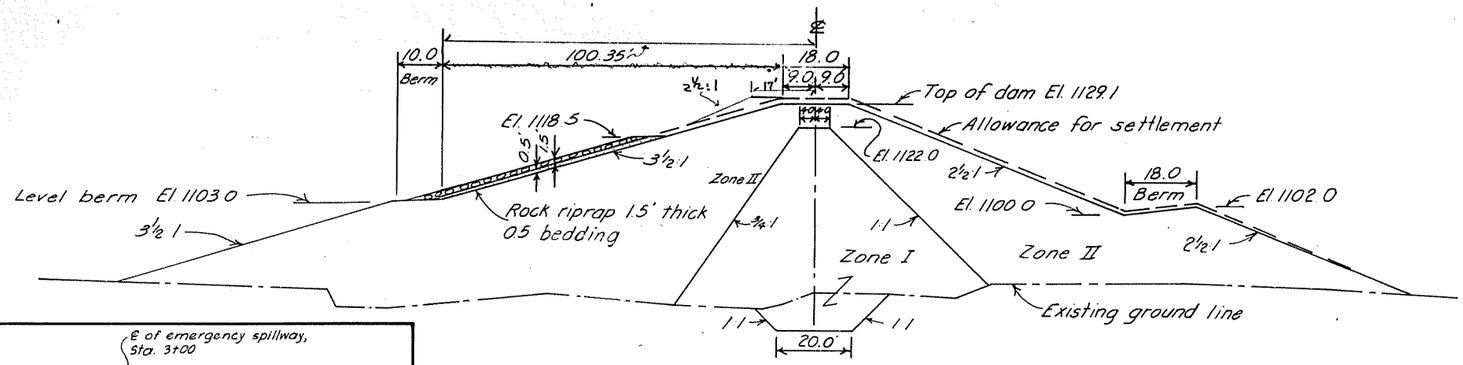
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No. 8 of 40	Drawing No. 5,E-29,772

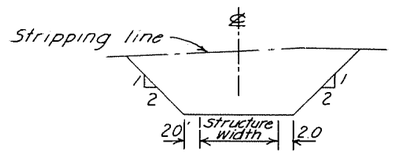
SCS-313 (9-64) -C

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

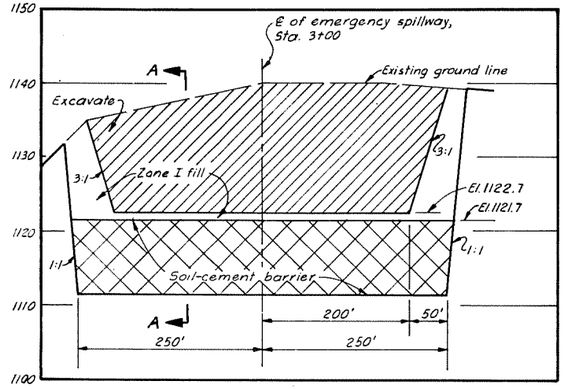


STATION 24+50
MAXIMUM CROSS SECTION OF DAM

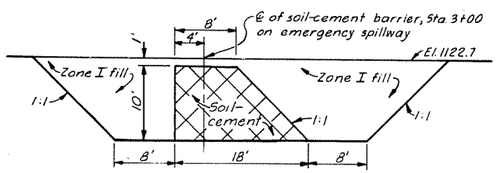
20 0 20 40
Scale in feet



TYPICAL SECTION - STRUCTURE EXCAVATION
BOX CONDUIT AND SAF

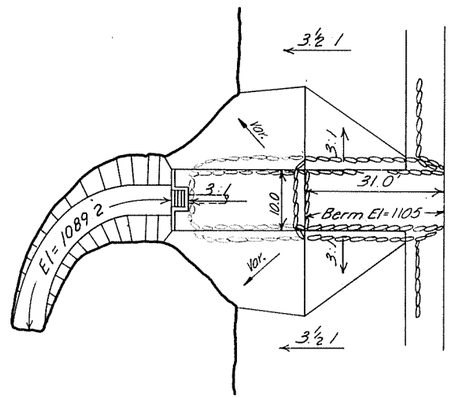


PROFILE ALONG ℄ OF SOIL-CEMENT BARRIER

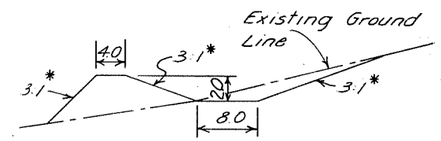


SECTION A-A

DETAILS OF SOIL-CEMENT BARRIER



PLAN VIEW OF UPSTREAM
LOCAL BERM AT RISER



TYPICAL CROSS-SECTION OF DIVERSION

* SIDE SLOPES WILL BE AS SHOWN UNLESS DIRECTED OTHERWISE BY THE ENGINEER.

EMBANKMENT MATERIAL SOURCES AND PLACEMENT REQUIREMENT

SOURCE OF MATERIAL				PLACEMENT AND MOISTURE DENSITY REQUIREMENT							
LOCATION	APPROX. DEPTH (FT.) FROM	TO	UNIFIED SOIL CLASSIFICATION	DEPTH OF LIFT	MAX. SIZE ROCK FRAGMENTS	FILL MATRIX SIZE TESTED	COMPACTION CLASS	REFERENCE TEST METHOD	REQ'D. (%) COMPACTION	ALLOWABLE MOISTURE RANGE FROM OPTIMUM(%)	FILL LOCATION
BORROW C	1	18	CL	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE I
EMERGENCY SPILLWAY	3	23	SM & SP	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
BORROW B	3	13	SM	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II
EMERGENCY SPILLWAY	0	5	SC	9"	6"	<#4	A	METHOD A ASTM D-698	95	0 AND ABOVE	ZONE II

LABORATORY TEST INFORMATION ON TYPICAL MATERIALS

UNIFIED SOIL CLASSIFICATION	TEST HOLE 111 CL	TEST HOLE 201 SM	TEST HOLE 102 SC	TEST HOLE 109 CL
REFERENCE TEST METHOD	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698	METHOD A ASTM D-698
MAXIMUM DRY DENSITY	106.0 P.C.F.	103.0 P.C.F.	98.0 P.C.F.	91.0 P.C.F.
OPTIMUM MOISTURE	18.0%	20.0%	21.5%	25.0%
DESCRIPTION	GLACIAL TILL	DELTA SEDIMENTS	DELTA SEDIMENTS	DELTA SEDIMENTS

NOTES:
1. LABORATORY TEST DATA ON THE SOIL INVESTIGATION IS AVAILABLE AT THE SCS WATERSHED OFFICE IN GRAFTON, NORTH DAKOTA.
2. FOR SOIL LEGEND AND SYMBOLS, SEE STANDARD DRAWING NO. 5-R-10.000.47.
3. MORE PLASTIC MATERIAL EXCAVATED FROM EMERGENCY SPILLWAY AND BORROW B IS TO BE SELECTIVELY PLACED ADJACENT TO THE UPSTREAM PORTION OF ZONE I. IN THE COMPACTED EARTH BARRIER AND ADJACENT TO THE SOIL-CEMENT BARRIER.
4. DO NOT BORROW CLOSER THAN 100' FROM BASE OF DAM UNLESS DIRECTED OTHERWISE BY THE ENGINEER IN THE FIELD.

AS BUILT
NOV 15 1978

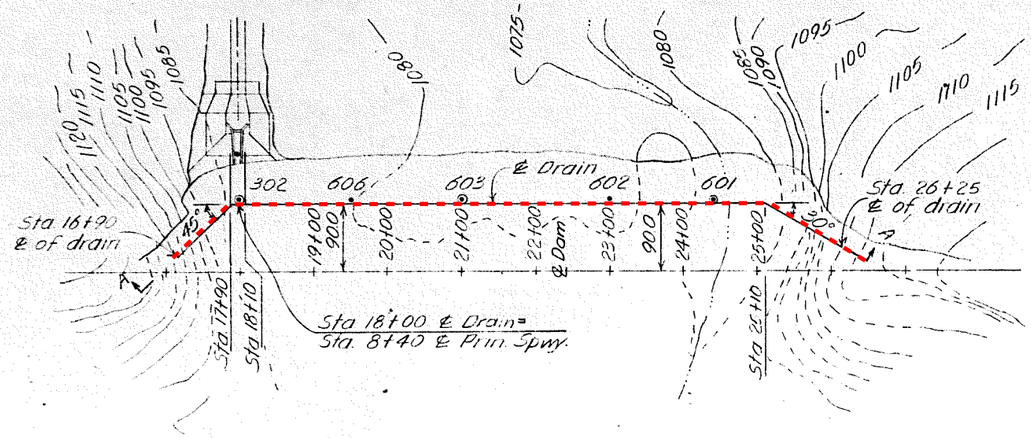
DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S.	Date 8/71	Approved by	
Drawn D.L.J.	8/71	Title	
Traced		Title	
Checked C.E.M.	10/71	Sheet No. 10 of 40	Drawing No. 5,E-29,772

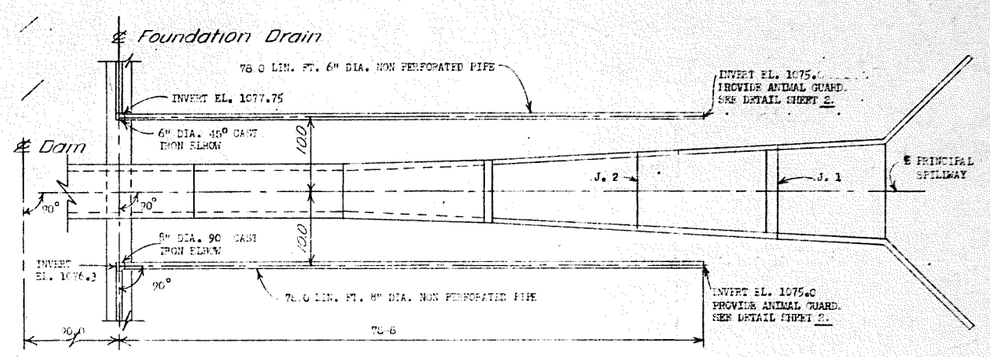
SCS-312-0-A11

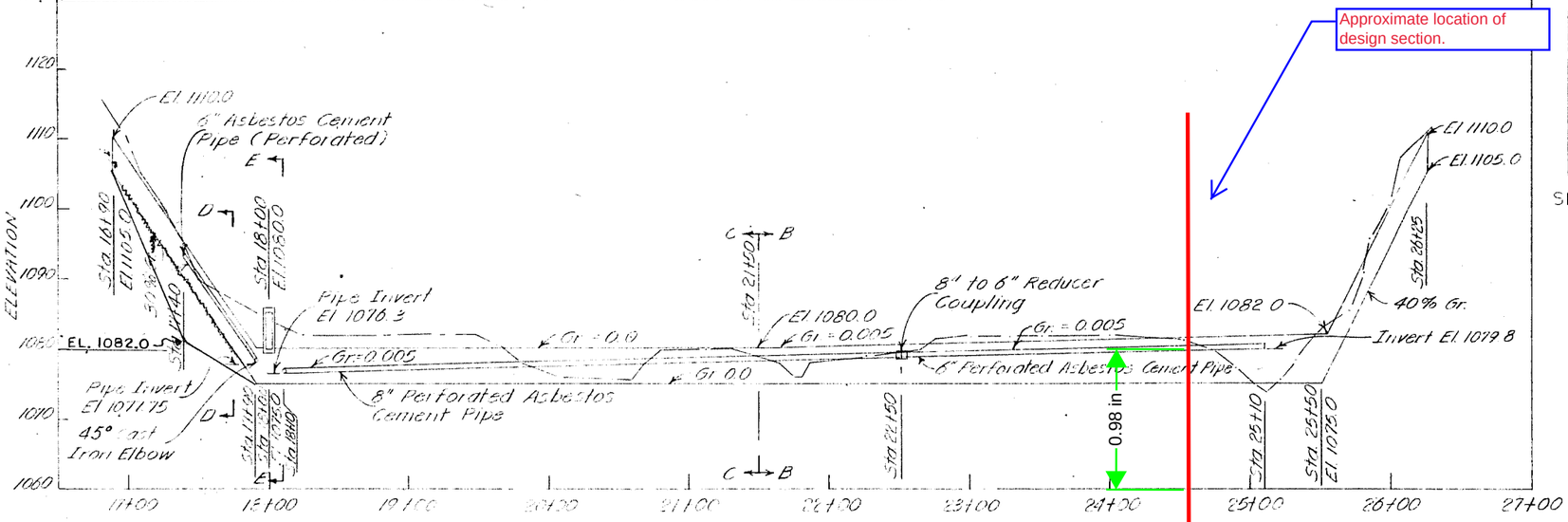
Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020



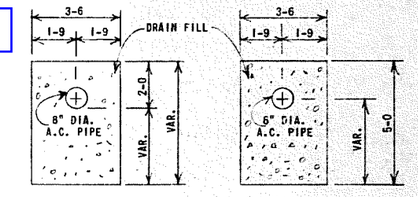
PLAN OF BASE OF DAM SHOWING FOUNDATION DRAIN

100 50 0 100 200 300
Scale in Feet

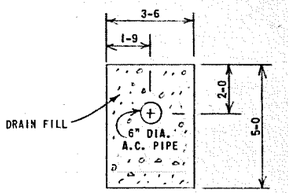




SECTION A-A
PROFILE ALONG ℄ OF TRANSVERSE FOUNDATION DRAIN



SECTION B-B SECTION C-C



SECTION D-D

AS BUILT
NOV 15 1978

NOTES:

1. PROVIDE ANIMAL GUARD AT OUTLET END OF OUTLET PIPES. FOR DETAILS OF ANIMAL GUARDS, SEE SHEET 2.
2. PLUG UPPER END OF PIPES WITH 6" OF CONCRETE OR PREFABRICATED CAP.
3. THE DEPTH OF FILL OVER THE DRAIN PIPE SHALL BE AT LEAST 2' BEFORE PASSING HEAVY EQUIPMENT OVER THE PIPE.
4. WHERE THE TRANSVERSE DRAIN TRENCH IS ABOVE THE GROUND LINE, PLACE COMPACTED EARTH FILL TO ELEVATION AT TOP OF DRAIN AND EXCAVATE DRAIN IN COMPACTED FILL.
5. STA. 17+90 THRU STA. 25+10 OF THE DRAIN CENTERLINE COINCIDE WITH STA. 17+90 THRU 25+10 OF THE DAM CENTERLINE.
6. PLACE TWO LAYERS OF ROOFING FELT UNDER THE PRINCIPAL SPILLWAY CONDUIT AT ITS INTERSECTION WITH THE FOUNDATION DRAIN.
7. DRAIN PIPE WILL OUTLET THROUGH RIPRAP. PLACE RIPRAP AROUND OUTLET AS DIRECTED BY ENGINEER.

DRAIN FILL GRADATION

SIEVE SIZE	PERCENT PASSING
3"	100
1"	90 - 100
#4	45 - 70
#10	10 - 50
#16	0 - 35
#40	5

QUANTITIES

ITEM	UNIT	QUANTITY
DRAIN FILL MATERIAL	CU.YD.	660
8" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	440
8" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
6" DIA. PERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	310
6" DIA. NONPERFORATED CLASS 150 ASBESTOS-CEMENT PIPE	LIN.FT.	78
8" DIA. 90° CAST IRON ELBOW	EACH	1
6" DIA. 45° CAST IRON ELBOW	EACH	1
8" TO 6" DIA. REDUCER COUPLING	EACH	1

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

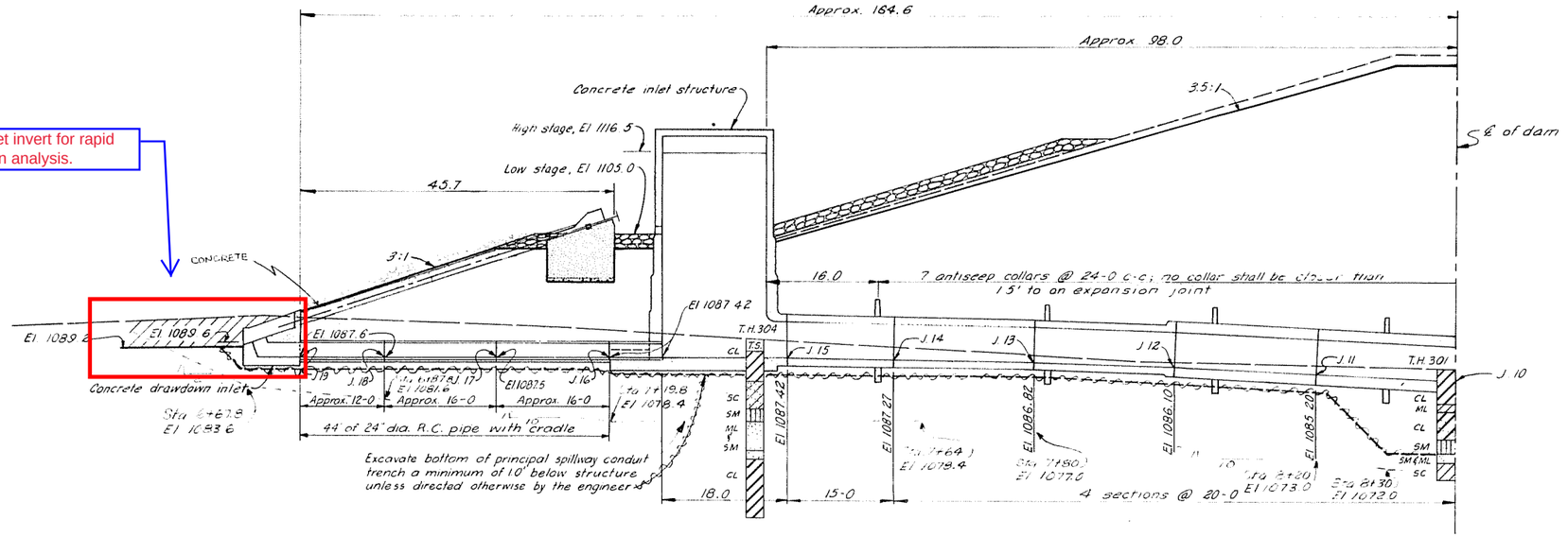
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date		
Designed	L.M.S.	9/71	Approved by	
Drawn	D.L.J.	12/71	Title	
Traced			Title	
Checked	C.E.M.	12/71	Sheet No. 11 of 40	Drawing No. 5,E-29,772

SCS-ENG-11-B Rev. 7-69

Calc By: EJB, Nov. 2020
Check By: TNK, Dec. 2020

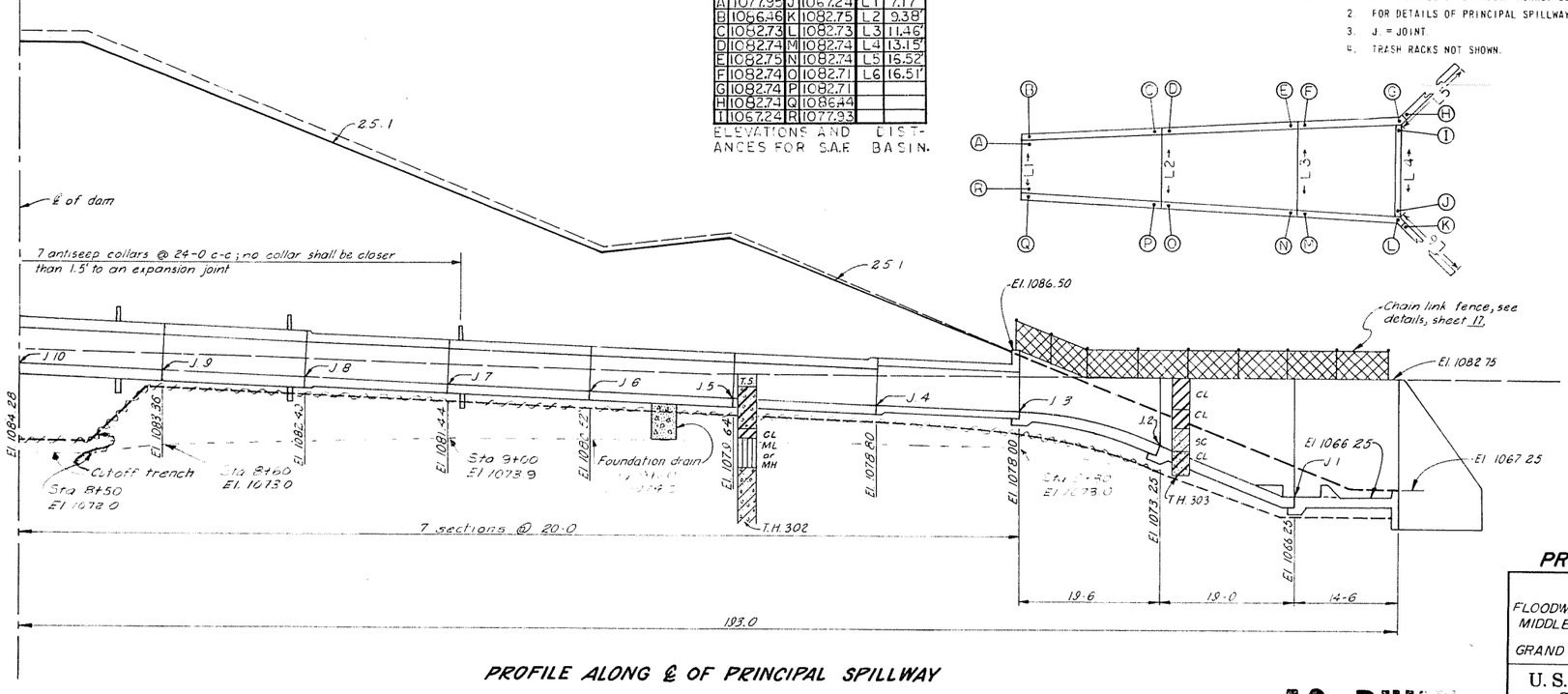
lowest inlet invert for rapid draw down analysis.



A	1077.95	J	1067.24	L1	7.17'
B	1066.46	K	1082.75	L2	9.38'
C	1082.73	L	1082.73	L3	11.46'
D	1082.74	M	1082.74	L4	13.15'
E	1082.75	N	1082.74	L5	16.52'
F	1082.74	O	1082.71	L6	16.51'
G	1082.74	P	1082.71		
H	1082.74	Q	1086.44		
I	1067.24	R	1077.93		

ELEVATIONS AND DISTANCES FOR S.A.E. BASIN.

NOTES:
1. FOR DETAILS OF DRAWDOWN WORKS, SEE SHEETS 37 TO 39
2. FOR DETAILS OF PRINCIPAL SPILLWAY CONDUIT, SEE SHEETS 25 TO 28
3. J. = JOINT.
4. TRASH RACKS NOT SHOWN.



JOINT	BEFORE FILL		AFTER FILL	
	US	DS	US	DS
J. 4		1076.69	1078.64	
J. 5	1080.00		1079.54	1079.44
J 6	1080.49	1080.40	1080.37	1080.28
J 7		1081.35	1081.30	1081.20
J. 8		1082.21	1082.05	1082.01
J. 9	1081.45		1083.06	1082.90
J.10	1084.20	1084.09	1083.82	1083.74
J.11	1085.09	1085.02	1084.68	1084.63
J.12	1085.91	1085.82	1085.57	1085.47
J.13	1086.72	1086.64	1086.46	1086.38
J.14	1087.20	1087.14	1087.02	1086.96
J.15		1087.36	1087.20	1087.21

NOTE: ELEVATIONS WERE TAKEN ONE FOOT UPSTREAM, AND ONE FOOT DOWNSTREAM FROM EACH JOINT. MEASUREMENTS WERE TAKEN ABOVE BATTER.

REVISED 1-75

PROFILE ALONG ℄ OF PRINCIPAL SPILLWAY

0 10 20 30 40
Scale in feet

AS BUILT
NOV 15 1978

PRINCIPAL SPILLWAY LAYOUT

DAM 4
FLOODWATER RETARDING & RECREATION STRUCTURE
MIDDLE-SOUTH BRANCH FOREST RIVER WATERSHED
GRAND FORKS COUNTY NORTH DAKOTA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed L.M.S. Date 9-71
Drawn
Traced
Checked R.D.S. 10-73
Approved by
Title
Sheet No. 12 of 40
Drawing No. 5,E-29,772

Ref. 5

Barben, Edward J.

From: Paul LeClaire <pleclaire@houstoneng.com>
Sent: Thursday, December 10, 2020 3:40 PM
To: Barben, Edward J.
Cc: Beenenga, Cari R.; Mike Opat
Subject: RE: Fordville Dam Tailwater

E.J.,

Mike is trying to track down some information for pool readings at the dams now.

I wanted to let you know that the headwater/tailwater values we sent you previously changed slightly after we realized that our initial pool elevation needed to be raised. There was also an error with the Bylin model that we didn't catch the first time around. See updated headwater/tailwater elevations below.

Fordville Headwater: ~~1128.3 ft, NAVD88~~ 1129.4 ft, NAVD88
Fordville Tailwater: 1086.2 ft, NAVD88

Bylin Headwater: ~~1523.1 ft, NAVD88~~ 1527.2 ft, NAVD88
Bylin Tailwater: ~~1495.6 ft, NAVD88~~ 1482.6 ft, NAVD88

I apologize for any inconvenience. We will be following up with you on what we find out for the pool readings.

Thanks,

Paul LeClaire, PE
Engineer III
Houston Engineering, Inc.
O 701.237.5065 | **D** 701.499.9461

1401 21st Avenue N • Fargo, ND • 58102

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From: Barben, Edward J. <ebarben@GFNET.com>
Sent: Thursday, December 10, 2020 1:26 PM
To: Mike Opat <mopat@houstoneng.com>
Cc: Beenenga, Cari R. <cbeenenga@GFNET.com>; Paul LeClaire <pleclaire@houstoneng.com>
Subject: RE: Fordville Dam Tailwater

[External Email]

Thanks Mike.

Another question, are daily pool readings available for Fordville and Bylin? I would like to show the pool levels with the recorded piezometer level plots. Daily readings would be ideal, but I'll take weekly, monthly, or whatever is available – just so I have something to plot.

Thanks,

E.J.

From: Mike Opat <mopat@houstoneng.com>
Sent: Wednesday, December 9, 2020 8:46 AM
To: Barben, Edward J. <ebarben@GFNET.com>
Cc: Beenenga, Cari R. <cbeenenga@GFNET.com>; Paul LeClaire <pleclaire@houstoneng.com>
Subject: RE: Fordville Dam Tailwater

E.J.,
Sorry for the delay. See below for the headwater/tailwater elevations for Fordville and Bylin Dams.

Fordville Headwater: 1128.3 ft, NAVD88
Fordville Tailwater: 1086.2 ft, NAVD88

Bylin Headwater: 1523.1 ft, NAVD88
Bylin Tailwater: 1495.6 ft, NAVD88

Let us know if you have any questions.

Thanks,
Mike

Mike Opat, PE, CFM
Sr Project Manager
Houston Engineering, Inc.
O 701.237.5065 | D 701.499.9473

From: Barben, Edward J. <ebarben@GFNET.com>
Sent: Wednesday, December 9, 2020 7:29 AM
To: Mike Opat <mopat@houstoneng.com>
Cc: Beenenga, Cari R. <cbeenenga@GFNET.com>; Paul LeClaire <pleclaire@houstoneng.com>
Subject: RE: Fordville Dam Tailwater

[External Email]

Mike/Paul,

I'm just checking in to see if PMF headwater/tailwater elevations are available for Fordville. While I'm thinking of it, we'll eventually need the same information for Bylin.

Thanks,

E.J.

From: Mike Opat <mopat@houstoneng.com>
Sent: Wednesday, December 2, 2020 3:12 PM
To: Barben, Edward J. <ebarben@GFNET.com>
Cc: Beenenga, Cari R. <cbeenenga@GFNET.com>; Paul LeClaire <pleclaire@houstoneng.com>
Subject: RE: Fordville Dam Tailwater

E.J.,
I'm assuming you are referring to PMF conditions. We just received guidance from the state of North Dakota following their review and subsequent updates to the PMF, so we are in the process of running those models now. Paul is hoping to have results by the end of the week and we will pass those along as soon as we can.

Thanks,
Mike

Mike Opat, PE, CFM
Sr Project Manager
Houston Engineering, Inc.
O 701.237.5065 | **D** 701.499.9473

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From: Barben, Edward J. <ebarben@GFNET.com>
Sent: Wednesday, December 2, 2020 2:06 PM
To: Mike Opat <mopat@houstoneng.com>
Cc: Beenenga, Cari R. <cbeenenga@GFNET.com>
Subject: Fordville Dam Tailwater

[External Email]

Hi Mike,

I'm working on the slope stability analysis for Fordville Dam. Per NRCS requirements, one of the loading cases I need to model is maximum pool. Based on your H&H modeling, would you mind providing me the elevations for maximum pool and the associated tailwater?

Thanks,

E.J.

E.J. Barben, P.E. | Geotechnical Engineer

Ref. 6

Gannett Fleming

Fordville Dam
Summary of Laboratory Soil Test Results

EJB, 9/2020
TNK, 12/2020

Test Boring Number	Sample Number	Sample Depth	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	% Gravel	% Sand	% Silt	% Clay	LL (%)	PL (%)	Plasticity Index	Natural Moisture (%)	Specific Gravity (dim.)	Dry Unit Weight (pcf)	Moist Unit Weight (pcf)	Crumb Dispersion Grade
FD2020-11	S-6 & S-7	12.5 - 17.5	1117.7	Zone II	SC	Clayey SAND	0.0	65.7	21.1	13.2	29	19	10	17.8	2.82			1
FD2020-11	U1	37.5 - 38.5	1092.7	Zone I	CL	Sandy lean CLAY	0.0	35.0	40.1	24.8	39	19	20	14.0	2.79	119.9	136.7	2
FD2020-11	S-22 & S-23	52.5 - 57.5	1077.7	Zone I	CL	Sandy lean CLAY	1.5	33.6	37.5	27.4	40	19	21	16.4				1
FD2020-11	S-26	62.5 - 65.0	1067.7	Embankment Foundation														1
FD2020-11	S-28	67.5 - 70.0	1062.7	Embankment Foundation	SC-SM	Silty, clayey SAND	0.2	80.0	12.9	6.9	24	20	4	29.6				
FD2020-11	S-31	72.5 - 75.0	1057.7	Embankment Foundation														1
FD2020-11	S-35	82.5 - 85.0	1047.7	Embankment Foundation	ML	Sandy SILT	2.9	45.3	29.1	22.7	32	24	8	27.5				1
FD2020-11	S-42	100.0 - 102.5	1030.2	Embankment Foundation	SC	Clayey SAND	6.9	56.9	31.0	5.1	32	22	10	24.1				
FD2020-212	S-1 & S-2	0.0 - 5.0	1123.8	ASW Foundation	SC	Clayey SAND	10.2	68.3	14.6	6.9	45	22	23	14.7				1
FD2020-212	S-4	7.5 - 10.0	1116.3	ASW Foundation	CL	Sandy lean CLAY	5.6	41.6	39.7	13.2	40	22	18	19.1				
FD2020-212	S-5 & S-6	10.0 - 15.0	1113.8	ASW Foundation	SM	Silty SAND	5.7	78.3	7.8	8.2	32	26	6	17.7				
FD2020-213	S-2 & S-3	2.5 - 7.5	1121.2	ASW Foundation	SM	Silty SAND	5.8	74.7	12.6	7.0	31	25	6	11.3				
FD2020-213	U-1	20.0 - 22.3	1103.7	ASW Foundation	ML	SILT	0.0	2.4	77.9	19.7	33	30	3	40.7		81.0	114.0	
FD2020-214	S-3 & S-4	5.0 - 10.0	1119.1	ASW Foundation	SM	Silty SAND	0.0	81.6	7.0	11.4	43	28	15	18.7				
FD2020-608	S-1 & S-2	0.0 - 5.0	1101.5	Zone II	SC	Clayey SAND	0.7	82.0	8.7	8.6	38	22	16	16.3	2.66			
FD2020-608	U-1	10.0 - 11.0	1091.5	Zone II	SC-SM	Silty, clayey SAND	0.0	69.9	18.5	11.7	27	21	6	22.6	2.65	91.7	112.4	2
FD2020-608	S-11	25.0 - 27.5	1076.5	Embankment Foundation	SC	Clayey SAND	0.0	73.1	15.9	11.0	29	18	11	27.0				
FD2020-608	S-13	32.5 - 35.0	1069.0	Embankment Foundation														1
FD2020-608	U-2	55.0 - 57.0	1046.5	Embankment Foundation	ML	Sandy SILT	0.0	34.0	42.6	23.5	34	31	3	25.7	2.48	96.6	121.4	
FD2020-609	S-2	2.5 - 5.0	1080.7	Embankment Foundation														1
FD2020-609	S-5	10.0 - 12.5	1073.2	Embankment Foundation	CL	Lean clay with SAND	0.0	28.6	63.5	8.0	39	24	15	34.4				
FD2020-609	U-1	30.0 - 32.0	1053.2	Embankment Foundation	ML	Sandy SILT	0.0	49.9	37.5	12.6	39	26	13	47.7	2.66	81.0	119.6	2

PERMEABILITY

Test Boring Number	Sample Number	Sample Depth (ft)	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	Permeability (cm/s)
FD2020-608	S-1 to S-7	0 - 17.5	1101.5	Zone II	SM	Silty SAND	6.50E-06
FD2020-11	S-10 to S-20	22.2 - 50.0	1108	Zone I	CL	Sand lean CLAY	7.70E-08
FD2020-608	U-2	55 - 57.0	1046.5	Foundation	ML	Sandy SILT	2.20E-08
FD2020-609	U-1	30 - 32	1053.2	Foundation	ML	Sandy SILT	3.50E-06

CU TRIAXIAL SHEAR

Test Boring Number	Sample Number	Sample Depth (ft)	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	Moisture (%)	Dry Unit Weight (pcf)	Moist Unit Weight (pcf)	Total Stress Cohesion (psf)	Total Stress Friction Angle (°)	Effective Stress Cohesion (psf)	Effective Stress Friction Angle (°)
FD2020-11	S-10 to S-20	22.5 - 50.0	1108.0	Zone I	CL	Sandy lean CLAY	21.0	109.8	132.9	701.3	25.4	529.9	34.4
							21.0	110.2	133.3				
							21.0	110.1	133.2				
FD2020-608	U-2	55.0 - 57.0	1046.5	Foundation	ML	Sandy SILT	26.6	90.9	115.1	159.8	22.0	230.4	32.3
							25.8	92.9	116.9				
							24.7	97.4	121.5				
FD2020-609	U-1	30.0 - 32.0	1053.2	Foundation	ML	Sandy SILT	26.6	96.9	122.7	463.7	19.5	0.0	35.5
							28.9	90.2	116.3				
							23.7	99.3	122.8				

DIRECT SHEAR

Test Boring Number	Sample Number	Sample Depth (ft)	Elevation Top of Sample (ft)	Stratum	USCS Class	Material Description	Moisture (%)	Dry Unit Weight (pcf)	Moist Unit Weight (pcf)	Effective Stress Cohesion (psi)	Effective Stress Friction Angle (deg)
							Remolded				
FD2020-608	S-1 to S-7	0.0 - 17.5	1101.5	Zone II	SM	Silty SAND	21	100	121	0.63	37

*Strength parameters may not match laboratory test report sheets because engineering judgment was utilized to evaluate the results for each material to develop recommended shear strength parameters.

Ref. 7

Table A-1 - Permeability (k_v) of Embankment Core Materials (k_v inversely related to % fines)

UNIFIED SOIL CLASSIFICATION	** k_v RANGE (ft/y OR $x10^{-6}$ cm/s)
GM-SM	0.0 to 10.0
GM or GC	0.0 to 10.0
SP-SM	0.0 to 10.0
SM	0.0 to 10.0
SM-SC	0.0 to 3.0
SM-ML	0.0 to 10.0
SC	0.0 to 3.0
ML	0.0 to 10.0
ML-CL	0.0 to 1.0
CL	0.0 to 1.0
MH	0.0 to 0.1
CH	0.0 to 0.1
References: [3],[5],[9],[32],[33]	

Table A-2 - Permeability (k_v) of Embankment Shell Materials (k_v inversely related to % fines)

UNIFIED SOIL CLASSIFICATION	k_v RANGE (ft/y OR $x10^{-6}$ cm/s)
GP	2,000 to 1,000,000
GW	1,000 to 100,000
GP-SP	1,000 to 50,000
GW-SW	500 to 5,000
GM	10 to 500
SP (m. to c.)	10,000 to 20,000
SP (f. to m.)	5,000 to 10,000
SP (v.f. to f.)	500 to 5,000
SW	300 to 5,000
SP-SM	10 to 1,000
SM	10 to 500
References: [3],[5],[7],[27],[34],[41]	

Table A-3 - Permeability (k_v) of washed Embankment Drain Materials (k_v increases with grain size)

MATERIAL	k_v RANGE (ft/y OR $x10^{-6}$ cm/s)
Coarse sand and gravel	150,000 to 500,000
Medium to coarse sand	50,000 to 150,000
Fine to medium sand	10,000 to 50,000
References: [5],[7],[27]	

For existing drainfill, use 100,000 $x10^6$ cm/sec (conservative)

Table A-4 - Anisotropy (k_h/k_v) of Embankment Materials (k_h/k_v increases with placement water content)

MATERIAL	k_h/k_v RANGE
Emb. Core	
USBR standard placement	4 to 9
None - Standard placement	9 to 36
Hydraulic Fill	64 to 225
Emb. Shell	
USBR standard	4 to 9
ns	
ndard	1 to 4
s: [2],[21],[22],[23],[32]	

** Table A-1 based primarily on USBR laboratory test data.

DS-13(8)-3 - 3/20/87

Table A-8 - Porosity (n) of Embankment Soils
(n increases with uniformity)

UNIFIED SOIL CLASSIFICATION	POROSITY, n RANGE
GP	0.25 to 0.35
GW	0.20 to 0.30
GM	0.20 to 0.35
GM - SM	0.20 to 0.25
GC	0.25 to 0.35
GC - SC	0.20 to 0.30
SP	0.25 to 0.35
SW	0.20 to 0.30
SM	0.25 to 0.35
SM - ML	0.25 to 0.35
SM - SC	0.25 to 0.35
SC	0.20 to 0.30
ML	0.30 to 0.40
ML-CL	0.25 to 0.40
CL	0.25 to 0.40
CH	0.35 to 0.50
References: [3],[5],[33]	

Table A-9 - Porosity (n) of Unconsolidated Natural Soils
(n inversely related to density)

SOIL	POROSITY, n RANGE
Gravel, coarse	0.25 to 0.40
Gravel, medium	0.25 to 0.45
Gravel, fine	0.25 to 0.45
Sand, coarse	0.25 to 0.45
Sand, medium	0.25 to 0.50
Sand, fine	0.25 to 0.50
Sand, fine	0.25 to 0.50
Sand, till	0.20 to 0.35
Sand, dune	0.40 to 0.50
Silt	0.30 to 0.60
Silt, till	0.30 to 0.40
Loess	0.45 to 0.60
Clay	0.35 to 0.80
References: [34],[39],[40],[42],[43]	

Pink highlight - Existing Drain Fill
Blue highlight - Sandy Overburden
Yellow highlight - Zone II (Shell)
Green highlight - Outwash/Alluvium
Orange highlight - Zone I (Core)

Table A-10 - Porosity (n) of Rocks.
(Range due to grain size, cementation, weathering)

ROCK	POROSITY, n	ROCK	POROSITY, n
Shale	0.01 to 0.10	Basalt	0.03 to 0.35
Claystone	0.40 to 0.45	Sandstone, fine	0.01 to 0.50
Siltstone	0.20 to 0.40	Sandstone, medium	0.30 to 0.45
Tuff	0.07 to 0.55	Gabbro (weathered)	0.35 to 0.45
Schist	0.04 to 0.50	Granite, weathered	0.35 to 0.55
Dolomite	0.20 to 0.35	Most other	< 0.01
Limestone	.07 to .55		
References: [39],[40],[42]			

Gannett Fleming

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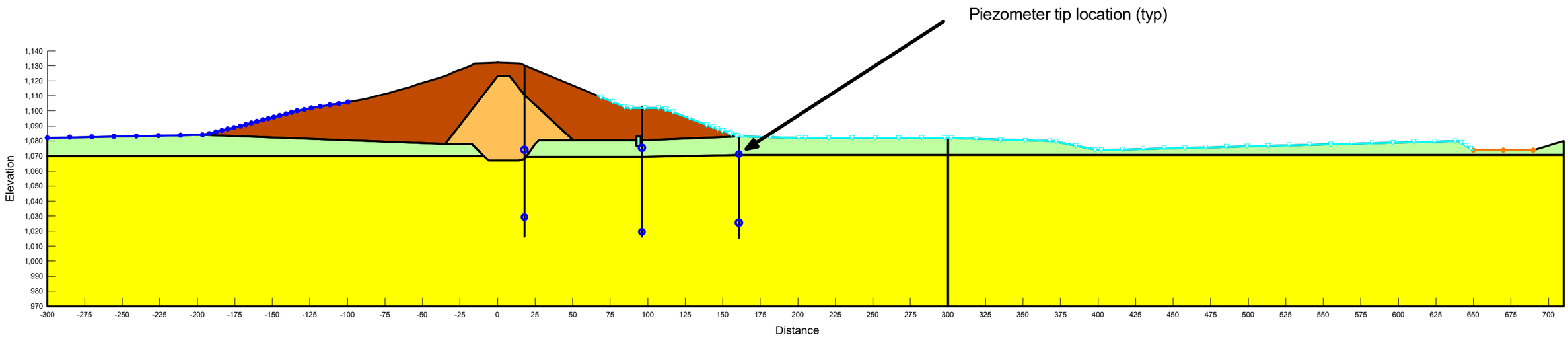
Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function
	Drain fill	Saturated / Unsaturated		Drainfill	Drainfill
	Outwash/Alluvium	Saturated Only	1.15e-07		
	Sandy Alluvium	Saturated / Unsaturated		Sandy Alluvium	Sandy Alluvium
	Zone I (Core)	Saturated / Unsaturated		Zone I	Zone I
	Zone II (Shell)	Saturated / Unsaturated		Zone II	Zone II



Analysis Type: SEEP/W	Scale: 1:800	Steady-State Seepage, Normal Pool
File Name: Fordville Dam.gsz		Calc By: EJB, November 2020
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\		Calc Checked By:TNK, December 2020

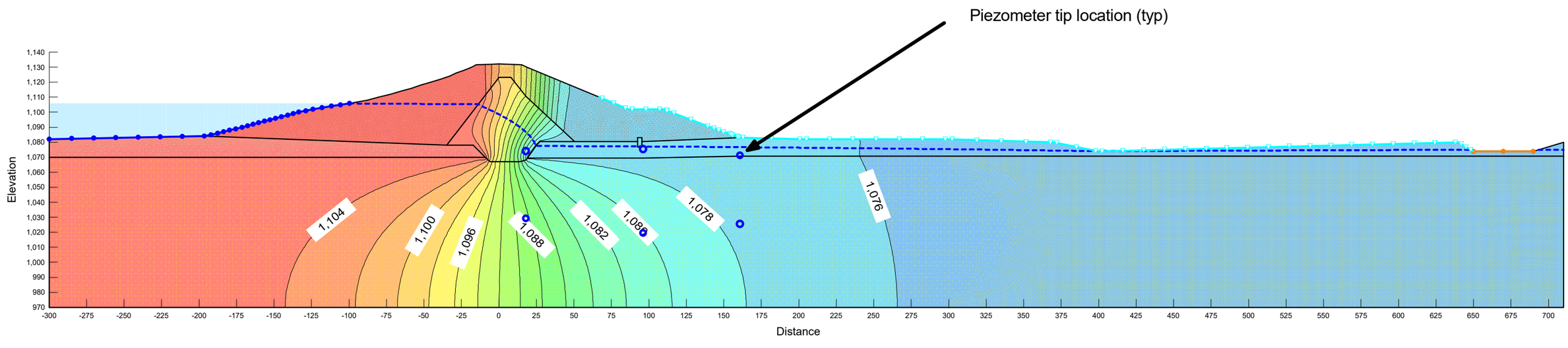
Fordville Dam

Sta. 24+50

Gannett Fleming

Excellence Delivered As Promised

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function
	Drain fill	Saturated / Unsaturated		Drainfill	Drainfill
	Outwash/Alluvium	Saturated Only	1.15e-07		
	Sandy Alluvium	Saturated / Unsaturated		Sandy Alluvium	Sandy Alluvium
	Zone I (Core)	Saturated / Unsaturated		Zone I	Zone I
	Zone II (Shell)	Saturated / Unsaturated		Zone II	Zone II



Analysis Type: SEEP/W	Scale: 1:800
File Name: Fordville Dam.gsz	
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\	

Fordville Dam

Sta. 24+50

Steady-State Seepage, Normal Pool
Calc By: EJB, November 2020
Calc Checked By:TNK, December 2020

Steady-State Seepage, Normal Pool

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File Information

File Version: 10.02
Title: Fordville Dam
Created By: Barben, Edward J.
Last Edited By: Barben, Edward J.
Revision Number: 147
Date: 12/18/2020
Time: 04:43:06 PM
Tool Version: 10.2.2.20559
File Name: Fordville Dam.gsz
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Steady-State Seepage, Normal Pool

Kind: SEEP/W
Method: Steady-State
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Maximum Number of Iterations: 500
- Maximum Difference: 0.005
- Significant Digits: 2
- Max # of Reviews: 10
- Under-Relaxation Criteria
  - Initial Rate: 1
  - Minimum Rate: 0.1
  - Rate Reduction Factor: 0.65
  - Reduction Frequency (iterations): 10

Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf

Time

Starting Time: 0 d
Duration: 0 d
Ending Time: 0 d

Materials

Zone I (Core)

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Zone I
K-Function: Zone I
Ky'/Kx' Ratio: 1
Rotation: 0 °

Zone II (Shell)

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Zone II
K-Function: Zone II
Ky'/Kx' Ratio: 10
Rotation: 0 °

Outwash/Alluvium

Hydraulic

Model: Saturated Only
Sat Kx: 1.15e-07 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.35
Compressibility: 2.4e-05 /psf

Drain fill

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Drainfill
K-Function: Drainfill
Ky'/Kx' Ratio: 1
Rotation: 0 °

Sandy Alluvium

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Sandy Alluvium

K-Function: Sandy Alluvium
Ky'/Kx' Ratio: 1
Rotation: 0 °

Boundary Conditions

Normal Pool

Category: Hydraulic
Kind: Water Total Head 1,106 ft
Review: No

Potential Seepage Face

Category: Hydraulic
Kind: Water Flux 0 ft/sec
Review: Yes

Tailwater

Category: Hydraulic
Kind: Water Total Head 1,075 ft
Review: No

Water K Functions

Zone I

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 2.53e-09 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 2.53e-09)
Data Point: (0.20885434, 2.4909698e-09)
Data Point: (0.38282598, 2.4752216e-09)
Data Point: (0.70171264, 2.4531196e-09)
Data Point: (1.2862257, 2.4222273e-09)
Data Point: (2.357627, 2.3791168e-09)
Data Point: (4.3214847, 2.3191374e-09)
Data Point: (7.9211981, 2.2360705e-09)
Data Point: (14.519403, 2.1217887e-09)
Data Point: (26.613786, 1.9661421e-09)
Data Point: (48.782557, 1.7575545e-09)
Data Point: (89.417486, 1.4854705e-09)
Data Point: (163.90053, 1.14755e-09)
Data Point: (300.42651, 7.6511682e-10)
Data Point: (550.67599, 4.0257087e-10)

Data Point: (1,009.3785, 1.5034896e-10)
Data Point: (1,850.1713, 3.7886616e-11)
Data Point: (3,391.3282, 6.8879465e-12)
Data Point: (6,216.2392, 1.0284036e-12)
Data Point: (11,394.247, 1.3963802e-13)
Data Point: (20,885.434, 1.8208586e-14)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Zone I
Saturated Kx: 2.53e-09 ft/sec
Residual Water Content: 0.033
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Zone II

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 2.13e-07 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 2.13e-07)
Data Point: (0.20885434, 2.1220507e-07)
Data Point: (0.38282598, 2.1158379e-07)
Data Point: (0.70171264, 2.1047442e-07)
Data Point: (1.2862257, 2.0850277e-07)
Data Point: (2.357627, 2.0500504e-07)
Data Point: (4.3214847, 1.9882707e-07)
Data Point: (7.9211981, 1.880198e-07)
Data Point: (14.519403, 1.6948678e-07)
Data Point: (26.613786, 1.3913292e-07)
Data Point: (48.782557, 9.4688246e-08)
Data Point: (89.417486, 4.4726876e-08)
Data Point: (163.90053, 1.170771e-08)
Data Point: (300.42651, 1.6210763e-09)
Data Point: (550.67599, 1.4847192e-10)
Data Point: (1,009.3785, 1.1379826e-11)
Data Point: (1,850.1713, 8.1984932e-13)
Data Point: (3,391.3282, 5.7912887e-14)
Data Point: (6,216.2392, 4.0659393e-15)
Data Point: (11,394.247, 2.8492573e-16)
Data Point: (20,885.434, 1.9955066e-17)

Estimation Properties

Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Zone II
Saturated Kx: 2.13e-07 ft/sec
Residual Water Content: 0.025

Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Sandy Alluvium

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 5e-05 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 5e-05)
Data Point: (0.20885434, 4.9876571e-05)
Data Point: (0.38282598, 4.9735e-05)
Data Point: (0.70171264, 4.9430027e-05)
Data Point: (1.2862257, 4.8776487e-05)
Data Point: (2.357627, 4.7381654e-05)
Data Point: (4.3214847, 4.4438933e-05)
Data Point: (7.9211981, 3.8451179e-05)
Data Point: (14.519403, 2.7489866e-05)
Data Point: (26.613786, 1.2667528e-05)
Data Point: (48.782557, 2.6205167e-06)
Data Point: (89.417486, 2.3104708e-07)
Data Point: (163.90053, 1.2694093e-08)
Data Point: (300.42651, 5.9267123e-10)
Data Point: (550.67599, 2.6447235e-11)
Data Point: (1,009.3785, 1.1663756e-12)
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Data Point: (3,391.3282, 2.2532475e-15)
Data Point: (6,216.2392, 9.8979248e-17)
Data Point: (11,394.247, 4.3476846e-18)
Data Point: (20,885.434, 1.9097059e-19)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Sandy Alluvium
Saturated Kx: 5e-05 ft/sec
Residual Water Content: 0.025
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Drainfill

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.0033 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)

Data Point: (0, 0.0033)
Data Point: (0.20885434, 0.0032918538)
Data Point: (0.38282598, 0.0032825103)
Data Point: (0.70171264, 0.0032623823)
Data Point: (1.2862257, 0.0032192491)
Data Point: (2.357627, 0.0031271908)
Data Point: (4.3214847, 0.0029329724)
Data Point: (7.9211981, 0.0025377821)
Data Point: (14.519403, 0.0018143365)
Data Point: (26.613786, 0.0008360606)
Data Point: (48.782557, 0.00017295496)
Data Point: (89.417486, 1.5249149e-05)
Data Point: (163.90053, 8.3780924e-07)
Data Point: (300.42651, 3.9116096e-08)
Data Point: (550.67599, 1.745501e-09)
Data Point: (1,009.3785, 7.6979738e-11)
Data Point: (1,850.1713, 3.3847413e-12)
Data Point: (3,391.3282, 1.4871106e-13)
Data Point: (6,216.2392, 6.5324591e-15)
Data Point: (11,394.247, 2.8693846e-16)
Data Point: (20,885.434, 1.2603623e-17)

Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Drainfill
Saturated Kx: 0.0033 ft/sec
Residual Water Content: 0.03
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Vol. Water Content Functions

Zone I

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.33033281
Residual Water Content: 0.033033281
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.33033281
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.33)
Data Point: (0.20885434, 0.32999958)
Data Point: (0.38282598, 0.32999907)
Data Point: (0.70171264, 0.32999793)

Data Point: (1.2862257, 0.3299953)
Data Point: (2.357627, 0.32998915)
Data Point: (4.3214847, 0.32997459)
Data Point: (7.9211981, 0.32993982)
Data Point: (14.519403, 0.32985615)
Data Point: (26.613786, 0.32965385)
Data Point: (48.782557, 0.32916345)
Data Point: (89.417486, 0.32797653)
Data Point: (163.90053, 0.32513116)
Data Point: (300.42651, 0.31849258)
Data Point: (550.67599, 0.30397654)
Data Point: (1,009.3785, 0.27626763)
Data Point: (1,850.1713, 0.23441806)
Data Point: (3,391.3282, 0.18766449)
Data Point: (6,216.2392, 0.14757289)
Data Point: (11,394.247, 0.11771315)
Data Point: (20,885.434, 0.095956808)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.33
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Zone II

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.25000191
Residual Water Content: 0.025000191
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.25000191
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.25)
Data Point: (0.20885434, 0.24999684)
Data Point: (0.38282598, 0.24999188)
Data Point: (0.70171264, 0.24997905)
Data Point: (1.2862257, 0.2499458)
Data Point: (2.357627, 0.24985955)
Data Point: (4.3214847, 0.24963577)
Data Point: (7.9211981, 0.2490561)
Data Point: (14.519403, 0.24756281)
Data Point: (26.613786, 0.24377394)

Data Point: (48.782557, 0.23452627)
Data Point: (89.417486, 0.21395221)
Data Point: (163.90053, 0.1763078)
Data Point: (300.42651, 0.12673754)
Data Point: (550.67599, 0.082653151)
Data Point: (1,009.3785, 0.053541366)
Data Point: (1,850.1713, 0.036463251)
Data Point: (3,391.3282, 0.026342494)
Data Point: (6,216.2392, 0.019972248)
Data Point: (11,394.247, 0.015672496)
Data Point: (20,885.434, 0.012567901)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.25
Sample Material: Silty Sand
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Sandy Alluvium

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.25000248
Residual Water Content: 0.025000248
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.25000248
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.25)
Data Point: (0.20885434, 0.24999642)
Data Point: (0.38282598, 0.24998845)
Data Point: (0.70171264, 0.24996251)
Data Point: (1.2862257, 0.24987782)
Data Point: (2.357627, 0.24960115)
Data Point: (4.3214847, 0.24870014)
Data Point: (7.9211981, 0.24580258)
Data Point: (14.519403, 0.23686024)
Data Point: (26.613786, 0.21244479)
Data Point: (48.782557, 0.16318507)
Data Point: (89.417486, 0.10417472)
Data Point: (163.90053, 0.062576914)
Data Point: (300.42651, 0.040025715)
Data Point: (550.67599, 0.027898977)
Data Point: (1,009.3785, 0.020816928)

Data Point: (1,850.1713, 0.016305017)
Data Point: (3,391.3282, 0.013214258)
Data Point: (6,216.2392, 0.010965717)
Data Point: (11,394.247, 0.0092397331)
Data Point: (20,885.434, 0.0078448584)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.25
Sample Material: Sand
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Drainfill

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.3000025
Residual Water Content: 0.03000025
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.3000025
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.3)
Data Point: (0.20885434, 0.2999957)
Data Point: (0.38282598, 0.29998614)
Data Point: (0.70171264, 0.29995502)
Data Point: (1.2862257, 0.29985338)
Data Point: (2.357627, 0.29952138)
Data Point: (4.3214847, 0.29844017)
Data Point: (7.9211981, 0.29496309)
Data Point: (14.519403, 0.28423228)
Data Point: (26.613786, 0.25493375)
Data Point: (48.782557, 0.19582209)
Data Point: (89.417486, 0.12500967)
Data Point: (163.90053, 0.075092297)
Data Point: (300.42651, 0.048030859)
Data Point: (550.67599, 0.033478772)
Data Point: (1,009.3785, 0.024980313)
Data Point: (1,850.1713, 0.019566021)
Data Point: (3,391.3282, 0.01585711)
Data Point: (6,216.2392, 0.013158861)
Data Point: (11,394.247, 0.01108768)
Data Point: (20,885.434, 0.0094138301)
Estimation Properties

Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.3
Sample Material: Sand
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	1,132.1 ft
Point 2	15 ft	1,131.5 ft
Point 3	-15 ft	1,131.5 ft
Point 4	8 ft	1,123.2 ft
Point 5	0 ft	1,123.2 ft
Point 6	109.5 ft	1,102 ft
Point 7	157.82 ft	1,084 ft
Point 8	53.1 ft	1,078.1 ft
Point 9	-34.7 ft	1,078.1 ft
Point 10	18 ft	1,068.2 ft
Point 11	18 ft	1,016.4 ft
Point 12	96.3 ft	1,102.4 ft
Point 13	96.3 ft	1,078.1 ft
Point 14	96.3 ft	1,016.5 ft
Point 15	18 ft	1,130.2 ft
Point 16	18 ft	1,110.7 ft
Point 17	160.8 ft	1,083.2 ft
Point 18	160.8 ft	1,080.7 ft
Point 19	160.8 ft	1,015.7 ft
Point 20	18.5 ft	1,130 ft

Point 21	86.5 ft	1,102 ft
Point 22	202.8 ft	1,082 ft
Point 23	300 ft	1,082 ft
Point 24	300 ft	970 ft
Point 25	-18 ft	1,130 ft
Point 26	-23.2 ft	1,128 ft
Point 27	-28.4 ft	1,126 ft
Point 28	-32.9 ft	1,124 ft
Point 29	-39.3 ft	1,122 ft
Point 30	-45.3 ft	1,120 ft
Point 31	-52.3 ft	1,118 ft
Point 32	-58.5 ft	1,116 ft
Point 33	-65.3 ft	1,114 ft
Point 34	-72.27 ft	1,112 ft
Point 35	-80 ft	1,110 ft
Point 36	-87.8 ft	1,108 ft
Point 37	-99.5 ft	1,106 ft
Point 38	-111.8 ft	1,104 ft
Point 39	-124 ft	1,102 ft
Point 40	-133.4 ft	1,100 ft
Point 41	-140.8 ft	1,098 ft
Point 42	-148.9 ft	1,096 ft
Point 43	-156.4 ft	1,094 ft
Point 44	-163.9 ft	1,092 ft
Point 45	-171.3 ft	1,090 ft
Point 46	-179.6 ft	1,088 ft
Point 47	-187.5 ft	1,086 ft
Point 48	-196.5 ft	1,084 ft
Point 49	-300 ft	1,082 ft
Point 50	42.7 ft	1,120 ft
Point 51	66.7 ft	1,110 ft
Point 52	114.5 ft	1,100 ft
Point 53	141.4 ft	1,090 ft
Point 54	7.6 ft	1,132 ft
Point 55	-6 ft	1,132 ft
Point 56	4 ft	1,067 ft

Point 57	14 ft	1,067 ft
Point 58	-6 ft	1,067 ft
Point 59	-17.1 ft	1,078.1 ft
Point 60	25.1 ft	1,078.1 ft
Point 61	-300 ft	970 ft
Point 62	18 ft	1,074.2 ft
Point 63	18 ft	1,029.2 ft
Point 64	96.3 ft	1,019.5 ft
Point 65	96.3 ft	1,075.5 ft
Point 66	160.8 ft	1,025.7 ft
Point 67	160.8 ft	1,071.2 ft
Point 68	94 ft	1,081.1 ft
Point 69	92.5 ft	1,083.1 ft
Point 70	95.5 ft	1,083.1 ft
Point 71	92.5 ft	1,076.7 ft
Point 72	95.5 ft	1,076.7 ft
Point 73	92.5 ft	1,078.1 ft
Point 74	95.5 ft	1,078.1 ft
Point 75	370 ft	1,080 ft
Point 76	400 ft	1,074 ft
Point 77	640 ft	1,080 ft
Point 78	650 ft	1,074 ft
Point 79	690 ft	1,074 ft
Point 80	710 ft	1,080 ft
Point 81	710 ft	970 ft
Point 82	96.3 ft	1,069.5 ft
Point 83	18.9 ft	1,069.5 ft
Point 84	710 ft	1,070.7 ft
Point 85	27.5 ft	1,080.5 ft
Point 86	160.8 ft	1,070.7 ft
Point 87	50.52 ft	1,080.5 ft
Point 88	92.5 ft	1,080.5 ft
Point 89	95.5 ft	1,080.5 ft
Point 90	96.3 ft	1,080.5 ft
Point 91	158.11 ft	1,080.5 ft
Point 92	-9 ft	1,070 ft

Point 93	-300 ft	1,070 ft
Point 94	151.8 ft	1,086.2 ft
Point 95	300 ft	1,070.7 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	9	5	56.904 ft	52.4 °	
Line 2	10	11	51.8 ft	90 °	
Line 3	12	13	24.3 ft	90 °	
Line 4	13	14	61.6 ft	90 °	
Line 5	5	4	8 ft	0 °	
Line 6	9	48	161.91 ft	-2.09 °	
Line 7	48	47	9.2195 ft	12.5 °	Normal Pool
Line 8	47	46	8.1492 ft	14.2 °	Normal Pool
Line 9	46	45	8.5376 ft	13.5 °	Normal Pool
Line 10	45	44	7.6655 ft	15.1 °	Normal Pool
Line 11	44	43	7.7621 ft	14.9 °	Normal Pool
Line 12	43	42	7.7621 ft	14.9 °	Normal Pool
Line 13	42	41	8.3433 ft	13.9 °	Normal Pool
Line 14	41	40	7.6655 ft	15.1 °	Normal Pool
Line 15	40	39	9.6104 ft	12 °	Normal Pool
Line 16	39	38	12.363 ft	9.31 °	Normal Pool
Line 17	38	37	12.462 ft	9.24 °	Normal Pool
Line 18	37	36	11.87 ft	9.7 °	
Line 19	36	35	8.0523 ft	14.4 °	
Line 20	35	34	7.9845 ft	14.5 °	
Line 21	34	33	7.2513 ft	16 °	
Line 22	33	32	7.088 ft	16.4 °	
Line 23	32	31	6.5146 ft	17.9 °	
Line 24	31	30	7.2801 ft	15.9 °	
Line 25	30	29	6.3246 ft	18.4 °	
Line 26	29	28	6.7052 ft	17.4 °	
Line 27	28	27	4.9244 ft	24 °	
Line 28	27	26	5.5714 ft	21 °	
Line 29	26	25	5.5714 ft	21 °	
Line 30	25	3	3.3541 ft	26.6 °	

Line 31	2	15	3.2696 ft	-23.4 °	
Line 32	15	20	0.53852 ft	-21.8 °	
Line 33	20	50	26.185 ft	-22.5 °	
Line 34	50	51	26 ft	-22.6 °	
Line 35	51	21	21.355 ft	-22 °	Potential Seepage Face
Line 36	21	6	23 ft	0 °	Potential Seepage Face
Line 37	6	52	5.3852 ft	-21.8 °	Potential Seepage Face
Line 38	52	53	28.699 ft	-20.4 °	Potential Seepage Face
Line 39	1	54	7.6007 ft	-0.754 °	
Line 40	54	2	7.4169 ft	-3.87 °	
Line 41	3	55	9.0139 ft	3.18 °	
Line 42	55	1	6.0008 ft	0.955 °	
Line 43	57	56	10 ft	0 °	
Line 44	56	58	10 ft	0 °	
Line 45	59	9	17.6 ft	0 °	
Line 46	4	16	16.008 ft	-51.3 °	
Line 47	10	57	4.1761 ft	16.7 °	
Line 48	24	61	600 ft	0 °	
Line 49	15	16	19.5 ft	90 °	
Line 50	16	62	36.5 ft	90 °	
Line 51	62	10	6 ft	90 °	
Line 52	66	19	10 ft	90 °	
Line 53	69	70	3 ft	0 °	
Line 54	74	72	1.4 ft	90 °	
Line 55	72	71	3 ft	0 °	
Line 56	71	73	1.4 ft	90 °	
Line 57	83	60	10.602 ft	54.2 °	
Line 58	23	22	97.2 ft	0 °	Potential Seepage Face
Line 59	22	17	42.017 ft	-1.64 °	Potential Seepage Face
Line 60	17	7	3.0855 ft	-15 °	Potential Seepage Face
Line 61	10	83	1.5811 ft	55.3 °	
Line 62	83	82	77.4 ft	0 °	
Line 63	84	80	9.3 ft	90 °	
Line 64	80	79	20.881 ft	16.7 °	
Line 65	79	78	40 ft	0 °	Tailwater
Line 66	78	77	11.662 ft	-31 °	Potential Seepage Face

Line 67	77	76	240.07 ft	1.43 °	Potential Seepage Face
Line 68	90	17	64.556 ft	2.4 °	
Line 69	70	89	2.6 ft	90 °	
Line 70	89	90	0.8 ft	0 °	
Line 71	88	69	2.6 ft	90 °	
Line 72	16	87	44.38 ft	-42.9 °	
Line 73	87	88	41.98 ft	0 °	
Line 74	60	85	3.3941 ft	45 °	
Line 75	85	87	23.02 ft	0 °	
Line 76	89	74	2.4 ft	90 °	
Line 77	73	88	2.4 ft	90 °	
Line 78	86	82	64.511 ft	1.07 °	
Line 79	59	92	11.455 ft	-45 °	
Line 80	92	58	4.2426 ft	-45 °	
Line 81	93	61	100 ft	90 °	
Line 82	92	93	291 ft	0 °	
Line 83	48	49	103.52 ft	1.11 °	Normal Pool
Line 84	49	93	12 ft	90 °	
Line 85	7	94	6.4094 ft	-20.1 °	Potential Seepage Face
Line 86	94	53	11.072 ft	-20.1 °	Potential Seepage Face
Line 87	66	67	45.5 ft	90 °	
Line 88	67	17	12 ft	90 °	
Line 89	24	95	100.7 ft	90 °	
Line 90	95	86	139.2 ft	0 °	
Line 91	95	23	11.3 ft	90 °	
Line 92	95	84	410 ft	0 °	
Line 93	76	75	30.594 ft	-11.3 °	Potential Seepage Face
Line 94	75	23	70.029 ft	-1.64 °	Potential Seepage Face
Line 95	84	81	100.7 ft	90 °	
Line 96	81	24	410 ft	0 °	

Regions

	Material	Points	Area
Region 1	Zone I (Core)	5,9,59,92,58,56,57,10,83,60,85,87,16,4	2,403.3 ft²
Region 2	Zone II (Shell)	1,55,3,25,26,27,28,29,30,31,32,33,34,35, 36,37,38,39,40,41,42,43,44,45,46,47,48,9,	7,716.8 ft²

		5,4,16,87,88,69,70,89,90,17,7,94,53,52,6,21,51,50,20,15,2,54	
Region 3	Outwash/Alluvium	93,61,24,95,86,82,83,10,57,56,58,92	59,990 ft²
Region 4	Sandy Alluvium	83,82,86,95,23,22,17,90,89,74,72,71,73,88,87,85,60	3,151.6 ft²
Region 5	Sandy Alluvium	84,80,79,78,77,76,75,23,95	2,743 ft²
Region 6	Drain fill	69,70,89,74,72,71,73,88	19.2 ft²
Region 7	Sandy Alluvium	92,59,9,48,49,93	3,308.8 ft²
Region 8	Outwash/Alluvium	95,84,81,24	41,287 ft²

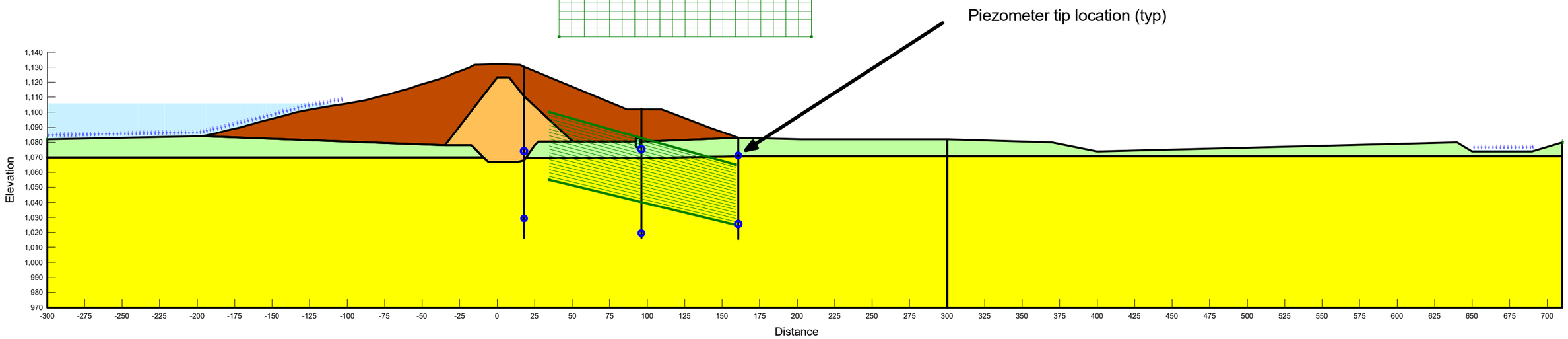
Mesh Properties

Global Element Size: 2.5 ft

Gannett Fleming

Excellence Delivered As Promised

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Drain fill	Mohr-Coulomb	110	0	36	0
	Outwash/Alluvium	Mohr-Coulomb	120	0	32	0
	Sandy Alluvium	Mohr-Coulomb	110	0	34	0
	Zone I (Core)	Mohr-Coulomb	133	0	33	0
	Zone II (Shell)	Mohr-Coulomb	121	0	37	0



Analysis Type: SLOPE/W	Scale: 1:800
File Name: Fordville Dam.gsz	
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\	

Fordville Dam

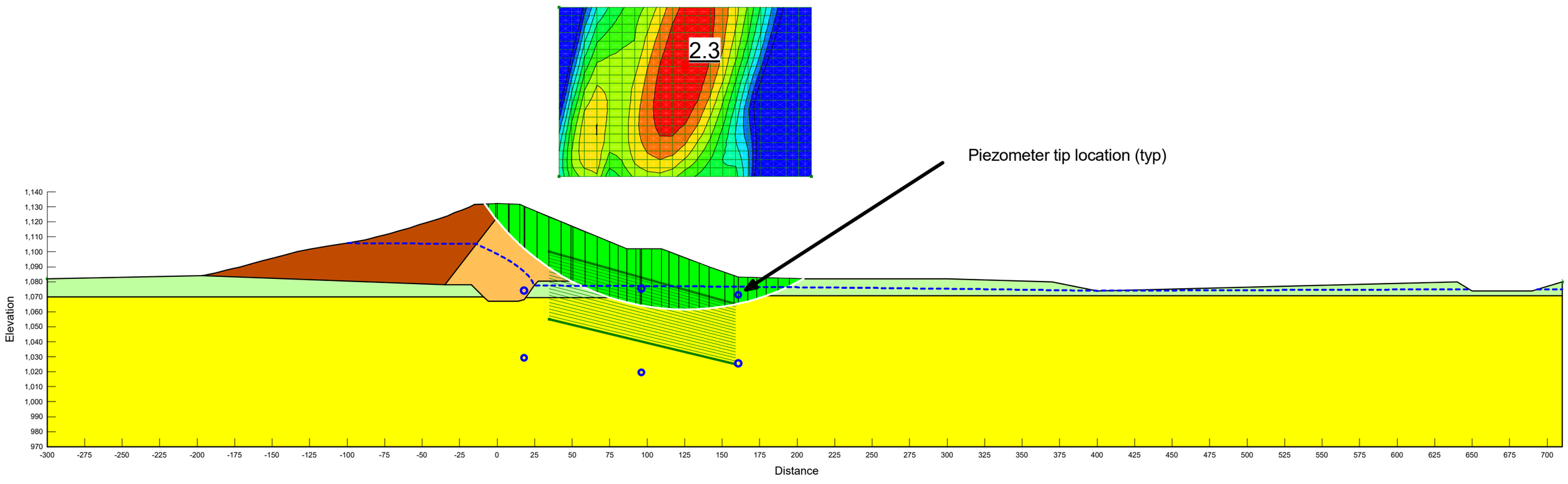
Sta. 24+50

Downstream Slope Stability, Normal Pool
Calc By: EJB, November 2020
Calc Checked By:TNK, December 2020

Gannett Fleming

Excellence Delivered As Promised

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)
	Drain fill	Mohr-Coulomb	110	0	36	0
	Outwash/Alluvium	Mohr-Coulomb	120	0	32	0
	Sandy Alluvium	Mohr-Coulomb	110	0	34	0
	Zone I (Core)	Mohr-Coulomb	133	0	33	0
	Zone II (Shell)	Mohr-Coulomb	121	0	37	0



Analysis Type: SLOPE/W	Scale: 1:800
File Name: Fordville Dam.gsz	
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\	

Fordville Dam

Sta. 24+50

Downstream Slope Stability, Normal Pool
Calc By: EJB, November 2020
Calc Checked By:TNK, December 2020

Downstream Slope Stability, Normal Pool

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File Information

File Version: 10.02
Title: Fordville Dam
Created By: Barben, Edward J.
Last Edited By: Barben, Edward J.
Revision Number: 147
Date: 12/18/2020
Time: 04:43:06 PM
Tool Version: 10.2.2.20559
File Name: Fordville Dam.gsz
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Downstream Slope Stability, Normal Pool

Kind: SLOPE/W
Parent: Steady-State Seepage, Normal Pool
Method: Spencer
Settings
    PWP Conditions from: Parent Analysis
    Unit Weight of Water: 62.430189 pcf
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Grid and Radius
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: No
    Tension Crack Option: (none)
Distribution
    F of S Calculation Option: Constant
Advanced
    Geometry Settings
        Minimum Slip Surface Depth: 3 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Zone I (Core)

Model: Mohr-Coulomb
Unit Weight: 133 pcf
Cohesion': 0 psf
Phi': 33 °
Phi-B: 0 °

Zone II (Shell)

Model: Mohr-Coulomb
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi': 37 °
Phi-B: 0 °

Outwash/Alluvium

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °

Drain fill

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °

Sandy Alluvium

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °

Slip Surface Grid

Upper Left: (41.29603, 1,263.0308) ft
Lower Left: (41.29603, 1,150.3294) ft
Lower Right: (209.58215, 1,150.3294) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (34.81677, 1,100.1) ft
Upper Right Coordinate: (158.81677, 1,065.1) ft
Lower Left Coordinate: (34.81677, 1,055.1) ft
Lower Right Coordinate: (158.81677, 1,025.1) ft
Number of Increments: 20
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-300, 1,082) ft
Right Coordinate: (710, 1,080) ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	1,132.1 ft
Point 2	15 ft	1,131.5 ft
Point 3	-15 ft	1,131.5 ft
Point 4	8 ft	1,123.2 ft
Point 5	0 ft	1,123.2 ft
Point 6	109.5 ft	1,102 ft
Point 7	157.82 ft	1,084 ft
Point 8	53.1 ft	1,078.1 ft

Point 9	-34.7 ft	1,078.1 ft
Point 10	18 ft	1,068.2 ft
Point 11	18 ft	1,016.4 ft
Point 12	96.3 ft	1,102.4 ft
Point 13	96.3 ft	1,078.1 ft
Point 14	96.3 ft	1,016.5 ft
Point 15	18 ft	1,130.2 ft
Point 16	18 ft	1,110.7 ft
Point 17	160.8 ft	1,083.2 ft
Point 18	160.8 ft	1,080.7 ft
Point 19	160.8 ft	1,015.7 ft
Point 20	18.5 ft	1,130 ft
Point 21	86.5 ft	1,102 ft
Point 22	202.8 ft	1,082 ft
Point 23	300 ft	1,082 ft
Point 24	300 ft	970 ft
Point 25	-18 ft	1,130 ft
Point 26	-23.2 ft	1,128 ft
Point 27	-28.4 ft	1,126 ft
Point 28	-32.9 ft	1,124 ft
Point 29	-39.3 ft	1,122 ft
Point 30	-45.3 ft	1,120 ft
Point 31	-52.3 ft	1,118 ft
Point 32	-58.5 ft	1,116 ft
Point 33	-65.3 ft	1,114 ft
Point 34	-72.27 ft	1,112 ft
Point 35	-80 ft	1,110 ft
Point 36	-87.8 ft	1,108 ft
Point 37	-99.5 ft	1,106 ft
Point 38	-111.8 ft	1,104 ft
Point 39	-124 ft	1,102 ft
Point 40	-133.4 ft	1,100 ft
Point 41	-140.8 ft	1,098 ft
Point 42	-148.9 ft	1,096 ft
Point 43	-156.4 ft	1,094 ft
Point 44	-163.9 ft	1,092 ft

Point 45	-171.3 ft	1,090 ft
Point 46	-179.6 ft	1,088 ft
Point 47	-187.5 ft	1,086 ft
Point 48	-196.5 ft	1,084 ft
Point 49	-300 ft	1,082 ft
Point 50	42.7 ft	1,120 ft
Point 51	66.7 ft	1,110 ft
Point 52	114.5 ft	1,100 ft
Point 53	141.4 ft	1,090 ft
Point 54	7.6 ft	1,132 ft
Point 55	-6 ft	1,132 ft
Point 56	4 ft	1,067 ft
Point 57	14 ft	1,067 ft
Point 58	-6 ft	1,067 ft
Point 59	-17.1 ft	1,078.1 ft
Point 60	25.1 ft	1,078.1 ft
Point 61	-300 ft	970 ft
Point 62	18 ft	1,074.2 ft
Point 63	18 ft	1,029.2 ft
Point 64	96.3 ft	1,019.5 ft
Point 65	96.3 ft	1,075.5 ft
Point 66	160.8 ft	1,025.7 ft
Point 67	160.8 ft	1,071.2 ft
Point 68	94 ft	1,081.1 ft
Point 69	92.5 ft	1,083.1 ft
Point 70	95.5 ft	1,083.1 ft
Point 71	92.5 ft	1,076.7 ft
Point 72	95.5 ft	1,076.7 ft
Point 73	92.5 ft	1,078.1 ft
Point 74	95.5 ft	1,078.1 ft
Point 75	370 ft	1,080 ft
Point 76	400 ft	1,074 ft
Point 77	640 ft	1,080 ft
Point 78	650 ft	1,074 ft
Point 79	690 ft	1,074 ft
Point 80	710 ft	1,080 ft

Point 81	710 ft	970 ft
Point 82	96.3 ft	1,069.5 ft
Point 83	18.9 ft	1,069.5 ft
Point 84	710 ft	1,070.7 ft
Point 85	27.5 ft	1,080.5 ft
Point 86	160.8 ft	1,070.7 ft
Point 87	50.52 ft	1,080.5 ft
Point 88	92.5 ft	1,080.5 ft
Point 89	95.5 ft	1,080.5 ft
Point 90	96.3 ft	1,080.5 ft
Point 91	158.11 ft	1,080.5 ft
Point 92	-9 ft	1,070 ft
Point 93	-300 ft	1,070 ft
Point 94	151.8 ft	1,086.2 ft
Point 95	300 ft	1,070.7 ft

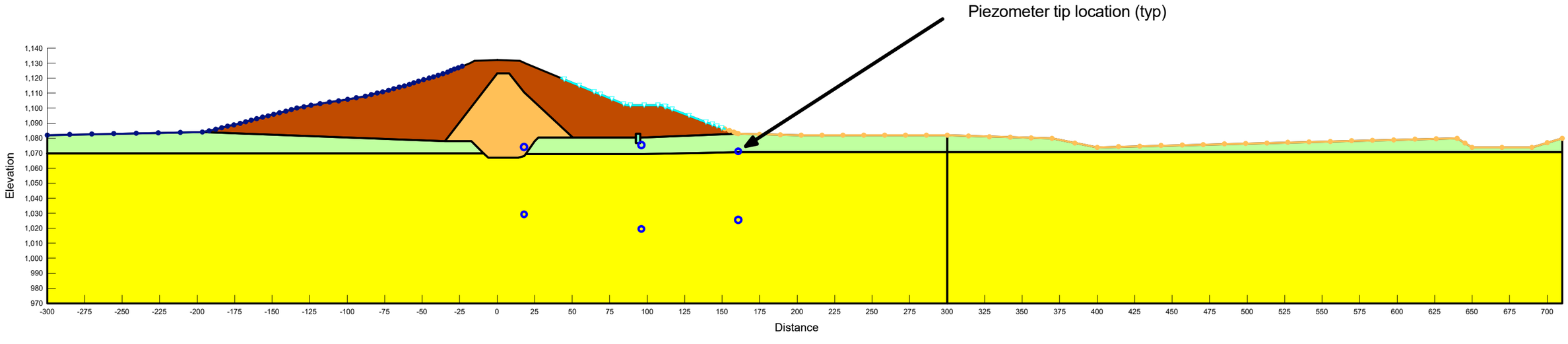
Regions

	Material	Points	Area
Region 1	Zone I (Core)	5,9,59,92,58,56,57,10,83,60,85,87,16,4	2,403.3 ft²
Region 2	Zone II (Shell)	1,55,3,25,26,27,28,29,30,31,32,33,34,35, 36,37,38,39,40,41,42,43,44,45,46,47,48,9, 5,4,16,87,88,69,70,89,90,17,7,94,53,52,6, 21,51,50,20,15,2,54	7,716.8 ft²
Region 3	Outwash/Alluvium	93,61,24,95,86,82,83,10,57,56,58,92	59,990 ft²
Region 4	Sandy Alluvium	83,82,86,95,23,22,17,90,89,74,72,71,73,88, 87,85,60	3,151.6 ft²
Region 5	Sandy Alluvium	84,80,79,78,77,76,75,23,95	2,743 ft²
Region 6	Drain fill	69,70,89,74,72,71,73,88	19.2 ft²
Region 7	Sandy Alluvium	92,59,9,48,49,93	3,308.8 ft²
Region 8	Outwash/Alluvium	95,84,81,24	41,287 ft²

Gannett Fleming

Excellence Delivered As Promised

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function
	Drain fill	Saturated / Unsaturated		Drainfill	Drainfill
	Outwash/Alluvium	Saturated Only	1.15e-07		
	Sandy Alluvium	Saturated / Unsaturated		Sandy Alluvium	Sandy Alluvium
	Zone I (Core)	Saturated / Unsaturated		Zone I	Zone I
	Zone II (Shell)	Saturated / Unsaturated		Zone II	Zone II



Analysis Type: SEEP/W	Scale: 1:800
File Name: Fordville Dam.gsz	
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\	

Fordville Dam

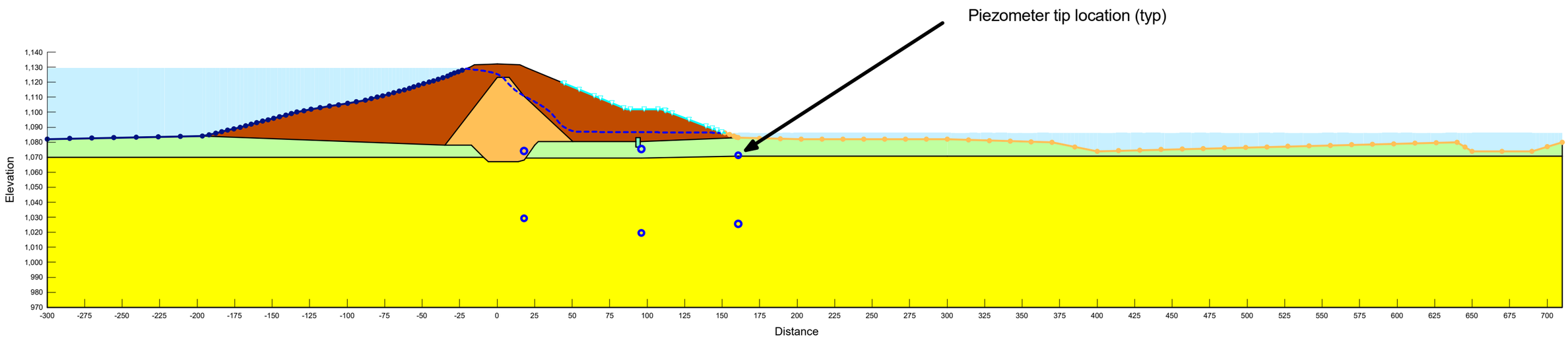
Sta. 24+50

Steady-State Seepage, Maximum Flood Pool
Calc By: EJB, November 2020
Calc Checked By:TNK, December 2020

Gannett Fleming

Excellence Delivered As Promised

Color	Name	Model	Sat Kx (ft/sec)	Vol. WC. Function	K-Function
	Drain fill	Saturated / Unsaturated		Drainfill	Drainfill
	Outwash/Alluvium	Saturated Only	1.15e-07		
	Sandy Alluvium	Saturated / Unsaturated		Sandy Alluvium	Sandy Alluvium
	Zone I (Core)	Saturated / Unsaturated		Zone I	Zone I
	Zone II (Shell)	Saturated / Unsaturated		Zone II	Zone II



Analysis Type: SEEP/W Scale: 1:800	Fordville Dam Sta. 24+50	Steady-State Seepage, Maximum Flood Pool
File Name: Fordville Dam.gsz		Calc By: EJB, November 2020
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\		Calc Checked By:TNK, December 2020

Steady-State Seepage, Maximum Flood Pool

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File Information

File Version: 10.02
Title: Fordville Dam
Created By: Barben, Edward J.
Last Edited By: Barben, Edward J.
Revision Number: 149
Date: 12/24/2020
Time: 10:37:56 AM
Tool Version: 10.2.2.20559
File Name: Fordville Dam.gsz
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\
Last Solved Date: 12/24/2020
Last Solved Time: 10:38:32 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Steady-State Seepage, Maximum Flood Pool

Kind: SEEP/W
Method: Steady-State
Physics
    Water Transfer
        Free convection: thermal effects: No
        Free convection: solute effects: No
        Vapor transfer: isothermal: No
        Vapor transfer: thermal: No
Water Settings
    Maximum Number of Iterations: 500
    Maximum Difference: 0.005
    Significant Digits: 2
    Max # of Reviews: 10
    Under-Relaxation Criteria
        Initial Rate: 1
        Minimum Rate: 0.1

Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 10
Unit Weight of Water: 62.430189 pcf
Bulk Modulus of Pore-Fluid: 43,511,321 psf
Time
Starting Time: 0 d
Duration: 0 d
Ending Time: 0 d

Materials

Zone I (Core)

Hydraulic
Model: Saturated / Unsaturated
Vol. WC. Function: Zone I
K-Function: Zone I
Ky'/Kx' Ratio: 1
Rotation: 0 °

Zone II (Shell)

Hydraulic
Model: Saturated / Unsaturated
Vol. WC. Function: Zone II
K-Function: Zone II
Ky'/Kx' Ratio: 10
Rotation: 0 °

Outwash/Alluvium

Hydraulic
Model: Saturated Only
Sat Kx: 1.15e-07 ft/sec
Ky'/Kx' Ratio: 1
Rotation: 0 °
Volumetric Water Content: 0.35
Compressibility: 2.4e-05 /psf

Drain fill

Hydraulic
Model: Saturated / Unsaturated
Vol. WC. Function: Drainfill
K-Function: Drainfill
Ky'/Kx' Ratio: 1
Rotation: 0 °

Sandy Alluvium

Hydraulic

Model: Saturated / Unsaturated
Vol. WC. Function: Sandy Alluvium
K-Function: Sandy Alluvium
Ky'/Kx' Ratio: 1
Rotation: 0 °

Boundary Conditions

Potential Seepage Face

Category: Hydraulic
Kind: Water Flux 0 ft/sec
Review: Yes

Maximum Flood Pool

Category: Hydraulic
Kind: Water Total Head 1,129.4 ft
Review: No

Maximum Flood Tailwater

Category: Hydraulic
Kind: Water Total Head 1,086.2 ft
Review: No

Water K Functions

Zone I

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 2.53e-09 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 2.53e-09)
Data Point: (0.20885434, 2.4909698e-09)
Data Point: (0.38282598, 2.4752216e-09)
Data Point: (0.70171264, 2.4531196e-09)
Data Point: (1.2862257, 2.4222273e-09)
Data Point: (2.357627, 2.3791168e-09)
Data Point: (4.3214847, 2.3191374e-09)
Data Point: (7.9211981, 2.2360705e-09)
Data Point: (14.519403, 2.1217887e-09)
Data Point: (26.613786, 1.9661421e-09)
Data Point: (48.782557, 1.7575545e-09)
Data Point: (89.417486, 1.4854705e-09)
Data Point: (163.90053, 1.14755e-09)

Data Point: (300.42651, 7.6511682e-10)
Data Point: (550.67599, 4.0257087e-10)
Data Point: (1,009.3785, 1.5034896e-10)
Data Point: (1,850.1713, 3.7886616e-11)
Data Point: (3,391.3282, 6.8879465e-12)
Data Point: (6,216.2392, 1.0284036e-12)
Data Point: (11,394.247, 1.3963802e-13)
Data Point: (20,885.434, 1.8208586e-14)

Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Zone I
Saturated Kx: 2.53e-09 ft/sec
Residual Water Content: 0.033
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Zone II

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 2.13e-07 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 2.13e-07)
Data Point: (0.20885434, 2.1220507e-07)
Data Point: (0.38282598, 2.1158379e-07)
Data Point: (0.70171264, 2.1047442e-07)
Data Point: (1.2862257, 2.0850277e-07)
Data Point: (2.357627, 2.0500504e-07)
Data Point: (4.3214847, 1.9882707e-07)
Data Point: (7.9211981, 1.880198e-07)
Data Point: (14.519403, 1.6948678e-07)
Data Point: (26.613786, 1.3913292e-07)
Data Point: (48.782557, 9.4688246e-08)
Data Point: (89.417486, 4.4726876e-08)
Data Point: (163.90053, 1.170771e-08)
Data Point: (300.42651, 1.6210763e-09)
Data Point: (550.67599, 1.4847192e-10)
Data Point: (1,009.3785, 1.1379826e-11)
Data Point: (1,850.1713, 8.1984932e-13)
Data Point: (3,391.3282, 5.7912887e-14)
Data Point: (6,216.2392, 4.0659393e-15)
Data Point: (11,394.247, 2.8492573e-16)
Data Point: (20,885.434, 1.9955066e-17)

Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Zone II

Saturated Kx: 2.13e-07 ft/sec
Residual Water Content: 0.025
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Sandy Alluvium

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 5e-05 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 5e-05)
Data Point: (0.20885434, 4.9876571e-05)
Data Point: (0.38282598, 4.9735e-05)
Data Point: (0.70171264, 4.9430027e-05)
Data Point: (1.2862257, 4.8776487e-05)
Data Point: (2.357627, 4.7381654e-05)
Data Point: (4.3214847, 4.4438933e-05)
Data Point: (7.9211981, 3.8451179e-05)
Data Point: (14.519403, 2.7489866e-05)
Data Point: (26.613786, 1.2667528e-05)
Data Point: (48.782557, 2.6205167e-06)
Data Point: (89.417486, 2.3104708e-07)
Data Point: (163.90053, 1.2694093e-08)
Data Point: (300.42651, 5.9267123e-10)
Data Point: (550.67599, 2.6447235e-11)
Data Point: (1,009.3785, 1.1663756e-12)
Data Point: (1,850.1713, 5.1284874e-14)
Data Point: (3,391.3282, 2.2532475e-15)
Data Point: (6,216.2392, 9.8979248e-17)
Data Point: (11,394.247, 4.3476846e-18)
Data Point: (20,885.434, 1.9097059e-19)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Sandy Alluvium
Saturated Kx: 5e-05 ft/sec
Residual Water Content: 0.025
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Drainfill

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %

Saturated Kx: 0.0033 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 0.0033)
Data Point: (0.20885434, 0.0032918538)
Data Point: (0.38282598, 0.0032825103)
Data Point: (0.70171264, 0.0032623823)
Data Point: (1.2862257, 0.0032192491)
Data Point: (2.357627, 0.0031271908)
Data Point: (4.3214847, 0.0029329724)
Data Point: (7.9211981, 0.0025377821)
Data Point: (14.519403, 0.0018143365)
Data Point: (26.613786, 0.0008360606)
Data Point: (48.782557, 0.00017295496)
Data Point: (89.417486, 1.5249149e-05)
Data Point: (163.90053, 8.3780924e-07)
Data Point: (300.42651, 3.9116096e-08)
Data Point: (550.67599, 1.745501e-09)
Data Point: (1,009.3785, 7.6979738e-11)
Data Point: (1,850.1713, 3.3847413e-12)
Data Point: (3,391.3282, 1.4871106e-13)
Data Point: (6,216.2392, 6.5324591e-15)
Data Point: (11,394.247, 2.8693846e-16)
Data Point: (20,885.434, 1.2603623e-17)
Estimation Properties
Hyd. K-Function Estimation Method: Van Genuchten Function
Volume Water Content Function: Drainfill
Saturated Kx: 0.0033 ft/sec
Residual Water Content: 0.03
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Vol. Water Content Functions

Zone I

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.33033281
Residual Water Content: 0.033033281
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.33033281
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.33)
Data Point: (0.20885434, 0.32999958)

Data Point: (0.38282598, 0.32999907)
Data Point: (0.70171264, 0.32999793)
Data Point: (1.2862257, 0.3299953)
Data Point: (2.357627, 0.32998915)
Data Point: (4.3214847, 0.32997459)
Data Point: (7.9211981, 0.32993982)
Data Point: (14.519403, 0.32985615)
Data Point: (26.613786, 0.32965385)
Data Point: (48.782557, 0.32916345)
Data Point: (89.417486, 0.32797653)
Data Point: (163.90053, 0.32513116)
Data Point: (300.42651, 0.31849258)
Data Point: (550.67599, 0.30397654)
Data Point: (1,009.3785, 0.27626763)
Data Point: (1,850.1713, 0.23441806)
Data Point: (3,391.3282, 0.18766449)
Data Point: (6,216.2392, 0.14757289)
Data Point: (11,394.247, 0.11771315)
Data Point: (20,885.434, 0.095956808)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.33
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Zone II

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.25000191
Residual Water Content: 0.025000191
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.25000191
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.25)
Data Point: (0.20885434, 0.24999684)
Data Point: (0.38282598, 0.24999188)
Data Point: (0.70171264, 0.24997905)
Data Point: (1.2862257, 0.2499458)
Data Point: (2.357627, 0.24985955)
Data Point: (4.3214847, 0.24963577)
Data Point: (7.9211981, 0.2490561)

Data Point: (14.519403, 0.24756281)
Data Point: (26.613786, 0.24377394)
Data Point: (48.782557, 0.23452627)
Data Point: (89.417486, 0.21395221)
Data Point: (163.90053, 0.1763078)
Data Point: (300.42651, 0.12673754)
Data Point: (550.67599, 0.082653151)
Data Point: (1,009.3785, 0.053541366)
Data Point: (1,850.1713, 0.036463251)
Data Point: (3,391.3282, 0.026342494)
Data Point: (6,216.2392, 0.019972248)
Data Point: (11,394.247, 0.015672496)
Data Point: (20,885.434, 0.012567901)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.25
Sample Material: Silty Sand
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Sandy Alluvium

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.25000248
Residual Water Content: 0.025000248
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.25000248
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.25)
Data Point: (0.20885434, 0.24999642)
Data Point: (0.38282598, 0.24998845)
Data Point: (0.70171264, 0.24996251)
Data Point: (1.2862257, 0.24987782)
Data Point: (2.357627, 0.24960115)
Data Point: (4.3214847, 0.24870014)
Data Point: (7.9211981, 0.24580258)
Data Point: (14.519403, 0.23686024)
Data Point: (26.613786, 0.21244479)
Data Point: (48.782557, 0.16318507)
Data Point: (89.417486, 0.10417472)
Data Point: (163.90053, 0.062576914)
Data Point: (300.42651, 0.040025715)

Data Point: (550.67599, 0.027898977)
Data Point: (1,009.3785, 0.020816928)
Data Point: (1,850.1713, 0.016305017)
Data Point: (3,391.3282, 0.013214258)
Data Point: (6,216.2392, 0.010965717)
Data Point: (11,394.247, 0.0092397331)
Data Point: (20,885.434, 0.0078448584)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.25
Sample Material: Sand
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Drainfill

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 2.4e-05 /psf
Saturated Water Content: 0.3000025
Residual Water Content: 0.03000025
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.3000025
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.3)
Data Point: (0.20885434, 0.2999957)
Data Point: (0.38282598, 0.29998614)
Data Point: (0.70171264, 0.29995502)
Data Point: (1.2862257, 0.29985338)
Data Point: (2.357627, 0.29952138)
Data Point: (4.3214847, 0.29844017)
Data Point: (7.9211981, 0.29496309)
Data Point: (14.519403, 0.28423228)
Data Point: (26.613786, 0.25493375)
Data Point: (48.782557, 0.19582209)
Data Point: (89.417486, 0.12500967)
Data Point: (163.90053, 0.075092297)
Data Point: (300.42651, 0.048030859)
Data Point: (550.67599, 0.033478772)
Data Point: (1,009.3785, 0.024980313)
Data Point: (1,850.1713, 0.019566021)
Data Point: (3,391.3282, 0.01585711)
Data Point: (6,216.2392, 0.013158861)
Data Point: (11,394.247, 0.01108768)

Data Point: (20,885.434, 0.0094138301)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.3
Sample Material: Sand
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 20,885.434 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	1,132.1 ft
Point 2	15 ft	1,131.5 ft
Point 3	-15 ft	1,131.5 ft
Point 4	8 ft	1,123.2 ft
Point 5	0 ft	1,123.2 ft
Point 6	109.5 ft	1,102 ft
Point 7	157.82 ft	1,084 ft
Point 8	53.1 ft	1,078.1 ft
Point 9	-34.7 ft	1,078.1 ft
Point 10	18 ft	1,068.2 ft
Point 11	18 ft	1,016.4 ft
Point 12	96.3 ft	1,102.4 ft
Point 13	96.3 ft	1,078.1 ft
Point 14	96.3 ft	1,016.5 ft
Point 15	18 ft	1,130.2 ft
Point 16	18 ft	1,110.7 ft
Point 17	160.8 ft	1,083.2 ft
Point 18	160.8 ft	1,080.7 ft
Point 19	160.8 ft	1,015.7 ft

Point 20	18.5 ft	1,130 ft
Point 21	86.5 ft	1,102 ft
Point 22	202.8 ft	1,082 ft
Point 23	300 ft	1,082 ft
Point 24	300 ft	970 ft
Point 25	-18 ft	1,130 ft
Point 26	-23.2 ft	1,128 ft
Point 27	-28.4 ft	1,126 ft
Point 28	-32.9 ft	1,124 ft
Point 29	-39.3 ft	1,122 ft
Point 30	-45.3 ft	1,120 ft
Point 31	-52.3 ft	1,118 ft
Point 32	-58.5 ft	1,116 ft
Point 33	-65.3 ft	1,114 ft
Point 34	-72.27 ft	1,112 ft
Point 35	-80 ft	1,110 ft
Point 36	-87.8 ft	1,108 ft
Point 37	-99.5 ft	1,106 ft
Point 38	-111.8 ft	1,104 ft
Point 39	-124 ft	1,102 ft
Point 40	-133.4 ft	1,100 ft
Point 41	-140.8 ft	1,098 ft
Point 42	-148.9 ft	1,096 ft
Point 43	-156.4 ft	1,094 ft
Point 44	-163.9 ft	1,092 ft
Point 45	-171.3 ft	1,090 ft
Point 46	-179.6 ft	1,088 ft
Point 47	-187.5 ft	1,086 ft
Point 48	-196.5 ft	1,084 ft
Point 49	-300 ft	1,082 ft
Point 50	42.7 ft	1,120 ft
Point 51	66.7 ft	1,110 ft
Point 52	114.5 ft	1,100 ft
Point 53	141.4 ft	1,090 ft
Point 54	7.6 ft	1,132 ft
Point 55	-6 ft	1,132 ft

Point 56	4 ft	1,067 ft
Point 57	14 ft	1,067 ft
Point 58	-6 ft	1,067 ft
Point 59	-17.1 ft	1,078.1 ft
Point 60	25.1 ft	1,078.1 ft
Point 61	-300 ft	970 ft
Point 62	18 ft	1,074.2 ft
Point 63	18 ft	1,029.2 ft
Point 64	96.3 ft	1,019.5 ft
Point 65	96.3 ft	1,075.5 ft
Point 66	160.8 ft	1,025.7 ft
Point 67	160.8 ft	1,071.2 ft
Point 68	94 ft	1,081.1 ft
Point 69	92.5 ft	1,083.1 ft
Point 70	95.5 ft	1,083.1 ft
Point 71	92.5 ft	1,076.7 ft
Point 72	95.5 ft	1,076.7 ft
Point 73	92.5 ft	1,078.1 ft
Point 74	95.5 ft	1,078.1 ft
Point 75	370 ft	1,080 ft
Point 76	400 ft	1,074 ft
Point 77	640 ft	1,080 ft
Point 78	650 ft	1,074 ft
Point 79	690 ft	1,074 ft
Point 80	710 ft	1,080 ft
Point 81	710 ft	970 ft
Point 82	96.3 ft	1,069.5 ft
Point 83	18.9 ft	1,069.5 ft
Point 84	710 ft	1,070.7 ft
Point 85	27.5 ft	1,080.5 ft
Point 86	160.8 ft	1,070.7 ft
Point 87	50.52 ft	1,080.5 ft
Point 88	92.5 ft	1,080.5 ft
Point 89	95.5 ft	1,080.5 ft
Point 90	96.3 ft	1,080.5 ft
Point 91	158.11 ft	1,080.5 ft

Point 92	-9 ft	1,070 ft
Point 93	-300 ft	1,070 ft
Point 94	151.8 ft	1,086.2 ft
Point 95	300 ft	1,070.7 ft

Lines

	Start Point	End Point	Length	Angle	Hydraulic Boundary
Line 1	9	5	56.904 ft	52.4 °	
Line 2	5	4	8 ft	0 °	
Line 3	9	48	161.91 ft	-2.09 °	
Line 4	48	47	9.2195 ft	12.5 °	Maximum Flood Pool
Line 5	47	46	8.1492 ft	14.2 °	Maximum Flood Pool
Line 6	46	45	8.5376 ft	13.5 °	Maximum Flood Pool
Line 7	45	44	7.6655 ft	15.1 °	Maximum Flood Pool
Line 8	44	43	7.7621 ft	14.9 °	Maximum Flood Pool
Line 9	43	42	7.7621 ft	14.9 °	Maximum Flood Pool
Line 10	42	41	8.3433 ft	13.9 °	Maximum Flood Pool
Line 11	41	40	7.6655 ft	15.1 °	Maximum Flood Pool
Line 12	40	39	9.6104 ft	12 °	Maximum Flood Pool
Line 13	39	38	12.363 ft	9.31 °	Maximum Flood Pool
Line 14	38	37	12.462 ft	9.24 °	Maximum Flood Pool
Line 15	37	36	11.87 ft	9.7 °	Maximum Flood Pool
Line 16	36	35	8.0523 ft	14.4 °	Maximum Flood Pool
Line 17	35	34	7.9845 ft	14.5 °	Maximum Flood Pool
Line 18	34	33	7.2513 ft	16 °	Maximum Flood Pool
Line 19	33	32	7.088 ft	16.4 °	Maximum Flood Pool
Line 20	32	31	6.5146 ft	17.9 °	Maximum Flood Pool
Line 21	31	30	7.2801 ft	15.9 °	Maximum Flood Pool
Line 22	30	29	6.3246 ft	18.4 °	Maximum Flood Pool
Line 23	29	28	6.7052 ft	17.4 °	Maximum Flood Pool
Line 24	28	27	4.9244 ft	24 °	Maximum Flood Pool
Line 25	27	26	5.5714 ft	21 °	Maximum Flood Pool
Line 26	26	25	5.5714 ft	21 °	
Line 27	25	3	3.3541 ft	26.6 °	
Line 28	2	15	3.2696 ft	-23.4 °	
Line 29	15	20	0.53852 ft	-21.8 °	

Line 30	20	50	26.185 ft	-22.5 °	
Line 31	50	51	26 ft	-22.6 °	Potential Seepage Face
Line 32	51	21	21.355 ft	-22 °	Potential Seepage Face
Line 33	21	6	23 ft	0 °	Potential Seepage Face
Line 34	6	52	5.3852 ft	-21.8 °	Potential Seepage Face
Line 35	52	53	28.699 ft	-20.4 °	Potential Seepage Face
Line 36	1	54	7.6007 ft	-0.754 °	
Line 37	54	2	7.4169 ft	-3.87 °	
Line 38	3	55	9.0139 ft	3.18 °	
Line 39	55	1	6.0008 ft	0.955 °	
Line 40	57	56	10 ft	0 °	
Line 41	56	58	10 ft	0 °	
Line 42	59	9	17.6 ft	0 °	
Line 43	4	16	16.008 ft	-51.3 °	
Line 44	10	57	4.1761 ft	16.7 °	
Line 45	24	61	600 ft	0 °	
Line 46	69	70	3 ft	0 °	
Line 47	74	72	1.4 ft	90 °	
Line 48	72	71	3 ft	0 °	
Line 49	71	73	1.4 ft	90 °	
Line 50	83	60	10.602 ft	54.2 °	
Line 51	23	22	97.2 ft	0 °	Maximum Flood Tailwater
Line 52	22	17	42.017 ft	-1.64 °	Maximum Flood Tailwater
Line 53	17	7	3.0855 ft	-15 °	Maximum Flood Tailwater
Line 54	10	83	1.5811 ft	55.3 °	
Line 55	83	82	77.4 ft	0 °	
Line 56	84	80	9.3 ft	90 °	
Line 57	80	79	20.881 ft	16.7 °	Maximum Flood Tailwater
Line 58	79	78	40 ft	0 °	Maximum Flood Tailwater
Line 59	78	77	11.662 ft	-31 °	Maximum Flood Tailwater
Line 60	77	76	240.07 ft	1.43 °	Maximum Flood Tailwater
Line 61	90	17	64.556 ft	2.4 °	
Line 62	70	89	2.6 ft	90 °	
Line 63	89	90	0.8 ft	0 °	
Line 64	88	69	2.6 ft	90 °	
Line 65	16	87	44.38 ft	-42.9 °	

Line 66	87	88	41.98 ft	0 °	
Line 67	60	85	3.3941 ft	45 °	
Line 68	85	87	23.02 ft	0 °	
Line 69	89	74	2.4 ft	90 °	
Line 70	73	88	2.4 ft	90 °	
Line 71	86	82	64.511 ft	1.07 °	
Line 72	59	92	11.455 ft	-45 °	
Line 73	92	58	4.2426 ft	-45 °	
Line 74	93	61	100 ft	90 °	
Line 75	92	93	291 ft	0 °	
Line 76	48	49	103.52 ft	1.11 °	Maximum Flood Pool
Line 77	49	93	12 ft	90 °	
Line 78	7	94	6.4094 ft	-20.1 °	Maximum Flood Tailwater
Line 79	94	53	11.072 ft	-20.1 °	Potential Seepage Face
Line 80	24	95	100.7 ft	90 °	
Line 81	95	86	139.2 ft	0 °	
Line 82	95	23	11.3 ft	90 °	
Line 83	95	84	410 ft	0 °	
Line 84	76	75	30.594 ft	-11.3 °	Maximum Flood Tailwater
Line 85	75	23	70.029 ft	-1.64 °	Maximum Flood Tailwater
Line 86	84	81	100.7 ft	90 °	
Line 87	81	24	410 ft	0 °	

Regions

	Material	Points	Area
Region 1	Zone I (Core)	5,9,59,92,58,56,57,10,83,60,85,87,16,4	2,403.3 ft²
Region 2	Zone II (Shell)	1,55,3,25,26,27,28,29,30,31,32,33,34,35, 36,37,38,39,40,41,42,43,44,45,46,47,48,9, 5,4,16,87,88,69,70,89,90,17,7,94,53,52,6,21, 51,50,20,15,2,54	7,716.8 ft²
Region 3	Outwash/Alluvium	93,61,24,95,86,82,83,10,57,56,58,92	59,990 ft²
Region 4	Sandy Alluvium	83,82,86,95,23,22,17,90,89,74,72,71,73,88,87,85,60	3,151.6 ft²
Region 5	Sandy Alluvium	84,80,79,78,77,76,75,23,95	2,743 ft²

Region 6	Drain fill	69,70,89,74,72,71,73,88	19.2 ft²
Region 7	Sandy Alluvium	92,59,9,48,49,93	3,308.8 ft²
Region 8	Outwash/Alluvium	95,84,81,24	41,287 ft²

Mesh Properties

Global Element Size: 2.5 ft

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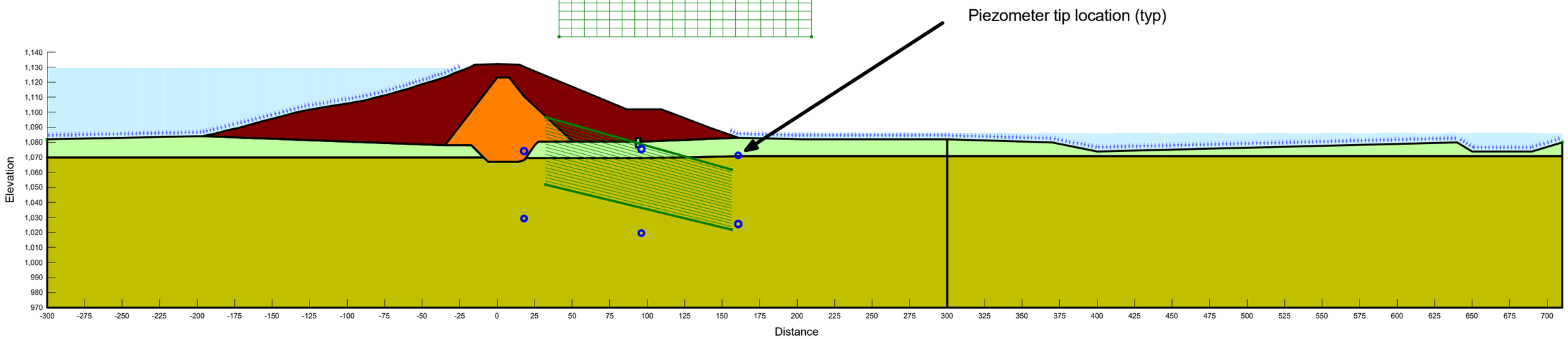
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)
	Drain fill	Mohr-Coulomb	110	0				36	0
	Outwash/Alluvium (Bilinear)	Bilinear	120	0	32	21	1,315		0
	Sandy Alluvium	Mohr-Coulomb	110	0				34	0
	Zone I (Core) (Bilinear)	Bilinear	133	0	33	25	3,146		0
	Zone II (Shell) (Bilinear)	Bilinear	121	0	37	25	2,005		0



Analysis Type: SLOPE/W	Scale: 1:800	Downstream Slope Stability, Maximum Flood Pool
File Name: Fordville Dam.gsz		Calc By: EJB, November 2020
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\		Calc Checked By:TNK, December 2020

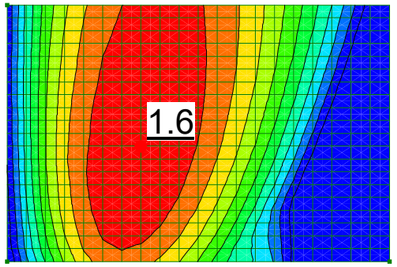
Fordville Dam

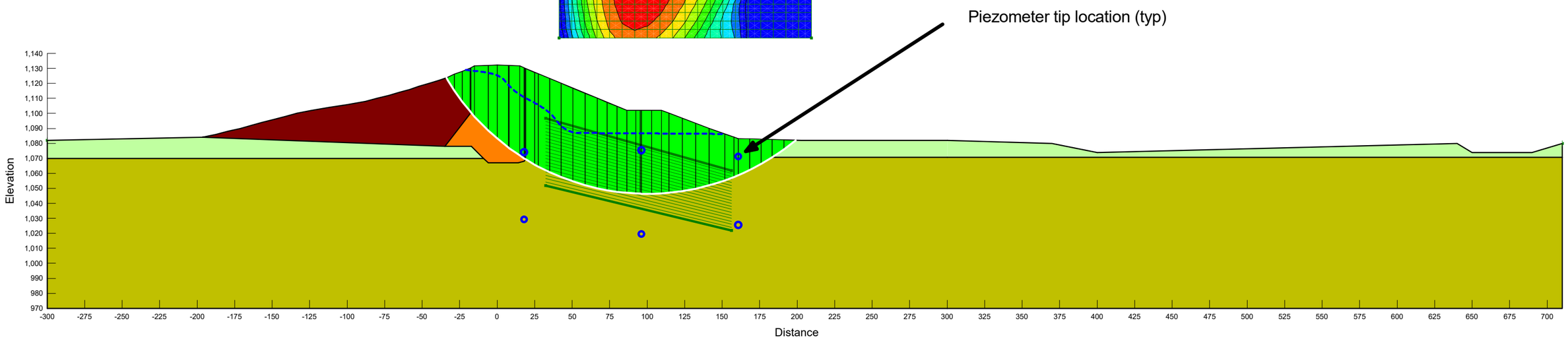
Sta. 24+50

Gannett Fleming

Excellence Delivered As Promised

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)
	Drain fill	Mohr-Coulomb	110	0				36	0
	Outwash/Alluvium (Bilinear)	Bilinear	120	0	32	21	1,315		0
	Sandy Alluvium	Mohr-Coulomb	110	0				34	0
	Zone I (Core) (Bilinear)	Bilinear	133	0	33	25	3,146		0
	Zone II (Shell) (Bilinear)	Bilinear	121	0	37	25	2,005		0





Analysis Type: SLOPE/W Scale: 1:800	Fordville Dam Sta. 24+50	Downstream Slope Stability, Maximum Flood Pool
File Name: Fordville Dam.gsz		Calc By: EJB, November 2020
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\		Calc Checked By:TNK, December 2020

Downstream Slope Stability, Maximum Flood Pool

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File Information

File Version: 10.02
Title: Fordville Dam
Created By: Barben, Edward J.
Last Edited By: Barben, Edward J.
Revision Number: 149
Date: 12/24/2020
Time: 10:37:56 AM
Tool Version: 10.2.2.20559
File Name: Fordville Dam.gsz
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\
Last Solved Date: 12/24/2020
Last Solved Time: 10:39:20 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Downstream Slope Stability, Maximum Flood Pool

Kind: SLOPE/W
Parent: Steady-State Seepage, Maximum Flood Pool
Method: Spencer
Settings
    PWP Conditions from: Parent Analysis
    Unit Weight of Water: 62.430189 pcf
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Grid and Radius
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: No
    Tension Crack Option: (none)
Distribution
    F of S Calculation Option: Constant
Advanced

Geometry Settings
- Minimum Slip Surface Depth: 3 ft
- Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

Drain fill
Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °

Sandy Alluvium
Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °

Outwash/Alluvium (Bilinear)
Model: Bilinear
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi 1: 32 °
Phi 2: 21 °
Bilinear Normal: 1,315 psf
Phi-B: 0 °

Zone I (Core) (Bilinear)
Model: Bilinear
Unit Weight: 133 pcf
Cohesion': 0 psf
Phi 1: 33 °
Phi 2: 25 °
Bilinear Normal: 3,146 psf
Phi-B: 0 °

Zone II (Shell) (Bilinear)

Model: Bilinear
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi 1: 37 °
Phi 2: 25 °
Bilinear Normal: 2,005 psf
Phi-B: 0 °

Slip Surface Grid

Upper Left: (41.29603, 1,263.0308) ft
Lower Left: (41.29603, 1,150.3294) ft
Lower Right: (209.58215, 1,150.3294) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (32.31677, 1,096.8) ft
Upper Right Coordinate: (156.31677, 1,061.8) ft
Lower Left Coordinate: (32.31677, 1,051.8) ft
Lower Right Coordinate: (156.31677, 1,021.8) ft
Number of Increments: 20
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-300, 1,082) ft
Right Coordinate: (710, 1,080) ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	1,132.1 ft

Point 2	15 ft	1,131.5 ft
Point 3	-15 ft	1,131.5 ft
Point 4	8 ft	1,123.2 ft
Point 5	0 ft	1,123.2 ft
Point 6	109.5 ft	1,102 ft
Point 7	157.82 ft	1,084 ft
Point 8	53.1 ft	1,078.1 ft
Point 9	-34.7 ft	1,078.1 ft
Point 10	18 ft	1,068.2 ft
Point 11	18 ft	1,016.4 ft
Point 12	96.3 ft	1,102.4 ft
Point 13	96.3 ft	1,078.1 ft
Point 14	96.3 ft	1,016.5 ft
Point 15	18 ft	1,130.2 ft
Point 16	18 ft	1,110.7 ft
Point 17	160.8 ft	1,083.2 ft
Point 18	160.8 ft	1,080.7 ft
Point 19	160.8 ft	1,015.7 ft
Point 20	18.5 ft	1,130 ft
Point 21	86.5 ft	1,102 ft
Point 22	202.8 ft	1,082 ft
Point 23	300 ft	1,082 ft
Point 24	300 ft	970 ft
Point 25	-18 ft	1,130 ft
Point 26	-23.2 ft	1,128 ft
Point 27	-28.4 ft	1,126 ft
Point 28	-32.9 ft	1,124 ft
Point 29	-39.3 ft	1,122 ft
Point 30	-45.3 ft	1,120 ft
Point 31	-52.3 ft	1,118 ft
Point 32	-58.5 ft	1,116 ft
Point 33	-65.3 ft	1,114 ft
Point 34	-72.27 ft	1,112 ft
Point 35	-80 ft	1,110 ft
Point 36	-87.8 ft	1,108 ft
Point 37	-99.5 ft	1,106 ft

Point 38	-111.8 ft	1,104 ft
Point 39	-124 ft	1,102 ft
Point 40	-133.4 ft	1,100 ft
Point 41	-140.8 ft	1,098 ft
Point 42	-148.9 ft	1,096 ft
Point 43	-156.4 ft	1,094 ft
Point 44	-163.9 ft	1,092 ft
Point 45	-171.3 ft	1,090 ft
Point 46	-179.6 ft	1,088 ft
Point 47	-187.5 ft	1,086 ft
Point 48	-196.5 ft	1,084 ft
Point 49	-300 ft	1,082 ft
Point 50	42.7 ft	1,120 ft
Point 51	66.7 ft	1,110 ft
Point 52	114.5 ft	1,100 ft
Point 53	141.4 ft	1,090 ft
Point 54	7.6 ft	1,132 ft
Point 55	-6 ft	1,132 ft
Point 56	4 ft	1,067 ft
Point 57	14 ft	1,067 ft
Point 58	-6 ft	1,067 ft
Point 59	-17.1 ft	1,078.1 ft
Point 60	25.1 ft	1,078.1 ft
Point 61	-300 ft	970 ft
Point 62	18 ft	1,074.2 ft
Point 63	18 ft	1,029.2 ft
Point 64	96.3 ft	1,019.5 ft
Point 65	96.3 ft	1,075.5 ft
Point 66	160.8 ft	1,025.7 ft
Point 67	160.8 ft	1,071.2 ft
Point 68	94 ft	1,081.1 ft
Point 69	92.5 ft	1,083.1 ft
Point 70	95.5 ft	1,083.1 ft
Point 71	92.5 ft	1,076.7 ft
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Point 75	370 ft	1,080 ft
Point 76	400 ft	1,074 ft
Point 77	640 ft	1,080 ft
Point 78	650 ft	1,074 ft
Point 79	690 ft	1,074 ft
Point 80	710 ft	1,080 ft
Point 81	710 ft	970 ft
Point 82	96.3 ft	1,069.5 ft
Point 83	18.9 ft	1,069.5 ft
Point 84	710 ft	1,070.7 ft
Point 85	27.5 ft	1,080.5 ft
Point 86	160.8 ft	1,070.7 ft
Point 87	50.52 ft	1,080.5 ft
Point 88	92.5 ft	1,080.5 ft
Point 89	95.5 ft	1,080.5 ft
Point 90	96.3 ft	1,080.5 ft
Point 91	158.11 ft	1,080.5 ft
Point 92	-9 ft	1,070 ft
Point 93	-300 ft	1,070 ft
Point 94	151.8 ft	1,086.2 ft
Point 95	300 ft	1,070.7 ft

Regions

	Material	Points	Area
Region 1	Zone I (Core) (Bilinear)	5,9,59,92,58,56,57,10,83,60,85,87,16,4	2,403.3 ft²
Region 2	Zone II (Shell) (Bilinear)	1,55,3,25,26,27,28,29,30,31,32,33,34,35, 36,37,38,39,40,41,42,43,44,45,46,47,48,9,5, 4,16,87,88,69,70,89,90,17,7,94,53,52,6,21,51,50,20,15,2,54	7,716.8 ft²
Region 3	Outwash/Alluvium (Bilinear)	93,61,24,95,86,82,83,10,57,56,58,92	59,990 ft²
Region 4	Sandy Alluvium	83,82,86,95,23,22,17,90,89,74,72,71,73, 88,87,85,60	3,151.6 ft²
Region 5	Sandy Alluvium	84,80,79,78,77,76,75,23,95	2,743 ft²

Region 6	Drain fill	69,70,89,74,72,71,73,88	19.2 ft^2
Region 7	Sandy Alluvium	92,59,9,48,49,93	3,308.8 ft^2
Region 8	Outwash/Alluvium (Bilinear)	95,84,81,24	41,287 ft^2

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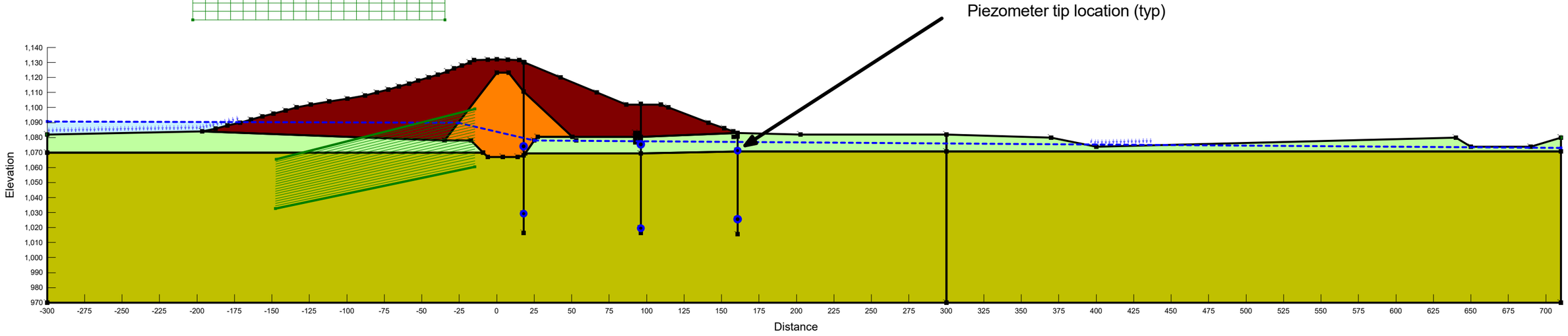
Excellence Delivered As Promised

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Drain fill	Mohr-Coulomb	110	0				36	0	1
	Outwash/Alluvium (Bilinear)	Bilinear	120	0	32	21	1,315		0	1
	Sandy Alluvium	Mohr-Coulomb	110	0				34	0	1
	Zone I (Core) (Bilinear)	Bilinear	133	0	33	25	3,146		0	1
	Zone II (Shell) (Bilinear)	Bilinear	121	0	37	25	2,005		0	1



Analysis Type: SLOPE/W	Scale: 1:800
File Name: Fordville Dam.gsz	
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\	

Fordville Dam

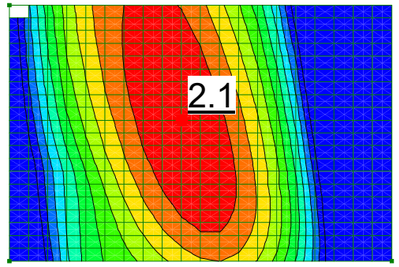
Sta. 24+50

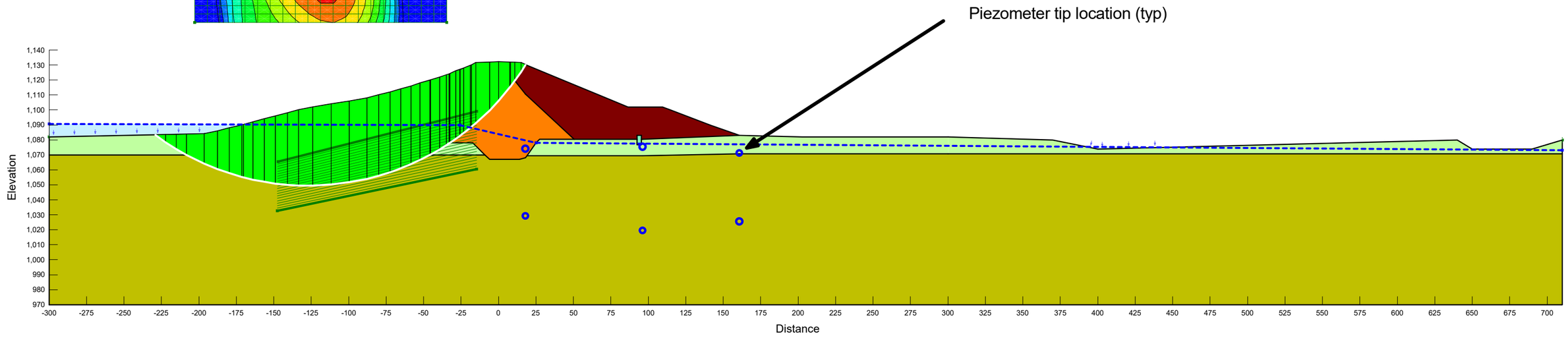
Rapid Drawdown
Calc By: EJB, November 2020
Calc Checked By:TNK, December 2020

Gannett Fleming

Excellence Delivered As Promised

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi 1 (°)	Phi 2 (°)	Bilinear Normal (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	Drain fill	Mohr-Coulomb	110	0				36	0	1
	Outwash/Alluvium (Bilinear)	Bilinear	120	0	32	21	1,315		0	1
	Sandy overburden	Mohr-Coulomb	110	0				34	0	1
	Zone I (Core) (Bilinear)	Bilinear	133	0	33	25	3,146		0	1
	Zone II (Shell) (Bilinear)	Bilinear	121	0	37	25	2,005		0	1





Analysis Type: SLOPE/W	Scale: 1:800
File Name: Fordville Dam.gsz	
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\	

Fordville Dam

Sta. 24+50

Rapid Drawdown
Calc By: EJB, November 2020
Calc Checked By:TNK, December 2020

Rapid Drawdown

Report generated using GeoStudio 2020. Copyright © 1991-2020 GEOSLOPE International Ltd.

File Information

File Version: 10.02
Title: Fordville Dam
Created By: Barben, Edward J.
Last Edited By: Barben, Edward J.
Revision Number: 147
Date: 12/18/2020
Time: 04:43:06 PM
Tool Version: 10.2.2.20559
File Name: Fordville Dam.gsz
Directory: C:\Users\ebarben\Desktop\ND NRCS Fordville\

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Rapid Drawdown

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Grid and Radius
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 3 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Drain fill

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Sandy Alluvium

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Outwash/Alluvium (Bilinear)

Model: Bilinear
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi 1: 32 °
Phi 2: 21 °
Bilinear Normal: 1,315 psf
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Zone I (Core) (Bilinear)

Model: Bilinear
Unit Weight: 133 pcf
Cohesion': 0 psf
Phi 1: 33 °
Phi 2: 25 °
Bilinear Normal: 3,146 psf

Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Zone II (Shell) (Bilinear)

Model: Bilinear
Unit Weight: 121 pcf
Cohesion': 0 psf
Phi 1: 37 °
Phi 2: 25 °
Bilinear Normal: 2,005 psf
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Grid

Upper Left: (-202.70397, 1,270.9934) ft
Lower Left: (-202.70397, 1,158.292) ft
Lower Right: (-34.41785, 1,158.292) ft
Grid Horizontal Increment: 20
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-147, 1,065.4) ft
Upper Right Coordinate: (-14.6, 1,099.1) ft
Lower Left Coordinate: (-147.7, 1,032.6) ft
Lower Right Coordinate: (-14.6, 1,060.6) ft
Number of Increments: 20
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-300, 1,082) ft
Right Coordinate: (710, 1,080) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-300 ft	1,090.8 ft
Coordinate 2	-25.85188 ft	1,089.8 ft
Coordinate 3	25 ft	1,078 ft
Coordinate 4	710 ft	1,073 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	1,132.1 ft
Point 2	15 ft	1,131.5 ft
Point 3	-15 ft	1,131.5 ft
Point 4	8 ft	1,123.2 ft
Point 5	0 ft	1,123.2 ft
Point 6	109.5 ft	1,102 ft
Point 7	157.82 ft	1,084 ft
Point 8	53.1 ft	1,078.1 ft
Point 9	-34.7 ft	1,078.1 ft
Point 10	18 ft	1,068.2 ft
Point 11	18 ft	1,016.4 ft
Point 12	96.3 ft	1,102.4 ft
Point 13	96.3 ft	1,078.1 ft
Point 14	96.3 ft	1,016.5 ft
Point 15	18 ft	1,130.2 ft
Point 16	18 ft	1,110.7 ft
Point 17	160.8 ft	1,083.2 ft

Point 18	160.8 ft	1,080.7 ft
Point 19	160.8 ft	1,015.7 ft
Point 20	18.5 ft	1,130 ft
Point 21	86.5 ft	1,102 ft
Point 22	202.8 ft	1,082 ft
Point 23	300 ft	1,082 ft
Point 24	300 ft	970 ft
Point 25	-18 ft	1,130 ft
Point 26	-23.2 ft	1,128 ft
Point 27	-28.4 ft	1,126 ft
Point 28	-32.9 ft	1,124 ft
Point 29	-39.3 ft	1,122 ft
Point 30	-45.3 ft	1,120 ft
Point 31	-52.3 ft	1,118 ft
Point 32	-58.5 ft	1,116 ft
Point 33	-65.3 ft	1,114 ft
Point 34	-72.27 ft	1,112 ft
Point 35	-80 ft	1,110 ft
Point 36	-87.8 ft	1,108 ft
Point 37	-99.5 ft	1,106 ft
Point 38	-111.8 ft	1,104 ft
Point 39	-124 ft	1,102 ft
Point 40	-133.4 ft	1,100 ft
Point 41	-140.8 ft	1,098 ft
Point 42	-148.9 ft	1,096 ft
Point 43	-156.4 ft	1,094 ft
Point 44	-163.9 ft	1,092 ft
Point 45	-171.3 ft	1,090 ft
Point 46	-179.6 ft	1,088 ft
Point 47	-187.5 ft	1,086 ft
Point 48	-196.5 ft	1,084 ft
Point 49	-300 ft	1,082 ft
Point 50	42.7 ft	1,120 ft
Point 51	66.7 ft	1,110 ft
Point 52	114.5 ft	1,100 ft
Point 53	141.4 ft	1,090 ft

Point 54	7.6 ft	1,132 ft
Point 55	-6 ft	1,132 ft
Point 56	4 ft	1,067 ft
Point 57	14 ft	1,067 ft
Point 58	-6 ft	1,067 ft
Point 59	-17.1 ft	1,078.1 ft
Point 60	25.1 ft	1,078.1 ft
Point 61	-300 ft	970 ft
Point 62	18 ft	1,074.2 ft
Point 63	18 ft	1,029.2 ft
Point 64	96.3 ft	1,019.5 ft
Point 65	96.3 ft	1,075.5 ft
Point 66	160.8 ft	1,025.7 ft
Point 67	160.8 ft	1,071.2 ft
Point 68	94 ft	1,081.1 ft
Point 69	92.5 ft	1,083.1 ft
Point 70	95.5 ft	1,083.1 ft
Point 71	92.5 ft	1,076.7 ft
Point 72	95.5 ft	1,076.7 ft
Point 73	92.5 ft	1,078.1 ft
Point 74	95.5 ft	1,078.1 ft
Point 75	370 ft	1,080 ft
Point 76	400 ft	1,074 ft
Point 77	640 ft	1,080 ft
Point 78	650 ft	1,074 ft
Point 79	690 ft	1,074 ft
Point 80	710 ft	1,080 ft
Point 81	710 ft	970 ft
Point 82	96.3 ft	1,069.5 ft
Point 83	18.9 ft	1,069.5 ft
Point 84	710 ft	1,070.7 ft
Point 85	27.5 ft	1,080.5 ft
Point 86	160.8 ft	1,070.7 ft
Point 87	50.52 ft	1,080.5 ft
Point 88	92.5 ft	1,080.5 ft
Point 89	95.5 ft	1,080.5 ft

Point 90	96.3 ft	1,080.5 ft
Point 91	158.11 ft	1,080.5 ft
Point 92	-9 ft	1,070 ft
Point 93	-300 ft	1,070 ft
Point 94	151.8 ft	1,086.2 ft
Point 95	300 ft	1,070.7 ft

Regions

	Material	Points	Area
Region 1	Zone I (Core) (Bilinear)	5,9,59,92,58,56,57,10,83,60,85,87,16,4	2,403.3 ft²
Region 2	Zone II (Shell) (Bilinear)	1,55,3,25,26,27,28,29,30,31,32,33,34,35,36,37, 38,39,40,41,42,43,44,45,46,47,48,9,5,4,16,87,88, 69,70,89,90,17,7,94,53,52,6,21,51,50,20,15,2,54	7,716.8 ft²
Region 3	Outwash/Alluvium (Bilinear)	93,61,24,95,86,82,83,10,57,56,58,92	59,990 ft²
Region 4	Sandy Alluvium	83,82,86,95,23,22,17,90,89,74,72,71,73,88,87,85,60	3,151.6 ft²
Region 5	Sandy Alluvium	84,80,79,78,77,76,75,23,95	2,743 ft²
Region 6	Drain fill	69,70,89,74,72,71,73,88	19.2 ft²
Region 7	Sandy Alluvium	92,59,9,48,49,93	3,308.8 ft²
Region 8	Outwash/Alluvium (Bilinear)	95,84,81,24	41,287 ft²

APPENDIX F

Stability Analysis Report

- SITES Output
- Auxiliary Spillway 6-Hour SDH Stability Analysis

DRAFT

SITES MODEL OUTPUT

– PSH RUNOFF DISTRIBUTION A

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:57

************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville_RunoffA          49.34     A1
 SAVMOV   0   101
 SAVMOV   101  1                                  1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Principal Spillway Hydrograph event (Runoff Curve A)
 *        - Principal spillway info based off of as-builts
 *        - Elevation Storage data from 2008-2009 LiDAR
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      1             PSH_Runoff_A
WSDATA    5C 1           49.34                1.5
 QDIRECT          2.35     4.7
 POOLDATA  ELEV            1105.971  1090.93               TR
 PSINLET   ELEV     0.4      30       1117.416  1       3.75
 PSDATA    1       235      5        5       0.013     1082.269
 GRAPHICS  I
 GO,DESIGN LCPN
 SAVMOV    2    101  1              1
 ENDJOB

********************************************************************************
```

1SITES XEQ 12/09/2020 ---------- COMMENT PAGE ----------
VER 2005.1.8 Fordville_RunoffA WSID = 1

- Data from HEC-HMS model derived by Houston Engineering Inc
- Principal Spillway Hydrograph event (Runoff Curve A)
- Principal spillway info based off of as-builts
- Elevation Storage data from 2008-2009 LiDAR

1SITES ----------
XEQ 12/09/2020 Fordville_RunoffA WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:57 SITE = 1 PASS= 1 PART= 1
********** BASIC Data **********
CLIMATE AREA - NOT DEFINED DESIGN CLASS C

STORM DISTRIBUTION USED FOR AUXILIARY SPILLWAY IS;
NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY Q-PS,10-DAY Q-SD Q-FB
2.35 4.70 0.00 0.00

WSDATA - CN DA-SM TC/L -/H QRF
0.00 49.34 0.00 0.00 1.50

SITEDATA- PERM POOL CREST PS FP SED VALLEY FL 378?
0.00 1105.97 1090.93 0.00 NO

BASEFLOW INITIAL EL EXTRA VOL SITE TYPE
0.00 0.00 0.00 DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 235.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.40 30.00 1082.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 0.00

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
0.00 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
0 0.00 0.00 0
AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?
0.000 0.00 0.000 0.000 NO

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
0.00 0.00 0.00 0.00 0.00

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,

SIDE SLOPE RATIOS		WAVE BERM WIDTH	MULTIPLE STABILITY BERMS U&D/S WIDTHS	DELTA H	SEPARATE STABILITY BERMS WIDTHS, ft		HEIGHTS, ft	
U/S	D/S	ft	ft	ft	U/S	D/S	U/S	D/S
2.50	2.50	10.0	0.0	0.00	0.00	0.00	0.00	0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000 0.0300 0.1000 0.1900 0.3100
0.4700 0.6600 0.8200 0.9300 0.9900
1.0000 0.9900 0.9300 0.8600 0.7800
0.6800 0.5600 0.4600 0.3900 0.3300
0.2800 0.2410 0.2070 0.1740 0.1470
0.1260 0.1070 0.0910 0.0770 0.0660
0.0550 0.0470 0.0400 0.0340 0.0290
0.0250 0.0210 0.0180 0.0150 0.0130
0.0110 0.0090 0.0080 0.0070 0.0060
0.0050 0.0040 0.0030 0.0020 0.0010
0.0000

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000 0.008 0.016 0.025 0.033

```
    0.043    0.052    0.063    0.074    0.086
    0.099    0.112    0.126    0.142    0.160
    0.180    0.205    0.255    0.345    0.437
    0.530    0.603    0.633    0.660    0.684
    0.705    0.724    0.742    0.759    0.775
    0.790    0.804    0.818    0.831    0.844
    0.856    0.868    0.879    0.890    0.900
    0.910    0.920    0.930    0.939    0.948
    0.957    0.966    0.975    0.983    0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 12/09/2020            Fordville_RunoffA               WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 12:46:57          SITE = 1              PASS=   1    PART=   2

MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 INFLOW HYDROGRAPH PROVIDED IN LOCATION  1,  PEAK=   1456.40 CFS, AT  34.00 HRS.
 TITLE = PSH_Runoff_A

 CREST PS      1105.97 FT    1858.4 ACFT      0.00 AC     795.7 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT      0.00 AC     795.7 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT      0.00 AC    1061.5 CFS

 START ELEV    1105.97 FT    1858.4 ACFT      0.00 AC       0.0 CFS

 NRCS-PSH  RAINFALL   1-DAY =   0.00 IN    10-DAY =   0.00 IN    DA =  49.34 SM
        RUNOFF     1-DAY =   0.00 IN    10-DAY =   0.00 IN

    CLIMATIC INDEX = 1.00    CN 10-DAY =  0.    CN 1-DAY =   0.
    QRF  =     74.01 CFS     1117.55 FEET,    GIVEN Value.

    PEAK =      1456.4 CFS, AT   34.0 HRS.

 ROUTED RESULT - HYD TYPE      EMAX        VOL-MAX       AMAX        QMAX
            NRCS-PSH   1121.64 FT    6114.8 ACFT      0.00 AC    827.8 CFS

    PS STORAGE    4256.4 ACFT,  BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

 DRAWDOWN (DDT) TEST       1109.01 FT    2496.8 ACFT     25.20 CFS
    CONTROL IS 0.150 DETENTION STORAGE
    TIME LIMIT REACHED = 10.00 DAYS. FLOW WAS    86.82 CFS,  ELEV =  1117.66
    (ELEVATION TO START ROUTING SDH AND/OR FBH HAS BEEN RAISED.)

    TIME TO DDT TEST DISCHARGE IS 29.29 DAYS - DRAWDOWN STOPPED.
```

***** NOTE - CREST OF AUX. RAISED TO HOLD 2900.17 ACFT NOT EVACUATED IN
DRAWDOWN TIME LIMIT. TOTAL STORAGE REQUIRED = 9014.93 ACFT,
NEW ELEVATION OF AUXILIARY SPILLWAY CREST = 1128.27 FT.

RATING TABLE DEVELOPED, SITE = 1 :
WITH PS DEVELOPED BY PROGRAM AND NO AUX. DATA GIVEN.

RATING TABLE NUMBER 1

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.76	208.86	208.86	0.00	5103.39	0.00
9	1120.11	478.45	478.45	0.00	5524.90	0.00
			FULL CONDUIT FLOW, ELEV = 1121.46 FT			
10	1121.46	826.40	826.40	0.00	6039.72	0.00
11	1138.31	988.52	988.52	0.00	14630.87	0.00
12	1155.15	1127.36	1127.36	0.00	30296.24	0.00
13	1172.00	1250.88	1250.88	0.00	55908.61	0.00

1SITES ----------
XEQ 12/09/2020 Fordville_RunoffA WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:57 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1128.27 FT 9015.0 ACFT 0.00 AC 882.5 CFS

PS STORAGE 7156.6 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.66 FT 4758.5 ACFT 0.00 AC 86.8 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

***** MESSAGE - NO INPUT DATA GIVEN FOR AUXILIARY SPILLWAY CREST AND/OR
BOTTOM WIDTH. NO AUXILIARY SPILLWAY ROUTINGS PERFORMED.

Inflow Hyd 1 PSH-Peak = 827.81 CFS at 76.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.

```
--------------------------------------------------------------------------------
1          Fordville_RunoffA

    0 SUBWATERSHED(S) ANALYZED.
    1 STRUCTURE(S) ANALYZED.
    1 HYDROGRAPHS ROUTED AT LOWEST SITE.
    0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

********************************************************************************
SITES.....COMPUTATIONS COMPLETE

                    SUMMARY TABLE  1        SITES VERSION 2005.1.8
                   ----------------          DATED 01/01/2005

WATERSHED ID                RUN DATE                   RUN TIME
------------                --------                   --------
1                        12/09/2020                    12:46:57

>>>  SITE   SUBWS   SUBWS DA   CURVE    TC   TOTAL DA   TYPE    STRUC   <<<
      ID     ID    (SQ MI)    NO.    (HRS)  (SQ MI)  DESIGN   CLASS
     -----  ----  --------  -----  ----  -------  -----  -----
     1      1      49.34     0.   0.00    49.34   TR60    C

PASS  DIA./  AUX.CREST  BTM.  MAX.    MAX.    EMB.  INTEGR.*  EXIT*    TYPE
 NO.  WIDTH   ELEV    WIDTH  HP     ELEV    VOL.   DIST.     VEL.     HYD
    (IN/FT)  (FT)     (FT)  (FT)    (FT)    (CY)   (FT)    (FT/SEC)
---- -----  -------  ------  ----  -------  -------  -----  ------  ---------
SITES.......SUMMARY TABLE 1 COMPLETED.

              NRCS  SITES    VERSION 2005.1.8  ,01/01/2005
                    1       FILES

INPUT  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffA.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffA.OUT
       DATED 12/09/2020 12:46:57

                  GRAPHICS FILES GENERATED

OPTION "L"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffA.DRG DATED 12/09/2020 12:46:57

OPTION "P"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffA.DHY DATED 12/09/2020 12:46:57

OPTION "E"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffA.DEM DATED 12/09/2020 12:46:57
```

SITES MODEL OUTPUT

– PSH RUNOFF DISTRIBUTION B

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:47:01

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.34     A1
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Principal Spillway Hydrograph event (Runoff Curve B)
 *        - Principal spillway info based off of as-builts
 *        - Elevation Storage data from 2008-2009 LiDAR
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      1             PSH_Runoff_B
WSDATA    5C 1           49.34                1.50
 QDIRECT          2.35     4.7
 POOLDATA  ELEV            1105.971  1090.93               TR
 PSINLET   ELEV     0.4      30       1117.416  1       3.75
 PSDATA    1       235      5        5       0.013     1082.269
 GRAPHICS  I
 GO,DESIGN LCPN
 SAVMOV    2    101  1              1
 ENDJOB

 ********************************************************************************
```

1SITES XEQ 12/09/2020 ---------- COMMENT PAGE ----------
VER 2005.1.8 Fordville WSID = 1

- Data from HEC-HMS model derived by Houston Engineering Inc
- Principal Spillway Hydrograph event (Runoff Curve B)
- Principal spillway info based off of as-builts
- Elevation Storage data from 2008-2009 LiDAR

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:47:01 SITE = 1 PASS= 1 PART= 1
********** BASIC Data **********
CLIMATE AREA - NOT DEFINED DESIGN CLASS C

STORM DISTRIBUTION USED FOR AUXILIARY SPILLWAY IS;
NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
2.35	4.70	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.34	0.00	0.00	1.50

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
0.00	1105.97	1090.93	0.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND	COND L	DIA/W	-/H
1.00	235.00	5.00	5.00

PS N	KE	WEIR L	TW EL
0.013	0.40	30.00	1082.27

2ND STG	ORF H	ORF L	START AUX.
1117.42	1.00	3.75	0.00

ASCRESTS - AUX.1	AUX.2	AUX.3	AUX.4	AUX.5
0.00	0.00	0.00	0.00	0.00

AUX.Data - REF.NO.	RETARD. Ci	TIE STATION	INLET LENGTH
0	0.00	0.00	0

AUX.Data - INLET N	SIDE SLOPE	EXIT N	EXIT SLOPE	ACTUAL AUX?
0.000	0.00	0.000	0.000	NO

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
0.00 0.00 0.00 0.00 0.00

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,

SIDE SLOPE RATIOS		WAVE BERM WIDTH	MULTIPLE STABILITY BERMS U&D/S WIDTHS	DELTA H	SEPARATE STABILITY BERMS WIDTHS, ft		HEIGHTS, ft	
U/S	D/S	ft	ft	ft	U/S	D/S	U/S	D/S
2.50	2.50	10.0	0.0	0.00	0.00	0.00	0.00	0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000 0.0300 0.1000 0.1900 0.3100
0.4700 0.6600 0.8200 0.9300 0.9900
1.0000 0.9900 0.9300 0.8600 0.7800
0.6800 0.5600 0.4600 0.3900 0.3300
0.2800 0.2410 0.2070 0.1740 0.1470
0.1260 0.1070 0.0910 0.0770 0.0660
0.0550 0.0470 0.0400 0.0340 0.0290
0.0250 0.0210 0.0180 0.0150 0.0130
0.0110 0.0090 0.0080 0.0070 0.0060
0.0050 0.0040 0.0030 0.0020 0.0010
0.0000

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).
0.000 0.008 0.016 0.025 0.033

```
    0.043    0.052    0.063    0.074    0.086
    0.099    0.112    0.126    0.142    0.160
    0.180    0.205    0.255    0.345    0.437
    0.530    0.603    0.633    0.660    0.684
    0.705    0.724    0.742    0.759    0.775
    0.790    0.804    0.818    0.831    0.844
    0.856    0.868    0.879    0.890    0.900
    0.910    0.920    0.930    0.939    0.948
    0.957    0.966    0.975    0.983    0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 12/09/2020              Fordville                  WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 12:47:01         SITE = 1             PASS=   1    PART=   2

MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 INFLOW HYDROGRAPH PROVIDED IN LOCATION  1,  PEAK=   1676.70 CFS, AT 262.00 HRS.
 TITLE = PSH_Runoff_B

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     795.7 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     795.7 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC    1061.5 CFS

 START ELEV    1105.97 FT    1858.4 ACFT     0.00 AC       0.0 CFS

 NRCS-PSH  RAINFALL   1-DAY =   0.00 IN    10-DAY =   0.00 IN    DA =  49.34 SM
       RUNOFF     1-DAY =   0.00 IN    10-DAY =   0.00 IN

    CLIMATIC INDEX = 1.00    CN 10-DAY =  0.    CN 1-DAY =   0.
    QRF  =     74.01 CFS     1117.55 FEET,    GIVEN Value.

    PEAK =      1676.7 CFS, AT  262.0 HRS.

 ROUTED RESULT - HYD TYPE      EMAX        VOL-MAX       AMAX        QMAX
           NRCS-PSH   1125.69 FT    7772.1 ACFT     0.00 AC    859.1 CFS

    PS STORAGE    5913.7 ACFT,  BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

 DRAWDOWN (DDT) TEST       1110.12 FT    2745.4 ACFT     34.27 CFS
    CONTROL IS 0.150 DETENTION STORAGE

    TIME LIMIT REACHED = 10.00 DAYS. FLOW WAS    57.28 CFS,  ELEV =  1116.61
    (ELEVATION TO START ROUTING SDH AND/OR FBH HAS BEEN RAISED.)
    TIME TO DDT TEST DISCHARGE IS 25.17 DAYS - DRAWDOWN STOPPED.
```

***** NOTE - CREST OF AUX. RAISED TO HOLD 2571.39 ACFT NOT EVACUATED IN
DRAWDOWN TIME LIMIT. TOTAL STORAGE REQUIRED = 10343.46 ACFT,
NEW ELEVATION OF AUXILIARY SPILLWAY CREST = 1130.86 FT.

RATING TABLE DEVELOPED, SITE = 1 :
WITH PS DEVELOPED BY PROGRAM AND NO AUX. DATA GIVEN.

RATING TABLE NUMBER 1

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.76	208.86	208.86	0.00	5103.39	0.00
9	1120.11	478.45	478.45	0.00	5524.90	0.00
			FULL CONDUIT FLOW, ELEV = 1121.46 FT			
10	1121.46	826.40	826.40	0.00	6039.72	0.00
11	1138.31	988.52	988.52	0.00	14630.87	0.00
12	1155.15	1127.36	1127.36	0.00	30296.24	0.00
13	1172.00	1250.88	1250.88	0.00	55908.61	0.00

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:47:01 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1130.86 FT 10343.5 ACFT 0.00 AC 907.6 CFS

PS STORAGE 8485.1 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1116.61 FT 4429.7 ACFT 0.00 AC 57.3 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

***** MESSAGE - NO INPUT DATA GIVEN FOR AUXILIARY SPILLWAY CREST AND/OR
BOTTOM WIDTH. NO AUXILIARY SPILLWAY ROUTINGS PERFORMED.

Inflow Hyd 1 PSH-Peak = 859.09 CFS at 287.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.

```
--------------------------------------------------------------------------------
1          Fordville

    0 SUBWATERSHED(S) ANALYZED.
    1 STRUCTURE(S) ANALYZED.
    1 HYDROGRAPHS ROUTED AT LOWEST SITE.
    0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.
********************************************************************************
SITES.....COMPUTATIONS COMPLETE

                    SUMMARY TABLE  1        SITES VERSION 2005.1.8
                   ----------------          DATED 01/01/2005

 WATERSHED ID                RUN DATE                   RUN TIME
 ------------                --------                   --------
 1                        12/09/2020                    12:47:01

 >>>  SITE   SUBWS   SUBWS DA   CURVE    TC   TOTAL DA   TYPE    STRUC   <<<
      ID     ID     (SQ MI)    NO.    (HRS)  (SQ MI)  DESIGN   CLASS
     -----  ----  --------  -----  ----  -------  -----  -----
     1      1      49.34     0.   0.00     49.34   TR60     C

 PASS  DIA./  AUX.CREST  BTM.  MAX.    MAX.    EMB.  INTEGR.*  EXIT*    TYPE
  NO.  WIDTH    ELEV    WIDTH  HP     ELEV    VOL.  DIST.     VEL.     HYD
    (IN/FT)   (FT)     (FT)  (FT)    (FT)    (CY)   (FT)   (FT/SEC)
 ---- -----  -------  ------  ----  -------  -------  -----  ------  ---------
 SITES.......SUMMARY TABLE 1 COMPLETED.

              NRCS  SITES    VERSION 2005.1.8  ,01/01/2005
                    1       FILES

 INPUT  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
 ND\Fordville_RunoffB.D2C
 OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
 ND\Fordville_RunoffB.OUT
        DATED 12/09/2020 12:47:01

                    GRAPHICS FILES GENERATED

 OPTION "L"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
 ND\Fordville_RunoffB.DRG DATED 12/09/2020 12:47:01

 OPTION "P"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
 ND\Fordville_RunoffB.DHY DATED 12/09/2020 12:47:01

 OPTION "E"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
 ND\Fordville_RunoffB.DEM DATED 12/09/2020 12:47:01
```

SITES MODEL OUTPUT

– PSH RUNOFF DISTRIBUTION C

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:47:03

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville                49.34     A1
 SAVMOV   0   101
 SAVMOV   101  1                                      1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Principal Spillway Hydrograph event (Runoff C)
 *        - Principal spillway info based off of as-builts
 *        - Elevation Storage data from 2008-2009 LiDAR
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      1             PSH_Runoff_C
WSDATA    5C 1           49.34                1.5
 QDIRECT          2.35     4.7
 POOLDATA  ELEV            1105.971  1090.93               TR
 PSINLET   ELEV     0.4      30       1117.416  1        3.75
 PSDATA    1       235      5        5        0.013     1082.269
 GRAPHICS  I
 GO,DESIGN LCPN
 SAVMOV    2    101  1              1
 ENDJOB

 ********************************************************************************
```

1SITES XEQ 12/09/2020 ---------- COMMENT PAGE ----------
VER 2005.1.8 Fordville WSID = 1

- Data from HEC-HMS model derived by Houston Engineering Inc
- Principal Spillway Hydrograph event (Runoff C)
- Principal spillway info based off of as-builts
- Elevation Storage data from 2008-2009 LiDAR

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:47:03 SITE = 1 PASS= 1 PART= 1
********** BASIC Data **********
CLIMATE AREA - NOT DEFINED DESIGN CLASS C

STORM DISTRIBUTION USED FOR AUXILIARY SPILLWAY IS;
NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
2.35	4.70	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.34	0.00	0.00	1.50

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
0.00	1105.97	1090.93	0.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND	COND L	DIA/W	-/H
1.00	235.00	5.00	5.00

PS N	KE	WEIR L	TW EL
0.013	0.40	30.00	1082.27

2ND STG	ORF H	ORF L	START AUX.
1117.42	1.00	3.75	0.00

ASCRESTS - AUX.1	AUX.2	AUX.3	AUX.4	AUX.5
0.00	0.00	0.00	0.00	0.00

AUX.Data - REF.NO.	RETARD. Ci	TIE STATION	INLET LENGTH
0	0.00	0.00	0

AUX.Data - INLET N	SIDE SLOPE	EXIT N	EXIT SLOPE	ACTUAL AUX?
0.000	0.00	0.000	0.000	NO

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
0.00 0.00 0.00 0.00 0.00

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,

SIDE SLOPE RATIOS		WAVE BERM WIDTH	MULTIPLE STABILITY BERMS U&D/S WIDTHS		SEPARATE STABILITY BERMS DELTA H		WIDTHS, ft		HEIGHTS, ft	
U/S	D/S	ft	ft	ft	U/S	D/S	U/S	D/S		
2.50	2.50	10.0	0.0	0.00	0.00	0.00	0.00	0.00		

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000 0.0300 0.1000 0.1900 0.3100
0.4700 0.6600 0.8200 0.9300 0.9900
1.0000 0.9900 0.9300 0.8600 0.7800
0.6800 0.5600 0.4600 0.3900 0.3300
0.2800 0.2410 0.2070 0.1740 0.1470
0.1260 0.1070 0.0910 0.0770 0.0660
0.0550 0.0470 0.0400 0.0340 0.0290
0.0250 0.0210 0.0180 0.0150 0.0130
0.0110 0.0090 0.0080 0.0070 0.0060
0.0050 0.0040 0.0030 0.0020 0.0010
0.0000

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

```
    0.000    0.008    0.016    0.025    0.033
    0.043    0.052    0.063    0.074    0.086
    0.099    0.112    0.126    0.142    0.160
    0.180    0.205    0.255    0.345    0.437
    0.530    0.603    0.633    0.660    0.684
    0.705    0.724    0.742    0.759    0.775
    0.790    0.804    0.818    0.831    0.844
    0.856    0.868    0.879    0.890    0.900
    0.910    0.920    0.930    0.939    0.948
    0.957    0.966    0.975    0.983    0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 12/09/2020              Fordville                  WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 12:47:03         SITE = 1             PASS=   1    PART=   2

MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 INFLOW HYDROGRAPH PROVIDED IN LOCATION  1,  PEAK=   1858.50 CFS, AT 149.00 HRS.
 TITLE = PSH_Runoff_C

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     795.7 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     795.7 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC    1061.5 CFS

 START ELEV    1105.97 FT    1858.4 ACFT     0.00 AC      0.0 CFS

 NRCS-PSH  RAINFALL   1-DAY =   0.00 IN    10-DAY =   0.00 IN    DA =  49.34 SM
        RUNOFF     1-DAY =   0.00 IN    10-DAY =   0.00 IN

    CLIMATIC INDEX = 1.00    CN 10-DAY =  0.    CN 1-DAY =   0.
    QRF  =     74.01 CFS     1117.55 FEET,    GIVEN Value.

    PEAK =      1858.5 CFS, AT  149.0 HRS.

 ROUTED RESULT - HYD TYPE      EMAX        VOL-MAX       AMAX        QMAX
            NRCS-PSH   1125.19 FT    7569.6 ACFT     0.00 AC    855.3 CFS

    PS STORAGE    5711.2 ACFT,  BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

 DRAWDOWN (DDT) TEST       1109.98 FT    2715.0 ACFT     33.16 CFS
    CONTROL IS 0.150 DETENTION STORAGE

    TIME LIMIT REACHED = 10.00 DAYS. FLOW WAS    56.49 CFS,  ELEV =  1116.35
    (ELEVATION TO START ROUTING SDH AND/OR FBH HAS BEEN RAISED.)
```

TIME TO DDT TEST DISCHARGE IS 23.75 DAYS - DRAWDOWN STOPPED.

***** NOTE - CREST OF AUX. RAISED TO HOLD 2489.54 ACFT NOT EVACUATED IN
DRAWDOWN TIME LIMIT. TOTAL STORAGE REQUIRED = 10059.09 ACFT,
NEW ELEVATION OF AUXILIARY SPILLWAY CREST = 1130.30 FT.

RATING TABLE DEVELOPED, SITE = 1 :
WITH PS DEVELOPED BY PROGRAM AND NO AUX. DATA GIVEN.

RATING TABLE NUMBER 1

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.76	208.86	208.86	0.00	5103.39	0.00
9	1120.11	478.45	478.45	0.00	5524.90	0.00
			FULL CONDUIT FLOW, ELEV = 1121.46 FT			
10	1121.46	826.40	826.40	0.00	6039.72	0.00
11	1138.31	988.52	988.52	0.00	14630.87	0.00
12	1155.15	1127.36	1127.36	0.00	30296.24	0.00
13	1172.00	1250.88	1250.88	0.00	55908.61	0.00

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:47:03 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1130.30 FT 10059.1 ACFT 0.00 AC 902.2 CFS

PS STORAGE 8200.8 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1116.35 FT 4347.9 ACFT 0.00 AC 56.5 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

***** MESSAGE - NO INPUT DATA GIVEN FOR AUXILIARY SPILLWAY CREST AND/OR
BOTTOM WIDTH. NO AUXILIARY SPILLWAY ROUTINGS PERFORMED.

Inflow Hyd 1 PSH-Peak = 855.27 CFS at 187.00 hrs., Location Point
HYDOUT 1 1
1SITES....JOB NO. 1 COMPLETE.

```
--------------------------------------------------------------------------------

1          Fordville
    0 SUBWATERSHED(S) ANALYZED.
    1 STRUCTURE(S) ANALYZED.
    1 HYDROGRAPHS ROUTED AT LOWEST SITE.
    0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

*******************************************************************************
SITES.....COMPUTATIONS COMPLETE

                    SUMMARY TABLE  1        SITES VERSION 2005.1.8
                   ----------------          DATED 01/01/2005

WATERSHED ID                RUN DATE                   RUN TIME
------------                --------                   --------
1                        12/09/2020                    12:47:03

>>>  SITE   SUBWS   SUBWS DA   CURVE    TC   TOTAL DA   TYPE    STRUC   <<<
      ID     ID    (SQ MI)    NO.    (HRS)  (SQ MI)  DESIGN   CLASS
     -----  ----  --------  -----  ----  --------  -----  -----
     1      1      49.34     0.   0.00     49.34    TR60    C

PASS  DIA./  AUX.CREST  BTM.  MAX.    MAX.    EMB.  INTEGR.*  EXIT*    TYPE
 NO.  WIDTH    ELEV    WIDTH  HP     ELEV    VOL.   DIST.     VEL.     HYD
    (IN/FT)   (FT)     (FT)  (FT)    (FT)    (CY)   (FT)    (FT/SEC)
---- -----  -------  ------  ----  -------  -------  -----  ------  ---------
SITES.......SUMMARY TABLE 1 COMPLETED.

              NRCS  SITES    VERSION 2005.1.8  ,01/01/2005
                    1       FILES

INPUT  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffC.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffC.OUT
       DATED 12/09/2020 12:47:03

                  GRAPHICS FILES GENERATED

OPTION "L"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffC.DRG DATED 12/09/2020 12:47:03

OPTION "P"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffC.DHY DATED 12/09/2020 12:47:03

OPTION "E"  = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP
ND\Fordville_RunoffC.DEM DATED 12/09/2020 12:47:03
```

SITES MODEL OUTPUT

– PSH RUNOFF 10D 100Y

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:56

************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.518    A1
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Principal Spillway Hydrograph event (10day, 100year event)
 *        - Principal spillway info based off of as-builts
 *        - Elevation Storage data from 2008-2009 LiDAR
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      1             PSH_10D_100Y at Fordville
WSDATA    5C 1            49.518                  1.5
 QDIRECT          2.35     4.7
 POOLDATA  ELEV            1105.971  1090.93               TR
 PSINLET   ELEV     0.4      30       1117.416  1       3.75
 PSDATA    1       235      5        5       0.013     1082.269
 GRAPHICS  I
 GO,DESIGN LCPN
 SAVMOV    2    101  1              1
 ENDJOB

********************************************************************************
```

1SITES XEQ 12/09/2020 ---------- COMMENT PAGE ----------
VER 2005.1.8 Fordville WSID = 1

- Data from HEC-HMS model derived by Houston Engineering Inc
- Principal Spillway Hydrograph event (10day, 100year event)
- Principal spillway info based off of as-builts
- Elevation Storage data from 2008-2009 LiDAR

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:56 SITE = 1 PASS= 1 PART= 1

********** BASIC Data **********
CLIMATE AREA - NOT DEFINED DESIGN CLASS C

STORM DISTRIBUTION USED FOR AUXILIARY SPILLWAY IS;
NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY Q-PS,10-DAY Q-SD Q-FB
2.35 4.70 0.00 0.00

WSDATA - CN DA-SM TC/L -/H QRF
0.00 49.52 0.00 0.00 1.50

SITEDATA- PERM POOL CREST PS FP SED VALLEY FL 378?
0.00 1105.97 1090.93 0.00 NO

BASEFLOW INITIAL EL EXTRA VOL SITE TYPE
0.00 0.00 0.00 DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 235.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.40 30.00 1082.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 0.00

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
0.00 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
0 0.00 0.00 0
AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?

```
          0.000        0.00        0.000        0.000          NO

 BTM WIDTH -    BW1          BW2          BW3          BW4          BW5
           0.00         0.00         0.00         0.00         0.00
1**********************     DETAILED LIST OF BASIC Data     **********************
 WEIR COEF. FOR ORIFICES..... 3.10    RATIO OF Ia TO S (CH.10,NEH4). 0.20
 WEIR COEF. FOR DROP INLET..... 3.10    TIME INCS TO PEAK OF UNIT HYD.  10.
 DISCHARGE COEF. FOR ORIFICES..... 0.60    NO. POINTS FOR DESIGN HYD. ... 5000

 HOOD, WEIR INLET COEF. ..... 0.60    DRAWDOWN TIME LIMIT - DAYS.... 10.0
 HOOD, PIPE ENTRANCE COEF. ..... 0.60    DRAWDOWN RATIO STORAGE LIMIT.. 0.15
 HOOD, SLUG FLOW COEF. ..... 0.00    OTHER DRAWDOWN RATIOS APPLY ?.   NO

 PS ACCURACY OF FULL FLOW CALC.,FT 0.01    WSP ALLOWABLE FSS VEL. CHANGE. 0.05
 FILLET SIZE FOR BOX CONDUITS..... 6.00    WSP FSS CALC. PRECISION, FT.. 0.005

 GRAVITATIONAL CONSTANT..... 32.16    AUX. SPILLWAY MIN. CAP. COEF. 237.0
 MIN. NHCP378 PS PIPE AREA SQFT.. 0.545    AUX. SPILLWAY MIN. CAP. EXP.  0.493

 MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00    MIN. AUX. BW IN BW SOLUTION,FT 20.0
 MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00    PRECISION OF BW SOLUTION.....  1.0
 MIN. NHCP378 DEPTH PS - AUX.CREST 1.00    OLD TR60 CRITERIA USED .......   NO
 MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00    OLD NHCP378 CRITERIA USED ....   NO

 EMBANKMENT TEMPLATE:  TOP WIDTH = (calc.),  MAX. CROWN = 0.667 ft,
 SIDE SLOPE   WAVE BERM   MULTIPLE STABILITY BERMS    SEPARATE STABILITY BERMS
   RATIOS     WIDTH     U&D/S WIDTHS   DELTA H     WIDTHS, ft   HEIGHTS, ft
  U/S  D/S     ft          ft        ft       U/S   D/S    U/S   D/S
 2.50 2.50     10.0          0.0       0.00      0.00  0.00   0.00  0.00

 DIMENSIONLESS UNIT HYDROGRAPH
 STANDARD DIMENSIONLESS UNIT HYDROGRAPH
 PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK =  10.
 VOLUME FACTOR =  48.3429

    0.0000    0.0300    0.1000    0.1900    0.3100
    0.4700    0.6600    0.8200    0.9300    0.9900
    1.0000    0.9900    0.9300    0.8600    0.7800
    0.6800    0.5600    0.4600    0.3900    0.3300
    0.2800    0.2410    0.2070    0.1740    0.1470
    0.1260    0.1070    0.0910    0.0770    0.0660
    0.0550    0.0470    0.0400    0.0340    0.0290
    0.0250    0.0210    0.0180    0.0150    0.0130
    0.0110    0.0090    0.0080    0.0070    0.0060
    0.0050    0.0040    0.0030    0.0020    0.0010
    0.0000
1NRCS DESIGN STORM RAINFALL DISTRIBUTION  (CHAPTER 21, NEH4 & TR-60).
     0.000     0.008     0.016     0.025     0.033
```

```
    0.043    0.052    0.063    0.074    0.086
    0.099    0.112    0.126    0.142    0.160
    0.180    0.205    0.255    0.345    0.437
    0.530    0.603    0.633    0.660    0.684
    0.705    0.724    0.742    0.759    0.775
    0.790    0.804    0.818    0.831    0.844
    0.856    0.868    0.879    0.890    0.900
    0.910    0.920    0.930    0.939    0.948
    0.957    0.966    0.975    0.983    0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 12/09/2020              Fordville                 WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 12:46:56         SITE = 1             PASS=   1    PART=   2

MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 INFLOW HYDROGRAPH PROVIDED IN LOCATION  1,  PEAK=   1012.30 CFS, AT 153.00 HRS.
 TITLE = PSH_10D_100Y at Fordville

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     795.7 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     795.7 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC    1061.5 CFS

 START ELEV    1105.97 FT    1858.4 ACFT     0.00 AC       0.0 CFS

 NRCS-PSH  RAINFALL   1-DAY =   0.00 IN    10-DAY =   0.00 IN    DA =  49.52 SM
        RUNOFF     1-DAY =   0.00 IN    10-DAY =   0.00 IN

    CLIMATIC INDEX = 1.00    CN 10-DAY =  0.    CN 1-DAY =   0.
    QRF  =     74.28 CFS     1117.55 FEET,    GIVEN Value.

    PEAK =      1012.3 CFS, AT  153.0 HRS.

 ROUTED RESULT - HYD TYPE      EMAX        VOL-MAX       AMAX        QMAX
            NRCS-PSH   1119.86 FT    5444.5 ACFT     0.00 AC    427.0 CFS

    PS STORAGE    3586.2 ACFT,  BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

 DRAWDOWN (DDT) TEST       1108.56 FT    2396.3 ACFT     21.53 CFS
    CONTROL IS 0.150 DETENTION STORAGE
    TIME LIMIT REACHED = 10.00 DAYS. FLOW WAS    57.33 CFS,  ELEV =  1116.63
    (ELEVATION TO START ROUTING SDH AND/OR FBH HAS BEEN RAISED.)
***** NOTE - EXTENSIVE TIME REQUIRED TO DRAWDOWN SITE; COMPUTATIONS
          STOPPED AT 30 DAYS (  46.79 CFS).
```

***** NOTE - CREST OF AUX. RAISED TO HOLD 2576.70 ACFT NOT EVACUATED IN
DRAWDOWN TIME LIMIT. TOTAL STORAGE REQUIRED = 8021.22 ACFT,
NEW ELEVATION OF AUXILIARY SPILLWAY CREST = 1126.30 FT.

RATING TABLE DEVELOPED, SITE = 1 :
WITH PS DEVELOPED BY PROGRAM AND NO AUX. DATA GIVEN.

RATING TABLE NUMBER 1

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.76	208.86	208.86	0.00	5103.39	0.00
9	1120.11	478.45	478.45	0.00	5524.90	0.00
			FULL CONDUIT FLOW, ELEV = 1121.46 FT			
10	1121.46	826.40	826.40	0.00	6039.72	0.00
11	1138.31	988.52	988.52	0.00	14630.87	0.00
12	1155.15	1127.36	1127.36	0.00	30296.24	0.00
13	1172.00	1250.88	1250.88	0.00	55908.61	0.00

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:56 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1126.30 FT 8021.2 ACFT 0.00 AC 863.8 CFS

PS STORAGE 6162.9 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1116.63 FT 4435.0 ACFT 0.00 AC 57.3 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

***** MESSAGE - NO INPUT DATA GIVEN FOR AUXILIARY SPILLWAY CREST AND/OR
BOTTOM WIDTH. NO AUXILIARY SPILLWAY ROUTINGS PERFORMED.

Inflow Hyd 1 PSH-Peak = 427.04 CFS at 207.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---

1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
1 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****

SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
---------- DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	12/09/2020	12:46:56

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.52	0.	0.00	49.52	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD

SITES.....SUMMARY TABLE 1 COMPLETED.

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_PSH.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_PSH.OUT
DATED 12/09/2020 12:46:56

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_PSH.DRG DATED 12/09/2020 12:46:56

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_PSH.DHY DATED 12/09/2020 12:46:56

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_PSH.DEM DATED 12/09/2020 12:46:56

SITES MODEL OUTPUT

– SDH / FBH HMR51 6H

```
********************************************************************************
 SITES XEQ 10/16/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 09:47:55

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.34    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *       - Data from HEC-HMS model derived by Houston Engineering Inc
 *       - Stability Design and Freeboard Hydrographs from TR-60
 *       - Spillway info based off of as builts
 *       - Soil data from surveyed soil borings 2020
 *       - Elevation Storage data from 2008-2009 LiDAR
 STRUCTURE 1       Fordville Dam - TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_6H_100Y
WSDATA    2C 1            49.34
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       253      5        5        0.013    1081.27
 ASSURFACE 41       1100.98   0.039
       0       208.68    0.035     0.5      3       1
       208.68    225.8     0.013     0        1
       225.8     1100.98   0.035     0.5      3       1
 ENDTABLE
```

```
ASDATA   41                  3                  1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                          1117.70
SAVMOV    2    101  1              1
ENDJOB

*******************************************************************************
1SITES XEQ 10/16/2020 ---------- COMMENT PAGE ------------------------------
     VER 2005.1.8               Fordville               WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - TOS Bathymetry SUBW= 1
TIME 09:47:55 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.34	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H

```
          1.00       253.00        5.00         5.00

          PS N         KE        WEIR L       TW EL
         0.013       0.75        30.00      1081.27

        2ND STG       ORF H       ORF L     START AUX.
        1117.42       1.00        3.75      1117.70

ASCRESTS -  AUX.1       AUX.2       AUX.3       AUX.4       AUX.5
        1124.30       0.00        0.00        0.00        0.00

AUX.Data -  REF.NO.    RETARD. Ci   TIE STATION    INLET LENGTH
             41        0.00       340.09            0

AUX.Data - INLET N     SIDE SLOPE      EXIT N      EXIT SLOPE     ACTUAL AUX?
          0.035        3.00        0.035        0.001          YES

BTM WIDTH -    BW1          BW2          BW3          BW4          BW5
 ft       400.00         0.00         0.00         0.00         0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1*********************     DETAILED LIST OF BASIC Data     **********************
WEIR COEF. FOR ORIFICES..... 3.10    RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10    TIME INCS TO PEAK OF UNIT HYD.  10.
DISCHARGE COEF. FOR ORIFICES..... 0.60    NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60    DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60    DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00    OTHER DRAWDOWN RATIOS APPLY ?.   NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01    WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00    WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16    AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545    AUX. SPILLWAY MIN. CAP. EXP.  0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00    MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00    PRECISION OF BW SOLUTION.....  1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00    OLD TR60 CRITERIA USED .....   NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00    OLD NHCP378 CRITERIA USED ....   NO

EMBANKMENT TEMPLATE:  TOP WIDTH = (calc.),  MAX. CROWN = 0.667 ft,
SIDE SLOPE   WAVE BERM   MULTIPLE STABILITY BERMS    SEPARATE STABILITY BERMS
   RATIOS     WIDTH     U&D/S WIDTHS   DELTA H     WIDTHS, ft   HEIGHTS, ft
  U/S  D/S     ft          ft         ft       U/S   D/S    U/S   D/S
 2.50 2.50     10.0          0.0       0.00      0.00  0.00   0.00  0.00
```

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

```
    0.910     0.920     0.930     0.939     0.948
    0.957     0.966     0.975     0.983     0.992
    1.000

1SITES ---------------------------------------------------------------------------
 XEQ 10/16/2020              Fordville                 WSID= 1
 VER 2005.1.8          Fordville Dam - TOS Bathymetry          SUBW= 1
 TIME 09:47:55         SITE = 1             PASS=   1    PART=  2

 ***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.3 SQ. MILES.

            DESIGN 0.85745     PS-1 DAY 0.94853     PS-10 DAY 0.97441.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC     981.3 CFS

 START ELEV    1117.70 FT    4770.6 ACFT     0.00 AC      90.3 CFS

 ********************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.

 RATING TABLE NUMBER  1
      ELEV.   Q-TOTAL   Q-PS    Q-AUX.   VOLUME     AREA
      FEET      CFS      CFS      CFS     AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                          TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.23   197.23     0.00   5080.99     0.00
  9  1119.97   445.71   445.71     0.00   5480.10     0.00
                          FULL CONDUIT FLOW, ELEV = 1121.25 FT
 10  1121.25   766.39   766.39     0.00   5951.64     0.00
 11  1138.16   914.51   914.51     0.00  14541.99     0.00
 12  1155.08  1041.65  1041.65     0.00  30191.25     0.00
 13  1172.00  1154.87  1154.87     0.00  55909.00     0.00
```

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 3864.90 CFS, AT 31.00 HRS.
TITLE = SDH_6H_100Y

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 11212.60 CFS, AT 30.00 HRS.
TITLE = FBH_6H_HMR51

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - TOS Bathymetry SUBW= 1
TIME 09:47:55 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.0 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.70 FT 4770.6 ACFT 0.00 AC 90.3 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 3864.9 CFS, AT 31.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 11212.6 CFS, AT 30.0 HRS.
AUX. AREAL CORRECTION USED =0.8574

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.23	197.23	0.00	5080.99	0.00
9	1119.97	445.71	445.71	0.00	5480.10	0.00
			FULL CONDUIT FLOW, ELEV = 1121.25 FT			

10	1121.25	766.39	766.39	0.00	5951.64	0.00
11	1122.26	776.28	776.28	0.00	6368.79	0.00
12	1123.28	785.86	785.86	0.00	6785.93	0.00
13	1124.30	795.32	795.32	0.00	7203.08	0.00
14	1126.69	3170.79	817.07	2353.72	8199.62	0.00
15	1129.07	9107.32	838.25	8269.07	9425.48	0.00
16	1133.36	27595.06	875.08	26719.98	11632.00	0.00
17	1138.61	60117.98	918.09	59199.89	14818.64	0.00
18	1148.15	147655.20	991.53	146663.67	22033.82	0.00
19	1160.07	292009.41	1076.30	290933.09	37523.88	0.00
20	1172.00	477806.78	1154.87	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.88	8297.3	0.0	2.58	1094.2

PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
DISCHARGE =	819.	2825.	3644.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 1.15	FT/SEC 6.07	FT/FT 0.017	FT/FT 0.023

AUXILIARY SPILLWAY DURATION FLOW = 61.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.7 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.6 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 2825. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.70	0.19	0.037	
6	509.	692.	2.96	0.035	7.16	1.81	1.100	max.
7	692.	908.	0.18	0.035	3.09	0.26	0.050	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1129.55	9670.3	0.0	5.25	2467.2

	PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
DISCHARGE =		842.	10316.	11159.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 2.72	FT/SEC 9.27	FT/FT 0.013	FT/FT 0.017

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 13.0 hours
and peaked at time = 32.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 56.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 18.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 17.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 16.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 16.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 16.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 16.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 15.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 30.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	99.0	82.6	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 4.5 FT/SEC

EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 5.6 FT

Inflow Hyd 1 SDH-Peak = 3643.77 CFS at 36.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 11158.53 CFS at 31.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---

1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****

SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
---------- DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	10/16/2020	09:47:55

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.34	0.	0.00	49.34	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	5.2	1129.6	0.<BREACH>		4.4	NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED HYDROGRAPH SHOWN UNDER TYPE HYD.

SITES.....SUMMARY TABLE 1 COMPLETED.

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_6H.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_6H.OUT
DATED 10/16/2020 09:47:55

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_6H.DRG DATED 10/16/2020 09:47:55

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_6H.DHY DATED 10/16/2020 09:47:55

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_6H.DEM DATED 10/16/2020 09:47:55

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_6H.DG* DATED 10/16/2020 09:47:55

SITES MODEL OUTPUT

– SDH / FBH HMR51 24H

```
********************************************************************************
 SITES XEQ 10/16/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 09:47:52
************************** 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.34    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 *        - Boring Data from Gannett Flemming
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_24H_100Y
WSDATA    2C 1            49.34
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       253      5        5        0.013    1081.27
 ASSURFACE 41       1100.98   0.039
       0       208.68    0.035     0.5      3       1
       208.68    225.8     0.013     0        1
       225.8     1100.98   0.035     0.5      3       1
 ENDTABLE
```

```
ASDATA   41                  3                  1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                          1117.70
SAVMOV    2    101  1              1
ENDJOB

*******************************************************************************
1SITES XEQ 10/16/2020 ---------- COMMENT PAGE ------------------------------
     VER 2005.1.8               Fordville               WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR
- Boring Data from Gannett Flemming

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 09:47:52 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.34	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 253.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.75 30.00 1081.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 1117.70

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
1124.30 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
41 0.00 340.09 0

AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?
0.035 3.00 0.035 0.001 YES

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
ft 400.00 0.00 0.00 0.00 0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,
SIDE SLOPE WAVE BERM MULTIPLE STABILITY BERMS SEPARATE STABILITY BERMS
RATIOS WIDTH U&D/S WIDTHS DELTA H WIDTHS, ft HEIGHTS, ft
U/S D/S ft ft ft U/S D/S U/S D/S
2.50 2.50 10.0 0.0 0.00 0.00 0.00 0.00 0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

```
    0.910     0.920     0.930     0.939     0.948
    0.957     0.966     0.975     0.983     0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 10/16/2020              Fordville                 WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 09:47:52         SITE = 1             PASS=   1    PART=  2

 ***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.3 SQ. MILES.

            DESIGN 0.85745     PS-1 DAY 0.94853     PS-10 DAY 0.97441.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC     981.3 CFS

 START ELEV    1117.70 FT    4770.6 ACFT     0.00 AC      90.3 CFS


 ********************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.

 RATING TABLE NUMBER  1
      ELEV.    Q-TOTAL    Q-PS     Q-AUX.    VOLUME     AREA
      FEET       CFS       CFS      CFS      AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                            TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.23   197.23     0.00   5080.99     0.00
  9  1119.97   445.71   445.71     0.00   5480.10     0.00
                             FULL CONDUIT FLOW, ELEV = 1121.25 FT
 10  1121.25   766.39   766.39     0.00   5951.64     0.00
 11  1138.16   914.51   914.51     0.00  14541.99     0.00
 12  1155.08  1041.65  1041.65     0.00  30191.25     0.00
 13  1172.00  1154.87  1154.87     0.00  55909.00     0.00
```

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 4620.20 CFS, AT 40.00 HRS.
TITLE = SDH_24H_100Y

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 14699.70 CFS, AT 39.00 HRS.
TITLE = FBH_24H_HMR51

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 09:47:52 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.0 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.70 FT 4770.6 ACFT 0.00 AC 90.3 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 4620.2 CFS, AT 40.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 14699.7 CFS, AT 39.0 HRS.
AUX. AREAL CORRECTION USED =0.8574

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
		TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT				
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.23	197.23	0.00	5080.99	0.00
9	1119.97	445.71	445.71	0.00	5480.10	0.00

FULL CONDUIT FLOW, ELEV = 1121.25 FT

10	1121.25	766.39	766.39	0.00	5951.64	0.00
11	1122.26	776.28	776.28	0.00	6368.79	0.00
12	1123.28	785.86	785.86	0.00	6785.93	0.00
13	1124.30	795.32	795.32	0.00	7203.08	0.00
14	1126.69	3170.79	817.07	2353.72	8199.62	0.00
15	1129.07	9107.32	838.25	8269.07	9425.48	0.00
16	1133.36	27595.06	875.08	26719.98	11632.00	0.00
17	1138.61	60117.98	918.09	59199.89	14818.64	0.00
18	1148.15	147655.20	991.53	146663.67	22033.82	0.00
19	1160.07	292009.41	1076.30	290933.09	37523.88	0.00
20	1172.00	477806.78	1154.87	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1127.21	8471.1	0.0	2.91	1268.0

PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
DISCHARGE =	822.	3664.	4485.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 1.37	FT/SEC 6.61	FT/FT 0.016	FT/FT 0.022

AUXILIARY SPILLWAY DURATION FLOW = 69.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 3.0 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 3.0 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 3664. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.99	0.22	0.043	
6	509.	692.	2.96	0.035	7.94	2.11	1.285	max.
7	692.	908.	0.18	0.035	3.42	0.30	0.058	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1130.35	10085.0	0.0	6.05	2881.9

PEAK - CFS DISCHARGE =	Q-PS 849.	Q-AUX. 13784.	Q-TOT. 14633.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 3.30	FT/SEC 10.19	FT/FT 0.012	FT/FT 0.016

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 21.0 hours
and peaked at time = 42.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 56.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 25.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 24.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 23.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 23.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 24.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 24.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 23.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 36.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	108.0	117.8	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 5.0 FT/SEC

EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 6.6 FT

Inflow Hyd 1 SDH-Peak = 4485.40 CFS at 43.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 14633.19 CFS at 41.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---

1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****

SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
---------- DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	10/16/2020	09:47:52

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.34	0.	0.00	49.34	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	6.1	1130.3	0.<BREACH>	5.0		NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
HYDROGRAPH SHOWN UNDER TYPE HYD.

SITES.....SUMMARY TABLE 1 COMPLETED.
NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_24H.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_24H.OUT
DATED 10/16/2020 09:47:52

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_24H.DRG DATED 10/16/2020 09:47:52

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_24H.DHY DATED 10/16/2020 09:47:52

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_24H.DEM DATED 10/16/2020 09:47:52

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_24H.DG* DATED 10/16/2020 09:47:52

SITES MODEL OUTPUT

– SDH / FBH HMR51 48H

```
********************************************************************************
 SITES XEQ 10/16/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 09:47:53
************************** 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.34    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 *        - Boring Data from Gannett Flemming
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_48H_100Y
WSDATA    2C 1            49.34
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       253      5        5        0.013    1081.27
 ASSURFACE 41       1100.98   0.039
       0       208.68    0.035     0.5      3       1
       208.68    225.8     0.013     0        1
       225.8     1100.98   0.035     0.5      3       1
 ENDTABLE
```

```
ASDATA   41                  3                  1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                          1117.7
SAVMOV    2    101  1              1
ENDJOB

*******************************************************************************
1SITES XEQ 10/16/2020 ---------- COMMENT PAGE ------------------------------
     VER 2005.1.8               Fordville              WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR
- Boring Data from Gannett Flemming

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 09:47:53 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	CLAY	PERCENT REMOVAL RATE	DETACH. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.34	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 253.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.75 30.00 1081.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 1117.70

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
1124.30 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
41 0.00 340.09 0

AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?
0.035 3.00 0.035 0.001 YES

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
ft 400.00 0.00 0.00 0.00 0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,
SIDE SLOPE WAVE BERM MULTIPLE STABILITY BERMS SEPARATE STABILITY BERMS
RATIOS WIDTH U&D/S WIDTHS DELTA H WIDTHS, ft HEIGHTS, ft
U/S D/S ft ft ft U/S D/S U/S D/S
2.50 2.50 10.0 0.0 0.00 0.00 0.00 0.00 0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

```
    0.910     0.920     0.930     0.939     0.948
    0.957     0.966     0.975     0.983     0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 10/16/2020              Fordville                  WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 09:47:53         SITE = 1             PASS=   1    PART=   2


 ***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.3 SQ. MILES.

            DESIGN 0.85745     PS-1 DAY 0.94853     PS-10 DAY 0.97441.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT      0.00 AC     738.1 CFS

 CREST PS      1105.97 FT    1858.4 ACFT      0.00 AC     738.1 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT      0.00 AC     738.1 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT      0.00 AC     981.3 CFS

 START ELEV    1117.70 FT    4770.6 ACFT      0.00 AC      90.3 CFS

 ********************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.

 RATING TABLE NUMBER  1
      ELEV.    Q-TOTAL    Q-PS     Q-AUX.    VOLUME     AREA
      FEET       CFS       CFS      CFS      AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                            TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.23   197.23     0.00   5080.99     0.00
  9  1119.97   445.71   445.71     0.00   5480.10     0.00
                            FULL CONDUIT FLOW, ELEV = 1121.25 FT
 10  1121.25   766.39   766.39     0.00   5951.64     0.00
 11  1138.16   914.51   914.51     0.00  14541.99     0.00
 12  1155.08  1041.65  1041.65     0.00  30191.25     0.00
 13  1172.00  1154.87  1154.87     0.00  55909.00     0.00
```

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 4477.80 CFS, AT 51.00 HRS.
TITLE = SDH_48H_100Y

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 15290.90 CFS, AT 52.00 HRS.
TITLE = FBH_48H_HMR51

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 09:47:53 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.0 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.70 FT 4770.6 ACFT 0.00 AC 90.3 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 4477.8 CFS, AT 51.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 15290.9 CFS, AT 52.0 HRS.
AUX. AREAL CORRECTION USED =0.8574

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
		TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT				
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.23	197.23	0.00	5080.99	0.00
9	1119.97	445.71	445.71	0.00	5480.10	0.00

FULL CONDUIT FLOW, ELEV = 1121.25 FT

10	1121.25	766.39	766.39	0.00	5951.64	0.00
11	1122.26	776.28	776.28	0.00	6368.79	0.00
12	1123.28	785.86	785.86	0.00	6785.93	0.00
13	1124.30	795.32	795.32	0.00	7203.08	0.00
14	1126.69	3170.79	817.07	2353.72	8199.62	0.00
15	1129.07	9107.32	838.25	8269.07	9425.48	0.00
16	1133.36	27595.06	875.08	26719.98	11632.00	0.00
17	1138.61	60117.98	918.09	59199.89	14818.64	0.00
18	1148.15	147655.20	991.53	146663.67	22033.82	0.00
19	1160.07	292009.41	1076.30	290933.09	37523.88	0.00
20	1172.00	477806.78	1154.87	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1127.16	8446.2	0.0	2.86	1243.2

	PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
DISCHARGE =		821.	3544.	4365.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 1.34	FT/SEC 6.54	FT/FT 0.016	FT/FT 0.022

AUXILIARY SPILLWAY DURATION FLOW = 75.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 3.0 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.9 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 3544. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.95	0.22	0.042	
6	509.	692.	2.96	0.035	7.83	2.07	1.259	max.
7	692.	908.	0.18	0.035	3.38	0.30	0.057	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1130.49	10155.8	0.0	6.19	2952.8

PEAK - CFS DISCHARGE =	Q-PS 851.	Q-AUX. 14376.	Q-TOT. 15227.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 3.39	FT/SEC 10.33	FT/FT 0.012	FT/FT 0.016

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 32.0 hours
and peaked at time = 54.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 66.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 36.0 hours

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 35.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 34.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 34.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 35.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 35.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 34.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 47.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	113.0	130.7	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 5.1 FT/SEC

EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 6.8 FT

Inflow Hyd 1 SDH-Peak = 4365.10 CFS at 55.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 15226.78 CFS at 53.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---

1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****

SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
---------- DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	10/16/2020	09:47:53

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.34	0.	0.00	49.34	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	6.2	1130.5	0.	<BREACH>	5.1	NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED HYDROGRAPH SHOWN UNDER TYPE HYD.

SITES.....SUMMARY TABLE 1 COMPLETED.

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water
Resources\SITES\Fordville\Fordville_FBH_SDH_48H.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water
Resources\SITES\Fordville\Fordville_FBH_SDH_48H.OUT
DATED 10/16/2020 09:47:53

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water
Resources\SITES\Fordville\Fordville_FBH_SDH_48H.DRG DATED 10/16/2020 09:47:53

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water
Resources\SITES\Fordville\Fordville_FBH_SDH_48H.DHY DATED 10/16/2020 09:47:53

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water
Resources\SITES\Fordville\Fordville_FBH_SDH_48H.DEM DATED 10/16/2020 09:47:53

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water
Resources\SITES\Fordville\Fordville_FBH_SDH_48H.DG* DATED 10/16/2020 09:47:53

SITES MODEL OUTPUT

– SDH / FBH HMR51 72H

```
********************************************************************************
 SITES XEQ 10/16/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 09:47:57
************************** 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.34    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 *        - Boring Data from Gannett Flemming
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
             1078                        0
             1078.5                       0.00061106
             1080                        0.24057936
             1081.5                       1.54891257
             1083                        4.66459408
             1084.5                       12.8691501
             1086                        32.4875840
             1093                        335.329835
             1100.5                       1058.25464
             1106.5                       1935.72119
             1114                        3613.92381
             1120.5                       5646.02916
             1126.5                       8104.49968
             1134                        11959.3876
             1140                        15680.7669
             1147                        20779.4314
             1153.5                       27869.3012
             1160                        37409.3599
             1166.5                       47341.0760
             1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_78H_100Y
WSDATA    2C 1            49.34
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       253      5        5        0.013    1081.27
 ASSURFACE 41       1100.98   0.039
       0       208.68    0.035     0.5      3       1
       208.68    225.8     0.013     0        1
       225.8     1100.98   0.035     0.5      3       1
 ENDTABLE
```

```
ASDATA   41                  3                  1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                          1117.7
SAVMOV    2    101  1              1
ENDJOB

*******************************************************************************
1SITES XEQ 10/16/2020 ---------- COMMENT PAGE ------------------------------
     VER 2005.1.8               Fordville              WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR
- Boring Data from Gannett Flemming

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 09:47:57 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.34	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 253.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.75 30.00 1081.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 1117.70

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
1124.30 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
41 0.00 340.09 0

AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?
0.035 3.00 0.035 0.001 YES

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
ft 400.00 0.00 0.00 0.00 0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,
SIDE SLOPE WAVE BERM MULTIPLE STABILITY BERMS SEPARATE STABILITY BERMS
RATIOS WIDTH U&D/S WIDTHS DELTA H WIDTHS, ft HEIGHTS, ft
U/S D/S ft ft ft U/S D/S U/S D/S
2.50 2.50 10.0 0.0 0.00 0.00 0.00 0.00 0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

```
    0.910     0.920     0.930     0.939     0.948
    0.957     0.966     0.975     0.983     0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 10/16/2020              Fordville                 WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 09:47:57         SITE = 1             PASS=   1    PART=  2

 ***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.3 SQ. MILES.

            DESIGN 0.85745     PS-1 DAY 0.94853     PS-10 DAY 0.97441.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     738.1 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC     981.3 CFS

 START ELEV    1117.70 FT    4770.6 ACFT     0.00 AC      90.3 CFS

 ********************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.


 RATING TABLE NUMBER  1
      ELEV.    Q-TOTAL    Q-PS     Q-AUX.    VOLUME     AREA
      FEET       CFS       CFS      CFS      AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                           TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.23   197.23     0.00   5080.99     0.00
  9  1119.97   445.71   445.71     0.00   5480.10     0.00
                           FULL CONDUIT FLOW, ELEV = 1121.25 FT
 10  1121.25   766.39   766.39     0.00   5951.64     0.00
 11  1138.16   914.51   914.51     0.00  14541.99     0.00
 12  1155.08  1041.65  1041.65     0.00  30191.25     0.00
 13  1172.00  1154.87  1154.87     0.00  55909.00     0.00
```

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 4038.70 CFS, AT 60.00 HRS.
TITLE = SDH_78H_100Y

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 14894.80 CFS, AT 63.00 HRS.
TITLE = FBH_72H_HMR51

1SITES ----------
XEQ 10/16/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 09:47:57 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.0 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.70 FT 4770.6 ACFT 0.00 AC 90.3 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 4038.7 CFS, AT 60.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.34 SQUARE MILES

PEAK = 14894.8 CFS, AT 63.0 HRS.
AUX. AREAL CORRECTION USED =0.8574

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00

8	1118.69	197.23	197.23	0.00	5080.99	0.00
9	1119.97	445.71	445.71	0.00	5480.10	0.00
			FULL CONDUIT FLOW, ELEV = 1121.25 FT			
10	1121.25	766.39	766.39	0.00	5951.64	0.00
11	1122.26	776.28	776.28	0.00	6368.79	0.00
12	1123.28	785.86	785.86	0.00	6785.93	0.00
13	1124.30	795.32	795.32	0.00	7203.08	0.00
14	1126.69	3170.79	817.07	2353.72	8199.62	0.00
15	1129.07	9107.32	838.25	8269.07	9425.48	0.00
16	1133.36	27595.06	875.08	26719.98	11632.00	0.00
17	1138.61	60117.98	918.09	59199.89	14818.64	0.00
18	1148.15	147655.20	991.53	146663.67	22033.82	0.00
19	1160.07	292009.41	1076.30	290933.09	37523.88	0.00
20	1172.00	477806.78	1154.87	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.99	8358.1	0.0	2.69	1155.1

PEAK - CFS Q-PS Q-AUX. Q-TOT.
DISCHARGE = 820. 3119. 3938.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 1.23	FT/SEC 6.27	FT/FT 0.017	FT/FT 0.023

AUXILIARY SPILLWAY DURATION FLOW = 81.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.8 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.7 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 3119. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.81	0.20	0.039	
6	509.	692.	2.96	0.035	7.45	1.92	1.167	max.
7	692.	908.	0.18	0.035	3.21	0.27	0.053	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1130.40	10108.6	0.0	6.10	2905.5

PEAK - CFS Q-PS Q-AUX. Q-TOT.
DISCHARGE = 850. 13981. 14831.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 3.33	FT/SEC 10.23	FT/FT 0.012	FT/FT 0.016

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 42.0 hours
and peaked at time = 65.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 77.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 47.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 46.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 45.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 45.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 45.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 46.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 45.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 58.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE

```
        AUXILIARY        HRS     ACFT/FT     AUX. CREST, FT
        SPILLWAY----    118.0     137.5        >>>BREACH<<<
                                Depth =   52.3 ft

        EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY=   5.0 FT/SEC
                                EXIT SLOPE  = 0.001 FT/FT
                                FLOW DEPTH  =   6.7 FT

Inflow Hyd 1 SDH-Peak =       3938.49 CFS  at   65.00 hrs.,  Location Point

 Inflow Hyd 1 FBH-Peak =      14830.79 CFS  at   64.00 hrs.,  Location Point
HYDOUT   1     1

1SITES....JOB NO.  1 COMPLETE.
 ------------------------------------------------------------------------------

 1          Fordville

     0 SUBWATERSHED(S) ANALYZED.
     1 STRUCTURE(S) ANALYZED.
     2 HYDROGRAPHS ROUTED AT LOWEST SITE.
     0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

 ********************************************************************************
 SITES.....COMPUTATIONS COMPLETE

                     SUMMARY TABLE  1        SITES VERSION 2005.1.8
                    ----------------            DATED 01/01/2005

 WATERSHED ID                 RUN DATE                    RUN TIME
 ------------                 --------                    --------
 1                         10/16/2020                    09:47:57

 >>>  SITE   SUBWS   SUBWS DA   CURVE    TC   TOTAL DA   TYPE    STRUC   <<<
      ID     ID     (SQ MI)    NO.    (HRS)  (SQ MI)  DESIGN   CLASS
     -----  ----   --------  -----  ----  -------  -----  -----
     1      1       49.34     0.   0.00    49.34   TR60    C

 PASS  DIA./  AUX.CREST  BTM.  MAX.    MAX.   EMB.  INTEGR.*  EXIT*    TYPE
  NO.  WIDTH    ELEV    WIDTH  HP     ELEV    VOL.   DIST.     VEL.     HYD
    (IN/FT)   (FT)     (FT)  (FT)    (FT)    (CY)   (FT)    (FT/SEC)
 ---- -----  -------  ------  ----  -------  -------  -----  ------  ---------
   1   5.0   1124.3   400.0   6.1   1130.4       0.<BREACH>    5.0  NRCS-FBH

 *  INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
    HYDROGRAPH SHOWN UNDER TYPE HYD

 SITES.......SUMMARY TABLE 1 COMPLETED.
```

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_72H.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_72H.OUT
DATED 10/16/2020 09:47:57

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_72H.DRG DATED 10/16/2020 09:47:57

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_72H.DHY DATED 10/16/2020 09:47:57

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_72H.DEM DATED 10/16/2020 09:47:57

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville\Fordville_FBH_SDH_72H.DG* DATED 10/16/2020 09:47:57

SITES MODEL OUTPUT

– SDH / FBH ND PMP 6H LOCAL

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:50

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.518    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 STRUCTURE 1       Fordville Dam - TOS Bathymetry
              1078                        0
              1078.5                       0.00061106
              1080                        0.24057936
              1081.5                       1.54891257
              1083                        4.66459408
              1084.5                       12.8691501
              1086                        32.4875840
              1093                        335.329835
              1100.5                       1058.25464
              1106.5                       1935.72119
              1114                        3613.92381
              1120.5                       5646.02916
              1126.5                       8104.49968
              1134                        11959.3876
              1140                        15680.7669
              1147                        20779.4314
              1153.5                       27869.3012
              1160                        37409.3599
              1166.5                       47341.0760
              1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_6H_Local
WSDATA    2C 1            49.518
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       235      5        5       0.013    1082.269
 ASSURFACE 41       1100.98   0.039
       0       208.68    0.035     0.5      3       1
       208.68    225.8     0.013     0        1
       225.8     1100.98   0.035     0.5      3       1
 ENDTABLE
```

```
ASDATA   41                  3                  1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                          1117.68
SAVMOV    2    101  1              1
ENDJOB

*******************************************************************************
1SITES XEQ 12/09/2020 ---------- COMMENT PAGE ------------------------------
    VER 2005.1.8              Fordville              WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - TOS Bathymetry SUBW= 1
TIME 12:46:50 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. -	Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
	0.00	0.00	0.00	0.00

WSDATA -	CN	DA-SM	TC/L	-/H	QRF
	0.00	49.52	0.00	0.00	0.00

SITEDATA-	PERM POOL	CREST PS	FP SED	VALLEY FL	378?
	1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 235.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.75 30.00 1082.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 1117.68

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
1124.30 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
41 0.00 340.09 0

AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?
0.035 3.00 0.035 0.001 YES

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
ft 400.00 0.00 0.00 0.00 0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,
SIDE SLOPE WAVE BERM MULTIPLE STABILITY BERMS SEPARATE STABILITY BERMS
RATIOS WIDTH U&D/S WIDTHS DELTA H WIDTHS, ft HEIGHTS, ft
U/S D/S ft ft ft U/S D/S U/S D/S
2.50 2.50 10.0 0.0 0.00 0.00 0.00 0.00 0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

0.910 0.920 0.930 0.939 0.948
0.957 0.966 0.975 0.983 0.992
1.000

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - TOS Bathymetry SUBW= 1
TIME 12:46:50 SITE = 1 PASS= 1 PART= 2

***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF 49.5 SQ. MILES.

DESIGN 0.85706 PS-1 DAY 0.94844 PS-10 DAY 0.97436.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

PERM POOL 1105.97 FT 1858.4 ACFT 0.00 AC 737.8 CFS

CREST PS 1105.97 FT 1858.4 ACFT 0.00 AC 737.8 CFS

SED ACCUM 1105.97 FT 1858.4 ACFT 0.00 AC 737.8 CFS

2ND STAGE 1117.42 FT 4681.9 ACFT 0.00 AC 985.5 CFS

START ELEV 1117.68 FT 4764.4 ACFT 0.00 AC 88.1 CFS

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 1

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00
9	1119.97	445.55	445.55	0.00	5479.87	0.00
			FULL CONDUIT FLOW, ELEV = 1121.24 FT			
10	1121.24	766.09	766.09	0.00	5951.19	0.00
11	1138.16	917.40	917.40	0.00	14541.46	0.00

```
 12  1155.08   1047.07   1047.07     0.00  30190.53     0.00
 13  1172.00   1162.37   1162.37     0.00  55908.80     0.00

INFLOW HYDROGRAPH PROVIDED IN LOCATION  3,  PEAK=   3322.30 CFS, AT  33.00 HRS.
TITLE = SDH_6H_Local

INFLOW HYDROGRAPH PROVIDED IN LOCATION  5,  PEAK=   8900.80 CFS, AT  31.00 HRS.
TITLE = FBH_6H_Local

1SITES ------------------------------------------------------------------------
XEQ 12/09/2020              Fordville                 WSID= 1
VER 2005.1.8          Fordville Dam - TOS Bathymetry          SUBW= 1
TIME 12:46:50          SITE = 1             PASS=    1     PART=   3


AUX. CREST     1124.30 FT    7203.1 ACFT      0.00 AC     788.1 CFS

    PS STORAGE   5344.7 ACFT,  BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV     1117.68 FT    4764.4 ACFT      0.00 AC      88.1 CFS

ELEVATION OF LOW POINT IS ZERO.  NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH   INFLOW HYDROGRAPH INPUT, DA =   49.52 SQUARE MILES

    PEAK =      3322.3 CFS, AT   33.0 HRS.

NRCS-FBH   INFLOW HYDROGRAPH INPUT, DA =   49.52 SQUARE MILES

    PEAK =      8900.8 CFS, AT   31.0 HRS.
          AUX. AREAL CORRECTION USED =0.8571

********************************************************************************
RATING TABLE DEVELOPED, SITE = 1    :
 BY PROGRAM FOR PS AND AUX. SPILLWAYS
 AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER  2
      ELEV.    Q-TOTAL    Q-PS     Q-AUX.    VOLUME     AREA
      FEET       CFS       CFS       CFS      AC-FT     ACRE
  1  1105.97     0.00      0.00      0.00   1858.35     0.00
  2  1106.16     0.99      0.99      0.00   1886.72     0.00
  3  1106.36     2.81      2.81      0.00   1915.08     0.00
                            TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16      5.16      0.00   1947.55     0.00
  5  1110.17    34.72     34.72      0.00   2757.81     0.00
  6  1113.79    48.83     48.83      0.00   3568.04     0.00
```

7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00
9	1119.97	445.55	445.55	0.00	5479.87	0.00
			FULL CONDUIT FLOW, ELEV = 1121.24 FT			
10	1121.24	766.09	766.09	0.00	5951.19	0.00
11	1122.26	776.02	776.02	0.00	6368.44	0.00
12	1123.28	785.84	785.84	0.00	6785.73	0.00
13	1124.30	795.53	795.53	0.00	7203.03	0.00
14	1126.69	3171.52	817.79	2353.72	8199.62	0.00
15	1129.07	9108.54	839.46	8269.07	9425.48	0.00
16	1133.36	27597.11	877.12	26719.98	11632.00	0.00
17	1138.61	60120.95	921.06	59199.89	14818.64	0.00
18	1148.15	147659.66	995.99	146663.67	22033.82	0.00
19	1160.07	292015.47	1082.38	290933.09	37523.88	0.00
20	1172.00	477814.28	1162.37	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.50	8104.7	0.0	2.20	901.7

PEAK - CFS Q-PS Q-AUX. Q-TOT.
DISCHARGE = 816. 2129. 2945.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 0.96	FT/SEC 5.53	FT/FT 0.018	FT/FT 0.025

AUXILIARY SPILLWAY DURATION FLOW = 54.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.4 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.2 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 2129. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.42	0.16	0.031	
6	509.	692.	2.96	0.035	6.40	1.53	0.928	max.
7	692.	908.	0.18	0.035	2.77	0.22	0.043	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1128.94	9358.1	0.0	4.64	2155.0

PEAK - CFS Q-PS Q-AUX. Q-TOT.
DISCHARGE = 838. 7944. 8782.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 2.29	FT/SEC 8.52	FT/FT 0.014	FT/FT 0.018

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 16.0 hours
and peaked at time = 35.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 70.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 21.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 20.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 18.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 18.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 19.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 19.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 18.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 34.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

AUXILIARY	DURATION FLOW HRS	ATTACK OE/B ACFT/FT	DIST. FROM MOST U/S HEADCUT TO U/S EDGE AUX. CREST, FT

```
        SPILLWAY----     91.0      61.2        >>>BREACH<<<
                                Depth =   52.3 ft

        EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY=   4.0 FT/SEC
                               EXIT SLOPE  = 0.001 FT/FT
                               FLOW DEPTH  =   4.8 FT

Inflow Hyd 1 SDH-Peak =       2945.33 CFS  at   39.00 hrs.,  Location Point

 Inflow Hyd 1 FBH-Peak =      8782.10 CFS  at   34.00 hrs.,  Location Point
HYDOUT   1     1

1SITES....JOB NO.  1 COMPLETE.
 ------------------------------------------------------------------------------

 1          Fordville

     0 SUBWATERSHED(S) ANALYZED.
     1 STRUCTURE(S) ANALYZED.
     2 HYDROGRAPHS ROUTED AT LOWEST SITE.
     0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

********************************************************************************

 SITES.....COMPUTATIONS COMPLETE

                     SUMMARY TABLE  1        SITES VERSION 2005.1.8
                    ----------------            DATED 01/01/2005

 WATERSHED ID                 RUN DATE                    RUN TIME
 ------------                 --------                    --------
 1                         12/09/2020                    12:46:50

 >>>  SITE   SUBWS   SUBWS DA   CURVE    TC   TOTAL DA   TYPE    STRUC   <<<
      ID     ID     (SQ MI)    NO.    (HRS)  (SQ MI)  DESIGN   CLASS
     -----  ----  --------  -----  ----  -------  -----  -----
     1      1       49.52     0.   0.00    49.52    TR60     C

 PASS  DIA./  AUX.CREST  BTM.  MAX.    MAX.   EMB.  INTEGR.*  EXIT*    TYPE
  NO.  WIDTH    ELEV    WIDTH  HP     ELEV    VOL.   DIST.     VEL.     HYD
    (IN/FT)   (FT)     (FT)  (FT)    (FT)    (CY)   (FT)    (FT/SEC)
---- -----  -------  ------  ----  -------  -------  -----  ------  ---------
  1   5.0   1124.3   400.0   4.6   1128.9       0.<BREACH>    4.0  NRCS-FBH

*  INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
   HYDROGRAPH SHOWN UNDER TYPE HYD.
```

SITES.....SUMMARY TABLE 1 COMPLETED

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_6H_Local.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_6H_Local.OUT
DATED 12/09/2020 12:46:50

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_6H_Local.DRG DATED 12/09/2020 12:46:50

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_6H_Local.DHY DATED 12/09/2020 12:46:50

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_6H_Local.DEM DATED 12/09/2020 12:46:50

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_6H_Local.DG* DATED 12/09/2020 12:46:50

SITES MODEL OUTPUT

– SDH / FBH ND PMP 12H LOCAL

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:36

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.518    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 STRUCTURE 1       Fordville Dam - TOS Bathymetry
              1078                        0
              1078.5                       0.00061106
              1080                        0.24057936
              1081.5                       1.54891257
              1083                        4.66459408
              1084.5                       12.8691501
              1086                        32.4875840
              1093                        335.329835
              1100.5                       1058.25464
              1106.5                       1935.72119
              1114                        3613.92381
              1120.5                       5646.02916
              1126.5                       8104.49968
              1134                        11959.3876
              1140                        15680.7669
              1147                        20779.4314
              1153.5                       27869.3012
              1160                        37409.3599
              1166.5                       47341.0760
              1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_12H_Local
WSDATA    2C 1            49.518
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       235      5        5       0.013    1082.269
 ASSURFACE 41       1100.98   0.039
       0       208.68    0.035     0.5      3       1
       208.68    225.8     0.013     0        1
       225.8     1100.98   0.035     0.5      3       1
 ENDTABLE
```

```
ASDATA   41                  3                  1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                          1117.68
SAVMOV    2    101  1              1
ENDJOB

*******************************************************************************
1SITES XEQ 12/09/2020 ---------- COMMENT PAGE ------------------------------
    VER 2005.1.8              Fordville              WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - TOS Bathymetry SUBW= 1
TIME 12:46:36 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY Q-PS,10-DAY Q-SD Q-FB
0.00 0.00 0.00 0.00

WSDATA - CN DA-SM TC/L -/H QRF
0.00 49.52 0.00 0.00 0.00

SITEDATA- PERM POOL CREST PS FP SED VALLEY FL 378?
1105.97 1105.97 1078.00 1072.00 NO
BASEFLOW INITIAL EL EXTRA VOL SITE TYPE
0.00 0.00 0.00 DESIGN
PSDATA - NO. COND COND L DIA/W -/H
1.00 235.00 5.00 5.00
PS N KE WEIR L TW EL

```
          0.013         0.75        30.00       1082.27

         2ND STG        ORF H         ORF L     START AUX.
         1117.42         1.00         3.75       1117.68

ASCRESTS -   AUX.1        AUX.2        AUX.3        AUX.4        AUX.5
         1124.30         0.00         0.00         0.00         0.00

AUX.Data -  REF.NO.    RETARD. Ci   TIE STATION    INLET LENGTH
             41         0.00       340.09            0

AUX.Data - INLET N     SIDE SLOPE      EXIT N      EXIT SLOPE     ACTUAL AUX?
           0.035         3.00         0.035         0.001          YES

BTM WIDTH -    BW1          BW2          BW3          BW4          BW5
  ft       400.00         0.00         0.00         0.00         0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1*********************     DETAILED LIST OF BASIC Data     **********************
 WEIR COEF. FOR ORIFICES..... 3.10    RATIO OF Ia TO S (CH.10,NEH4). 0.20
 WEIR COEF. FOR DROP INLET..... 3.10    TIME INCS TO PEAK OF UNIT HYD.  10.
 DISCHARGE COEF. FOR ORIFICES..... 0.60    NO. POINTS FOR DESIGN HYD. ... 5000

 HOOD, WEIR INLET COEF. ..... 0.60    DRAWDOWN TIME LIMIT - DAYS.... 10.0
 HOOD, PIPE ENTRANCE COEF. ..... 0.60    DRAWDOWN RATIO STORAGE LIMIT.. 0.15
 HOOD, SLUG FLOW COEF. ..... 0.00    OTHER DRAWDOWN RATIOS APPLY ?.   NO

 PS ACCURACY OF FULL FLOW CALC.,FT 0.01    WSP ALLOWABLE FSS VEL. CHANGE. 0.05
 FILLET SIZE FOR BOX CONDUITS..... 6.00    WSP FSS CALC. PRECISION, FT.. 0.005

 GRAVITATIONAL CONSTANT..... 32.16    AUX. SPILLWAY MIN. CAP. COEF. 237.0
 MIN. NHCP378 PS PIPE AREA SQFT.. 0.545    AUX. SPILLWAY MIN. CAP. EXP.  0.493

 MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00    MIN. AUX. BW IN BW SOLUTION,FT 20.0
 MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00    PRECISION OF BW SOLUTION.....  1.0
 MIN. NHCP378 DEPTH PS - AUX.CREST 1.00    OLD TR60 CRITERIA USED .....   NO
 MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00    OLD NHCP378 CRITERIA USED ....   NO

 EMBANKMENT TEMPLATE:  TOP WIDTH = (calc.),  MAX. CROWN = 0.667 ft,
 SIDE SLOPE   WAVE BERM   MULTIPLE STABILITY BERMS    SEPARATE STABILITY BERMS
   RATIOS     WIDTH     U&D/S WIDTHS   DELTA H     WIDTHS, ft   HEIGHTS, ft
  U/S  D/S      ft           ft         ft       U/S   D/S    U/S   D/S
 2.50 2.50     10.0          0.0        0.00      0.00  0.00   0.00  0.00

 DIMENSIONLESS UNIT HYDROGRAPH
 STANDARD DIMENSIONLESS UNIT HYDROGRAPH
 PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK =  10.
```

VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900
0.910	0.920	0.930	0.939	0.948
0.957	0.966	0.975	0.983	0.992
1.000				

```
1SITES ------------------------------------------------------------------------
 XEQ 12/09/2020              Fordville                 WSID= 1
 VER 2005.1.8          Fordville Dam - TOS Bathymetry          SUBW= 1
 TIME 12:46:36         SITE = 1             PASS=    1    PART=   2

***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.5 SQ. MILES.

            DESIGN 0.85706     PS-1 DAY 0.94844     PS-10 DAY 0.97436.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT      0.00 AC     737.8 CFS

 CREST PS      1105.97 FT    1858.4 ACFT      0.00 AC     737.8 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT      0.00 AC     737.8 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT      0.00 AC     985.5 CFS

 START ELEV    1117.68 FT    4764.4 ACFT      0.00 AC      88.1 CFS
*******************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.

 RATING TABLE NUMBER  1
      ELEV.   Q-TOTAL    Q-PS    Q-AUX.    VOLUME     AREA
      FEET      CFS      CFS      CFS      AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                           TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.17   197.17     0.00   5080.87     0.00
  9  1119.97   445.55   445.55     0.00   5479.87     0.00
                           FULL CONDUIT FLOW, ELEV = 1121.24 FT
 10  1121.24   766.09   766.09     0.00   5951.19     0.00
 11  1138.16   917.40   917.40     0.00  14541.46     0.00
 12  1155.08  1047.07  1047.07     0.00  30190.53     0.00
 13  1172.00  1162.37  1162.37     0.00  55908.80     0.00

 INFLOW HYDROGRAPH PROVIDED IN LOCATION  3,  PEAK=   3748.80 CFS, AT  36.00 HRS.
 TITLE = SDH_12H_Local

 INFLOW HYDROGRAPH PROVIDED IN LOCATION  5,  PEAK=  10631.70 CFS, AT  34.00 HRS.
 TITLE = FBH_12H_Local
```

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - TOS Bathymetry SUBW= 1
TIME 12:46:36 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.1 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.68 FT 4764.4 ACFT 0.00 AC 88.1 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 3748.8 CFS, AT 36.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 10631.7 CFS, AT 34.0 HRS.
AUX. AREAL CORRECTION USED =0.8571

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00
9	1119.97	445.55	445.55	0.00	5479.87	0.00
			FULL CONDUIT FLOW, ELEV = 1121.24 FT			
10	1121.24	766.09	766.09	0.00	5951.19	0.00
11	1122.26	776.02	776.02	0.00	6368.44	0.00
12	1123.28	785.84	785.84	0.00	6785.73	0.00
13	1124.30	795.53	795.53	0.00	7203.03	0.00
14	1126.69	3171.52	817.79	2353.72	8199.62	0.00
15	1129.07	9108.54	839.46	8269.07	9425.48	0.00

16	1133.36	27597.11	877.12	26719.98	11632.00	0.00
17	1138.61	60120.95	921.06	59199.89	14818.64	0.00
18	1148.15	147659.66	995.99	146663.67	22033.82	0.00
19	1160.07	292015.47	1082.38	290933.09	37523.88	0.00
20	1172.00	477814.28	1162.37	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.81	8264.6	0.0	2.51	1061.6

	PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
	DISCHARGE =	819.	2667.	3486.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
	FT	FT/SEC	FT/FT	FT/FT
AUXILIARY SPILLWAY ---	1.11	5.96	0.017	0.024

AUXILIARY SPILLWAY DURATION FLOW = 59.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.6 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.5 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 2667. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.64	0.18	0.035	
6	509.	692.	2.96	0.035	7.00	1.75	1.062	max.
7	692.	908.	0.18	0.035	3.02	0.25	0.049	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1129.41	9601.7	0.0	5.11	2398.6

PEAK - CFS DISCHARGE =	Q-PS	Q-AUX.	Q-TOT.
	843.	9742.	10585.

AUXILIARY SPILLWAY ---	CRITICAL DEPTH FT	CRITICAL VELOCITY FT/SEC	CRITICAL SLOPE-Sc FT/FT	25% OF Q Sc FT/FT
	2.62	9.10	0.013	0.018

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 17.0 hours
and peaked at time = 37.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 63.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 22.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 21.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 20.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 20.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 21.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 21.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 20.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 34.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION OF FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	98.0	77.4	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 4.4 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 5.4 FT

Inflow Hyd 1 SDH-Peak = 3486.20 CFS at 41.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 10584.71 CFS at 36.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---

1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****

SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	12/09/2020	12:46:36

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.52	0.	0.00	49.52	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	5.1	1129.4	0.<BREACH>	4.4		NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
HYDROGRAPH SHOWN UNDER TYPE HYD.

SITES.....SUMMARY TABLE 1 COMPLETED.

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_12H_Local.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_12H_Local.OUT
DATED 12/09/2020 12:46:36

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_12H_Local.DRG DATED 12/09/2020 12:46:36

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_12H_Local.DHY DATED 12/09/2020 12:46:36

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_12H_Local.DEM DATED 12/09/2020 12:46:36

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_12H_Local.DG* DATED 12/09/2020 12:46:36

SITES MODEL OUTPUT

– SDH / FBH ND PMP 24H LOCAL

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:45

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.518    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 *        - Boring Data from Gannett Flemming
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
              1078                        0
              1078.5                       0.00061106
              1080                        0.24057936
              1081.5                       1.54891257
              1083                        4.66459408
              1084.5                       12.8691501
              1086                        32.4875840
              1093                        335.329835
              1100.5                       1058.25464
              1106.5                       1935.72119
              1114                        3613.92381
              1120.5                       5646.02916
              1126.5                       8104.49968
              1134                        11959.3876
              1140                        15680.7669
              1147                        20779.4314
              1153.5                       27869.3012
              1160                        37409.3599
              1166.5                       47341.0760
              1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_24H_Local
WSDATA    2C 1            49.518
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       235      5        5        0.013    1082.269
 ASSURFACE 41       1100.98   0.039
        0       208.68    0.035     0.5      3       1
        208.68    225.8     0.013     0       1
        225.8     1100.98   0.035     0.5      3       1
```

```
ENDTABLE
ASDATA   41                  3                   1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                              1117.68
SAVMOV   2   101  1              1
ENDJOB

**************************************************************************
```

1SITES XEQ 12/09/2020 ---------- COMMENT PAGE ----------
VER 2005.1.8 Fordville WSID = 1

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR
- Boring Data from Gannett Flemming

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:45 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.52	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 235.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.75 30.00 1082.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 1117.68

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
1124.30 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
41 0.00 340.09 0

AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?
0.035 3.00 0.035 0.001 YES

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
ft 400.00 0.00 0.00 0.00 0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,
SIDE SLOPE WAVE BERM MULTIPLE STABILITY BERMS SEPARATE STABILITY BERMS
RATIOS WIDTH U&D/S WIDTHS DELTA H WIDTHS, ft HEIGHTS, ft
U/S D/S ft ft ft U/S D/S U/S D/S
2.50 2.50 10.0 0.0 0.00 0.00 0.00 0.00 0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

```
    0.910     0.920     0.930     0.939     0.948
    0.957     0.966     0.975     0.983     0.992
    1.000

1SITES ---------------------------------------------------------------------------
 XEQ 12/09/2020              Fordville                 WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 12:46:45         SITE = 1             PASS=   1    PART=   2

 ***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.5 SQ. MILES.

            DESIGN 0.85706     PS-1 DAY 0.94844     PS-10 DAY 0.97436.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT      0.00 AC     737.8 CFS

 CREST PS      1105.97 FT    1858.4 ACFT      0.00 AC     737.8 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT      0.00 AC     737.8 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT      0.00 AC     985.5 CFS

 START ELEV    1117.68 FT    4764.4 ACFT      0.00 AC      88.1 CFS

 ********************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.

 RATING TABLE NUMBER  1
      ELEV.   Q-TOTAL    Q-PS    Q-AUX.    VOLUME     AREA
      FEET      CFS       CFS      CFS      AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                          TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.17   197.17     0.00   5080.87     0.00
  9  1119.97   445.55   445.55     0.00   5479.87     0.00
                          FULL CONDUIT FLOW, ELEV = 1121.24 FT
 10  1121.24   766.09   766.09     0.00   5951.19     0.00
 11  1138.16   917.40   917.40     0.00  14541.46     0.00
 12  1155.08  1047.07  1047.07     0.00  30190.53     0.00
 13  1172.00  1162.37  1162.37     0.00  55908.80     0.00
```

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 3751.80 CFS, AT 42.00 HRS.
TITLE = SDH_24H_Local

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 10634.10 CFS, AT 40.00 HRS.
TITLE = FBH_24H_Local

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:45 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.1 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.68 FT 4764.4 ACFT 0.00 AC 88.1 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 3751.8 CFS, AT 42.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 10634.1 CFS, AT 40.0 HRS.
AUX. AREAL CORRECTION USED =0.8571

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00
9	1119.97	445.55	445.55	0.00	5479.87	0.00
			FULL CONDUIT FLOW, ELEV = 1121.24 FT			

10	1121.24	766.09	766.09	0.00	5951.19	0.00
11	1122.26	776.02	776.02	0.00	6368.44	0.00
12	1123.28	785.84	785.84	0.00	6785.73	0.00
13	1124.30	795.53	795.53	0.00	7203.03	0.00
14	1126.69	3171.52	817.79	2353.72	8199.62	0.00
15	1129.07	9108.54	839.46	8269.07	9425.48	0.00
16	1133.36	27597.11	877.12	26719.98	11632.00	0.00
17	1138.61	60120.95	921.06	59199.89	14818.64	0.00
18	1148.15	147659.66	995.99	146663.67	22033.82	0.00
19	1160.07	292015.47	1082.38	290933.09	37523.88	0.00
20	1172.00	477814.28	1162.37	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.81	8265.1	0.0	2.51	1062.0

PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
DISCHARGE =	819.	2669.	3488.

CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc

AUXILIARY FT FT/SEC FT/FT FT/FT
SPILLWAY --- 1.11 5.96 0.017 0.024

AUXILIARY SPILLWAY DURATION FLOW = 60.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.6 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.5 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 2669. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.64	0.18	0.035	
6	509.	692.	2.96	0.035	7.00	1.75	1.063	max.
7	692.	908.	0.18	0.035	3.02	0.25	0.049	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1129.41	9602.2	0.0	5.11	2399.2

PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
DISCHARGE =	843.	9747.	10590.

	CRITICAL DEPTH FT	CRITICAL VELOCITY FT/SEC	CRITICAL SLOPE-Sc FT/FT	25% OF Q Sc FT/FT
AUXILIARY				
SPILLWAY ---	2.62	9.11	0.013	0.018

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 24.0 hours
and peaked at time = 43.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 69.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 29.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 27.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 26.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 26.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 27.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 27.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 26.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 41.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	97.0	77.9	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 4.4 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 5.4 FT

Inflow Hyd 1 SDH-Peak = 3488.44 CFS at 47.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 10589.55 CFS at 42.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---
1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****
SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	12/09/2020	12:46:45

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.52	0.	0.00	49.52	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	5.1	1129.4	0.<BREACH>		4.4	NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
HYDROGRAPH SHOWN UNDER TYPE HYD.

SITES.....SUMMARY TABLE 1 COMPLETED.

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_Local.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_Local.OUT
DATED 12/09/2020 12:46:45

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_Local.DRG DATED 12/09/2020 12:46:45

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_Local.DHY DATED 12/09/2020 12:46:45

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_Local.DEM DATED 12/09/2020 12:46:45

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_Local.DG* DATED 12/09/2020 12:46:45

SITES MODEL OUTPUT

– SDH / FBH ND PMP 24H GENERAL

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:40

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.518    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 *        - Boring Data from Gannett Flemming
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
              1078                        0
              1078.5                       0.00061106
              1080                        0.24057936
              1081.5                       1.54891257
              1083                        4.66459408
              1084.5                       12.8691501
              1086                        32.4875840
              1093                        335.329835
              1100.5                       1058.25464
              1106.5                       1935.72119
              1114                        3613.92381
              1120.5                       5646.02916
              1126.5                       8104.49968
              1134                        11959.3876
              1140                        15680.7669
              1147                        20779.4314
              1153.5                       27869.3012
              1160                        37409.3599
              1166.5                       47341.0760
              1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_24H_General
WSDATA    2C 1            49.518
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       235      5        5        0.013    1082.269
 ASSURFACE 41       1100.98   0.039
        0       208.68    0.035     0.5      3        1
        208.68    225.8     0.013     0        1
        225.8     1100.98   0.035     0.5      3        1
```

```
ENDTABLE
ASDATA   41                  3                   1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                              1117.68
SAVMOV   2   101  1              1
ENDJOB
*******************************************************************************
1SITES XEQ 12/09/2020 ------------ COMMENT PAGE ------------------------------
    VER 2005.1.8               Fordville               WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR
- Boring Data from Gannett Flemming

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:40 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.52	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H

```
          1.00       235.00        5.00         5.00

          PS N         KE        WEIR L       TW EL
         0.013        0.75        30.00      1082.27

        2ND STG       ORF H        ORF L     START AUX.
        1117.42        1.00         3.75      1117.68

ASCRESTS -  AUX.1        AUX.2        AUX.3        AUX.4        AUX.5
        1124.30        0.00         0.00         0.00         0.00

AUX.Data -  REF.NO.    RETARD. Ci   TIE STATION    INLET LENGTH
            41         0.00       340.09            0

AUX.Data - INLET N     SIDE SLOPE      EXIT N      EXIT SLOPE     ACTUAL AUX?
          0.035         3.00         0.035         0.001          YES

BTM WIDTH -    BW1          BW2          BW3          BW4          BW5
 ft       400.00         0.00         0.00         0.00         0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1*********************     DETAILED LIST OF BASIC Data     **********************
WEIR COEF. FOR ORIFICES..... 3.10    RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10    TIME INCS TO PEAK OF UNIT HYD.  10.
DISCHARGE COEF. FOR ORIFICES..... 0.60    NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60    DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60    DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00    OTHER DRAWDOWN RATIOS APPLY ?.   NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01    WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00    WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16    AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545    AUX. SPILLWAY MIN. CAP. EXP.  0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00    MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00    PRECISION OF BW SOLUTION.....  1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00    OLD TR60 CRITERIA USED .....   NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00    OLD NHCP378 CRITERIA USED ....   NO

EMBANKMENT TEMPLATE:  TOP WIDTH = (calc.),  MAX. CROWN = 0.667 ft,
SIDE SLOPE   WAVE BERM   MULTIPLE STABILITY BERMS    SEPARATE STABILITY BERMS
   RATIOS     WIDTH     U&D/S WIDTHS   DELTA H     WIDTHS, ft   HEIGHTS, ft
  U/S  D/S     ft          ft         ft       U/S   D/S    U/S   D/S
 2.50 2.50     10.0          0.0       0.00      0.00  0.00   0.00  0.00
```

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

```
    0.910     0.920     0.930     0.939     0.948
    0.957     0.966     0.975     0.983     0.992
    1.000

1SITES ------------------------------------------------------------------------
 XEQ 12/09/2020              Fordville                 WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 12:46:40         SITE = 1             PASS=   1    PART=   2

 ***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.5 SQ. MILES.

            DESIGN 0.85706     PS-1 DAY 0.94844     PS-10 DAY 0.97436.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT     0.00 AC     737.8 CFS

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     737.8 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     737.8 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC     985.5 CFS

 START ELEV    1117.68 FT    4764.4 ACFT     0.00 AC      88.1 CFS

 ********************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.

 RATING TABLE NUMBER  1
      ELEV.   Q-TOTAL   Q-PS    Q-AUX.   VOLUME     AREA
      FEET      CFS      CFS      CFS     AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                          TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.17   197.17     0.00   5080.87     0.00
  9  1119.97   445.55   445.55     0.00   5479.87     0.00
                          FULL CONDUIT FLOW, ELEV = 1121.24 FT
 10  1121.24   766.09   766.09     0.00   5951.19     0.00
 11  1138.16   917.40   917.40     0.00  14541.46     0.00
 12  1155.08  1047.07  1047.07     0.00  30190.53     0.00
 13  1172.00  1162.37  1162.37     0.00  55908.80     0.00
```

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 3628.00 CFS, AT 46.00 HRS.
TITLE = SDH_24H_General

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 10165.70 CFS, AT 44.00 HRS.
TITLE = FBH_24H_General

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:40 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.1 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.68 FT 4764.4 ACFT 0.00 AC 88.1 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 3628.0 CFS, AT 46.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 10165.7 CFS, AT 44.0 HRS.
AUX. AREAL CORRECTION USED =0.8571

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00
9	1119.97	445.55	445.55	0.00	5479.87	0.00
			FULL CONDUIT FLOW, ELEV = 1121.24 FT			

10	1121.24	766.09	766.09	0.00	5951.19	0.00
11	1122.26	776.02	776.02	0.00	6368.44	0.00
12	1123.28	785.84	785.84	0.00	6785.73	0.00
13	1124.30	795.53	795.53	0.00	7203.03	0.00
14	1126.69	3171.52	817.79	2353.72	8199.62	0.00
15	1129.07	9108.54	839.46	8269.07	9425.48	0.00
16	1133.36	27597.11	877.12	26719.98	11632.00	0.00
17	1138.61	60120.95	921.06	59199.89	14818.64	0.00
18	1148.15	147659.66	995.99	146663.67	22033.82	0.00
19	1160.07	292015.47	1082.38	290933.09	37523.88	0.00
20	1172.00	477814.28	1162.37	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.76	8236.1	0.0	2.46	1033.1

	PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
	DISCHARGE =	818.	2530.	3348.

AUXILIARY	CRITICAL DEPTH FT	CRITICAL VELOCITY FT/SEC	CRITICAL SLOPE-Sc FT/FT	25% OF Q Sc FT/FT

SPILLWAY --- 1.07 5.85 0.018 0.024

AUXILIARY SPILLWAY DURATION FLOW = 59.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.6 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.4 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 2530. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.59	0.18	0.034	
6	509.	692.	2.96	0.035	6.85	1.69	1.029	max.
7	692.	908.	0.18	0.035	2.96	0.24	0.047	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1129.30	9545.5	0.0	5.00	2342.5

PEAK - CFS DISCHARGE =	Q-PS	Q-AUX.	Q-TOT.
	842.	9273.	10114.

AUXILIARY SPILLWAY ---	CRITICAL DEPTH FT	CRITICAL VELOCITY FT/SEC	CRITICAL SLOPE-Sc FT/FT	25% OF Q Sc FT/FT
	2.54	8.96	0.013	0.018

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 28.0 hours
and peaked at time = 47.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 74.0 hours

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 33.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 32.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 30.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 30.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 31.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 31.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 30.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 45.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	97.0	76.1	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 4.3 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 5.2 FT

Inflow Hyd 1 SDH-Peak = 3348.23 CFS at 52.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 10114.40 CFS at 46.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---
1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****
SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	12/09/2020	12:46:40

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.52	0.	0.00	49.52	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	5.0	1129.3	0.<BREACH>		4.3	NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
HYDROGRAPH SHOWN UNDER TYPE HYD

SITES.....SUMMARY TABLE 1 COMPLETED.
NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_General.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_General.OUT
DATED 12/09/2020 12:46:40

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_General.DRG DATED 12/09/2020 12:46:40

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_General.DHY DATED 12/09/2020 12:46:40

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_General.DEM DATED 12/09/2020 12:46:40

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_24H_General.DG* DATED 12/09/2020 12:46:40

SITES MODEL OUTPUT

– SDH / FBH ND PMP 48H GENERAL

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:48

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville                49.518    C2
 SAVMOV   0   101
 SAVMOV   101  1                                      1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 *        - Boring Data from Gannett Flemming
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
              1078                        0
              1078.5                       0.00061106
              1080                        0.24057936
              1081.5                       1.54891257
              1083                        4.66459408
              1084.5                       12.8691501
              1086                        32.4875840
              1093                        335.329835
              1100.5                       1058.25464
              1106.5                       1935.72119
              1114                        3613.92381
              1120.5                       5646.02916
              1126.5                       8104.49968
              1134                        11959.3876
              1140                        15680.7669
              1147                        20779.4314
              1153.5                       27869.3012
              1160                        37409.3599
              1166.5                       47341.0760
              1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_48H_General
WSDATA    2C 1            49.518
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       235      5        5        0.013    1082.269
 ASSURFACE 41       1100.98   0.039
        0       208.68    0.035     0.5      3        1
        208.68    225.8     0.013     0        1
        225.8     1100.98   0.035     0.5      3        1
```

```
ENDTABLE
ASDATA   41                  3                   1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                              1117.68
SAVMOV   2   101  1              1
ENDJOB
*******************************************************************************
1SITES XEQ 12/09/2020 ------------ COMMENT PAGE ------------------------------
    VER 2005.1.8               Fordville               WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR
- Boring Data from Gannett Flemming

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:48 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh (Ft/H)/(lb/SqFt)	PERCENT CLAY	DETACH. RATE	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.52	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND	COND L	DIA/W	-/H
1.00	235.00	5.00	5.00

```
          PS N          KE        WEIR L        TW EL
          0.013         0.75       30.00       1082.27

         2ND STG        ORF H         ORF L      START AUX.
         1117.42         1.00         3.75       1117.68

ASCRESTS -   AUX.1        AUX.2        AUX.3         AUX.4         AUX.5
         1124.30         0.00         0.00          0.00          0.00

AUX.Data -  REF.NO.    RETARD. Ci   TIE STATION    INLET LENGTH
             41         0.00       340.09            0

AUX.Data - INLET N     SIDE SLOPE      EXIT N      EXIT SLOPE     ACTUAL AUX?
           0.035         3.00         0.035         0.001          YES

BTM WIDTH -    BW1          BW2          BW3          BW4          BW5
  ft       400.00         0.00         0.00          0.00         0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1*********************     DETAILED LIST OF BASIC Data     **********************
WEIR COEF. FOR ORIFICES.......... 3.10    RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET........ 3.10    TIME INCS TO PEAK OF UNIT HYD.  10.
DISCHARGE COEF. FOR ORIFICES..... 0.60    NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ........... 0.60    DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ....... 0.60    DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ............ 0.00    OTHER DRAWDOWN RATIOS APPLY ?.   NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01    WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00    WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT........... 32.16    AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545    AUX. SPILLWAY MIN. CAP. EXP.  0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00    MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00    PRECISION OF BW SOLUTION......  1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00    OLD TR60 CRITERIA USED .......   NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00    OLD NHCP378 CRITERIA USED ....   NO

EMBANKMENT TEMPLATE:  TOP WIDTH = (calc.),  MAX. CROWN = 0.667 ft,
SIDE SLOPE   WAVE BERM   MULTIPLE STABILITY BERMS    SEPARATE STABILITY BERMS
   RATIOS      WIDTH      U&D/S WIDTHS   DELTA H     WIDTHS, ft   HEIGHTS, ft
  U/S  D/S      ft           ft         ft       U/S   D/S    U/S   D/S
 2.50 2.50     10.0           0.0        0.00       0.00  0.00   0.00  0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
```

PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900
0.910	0.920	0.930	0.939	0.948
0.957	0.966	0.975	0.983	0.992

1.000

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:48 SITE = 1 PASS= 1 PART= 2

***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF 49.5 SQ. MILES.

DESIGN 0.85706 PS-1 DAY 0.94844 PS-10 DAY 0.97436.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

PERM POOL 1105.97 FT 1858.4 ACFT 0.00 AC 737.8 CFS

CREST PS 1105.97 FT 1858.4 ACFT 0.00 AC 737.8 CFS

SED ACCUM 1105.97 FT 1858.4 ACFT 0.00 AC 737.8 CFS

2ND STAGE 1117.42 FT 4681.9 ACFT 0.00 AC 985.5 CFS

START ELEV 1117.68 FT 4764.4 ACFT 0.00 AC 88.1 CFS

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 1

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
		TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT				
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00
9	1119.97	445.55	445.55	0.00	5479.87	0.00
		FULL CONDUIT FLOW, ELEV = 1121.24 FT				
10	1121.24	766.09	766.09	0.00	5951.19	0.00
11	1138.16	917.40	917.40	0.00	14541.46	0.00
12	1155.08	1047.07	1047.07	0.00	30190.53	0.00
13	1172.00	1162.37	1162.37	0.00	55908.80	0.00

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 3737.60 CFS, AT 58.00 HRS.

TITLE = SDH_48H_General

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 10541.10 CFS, AT 56.00 HRS.
TITLE = FBH_48H_General

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:48 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.1 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.68 FT 4764.4 ACFT 0.00 AC 88.1 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 3737.6 CFS, AT 58.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 10541.1 CFS, AT 56.0 HRS.
AUX. AREAL CORRECTION USED =0.8571

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00
9	1119.97	445.55	445.55	0.00	5479.87	0.00
			FULL CONDUIT FLOW, ELEV = 1121.24 FT			
10	1121.24	766.09	766.09	0.00	5951.19	0.00

11	1122.26	776.02	776.02	0.00	6368.44	0.00
12	1123.28	785.84	785.84	0.00	6785.73	0.00
13	1124.30	795.53	795.53	0.00	7203.03	0.00
14	1126.69	3171.52	817.79	2353.72	8199.62	0.00
15	1129.07	9108.54	839.46	8269.07	9425.48	0.00
16	1133.36	27597.11	877.12	26719.98	11632.00	0.00
17	1138.61	60120.95	921.06	59199.89	14818.64	0.00
18	1148.15	147659.66	995.99	146663.67	22033.82	0.00
19	1160.07	292015.47	1082.38	290933.09	37523.88	0.00
20	1172.00	477814.28	1162.37	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.82	8267.0	0.0	2.52	1064.0

PEAK - CFS DISCHARGE =	Q-PS	Q-AUX.	Q-TOT.
	819.	2679.	3498.

CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc

AUXILIARY FT FT/SEC FT/FT FT/FT
SPILLWAY --- 1.11 5.96 0.017 0.023

AUXILIARY SPILLWAY DURATION FLOW = 61.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.6 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.5 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 2679. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.65	0.18	0.036	
6	509.	692.	2.96	0.035	7.01	1.75	1.065	max.
7	692.	908.	0.18	0.035	3.03	0.25	0.049	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1129.39	9590.3	0.0	5.09	2387.3

PEAK - CFS DISCHARGE =	Q-PS	Q-AUX.	Q-TOT.
	842.	9648.	10490.

	CRITICAL DEPTH FT	CRITICAL VELOCITY FT/SEC	CRITICAL SLOPE-Sc FT/FT	25% OF Q Sc FT/FT
AUXILIARY SPILLWAY ---	2.61	9.08	0.013	0.018

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 39.0 hours
and peaked at time = 59.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 84.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 44.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 43.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 42.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 42.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 42.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 43.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 42.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 56.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	99.0	80.4	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 4.3 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 5.3 FT

Inflow Hyd 1 SDH-Peak = 3497.99 CFS at 64.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 10490.00 CFS at 58.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.

---

1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****

SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	12/09/2020	12:46:48

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.52	0.	0.00	49.52	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	5.1	1129.4	0.<BREACH>		4.3	NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
HYDROGRAPH SHOWN UNDER TYPE HYD.

SITES.....SUMMARY TABLE 1 COMPLETED.

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_48H_General.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_48H_General.OUT
DATED 12/09/2020 12:46:48

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_48H_General.DRG DATED 12/09/2020 12:46:48

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_48H_General.DHY DATED 12/09/2020 12:46:48

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_48H_General.DEM DATED 12/09/2020 12:46:48

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_48H_General.DG* DATED 12/09/2020 12:46:48

SITES MODEL OUTPUT

– SDH / FBH ND PMP 72H GENERAL

```
********************************************************************************
 SITES XEQ 12/09/2020   WATER RESOURCE SITE ANALYSIS COMPUTER PROGRAM
    VER 2005.1.8            (USER MANUAL - DATED DECEMBER 2005)
    TIME 12:46:53

 ************************* 80-80 LIST OF INPUT Data **************************

 SITES    01/01/20051       Fordville               49.518    C2
 SAVMOV   0   101
 SAVMOV   101  1                                     1
 *        - Data from HEC-HMS model derived by Houston Engineering Inc
 *        - Stability Design and Freeboard Hydrographs from TR-60
 *        - Spillway info based off of as builts
 *        - Soil data from surveyed soil borings 2020
 *        - Elevation Storage data from 2008-2009 LiDAR
 *        - Boring Data from Gannett Flemming
 STRUCTURE 1       Fordville Dam - From TOS Bathymetry
              1078                        0
              1078.5                       0.00061106
              1080                        0.24057936
              1081.5                       1.54891257
              1083                        4.66459408
              1084.5                       12.8691501
              1086                        32.4875840
              1093                        335.329835
              1100.5                       1058.25464
              1106.5                       1935.72119
              1114                        3613.92381
              1120.5                       5646.02916
              1126.5                       8104.49968
              1134                        11959.3876
              1140                        15680.7669
              1147                        20779.4314
              1153.5                       27869.3012
              1160                        37409.3599
              1166.5                       47341.0760
              1172                        55908.8053
 ENDTABLE
 HYD      3             SDH_72H_General
WSDATA    2C 1            49.518
 PDIRECT                      0.00     0.00
 POOLDATA  ELEV     1105.971  1105.971  1078           1072     TR
 PSINLET   ELEV     0.75     30       1117.416  1       3.75
 PSDATA    1       235      5        5        0.013    1082.269
 ASSURFACE 41       1100.98   0.039
        0       208.68    0.035     0.5      3        1
        208.68    225.8     0.013     0        1
        225.8     1100.98   0.035     0.5      3        1
```

```
ENDTABLE
ASDATA   41                  3                   1
BTMWIDTH  FEET     400
ASMATERIAL
      1       23      0.059    7       105      0.22
      2       18      0.02     13      101      0.1
      3       9       0.039    9       100      0.061
      4       3       0.0013   20      75       0.0065
ENDTABLE
ASCOORD   1      SoilCementY
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1124.3   240.56   1124.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   2      Clay
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1116.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   3      Silty Sand
      0       1123.0   46.81    1124.3   208.59   1124.3
      217.95   1116.3   240.56   1114.3   245.4    1124.3
      247.84   1124.3   340.09   1124.3   509.15   1124.1
      691.68   1118.7   908.19   1118.3   938.69   1118.3
      1091.28  1118.3   1124.17  1106.4   1151.16  1101.1
      1202.58  1097.9   1310.81  1086.1   1335.57  1070.4
ENDTABLE
ASCOORD   4      Glac-Lacus
      0       1107.5   46.81    1108.8   208.59   1108.8
      217.95   1100.8   240.56   1107.3   245.4    1108.8
      247.84   1108.7   340.09   1106.6   509.15   1102.4
      691.68   1097.0   908.19   1096.6   938.69   1096.6
      1091.28  1096.6   1124.17  1084.7   1151.16  1079.4
      1202.58  1076.2   1310.81  1064.4   1335.57  1048.7
ENDTABLE
GRAPHICS  I
GO,DESIGN LCP                              1117.68
SAVMOV   2   101  1              1
ENDJOB
*******************************************************************************
1SITES XEQ 12/09/2020 ------------ COMMENT PAGE ------------------------------
    VER 2005.1.8               Fordville               WSID = 1
```

- Data from HEC-HMS model derived by Houston Engineering Inc
- Stability Design and Freeboard Hydrographs from TR-60
- Spillway info based off of as builts
- Soil data from surveyed soil borings 2020
- Elevation Storage data from 2008-2009 LiDAR
- Boring Data from Gannett Flemming

***** MESSAGE - DEFAULT TOPSOIL FILL MATERIAL PARAMETERS USED.

***** MESSAGE - AUXILIARY SPILLWAY CREST ELEVATION IS SET TO 1124.30
FROM THE ASCOORD RECORDS.

***** MESSAGE - VALUES FROM ASSURFACE, REACH 2 IMPLY NO VEGETAL COVER WITH
"n" OF 0.013.

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:53 SITE = 1 PASS= 1 PART= 1

********** MATERIAL PROPERTIES **********

MATERIAL	PI	DRY DENSITY lbs/CuFt	Kh	PERCENT CLAY	DETACH. RATE (Ft/H)/(lb/SqFt)	REP. DIAMETER inches
SoilCement	23.	105.	0.22	7.0	--	0.05900
Clay	18.	101.	0.10	13.0	--	0.02000
Silty Sand	9.	100.	0.06	9.0	--	0.03900
Glac-Lacus	3.	75.	0.01	20.0	--	0.00130
TS_FILL	0.	100.	0.05	0.0	--	0.05000
GEN_FILL	23.	105.	0.22	7.0	--	0.05900

********** BASIC Data **********
HUMID- SUBHUMID CLIMATE AREA DESIGN CLASS C

INFLOW HYDROGRAPH(S) ENTERED

PRECIP. - Q-PS,1-DAY	Q-PS,10-DAY	Q-SD	Q-FB
0.00	0.00	0.00	0.00

WSDATA - CN	DA-SM	TC/L	-/H	QRF
0.00	49.52	0.00	0.00	0.00

SITEDATA- PERM POOL	CREST PS	FP SED	VALLEY FL	378?
1105.97	1105.97	1078.00	1072.00	NO

BASEFLOW	INITIAL EL	EXTRA VOL	SITE TYPE
0.00	0.00	0.00	DESIGN

PSDATA - NO. COND COND L DIA/W -/H
1.00 235.00 5.00 5.00

PS N KE WEIR L TW EL
0.013 0.75 30.00 1082.27

2ND STG ORF H ORF L START AUX.
1117.42 1.00 3.75 1117.68

ASCRESTS - AUX.1 AUX.2 AUX.3 AUX.4 AUX.5
1124.30 0.00 0.00 0.00 0.00

AUX.Data - REF.NO. RETARD. Ci TIE STATION INLET LENGTH
41 0.00 340.09 0

AUX.Data - INLET N SIDE SLOPE EXIT N EXIT SLOPE ACTUAL AUX?
0.035 3.00 0.035 0.001 YES

BTM WIDTH - BW1 BW2 BW3 BW4 BW5
ft 400.00 0.00 0.00 0.00 0.00

AUXILIARY SPILLWAY RATING DEVELOPED USING WSPVRT.

1********** DETAILED LIST OF BASIC Data **********
WEIR COEF. FOR ORIFICES..... 3.10 RATIO OF Ia TO S (CH.10,NEH4). 0.20
WEIR COEF. FOR DROP INLET..... 3.10 TIME INCS TO PEAK OF UNIT HYD. 10.
DISCHARGE COEF. FOR ORIFICES..... 0.60 NO. POINTS FOR DESIGN HYD. ... 5000

HOOD, WEIR INLET COEF. ..... 0.60 DRAWDOWN TIME LIMIT - DAYS.... 10.0
HOOD, PIPE ENTRANCE COEF. ..... 0.60 DRAWDOWN RATIO STORAGE LIMIT.. 0.15
HOOD, SLUG FLOW COEF. ..... 0.00 OTHER DRAWDOWN RATIOS APPLY ?. NO

PS ACCURACY OF FULL FLOW CALC.,FT 0.01 WSP ALLOWABLE FSS VEL. CHANGE. 0.05
FILLET SIZE FOR BOX CONDUITS..... 6.00 WSP FSS CALC. PRECISION, FT.. 0.005

GRAVITATIONAL CONSTANT..... 32.16 AUX. SPILLWAY MIN. CAP. COEF. 237.0
MIN. NHCP378 PS PIPE AREA SQFT.. 0.545 AUX. SPILLWAY MIN. CAP. EXP. 0.493

MIN. TR60 DEPTH AUX. TO TOP DAM.. 3.00 MIN. AUX. BW IN BW SOLUTION,FT 20.0
MIN. NHCP378 DEPTH AUX.TO TOP DAM 2.00 PRECISION OF BW SOLUTION..... 1.0
MIN. NHCP378 DEPTH PS - AUX.CREST 1.00 OLD TR60 CRITERIA USED ..... NO
MIN. NHCP378 DEPTH DESIGN Q - TOD 1.00 OLD NHCP378 CRITERIA USED .... NO

EMBANKMENT TEMPLATE: TOP WIDTH = (calc.), MAX. CROWN = 0.667 ft,
SIDE SLOPE WAVE BERM MULTIPLE STABILITY BERMS SEPARATE STABILITY BERMS
RATIOS WIDTH U&D/S WIDTHS DELTA H WIDTHS, ft HEIGHTS, ft
U/S D/S ft ft ft U/S D/S U/S D/S
2.50 2.50 10.0 0.0 0.00 0.00 0.00 0.00 0.00

DIMENSIONLESS UNIT HYDROGRAPH
STANDARD DIMENSIONLESS UNIT HYDROGRAPH
PEAK FACTOR = 484.0 | TIME INC. =0.020 | NO. INC. TO PEAK = 10.
VOLUME FACTOR = 48.3429

0.0000	0.0300	0.1000	0.1900	0.3100
0.4700	0.6600	0.8200	0.9300	0.9900
1.0000	0.9900	0.9300	0.8600	0.7800
0.6800	0.5600	0.4600	0.3900	0.3300
0.2800	0.2410	0.2070	0.1740	0.1470
0.1260	0.1070	0.0910	0.0770	0.0660
0.0550	0.0470	0.0400	0.0340	0.0290
0.0250	0.0210	0.0180	0.0150	0.0130
0.0110	0.0090	0.0080	0.0070	0.0060
0.0050	0.0040	0.0030	0.0020	0.0010
0.0000				

EXISTING SURFACE OF AUXILIARY SPILLWAY - X,Y COORDINATES:

0.	1123.00
47.	1124.30
209.	1124.30
218.	1124.30
241.	1124.30
245.	1124.30
248.	1124.30
340.	1124.30
509.	1124.10
692.	1118.70
908.	1118.30
939.	1118.30
1091.	1118.30
1124.	1106.40
1151.	1101.10
1203.	1097.90
1311.	1086.10
1333.	1072.00

1NRCS DESIGN STORM RAINFALL DISTRIBUTION (CHAPTER 21, NEH4 & TR-60).

0.000	0.008	0.016	0.025	0.033
0.043	0.052	0.063	0.074	0.086
0.099	0.112	0.126	0.142	0.160
0.180	0.205	0.255	0.345	0.437
0.530	0.603	0.633	0.660	0.684
0.705	0.724	0.742	0.759	0.775
0.790	0.804	0.818	0.831	0.844
0.856	0.868	0.879	0.890	0.900

```
    0.910     0.920     0.930     0.939     0.948
    0.957     0.966     0.975     0.983     0.992
    1.000

1SITES ---------------------------------------------------------------------------
 XEQ 12/09/2020              Fordville                 WSID= 1
 VER 2005.1.8        Fordville Dam - From TOS Bathymetry        SUBW= 1
 TIME 12:46:53         SITE = 1             PASS=   1    PART=   2

 ***** MESSAGE - AREAL CORRECTIONS BASED ON DRAINAGE AREA OF   49.5 SQ. MILES.

            DESIGN 0.85706     PS-1 DAY 0.94844     PS-10 DAY 0.97436.
MESSAGE ---- Climatic Index changed from 0.0 to 1.0 for this run.

 PERM POOL     1105.97 FT    1858.4 ACFT     0.00 AC     737.8 CFS

 CREST PS      1105.97 FT    1858.4 ACFT     0.00 AC     737.8 CFS

 SED ACCUM     1105.97 FT    1858.4 ACFT     0.00 AC     737.8 CFS

 2ND STAGE     1117.42 FT    4681.9 ACFT     0.00 AC     985.5 CFS

 START ELEV    1117.68 FT    4764.4 ACFT     0.00 AC      88.1 CFS

 ********************************************************************************
 RATING TABLE DEVELOPED, SITE = 1    :
  BY PROGRAM FOR PS AND AUX. SPILLWAYS
  AUX. RATING USED WSPVRT METHOD.

 RATING TABLE NUMBER  1
      ELEV.   Q-TOTAL    Q-PS    Q-AUX.    VOLUME     AREA
      FEET      CFS       CFS      CFS      AC-FT     ACRE
  1  1105.97     0.00     0.00     0.00   1858.35     0.00
  2  1106.16     0.99     0.99     0.00   1886.72     0.00
  3  1106.36     2.81     2.81     0.00   1915.08     0.00
                          TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT
  4  1106.55     5.16     5.16     0.00   1947.55     0.00
  5  1110.17    34.72    34.72     0.00   2757.81     0.00
  6  1113.79    48.83    48.83     0.00   3568.04     0.00
  7  1117.42    59.70    59.70     0.00   4681.84     0.00
  8  1118.69   197.17   197.17     0.00   5080.87     0.00
  9  1119.97   445.55   445.55     0.00   5479.87     0.00
                          FULL CONDUIT FLOW, ELEV = 1121.24 FT
 10  1121.24   766.09   766.09     0.00   5951.19     0.00
 11  1138.16   917.40   917.40     0.00  14541.46     0.00
 12  1155.08  1047.07  1047.07     0.00  30190.53     0.00
 13  1172.00  1162.37  1162.37     0.00  55908.80     0.00
```

INFLOW HYDROGRAPH PROVIDED IN LOCATION 3, PEAK= 3747.60 CFS, AT 70.00 HRS.
TITLE = SDH_72H_General

INFLOW HYDROGRAPH PROVIDED IN LOCATION 5, PEAK= 10523.30 CFS, AT 68.00 HRS.
TITLE = FBH_72H_General

1SITES ----------
XEQ 12/09/2020 Fordville WSID= 1
VER 2005.1.8 Fordville Dam - From TOS Bathymetry SUBW= 1
TIME 12:46:53 SITE = 1 PASS= 1 PART= 3

AUX. CREST 1124.30 FT 7203.1 ACFT 0.00 AC 788.1 CFS

PS STORAGE 5344.7 ACFT, BETWEEN AUX. CREST AND SED. ACCUM ELEVATIONS.

START ELEV 1117.68 FT 4764.4 ACFT 0.00 AC 88.1 CFS

ELEVATION OF LOW POINT IS ZERO. NO CRITERIA CHECK MADE FOR
STRUCTURE CLASSIFICATION.

NRCS-SDH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 3747.6 CFS, AT 70.0 HRS.

NRCS-FBH INFLOW HYDROGRAPH INPUT, DA = 49.52 SQUARE MILES

PEAK = 10523.3 CFS, AT 68.0 HRS.
AUX. AREAL CORRECTION USED =0.8571

****
RATING TABLE DEVELOPED, SITE = 1 :
BY PROGRAM FOR PS AND AUX. SPILLWAYS
AUX. RATING USED WSPVRT METHOD.

RATING TABLE NUMBER 2

	ELEV. FEET	Q-TOTAL CFS	Q-PS CFS	Q-AUX. CFS	VOLUME AC-FT	AREA ACRE
1	1105.97	0.00	0.00	0.00	1858.35	0.00
2	1106.16	0.99	0.99	0.00	1886.72	0.00
3	1106.36	2.81	2.81	0.00	1915.08	0.00
			TRANSITION TO ORIFICE FLOW, ELEV = 1106.55 FT			
4	1106.55	5.16	5.16	0.00	1947.55	0.00
5	1110.17	34.72	34.72	0.00	2757.81	0.00
6	1113.79	48.83	48.83	0.00	3568.04	0.00
7	1117.42	59.70	59.70	0.00	4681.84	0.00
8	1118.69	197.17	197.17	0.00	5080.87	0.00

9	1119.97	445.55	445.55	0.00	5479.87	0.00
			FULL CONDUIT FLOW, ELEV = 1121.24 FT			
10	1121.24	766.09	766.09	0.00	5951.19	0.00
11	1122.26	776.02	776.02	0.00	6368.44	0.00
12	1123.28	785.84	785.84	0.00	6785.73	0.00
13	1124.30	795.53	795.53	0.00	7203.03	0.00
14	1126.69	3171.52	817.79	2353.72	8199.62	0.00
15	1129.07	9108.54	839.46	8269.07	9425.48	0.00
16	1133.36	27597.11	877.12	26719.98	11632.00	0.00
17	1138.61	60120.95	921.06	59199.89	14818.64	0.00
18	1148.15	147659.66	995.99	146663.67	22033.82	0.00
19	1160.07	292015.47	1082.38	290933.09	37523.88	0.00
20	1172.00	477814.28	1162.37	476651.91	55908.80	0.00

****

SUMMARY OF AUXILIARY SPILLWAY SURFACE CONDITIONS USED IN COMPUTATIONS BY REACH

REACH	FROM STA (ft)	TO STA (ft)	SLOPE (%)	RETARDANCE CURVE INDEX@	VEGETAL COVER FACTOR	MAINT. CODE	ROOTING DEPTH (ft)	REACH LOCATION *
1	0.	47.	-2.8	0.035	**	**	**	INLET
2	47.	209.	0.0	0.035	**	**	**	CREST
3	209.	226.	0.0	0.013	**	**	**	CREST
4	226.	340.	0.0	0.035	**	**	**	CREST
5	340.	509.	0.1	0.035	0.50	3	1.0	EXIT !
6	509.	692.	3.0	0.035	0.50	3	1.0	EXIT
7	692.	908.	0.2	0.035	0.50	3	1.0	EXIT
8	908.	1091.	0.0	0.035	0.50	3	1.0	EXIT
9	1091.	1124.	36.2	0.035	0.50	3	1.0	exit
10	1124.	1151.	19.6	0.035	0.50	3	1.0	exit
11	1151.	1203.	6.2	0.035	0.50	3	1.0	exit
12	1203.	1311.	10.9	0.035	0.50	3	1.0	exit
13	1311.	1333.	63.4	0.035	0.50	3	1.0	exit

@ The program interprets retardance curve index entries of less than 1 as
Manning's n values.
* Upper case indicates a reach of constructed spillway channel.
** The program does not use vegetal cover factor, maintenance code, and
rooting depth for inlet and crest reaches in computations.
! Reach 5 used in computing exit channel velocities.

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-SDH	400.0	1126.82	8269.4	0.0	2.52	1066.4

	PEAK - CFS	Q-PS	Q-AUX.	Q-TOT.
DISCHARGE =		819.	2691.	3510.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 1.12	FT/SEC 5.97	FT/FT 0.017	FT/FT 0.023

AUXILIARY SPILLWAY DURATION FLOW = 61.0 HOURS

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 2.6 FT/SEC
EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 2.5 FT

****

EROSIONALLY EFFECTIVE STRESS FOR STABILITY ANALYSIS OF AUX. EXIT CHANNEL
(Refer to Ag. Handbook 667, Chapt. 3, for allowable stresses.)
Aux. Spillway Discharge = 2691. cfs; Bottom Width = 400. ft

REACH NO.	FROM STA	TO STA	SLOPE %	MANNING`S n	VELOCITY ft/s	TOTAL STRESS lb/ft^2	EFFECTIVE STRESS lb/ft^2	
5	340.	509.	0.12	0.035	2.65	0.18	0.036	
6	509.	692.	2.96	0.035	7.02	1.76	1.068	max.
7	692.	908.	0.18	0.035	3.03	0.25	0.049	
8	908.	1091.	0.00	0.000	0.00	0.00	0.000	

****

ROUTED RESULTS	BTM WIDTH FT	MAX ELEV FT	VOL-MAX ACFT	AREA-MAX AC	AUX.-HP FT	VOL-AUX. ACFT
NRCS-FBH	400.0	1129.39	9588.7	0.0	5.09	2385.7

PEAK - CFS DISCHARGE =	Q-PS 842.	Q-AUX. 9634.	Q-TOT. 10476.

	CRITICAL DEPTH	CRITICAL VELOCITY	CRITICAL SLOPE-Sc	25% OF Q Sc
AUXILIARY SPILLWAY ---	FT 2.60	FT/SEC 9.07	FT/FT 0.013	FT/FT 0.018

INTEGRITY ANALYSIS - REACH SURFACE PERFORMANCE SUMMARY
(The auxiliary spillway began flow at time = 51.0 hours
and peaked at time = 70.0 hours.)

REACH 5: FROM STATION 340. TO 509. ON 0.1% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 95.0 hours.

REACH 6: FROM STATION 509. TO 692. ON 3.0% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 56.0 hours.

REACH 7: FROM STATION 692. TO 908. ON 0.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 55.0 hours.

REACH 8: FROM STATION 908. TO 1091. ON 0.0% SLOPE.
Surface unfailed: Stressed to 0% of allowable.

REACH 9: FROM STATION 1091. TO 1124. ON 36.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 54.0 hours.

REACH 10: FROM STATION 1124. TO 1151. ON 19.6% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 54.0 hours.

REACH 11: FROM STATION 1151. TO 1203. ON 6.2% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 54.0 hours.

REACH 12: FROM STATION 1203. TO 1311. ON 10.9% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 54.0 hours.

REACH 13: FROM STATION 1311. TO 1333. ON 63.4% SLOPE.
Vegetal cover failed and concentrated flow developed
at time = 53.0 hours.

INTEGRITY ANALYSIS - HEADCUT EROSION DAMAGE SUMMARY

The headcut BREACHED the spillway crest at
time equal approximately 68.0 hours.
Computations terminated at that point!

The most upstream headcut began at station 509.
and progressed upstream to station 47.
The final height of the headcut was 52.3 ft.

The deepest headcut is also the furthest upstream.

THE HYDROGRAPH WAS NOT ADJUSTED FOR THE EFFECTS OF EROSION.

	DURATION FLOW	ATTACK OE/B	DIST. FROM MOST U/S HEADCUT TO U/S EDGE
AUXILIARY	HRS	ACFT/FT	AUX. CREST, FT
SPILLWAY----	99.0	80.3	>>>BREACH<<<
		Depth = 52.3 ft	

EXIT CHANNEL FLOW SUBCRITICAL: MAX VELOCITY= 4.3 FT/SEC

EXIT SLOPE = 0.001 FT/FT
FLOW DEPTH = 5.3 FT

Inflow Hyd 1 SDH-Peak = 3509.63 CFS at 75.00 hrs., Location Point

Inflow Hyd 1 FBH-Peak = 10476.45 CFS at 69.00 hrs., Location Point
HYDOUT 1 1

1SITES....JOB NO. 1 COMPLETE.
---

1 Fordville

0 SUBWATERSHED(S) ANALYZED.
1 STRUCTURE(S) ANALYZED.
2 HYDROGRAPHS ROUTED AT LOWEST SITE.
0 TRIALS TO OBTAIN BOTTOM WIDTH FOR SPECIFIED STRESS OR VELOCITY.

****
SITES.....COMPUTATIONS COMPLETE

SUMMARY TABLE 1 SITES VERSION 2005.1.8
DATED 01/01/2005

WATERSHED ID	RUN DATE	RUN TIME
1	12/09/2020	12:46:53

>>> SITE ID	SUBWS ID	SUBWS DA (SQ MI)	CURVE NO.	TC (HRS)	TOTAL DA (SQ MI)	TYPE DESIGN	STRUC CLASS <<<
1	1	49.52	0.	0.00	49.52	TR60	C

PASS NO.	DIA./ WIDTH (IN/FT)	AUX.CREST ELEV (FT)	BTM. WIDTH (FT)	MAX. HP (FT)	MAX. ELEV (FT)	EMB. VOL. (CY)	INTEGR.* DIST. (FT)	EXIT* VEL. (FT/SEC)	TYPE HYD
1	5.0	1124.3	400.0	5.1	1129.4	0.<BREACH>		4.3	NRCS-FBH

* INTEGRITY DIST. AND EXIT VEL. VALUES ARE BASED ON THE ROUTED
HYDROGRAPH SHOWN UNDER TYPE HYD.

SITES.....SUMMARY TABLE 1 COMPLETED.

NRCS SITES VERSION 2005.1.8 ,01/01/2005
1 FILES

INPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_72H_General.D2C
OUTPUT = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_72H_General.OUT
DATED 12/09/2020 12:46:53

GRAPHICS FILES GENERATED

OPTION "L" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_72H_General.DRG DATED 12/09/2020 12:46:53

OPTION "P" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_72H_General.DHY DATED 12/09/2020 12:46:53

OPTION "E" = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_72H_General.DEM DATED 12/09/2020 12:46:53

AUX.GRAPHICS = h:\JBN\7100\7135\7135_0036\Engineering\Water Resources\SITES\Fordville - PMP ND\Fordville_FBH_SDH_72H_General.DG* DATED 12/09/2020 12:46:53