Engineer’s Report

City of Newfolden Flood Prevention Project

Prepared For:
Middle-Snake-Tamarac Rivers Watershed District

November 6, 2023

Engineer's Report

CITY OF NEWFOLDEN FLOOD PREVENTION PROJECT

Middle-Snake-Tamarac Rivers Watershed District

November 6, 2023

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 Professional Engineer under the laws of the State of Minnesota.

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Contents

1 Executive Summary 1

2 Introduction 1

2.1 Purpose 1

2.2 Location 4

3 Compatibility with Existing Plans, Statutes, and Permits 4

3.1 Middle-Snake-Tamarac Rivers Watershed District Plan 4

3.2 Marshall County Local Water Management Plan 5

3.3 Red River Basin Region Wide Goal Initiative 5

3.4 Minnesota Statutes and Rules Statutes 5

3.5 Classification Criteria and Requirements 6

3.6 State Environmental Review 7

3.7 US Army Corps of Engineers Section 404 7

3.8 Minnesota Department of Natural Resources 7

3.9 Wetland Conservation Act 7

3.10 National Pollutant Discharge Elimination System Requirements (NPDES) 7

3.11 FEMA Map Revision 8

3.12 Red River Basin Flood Mitigation Strategies 8

4 Alternatives Considered 11

4.1 Railroad Crossing Structure Modification 11

4.2 Levee Construction 11

4.3 Impoundment Sites 12

4.4 Pierce Impoundment Site 16

4.5 Diversion Channel 16

4.6 Comprehensive Project 17

5 Alternatives Analysis 19

5.1 Comparison of Alternatives 19

5.2 Alternatives Screening 20

5.3 Alternative Review 24

6 Design Guidance 24

6.1 Embankment Design Guidance 24

7 Project Components 25

7.1 Railroad Structure Modification 26

7.2 Newfolden Impoundment 26

8 Hydrology 29

8.1 Middle River Watershed 29

8.2 Design Storm Data 31

9 Existing Condition 33

9.1 Data Collection 33

9.2 Hydraulic Model Development 33

10 Proposed Condition - Railroad Structure Modification 35
10.1 Conditional Letter of Map Revision 36
11 Proposed Condition - Newfolden Impoundment 36
11.1 Geotechnical Investigation 36
11.2 Newfolden Impoundment 38
11.3 Maximum Water Surface Elevations & Downstream Impacts 43
12 Additional Considerations 45
12.1 Permitting 45
12.2 Wetland Avoidance and Mitigation 46
12.3 Right-of-Way Impacts 46
12.4 Utilities 47
12.5 Potential Groundwater Impacts 48
12.6 Environmental Consequences 48
12.7 Erosion Control 48
13 Social, Economic, and Environmental Impacts 49
13.1 Social & Economic Impacts 49
14 Operating Plan 50
15 Opinion of Probable Cost 51
16 Summary 51
Bibliography 53

Tables

Table 3-1: Red River Basin Flood Damage Reduction Measures 9
Table 4-1: Impoundment Site Ranking Matrix 13
Table 4-2: Alternatives Summary 17
Table 5-1: Pros and Cons for Improved Railroad Crossing 19
Table 5-2: Pros and Cons for Diversion Channel 20
Table 5-3: Pros and Cons for Levee 20
Table 5-4: Pros and Cons for Impoundment Sites / Comprehensive Project 20
Table 5-5: Alternatives Screening First Round 21
Table 5-6: Alternatives Screening Second Round 22
Table 5-7: Alternatives Screening Third Round 24
Table 8-1: Design Storm Rainfall Depths 32
Table 9-1: Data Sources 33
Table 9-2: NLCD Classifications Manning's n Values 34
Table 9-3: Hydraulic Loss Coefficients 34
Table 9-4: Hydraulic Structure Manning's n Values 35
Table 11-1: Outlet Structure Details 41
Table 12-1: Wetland Mitigation Requirements 46
Table 12-2: Landowner Right-of-Way 46
Table 12-3: Impoundment Utility Schedule 47

Table 14-1: Operating Plan Considerations 50
Table 15-1: Engineer's Estimate of Probable Project Costs 51

Figures

Figure 2-1: FEMA Firm Panel 2
Figure 2-2: Middle River Subwatershed 4
Figure 4-1: Alternative Locations 18
Figure 4-2: Pierce Site Location 18
Figure 5-1: Downstream Impacts Resulting from Minimum Railroad Crossing Improvement 23
Figure 7-1: Recommended Alternatives 25
Figure 7-2: Existing Railroad Structures at Newfolden 26
Figure 8-1: Subwatershed Drainage Areas 29
Figure 8-2: Middle River Subwatershed Topography 30
Figure 8-3: Middle River Subwatershed Land Use 31
Figure 10-1: Proposed Railroad Bridge Cross Section 35
Figure 10-2: Existing Landowners in Railroad Modification Footprint 36
Figure 11-1: Geotechnical Boring Locations 37
Figure 11-2: Impoundment Layout 38
Figure 11-3: Inlet Channel Typical Ditch Section 39
Figure 11-4: Typical Embankment Detail 40
Figure 11-5: Impoundment Stage-Storage Curve 40
Figure 11-6: Outlet Structure Details 41
Figure 11-7: Outlet Channel Plan View 42
Figure 11-8: Existing Outlet Channel 43
Figure 11-9: Pre-Project vs. Post-Project Inundation Extents 44
Figure 11-10: Existing vs. Proposed Middle River 100-Year 10-Day Hydrograph 45
Figure 12-1: Utility Locations 47
Figure 16-1: Proposed – 100-Year 10-Day Snowmelt Event 52

Appendices

Appendix A. Geotechnical Investigation – NTI Report 1
Appendix B. Geotechnical Evaluation – HDR 1

Acronyms

ASH	Auxiliary Spillway Hydrograph
BFE	Base Flood Elevation
BWSR	Minnesota Board of Water and Soil Resources
CD	County ditch
CFS	Cubic Feet per Second
CLOMR	Conditional Letter of Map Revision
CN	Curve Number
CPKCR	Canadian Pacific Kansas City Railway
CRP	Conservation Reserve Program
CSAH	County State Aid Highway
CSP	Corrugated Steel Pipe
DEM	Digital Elevation Model
EAW	Environmental Assessment Worksheet
FBH	Free Board Hydrograph
FDR	Flood Damage Reduction
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GLS	Glacial Lake Sediment
JD	Judicial Ditch
LiDAR	Light Detection and Ranging (survey technology)
LMGT	Lake Modified Glacial Till
LTFS	Long Term Flood Solutions
MnDNR	Minnesota Department of Natural Resources
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MSTRWD	Middle-Snake-Tamarac Rivers Watershed District
NAVD 88	North American Vertical Datum of 1988
NEH	National Engineering Handbook
NLCD	National Landcover Dataset
NOAA	National Oceanic and Atmospheric Administration
P&N	Purpose & Need Statement
PMP	Probable Maximum Precipitation
R	SCS Storage Coefficient
RCB	Reinforced Concrete Box

RCP	Reinforced Concrete Pipe
RCPA	Reinforced Concrete Pipe Arch
Red River	Red River of the North
ROW	Right-of-Way
RRBWMA	Red River Basin-Wide Modeling Approach
RRFDRWG	Red River Flood Damage Reduction Work Group
RRWMB	Red River Watershed Management Board
SSP	Smooth-Steel Casing Pipe
SWPPP	Stormwater Pollution Prevention Plan
T_C	Time of Concentration
TP 11	Technical Paper 11
TSAC	Technical and Scientific Advisory Committee
USACE	United States Army Corp of Engineers
USGS	U.S. Geological Survey
WCA	Wetland Conservation Act
WSE	Water Surface Elevation

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1 Executive Summary

The railroad structure modification and Newfolden Impoundment together form the City of Newfolden Flood Prevention Project that meets the Purpose and Need (P&N) to remove the City of Newfolden from the 1% Annual Chance Floodplain a minimum of 1 foot below the effective Base Flood Elevation set by FEMA, provide downstream flood reduction benefits, provide improvements to the local flooding near the Project location, and contribute to the Red River Basin flood reduction goals. The railroad structure modification reduces Middle River water levels in Newfolden and removes structures from the floodplain. The Newfolden Impoundment reduces runoff and breakout flows from the Judicial Ditch 21 (JD 21) system, mitigating downstream impacts to Newfolden and the Middle River, while contributing to the Red River Basin flood reduction goals. The increased flow capacity through the railroad is discussed but the main focus of this report is on the design of the impoundment. A CLOMR for the railroad structure has been submitted and reviewed by FEMA and in January 2023 construction started on the railroad structure.

This report is the Engineer Report as defined by Sec. 103D.711 MN Statutes and includes the following Project information:

- Project summary, components, and site maps
- Compatibility with existing plans, statutes, and permits
- Alternatives Analysis
- Hydrology, hydraulics, storage, inflow, and outflow
- Project components
- Geotechnical and structural design
- Wetland, right-of-way, and utility impacts, permitting
- Environmental consequences
- Erosion control
- Social and economic impacts
- Operation
- Cost estimate

2 Introduction

2.1 Purpose

The Federal Emergency Management Agency (FEMA) released a preliminary Flood Insurance Rate Map (FIRM) and Flood Insurance Study (FIS) dated October 20, 2016 placing the eastern half of the City of Newfolden in the 1% Annual Chance Floodplain, obligating all residents with structures in the floodplain area and federally secured mortgages to obtain flood insurance. This mapping became effective on March 23, 2021 as displayed in Figure 2-1.

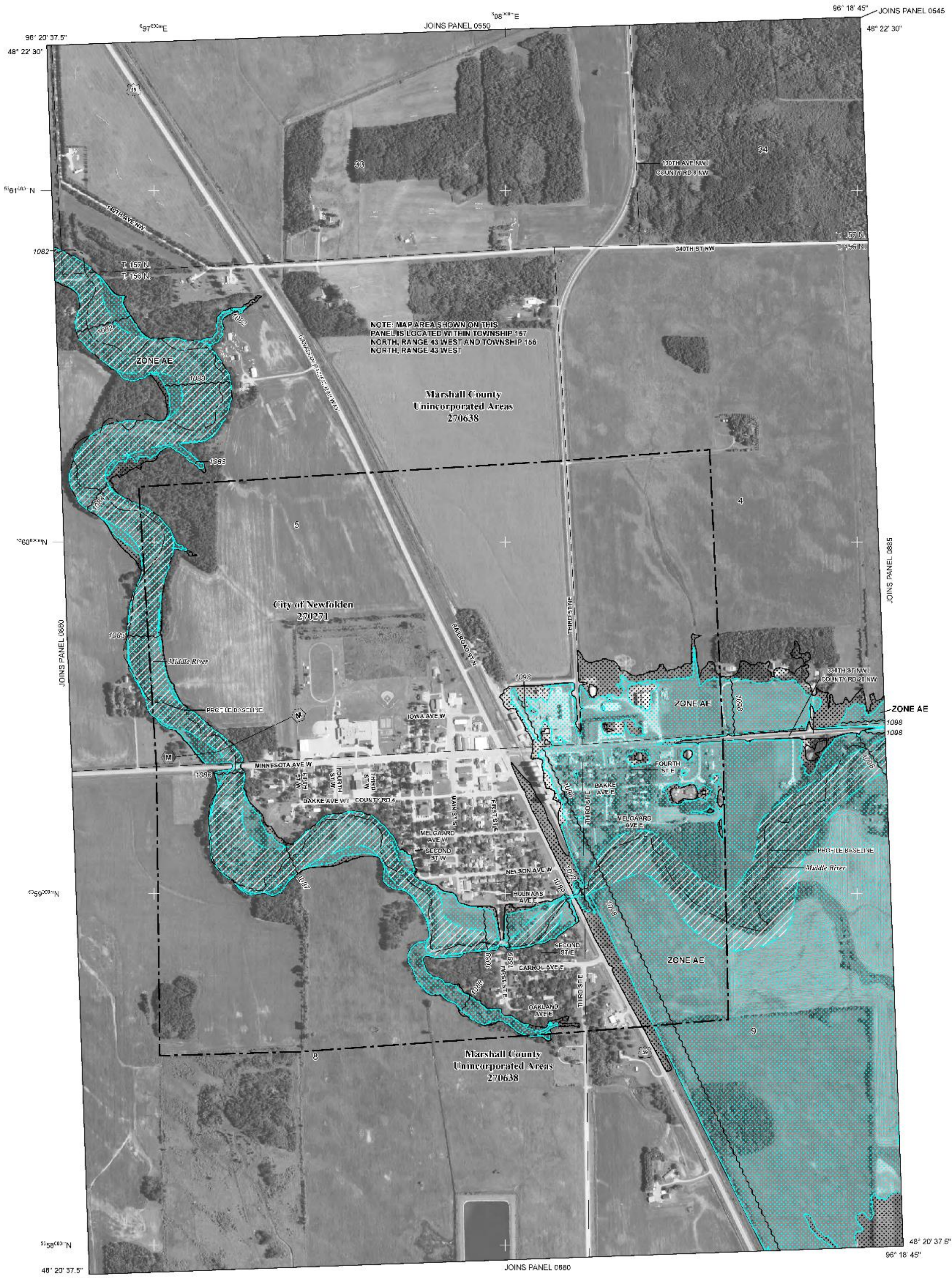


Figure 2-1: FEMA Firm Panel

A Project Work Team consisting of local landowners, the Middle-Snake-Tamarac Rivers Watershed District (MSTRWD), the City of Newfolden (City), the Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MNDNR), the United States Army Corps of Engineers (USACE), and the Minnesota Board of Water and Soil Resources (BWSR) was formed to address flooding in the area. The Project Work Team Process developed and accepted the following Purpose & Need (P&N) statement:

> *"The purpose of the Project is to remove the City of Newfolden form the 1% Annual (100-year) Floodplain a minimum of 1 foot below the accepted Base Flood Elevation (BFE) set by FEMA."*

The City partnered with the MSTRWD in 2017 and hired HDR to perform a flood damage reduction study within the Middle River Subwatershed near the City of Newfolden, Minnesota.

The alternatives evaluated from the "Concept Feasibility Study" and the "Alternatives Analysis Study" were modifications to the railroad crossing structure within the Middle River, two levee alignments protecting the eastern portion of Newfolden, two diversion channel alignments to direct flows from the Middle River around Newfolden, and six impoundment sites. A comprehensive project was also considered which would include a combination of the alternatives previously listed.

The selected Project consists of increased flow capacity through the railroad and an impoundment. The Project's primary goal is to meet the P&N statement, while providing downstream flood reduction benefits, and improvements to the local flooding near the Project location.

2.2 Location

The Middle River Subwatershed is located in northwestern Minnesota and is one of three watersheds that form the Middle-Snake-Tamarac Rivers Watershed District. The Middle River has a drainage area of approximately 295 square miles, is 95 miles long, and joins the Snake River before entering the Red River of the North, see Figure 2-2.

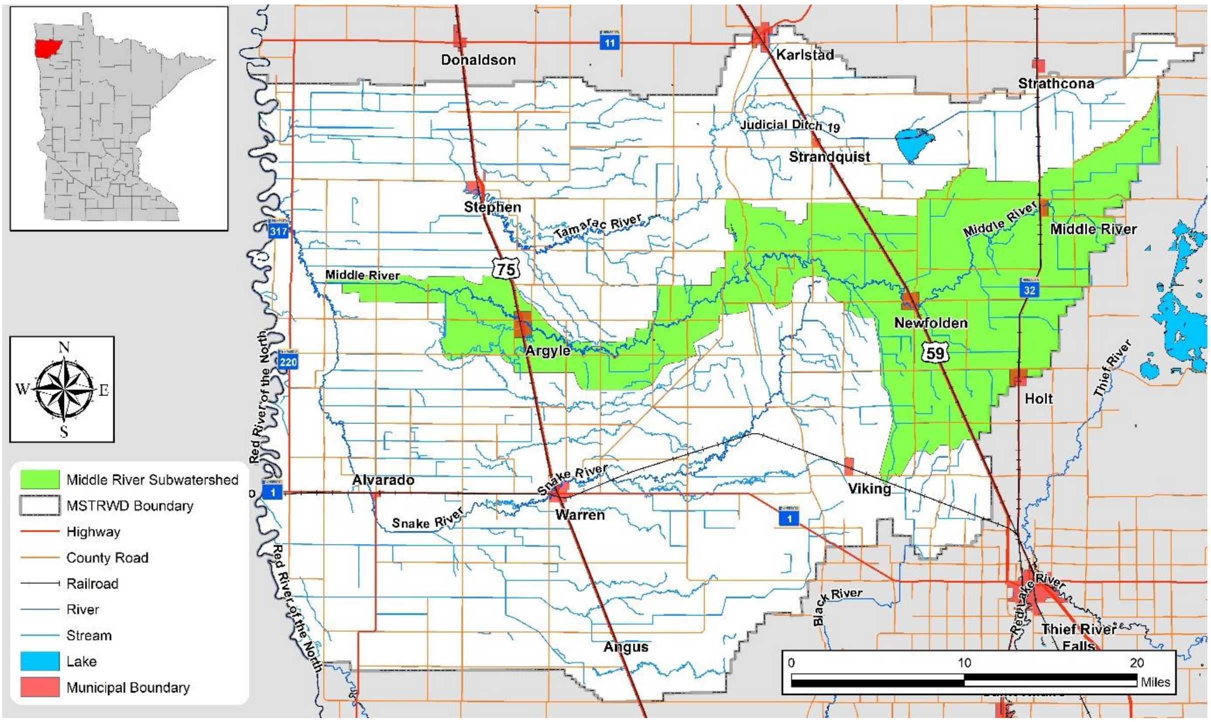


Figure 2-2: Middle River Subwatershed

All elevations in this report are in the North American Vertical Datum of 1988 (NAVD 88).

3 Compatibility with Existing Plans, Statutes, and Permits

The following plans, statues, rules, and initiatives were used to establish the criteria used to design the Project.

3.1 Middle-Snake-Tamarac Rivers Watershed District Plan

The mission of the Middle-Snake-Tamarac Rivers Watershed District is to manage the District's resources for the efficient movement of water across the District for purposes of reducing flooding, providing agricultural drainage and to protect and improve water quality.

It is the intention of the Board to manage the waters and related resources within the Watershed District in a reasonable and orderly manner to improve the general welfare and public health of the residents of the Watershed District in accordance with their 10-year overall comprehensive plan.

The managers of the MSTRWD accept the responsibilities with which they are charged as a governing body by Minnesota Statutes. Said Board of Managers, in the conduct, duties and responsibilities conferred upon them, do not intend to usurp the authority or responsibilities of other agencies or governing bodies; however, said Board of Managers will not avoid their responsibilities and obligations.

3.2 Marshall County Local Water Management Plan

The purpose of the Local Water Management Plan for Marshall County is:

- To identify existing and potential problems and opportunities for protection, management and development of water resources and related land resources in Marshall County.

Goals in this water plan that contribute to the Project include:

- Priority Concern 1: Wind and water soil erosion as they relate to impairments to surface waters and loss of soil.
- Priority Concern 3: Continued flood damage reduction, management of drainage, and coordination of agencies with management impoundments and reservoirs.

3.3 Red River Basin Region Wide Goal Initiative

The Red River Basin Commission established a 20 percent reduction in peak flows goal along the Red River of the North during a flood event similar to the 1997 event. The plan in place specifies that each tributary along the Red River must strive to meet their individual specific goals in reducing both peak flow and volume that have been set for them in the Red River Basin Commission's (RRBC) Long Term Flood Solutions (LTFS) Basin Wide Flood Flow Reduction Strategy Report. The goals for the Middle River Subwatershed were determined to be a 35% peak flow reduction and a 23% overall volume reduction at the USGS gage on the Middle River at Argyle, MN (USGS Gage 05087500). This 35% peak flow reduction is equivalent to 1,330 cubic feet per second (cfs) and the 23% volume reduction is equivalent to storing 15,067 acre-feet of water. The MSTRWD has constructed several impoundment facilities since 1997 and is continually looking for opportunities to contribute toward the overall flood damage reduction goals and enhance the region. There are currently no impoundment facilities within the Middle River Subwatershed.

3.4 Minnesota Statutes and Rules Statutes

Section 103D of Minnesota Statutes pertains to Watershed Districts. Section 103D.335, Subd. 5 enables watershed districts to exercise the power to "…make necessary surveys or utilize other reliable surveys and data and develop projects to accomplish the purposes for which the district is organized." Section 103D.335, Subd. 8 gives the watershed district the power to "…construct, clean, repair, alter, abandon, consolidate, reclaim, or change the course or terminus of any public ditch, drain, sewer, river, watercourse, natural or artificial, within the district." In addition, Section 103D.335, Subd. 9 give the power to "…acquire, operate, construct, and maintain dams, levees, and reservoirs, and appurtenant works.

Also required by Section 103D.711 is the preparation of an "Engineer's Report" with the following requirements:

- A scaled map of the area to be improved.
- Location of the proposed improvements; location of respective outlets.

- The watershed of the Project Area; the location of existing highways, bridges and culverts.
- All lands, highways, and utilities affected, together with the names of the owners thereof, so far as known; the outlines of any public lands and public bodies of water affected; potential benefiting lands; easement maps; and principal Project features.

3.5 Classification Criteria and Requirements

Criteria for dam hazard classification are provided from the State of Minnesota. The State of Minnesota may regulate dams if the impoundment storage is more than 15 acre-feet and the height of dam is more than 6 feet. The State classifies dams into three hazard types, as described in Minnesota Administrative Rules 6115.0340, Classification of Dams:

- Hazard Class I: any loss of life or serious hazard, or damage to health, main highways, high-value industrial or commercial properties, major public utilities, or serious direct or indirect, economic loss to the public;
- Hazard Class II: possible health hazard or probable loss of high-value property, damage to secondary highways, railroads, or other public utilities, or limited direct or indirect economic loss to the public other than that described in Class III; and
- Hazard Class III: property losses restricted mainly to rural buildings and local county and township roads which are an essential part of the rural transportation system serving the area involved.

Below is a summary of requirements according to MN Rule 6115.0410, New Dams or Enlargements.

- Permit Application – owner and dam description
- Preliminary Report
    - project features
    - site maps,
    - site conditions,
    - typical cross sections,
    - design assumptions,
    - hydrology & hydraulics,
    - flood routing/breach analysis,
    - operations,
    - structural,
    - geotech,
    - boring logs,
    - cost estimate,
- Final Design Requirements – project description, service life, storage area, free board, dam break flood, construction considerations, construction quantities, seepage studies, responsibilities, emergency procedure, detailed cost estimate
- Plans and Specifications
- Permit Standards – potential hazards to the public and environment
- Work Inspection and Construction Reports – conformity with approved designs, plans, and specs, permanent vertical and horizontal control, construction report
- As-built Plans

- Statement of Completion
- Issuance of Approval
- Performance Reports

3.6 State Environmental Review

Minnesota Rules Chapter 4410 requires the preparation of an Environmental Assessment worksheet (EAW). The mandatory preparation of an EAW (Minnesota Rules 4410.4300, subpart 24) is necessary for "Construction of a dam with an upstream drainage area of 50 square miles or more" or "permanent impoundment of water creating additional water surface of 160 or more acres", or (Minnesota Rules 4410.4300, subpart 27) "for projects that will change or diminish the course, current, or cross-section of one acre or more of any public water or public waters wetland except for those to be drained without a permit pursuant to Minnesota Statutes, chapter 103G." The Newfolden Impoundment has a drainage area of approximately 11 square miles, and the proposed impoundment will be "dry", not permanently impounding water. Also, the Project is not considered to be filling or draining public waters, and the Project is not anticipated to disturb more than one acre of public water wetlands. Based on this information, the mandatory preparation of an EAW for this Project is not required.

3.7 US Army Corps of Engineers Section 404

A Section 404 permit will be required by the USACE because wetland impacts will occur by the construction and operation of the proposed Project, such as placement of fill within wetlands, common excavation, and impacts from general construction practices within the construction footprint. USACE permitting authorities will be consulted regarding the proposed Project. The permit will also review any additional wetland impacts due to construction.

3.8 Minnesota Department of Natural Resources

The proposed Project requires a dam safety permit from the MnDNR in accordance with Minnesota Rules 115.0410. The purpose of these rules is to regulate the construction and enlargement of dams, as well as the repair, alteration, maintenance, operation, and abandonment, in such a manner as to best provide for public health, safety, and welfare.

A Minnesota Department of Natural Resources Public Waters Permit, in accordance with Minnesota Rules 6115.015, will be required for construction taking place within a public water or below the Ordinary High Water (OHW) elevation of a public water. The Middle River is considered a public water and modification of the railroad structure will require a permit.

3.9 Wetland Conservation Act

A Wetland Conservation Act (WCA) permit will be required for the Project. The permit will include a review of all wetland impacts due to the footprint, operation, bounce, flood frequency, water depth, and construction of the proposed Project.

3.10 National Pollutant Discharge Elimination System Requirements (NPDES)

A storm water permit will be required for the construction of this Project. The permitee will develop a stormwater pollution prevention plan (SWPPP) that focuses on discharges from the site into public waters. Each party under regulation determines the most appropriate best management practices (BMPs) that should be implemented to minimize pollution for the specific site.

3.11 FEMA Map Revision

The remapping of the City of Newfolden due to the design of a flood damage reduction project will first go through the process of submitting a Conditional Letter of Map Revision (CLOMR) to the MnDNR for review and then to FEMA. Once the CLOMR process is determined complete, a Letter of Map Revision (LOMR) would be submitted to FEMA finalize the remapping effort.

3.12 Red River Basin Flood Mitigation Strategies

The Red River Flood Damage Reduction Work Group (RRFDRWG) Agreement of December 1998 is the framework for FDR projects in the Red River Basin. The purpose of the mediation process was to reach an agreement on long-term solutions for reducing flood damage and ensuring the protection and enhancement of natural resources. The MSTRWD encourages participation by local, state and federal governments, natural resource agencies, conservation organizations, and local citizens in the planning process. The Project is consistent with the Mediation Agreement goals adopted by the RRWMB and RRFDRWG.

The RRFDRWG formed a Technical and Scientific Advisory Committee (TSAC) to provide a series of technical papers that provide guidance to FDR methods. Technical Paper 11 (TP 11) was designed to provide guidance on where specific FDR methods can be placed in the Red River Basin to achieve the greatest benefits locally and downstream.

TP 11 has divided the Red River Basin into three timing zones for flows entering the main stem of the Red River of the North. These zones are the “Early Zone”, “Middle Zone”, and “Late Zone” runoff areas. Each area has recommended potential flood damage reduction measures that can be implemented to reduce flooding throughout the watershed. The Middle River Subwatershed is located near the border of the “Middle Zone” and “Late Zone”. Table 3-1 provides a list of the flood reduction measure types, how they may be implemented within the Middle River Subwatershed, and the effectiveness in meeting the Project goal. These reduction measures become important to consider for State Flood Damage Reduction and Red River Watershed Management Board funding. In order to obtain the maximum funding from either of these sources, it is beneficial to have a multi-purpose project that benefits the local and regional subwatersheds.

Table 3-1: Red River Basin Flood Damage Reduction Measures

Reduction Measure Types	Potential Applications within Middle River Subwatershed	Appropriateness / Ranking
Reduction of Flood Volumes	Conversion of upland areas to alternate land use, creation of wetlands, or cropland BMPs to reduce downstream runoff volumes and rates	Likely or substantial positive effects on downstream flooding
Increase Crossing Capacity	Increasing the flow capacity of the existing railroad structure within the Middle River or construct a diversion of the Middle River to reduce flood damages within Newfolden	Negative impact to downstream flooding
Protection / Avoidance	Evacuation of the floodplain or flood proofing of structures	Negative impact to the City of Newfolden & local economy
Temporary Flood Storage	Create Impoundments to reduce downstream peak flow rates	Likely or substantial positive effects on downstream flooding

Reduction of Flood Volumes

TP 11 specifies that a significant reduction in flood volumes could be attained by the creation or restoration of wetlands, converting cropland to grassland or forest, or implementing cropland BMP's such as forms of conservation tillage.

Transforming lands could potentially have a negative impact on the local economy and landowners. Requiring landowners to convert existing cropland to unproductive lands or implement best management practices would not be a practical solution as a flood control measure due to the limited percentage of land in production that is existing near Newfolden and the likely resistance from landowners due to loss of income. There is currently a high percentage of land that is forested or native grasslands in the surrounding area and upstream of Newfolden. Therefore, converting the remaining land would not result in benefits greater than the costs. As a result, this alternative has been dismissed from further consideration.

Increase Road Crossing Capacity

Increases to the railroad crossing capacity would reduce the flooding impacts east of the railroad tracks within Newfolden. An approach to increase the capacity could be to horizontally bore a smooth-steel casing pipe (SSP) through the existing railroad embankment, construct a new crossing with increased culvert sizes, or construction of a bridge. Another potential approach would be to divert a portion of the flow from the Middle River around the City of Newfolden to regulate the flows through the city. Each of these approaches could alleviate the flooding damages east of the railroad tracks but may also increase flow rates and the potential flooding in downstream areas. Technical Paper 11 states that there would be "likely negative impacts to downstream flooding" as a result of increasing conveyance capacities. As a result, this strategy would be difficult to fund through the Red River Watershed Management Board or the State Flood Damage Reduction program. Obtaining a Minnesota Department of Natural Resources Public Waters Permit and a MSTRWD permit without a retention area to mitigate the increased flow would be difficult due to the increased flow rates and potential downstream flood impacts. These strategies were outlined in the "Concept Feasibility Study" dated October 17, 2016 and were carried forward to the alternatives analysis since they could address the Purpose & Need statement either as a stand-alone alternative or within a comprehensive project.

Protection / Avoidance

Protection or avoidance is the removal of assets from the possibility of being impacted by flood damage. This strategy could be implemented within the City of Newfolden by the following:

- Buy-out of flood threatened homes and structures within the floodplain and restrict development in those areas
- Construct levees through the City along the Middle River
- Raise homes and structures above the BFE
- Flood-proof homes and structures at their current locations

The buy-out of flood threatened homes and structures would remove the entire eastern half of the city, force dozens of families to find new homes, and cause a tremendous negative impact to the area economy. The construction of levees would not address the Purpose & Need statement, would potentially result in the buyout of several homes, and could negatively impact landowners upstream and adjacent to the levee by increasing the floodwater elevation. Raising and the flood-proofing of homes also does not address the Purpose & Need statement and could cause an economic strain on landowners. Raising homes and structures also leads to uncertainty each year that natural occurrences such as ice jams could lead to a higher than anticipated flood elevation. As a result, this strategy was removed from further consideration but the results from the levee alternative were documented and studied in the "Concept Feasibility Study" dated October 17, 2016. This study does address the pros and cons of this strategy for this analysis.

Temporary Flood Storage

Flood storage is an effective method to reduce flood damage when impoundments are created to capture water at specific times of the local hydrograph. Impoundments can be designed for all three areas within the Red River Basin but are most effective at reducing downstream flooding when they are located within the "Middle" or "Late" zones. These locations would remove water from the early limb and peak of the local hydrograph. This would reduce the local water from contributing to the peak of the main river flows. Impoundments located in the "Early" area would be designed to remove water from the falling limb of the local hydrograph to prevent the later water from contributing additional water to a flood situation.

The "Concept Feasibility Study" determined that temporary flood storage could be an effective method in reducing the BFE at Newfolden and provide local drainage benefits. The BFE reduction will likely require a risk assessment to determine credible potential failure modes and consequences and analyze whether the Project will successfully reduce the risks to the desired level. The reduced risk determination would then be reflected in reduced BFE's. The Feasibility Study documented the vetting of ten potential impoundment sites. From the study, five favorable sites were recommended as alternatives to carry forward for further analysis. These five sites were carried forward in the "Alternatives Analysis Study" dated April 2, 2018 as stand-alone alternatives and as a comprehensive alternative in conjunction with other flood reduction measures for further evaluation.

4 Alternatives Considered

The alternatives evaluated from the "Concept Feasibility Study" and the "Alternatives Analysis Study" were modifications to the railroad crossing structure within the Middle River, two levee alignments protecting the eastern portion of Newfolden, two diversion channel alignments to direct flows from the Middle River around Newfolden, and six impoundment sites. A comprehensive project was also considered which would include a combination of the alternatives previously listed.

4.1 Railroad Crossing Structure Modification

Six culvert structure alternatives under the railroad were initially analyzed. The structures vary in size and type from a single smooth-steel pipe to multiple box culverts. The goal of a one-foot reduction was applied to the results and it was concluded that the minimum structure required to meet the reduction goal would be the addition of two 60" Smooth-Steel Pipes. Based on this level of study, a structure with a minimum flow area of approximately 39 square feet would be required in addition to the existing structures to meet the P&N statement.

4.2 Levee Construction

Two levee alignments were analyzed to protect Newfolden east of the railroad tracks. These levees would require formal levee certification by an engineer, have a minimum side slope of 3:1 (H:V), and be constructed to a top elevation that is a minimum of three feet above the BFE to account for the required freeboard.

The first levee alignment would start at the Newfolden Co-Op Elevator and be constructed south, parallel to the railroad tracks. The levee would then pass east along East Melgaard Avenue to the eastern city limits. At that point, it would follow the city limits north until it reaches East Minnesota Avenue. This alignment would not provide protection to at least three homes due to their close proximity to the Middle River and may require the buyout of the homes or buildings. This alignment would also require the relocation of utilities and potentially the realignment or modification of existing City streets.

The second alignment would be identical to the first alignment but would continue east of East Melgaard Avenue and include the field directly east of the existing City limits. This additional land was included to account for potential future developments and provide additional flood protection. Each levee alignment is displayed in the "Alternatives Analysis Study".

4.3 Impoundment Sites

To meet the goals set by the Project Team, temporary storage of floodwaters upstream or downstream of Newfolden through the use of impoundment sites has been analyzed as an alternative. Using the regional assessment locations previously discussed, a LiDAR-derived digital elevation model (DEM) was utilized in ArcGIS to assess the Middle River Subwatershed and locate sites which have the potential to temporarily store excess runoff and therefore reduce peak discharges that would impact Newfolden. Sites were identified where there was a sufficient difference in topography for gated storage and where there would be minimal impact to residences and farms. These sites were further analyzed to determine where feasible bypass ditches could be constructed to divert runoff into the impoundment sites. The potential sites evaluated were ranked based on eight criteria to create an overall ranking matrix of the sites. The ranking criteria relates to storage capabilities, environmental impacts, landowner impacts, and constructability. The list of ranking criteria from the "Alternatives Analysis Study" is displayed in Table 4-1.

Table 4-1: Impoundment Site Ranking Matrix

Rating Multiplier	3.5		1		0.5		3		4		2.5		2		1.5			
SITE	Drainage Area Captured (Sq. Mi)	Rank	Elevation Drop Across Site (Ft)	Rank	Embankment Height (Ft)	Rank	Acres of Wetlands Impacted	Rank	AC-FT Storage	Rank	Inches of Runoff Captured	Rank	Number of Landowners Affected	Rank	Footprint (Acres)	Rank	Sum	Final Rank
A	22.7	4	10.0	6	12.0	5	27	5	1640.7	6	1.4	8	5	6	411	5	101.0	7
B	20.7	5	10.5	5	12.5	6	4	1	2493.0	3	2.3	4	2	2	463	6	63.5	1
C	62.7	1	11.5	2	13.5	8	6	2	2256.8	4	0.7	10	3	3	622	8	74.5	2
D	33.5	2	11.5	2	13.5	8	65	9	2876.1	2	1.4	7	7	10	642	9	99.0	6
E	25.0	3	6.0	8	8.0	2	50	7	1582.0	8	1.2	9	5	6	581	7	117.5	9
F	19.5	6	11.0	4	13.0	7	8	4	1630.5	7	1.6	6	3	3	293	3	94.0	4
G	9.7	7	9.0	7	11.0	4	6	3	1747.0	5	3.4	2	3	3	292	2	76.5	3
H	8.9	8	17.5	1	19.5	10	467	10	11318.0	1	23.8	1	5	6	1295	10	97.5	5
I	4.5	10	4.5	10	6.5	1	44	6	452.9	10	1.9	5	5	6	134	1	129.5	10
J	7.7	9	6.0	8	8.0	2	52	8	991.4	9	2.4	3	1	1	364	4	116.0	8

Legend	
1	Most Favorable
2	
3	
4	
5	
6	
7	
8	
9	
10	Least Favorable

Storage volume and drainage area were chosen as the priority ranking criteria for each site. Each potential drainage area was chosen using LiDAR to determine where runoff could be captured based on topography and existing waterways. The watershed planning tool on the Red River Basin Decision Information Network website was used to calculate the drainage area captured by each waterway that would be directed into the impoundment site. The total inches of runoff over the drainage area that the impoundment site would effectively store was determined by dividing the storage capacity by the total drainage area. Using ArcGIS, the potential site footprint was estimated, and the gated storage elevation was determined based on the adjacent land elevation of the upstream ditches or roads. A stage-storage curve was created to determine the capacity of the gated storage. Two feet of freeboard was then added to the gated storage elevation to obtain the top of embankment elevation to provide the recommended freeboard. Using the flooded footprint, the impacts to wetlands and landowners was then determined. Table 4-1 summarizes the ranking procedure outlined in the following section. A total of ten sites were ranked with a value of one being the most favorable and a value of ten as the least favorable. A weighted value was assigned to each ranking criteria, with a higher weight assigned to the criteria that were deemed to be more influential in site feasibility. The weighted rank values where then summed for each of the sites with the lowest total receiving a final rank of one and the largest value a rank of ten.

Site Analysis

The top five retention sites based on the results of the matrix displayed in Table 4-1 were analyzed. The sites included Site A, Site B, Site C, Site F, and Site G. The location of these sites is displayed in Figure 4-1. A majority of the landowners within these sites were contacted in order to obtain feedback regarding these locations, identify poorly draining areas, and their current interest in participating in the alternatives process. The sites were then analyzed to determine the feasibility of capturing a large volume of water that would reduce the water surface elevation a minimum of 1' below the existing BFE for the eastern portion of Newfolden. These sites are all preliminary and changes may occur in geometry, storage capacity, and effectiveness.

HEC-RAS was used to analyze the potential effects the top five sites would have on reducing the flood impacts east of the railroad tracks in Newfolden. Each of the sites was modeled by modifying the existing conditions unsteady HEC-RAS model in order to keep the geometry consistent. Site specific operating plans for each of the potential sites, inlet/outlet structure sizing, and ditch capacities were approximated. A summary of the results is provided in the following sections. The layout of each site was determined based on maximizing the benefits to Newfolden and the local drainage area.

Site A

Site A is located in section 10 of New Folden Township, one mile east of Newfolden. The tentative footprint is approximately 460 acres and impacts four landowners. There is an average of eight feet in elevation difference across the site from east to west. There would be approximately 2,300 acre-feet of storage at the maximum elevation of 1109.5' and the top of the embankment walls would be at an elevation of 1111.5'. Water would be diverted from the County Ditch 2 (CD 2) and County Ditch 25 Lateral 4 (CD 25 Lat. 4) drainage areas by constructing a gated structure within the ditch channel. A new inlet ditch would be constructed parallel to County State Aid Highway (CSAH) 28 on the south edge and would transport the diverted flows to the site. Minor diking would occur along the ditch near the site to prevent water from breaking into the neighboring landscape when the impoundment was at maximum capacity. Exterior ditches would be constructed along the dry side of the embankment walls to direct exterior runoff around the site. The outlet would be located on the west wall of the site and discharge to the Middle River through an existing coulee.

Site B

Site B is located in Section 11 of New Folden Township, two miles east of Newfolden. The current footprint is approximately 480 acres and impacts one landowner. There is an average of twelve feet in elevation difference across the site from east to west. There would be approximately 2,500 acre-feet of storage at an elevation of 1119.0' and the top of the embankment walls would be at an elevation of 1122.0'. Water would be diverted from the CD 2 and CD 25 Lat. 4 drainage areas by replacing the existing reinforced concrete arch pipe (RCPA) with a small diameter culvert and constructing an inlet channel to bypass flows to the impoundment site. The new inlet channel would be constructed parallel to CSAH 28 on the south side. Minor diking would occur along the ditch near the site to prevent water from breaking into the neighboring landscape when the impoundment was at maximum capacity. Exterior ditches would be constructed along the dry side of the embankment walls to direct exterior water around the site. The outlet would be located on the west wall of the site and discharge to the Middle River through an improved ditch along the southern side of CSAH 28.

Site C

Site C is located in Section 3 of Marsh Grove Township and is three miles west of Newfolden. The current footprint is approximately 625 acres and impacts three landowners. There is approximately ten feet in elevation difference across the site from east to west. There is approximately 2,250 acre-feet of storage at an elevation of 1073.0' and the top of the embankment walls would be at an elevation of 1075.0'. Water would be diverted from Judicial Ditch 15 (JD 15) along the north side of CSAH 28 through the construction of an inlet ditch and a gated structure within JD 15. Dikes would be required along the diversion ditch in order to prevent water from high flows from breaking out into adjacent overland areas. Exterior ditches would be constructed on the dry side of the embankment walls to direct exterior runoff around the site. The outlet would be located in the northwest corner of the site and discharge under 180th Avenue Northwest to an improved existing ditch. This site provides downstream storage for Newfolden. To achieve the most for Newfolden, flows from County Ditch 40 (CD 40) could be diverted west through the railroad tracks and enter the County Ditch 15 system (CD 15). The CD 15 system would then be diverted west to the JD 15 system. Each system would need modifications to increase their capacity.

Site F

Site F is located in Section 36 of New Main Township and Section 31 of Spruce Valley Township. It is approximately four miles northeast of Newfolden. The proposed footprint is approximately 300 acres and impacts three landowners. There is approximately eleven feet in elevation difference from east to west across the site which equates to approximately 900 acre-feet of storage. The maximum water surface elevation within the site is 1124.0' and the top of embankments walls is at an elevation of 1126.0'. Water would be diverted from County Ditch 2 (CD 2) to the northeast corner of the site by constructing a gated structure within CD 2 and directing flows to an inlet ditch. In order for the impoundment to fill to its maximum elevation, a gate or weir structure would be required at the inlet to prevent the stored water from back flowing through the inlet ditch as the water in CD 2 recedes. Exterior ditches would be constructed along the dry side of the embankment walls for exterior runoff at the site. The outlet would be located in the west wall of the site and would outflow to an existing coulee.

Site G

Site G is located in Section 33 of New Maine Township, which is approximately 1.5 miles north of Newfolden. The proposed footprint is approximately 396 acres and impacts four landowners. There is an average of eleven feet of elevation difference across the site from north to south. There is approximately 2,000 acre-feet of storage at an elevation of 1106.0 feet. The top of the embankment walls would be at an elevation of 1109.0 feet. Water would be diverted from Judicial Ditch (JD) 21 to the west on the north side of County Road 30 (350th St. NW), pass under County Highway 8, and flow south into the site. Exterior ditches would be constructed along the dry side of the embankment walls for local runoff at the site. The outlet would be on the southern wall and discharge back into JD 21.

4.4 Pierce Impoundment Site

The Pierce Impoundment Site is located on the JD 21 system at Hawkes Manufacturing Inc. Hawkes Manufacturing Inc. currently has a peat harvesting site approximately five miles north of Newfolden. The impoundment site would utilize the storage and berms created when the peat is harvested. There are currently six potential sites that could be transitioned into temporary storage locations and additional sites will be created as future harvests take place. The site would capture flows from the JD 21 system through earthwork and the construction of gates or weirs. These sites would discharge back into JD 21. Hawkes Manufacturing Inc. and the six parcels are displayed in Figure 4-2.

4.5 Diversion Channel

A diversion channel was proposed north of Newfolden along the southern side of 340th Street Northwest. The channel would begin at the Middle River at an invert of approximately 1097.0' and divert high water approximately 2.25 miles west under County Highway 8 to the railroad tracks. The channel would then pass water into the existing JD 21 outlet, through the railroad tracks, and under U.S. Highway 59 into an existing coulee to the river. The bottom width would be approximately 20 feet and have side slopes of 4:1 (H:V). The existing coulee would be improved by increasing the capacity, stabilizing the banks by cutting the slopes back, and implementing rock drop structures to prevent erosion at the river.

A second diversion channel alignment was analyzed on the north side of County Road 30. The channel would begin at the Middle River and divert high water to the west for approximately 2.25 miles to JD 21. The water could then travel around Newfolden within an improved JD 21 channel or continue to travel west to the location of Site G. Diverting the water upstream of Site G would provide the opportunity for storable water from the Middle River. The second diversion channel would require a deep cut through a ridge containing a mixture of silty gravel. The side slopes required would be at a minimum of 4:1 (H:V). The top width of the channel is approximately 200 feet in areas through the ridge and approximately 20 feet in depth. Each diversion alignment is displayed in Figure 4-1.

4.6 Comprehensive Project

A comprehensive project was considered to maximize the benefits by combining multiple alternatives into one project. The combinations include the construction of an impoundment site with a diversion channel alignment or an impoundment site with a diversion channel and railroad crossing improvement. Combining multiple project aspects into one provides an increase in flood damage reduction and a greater factor of safety for the City.

A summary of the alternatives is displayed in Table 4-2.

Table 4-2: Alternatives Summary

Railroad Crossing Improvement	Levee East of Railroad Tracks	Impoundment Site	Diversion Channel	Comprehensive Project
48" SSP	Existing City Limits	Site A	North Diversion Channel	Site A + Diversion
54" SSP	Expanded City Limits	Site B	South Diversion Channel	Site B + Diversion
60" SSP		Site C		Site C + Diversion
2 – 54" SSP		Site G		Site G + Diversion
2 – 60" SSP		Site F		Site F + Diversion
Box Culverts / Bridge		Pierce Site		Impoundment Site + Diversion Channel + Crossing Improvement

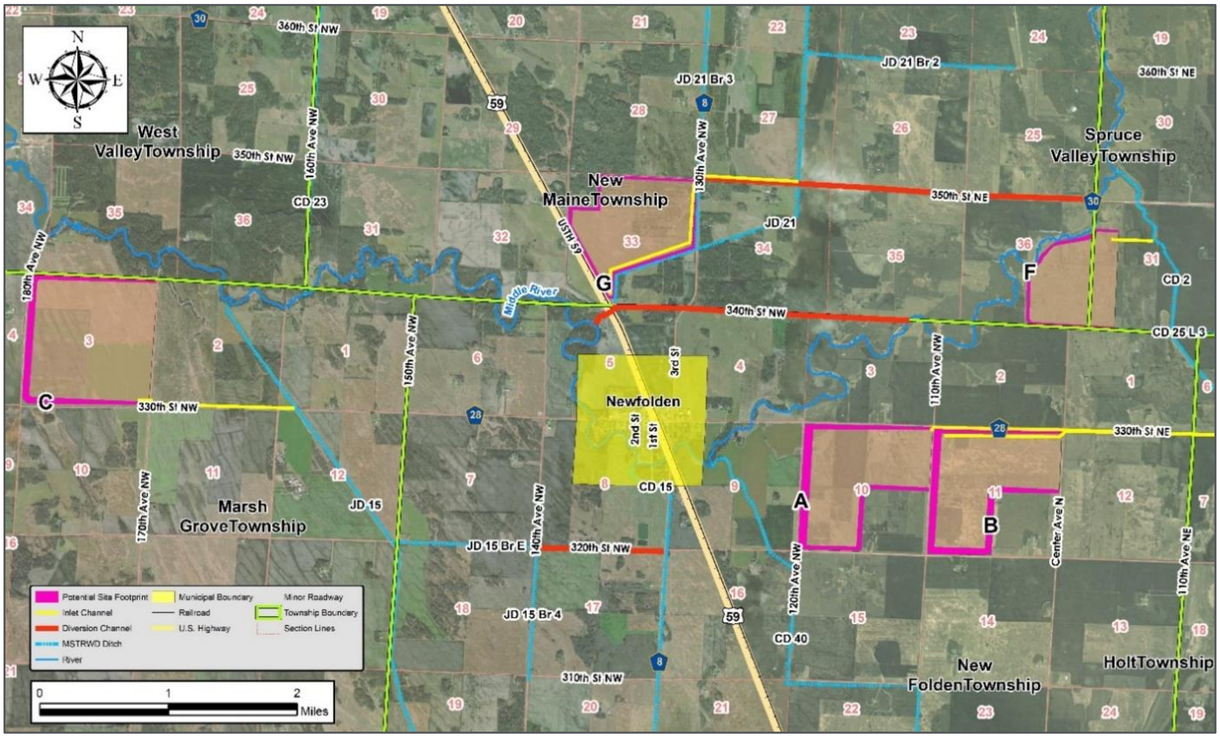


Figure 4-1: Alternative Locations

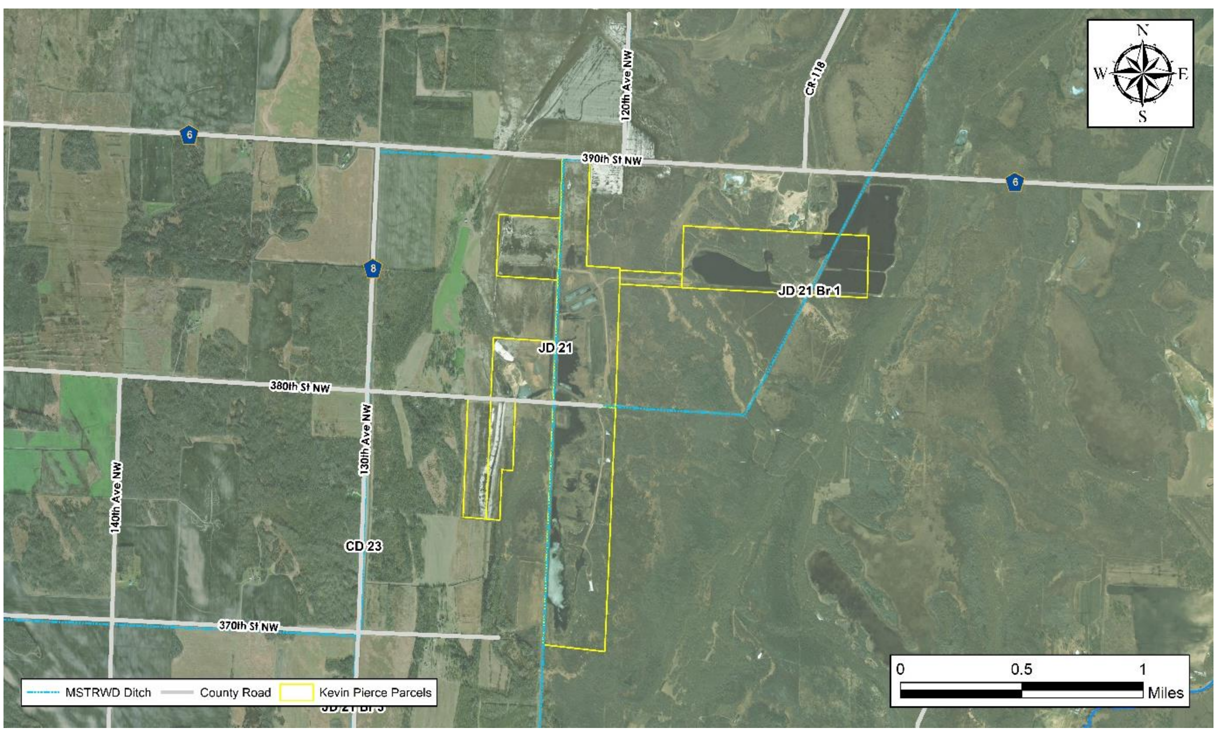


Figure 4-2: Pierce Site Location

5 Alternatives Analysis

5.1 Comparison of Alternatives

Five types of alternatives were analyzed that would potentially remove the City of Newfolden from the the1% Annual Chance Floodplain (100-year event). Each of the alternative types was analyzed based on meeting the Project design goals, Project implementation, and overall cost.

The pros and cons of each alternative were considered prior to the narrowing process. The findings from this study show that a modification to the railroad crossing will remove Newfolden from the floodplain, improve upstream drainage, and provide increased safety for train traffic. As a result, to the improved flow capacity, there are increases in potential flood impacts downstream. These increases limit the potential funding partners and also make obtaining the required permits difficult. An improvement to only the railroad crossing would also leave the City susceptible to ice and log jams.

A levee would remove the City of Newfolden from the floodplain but would require certification and the potential relocation of utilities, infrastructure, and homes. This would all add a large cost to the project and if a future remapping of the area found that there was an increase in the BFE, the project would require modifications and recertification. A levee would also increase the potential flood impacts upstream and downstream.

The construction of a detention site or comprehensive project would remove Newfolden from the floodplain, improve upstream and downstream drainage, provide local flood benefits, alleviate the large head of water on the railroad crossing, and provide some environmental benefits. Due to their complexity and multiple benefits, they often have a greater funding source. This is beneficial because these projects are large and do have a high cost associated with them.

A diversion channel that would direct high flows from the Middle River around the City would remove Newfolden from the floodplain and provide improved upstream drainage. Similar to the railroad crossing improvement a diversion channel would increase the potential flood impacts downstream, limit the funding partners, and would be difficult to obtain the required permits.

The pros and cons of each alternative type is summarized in Table 5-1 through Table 5-4.

Table 5-1: Pros and Cons for Improved Railroad Crossing

Pros	Cons
Improves drainage flooding / drainage upstream	Increases flows and water elevations downstream
Removes Newfolden from floodplain	Permitting
Increases level of safety for train traffic	Limited funding partners
	Susceptible to ice and log jams

Table 5-2: Pros and Cons for Diversion Channel

Pros	Cons
Improves drainage along system	Increases flows and water elevations downstream
Removes Newfolden from floodplain	Difficult to obtain permitting
Provides improved drainage upstream	Limited funding partners (No FDR or RRWMB on its own)
	Does not address railroad crossing issues

Table 5-3: Pros and Cons for Levee

Pros	Cons
Removes Newfolden from floodplain	Large costs (Relocating of utilities, infrastructure, homes, etc.)
	Increases flows and water elevation upstream/downstream
	Must be certified
	Can be insufficient if BFE is re-evaluated in future

Table 5-4: Pros and Cons for Impoundment Sites / Comprehensive Project

Pros	Cons
Improves drainage along system	Large costs
Removes Newfolden from floodplain	Potential wetland impacts
Reduces peak flows / volumes downstream	FEMA certification & risk analysis
Improves rural flooding along drainage systems	
Can provide riparian and environmental benefits	
Alleviates large head of water on railroad crossing	

5.2 Alternatives Screening

To begin the narrowing of alternatives, each was evaluated by the P&N statement. If the alternative met the criteria of removing Newfolden a minimum of 1' below the accepted Base Flood Elevation (BFE) set by FEMA, as stated in the P&N, it was not eliminated. This removed all improvements to the railroad crossing that did not increase the hydraulic capacity a minimum of approximately 39 square feet. This is equivalent to two 60" Smooth Steel pipes. The two levee alternatives were removed since they each increased the water surface elevations upstream and downstream of the railroad tracks. This occurred because the existing storage area within the City was removed with the construction of a levee. The water is then forced to rise on the surrounding landscape and create greater head pressure on the existing culverts. This increases the flows passing through the existing culverts and results in a higher water surface elevation and flow downstream. Detention sites C, G, F, and the Pierce location did not provide the storage capacity required to meet the P&N goal as a stand-alone alternative. As a result, these sites were also removed as viable alternatives. Each of the alternatives removed are still options for a comprehensive project but not as a stand-alone alternative.

Table 5-5: Alternatives Screening First Round

Railroad Crossing Improvement	Levee East of Railroad Tracks	Impoundment Site	Diversion Channel	Comprehensive Project
~~48" SSP~~	~~Existing City Limits~~	Site A	North Diversion Channel	Site A + Diversion
~~54" SSP~~	~~Expanded City Limits~~	Site B	South Diversion Channel	Site B + Diversion
~~60" SSP~~		~~Site C~~		Site C + Diversion
~~2 – 54" SSP~~		~~Site G~~		Site G + Diversion
2 – 60" SSP		~~Site F~~		Site F + Diversion
Box Culverts / Bridge		~~Pierce Site~~		Impoundment Site + Diversion Channel + Crossing Improvement

The remaining alternatives were then analyzed based on their local benefits such as not increasing flows upstream or downstream and improving the local drainage. The remaining railroad improvement alternatives and the diversion alternatives will improve local drainage but will also increase flows downstream. The additional flows downstream will increase the potential for flood damages to structures. These increases dismissed the railroad crossing improvements and diversion alternatives as viable options.

Table 5-6: Alternatives Screening Second Round

Railroad Crossing Improvement	Levee East of Railroad Tracks	Impoundment Site	Diversion Channel	Comprehensive Project
~~48" SSP~~	~~Existing City Limits~~	Site A	~~North Diversion Channel~~	Site A + Diversion
~~54" SSP~~	~~Expanded City Limits~~	Site B	~~South Diversion Channel~~	Site B + Diversion
~~60" SSP~~		~~Site C~~		Site C + Diversion
~~2 – 54" SSP~~		~~Site G~~		Site G + Diversion
~~2 – 60" SSP~~		~~Site F~~		Site F + Diversion
~~Box Culverts / Bridge~~		~~Pierce Site~~		Impoundment Site + Diversion Channel + Crossing Improvement

The map displayed in Figure 5-1 shows the areas of increased flows and water surface elevations created by the installation of two additional 60" SSP. As stated previously, this is the minimum railroad crossing improvement required to meet the P&N. Directly downstream of the railroad crossing, the model shows an increase of 0.3' – 0.5' in water surface elevation. This increase appears to become negligible downstream near the City of Argyle, Minnesota, because floodwaters begin to break out of the Middle River and this overland flooding is difficult to attribute to a specific flooding source. The increase in flows downstream of the railroad tracks as a result of the modified crossing is approximately 100 – 150 cubic feet per second (cfs).

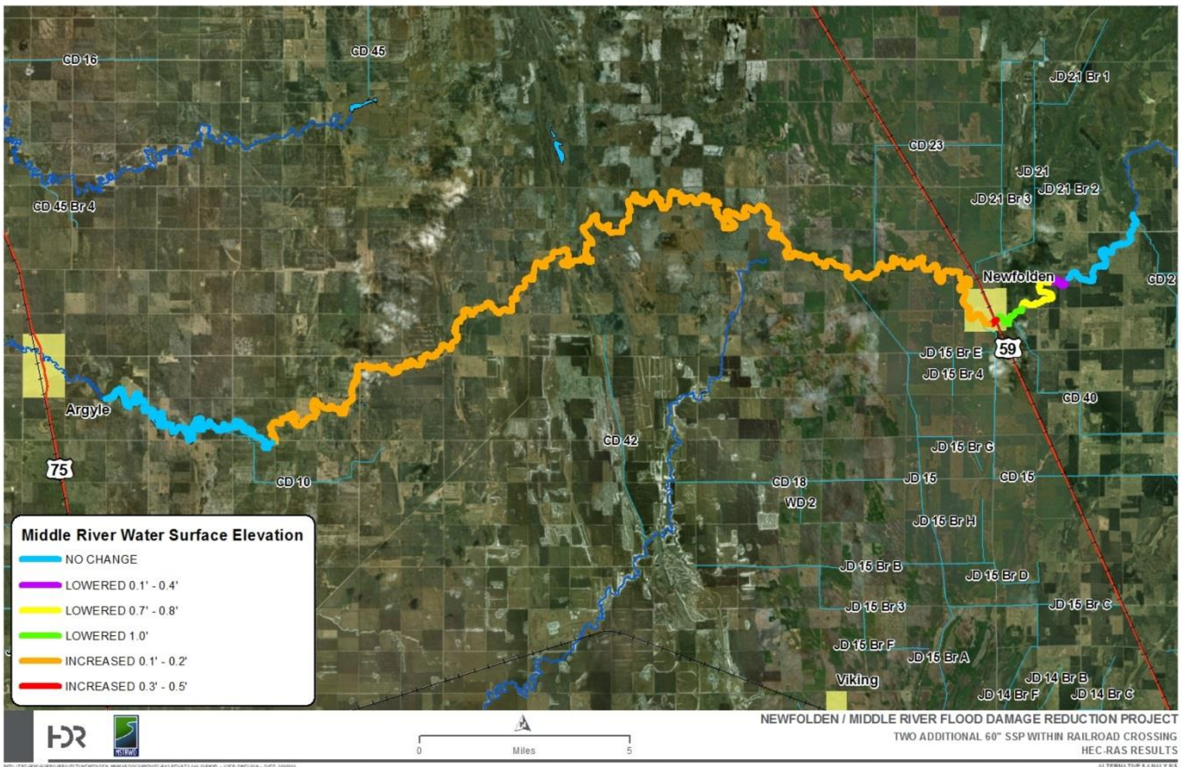


Figure 5-1: Downstream Impacts Resulting from Minimum Railroad Crossing Improvement

Each of the remaining alternatives include a detention site that would provide runoff storage that will meet the P&N, provide local drainage improvements, and not increase flood potential upstream or downstream. Public safety is always a concern when designing and operating a flood control project. These detention sites are required to follow design guidelines set by the Minnesota Dam Safety Standards and obtain a dam safety permit through the MnDNR. This ensures that these projects are designed and operated with the safety and well-being of the public as the main priority. Even so, all risk cannot be removed from anything that is done in all aspects of life. It is preferred that these sites not be constructed with homes or farmsteads immediately downstream of the embankment wall when possible. Using that recommendation as criteria for choosing preferred alternatives, Site A, Site A + Diversion, Site F + Diversion, and Site C + Diversion were removed from the remaining alternatives because there are homes located within 1,000 feet or less of the downstream embankment wall.

Table 5-7: Alternatives Screening Third Round

Railroad Crossing Improvement	Levee East of Railroad Tracks	Impoundment Site	Diversion Channel	Comprehensive Project
~~48" SSP~~	~~Existing City Limits~~	~~Site A~~	~~North Diversion Channel~~	~~Site A + Diversion~~
~~54" SSP~~	~~Expanded City Limits~~	Site B	~~South Diversion Channel~~	Site B + Diversion
~~60" SSP~~		~~Site C~~		~~Site C + Diversion~~
~~2 – 54" SSP~~		~~Site G~~		Site G + Diversion
~~2 – 60" SSP~~		~~Site F~~		~~Site F + Diversion~~
~~Box Culverts~~		~~Pierce Site~~		Impoundment Site + Diversion Channel + Crossing Improvement

5.3 Alternative Review

HDR's Preliminary Engineers Report dated April 1, 2019 concluded the Site G (Newfolden) Impoundment and diversion channel met the P&N statement. Further hydraulic modeling of the JD 21 system and discussions with the Project Team revealed that overland flooding of the JD 21 system contributes to the flooding on the east portion of the City. Site G is critical to prevent this overland flooding from occurring. On April 2nd, 2018, the MSTRWD Board of Managers accepted the "Alternatives Analysis Study" and directed HDR to conduct the preliminary design of the preferred alternative with the option of a railroad modification. The diversion channel was later removed from the proposed Project because the railroad structure modification reduced water levels sufficiently through Newfolden. This change occurred as a result of the addition of Canadian Pacific Kansas City Railway (CPKCR) as a Project partner. CPKCR was in-favor of removing the existing culvert structure and replacing it with a pre-cast bridge.

6 Design Guidance

6.1 Embankment Design Guidance

The following Natural Resource Conservation Service (NRCS) standards were used in the design of the impoundment:

- Technical Release (TR) 210-60: Earth Dams and Reservoirs
- TR 66: Simplified Dam-Breach Routing Procedure

7 Project Components

The City of Newfolden Flood Prevention Project consists of increased capacity through the railroad at the City and an impoundment approximately 1.5 miles north identified as the Newfolden Impoundment (formerly Site G), see Figure 7-1. The following sections include a summary of the increased capacity through the railroad and the impoundment components.

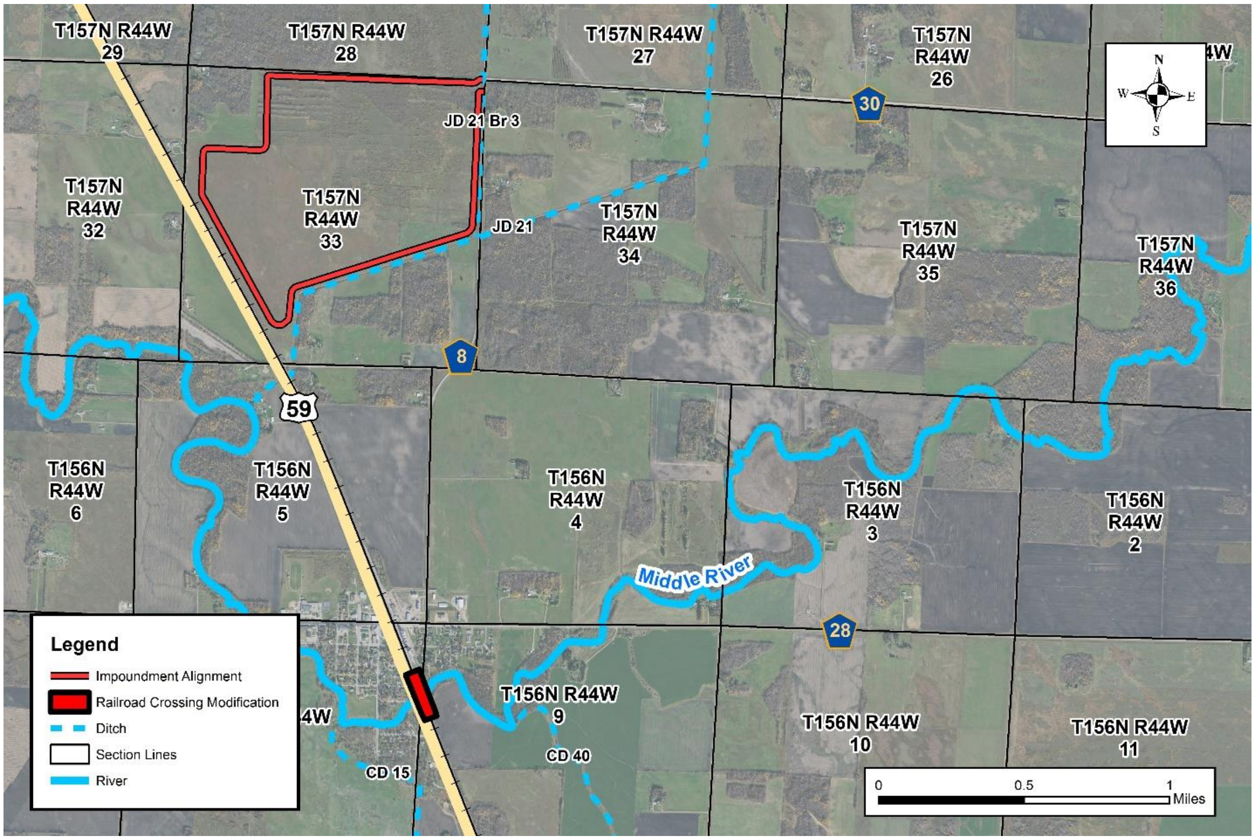


Figure 7-1: Recommended Alternatives

7.1 Railroad Structure Modification

The existing Canadian Pacific Kansas City Railway waterway structures, located within the Middle River east of Trunk Highway 59 at Newfolden, MN, consists of two 96" corrugated steel pipes (CSP) and three 66" reinforced concrete pipes (RCP), see Figure 7-2.

Figure 7-2: Existing Railroad Structures at Newfolden

HDR conducted a hydraulic analysis and determined 39 square feet of additional flow area was necessary to meet the P&N statement. HDR coordinated with the Canadian Pacific Kansas City Railway to develop a preferred replacement consisting of a 3-span prestressed concrete bridge. The bridge will have a length of 105'-2" with two pipe pile bents and precast concrete straddle pier caps. A trapezoidal channel with a 40 ft bottom width and 2:1 (H:V) side slopes at an invert elevation of 1078.7 feet will be graded through the rail right of way to tie into the upstream and downstream channel.

7.2 Newfolden Impoundment

The Newfolden Impoundment captures runoff from approximately 11 square miles of the JD 21 system. The site has the ability to capture 2,000 acre-feet of the approximately 4,250 acre-feet that passes through the JD 21 system during the 100-year 10-day spring snowmelt event. Once the pool reaches an elevation of 1106.0 feet the remaining flow will pass through the site, over the auxiliary spillway, and into the existing JD 21 system to the Middle River.

Summary

- Stream - Judicial Ditch 21 (JD 21)
- Year Completed – not applicable, this is a proposed embankment
- Purpose - reduce flood damages from JD 21 breakout water and store flood water as part of regional retention goal
- Drainage Area - 11 square miles
- Dam Height – 14.4 feet near outlet structure

- Embankment Type - Earthen embankment
- Embankment Volume – 402,000 CY
- Embankment Slopes – 4H:1V dry side and 5H:1V wet side
- Total Embankment Length – 16,650 feet (3.15 miles)
- Design Storage Capacity
  - Gated Storage = 2,000 acre-feet @ elevation 1106.0'
  - Flood Surcharge = 335 acre-feet between elevations 1106.0' and 1107.0'
  - Total = 2,335 acre-feet @ elevation 1107.0'

Inlet Channel

- Channel
  - Size and Type: Trapezoidal vegetated earth
  - Length: 4,185 feet
  - Bottom Width: 13 feet
  - Depth: 6 - 12 feet
  - Side Slopes: 4H:1V
  - Channel Slope: 0.001 ft/ft

Gated Outlet

- Outlet Structure
  - Size and Type: 6 feet high and 8 feet wide reinforced concrete box culvert
  - Sluice Gate: 6 feet wide and 4 feet high
  - Gate Invert: 1090.4'
  - Top of Openings – 1094.4'
  - Top of Structure – 1106.0'
  - Actuator Elevation – 1112.0'
  - Energy Dissipator – D50 12-inch riprap (MnDOT Class IV) 3 feet

Auxiliary Spillway

- Weir at Outlet Structure
  - Type – Long sharp crested weir
  - Size and Type (O.D.) – 38' x 17'
  - Size and Type (I.D.) – 35' x 14' (98' total length)
  - Crest Elevation – 1106.0'
  - Peak WSE during ASH – 1107.2'
  - Drop inlet will discharge into an 8-foot wide 6-foot-high box culvert

Emergency Spillway

- Weir near inlet of pool
  - Size and Type – 400-foot-long vegetated earthen broad crested weir with 12-foot top width
  - Crest Elevation – 1107.0'
  - Peak WSE for FBH – 1107.5'
  - Spillway discharges into exterior ditch which outlets to Judicial Ditch 21

Main Pool

- Minimum Pool (pool drained every winter)
    - Elevation = 1094.4' (Existing Ground @ outlet)
    - Area = 0 acres
    - Volume = 0 acre-feet
- Maximum Flood Pool – 100-Year 10-Day Snowmelt Event
    - Elevation = 1106.7'
    - Area = 396 acres
    - Volume = 2,240 acre-feet
- Top of Embankment Pool
    - Elevation = 1109.0'
    - Area = 396 acres
    - Volume = 3,021 acre-feet

Embankments

- Top of Settled Earthen Embankment Dam Crest Elevation 1109.0 feet
- Reservoir Shoreline/Slope - vegetated 5H:1V
- Dry side slope - vegetated 4H:1V
- Embankment top width – 12 ft vegetated

Instrumentation and Monitoring Devices

- Instrumentation – none

Perimeter Fence

- No perimeter fences

8 Hydrology

The HEC-HMS hydrologic model of the Snake and Middle River basins developed for the U.S. Army Corps of Engineers (USACE) in 2012 as part of the Red River Basin-Wide Modeling Approach (RRBWMA) project is the base model for the hydrologic analysis.

8.1 Middle River Watershed

Drainage Area

The Middle River drainage area upstream of Argyle, MN is approximately 257 square miles with 106 square miles lying upstream of Newfolden, MN, see Figure 8-1 for the contributing drainage area.

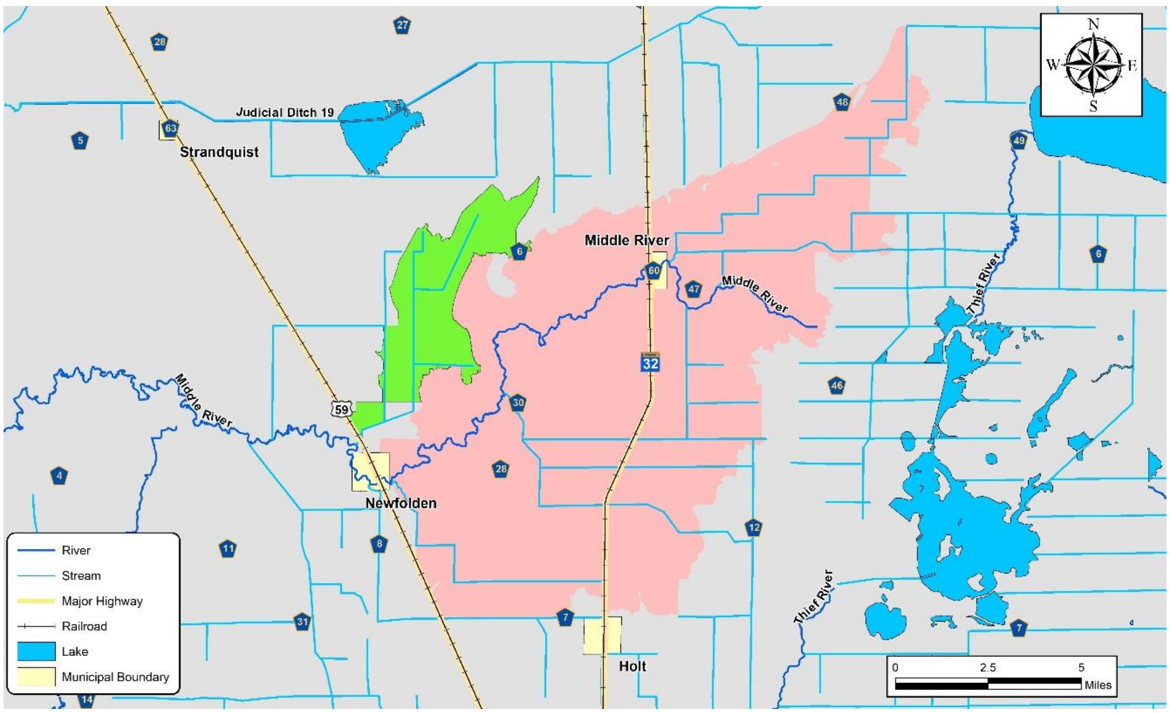


Figure 8-1: Subwatershed Drainage Areas

Topography

The watershed drains from east to west with more elevation difference in the Eastern half. The western portion of the watershed is flat Red River Valley agricultural land. Figure 8-2 displays the topographic changes throughout the Subwatershed.

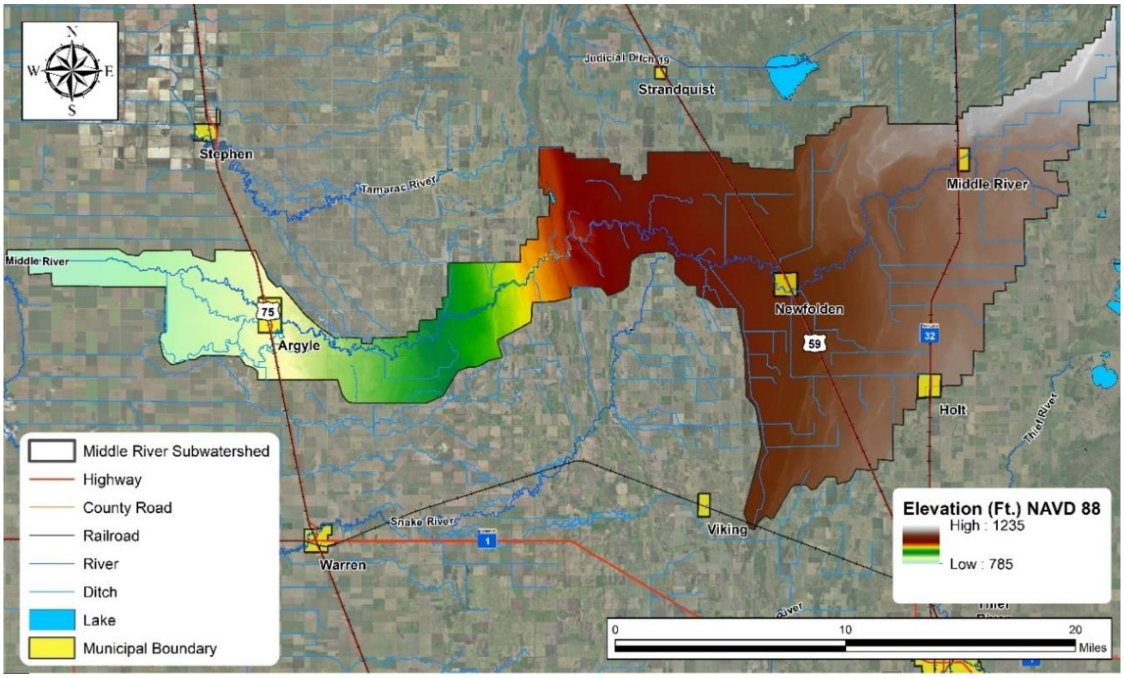


Figure 8-2: Middle River Subwatershed Topography

Land Use

Per NLCD 2011 data, the eastern portion of the Middle River Subwatershed is composed of grasslands and wooded areas with agricultural land scattered throughout while the western portion is in the Red River Valley consisting primarily of agricultural land, see Figure 8-3.

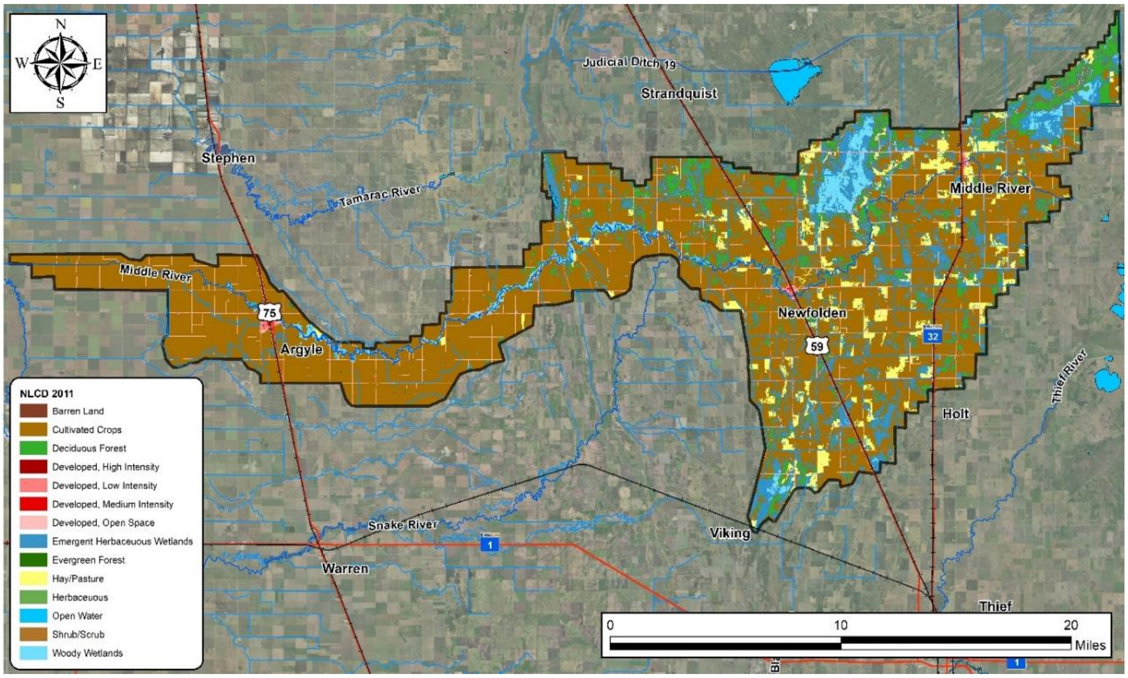


Figure 8-3: Middle River Subwatershed Land Use

8.2 Design Storm Data

The Project design is based on the 100-year 10-day spring snowmelt event. A rainfall/precipitation depth grid was developed based upon the resultant runoff depth shown in United States Department of Agriculture (USDA) "Earths Dams and Reservoirs TR 210-60".

The precipitation depths for the 100-year, 50-year, 25-year, 10-year, and 2-year 24-hour events are based on the Precipitation Frequency Atlas for Midwestern States, USA from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Volume 8 data.

The size and general features of the primary outlet structure were sized using the 100-year 10-day spring snowmelt event and 24-hr auxiliary spillway hydrograph (ASH). The 24-hour freeboard hydrograph (FBH) is used to size the emergency spillway to prevent overtopping of the impoundment embankment crest. The computed depths for the ASH and FBH are based on TR-60 assuming a significant hazard dam classification.

The ASH value is based on the following equation:

$$ASH = P_{100} + 0.12*(PMP-P_{100})$$

The FBH value is based on the following equation:

$$FBH = P_{100} + 0.40*(PMP - P_{100})$$

Where P_{100} is either the 100-Year 24-Hour or 100-Year 6-Hour event

Probable Maximum Precipitation (PMP) is either the 24-Hour PMP or 6-Hour PMP event for an area of 10 mi^2, consistent with the choice of P_{100}.

The PMP is 27.4 inches based on Hydrometeorological Report Number 51 Figure 20 – All season PMP (in.) for 24 hr 10mi^2. Table 8-1 provides the design rainfall depths used in the HEC-HMS analysis.

Table 8-1: Design Storm Rainfall Depths

Rainfall Event	Site G Precipitation Depth (In)
2-Year 24-Hour	2.40
10-Year 24-Hour	3.64
25-Year 24-Hour	4.53
50-Year 24-Hour	5.28
100-Year 24-Hour	6.08
100-Year 10-Day	8.70
Auxiliary Spillway Hydrograph (ASH 24-Hour)	8.64
Freeboard Hydrograph (FBH 24-Hour)	14.61
HMR 51 24-Hour PMP	27.4

Design Rainfall Distribution

The 100-year 10-day distribution is from Minnesota Hydrology Guide (Principal Spillway Hydrograph Figure 6-4), which simulates the spring snowmelt event.

The 24-hour events were based upon a site-specific rainfall distribution method as described in the United States Department of Agriculture (USDA) National Engineering Handbook (NEH) Chapter 4: Storm Rainfall Depth and Distribution (Draft) Appendix 4C. The 2-year, 10-year, 25-year, 50-year, and 100-year 24-hour rainfall event individual rainfall distributions were created.

Time of Concentration

The time of concentration (T_c) travel time data is derived using the HEC-HMS model and MNDNR Travel Time Routine that applies a gridded version of the Manning's equation to calculate flow velocities throughout the contributing watershed based on the 2001 National Landcover Dataset (NLCD) land use, slope, and stream network. The velocities were converted into travel times and summed along the flow paths that terminate in the watershed outlet.

Precipitation Losses

The basin models use the SCS Curve Number (CN) as a loss method. The 24-hour scenario CN values were determined by hydrologic soil group types (Soil Survey Geographic Database) and the land use (2011 National Land Cover Data) prevalent in the area. Using the USDA National Engineering Handbook Chapter 9 and the USACE hydrologic modeling approach for the Red River of the North Basin models, with a composite curve number for each subwatershed.

Hydrograph Shape

The hydrograph transformation used in the RRBWMA is the Clark synthetic unit hydrograph using T_c and the SCS storage coefficient (R) inputs for this method.

Peak Excess Runoff and Flows

The HEC-HMS model was used to calculate the excess runoff. The precipitation that does not infiltrate into the soil is the excess that runs off and is used to develop runoff hydrographs for each subwatershed.

9 Existing Condition

MNDNR created a steady-state HEC-RAS hydraulic model to assist FEMA with the City of Newfolden floodplain mapping initiative, and this model became the regulatory model which is the base condition of the hydraulic analysis. HEC-RAS version 6.3.1 was used to perform all hydraulic computations of the existing conditions as well as the proposed design of the alternatives.

9.1 Data Collection

Table 9-1 is a summary of the topographic data used to update the hydraulic model and evaluate the alternatives.

Table 9-1: Data Sources

Data	Date	Source	Vertical Datum	Description
Survey Data	2018, 2021, 2023	HDR	NAVD 1988	Survey of existing drainage systems including ditch geometry, culverts, utilities, impoundment topography, railroad tracks, and TH 59.
LiDAR	2008	International Water Institute	NAVD 1988	1 Meter DEM and 2-foot contours

Ditch invert elevations were taken from available NAVD 1988 LiDAR data for the Red River Basin where as-built and survey data are not available. HDR assumed all features within the existing drainage systems are in good condition and functioning correctly.

9.2 Hydraulic Model Development

HDR modified the original MnDNR 1D steady-state HEC-RAS model by applying 2D flow areas along the overbank areas and converting the 1D portion of the model from a steady-state flow condition to an unsteady-state flow. Lateral structures were created to connect the 1D cross-sections to the 2D flow areas. This allowed the flows to pass between the 1D/2D areas to accurately determine the inundation extents. HDR did not alter the 1D cross-section geometry obtained from the MnDNR.

A field survey of all ditches, hydraulic structures, and overbank areas along the alternative alignments was completed and used to create an existing ground surface in AutoCAD Civil 3D 2018. LiDAR data was obtained from the Red River Basin Mapping Initiative from the International Water Institute for the Red River of the North watershed. The existing ground surface was overlaid on the LiDAR surface and used to create an updated terrain of the Project area.

The hydraulic structures were input into the model based on the gathered survey data and using aerial imagery where information was not known.

The runoff hydrographs for each of the design scenarios were obtained from the HEC-HMS runoff analysis previously discussed. These runoff hydrographs were input as a precipitation boundary condition within at their respective geographical location within the geometry.

Hydraulic Losses

System losses throughout the hydraulic models were accounted for through defining flow retardation resulting from overland Manning's values as well as loss coefficients and surface roughness for culverts. Manning's n values associated with landuse classifications are summarized in Table 9-2. Loss coefficients used in the hydraulic structures are summarized in Table 9-3. Standard roughness values were used where applicable for the culverts are summarized in Table 9-4.

Table 9-2: NLCD Classifications Manning's n Values

NLCD Name	Manning's n
Cultivated crops	0.035
Deciduous forest	0.16
Developed, high intensity	0.15
Developed, low intensity	0.1
Developed, medium intensity	0.08
Developed, open space	0.04
Emergent herbaceous wetlands	0.07
Evergreen forest	0.16
Grassland/herbaceous	0.035
Open water	0.04
Pasture/hay	0.03
Shrub/scrub	0.1
Woody wetlands	0.12

Table 9-3: Hydraulic Loss Coefficients

Description	Loss Coefficient
Culvert Entrance Loss	0.5
Culvert Exit Loss	1.0

Table 9-4: Hydraulic Structure Manning's n Values

Description	Manning's n
Precast Reinforced Concrete Pipe/Box	0.013
Corrugated Steel/Metal Pipe	0.024

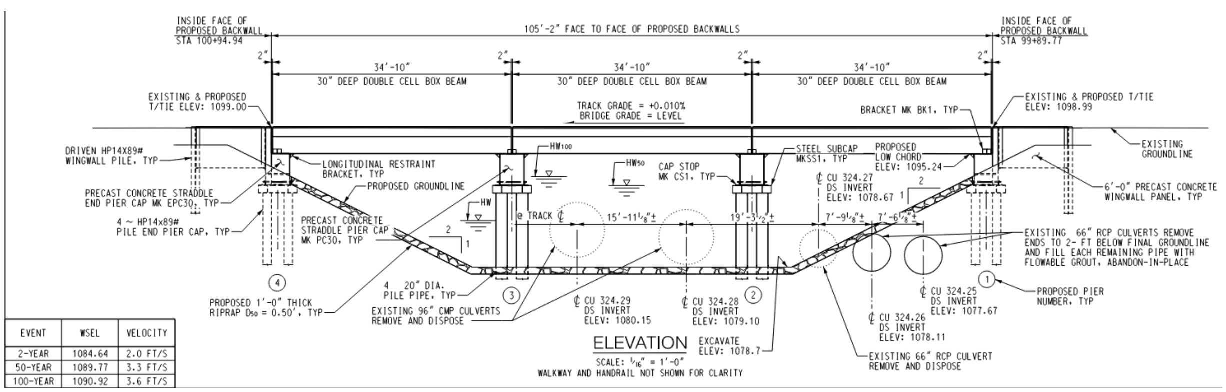
10 Proposed Condition - Railroad Structure Modification

The existing CPKCR waterway structures, located within the Middle River east of Highway 59 at Newfolden, MN, consists of two 96" CSP and three 66" RCP, see Figure 7-2.

The railroad structures restrict Middle River flow causing a backwater effect which increases flooding in the eastern portion of Newfolden. HDR conducted a hydraulic analysis and determined 39 square feet of additional flow area was necessary to meet the P&N statement.

HDR coordinated with the CPKCR to develop a preferred replacement consisting of a 3 span prestressed concrete 105'-2" long bridge with two pipe pile bents and precast concrete straddle pier caps. A 40 ft bottom width trapezoidal channel with 2:1 (H:V) side slopes and 1078.7 invert elevation will be graded through the rail right of way to tie into the upstream and downstream channel, see Figure 10-1.

The railroad structure modification replaces the existing pipes with a bridge and reduces water surface elevations at Newfolden by approximately 6.0 feet and increases downstream flows by approximately 100 – 150 cubic feet per second (cfs). The existing landowners within the railroad modification footprint are the CPKCR and the Minnesota Department of Transportation (MnDOT) right-of-way (ROW), see Figure 10-2.



EVENT	WSEL	VELOCITY
2-YEAR	1084.64	2.0 FT/S
50-YEAR	1089.77	3.3 FT/S
100-YEAR	1090.92	3.6 FT/S

Figure 10-1: Proposed Railroad Bridge Cross Section

Figure 10-2: Existing Landowners in Railroad Modification Footprint

10.1 Conditional Letter of Map Revision

A Conditional Letter Of Map Revision (CLOMR) for the railroad structure modification has been submitted for review by FEMA and shows an approximately 6 foot lowering of the 100-year water surface elevation upstream of the railroad and removes approximately 87 structures from the floodplain that consist of homes, an apartment building, businesses, and a church from the floodplain.

11 Proposed Condition - Newfolden Impoundment

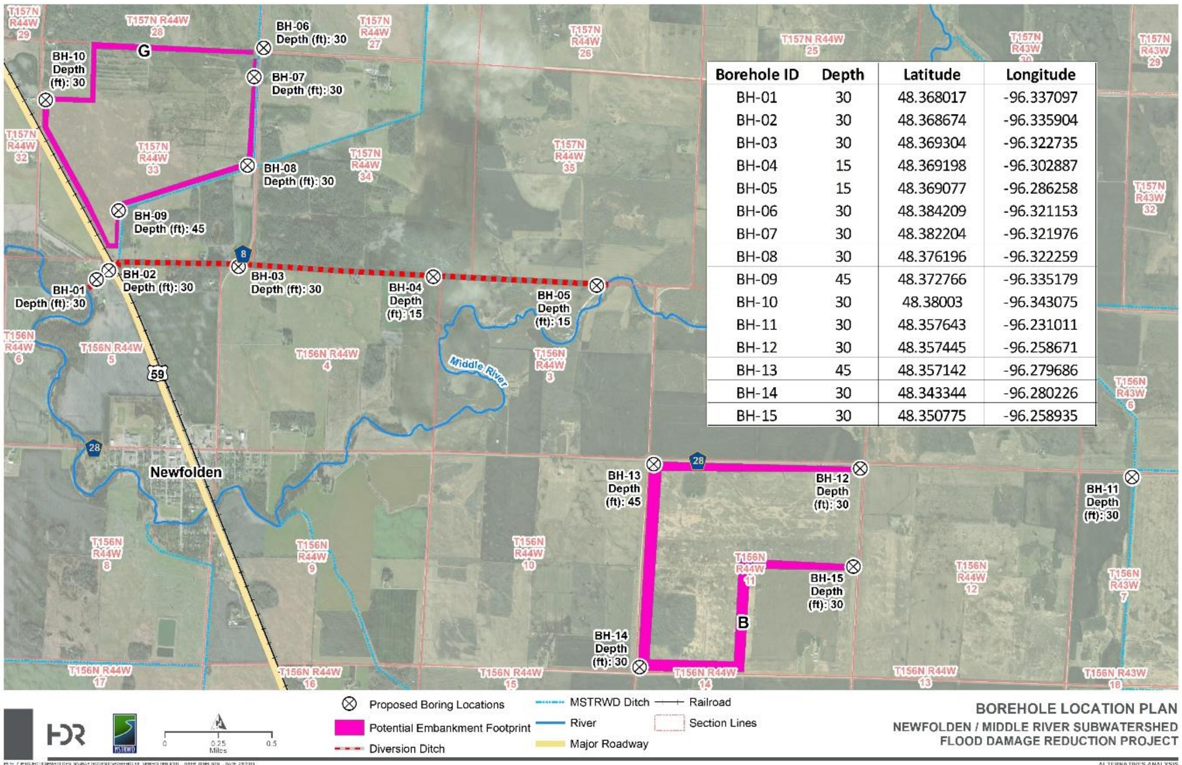
Impoundment sites with the potential to temporarily store excess runoff and therefore reduce peak discharges at Newfolden were identified and evaluated based on storage, environmental impacts, landowner impacts, and constructability. The impoundment as a stand-alone alternative does not provide enough storage capacity to remove the eastern portion of Newfolden from the 1% Annual Chance Floodplain . The proposed impoundment in conjunction with the railroad crossing modification meets the P&N and the regional goals of increasing flood storage to reduce peak flows. The impoundment design follows design guidelines set by the Minnesota Dam Safety Standards.

11.1 Geotechnical Investigation

Geotechnical Borings

A geotechnical investigation was performed by Northern Technologies, LLC of Fargo, North Dakota. A total of 15 standard penetration borings were completed for the Project alternatives. The location of each boring is displayed in Figure 11-1.The borings extended to a depth of 16 to 46 feet. The borings had an average topsoil depth of 0.2 to 4.5 feet which can be classified as Glacial Lake Sediment (GLS), which are sand and silty sand. The remainder of each boring consists of medium to stiff Lake Modified Glacial Till (LMGT), which are lean clay, silty clay, silt, and occasional sand.

Groundwater was encountered at several boring locations from a depth of 1 to 15 feet corresponding to the sand and silt layers. Water levels can vary but these layers likely bear water during the spring thaw and after heavy precipitation. Location specific information, boring logs, and engineering review are in Appendix A.



Borehole ID	Depth	Latitude	Longitude
BH-01	30	48.368017	-96.337097
BH-02	30	48.368674	-96.335904
BH-03	30	48.369304	-96.322735
BH-04	15	48.369198	-96.302887
BH-05	15	48.369077	-96.286258
BH-06	30	48.384209	-96.321153
BH-07	30	48.382204	-96.321976
BH-08	30	48.376196	-96.322259
BH-09	45	48.372766	-96.335179
BH-10	30	48.38003	-96.343075
BH-11	30	48.357643	-96.231011
BH-12	30	48.357445	-96.258671
BH-13	45	48.357142	-96.279686
BH-14	30	48.343344	-96.280226
BH-15	30	48.350775	-96.258935

Figure 11-1: Geotechnical Boring Locations

Geotechnical Evaluation

HDR completed a geotechnical analysis and engineering evaluation based on the lab results from the NTI report. The memorandum presents findings, conclusions, and recommendations regarding:

- Subsurface soil and groundwater conditions
- Evaluation of the engineering characteristics of the embankment and foundations soils
- Evaluation of foundation underseepage and embankment seepage
- Evaluation of the slope stability of the embankment and foundation soils
- Estimation of settlements of the embankment crest
- Recommendations for construction

See the complete memorandum in Appendix B for the detailed results of the analysis.

11.2 Newfolden Impoundment

The Newfolden Impoundment is located in Section 33 of New Maine Township, which is approximately 1.5 miles north of Newfolden. The proposed footprint is approximately 396 acres and impacts three landowners. There is an average of eleven feet of elevation difference across the site from north to south with approximately 2,000 acre-feet of storage at an elevation of 1106.0 feet. The proposed top of the embankment is elevation 1109.0 feet.

The Newfolden Impoundment captures runoff from approximately 11 square miles of the JD 21 system. The inlet channel diverts flow from Judicial Ditch 21 (JD 21) to the west on the north side of Marshall County State Aid Highway 30 (CSAH 30 / 350th St. NW), passes under County State Aid Highway 8 (CSAH 8), and south into the site. Exterior ditches convey local runoff around the site. The outlet is on the southernmost point of the embankment and allows impounded flow to discharge back into JD 21.

The site has the ability to capture 2,000 acre-feet of the approximately 4,250 acre-feet that passes through the JD 21 system during the 100-year 10-day spring snowmelt event. Once the pool reaches the maximum elevation of 1106.0 feet the remaining flow will pass through the site, over the auxiliary spillway, and into the existing JD 21 system to the Middle River. See Figure 11-2 for the site layout.

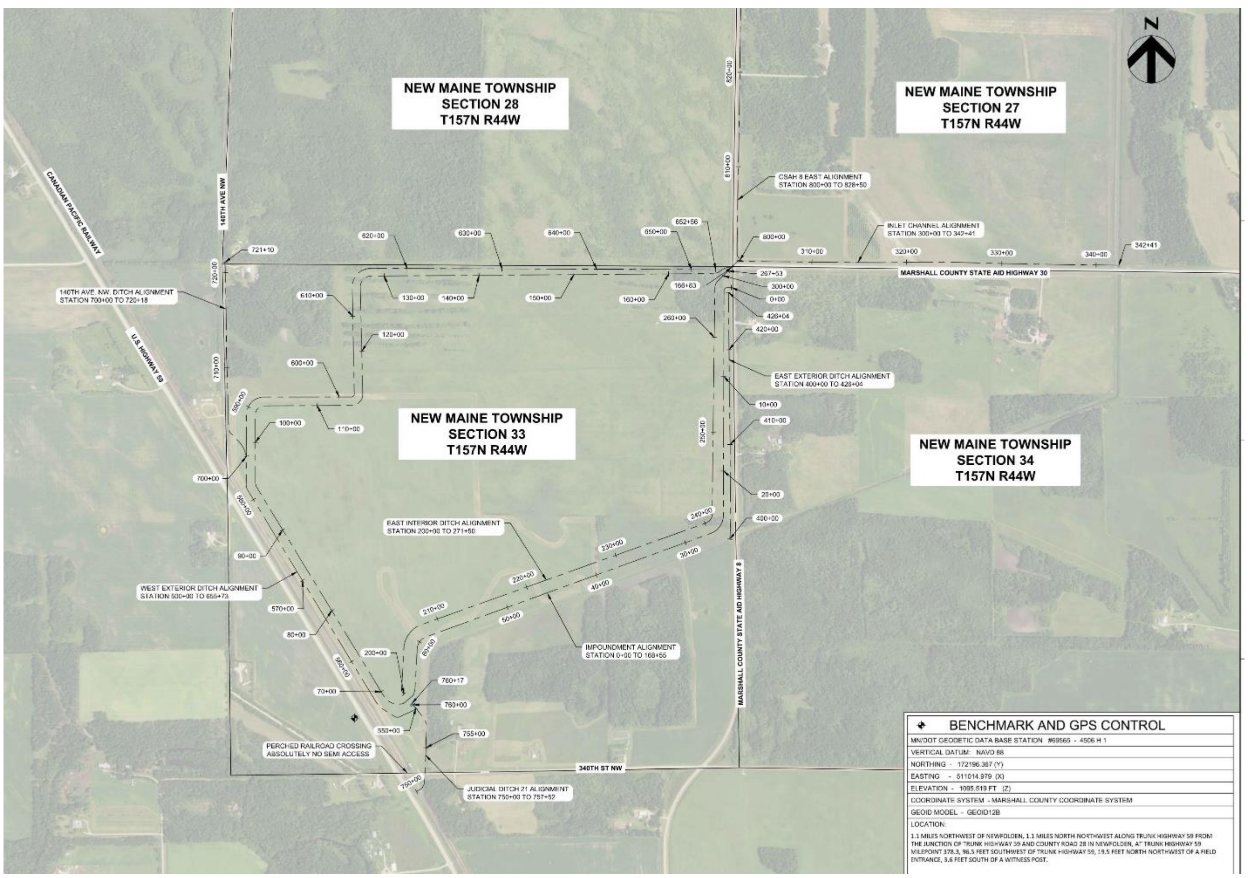


Figure 11-2: Impoundment Layout

Inlet Channel

The impoundment inlet channel is six to twelve feet in depth with a bottom width of 13 feet and 4:1 (H:V) side slopes. A one-foot clay cap will be constructed on the side slopes where the channel passes through existing wetlands to prevent lateral drainage. The typical inlet channel cross-section is displayed in Figure 11-3

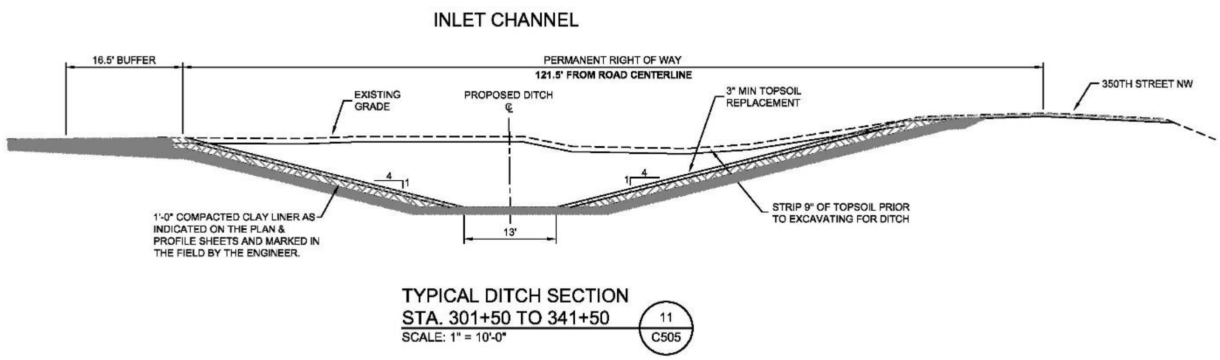


Figure 11-3: Inlet Channel Typical Ditch Section

Spoil from the inlet channel will be hauled west, into the impoundment and placed within the northeast borrow area. The landowner has indicated that they do not wish to have spoil placed within the temporary right-of-way.

The existing 115-inch x 72- inch reinforced concrete pipe arch through CSAH 30 will be removed. This will direct all water from JD 21 upstream of this location, west into the impoundment. The adjacent terrain is sufficient to retain water in the inlet channel at the maximum impoundment design water surface elevation.

The crossing north of the inlet channel within JD 21 Branch 3 will have a 36-inch corrugated aluminized steel pipe (CASP) with a flap gate to replace the existing 18-inch CSP. The south side of the inlet channel will be a dry crossing where the embankment ties into CSAH 8.

Typical Embankment Cross-Section

The embankment cross-section for the site will have a 12-foot-wide levee top, exterior side slopes of 4:1 (H:V) and interior side slopes of 5:1(H:V). The 5:1 side slopes provide improved resistance to erosion, wave dissipation, under seepage resistance, and overall embankment stability. The top of the embankment is at an elevation of 1109.0 feet and has a maximum height of approximately 15 feet above existing ground. This elevation provides three feet of freeboard above the design water surface elevation 1106.0 feet. The embankment will be constructed using lean clay material and will be overbuilt by 0.25 feet to account for settling. A 13-foot-wide key trench will be recessed one foot into the existing clay soils. Figure 11-4 displays the typical embankment cross-section.

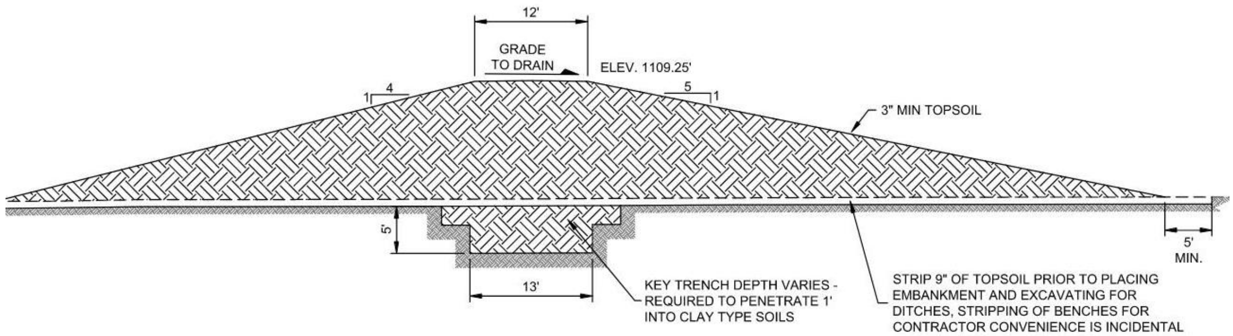


Figure 11-4: Typical Embankment Detail

Hydraulic Data

The stage-storage curve for Newfolden Impoundment is displayed in Figure 11-5 and is designed to provide gated and non-gated storage up to the 100-year 10-day spring snowmelt event with the ability to safely pass larger events over the auxiliary and emergency spillway.

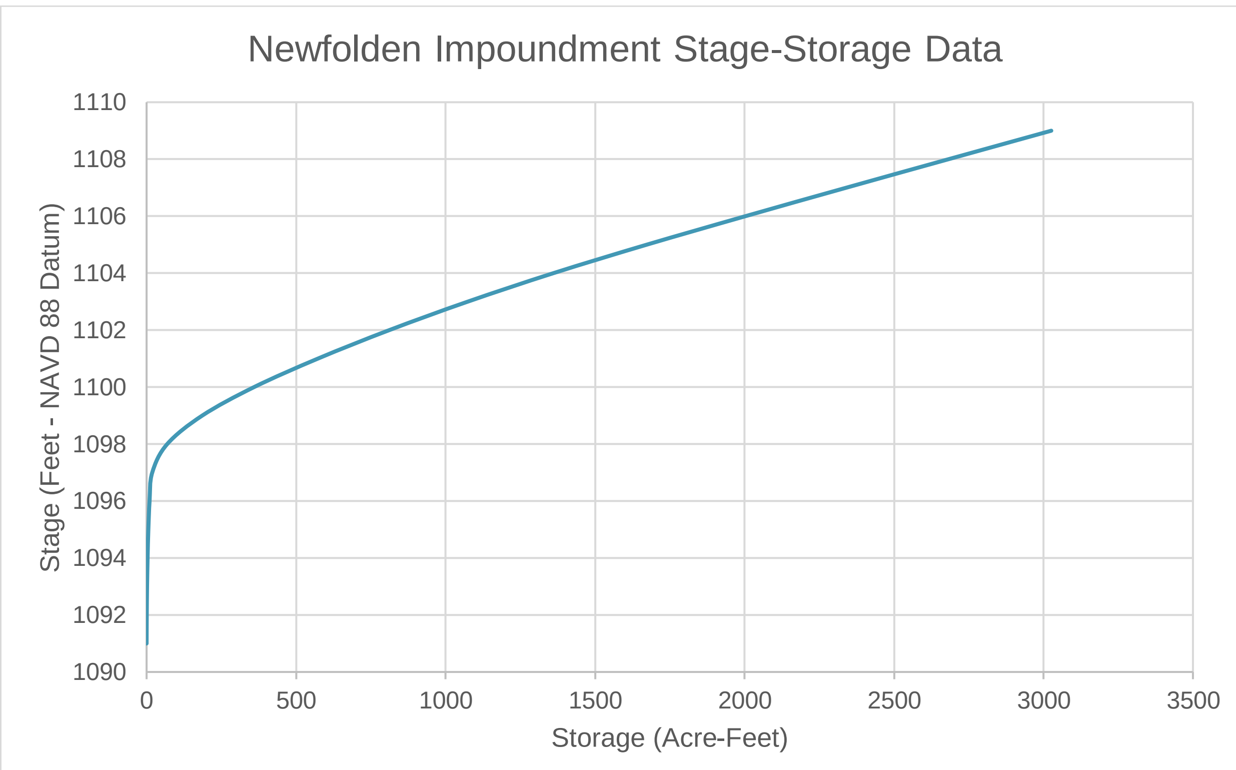


Figure 11-5: Impoundment Stage-Storage Curve

Outlet Structure

The Project has a single outlet structure consisting of an 8-foot by 6-foot box culvert through the embankment, a gated primary outlet, and an auxiliary spillway weir.

Table 11-1: Outlet Structure Details

Feature	Outlet
Top of Embankment [ft]	1109.0
Primary Outlet Invert [ft]	1094.4
Primary Outlet Culvert Size [WxH]	1 – 8 ft x 6 ft
Primary Outlet Gate Size [WxH]	1 – 6 ft x 4 ft
Maximum Outflow [cfs]	310
Secondary Outlet Maximum Weir Crest Elevation [ft]	1106.0
Secondary Outlet Minimum Weir Length [ft]	98
Emergency Spillway Elevation [ft]	1107.0
Emergency Spillway width [ft]	400

Figure 11-6 provides the typical details of the outlet structure. A single sluice gate will be manually closed during filling of the impoundment and opened after the flood event. The gate was sized using TR 210-60 design guidelines which state that the principal outlet shall have the capacity to adequately drawdown the impoundment from its maximum pool elevation within 10 days or less.

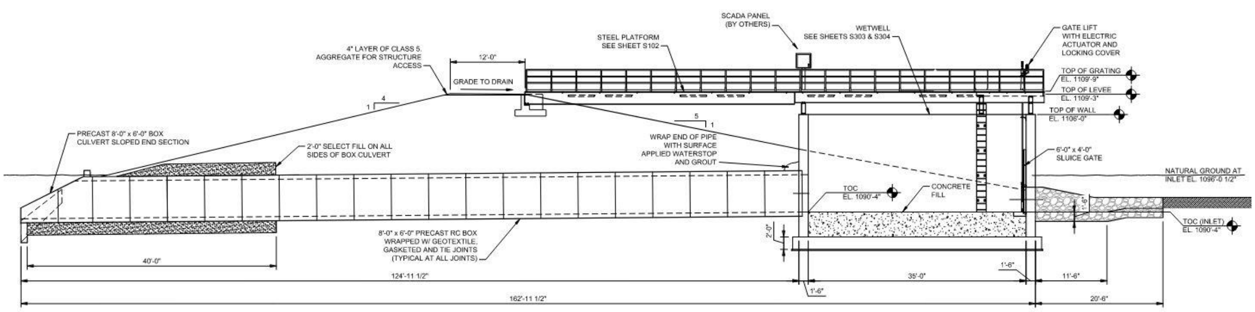


Figure 11-6: Outlet Structure Details

The auxiliary spillway consists of a drop inlet sharp crested weir with a length of 98 feet set at the maximum pool elevation of 1106.0. The auxiliary spillway weir was set at an elevation to safely pass ASH design event flows with the gate closed and a pool elevation at 1106.0 at the beginning of the ASH event. During the ASH design event, the water depth over the auxiliary spillway is 1.2 feet.

The emergency spillway was designed to provide a sufficient factor of safety while the impoundment is operating. The emergency spillway is located along the northeast side of the impoundment where the embankment is at its lowest height relative to natural ground. It is at an elevation of 1107.0' and designed to pass the maximum FBH water surface elevation through the site where it discharges into the existing CSAH 8 roadside ditch, which outlets to JD 21. The depth of water passing over the emergency spillway during the FBH design event is 0.5 feet.

The design of the box culvert through the embankment accounts for seepage around the pipe through use of anti-seep technologies including careful compaction of lean clay around the pipe and a filter drain at the downstream end. The maximum velocities at the outlet occur when the impoundment is full and both the gated and drop inlets are discharging flow. Random Riprap – Class 4 at the outlet will provide erosion control downstream.

Exterior ditches will be located along the outer perimeter of the impoundment to divert local runoff around the site and provide relief if the maximum water surface elevation is reached. An interior ditch is located inside the impoundment and is a continuation of the inlet channel to provide a low flow channel and efficiently drain the impoundment.

Roadway Culverts

A new 12' x 6' reinforced concrete box culvert structure will be constructed through CSAH 8 with the construction of Newfolden Impoundment. No additional or new modifications to the roadway design will take place and they will be returned at a minimum to their respective state before construction. This culvert will pass flows from the inlet channel into the impoundment.

Side Inlets and Approaches

There are no side inlet culverts proposed at the time of this report within the Project design.

Outlet Channel

The Project will discharge flows to the Middle River through a natural meandering coulee that currently discharges flow from JD 21 to the Middle River. This coulee, or outlet channel, is located north of Newfolden and west of U.S. Highway 59.

The location and existing topography of the outlet channel are displayed in Figure 11-7.

Figure 11-7: Outlet Channel Plan View

The outlet channel is approximately 800 feet long and drops 10 vertical feet between U.S. Highway 59 (Hwy 59) and the Middle River (average 1.25% grade). The channel depth ranges from 10 feet near Hwy 59 to 17 feet near the Middle River. The soils in and around the coulee are a mixture of sand, silt, and clay material with an underlying layer of fine gravel based on site observations, see Figure 11-8.

Figure 11-8: Existing Outlet Channel

The Newfolden Impoundment reduces flows in the outlet conveyance channel as compared to existing conditions. Currently flows pass through this channel from JD 21 unregulated and with the operation of the impoundment, the flows will be released in a controlled manner based on downstream trigger points. With this reduction in peak flow and the ability to operate the release of water into this channel, channel stabilization measures are not required.

Adequacy of the Outlet

The outlet for the proposed alternative is the Middle River which has a drainage area of approximately 106 square miles upstream of Newfolden, while the size of the Project drainage area is as approximately 11 square miles. The retention component of the Project will reduce the peak and volume within the Middle River downstream of the Site.

The Project is consistent with the Mediation Agreement goals adopted by the RRWMB and Red River Basin Flood Damage Reduction Work Group. The flood water is considered to be in the middle area for the Red River of the North based on the Flood Damage Reduction Work Group Technical Paper #11. The peak of the Middle River at Newfolden is approximately 4.5 days before the peak on the Red River. Reducing the peak and storing late water at Newfolden has a positive impact on removing water contributing to the peak on the Red River. Flood Damage Reduction (FDR) measures, such as a gated impoundment, receives a positive rating in a middle area and a diversion receives a "variable" rating.

11.3 Maximum Water Surface Elevations & Downstream Impacts

The 100-year 10-day spring snowmelt event was used to establish the maximum water surface within the impoundment. The 100-year 10-day spring snowmelt event yields greater volume than the 100-year 24-hour event and has historically resulted in the highest flood levels.

The 100-year 10-day spring snowmelt event and 24-hr freeboard hydrograph (FBH) events were used to size the emergency spillway to prevent overtopping of the impoundment. The Newfolden

Impoundment, outlet structure, and emergency spillway are sized to decrease flows within the Middle River downstream of the Project location.

In addition to the snowmelt event, the 10-year, 25-year, and 100-year 24-hour rainfall events were analyzed to determine the local flood improvements from the Newfolden Impoundment. These events generally occur over a smaller area than a spring snowmelt event and are more likely to result in agricultural damages because they occur during the growing season. For this reason, the flow retention of the Newfolden Impoundment during 24-hour rainfall events provides a greater benefit to the local farmers. The proposed inundation extents and depth for the pre-Project and post-Project 100-year 10-day spring snowmelt event is displayed in Figure 11-9.

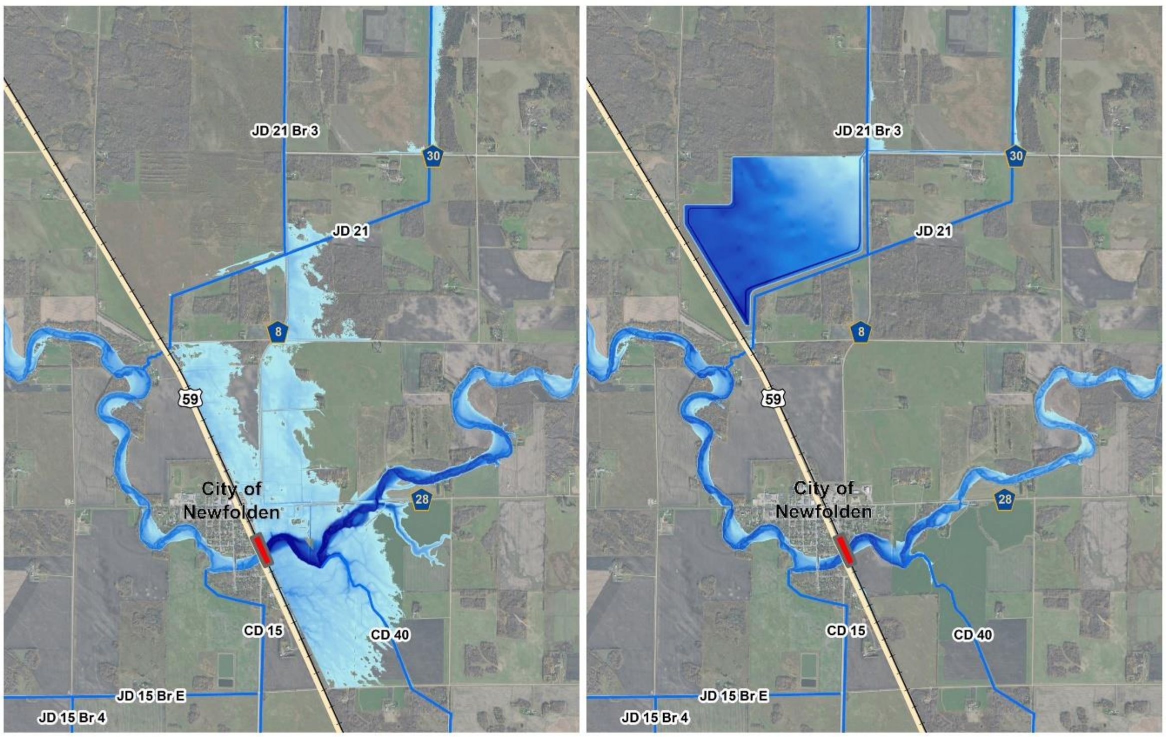


Figure 11-9: Pre-Project vs. Post-Project Inundation Extents

The pre- and post Project 100-year 10-day spring snowmelt hydrograph for the Middle River near CSAH 28 is displayed in Figure 11-10. The removal of approximately 2,000 acre-feet of water from the peak and falling limb of the hydrograph is displayed. This water is then stored up to 30 days and released.

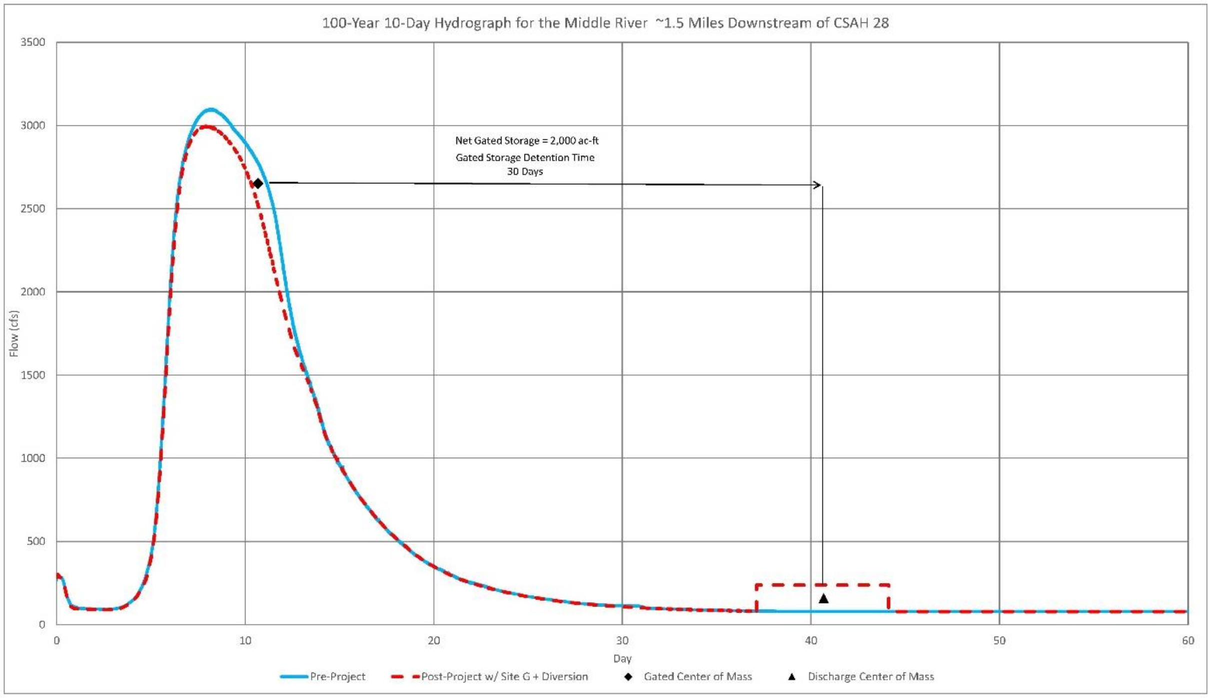


Figure 11-10: Existing vs. Proposed Middle River 100-Year 10-Day Hydrograph

12 Additional Considerations

12.1 Permitting

The following permits will be obtained for each respective component of the Project prior to construction.

- MnDNR Public Waters Permit
- MnDNR Dam Safety Permit
- USACE Section 404 Permit
- USACE Transportation General Permit
- State of Minnesota WCA Permit
- Minnesota Pollution Control Agency – Section 401 Water Quality Certification
- Marshall County Right-of-Way Permit
- Minnesota Pollution Control Agency – Construction Stormwater Permit

12.2 Wetland Avoidance and Mitigation

The following wetland impacts and mitigation requirements in Table 12-1 were determined through a wetland delineation and coordination with the USACE, State of Minnesota BWSR, Marshall County SWCD, and MPCA. Where ditches cross wetland locations, a one-foot clay cap will be compacted on the side slopes to mitigate for potential lateral drainage.

Table 12-1: Wetland Mitigation Requirements

Activity	Acres Impacted	Replacement Ratio	Credits Required
Embankment Construction (100% Hayed) Agricultural Wetlands	10.46	1:1	10.46
Embankment Construction (100% Hayed) Non-Agricultural Wetlands	0.12	2:1	0.24
Borrow Excavation	3.07	2:1	6.14
Transition from Embankment to exterior drain	3.46	1:1	3.46
Excavation of ditches through Type 2 Reed Canary Grass Dominated wetlands	8.17	0:0	0
Total Replacement Required			20.3

12.3 Right-of-Way Impacts

Right of way (ROW) information was determined using parcel deed information in conjunction with a legal survey of the four sections around the Project footprint. Permanent right-of-way will be obtained for the embankment, flood control structure, ditches, ditch buffers, and borrow locations. The Project will have a minimum 16.5-foot buffer on all ditches. A flowage easement will be obtained on all lands within the impoundment that is not permanent. This land will be used for the temporary storage of water during operational events. A 20-foot temporary easement will be obtained along the inlet channel for construction practices. The permanent and flowage / temporary impacts are summarized by parcel in Table 12-2.

Table 12-2: Landowner Right-of-Way

Parcel Number	Permanent Right-of-Way (Acres)	Flowage / Temp Easement (Acres)
31-0158-000	5.97	1.65
31-0187-000	41.77	158.23
31-0189-000	87.81	94.1
31-0192-000	12.75	0.0

12.4 Utilities

HDR conducted a Gopher State One Call to obtain design-locate information for all utilities located within the impoundment and diversion alternative footprints. The identified utilities include underground and overhead electric, telephone, and fiber optic cable. These utility conflicts as well as others identified are shown in Figure 12-1 and Table 12-3. Utilities within the railroad modification include a fiber optic cable that will require relocation.

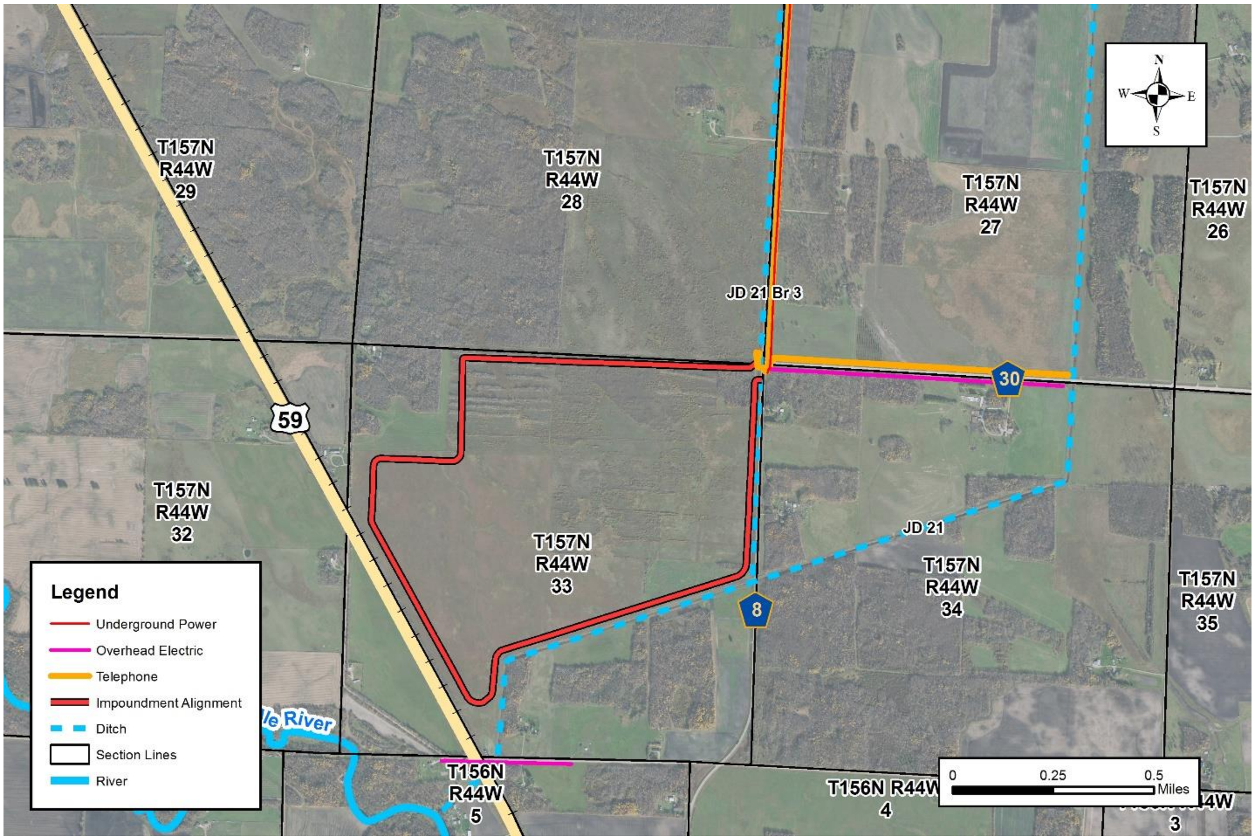


Figure 12-1: Utility Locations

Table 12-3: Impoundment Utility Schedule

Alignment	Station	Item In-Place	Owner
Impoundment	166+15	Telephone	Wiktel
Impoundment	166+27	Telephone	Wiktel
East Interior Ditch	267+34	Pedestal	Wiktel
East Interior Ditch	267+34 to 267+63	Telephone	Wiktel
Inlet Channel	300+00 to 341+00	Telephone	Wiktel
Inlet Channel	301+64	Pedestal	Wiktel
Inlet Channel	301+90	Underground Power	Red Lake Electric
Inlet Channel	312+86	Pedestal	Wiktel

Alignment	Station	Item In-Place	Owner
Inlet Channel	325+87	Pedestal	Wiktel
Inlet Channel	333+33	Pedestal	Wiktel
Inlet Channel	341+03	Pedestal	Wiktel
CSAH 8 East	800+00 to 810+00	Underground Power	Red Lake Electric
CSAH 8 East	800+00 to 810+00	Telephone	Wiktel

12.5 Potential Groundwater Impacts

It is not anticipated that the impoundment alternative will have an impact on the local groundwater as a result of the occasional storage of surface water or as a result of construction. Groundwater was encountered at the inlet channel during the geotechnical drilling and was encountered at a depth of five feet. Where ditches cross wetland locations, a one-foot clay cap will be compacted on the side slopes to mitigate for potential lateral drainage. It is also not anticipated that a modification to the railroad crossing will have an impact on the local groundwater.

12.6 Environmental Consequences

Fish and Wildlife

It is not anticipated that the Project is expected to cause negative environmental consequences. It is anticipated that the Project will enhance fish and wildlife habitat through the removal of the culvert structure within the Middle River and replacing it with a bridge. Wetland and upland habitats exist on the Project Site. The upland habitat within the impoundment will be subject to periods of inundation in accordance with the operating plan. When the impoundment is not in use, the present landuse of CRP will be maintained.

Water Quality

Based on the Minnesota Pollution Control Agency 2022 Impaired Waters List, the Middle River is impaired for dissolved oxygen and aquatic life. There is limited water quality information available in regard to monitoring downstream of the JD 21 and Middle River confluence.

The JD 21 system currently experiences bank erosion at several locations along the Project footprint due to overland flows across the Project site entering the system in low draws. The construction of the impoundment embankment will reduce the overland flows from the 396-acre site. The impoundment will also provide sediment trapping for the JD 21 system upstream of the site because of the detention times. These times can vary from 7 – 30 days.

12.7 Erosion Control

Erosion Control During Construction

A Storm Water Pollution Prevention Plan (SWPPP) will be implemented to reduce erosion and soil loss during construction. Best management practices such as buffer strips, cofferdams, temporary cover, silt fences, floating silt curtains, sediment control logs, etc. will be laid out as part of the design.

Vegetation

The embankment and ditches will be vegetated with the MnDOT 25-141, Mesic General Roadside mix. The East Interior Ditch will be seeded with the BWSR 34-172, wetland rehabilitation mix. All temporary construction impacts outside of the permanent right-of-way will be reseeded with the Minnesota CP-1, CRP mix.

Permanent Erosion Control

Culverts with a diameter of 42 inches and less than 60 inches, will have a rock apron constructed of Random Riprap Class 3. The apron will extend 5 feet outward on the inlet side and 15 feet on the downstream side. Culverts less than 42 inches will have the same rock apron with a length of 5 feet on the inlet side and 10 feet on the outlet side.

The dual 66-inch culverts within the inlet channel will have a rock apron with a length of 12 feet at the inlet and a stilling basin at the outlet. The stilling basin will have a basin depth of 2 feet and a length of 20 feet.

The Reinforced Concrete Box Culvert through CSAH 8 will have a similar riprap configuration as the dual 66-inch culverts. The stilling basin will have a depth of 2 feet and a length of 36 feet.

The outlet structure will have a rock apron at the inlet with a length of 20.5 feet. The outlet end of the box culvert will have a stilling basin with a depth of 3 feet and overall length of 55 feet. Random Riprap Class 4 with a D50 of 12 inches and thickness of 3 feet will be used.

Additional Random Riprap Class 3 will be placed along portions of the inlet channel where we cut through an existing gravel ridge to prevent erosion. The riprap will extend from the toe of the ditch up the backslope up to 6 feet and will vary along the channel. The main purpose of this is to prevent erosion of the slope due to groundwater weeping through the gravel ridge. Random Riprap Class 3 will also be placed immediately downstream of the box culvert through CSAH 8 up the side slopes of the East Inlet Ditch where it curves south. This is to prevent any erosion of the slopes as water changes direction within the channel.

13 Social, Economic, and Environmental Impacts

13.1 Social & Economic Impacts

The Project will produce a positive economic impact for the long-term growth and development of the benefitting area. The initial Project investment will be equalized over time by the reduced flood damage costs to the surrounding rural and urban areas. Given the area and extents of the Project, the benefits should impact the community at present, and the long-term planning and expansion of the community.

This Project will benefit local landowners by reducing property damage and crop loss due to flooding. Public benefits include increased assurances created by the reduction in flood damages to the City and will promote residential and commercial growth.

14 Operating Plan

No gate operation is necessary to direct runoff to the impoundment. The existing JD21 ditch system collects runoff which is conveyed to the Newfolden Impoundment through the inlet channel.

In accordance with the Red River Water Management Board (RRWMB) criteria for the Red River of the North (Red River), impoundments hold water up to a maximum of 30 days while the Red River is at flood stage. The USGS / National Weather Service flood stages at downstream gage sites on the Middle River and Red River are used to address the timing of flows from the Middle-Snake-Tamarac Rivers Watershed.

Once downstream flooding has subsided, the stored water within the impoundment will be released in a controlled manner with the water surface elevations and extent of downstream flooding being used to determine when the outlet gate will be opened to discharge flow from the impoundment. The trigger elevations for the release of floodwater are the "moderate flood stage" at known gages. The gate at the Newfolden Impoundment can be opened to release the retained flow and drain the site in anticipation of the next flood event when the Red River and Middle River are below the following trigger elevations are reached:

- Red River at Oslo, MN is below the trigger elevation of 30.0 feet.
- Middle River at Argyle, MN is below the trigger elevation of 12.0 feet.

Table 14-1 displays the operating plan considerations. The operating plan does not include a permanent pool elevation.

Table 14-1: Operating Plan Considerations

Upstream Flow Directed to Impoundment	Pool			Downstream Gate Operating Triggers to Release Water from Newfolden Impoundment	
Local County Ditch JD 21	Rising Limb of Hydrograph	During Flood	Falling Limb of Hydrograph	Red River Stage at Oslo	Middle River Stage at Argyle
Flow directed to pool due to removal of culvert through CSAH 30	Gate closed during rising limb to begin retaining runoff	Gated operated to keep Max Pool below Elev. 1107.4	Gate opened after flood has passed and downstream triggers are met	30.0	12.0

15 Opinion of Probable Cost

Table 15-1 displays estimated costs for the Newfolden Impoundment as of October 2023 and is based on 2023 rates. A statement of estimated quantities and unit costs for individual bid items is available upon request.

Table 15-1: Engineer's Estimate of Probable Project Costs

Construction [1]	Engineering & Administration	Utility Relocation	Permanent ROW	Flowage Easement	Wetland Mitigation	Estimated Project Cost
$5,100,000	$1,100,000	$34,000	$222,450	$220,789	$355,250	$7,032,489

[1] Summation of estimated quantities and unit costs.

Potential funding partners for the Project include MnDNR State funding through the Flood Hazard Mitigation (FHM) grant program, RRWMB, MSTRWD, and the City of Newfolden.

16 Summary

The City of Newfolden Flood Prevention Project is a comprehensive project to remove the City of Newfolden from the 1% Annual Chance Floodplain. The railroad structure modification and Newfolden Impoundment together form the City of Newfolden Flood Prevention Project that meets the Purpose and Need (P&N) to remove the City of Newfolden from the 1% Annual Chance Floodplain a minimum of 1 foot below the effective Base Flood Elevation set by FEMA, provide downstream flood reduction benefits, provide improvements to the local flooding near the Project location, and contribute to the Red River Basin flood reduction goals. The railroad structure modification reduces Middle River water levels in Newfolden and removes structures from the floodplain. The Newfolden Impoundment reduces runoff and breakout flows from the Judicial Ditch 21 (JD 21) system, mitigating downstream impacts to Newfolden and the Middle River, while contributing to the Red River Basin flood reduction goals.

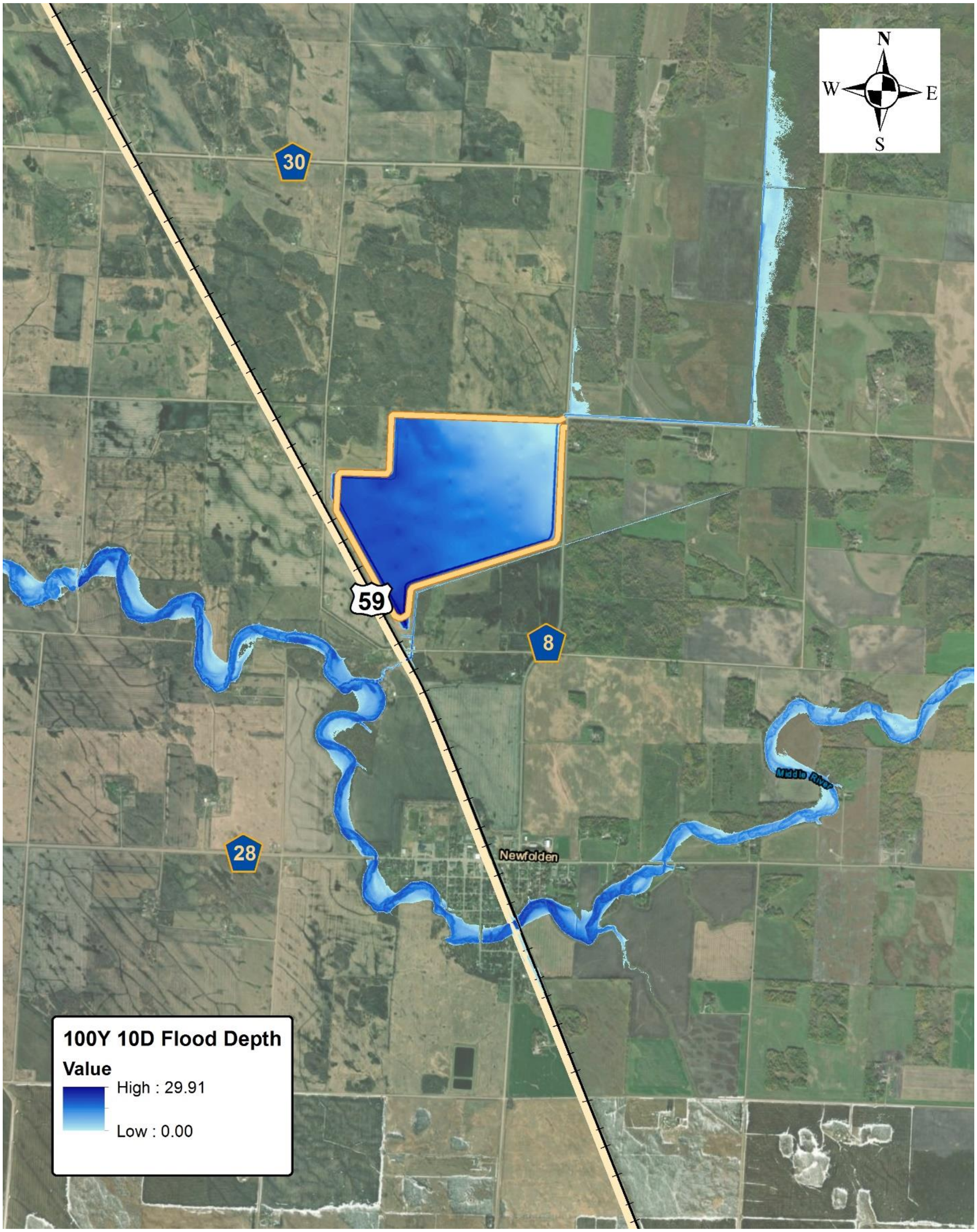


Figure 16-1: Proposed – 100-Year 10-Day Snowmelt Event

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Appendix A. Geotechnical Investigation – NTI Report

GEOTECHNICAL EXPLORATION
AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

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Unearthing confidence™

December 10, 2018

Middle-Snake-Tamarac Rivers Watershed District (MSTRWD)
453 North McKinley St.
Warren, MN 56762

Attn: Mr. Joel Praska, Administrator

Subject: Geotechnical Exploration (factual)
Proposed Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota
NTI Project No. 18.FGO.06666

In accordance with your request and subsequent August 31, 2018 authorization, Northern Technologies, LLC (NTI) conducted a Geotechnical Exploration for the above referenced project. Our services included advancement of exploration borings and preparation of a factual engineering report with respect to our geotechnical services. Our work was performed in general accordance with our proposal of August 28, 2018.

Soil samples obtained at the site will be held for 60 days (from issue of report) at which time they will be discarded. Please advise us in writing if you wish to have us retain them for a longer period. You will be assessed an additional fee if soil samples are retained beyond 60 days.

We appreciate the opportunity to have been of service on this project. If there are any questions regarding the soils explored or our review and recommendations, please contact us at your convenience at (701) 232-1822.

Northern Technologies, LLC

Daniel Gibson

Dan Gibson, P.E.
Senior Engineer

Josh Holmes, P.E.
Senior Engineer

cc: HDR

GEOTECHNICAL EXPLORATION
AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

TABLE OF CONTENTS
GEOTECHNICAL EXPLORATION AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

Contents Page

1.0 INTRODUCTION 1
  1.1 Site / Project Description 1
  1.2 Scope of Services 1
2.0 EXPLORATION PROGRAM RESULTS 1
  2.1 Exploration Scope and Procedures 1
  2.2 Surface Conditions 2
  2.3 Subsurface Conditions 2
  2.4 Groundwater Conditions 2
  2.5 Laboratory Test Program 3
3.0 CLOSURE 4

APPENDICES

Appendix A - Geotechnical Evaluation of Recovered Soil Samples, Field Exploration Procedures, General Notes, Classification of Soils for Engineering Purposes

Appendix B - Laboratory Summary, Atterberg Limits Testing, Hydrometer Testing, Proctor Test, Unconfined Compression Tests, Consolidation Test, Hydraulic Conductivity Test, C-U Triaxial Test

Appendix C - Boring Logs, MDH Sealing Records, Site Diagram

GEOTECHNICAL EXPLORATION AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

1.0 INTRODUCTION

1.1 Site / Project Description

The proposed Newfolden/Middle River Subwatershed Flood Damage Reduction Project is to be constructed in rural areas to the north and east of Newfolden, Minnesota as shown on the appended Borehole Location Plan provided by HDR. The project will consist of a diversion channel and embankments to reduce flood damage in the Newfolden area. The purpose of our investigation was to identify soils and perform laboratory testing as directed by HDR.

1.2 Scope of Services

The purpose of this report is to present a summary of our geotechnical exploration and laboratory testing for founding of the project. Our "scope of services" was limited to the following:

1. Explore the project subsurface by means of fifteen (15) standard penetration borings extending to depths of 16 to 46 feet, and conduct laboratory tests (as directed by HDR) on representative samples to characterize the engineering and index properties of the soils.
2. Prepare a factual report presenting our findings from our field exploration and laboratory testing based on the Scope of Work provided by HDR.

2.0 EXPLORATION PROGRAM RESULTS

2.1 Exploration Scope and Procedures

Site geotechnical drilling occurred on October 16, 17, & 18, 2018 with individual borings advanced at approximate locations as presented on the diagrams and corresponding coordinates within the appendices. Coordinates on the boring logs may differ slightly than the original plan to allow for access or avoidance of utilities. HDR staked the boring locations and provided elevations. NTI performed the borings in relatively close proximity to the staked locations.

NTI and its sub consultant (Soil Engineering Testing) performed the field exploration and laboratory under guidance from ASTM Standards and common practice within the geotechnical engineering field. We provide additional information on field and laboratory procedures within the report appendices.

2.2 Surface Conditions

The property for the proposed Newfolden/Middle River Subwatershed Flood Damage Reduction Project is currently farm fields, grasslands, wooded areas, and roadway ditches. Surfaces consist of grass cover and fallow farm land at the boring locations.

2.3 Subsurface Conditions

Please refer to the boring logs within the appendices for a detailed description and depths of stratum at each boring. The boreholes were abandoned using high solids bentonite grout per Minnesota Department of Health statutes. Minor settlement of upper infill soil and grout will occur with Owner responsible for final closure of the boreholes. The general geologic origin of retained soil samples is listed on the boring logs. The upper portion of the soil profile for each boring was sampled using auger flights and is approximate.

The overall subsurface soil profile at the borings consists of approximately 0.2 to 4.5 feet of topsoil and topsoil/fill underlain by relatively thin layers of loose to medium dense Glacial Lake Sediment (GLS) soils followed by medium to stiff Lake Modified Glacial Till (LMGT) which extends to the termination depth of the borings (maximum 46 feet). The GLS soils are comprised of sand and silty sand. LMGT soils are comprised of lean clay, silty clay, silt, occasional layers of sand. The soils have varying color, moisture content and unit weight. The LMGT clay soils have trace amounts of sand and gravel. Additional comment on the evaluation of recovered soil samples is presented within the report appendices and boring logs.

2.4 Groundwater Conditions

The drill crew observed the borings for groundwater and noted cave-in depth of borings, if any, during and at the completion of drilling activities. These observations and measurements are noted on the boring logs.

Measurable groundwater was encountered from depths of 1 to 15 feet below grade at select boring locations during and / or at the completion of drilling operations. Boring logs noted if samples were saturated during classification of the samples. The groundwater was contained within silt and sand soils that were generally confined by clay soils above and/or below the sand and silt layers. Additionally, occasional silt and sand seems are likely present and may be water bearing during spring thaw or times of heavy precipitation at all boring locations. The moisture content of lens soils and host clays can vary annually and per recent precipitation. Such soils and other regional dependent conditions may produce groundwater entry of project excavations.

2.5 Laboratory Test Program

2.5.1 SPT and Hand Penetrometer – Boring logs include SPT "N"-values and hand penetrometer readings obtained on cohesive soils during laboratory classification of retained soils.

2.5.2 Moisture and Density – We performed moisture and density testing on the samples requested by HDR as well as a number of other samples. Moisture and dry density of the soils ranged from 9 to 24 percent (excluding topsoil) and 108 to 134 lbs/ft^3, respectively. Results of all tests are included within the boring logs and testing summary.

2.5.3 Atterberg Limits (LL/PL) – We performed a total of fifteen (15) Atterberg limit tests on samples selected by HDR. The liquid limits (LL) ranged from 13 to 33 and the plastic limits (PL) ranged from 9 to 19. Results of all tests are included within the boring logs, testing summary, and Appendix B.

2.5.4 Hydrometer / Grain Size Analysis – Four (4) hydrometer / Grain Size Analysis tests were performed on samples chosen by HDR. The results are included in Appendix B of this report.

2.5.5 Standard Proctor Test – A single Standard Proctor test was conducted on a composite sample from augur cuttings of soils encountered from 1 to 10 feet below grade at soil boring SB-13. The test report is included within Appendix B.

2.5.5 Unconfined Compression Tests and CU Test (3 pressures) – We performed two unconfined compression tests and one UU Triaxial Test on samples chosen by HDR. Results are included in the testing summary and/or on individual reports within the appendices of this report. Additional information and data on the compressive strength of soils is included within the pocket pen. column on the boring logs.

2.5.6 Consolidation Test – We performed a single consolidation test on a thin wall tube sample obtained at a depth of 15 feet at soil boring SB-13. The result of the test is in Appendix B.

2.5.7 Hydraulic Conductivity Test – A single hydraulic conductivity or permeability test was performed on a thin wall tube sample obtained at a depth of 15 feet at soil boring SB-9. The result of the test is in Appendix B.

3.0 CLOSURE

The area coverage of borings in relation to the entire project is very small. For this and other reasons, we do not warrant conditions below the depth of our borings, or that the strata logged from our borings are necessarily typical of the site.

This factual report has been prepared for the exclusive use of Middle-Snake-Tamarac Rivers Watershed District (MSTRWD) and HDR for specific application to the proposed Flood Damage Reduction Project in rural Newfolden, Minnesota. Northern Technologies, LLC has endeavored to comply with generally accepted geotechnical engineering practice common to the local area. Northern Technologies, LLC makes no other warranty, expressed or implied.

Northern Technologies, LLC

Daniel Gibson

Dan Gibson, P.E.
Senior Engineer

Josh Holmes, P.E.
Senior Engineer

DG:jh

Attachments

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APPENDIX A

GEOTECHNICAL EVALUATION OF RECOVERED SOIL SAMPLES

We visually examined recovered soil samples to estimate distribution of grain sizes, plasticity, consistency, moisture condition, color, presence of lenses and seams, and apparent geologic origin. We then classified the soils according to the Unified Soil Classification System (ASTM D2488). A chart describing this classification system and general notes explaining soil sampling procedures are presented within the appendices.

The stratification depth lines between soil types on the logs are estimated based on the available data. Insitu, the transition between type(s) may be distinct or gradual in either the horizontal or vertical directions. The soil conditions have been established at our specific boring locations only. Variations in the soil stratigraphy may occur between and around the borings, with the nature and extent of such change not readily evident until exposed by excavation. These variations must be properly assessed when utilizing information presented on the boring logs. We request that you, your design team or contractors contact NTI immediately if local conditions differ from those assumed by this report, as we would need to review how such changes impact our recommendations. Such contact would also allow us to revise our recommendations as necessary to account for the changed site conditions.

FIELD EXPLORATION PROCEDURES

Soil Sampling – Standard Penetration Boring:

Soil sampling was performed according to the procedures described by ASTM D-1586. Using this procedure, a 2 inch O.D. split barrel sampler is driven into the soil by a 140 pound weight falling 30 inches. After an initial set of six inches, the number of blows required to drive the sampler an additional 12 inches is recorded (known as the penetration resistance (i.e. "N-value") of the soil at the point of sampling. The N-value is an index of the relative density of cohesionless soils and an approximation of the consistency of cohesive soils.

Soil Sampling – Power Auger Boring:

The boring(s) was/were advanced with a 6 inch nominal diameter continuous hollow stem flight auger. As a result, samples recovered from the boring are disturbed, and our determination of the depth, extent of various stratum and layers, and relative density or consistency of the soils is approximate.

Soil Classification:

Soil samples were visually and manually classified in general conformance with ASTM D-2488 as they were removed from the sampler(s). Representative fractions of soil samples were then sealed within respective containers and returned to the laboratory for further examination and verification of the field classification. In addition, select samples were submitted for laboratory tests. Individual sample information, identification of sampling methods, method of advancement of the samples and other pertinent information concerning the soil samples are presented on boring logs and related report attachments.

General Notes

DRILLING & SAMPLING SYMBOLS		LABORATORY TEST SYMBOLS	
SYMBOL	**DEFINITION**	**SYMBOL**	**DEFINITION**
C.S.	Continuous Sampling	W	Moisture content-percent of dry weight
P.D.	2-3/8" Pipe Drill	D	Dry Density-pounds per cubic foot
C.O.	Cleanout Tube	LL, PL	Liquid and plastic limits determined in accordance with ASTM D 423 and D 424
3 HSA	3 ¼" I.D. Hollow Stem Auger	Q_u	Unconfined compressive strength-pounds per square foot in accordance with ASTM D 2166-66
4 FA	4" Diameter Flight Auger		
6 FA	6" Diameter Flight Auger		
2 ½ C	2 ½" Casing		
4 C	4" Casing	**Additional insertions in Qu Column**	
D.M.	Drilling Mud	Pq	Penetrometer reading-tons/square foot
J.W.	Jet Water	S	Torvane reading-tons/square foot
H.A.	Hand Auger	G	Specific Gravity – ASTM D 854-58
NXC	Size NX Casing	SL	Shrinkage limit – ASTM 427-61
BXC	Size BX Casing	pH	Hydrogen ion content-meter method
AXC	Size AX casing	O	Organic content-combustion method
SS	2" O.D. Split Spoon Sample	M.A.*	Grain size analysis
2T	2" Thin Wall Tube Sample	C*	One dimensional consolidation
3T	3" Thin Wall Tube Sample	Q_c*	Triaxial Compression
			* See attached data Sheet and/or graph

Water Level Symbol

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable groundwater levels. In clay soils, it is not possible to determine the groundwater level within the normal scope of a test boring investigation, except where lenses or layers of more pervious water bearing soil is present and then a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed soils may not indicate the true level of the groundwater table. The available water level information is given at the bottom of the log sheet.

Descriptive Terminology

DENSITY		CONSISTENCY	
TERM	**"N" VALUE**	**TERM**	**"N" VALUE**
Very Loose	0-4	Soft	0-4
Loose	5-8	Medium	5-8
Medium Dense	9 – 15	Rather Stiff	9 – 15
Dense	16 – 30	Stiff	16 – 30
Very Dense	Over 30	Very Stiff	Over 30

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon.

Relative Proportions

TERMS	RANGE
Trace	0-5%
A little	5-15%
Some	15-30%
With	30-50%

Particle Sizes

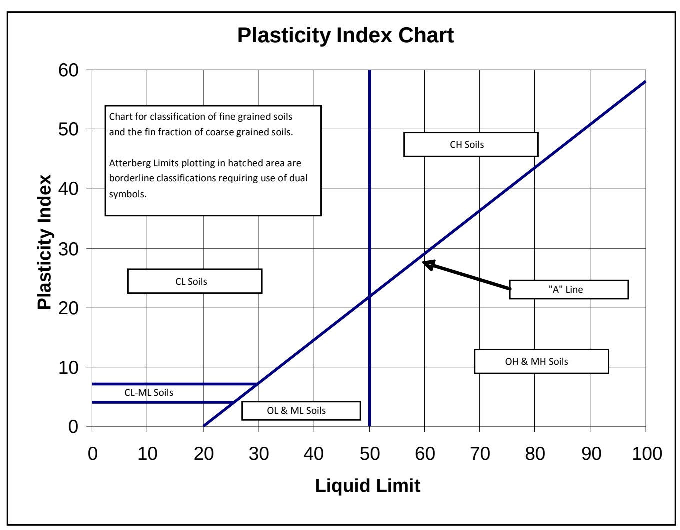
Boulders		Over 3"
Gravel -	Coarse	¾" – 3"
	Medium	#4 – ¾"
Sand -	Coarse	#4 - #10
	Medium	#10 - #40
	Fine	#40 - #200
Silt and Clay		Determined by plasticity characteristics.

Note: Sieve sizes are U.S. Standard.

Classification of Soils for Engineering Purposes

ASTM Designation D-2487 and D 2488 (Unified Soil Classification System)

Major Divisions			Group Symbol	Typical Names	Classification Criteria		
Course Grained Soils More than 50% retained on No. 200 sieve *	***Gravels*** 50% or more of coarse fraction retained on No. 4 sieve.	Clean Gravels	**GW**	Well –graded gravels and gravel-sand mixtures, little or no fines.	***Classification on basis of percentage of fines.*** Less than 5% passing No. 200 Sieve: GW, GP, SW, SP More than 12% passing No. 200 Sieve: GM, GC, SM, SC From 5% to 12% passing No. 200 Sieve: Borderline Classification requiring use of duel symbols.	$C_u = D_{60} / D_{10}$ greater than 4. $C_z = (D_{30})^2 / (D_{10} \times D_{60})$ between 1 & 3.	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.		Not meeting both criteria for GW materials.	
		Gravels with Fines	**GM**	Silty gravels, gravel-sand-silt mixtures.		Atterberg limits below "A" line, or P.I. less than 4.	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures.		Atterberg limits above "A" line with P.I. greater than 7.	
	Sands More than 50% of coarse fraction passes No 4 sieve.	Clean Sands	**SW**	Well-graded sands and gravelly sands, little or no fines.		$C_u = D_{60} / D_{10}$ greater than 6. $C_z = (D_{30})^2 / (D_{10} \times D_{60})$ between 1 & 3.	
			SP	Poorly-graded sands and gravelly sands, little or no fines.		Not meeting both criteria for SW materials.	
		Sands with Fines	**SM**	Silty sands, sand-silt mixtures.		Atterberg limits below "A" line, or P.I. less than 4.	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.		Atterberg limits above "A" line with P.I. greater than 7.	
Fine Grained Soils More than 50% passes No. 200 sieve *	***Silts and Clays*** Liquid Limit of 50% or less		**ML**	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.			
			OL	Organic silts and organic silty clays of low plasticity.			
	Silts and Clays Liquid Limit greater than 50%.		**MH**	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.			
			CH	Inorganic clays of high plasticity, fat clays.			
			OH	Organic clays of medium to high plasticity.			
	Highly Organic Soils		**Pt**	Peat, muck and other highly organic soils.			



APPENDIX B

SUMMARY OF LABORATORY RESULTS

NTI NORTHERN TECHNOLOGIES, LLC

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Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Borehole	Sample #	Depth (ft)	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Maximum Size (mm)	% < #200 Sieve	Unconfined Compression		Void Ratio	Other Tests
									Peak (psf)	%		
SB-01	2	2.0	12.0	121.3	33	12						
SB-01	3	4.5	13.1	117.1								
SB-01	4	7.0	12.9	121.1								
SB-01	5	9.5	13.1	124.0								
SB-01	6	12.0	13.7	122.7								
SB-01	8	17.0	13.0	126.4								
SB-01	9	19.5	20.5	114.9								
SB-01	10	24.5	12.7	126.3								
SB-01	11	29.5	14.9	122.5								
SB-02	1	0.0	19.4									
SB-02	2	2.0	16.0	112.4								
SB-02	3	4.5	13.4	122.7								
SB-02	4	7.0	14.1	124.6								
SB-02	5	9.5	15.7	115.7								
SB-02	6	12.0	15.1	121.6	30	12						
SB-02	8	17.0	13.5	125.4								
SB-02	9	19.5	11.8	127.6								
SB-02	10	24.5	13.3	123.3								
SB-02	11	29.5	12.9	127.5								
SB-03	1	0.0	16.7									
SB-03	3	4.5	23.8	107.7								
SB-03	4	7.0	10.0		15	9						
SB-03	5	9.5	13.2	128.0								
SB-03	6	12.0	14.2	130.4								
SB-03	8	17.0	13.3	123.4								
SB-03	9	19.5	12.7	126.7								
SB-03	10	24.5	13.2	125.9								
SB-03	11	29.5	14.4	121.7								
SB-04	1	0.0	20.3									
SB-04	5	9.5	13.3	129.7								
SB-04	6	12.0	13.4	131.7								
SB-04	7	14.5	13.0	129.5								
SB-05	1	0.0	18.8									
SB-05	2	2.0	17.5									
SB-05	3	4.5	21.4	120.1								
SB-05	4	7.0	8.9	133.9								
SB-05	5	9.5	12.2									
SB-05	6	12.0	14.7	119.2								

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SUMMARY OF LABORATORY RESULTS

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Borehole	Sample #	Depth (ft)	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Maximum Size (mm)	% < #200 Sieve	Unconfined Compression		Void Ratio	Other Tests
									Peak (psf)	%		
SB-05	7	14.5	12.5	124.0								
SB-06	3	4.5	22.7				4.75	12				
SB-07	3	4.5	12.9				9.5	63				
SB-08	2	2.0	17.9	109.4	20	11						
SB-08	3	4.5	14.4	121.5								
SB-08	4	7.0	11.7	125.6								
SB-08	5	9.5	13.2	118.2								
SB-08	6	12.0	12.1	130.7								
SB-08	7	14.5	13.2	128.5								
SB-08	8	17.0	14.2	123.9								
SB-08	9	19.5	13.6	125.8								
SB-08	10	24.5	14.9	120.4								
SB-08	11	29.5	17.1	115.5								
SB-09	1	0.0	29.9									
SB-09	2	2.0	12.8				9.5	23				
SB-09	3	4.5	15.7	123.2	25	11			3570	12.6		
SB-09	4	7.0	14.0	126.3								
SB-09	5	9.5	14.2	122.5								
SB-09	6	12.0	13.8	121.3								
SB-09	8	17.0	16.6									
SB-09	9	19.5	13.3	125.3	25	12						
SB-09	10	24.5	14.0	123.3								
SB-09	11	29.5	8.8	130.2								
SB-09	12	34.5	6.4	127.2								
SB-09	13	39.5	6.0		13	10						
SB-09	14	44.5	9.4									
SB-10	2	2.0	24.0				2	19				
SB-11	5	9.5	12.9	126.0	22	11						
SB-12	4	7.0	11.0		23	11						
SB-12	11	29.5	17.3	117.3	22	11						
SB-13	1	0.0	20.4									
SB-13	2	2.0	10.2	116.7								
SB-13	Bag	3.0	11.9	121.6								
SB-13	3	4.5	12.6	125.4								
SB-13	4	7.0	13.4	122.0	25	11						
SB-13	5	9.5	14.0	126.8	24	12			4730	15.0		
SB-13	6	12.0	12.8	122.2								
SB-13	7	14.5	14.7	114.7							0.470	

SUMMARY OF LABORATORY RESULTS

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Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Borehole	Sample #	Depth (ft)	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Maximum Size (mm)	% < #200 Sieve	Unconfined Compression		Void Ratio	Other Tests
									Peak (psf)	%		
SB-13	8	17.0	16.6	114.2								
SB-13	9	19.5	12.4	123.5								
SB-13	10	24.5	13.7	120.9								
SB-13	11	29.5	20.6	106.8								
SB-13	12	34.5	13.9	118.3	27	12						
SB-13	13	39.5	8.2	128.8								
SB-13	14	44.5	8.2	128.6								
SB-14	10	24.5	15.7	119.5	31	12						
SB-15	6	12.0	13.2	123.6	26	19						

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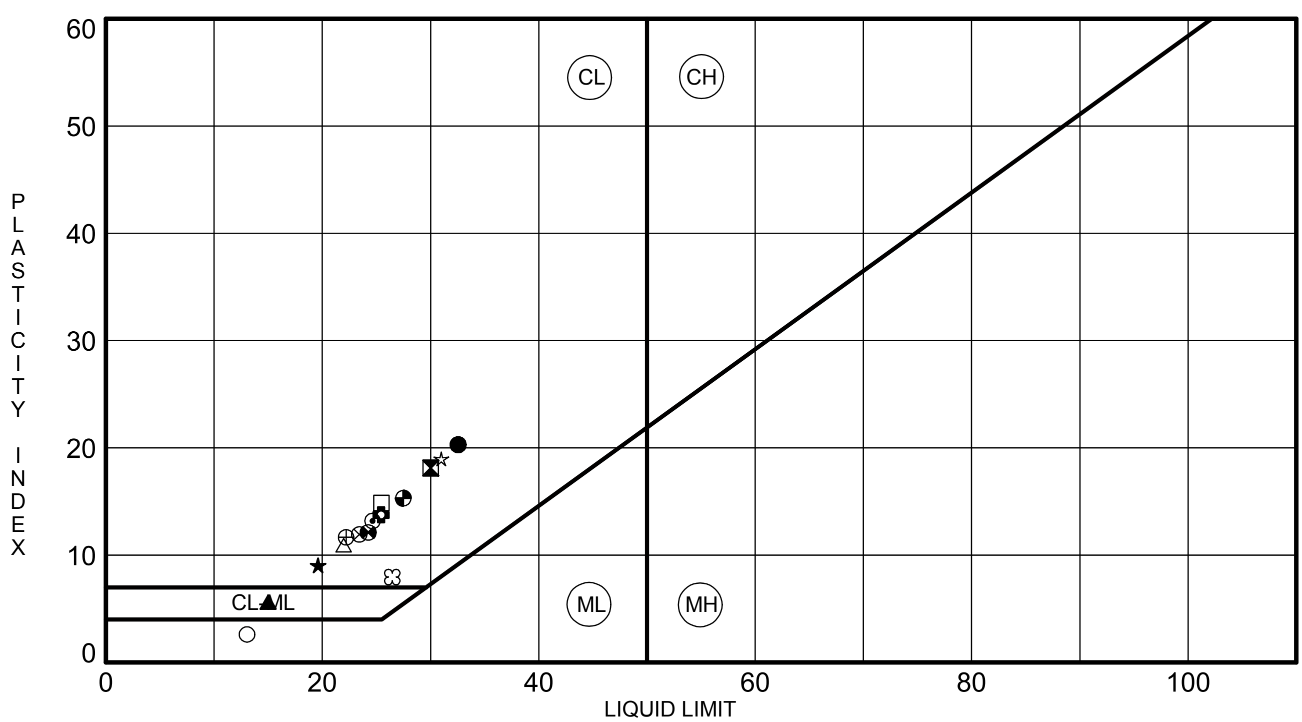
ATTERBERG LIMITS' RESULTS

ASTM D4318

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Data

	BOREHOLE	SAMPLE #	DEPTH	LL	PL	PI	Fines	Classification
●	SB-01	2	2.0	33	12	21		LEAN CLAY (CL)
⧗	SB-02	6	12.0	30	12	18		LEAN CLAY (CL)
▲	SB-03	4	7.0	15	9	6		SILTY LEAN CLAY (CL-ML)
★	SB-08	2	2.0	20	11	9		LEAN CLAY (CL)
⊙	SB-09	3	4.5	25	11	14		LEAN CLAY (CL)
✿	SB-09	9	19.5	25	12	13		LEAN CLAY (CL)
○	SB-09	13	39.5	13	10	3		SILT (ML)
△	SB-11	5	9.5	22	11	11		LEAN CLAY (CL)
⊗	SB-12	4	7.0	23	11	12		LEAN CLAY (CL)
⊕	SB-12	11	29.5	22	11	11		LEAN CLAY (CL)



Cc:

Submitted by,
Northern Technologies, LLC

Dan Gibson
(12/7/18)

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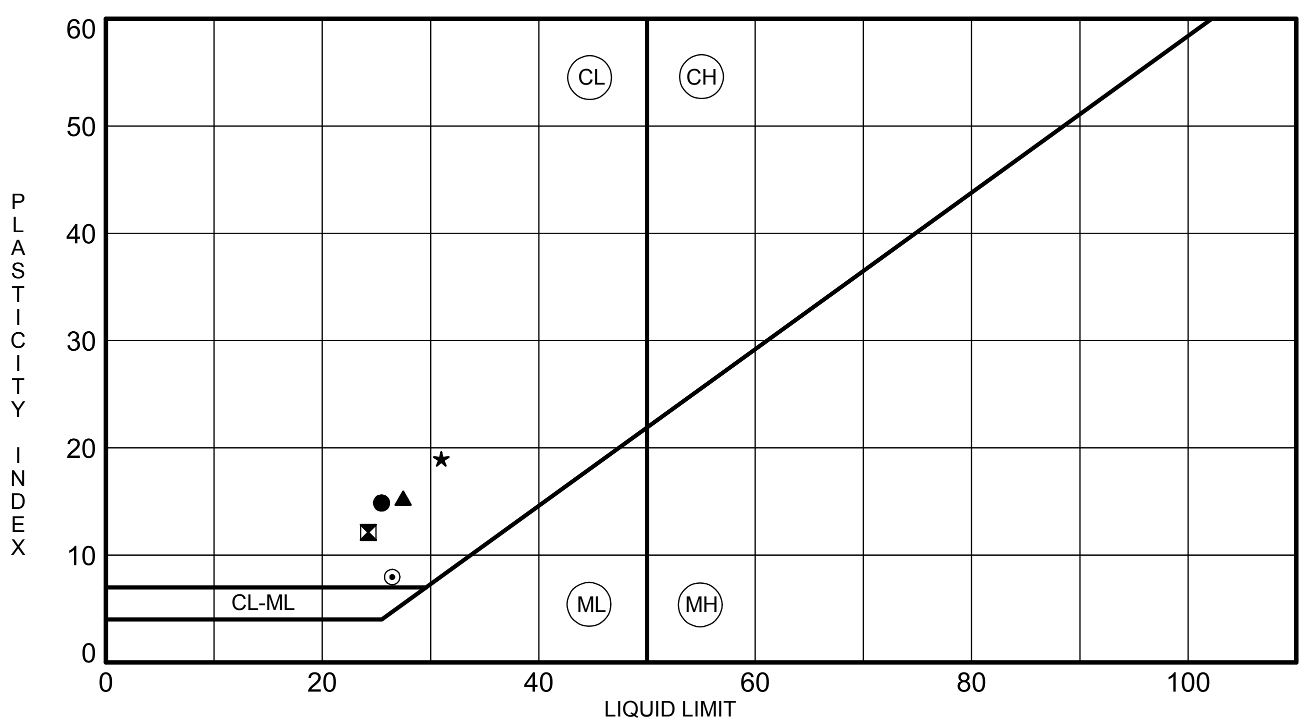
ATTERBERG LIMITS' RESULTS

ASTM D4318

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Data

	BOREHOLE	SAMPLE #	DEPTH	LL	PL	PI	Fines	Classification
●	SB-13	4	7.0	25	11	14		LEAN CLAY (CL)
⊠	SB-13	5	9.5	24	12	12		LEAN CLAY (CL)
▲	SB-13	12	34.5	27	12	15		LEAN CLAY (CL)
★	SB-14	10	24.5	31	12	19		LEAN CLAY (CL)
⊙	SB-15	6	12.0	26	19	7		LEAN CLAY (CL)



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GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

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Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

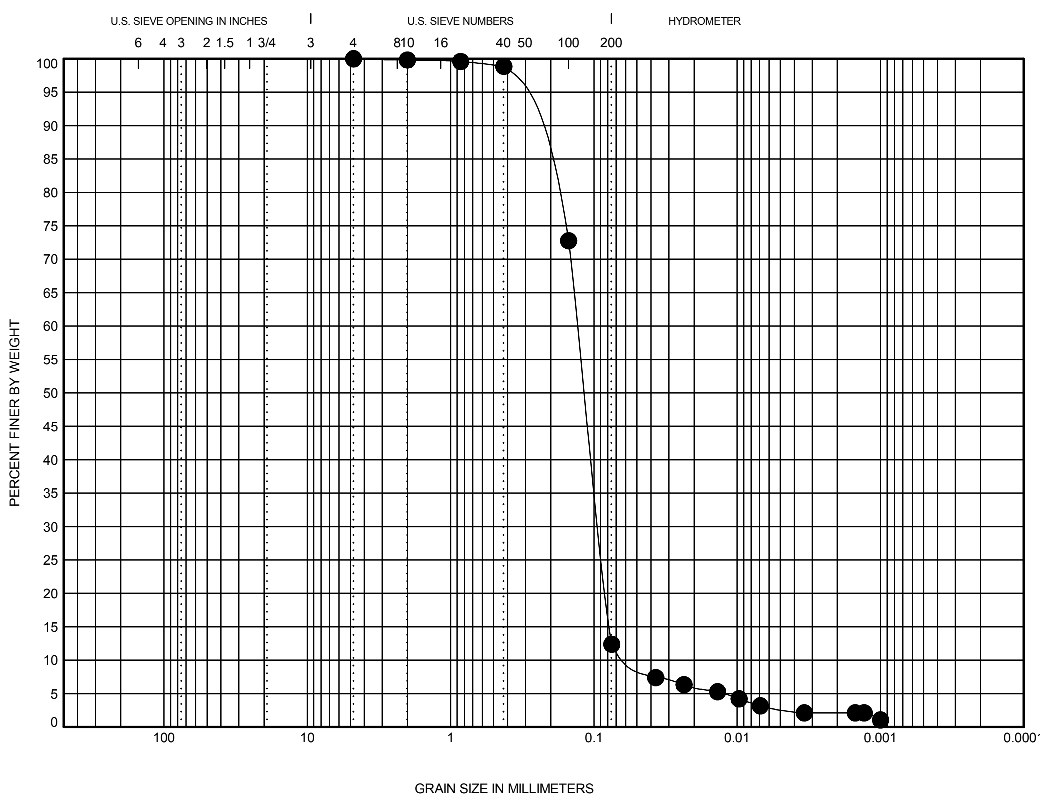
Sample Information

Boring Number:	SB-06	Date Sampled:	10/17/2018
Sample Number:	3	Sampled By:	NTI
Sample Depth (ft):	4.5	Sample Type:	SS
Classification:	SILTY SAND, fine grained		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
1.21	2.42	4.75	0.13	0.092	0.054	0.0	87.6	9.7	2.7

Sieve Name	Percent Finer	Project Specs
#4	100.0	
#10	99.8	
#20	99.6	
#40	98.9	
#100	72.8	
#200	12.4	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	12.3
0.02 mm	6.0
0.005 mm	2.7
0.002 mm	2.1
0.001 mm	1.1

Notes:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

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GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

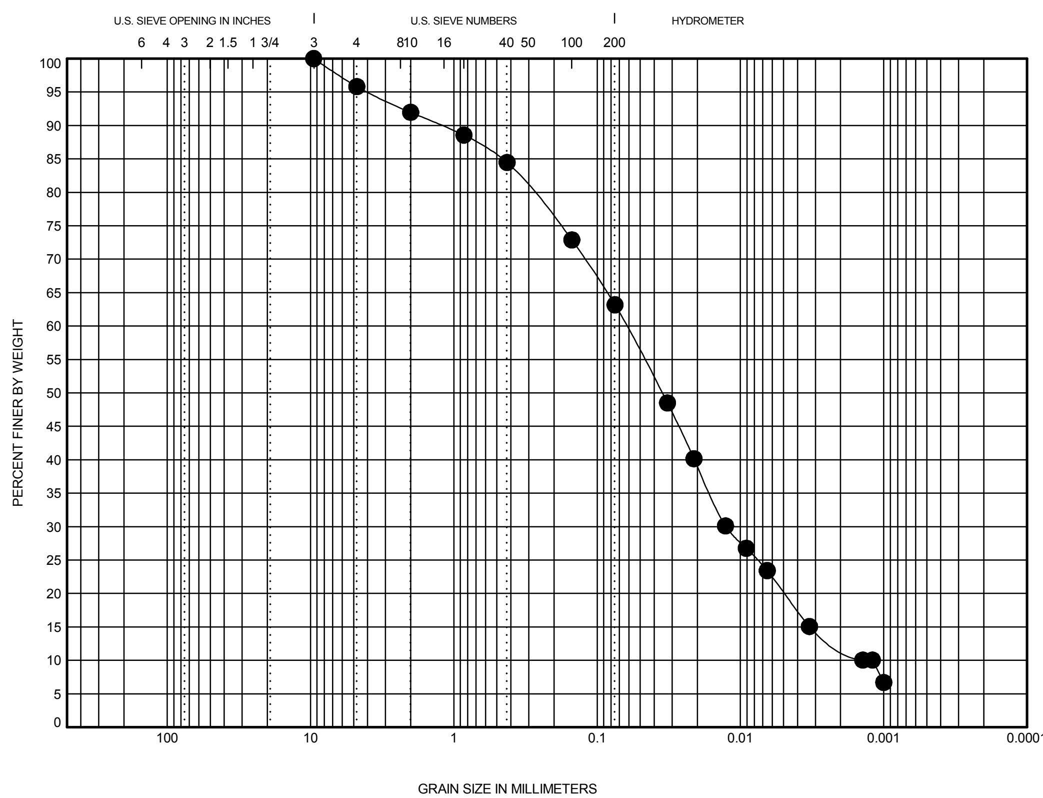
Sample Information

Boring Number:	SB-07	Date Sampled:	10/17/2018
Sample Number:	3	Sampled By:	NTI
Sample Depth (ft):	4.5	Sample Type:	SS
Classification:	SILT, with sand, trace of gravel		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
2.11	52.19	9.5	0.063	0.013	0.001	4.2	32.6	43.0	20.2

Sieve Name	Percent Finer	Project Specs
3/8"	100.0	
#4	95.8	
#10	92.0	
#20	88.6	
#40	84.5	
#100	72.9	
#200	63.2	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	62.9
0.02 mm	39.1
0.005 mm	20.2
0.002 mm	12.1
0.001 mm	6.7

Notes:

Cc:

Submitted by,
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Chris Nelson
(12/7/18)

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GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

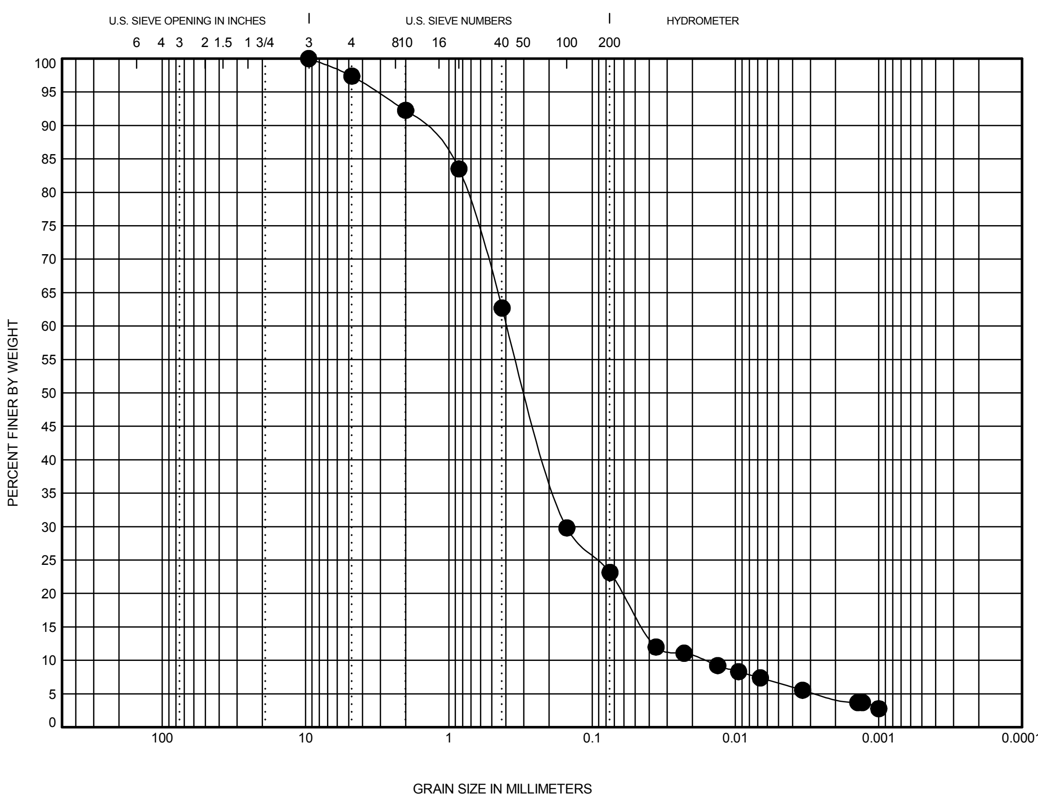
Sample Information

Boring Number:	SB-09	Date Sampled:	10/17/2018
Sample Number:	2	Sampled By:	NTI
Sample Depth (ft):	2	Sample Type:	SS
Classification:	SILTY SAND, fine to coarse grained, trace of gravel		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
3.49	23.36	9.5	0.39	0.151	0.017	2.6	74.2	16.6	6.6

Sieve Name	Percent Finer	Project Specs
3/8"	100.0	
#4	97.4	
#10	92.3	
#20	83.5	
#40	62.7	
#100	29.8	
#200	23.1	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	22.9
0.02 mm	10.6
0.005 mm	6.6
0.002 mm	4.4
0.001 mm	2.8

Notes:

Cc:

Submitted by,
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(12/7/18)

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GRAIN SIZE DISTRIBUTION

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Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

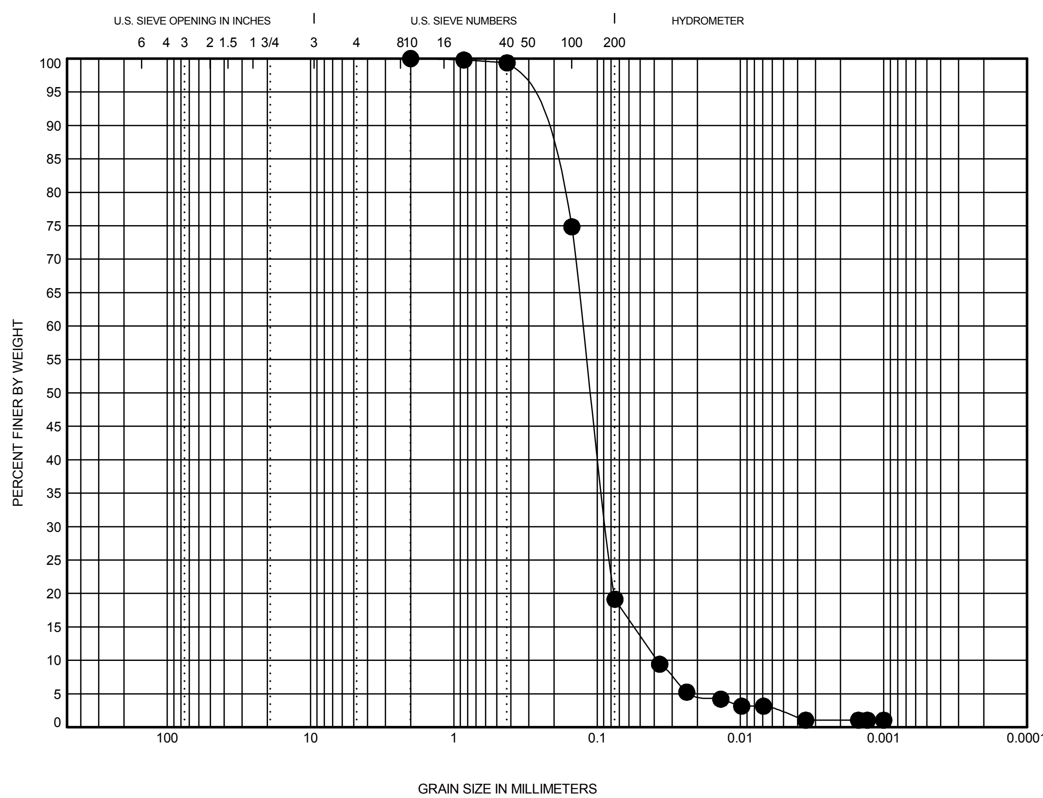
Sample Information

Boring Number:	SB-10	Date Sampled:	10/17/2018
Sample Number:	2	Sampled By:	NTI
Sample Depth (ft):	2	Sample Type:	SS
Classification:	SILTY SAND, fine to medium grained		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
1.55	3.26	2	0.125	0.086	0.038	0.0	80.9	17.0	2.1

Sieve Name	Percent Finer	Project Specs
#10	100.0	
#20	99.8	
#40	99.4	
#100	74.8	
#200	19.1	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	18.9
0.02 mm	4.9
0.005 mm	2.1
0.002 mm	1.0
0.001 mm	1.0

Notes:

Cc:

Submitted by,
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(12/7/18)

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LABORATORY COMPACTION CHARACTERISTICS OF SOIL

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

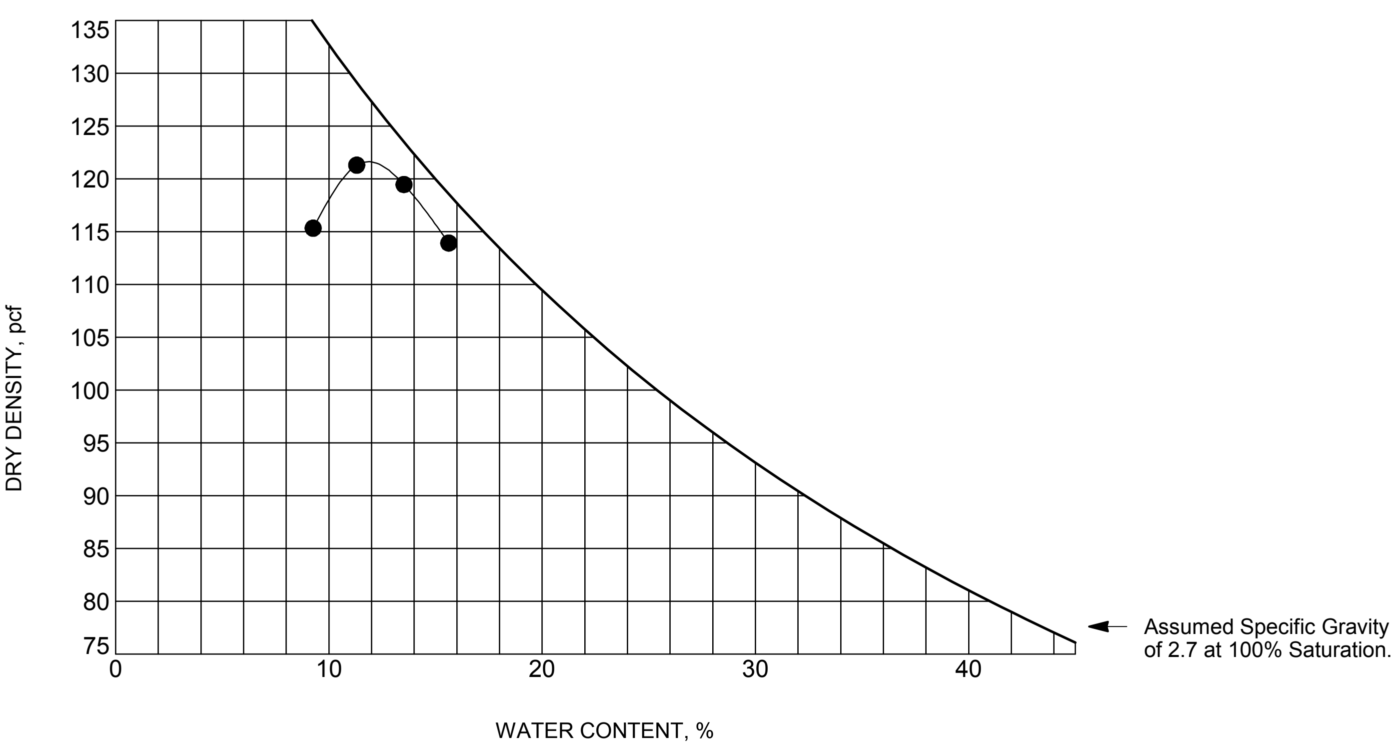
Sample Location:	SB-13	Date Sampled:	10/17/2018
Sample Number:	NA	Sample Type:	Bag Samples
Soil Description:	Lean Clay, trace of gravel, light brown		

Laboratory Information

Test Method:	ASTM D698 Method A	Rammer Type:	Manual
Preparation Method:	Dry		

Sample Data

Maximum Dry Density:	121.6 pcf	Liquid Limit:	
Optimum Water Content:	11.9 %	Plastic Limit:	



Comments:

Cc:

Submitted by.
Northern Technologies, LLC

Chris Nelson
(12/10/18)

UNCONFINED COMPRESSION TEST
ASTM D2166

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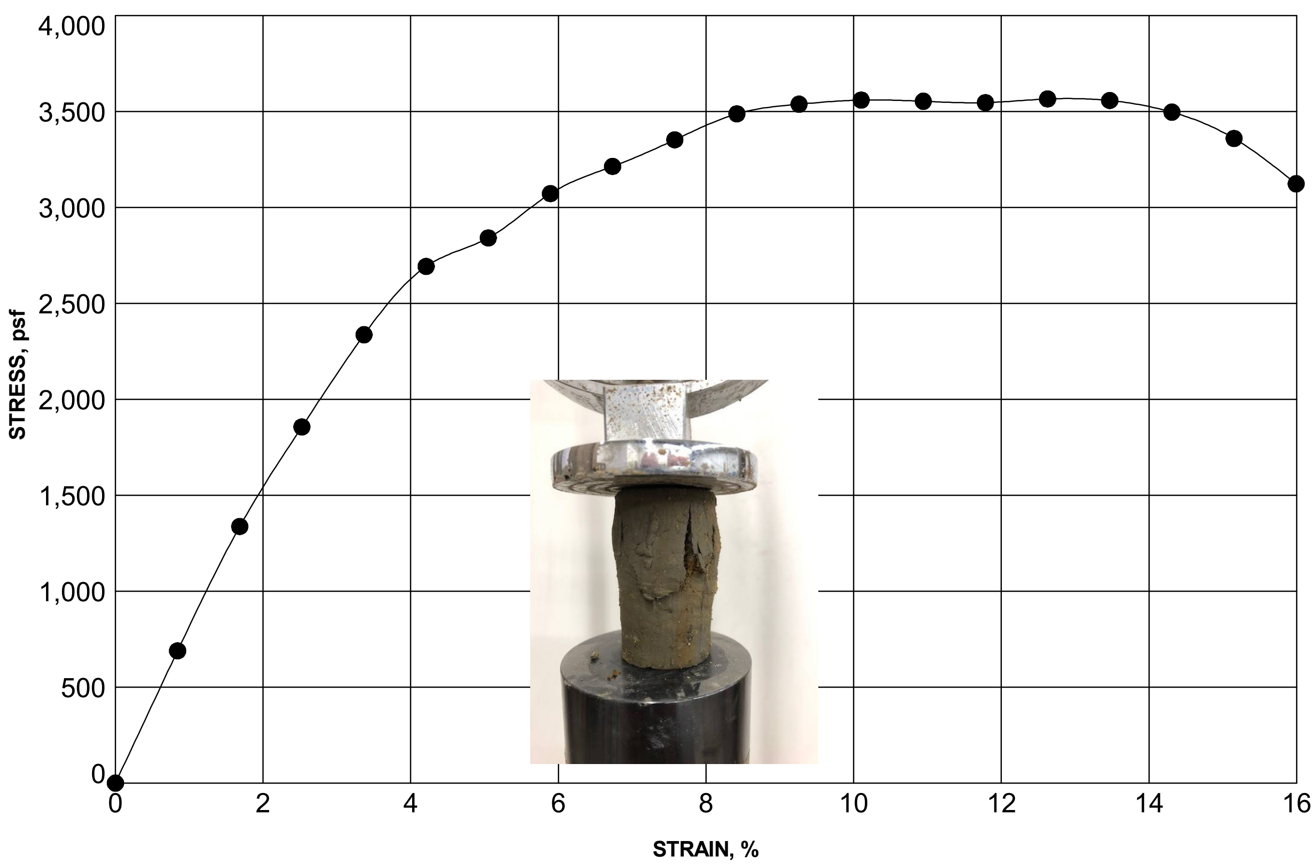
Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

Borehole:	SB-09	Sample Number:	3	Depth (ft):	4.5
Classification:	LEAN CLAY (CL)				

Sample Data

Dry Density:	123	Liquid Limit:	25	Peak (psf):	3570 @ 12.6%
Moisture Content (%):	16	Plastic Limit:	11		



Comments:

Cc:

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Chris Nelson
(12/7/18)

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UNCONFINED COMPRESSION TEST

ASTM D2166

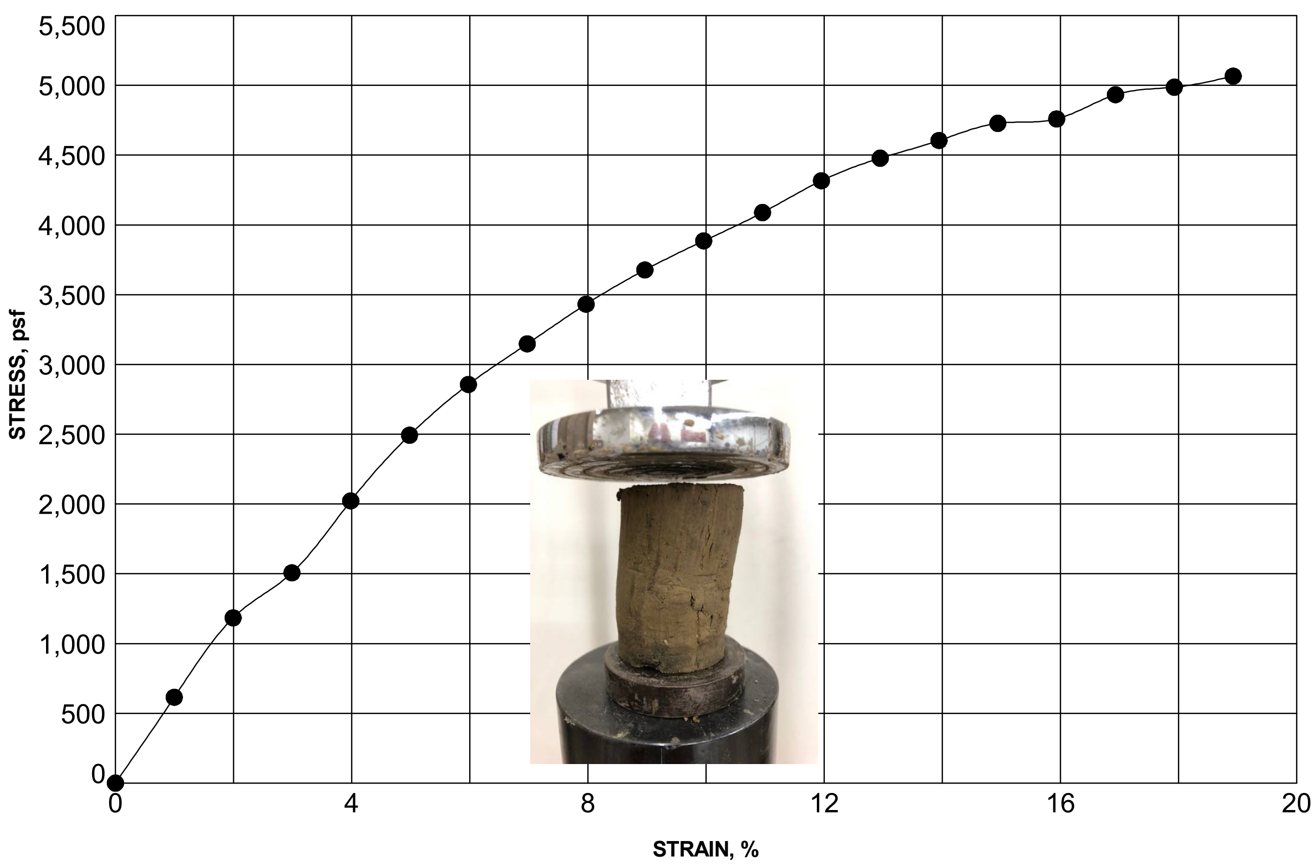
Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

Borehole:	SB-13	Sample Number:	5	Depth (ft):	9.5
Classification:	LEAN CLAY (CL)				

Sample Data

Dry Density:	127	Liquid Limit:	24	Peak (psf):	4730 @ 15.0%
Moisture Content (%):	14	Plastic Limit:	12		



Comments:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

CONSOLIDATION TEST

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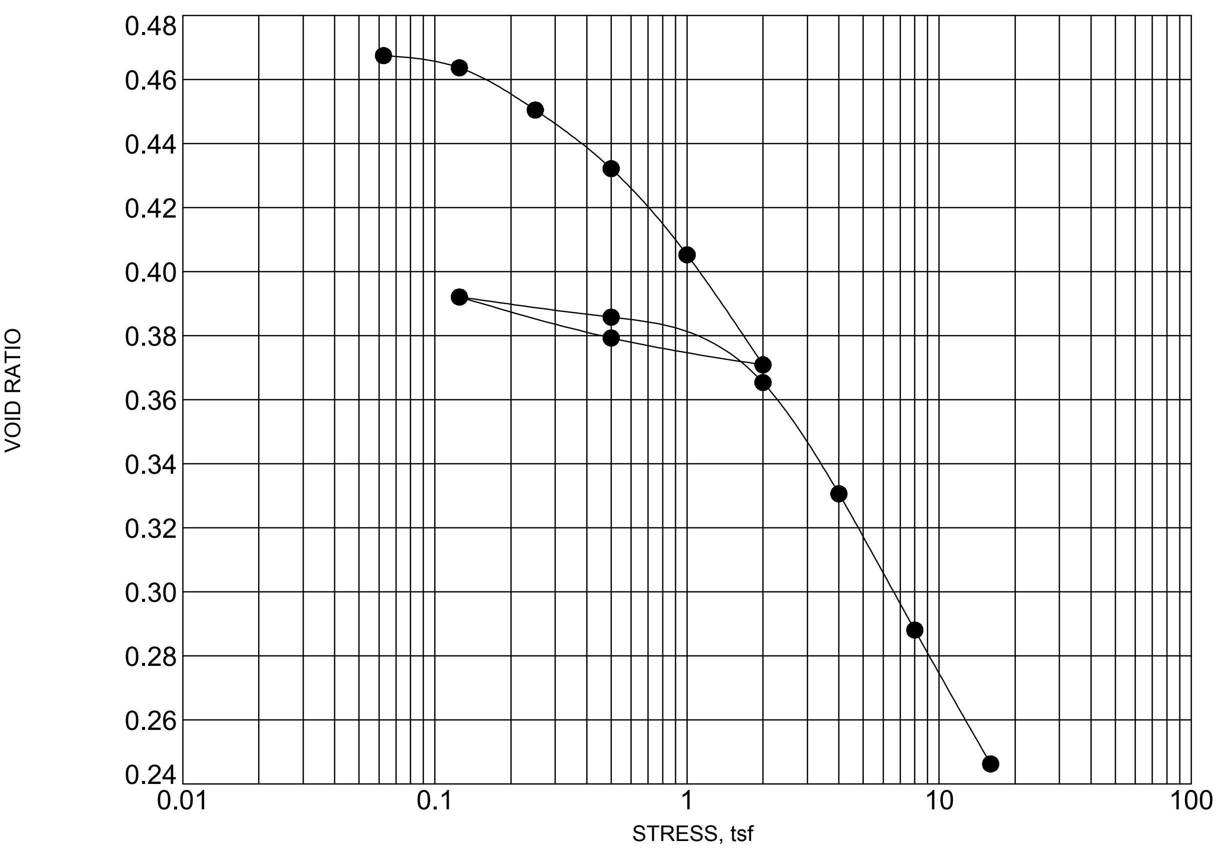
Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

Borehole:	SB-13	Sample Number:	7	Depth (ft):	14.5
Soil Classification:	SANDY LEAN CLAY (CLS)				

Sample Data

Deg of Sat (%)	MC (%)	γ_d	LL	PI	Sp Gravity	Overburden (tsf)	Pc (tsf)	Cc	Cr	Initial Void Ratio
	15	115			2.70					0.470



Comments:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/10/18)

Hydraulic Conductivity Test Data ASTM D5084

Project: Newfolden — Date: 11/26/2018

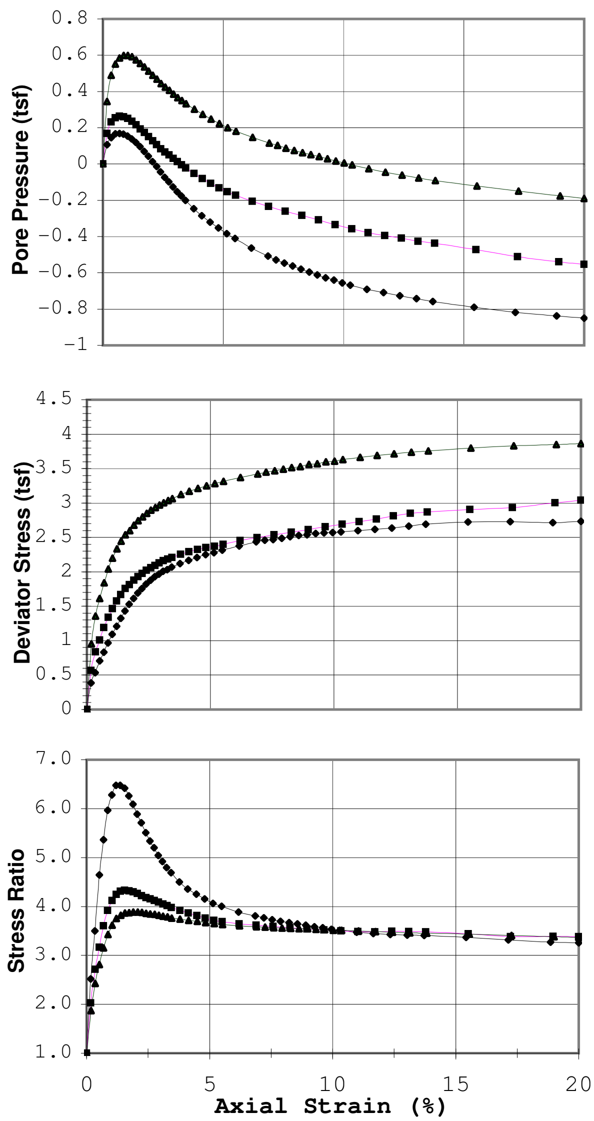
Client: Northern Technologies, LLC — Job No.: 11715

Boring No.:	9						
Sample No.:	7						
Depth (ft):	15						
Location:							
Sample Type:	TWT						
Soil Type:	Clayey Sand w/gravel (SC)						
Atterberg Limits							
LL							
PL							
PI							
Permeability Test	Intact						
Before Test Conditions: Saturation %:							
Porosity:							
Ht. (in):	2.81						
Dia. (in):	2.87						
Dry Density (pcf):	136.4						
Water Content:	8.1%						
Test Type:	Falling						
Max Head (ft):	5.0						
Confining press. (Effective-psi):	2.0						
Trial No.:	8-12						
Water Temp °C:	22.0						
% Compaction							
% Saturation (After Test)	100.7%						
Coefficient of Permeability							
K @ 20 °C (cm/sec)	**1.6×10^{-8}**						
K @ 20 °C (ft/min)	**3.3×10^{-8}**						
Notes:							

TRIAXIAL TEST ASTM: D 4767

Job No. **11715**
Date: **11/28/18**

Project: **Newfolden / Northern Technologies, LLC**
Boring #: **7** Sample #: **7** Type: **3T** Depth (ft): **14.5-16**
Soil Type: **Sandy Lean Clay w/a little gravel (CL)**

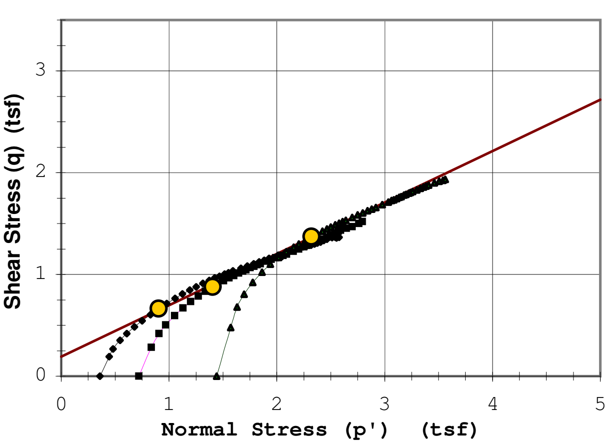


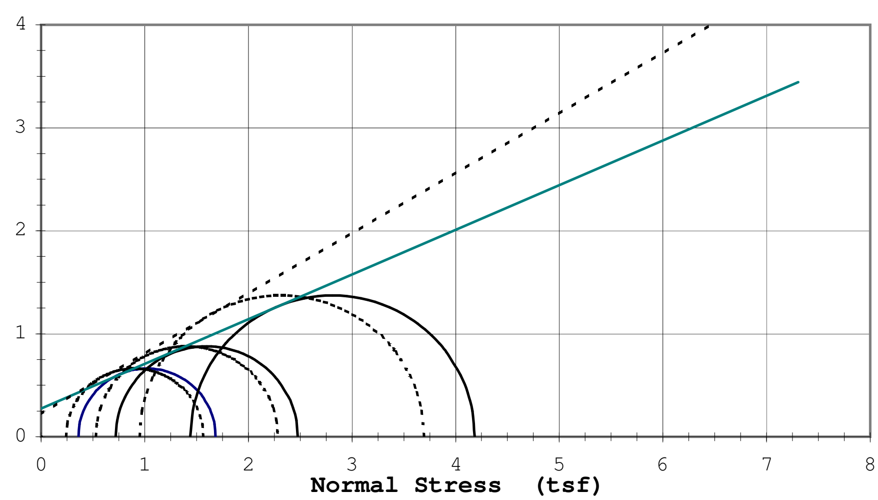
Failure Criterion:	**Max. Stress Ratio**		
Angle of internal friction, ϕ' =	**30.3 °**		
Apparent Cohesion, c' =	**0.22 (tsf)**		
Test Date:	11/16/18	Liquid Limit:	
Test Type:	CU w/pp	Plastic Limit:	
Strain Rate (in/min):	0.00073	Plasticity Index:	
Strain Rate (%/min):	0.025	Spec. Gravity (Assumed):	2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44	1.44	1.44		
Height (in)	2.92	2.92	2.92		
Water Content (%)	17.5	16.7	16.5		
Dry Density (pcf)	112.6	113.2	113.6		
Void Ratio	0.49	0.48	0.48		
After Consolidation					
Diameter (in)	1.44	1.43	1.43		
Height (in)	2.92	2.90	2.90		
Water Content (%)	18.0	17.0	16.2		
Dry Density (pcf)	113.1	115.3	117.0		
Void Ratio	0.48	0.46	0.43		
Back Pressure (tsf)	4.4	8.5	6.6		
Minor Principal Stress (tsf)	0.36	0.72	1.44		
Max. Deviator Stress (tsf)	2.73	3.04	3.87		
Ultimate Deviator Stress (tsf)	2.73	3.04	3.87		
Deviator Stress at Failure (tsf)	1.32	1.76	2.74		
Max. Pore Pressure Buildup (tsf)	0.17	0.26	0.60		
Pore Pressure Parameter "B"	0.95	0.95	0.95		
Pct. Axial Strain at Failure	1.4	1.6	2.1		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





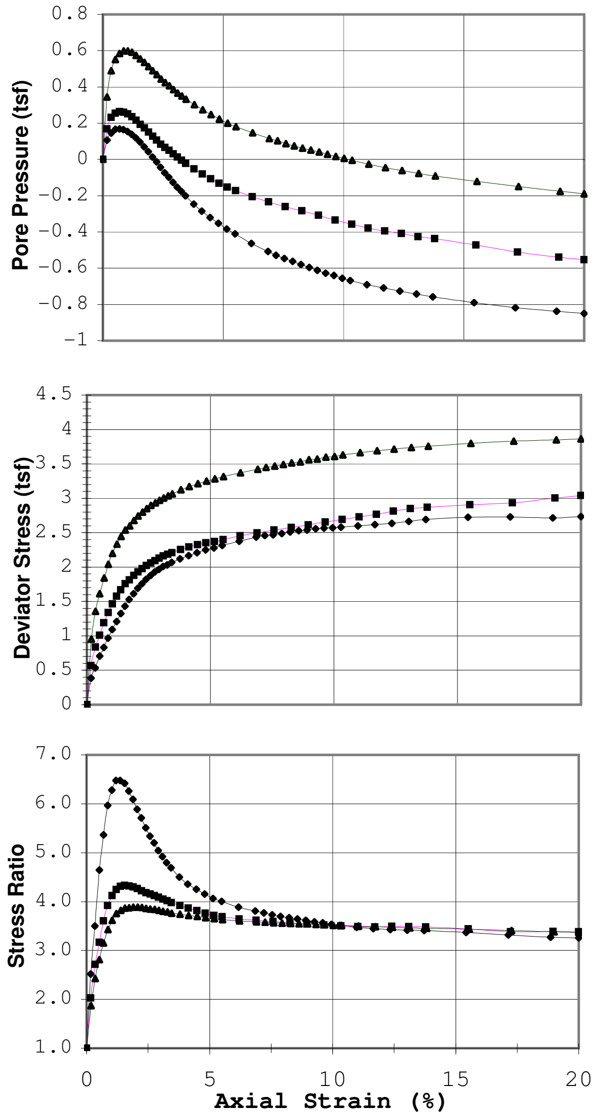
Rupture Envelope at Failure	
α = 26.8 °	a = 0.2 (tsf)

------------	Effective ϕ':	30.3 °	c'=	0.22 (tsf)
________	Total ϕ:	23.5 °	c=	0.27 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. **11715**
Date: **11/28/18**

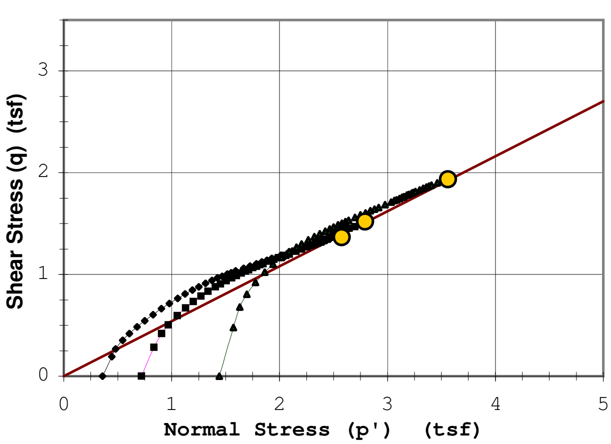
Project: **Newfolden / Northern Technologies, LLC**
Boring #: **7** Sample #: **7** Type: **3T** Depth (ft): **14.5-16**
Soil Type: **Sandy Lean Clay w/a little gravel (CL)**

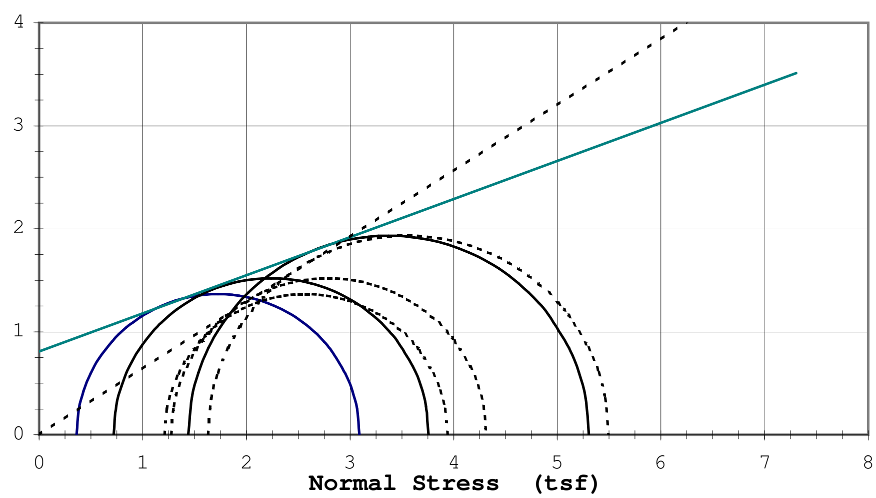


Failure Criterion:	**Max. Deviator Stress**					
Angle of internal friction, ϕ' =	**32.7 °**					
Apparent Cohesion, c' =	**0.00 (tsf)**					
Test Date: 11/16/18	Liquid Limit:					
Test Type: CU w/pp	Plastic Limit:					
Strain Rate (in/min): 0.00073	Plasticity Index:					
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69					
Before Consolidation	**A**	**B**	**C**	**D**	**E**	
Diameter (in)	1.44	1.44	1.44			
Height (in)	2.92	2.92	2.92			
Water Content (%)	17.5	16.7	16.5			
Dry Density (pcf)	112.6	113.2	113.6			
Void Ratio	0.49	0.48	0.48			
After Consolidation						
Diameter (in)	1.44	1.43	1.43			
Height (in)	2.92	2.90	2.90			
Water Content (%)	18.0	17.0	16.2			
Dry Density (pcf)	113.1	115.3	117.0			
Void Ratio	0.48	0.46	0.43			
Back Pressure (tsf)	4.4	8.5	6.6			
Minor Principal Stress (tsf)	0.36	0.72	1.44			
Max. Deviator Stress (tsf)	2.73	3.04	3.87			
Ultimate Deviator Stress (tsf)	2.73	3.04	3.87			
Deviator Stress at Failure (tsf)	2.73	3.04	3.87			
Max. Pore Pressure Buildup (tsf)	0.17	0.26	0.60			
Pore Pressure Parameter "B"	0.95	0.95	0.95			
Pct. Axial Strain at Failure	20.0	20.0	20.0			

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





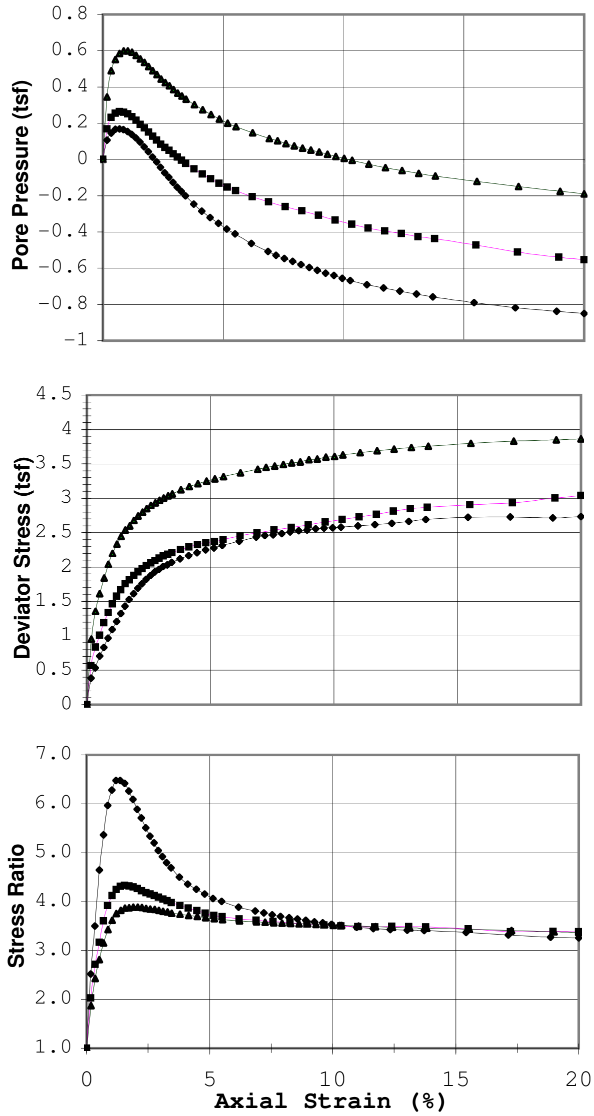
Rupture Envelope at Failure	
α = 28.4 °	a = 0.0 (tsf)

------------	Effective ϕ':	32.7 °	c'=	0.00 (tsf)
________	Total ϕ:	20.3 °	c=	0.81 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. **11715**
Date: **11/28/18**

Project: **Newfolden / Northern Technologies, LLC**
Boring #: **7** Sample #: **7** Type: **3T** Depth (ft): **14.5-16**
Soil Type: **Sandy Lean Clay w/a little gravel (CL)**



Failure Criterion: **Given Strain of: 15%**

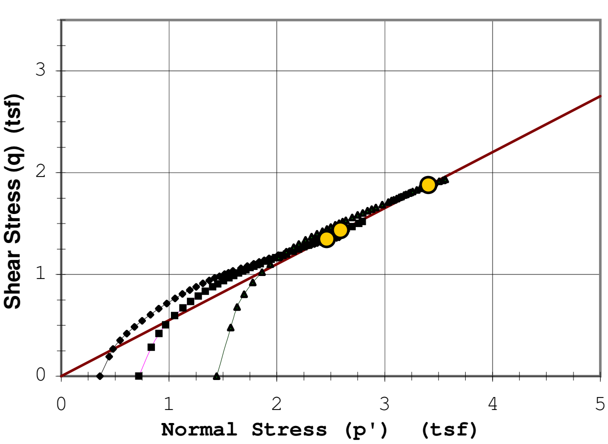
Angle of internal friction, ϕ' = **33.4 °**
Apparent Cohesion, c' = **0.00 (tsf)**

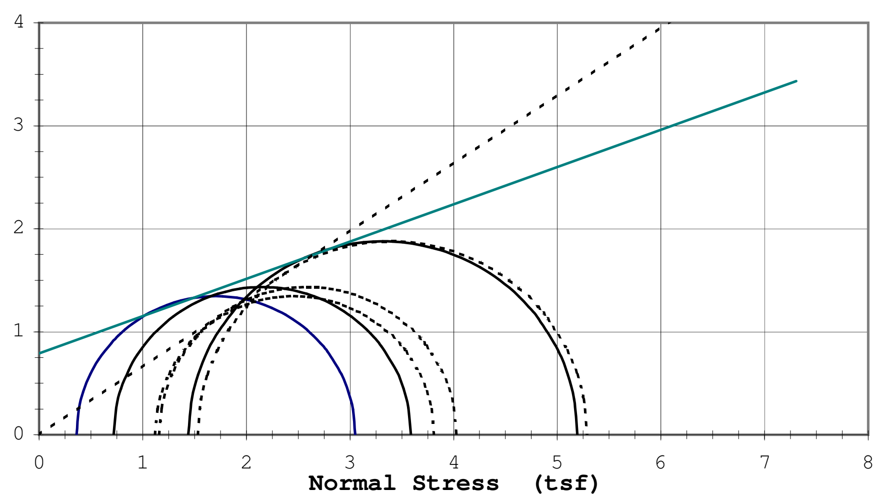
Test Date:	11/16/18	Liquid Limit:	
Test Type:	CU w/pp	Plastic Limit:	
Strain Rate (in/min):	0.00073	Plasticity Index:	
Strain Rate (%/min):	0.025	Spec. Gravity (Assumed):	2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44	1.44	1.44		
Height (in)	2.92	2.92	2.92		
Water Content (%)	17.5	16.7	16.5		
Dry Density (pcf)	112.6	113.2	113.6		
Void Ratio	0.49	0.48	0.48		
After Consolidation					
Diameter (in)	1.44	1.43	1.43		
Height (in)	2.92	2.90	2.90		
Water Content (%)	18.0	17.0	16.2		
Dry Density (pcf)	113.1	115.3	117.0		
Void Ratio	0.48	0.46	0.43		
Back Pressure (tsf)	4.4	8.5	6.6		
Minor Principal Stress (tsf)	0.36	0.72	1.44		
Max. Deviator Stress (tsf)	2.73	3.04	3.87		
Ultimate Deviator Stress (tsf)	2.73	3.04	3.87		
Deviator Stress at Failure (tsf)	2.69	2.87	3.75		
Max. Pore Pressure Buildup (tsf)	0.17	0.26	0.60		
Pore Pressure Parameter "B"	0.95	0.95	0.95		
Pct. Axial Strain at Failure	15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 28.8 °	a = 0.0 (tsf)

------------	Effective ϕ':	33.4 °	c'=	0.00 (tsf)
________	Total ϕ:	19.9 °	c=	0.79 (tsf)

Triaxial Data

Job: **11715**

Boring: 7 Sample: 7 Depth: 14.5-16 Date: 11/28/18

Sample 1			Sample 2			Sample 3			Sample 4			Sample 5		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
0.17	0.38	0.11	0.17	0.57	0.17	0.18	0.95	0.34						
0.34	0.54	0.15	0.34	0.84	0.23	0.35	1.36	0.49						
0.51	0.71	0.17	0.52	1.01	0.25	0.52	1.61	0.55						
0.69	0.83	0.17	0.69	1.19	0.26	0.69	1.84	0.58						
0.86	0.97	0.16	0.86	1.34	0.26	0.87	2.04	0.60						
1.03	1.09	0.15	1.03	1.46	0.25	1.04	2.20	0.60						
1.20	1.21	0.14	1.21	1.57	0.23	1.21	2.33	0.59						
1.37	1.32	0.12	1.38	1.67	0.22	1.39	2.44	0.57						
1.54	1.43	0.10	1.55	1.76	0.19	1.56	2.54	0.55						
1.71	1.53	0.07	1.72	1.81	0.17	1.73	2.60	0.54						
1.89	1.61	0.04	1.90	1.88	0.15	1.90	2.68	0.51						
2.06	1.69	0.01	2.07	1.93	0.13	2.08	2.74	0.49						
2.23	1.76	-0.01	2.24	1.98	0.11	2.25	2.80	0.47						
2.40	1.82	-0.04	2.41	2.02	0.08	2.42	2.85	0.44						
2.57	1.88	-0.07	2.58	2.06	0.07	2.59	2.89	0.42						
2.74	1.93	-0.10	2.76	2.09	0.05	2.77	2.93	0.41						
2.91	1.96	-0.13	2.93	2.13	0.03	2.94	2.97	0.39						
3.09	2.01	-0.15	3.10	2.16	0.01	3.11	3.00	0.37						
3.26	2.03	-0.18	3.27	2.19	0.00	3.28	3.04	0.35						
3.43	2.07	-0.20	3.45	2.21	-0.02	3.46	3.06	0.33						
3.77	2.12	-0.25	3.79	2.25	-0.05	3.80	3.12	0.30						
4.11	2.17	-0.28	4.14	2.29	-0.08	4.15	3.17	0.27						
4.46	2.21	-0.32	4.48	2.32	-0.11	4.49	3.21	0.25						
4.80	2.25	-0.35	4.82	2.35	-0.13	4.84	3.25	0.22						
5.14	2.28	-0.38	5.17	2.37	-0.15	5.18	3.28	0.20						
5.49	2.32	-0.41	5.51	2.40	-0.17	5.53	3.32	0.18						
6.17	2.38	-0.46	6.20	2.45	-0.21	6.22	3.37	0.15						
6.86	2.44	-0.51	6.89	2.50	-0.23	6.91	3.42	0.12						
7.20	2.46	-0.53	7.58	2.54	-0.26	7.26	3.45	0.10						
7.54	2.47	-0.55	8.27	2.57	-0.28	7.60	3.47	0.09						
7.89	2.49	-0.56	8.96	2.61	-0.31	7.95	3.49	0.08						
8.23	2.51	-0.58	9.65	2.65	-0.33	8.29	3.52	0.06						
8.57	2.53	-0.60	10.34	2.69	-0.36	8.64	3.53	0.05						
8.91	2.54	-0.61	11.03	2.73	-0.38	8.98	3.56	0.04						
9.26	2.55	-0.63	11.72	2.76	-0.39	9.33	3.57	0.03						
9.60	2.56	-0.64	12.41	2.81	-0.41	9.67	3.60	0.02						
9.94	2.57	-0.66	13.10	2.85	-0.43	10.02	3.61	0.01						
10.29	2.58	-0.67	13.79	2.87	-0.44	10.37	3.63	0.00						
10.97	2.60	-0.69	15.51	2.91	-0.47	11.06	3.66	-0.03						
11.66	2.62	-0.71	17.23	2.93	-0.51	11.75	3.69	-0.04						
12.34	2.64	-0.73	18.96	3.00	-0.54	12.44	3.72	-0.06						
13.03	2.66	-0.74	20.00	3.04	-0.55	13.13	3.74	-0.08						
13.71	2.69	-0.76				13.82	3.75	-0.09						
15.43	2.72	-0.79				15.55	3.80	-0.12						
17.14	2.73	-0.82				17.27	3.83	-0.15						
18.86	2.71	-0.84				19.00	3.85	-0.18						
20.00	2.73	-0.85				20.00	3.87	-0.19						

APPENDIX C

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-01

Long: -96° 20' 12.876"
Lat: 48° 22' 5.16"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1093.266 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 15.50 ft / Elev 1077.77 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

Depth (ft)	Elev.	Material Description	Sample Type Number	Recovery % (RQD)	Blow Counts (N Value)	Pocket Pen. (tsf)	Dry Unit Wt. (pcf)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Fines
0.0–0.9	1092.3	ORGANIC SILTY SAND, (OL) black, fine grained	AU 1									
0.9–7.0	1086.3	LEAN CLAY, (CL) light brown to light gray, stiff, trace sand	SS 2	100	5-7-9 (16)	6.0	121	12	33	12	21	
			SS 3	94	5-8-9 (17)	4.0	117	13				
7.0–9.0	1084.3	LEAN CLAY, (CL) light brown to light gray, stiff, trace sand, trace gravel	SS 4	100	6-8-9 (17)	5.7	121	13				
9.0–12.5	1080.8	LEAN CLAY, (CL) brown, stiff, trace sand, trace gravel	SS 5	100	5-7-9 (16)	4.6	124	13				
12.5–15.5 ▽	1077.8	LEAN CLAY, (CL) dark gray, stiff, trace sand, trace gravel	SS 6	100	6-8-8 (16)	4.1	123	14				
			SS 7	67	8-12-11 (23)							
15.5–18.0	1075.3	POORLY GRADED SAND, (SP) brown, fine to coarse grained, wet, dense	SS 8	67	3-5-12 (17)	2.0	126	13				
18.0–19.0	1074.3	LEAN CLAY, (CL) dark gray, stiff, trace sand, trace gravel										
19.0–23.0	1070.3	SILTY FAT CLAY, (CH/CL) dark gray, rather stiff	SS 9	83	5-5-7 (12)	1.0	115	21				
23.0–31.0	1062.3	LEAN CLAY, (CL) dark gray, stiff, trace sand	SS 10	100	4-7-9 (16)	2.1	126	13				
			SS 11	111	5-8-9 (17)	2.2	123	15				

Bottom of borehole at 31.0 feet.
Borehole grouted.

NTI NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-02

Long: -96° 20' 8.52"
Lat: 48° 22' 6.708"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1093.013 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	ELEV.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0.7	ORGANIC SILTY SAND, (OL) dark brown, fine grained	1092.3	AU 1					19				
	LEAN CLAY, (CL) light brown to light gray, rather stiff, trace sand, trace gravel		SS 2	67	4-5-6 (11)	6.0	112	16				
			SS 3	89	3-4-7 (11)	4.1	123	13				
			SS 4	100	4-5-6 (11)	2.5	125	14				
9.5		1083.5										
	LEAN CLAY, (CL) dark brown, rather stiff, trace sand, trace gravel		SS 5	56	4-6-10 (16)	2.4	116	16				
11.5		1081.5										
	LEAN CLAY, (CL) brown, rather stiff, trace sand, trace gravel		SS 6	44	3-4-6 (10)	1.9	122	15	30	12	18	
			ST 7									
16.5		1076.5										
	LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel		SS 8	100	2-3-6 (9)	1.7	125	13				
			SS 9	89	2-6-8 (14)	2.8	128	12				
			SS 10	56	6-10-11 (21)	1.9	123	13				
31.0		1062.0	SS 11	89	6-10-10 (20)	2.9	127	13				

Bottom of borehole at 31.0 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-03

Long: -96° 19' 21.468"
Lat: 48° 22' 9.876"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1100.962 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0.8	ORGANIC SILTY SAND, (OL) black, fine grained (1100.2)	AU 1					17				
	POORLY GRADED SAND WITH SILT, (SP-SM) brown, fine to coarse grained, medium dense	SS 2	83	4-5-7 (12)							
5.5	(1095.5)	SS 3	67	1-3-3 (6)	2.5	108	24				
6.5	LEAN CLAY, (CL/CH) light brown to light gray, medium (1094.5)										
	SILTY LEAN CLAY, (CL-ML) light brown, rather stiff, trace sand, trace gravel	SS 4	56	2-5-6 (11)	4.1		10	15	9	6	
10.5	(1090.5)	SS 5	100	3-6-8 (14)	3.5	128	13				
	LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel	SS 6	94	2-4-6 (10)	0.6	130	14				
		ST 7									
		SS 8	89	2-4-7 (11)	2.7	123	13				
		SS 9	67	7-9-9 (18)	2.7	127	13				
		SS 10	111	6-10-11 (21)	1.6	126	13				
31.0	(1070.0)	SS 11	122	7-10-10 (20)	2.7	122	14				

Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-04

NTI NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: 96° 18' 10.44"
Lat: 48° 22' 9.048"

CLIENT MSTRWD

PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction

PROJECT NUMBER 18.FGO06666.000

PROJECT LOCATION Newfolden, Minnesota

DATE STARTED 10/17/18 **COMPLETED** 10/17/18

GROUND ELEVATION 1107.192 feet **HOLE SIZE** 6 1/2 in.

DRILLING CONTRACTOR NTI

GROUND WATER LEVELS:

DRILLING METHOD 3 1/4 in H.S.A

∇ **AT TIME OF DRILLING** 1.00 ft / Elev 1106.19 ft

LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson

AT END OF DRILLING ---

CAVE IN (ft) NR **FROST DEPTH (ft)** NA

AFTER DRILLING ---

NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0–0.8		ORGANIC SILTY SAND, (OL) black (1106.4)	AU 1					20				
0.8–4.5		∇ POORLY GRADED SAND, (SP) light brown, fine grained, wet, medium dense (1102.7)	SS 2	56	1-4-6 (10)							
4.5–6.5		SILTY SAND, (SM) gray, fine grained, moist, medium dense (1100.7)	SS 3	67	2-4-6 (10)							
6.5–10.0		POORLY GRADED SAND, (SP) gray, fine grained, wet, loose (1097.2)	SS 4	78	3-3-3 (6)							
10.0–16.0		LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel (1091.2)	SS 5	94	2-4-6 (10)	2.3	130	13				
			SS 6	89	2-4-6 (10)	1.8	132	13				
			SS 7	89	2-4-7 (11)	2.1	130	13				

Bottom of borehole at 16.0 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-05

Long: -96° 17' 9.528"
Lat: 48° 22' 8.508"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1104.952 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 5.00 ft / Elev 1099.95 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	ELEV.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.4	ORGANIC CLAY WITH SAND, (OL) dark brown, trace gravel	1104.5	AU 1					19				
	LEAN CLAY, (CL) light brown, rather stiff, trace sand, trace gravel		SS 2	44	3-5-9 (14)	4.2		18				
5.0 ▽	SILT, (ML) light brown, moist, rather stiff, trace sand	1100.0	SS 3	100	3-6-9 (15)	1.5	120	21				
7.0	LEAN CLAY, (CL) light brown, rather stiff to stiff, trace sand, trace gravel	1098.0	SS 4	89	3-5-7 (12)	4.8	134	9				
			SS 5	44	7-9-15 (24)			12				
11.5	LEAN CLAY, (CL) brown to dark gray, stiff, trace sand, trace gravel	1093.5	SS 6	89	7-9-13 (22)	3.9	119	15				
15.5	LEAN CLAY, (CL) dark gray, stiff, trace sand, trace gravel	1089.5	SS 7	111	5-7-11 (18)	4.4	124	13				
16.0		1089.0										

Bottom of borehole at 16.0 feet.
Borehole grouted.

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-06

Long: -96° 19' 16.14"
Lat: 48° 23' 3.264"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1106.683 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
∇ **AT TIME OF DRILLING** 5.00 ft / Elev 1101.68 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.8	ORGANIC SILTY SAND, (OL) black, fine grained	1105.9	AU 1									
5.0	POORLY GRADED SAND WITH SILT, (SP-SM) light brown, fine grained, medium dense	1101.7	SS 2	72	3-4-7 (11)							
8.0	∇ SILTY SAND, (SM) brown, fine grained, wet, medium dense	1098.7	SS 3	78	3-5-7 (12)			23				12
11.5	FAT CLAY, (CH) gray, medium, trace sand	1095.2	SS 4	78	3-2-3 (5)	1.4						
			SS 5	94	2-3-5 (8)	1.3						
17.5	SILT, (ML) gray, moist, rather stiff	1089.2	SS 6	78	2-4-7 (11)	4.9						
			SS 7	78	3-4-9 (13)	3.3						
23.0	FAT CLAY, (CH) gray, rather stiff, trace sand	1083.7	SS 8	89	2-4-6 (10)	2.0						
			SS 9	122	2-4-7 (11)	2.0						
30.5	LEAN CLAY, (CL) gray, stiff, trace sand, trace gravel	1076.2	SS 10	111	4-6-11 (17)	1.7						
			SS 11	183	4-6-10/0"	1.9						

Bottom of borehole at 30.5 feet.
Borehole grouted.

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-07

Long: -96° 19' 19.1136"
Lat: 48° 22' 55.9344"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1104.681 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.8		ORGANIC SILTY SAND, (OL) black	1103.9	AU 1									
		SILT, (ML) brown to light brown, rather stiff, with sand, trace gravel		SS 2	89	3-5-6 (11)							
5.0		LEAN CLAY, (CL) gray to dark gray, medium to stiff, with sand, trace gravel	1099.7	SS 3	83	2-3-3 (6)	1.4		13				63
				SS 4	72	2-3-5 (8)	1.6						
				SS 5	100	1-3-6 (9)	2.0						
				SS 6	100	3-6-8 (14)	2.4						
				ST 7			1.8						
				SS 8	94	3-5-8 (13)	2.4						
				SS 9	100	3-5-8 (13)							
				SS 10	100	4-9-10 (19)	1.2						
31.0			1073.7	SS 11	100	4-9-10 (19)	2.1						

Bottom of borehole at 31.0 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-08

PAGE 1 OF 1
Long: -96° 19' 19.164"
Lat: 48° 22' 34.608"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1100.469 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.7	ORGANIC SILTY SAND, (OL) black	1099.8	AU 1									
	LEAN CLAY, (CL) light brown, soft to rather stiff, trace sand, trace gravel		SS 2	67	3-2-1 (3)	0.6	109	18	20	11	9	
			SS 3	78	2-3-5 (8)	1.4	121	14				
			SS 4	94	3-4-6 (10)	3.0	126	12				
10.0	LEAN CLAY, (CL) dark brown, rather stiff, trace sand, trace gravel	1090.5	SS 5	100	4-5-7 (12)	3.8	118	13				
12.0	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel	1088.5	SS 6	89	3-4-6 (10)	3.3	131	12				
			SS 7	89	2-4-5 (9)	1.9	129	13				
			SS 8	111	3-4-6 (10)	2.0	124	14				
			SS 9	111	2-4-6 (10)	2.2	126	14				
			SS 10	111	3-6-8 (14)	5..2	120	15				
31.0		1069.5	SS 11	111	3-7-8 (15)	2.7	116	17				

Bottom of borehole at 31.0 feet.
Borehole grouted.

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Fargo, North Dakota 58103

BORING NUMBER SB-09

Long: -96° 20' 6.864"
Lat: 48° 22' 14.232"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1093.245 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.6	ORGANIC SILTY SAND, (OL) black (1092.7)	AU 1					30				
4.0	SILTY SAND, (SM) light brown to light gray, fine to coarse grained, loose, trace gravel (1089.2)	SS 2	56	1-2-4 (6)			13				23
7.0	LEAN CLAY, (CL) gray, rather stiff, trace sand, trace gravel (1086.2)	SS 3	67	3-4-5 (9)	2.0	123	16	25	11	14	
	LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel	SS 4	111	2-4-6 (10)	2.2	126	14				
		SS 5	83	4-4-5 (9)	1.3	123	14				
		SS 6	89	3-4-6 (10)	2.6	121	14				
		ST 7									
		SS 8	44	6-9-12 (21)	1.1		17				
		SS 9	100	4-6-10 (16)	2.4	125	13	25	12	13	
		SS 10	89	3-6-9 (15)	2.1	123	14				

(Continued Next Page)

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-09

Long: -96° 20' 6.864"
Lat: 48° 22' 14.232"

CLIENT MSTRWD **PROJECT NAME** Newfolden / MR Subwatershed Flood Damage Reduction

PROJECT NUMBER 18.FGO06666.000 **PROJECT LOCATION** Newfolden, Minnesota

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
		LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel *(continued)*										
30			SS 11	89	12-20-28 (48)	6.0	130	9				
33.0		(1060.2) SANDY LEAN CLAY, (CL) gray, very stiff, trace gravel										
35			SS 12	111	20-55-46 (101)	6.0	127	6				
40			SS 13	100	47-70			6	13	10	3	
45			SS 14	100	52-68	3.6		9				
45.5		(1047.7)										

Bottom of borehole at 45.5 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-10

Long: -96° 20' 34.944"
Lat: 48° 22' 47.856"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1095.869 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 1.00 ft / Elev 1094.87 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.4	ORGANIC SILTY SAND, (OL) black	1095.4	AU 1									
	▽ SILTY SAND, (SM) light brown, fine to medium grained, wet, medium dense		SS 2	56	2-5-5 (10)			24				19
5.5		1090.4	SS 3	67	2-3-2 (5)							
	LEAN CLAY, (CL) gray, medium to rather stiff, trace sand		SS 4	89	1-2-4 (6)	2.4						
			SS 5	94	2-4-7 (11)	4.8						
11.5	LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel	1084.4	SS 6	89	2-4-6 (10)	1.4						
			SS 7	100	2-4-5 (9)	2.0						
			SS 8	122	3-4-6 (10)	1.8						
			SS 9	100	3-4-6 (10)	1.7						
			SS 10	111	3-7-10 (17)	4.4						
31.0		1064.9	SS 11	122	3-7-10 (17)	2.3						

Bottom of borehole at 31.0 feet.
Borehole grouted.

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Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-11

Long: -96° 13' 51.276"
Lat: 48° 21' 28.044"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1131.395 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	ELEV.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0	FILL, FAT CLAY, brown to black		AU 1									
2.5	BURIED TOPSOIL, ORGANIC CLAY WITH SAND, (OL) black	1128.9	SS 2	78	2-4-7 (11)							
4.5	LEAN CLAY, (CL) brown, medium to stiff, trace sand, trace gravel	1126.9	SS 3	89	2-3-5 (8)	2.5						
			SS 4	100	3-4-7 (11)	3.3						
			SS 5	89	3-9-13 (22)	4.7	126	13	22	11	11	
13.0	LEAN CLAY, (CL) olive gray, stiff, trace sand, trace gravel	1118.4	SS 6	133	3-13-13 (26)	6.0						
14.0	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel	1117.4	SS 7	56	4-7-8 (15)	2.0						
			SS 8	89	3-4-7 (11)	3.4						
			SS 9	100	3-4-6 (10)	2.7						
23.0	LEAN CLAY, (CL) light brown, rather stiff, trace sand, trace gravel	1108.4	SS 10	100	3-5-8 (13)	2.0						
31.0		1100.4	SS 11	111	3-5-8 (13)	5.5						

Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-12

PAGE 1 OF 1

Long: -96° 15' 30.636"
Lat: 48° 21' 27.216"

NTI NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1120.968 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 15.00 ft / Elev 1105.97 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	Depth / Elev.	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0	0.7 / 1120.3	ORGANIC SILTY SAND, (OL) black, fine grained	AU 1									
		LEAN CLAY, (CL) light brown, soft to medium, trace sand, trace gravel	SS 2	56	2-2-2 (4)	1.5						
5	6.5 / 1114.5		SS 3	78	2-3-5 (8)	2.1						
		LEAN CLAY, (CL) brown, stiff, trace sand, trace gravel	SS 4	94	5-8-13 (21)	6.0		11	23	11	12	
10	12.0 / 1109.0		SS 5	89	5-9-11 (20)	6.0						
		LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel	SS 6	89	2-4-6 (10)	2.6						
15	15.0 ▽ / 1106.0	SILTY SAND, (SM) gray, fine grained, moist, very dense	SS 7	78	5-16-17 (33)							
	17.5 / 1103.5	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel	SS 8	94	5-5-8 (13)	1.2						
20			SS 9	94	2-4-7 (11)	2.2						
25	27.0 / 1094.0		SS 10	100	2-4-6 (10)	1.3						
30	31.0 / 1090.0	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel	SS 11	100	2-5-6 (11)	2.0	117	17	22	11	11	

Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-13

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: -95° 16' 48.144"
Lat: 48° 21' 25.812"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1109.352 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0	ORGANIC CLAY WITH SAND, (OL) black	AU 1					20				
0.8 (1108.6)	LEAN CLAY, (CL) light brown to light gray, rather stiff, trace sand	SS 2	67	3-5-7 (12)	6.0	117	10				
		SS 3	78	2-4-5 (9)	2.5	125	13				
		SS 4	78	3-4-5 (9)	2.5	122	13	25	11	14	
9.0 (1100.4)	LEAN CLAY, (CL) brown, rather stiff, trace sand, trace gravel	SS 5	89	3-4-6 (10)	2.6	127	14	24	12	12	
11.5 (1097.9)	SANDY LEAN CLAY, (CL) brown, stiff, trace gravel	SS 6	89	3-6-10 (16)	2.5	122	13				
		ST 7	52		1.6	115	15				
16.5 (1092.9)	LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel	SS 8	89	3-6-10 (16)	2.4	114	17				
		SS 9	89	5-6-8 (14)	2.5	123	12				
		SS 10	94	2-5-8 (13)	3.4	121	14				

(Continued Next Page)

NTI
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Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-13

Long: -95° 16' 48.144"
Lat: 48° 21' 25.812"

CLIENT MSTRWD **PROJECT NAME** Newfolden / MR Subwatershed Flood Damage Reduction

PROJECT NUMBER 18.FGO06666.000 **PROJECT LOCATION** Newfolden, Minnesota

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
		LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel *(continued)*										
30			SS 11	100	5-7-12 (19)	3.5	107	21				
35			SS 12	111	6-8-14 (22)	4.2	118	14	27	12	15	
40			SS 13	111	10-26-36 (62)	6.0	129	8				
45		46.0 — 1063.4	SS 14	111	12-22-35 (57)	6.0	129	8				

Bottom of borehole at 46.0 feet.
Borehole grouted.

BORING NUMBER SB-14

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

PAGE 1 OF 1
Long: -96° 16' 47.928"
Lat: 48° 20' 35.016"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1110.355 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.4 ORGANIC CLAY WITH SAND, (OL) black 1109.9	AU 1									
		LEAN CLAY, (CL) brown, medium to rather stiff, trace sand, trace gravel	SS 2	67	1-3-5 (8)	2.1						
5			SS 3	83	3-4-5 (9)	3.9						
		7.0 (1103.4) LEAN CLAY, (CL) brown to dark gray, rather stiff, trace sand, trace gravel	SS 4	100	3-5-7 (12)	4.4						
10		9.0 (1101.4) LEAN CLAY, (CL) dark brown, stiff, trace sand, trace gravel	SS 5	100	4-6-11 (17)	4.4						
		12.0 (1098.4) LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel	SS 6	89	3-7-10 (17)	3.0						
15			SS 7	11	6-7-8 (15)	1.5						
			SS 8	67	6-10-10 (20)	1.5						
20		19.0 (1091.4) SANDY LEAN CLAY, (CL) light brown, rather stiff, trace gravel	SS 9	89	3-5-8 (13)	6.0						
25		23.0 (1087.4) LEAN CLAY, (CL) dark gray, rather stiff, trace sand	SS 10	39	4-5-5 (10)	0.9	120	16	31	12	19	
30		31.0 (1079.4)	SS 11	67	5-6-4 (10)	1.5						

Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-15

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: -96° 15' 31.032"
Lat: 48° 21' 2.448"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1117.051 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.2	ORGANIC CLAY WITH SAND, (OL) dark brown (1116.9)	AU 1									
	LEAN CLAY, (CL) brown, rather stiff to stiff, trace sand, trace gravel	SS 2	89	2-5-7 (12)	4.0						
		SS 3	22	4-8-10 (18)							
		SS 4	78	3-6-9 (15)	4.0						
		SS 5	100	3-7-9 (16)	2.9						
		SS 6	89	5-8-10 (18)	3.0	124	13	26	19	7	
14.0	(1103.1) LEAN CLAY, (CL) dark gray, stiff to rather stiff, trace sand, trace gravel	SS 7	100	4-7-9 (16)	2.4						
		SS 8	100	5-7-9 (16)	2.4						
		SS 9	133	5-6-8 (14)	1.6						
		SS 10	111	2-4-6 (10)	1.4						
27.0	(1090.1) SILTY FAT CLAY, (CH/CL) dark gray, rather stiff, trace sand, trace gravel										
31.0	(1086.1)	SS 11	111	3-5-6 (11)	1.6						

Bottom of borehole at 31.0 feet.
Borehole grouted.

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No.
Minnesota Unique Well No. or W-series No. (Leave blank if not known)
H 362967

WELL OR BORING LOCATION

County Name: Marshall

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)	Date Sealed	Date Well or Boring Constructed
New Maine	157 N	44 W	33	NE ¼ SE ¼ SW ¼	10/17/2018	10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)
Latitude ____ Longitude ____

Depth at Time of Sealing 30 ft. Original Depth 30 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location
Various Locations in New Maine Twp.

AQUIFER(S) ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING ☐ Water-Supply Well ☐ Monit. Well ☒ Env. Bore Hole ☐ Other ____

STATIC WATER LEVEL
☒ Measured Date Measured 10/17/2018 ☐ Estimated
DRY ft. ☒ below ☐ above land surface

Show exact location of well or boring in section grid with "X."
Sketch map of well or boring location, showing property lines, roads, and buildings.

N W E S ½ Mile 1 Mile

See Attached Map

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ☒ Other N/A

WELLHEAD COMPLETION
Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ☒ Other ____
Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ☒ Other ____

PROPERTY OWNER'S NAME/COMPANY NAME
Middle-Snake-Tamarac Rivers Watershed District
Property owner's mailing address if different than well location address indicated above
453 N McKinley St.
Warren, MN 56762

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

WELL OWNER'S NAME/COMPANY NAME
Same as above
Well owner's mailing address if different than property owner's address indicated above
Same as above

SCREEN/OPEN HOLE
Screen from N/A to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ☒ No Obstruction
Type of Obstructions (Describe) ____
Obstructions removed? ☐ Yes ☐ No Describe ____

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

PUMP
☒ Not Present ☐ Present, Removed Prior to Sealing ☐ Other ____
Type ____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE
☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ☒ Casing Perforation/Removal
Casing Diameter
N/A in. from ____ to ____ ft. ☐ Perforated ☐ Removed
____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed
Type of Perforator N/A

VARIANCE
Was a variance granted from the MDH for this well? ☐ Yes ☒ No TN# ____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material Bentonite Grout from 0 to End ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS
Other unsealed and unused well or boring on property? ☐ Yes ☒ No How many? ____

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Newfolden Flood Redux
(FGO06666)
BH-06 through BH-10

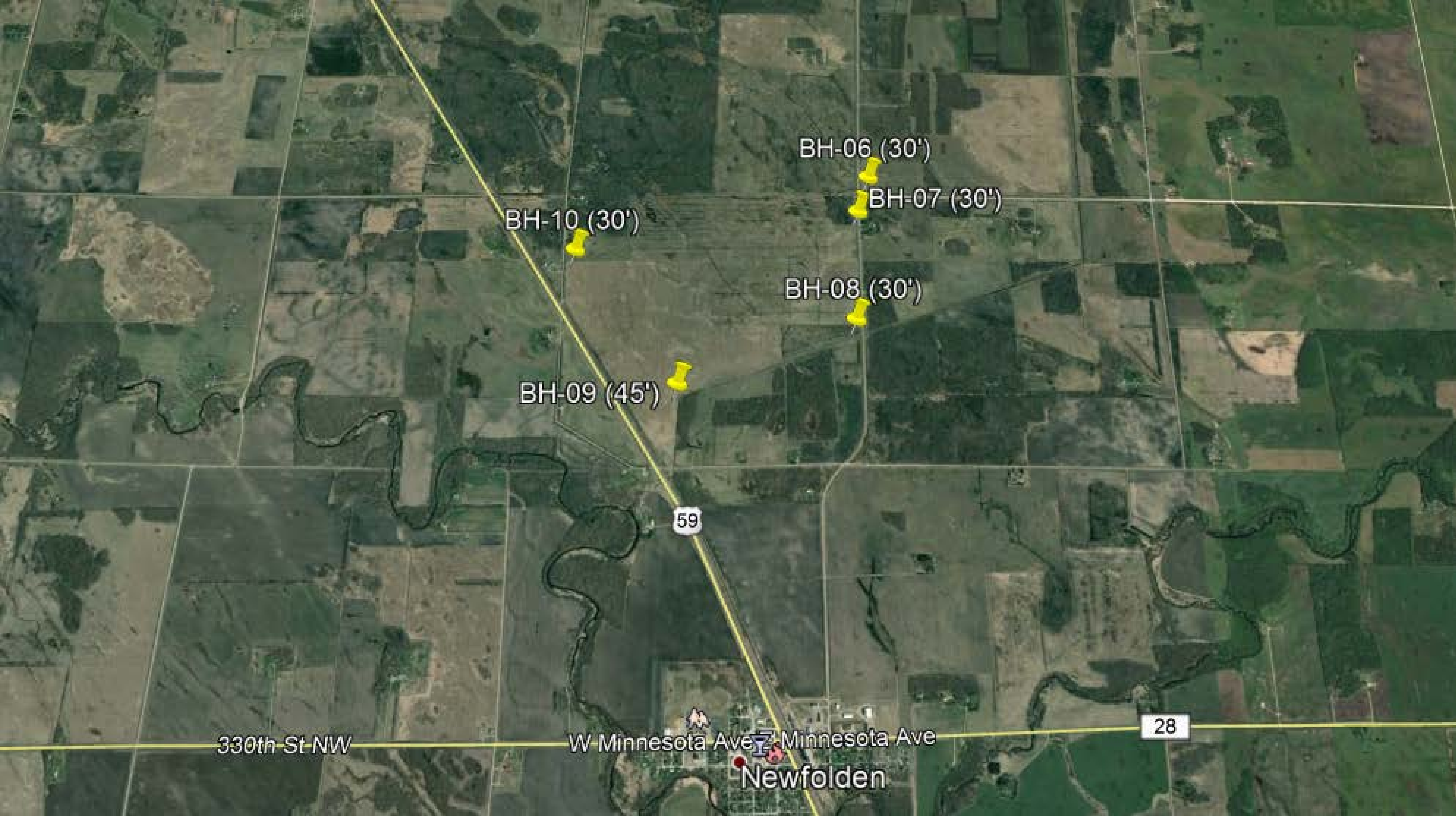
LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — 3574
Licensee Business Name — *License or Registration No.*

Christopher Kaiser for Bill Canty — 11/16/2018
Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson
Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY
H 362967



BH-06 (30')
BH-07 (30')
BH-10 (30')
BH-08 (30')
BH-09 (45')
59
28
330th St NW
W Minnesota Ave
Minnesota Ave
Newfolden

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. / Minnesota Unique Well No. or W-series No. (Leave blank if not known): H 362968

WELL OR BORING LOCATION
County Name: Marshall

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
New Folden	156 N	44 W	4	NE ¼ SW ¼ NW ¼

Date Sealed: 10/17/2018
Date Well or Boring Constructed: 10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)
Latitude ______ Longitude ______

Depth at Time of Sealing: 46 ft.
Original Depth: 45 ft.

AQUIFER(S)
☐ Single Aquifer ☐ Multiaquifer

WELL/BORING
☐ Water-Supply Well ☐ Monit. Well
■ Env. Bore Hole ☐ Other ______

STATIC WATER LEVEL
■ Measured Date Measured: 10/17/2018 ☐ Estimated
15.00 ft. ■ below ☐ above land surface

Numerical Street Address or Fire Number and City of Well or Boring Location
Various Locations in New Folden Twp.

Show exact location of well or boring in section grid with "X."
N / S / E / W — ½ Mile — 1 Mile

Sketch map of well or boring location, showing property lines, roads, and buildings.
See Attached Map

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ■ Other: N/A

WELLHEAD COMPLETION
Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ■ Other ______
Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ■ Other ______

PROPERTY OWNER'S NAME/COMPANY NAME
Middle-Snake-Tamarac Rivers Watershed District
Property owner's mailing address if different than well location address indicated above
453 N McKinley St.
Warren, MN 56762

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ______	to ______ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
______ in. from ______	to ______ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
______ in. from ______	to ______ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

WELL OWNER'S NAME/COMPANY NAME
Same as above
Well owner's mailing address if different than property owner's address indicated above
Same as above

SCREEN/OPEN HOLE
Screen from N/A to ______ ft. Open Hole from ______ to ______ ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ■ No Obstruction
Type of Obstructions (Describe) ______
Obstructions removed? ☐ Yes ☐ No Describe ______

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

PUMP
■ Not Present ☐ Present, Removed Prior to Sealing ☐ Other ______
Type ______

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE
☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ■ Casing Perforation/Removal
Casing Diameter
N/A in. from ______ to ______ ft. ☐ Perforated ☐ Removed
______ in. from ______ to ______ ft. ☐ Perforated ☐ Removed
Type of Perforator: N/A

VARIANCE
Was a variance granted from the MDH for this well? ☐ Yes ■ No TN# ______

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material: Bentonite Grout from 0 to End ft. ______ yards ______ bags
______ from ______ to ______ ft. ______ yards ______ bags
______ from ______ to ______ ft. ______ yards ______ bags

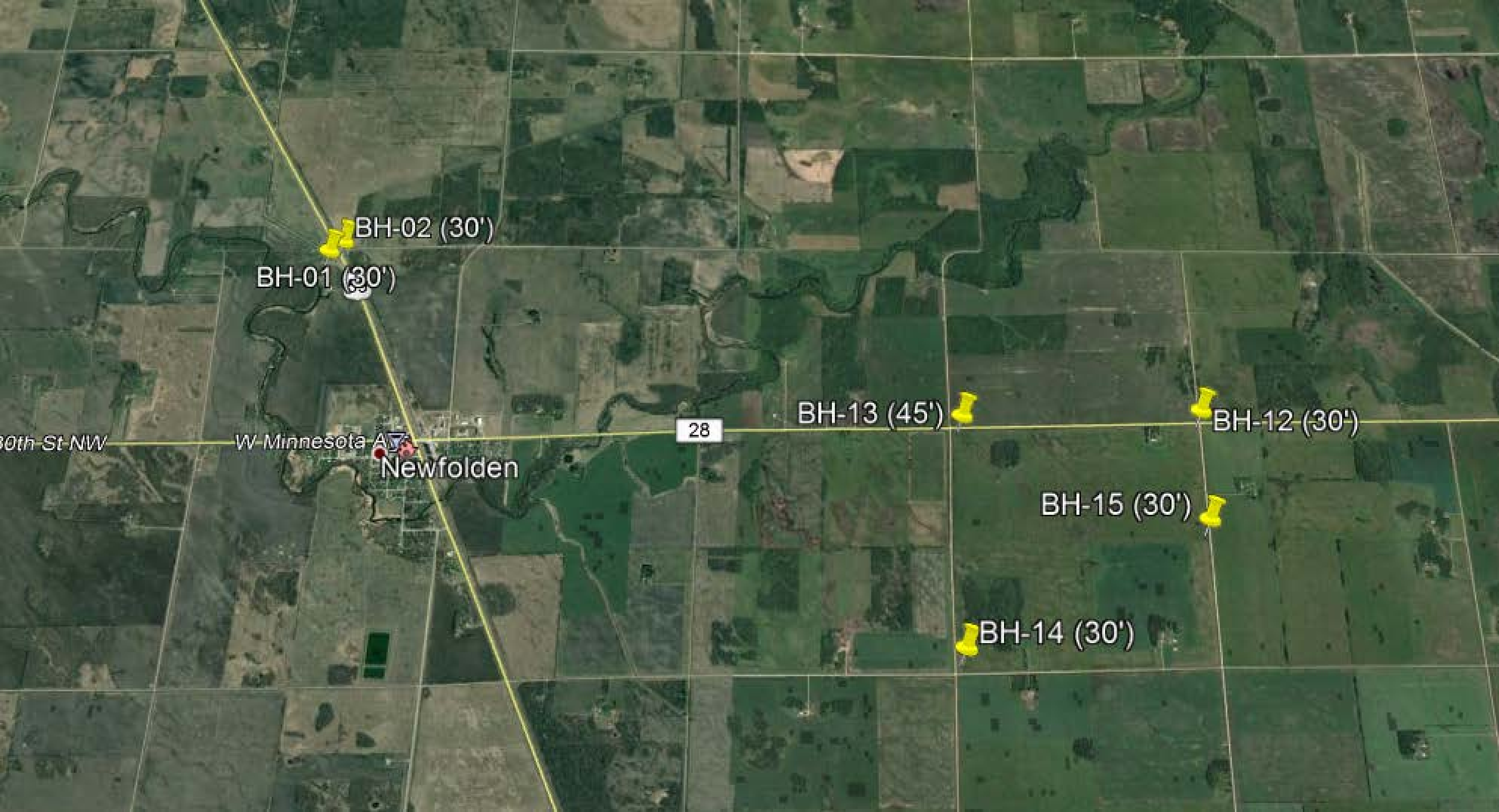
OTHER WELLS AND BORINGS
Other unsealed and unused well or boring on property? ☐ Yes ■ No How many? ______

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Newfolden Flood Redux
(FGO06666)
BH-1, 02 and BH-12 through
BH-15

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — *Licensee Business Name*
3574 — *License or Registration No.*
Christopher Kaiser for Bill Canty — *Certified Representative Signature*
Certified Rep. No.
11/16/2018 — *Date*
Bradley Halvorson — *Name of Person Sealing Well or Boring*

MINN. DEPT OF HEALTH COPY H 362968


BH-02 (30')
BH-01 (30')
BH-13 (45')
BH-12 (30')
28
30th St NW
W Minnesota A
Newfolden
BH-15 (30')
BH-14 (30')

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. Minnesota Unique Well No. or W-series No. (Leave blank if not known): H 362969

WELL OR BORING LOCATION

County Name: Marshall

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)	Date Sealed	Date Well or Boring Constructed
New Folden	156 N	44 W	3	NE ¼ NW ¼ NE ¼	10/17/2018	10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)

Latitude ____ Longitude ____

Depth at Time of Sealing 16 ft. Original Depth 15 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location: Near 340th St NW and 130th Ave NW

Show exact location of well or boring in section grid with "X." N S E W ½ Mile 1 Mile

Sketch map of well or boring location, showing property lines, roads, and buildings: See Attached Map

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water-Supply Well ☐ Monit. Well [✓ Env. Bore Hole] ☐ Other ____

STATIC WATER LEVEL: [✓ Measured] Date Measured 10/17/2018 ☐ Estimated

1.00 ft. [✓ below] ☐ above land surface

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile [✓ Other] N/A

WELLHEAD COMPLETION

Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried [✓ Other] ____

Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried [✓ Other] ____

PROPERTY OWNER'S NAME/COMPANY NAME: Middle-Snake-Tamarac Rivers Watershed District

Property owner's mailing address if different than well location address indicated above:

453 N McKinley St.
Warren, MN 56762

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

WELL OWNER'S NAME/COMPANY NAME: Same as above

Well owner's mailing address if different than property owner's address indicated above: Same as above

SCREEN/OPEN HOLE: Screen from N/A to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTIONS: ☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill [✓ No Obstruction]

Type of Obstructions (Describe) ____

Obstructions removed? ☐ Yes ☐ No Describe ____

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

PUMP: [✓ Not Present] ☐ Present, Removed Prior to Sealing ☐ Other ____

Type ____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE

☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe [✓ Casing Perforation/Removal]

Casing Diameter

N/A in. from ____ to ____ ft. ☐ Perforated ☐ Removed

____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed

Type of Perforator N/A

VARIANCE

Was a variance granted from the MDH for this well? ☐ Yes [✓ No] TN# ____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)

Grouting Material Bentonite Grout from 0 to End ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS

Other unsealed and unused well or boring on property? ☐ Yes [✓ No] How many? ____

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Newfolden Flood Redux
(FGO06666)
BH-04, 05

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — 3574

Licensee Business Name — *License or Registration No.*

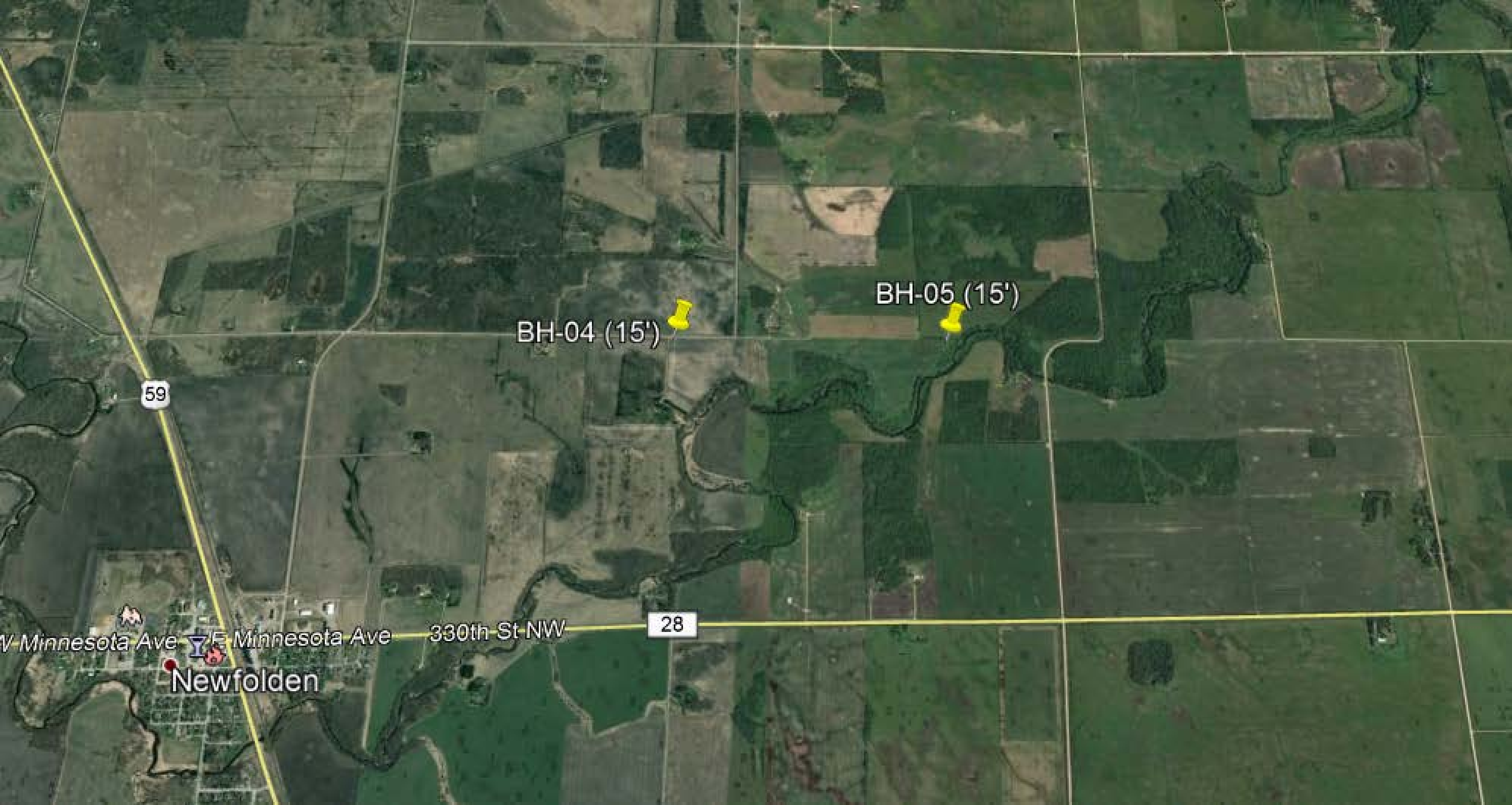
Christopher Kaiser for Bill Canty — 11/16/2018

Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson

Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 362969


BH-05 (15')
BH-04 (15')
59
28
330th St NW
W Minnesota Ave
E Minnesota Ave
Newfolden

MINNESOTA DEPARTMENT OF HEALTH

WELL AND BORING SEALING RECORD

Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No.
Minnesota Unique Well No. or W-series No. (Leave blank if not known)

H 362970

WELL OR BORING LOCATION				
County Name: Marshall				
Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)
Holt	156 N	43 W	7	NE ¼ NW ¼ NW ¼

Date Sealed: 10/17/2018

Date Well or Boring Constructed: 10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)

Latitude ______ Longitude ______

Depth at Time of Sealing 31 ft. Original Depth 30 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location

Near 110th Ave NE and 330th St NE

Show exact location of well or boring in section grid with "X."

N / W / E / S — ½ Mile — 1 Mile

Sketch map of well or boring location, showing property lines, roads, and buildings.

See Attached Map

AQUIFER(S)
☐ Single Aquifer ☐ Multiaquifer

WELL/BORING
☐ Water-Supply Well ☐ Monit. Well
☒ Env. Bore Hole ☐ Other ______

STATIC WATER LEVEL
☒ Measured Date Measured 10/17/2018 ☐ Estimated
DRY ft. ☒ below ☐ above land surface

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ☒ Other N/A

WELLHEAD COMPLETION
Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ☒ Other ______
Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ☒ Other ______

PROPERTY OWNER'S NAME/COMPANY NAME
Middle-Snake-Tamarac Rivers Watershed District

Property owner's mailing address if different than well location address indicated above

453 N McKinley St.
Warren, MN 56762

WELL OWNER'S NAME/COMPANY NAME
Same as above

Well owner's mailing address if different than property owner's address indicated above

Same as above

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

SCREEN/OPEN HOLE
Screen from N/A to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ☒ No Obstruction

Type of Obstructions (Describe) ______

Obstructions removed? ☐ Yes ☐ No Describe ______

PUMP
☒ Not Present ☐ Present, Removed Prior to Sealing ☐ Other ______
Type ______

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE
☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ☒ Casing Perforation/Removal

Casing Diameter
N/A in. from ____ to ____ ft. ☐ Perforated ☐ Removed
____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed

Type of Perforator N/A

VARIANCE
Was a variance granted from the MDH for this well? ☐ Yes ☒ No TN# ______

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)

Grouting Material Bentonite Grout from 0 to End ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS
Other unsealed and unused well or boring on property? ☐ Yes ☒ No How many? ______

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Newfolden Flood Redux
(FGO06666)
BH-11

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

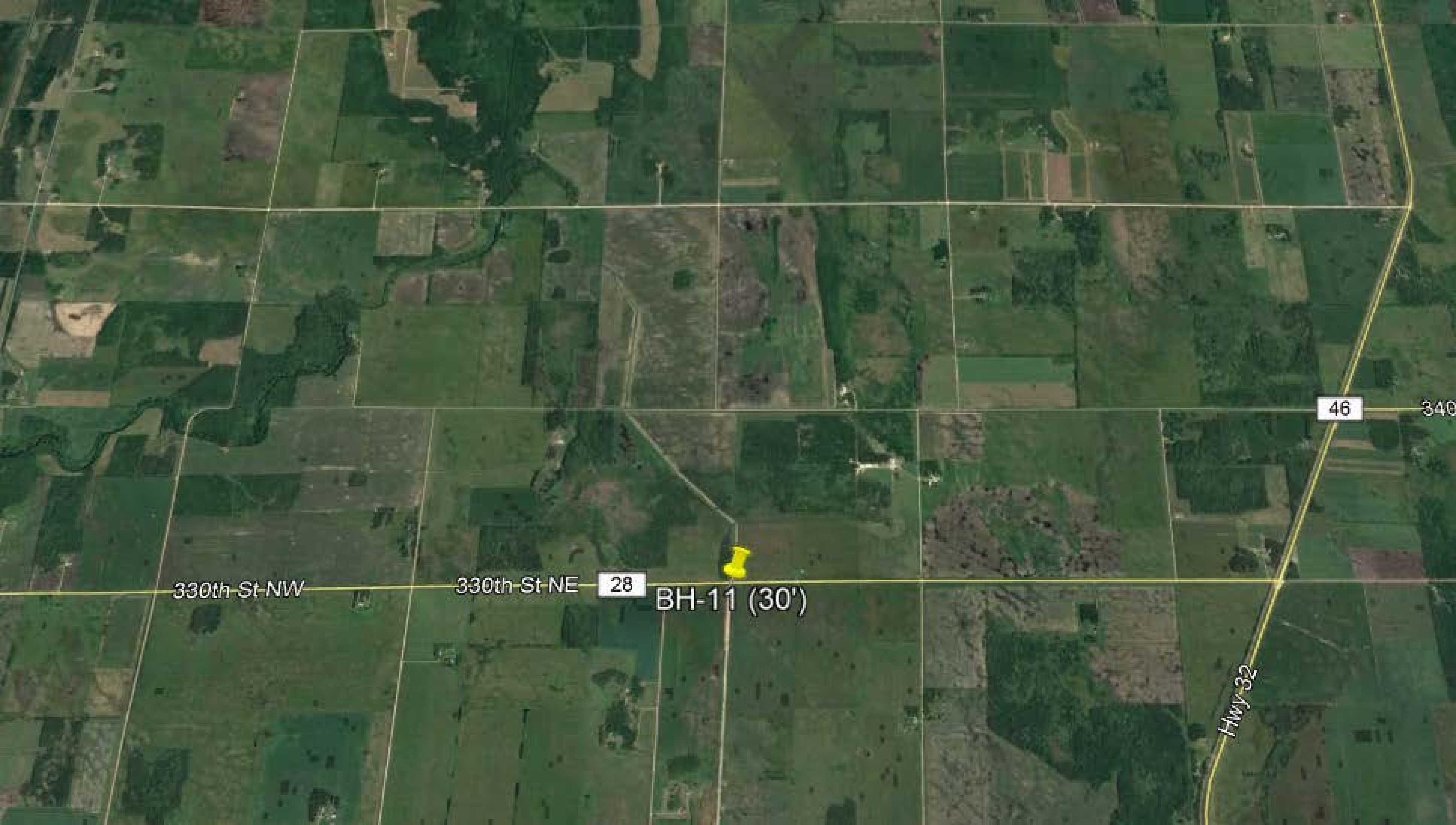
Northern Technologies, LLC — 3574
Licensee Business Name — *License or Registration No.*

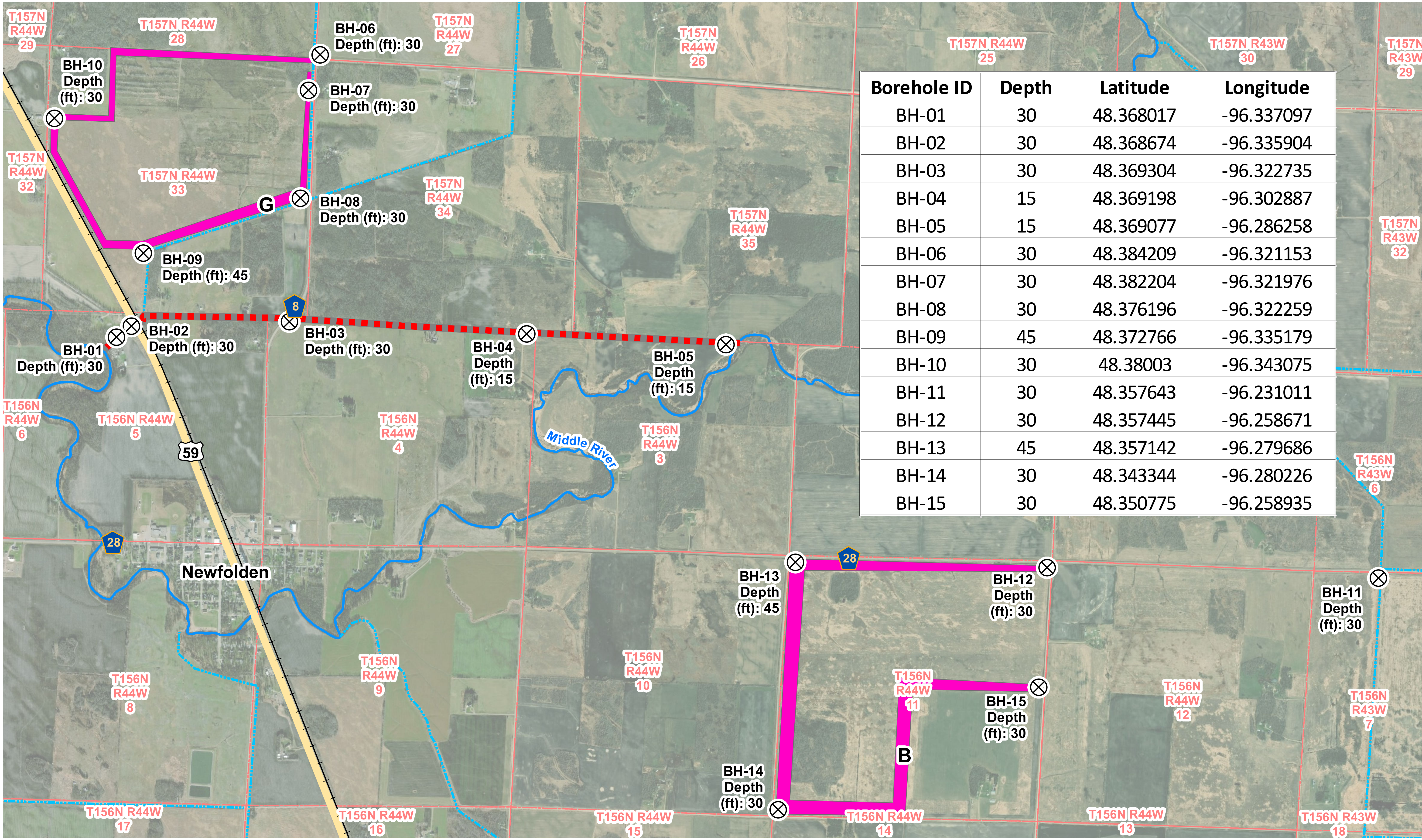
Christopher Kaiser for Bill Canty — 11/16/2018
Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson
Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY

H 362970


330th St NW
330th St NE
28
BH-11 (30')
46
340
Hwy 32



Borehole ID	Depth	Latitude	Longitude
BH-01	30	48.368017	-96.337097
BH-02	30	48.368674	-96.335904
BH-03	30	48.369304	-96.322735
BH-04	15	48.369198	-96.302887
BH-05	15	48.369077	-96.286258
BH-06	30	48.384209	-96.321153
BH-07	30	48.382204	-96.321976
BH-08	30	48.376196	-96.322259
BH-09	45	48.372766	-96.335179
BH-10	30	48.38003	-96.343075
BH-11	30	48.357643	-96.231011
BH-12	30	48.357445	-96.258671
BH-13	45	48.357142	-96.279686
BH-14	30	48.343344	-96.280226
BH-15	30	48.350775	-96.258935

Proposed Boring Locations
Potential Embankment Footprint
Diversion Ditch
MSTRWD Ditch
River
Major Roadway
Railroad
Section Lines

0 0.25 0.5
Miles

BOREHOLE LOCATION PLAN

NEWFOLDEN / MIDDLE RIVER SUBWATERSHED FLOOD DAMAGE REDUCTION PROJECT

Appendix B. Geotechnical Evaluation – HDR

Geotechnical Memo

Date: Tuesday, July 20, 2021

Project: Newfolden / Middle River Subwatershed Flood Damage Reduction Project
Middle-Snake-Tamarac Rivers Watershed District (MSTRWD)
Newfolden, MN
Project No.: 10254300

To: File

From: Kerrie Berg, PE, HDR Engineering Inc.

Steve Olson, PE, HDR Engineering Inc.

Subject: Geotechnical Memo

Introduction

This technical memorandum presents the results of the geotechnical analyses and engineering evaluation of the proposed earthen embankment retention basin (Site G) and diversion channel. The project is located within the Middle River Subwatershed in northwestern Minnesota and the proposed project site is near the City of Newfolden. The purpose of this memorandum is to provide geotechnical design recommendations for the proposed earthen embankment, as well as construction recommendations based on the encountered subsurface conditions at the project site.

This memorandum presents findings, conclusions, and recommendations regarding:

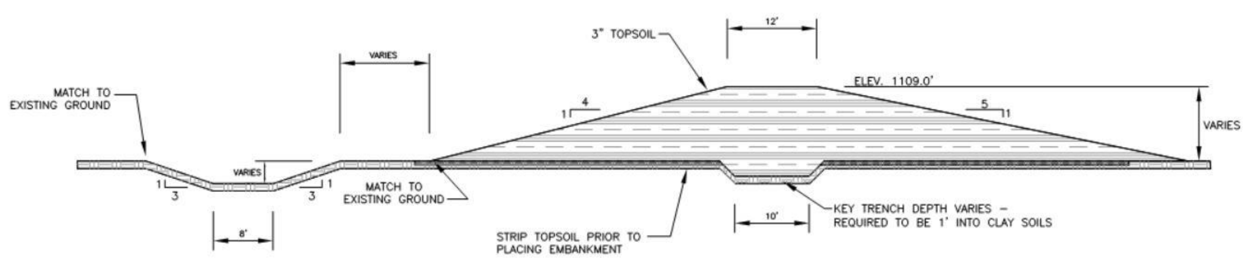
- Subsurface soil and groundwater conditions
- Evaluation of the engineering characteristics of the embankment and foundations soils
- Evaluation of foundation underseepage and embankment seepage
- Evaluation of the slope stability of the embankment and foundation soils
- Estimation of settlements of the embankment crest
- Recommendations for construction

Project Description

The Site G retention basin and diversion channel are located in Section 33 of New Maine Township, which is approximately 1.5 miles north of Newfolden at the edge of the relatively flat, ancestral bed of glacial Lake Agassiz. The proposed footprint is approximately 396 acres. There is an average of eleven feet of elevation difference across the site from north to south. There is approximately 2,200 acre-feet of storage at an elevation of 1106.0 feet. The top of the embankment would be at an elevation of 1109.0 feet.

Figure 1 illustrates the proposed embankment cross section for the retention basin based on HDR's Preliminary Engineers Report, dated April 1, 2019. The embankment cross-section for the site will have a 12 foot wide levee top, exterior side slopes of 4:1 (H:V) and interior side slopes of 5:1(H:V). The top of embankment is at an elevation of 1109.0 feet and has a maximum height of approximately 16 feet above existing ground. This elevation provides three feet of freeboard above the maximum water surface elevation of 1106.0 feet. The embankment will be constructed using lean clay material and will have a key trench that is 10 feet in width. The key trench will be required to be recessed one foot into the existing clay soils. One design update is that the exterior drainage ditch will have 4:1 side slopes rather than the 3:1 side slopes shown in Figure 1. See Figure 2 for a plan view of the project site and features.

Figure 1. Site G Typical Embankment Cross Section



Geology and NRCS Soil Survey Information

Published information from the Minnesota Geological Survey (Hobbs MGS, 1982, Figure 3) indicates peat deposits and lake-modified till of the Erskine Moraine associated with the Des Moines Lobe are located within the embankment footprint. The lake-modified till is described as an extremely clayey till deposited by a readvance into Glacial Lake Agassiz.

The NRCS Web Soil Survey (NRCS 2021) was utilized to evaluate soil information at the Project site. The complete list of soil types within and surrounding the project area are displayed in Table 1. The proposed embankment footprint shows of Deerwood muck, Poppleton fine sand, and Ulen loamy fine sand. Soil types found within and near the project area are displayed in Figure 4.

Table 1. Soil Map Unit Descriptions

Map Unit	Map Unit Description
116	Redby loamy fine sand, 0 to 3 percent slopes
I11A	Deerwood muck, 0 to 1 percent slopes
I18A	Foldahl loamy fine sand, loamy till substratum, 0 to 3 percent slopes
I24A	Grimstad fine sandy loam, 0 to 2 percent slopes, aspen parkland
I41A	Markey muck, 0 to 1 percent slopes
I43A	Mavie fine sandy loam, 0 to 1 percent slopes
I45A	Northwood muck, 0 to 1 percent slopes
I47A	Poppleton fine sand, 0 to 2 percent slopes
I48A	Radium loamy sand, 0 to 2 percent slopes
I53A	Roliss loam, 0 to 2 percent slopes
I55A	Rosewood fine sandy loam, Aspen Parkland, 0 to 1 percent slopes
I62A	Syrene sandy loam, 0 to 2 percent slopes
I65A	Ulen loamy fine sand, 0 to 2 percent slopes
I690A	Vallers loam, 0 to 2 percent slopes
I707A	Roliss-Vallers loams, 0 to 1 percent slopes
I70A	Strathcona fine sandy loam, 0 to 1 percent slopes
I727B	Corliss loamy sand, 2 to 6 percent slopes
I747A	Enstrom loamy fine sand, 0 to 2 percent slopes
I76A	Karlstad loamy sand, 0 to 2 percent slopes
I95A	Kratka and Strathcona soils, dense till, 0 to 1 percent slopes

Figure 2. Project Features – Site G and Diversion Channel

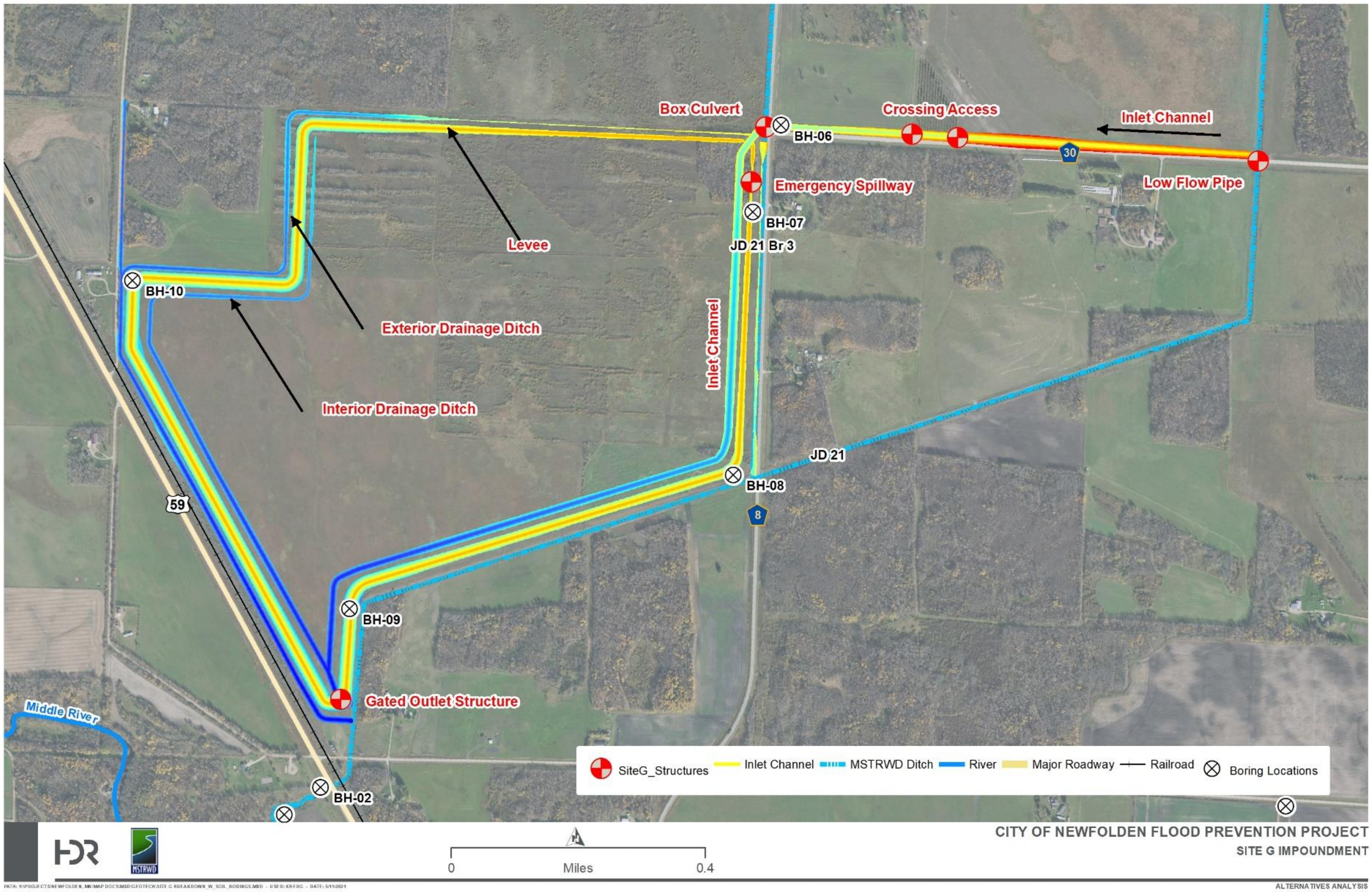


Figure 3. Quaternary Geology

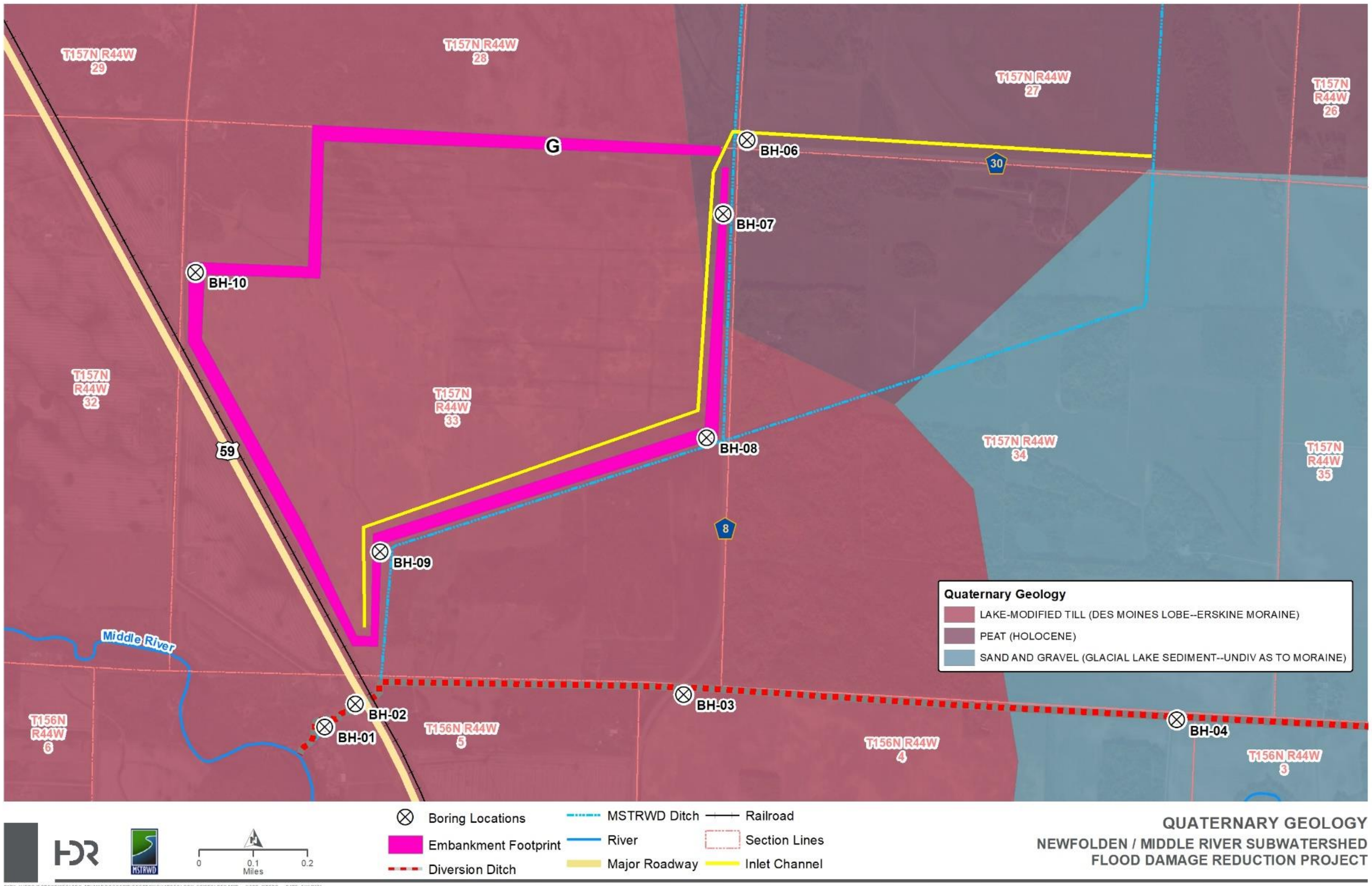
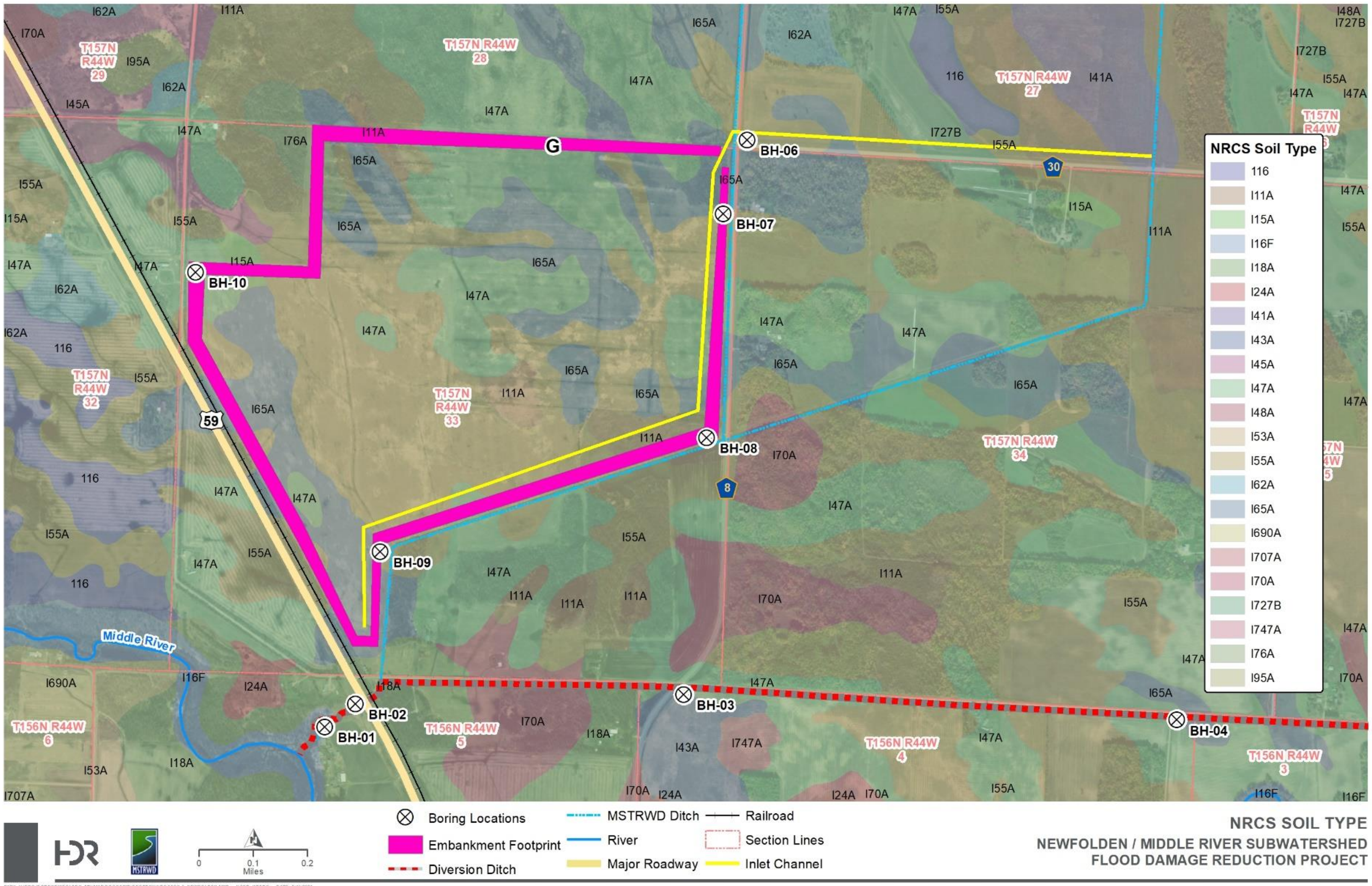


Figure 4. NRCS Soil Survey Data



Subsurface Exploration and Laboratory Testing

MSTRWD contracted Northern Technologies, LLC of Fargo, North Dakota to perform a geotechnical exploration at the project location (Site G and the diversion channel) that consisted of 5 soil borings (BH-06 through BH-10) at depths of 30 or 45 feet. The soil borings were completed on October 17, 2018. Borehole locations are shown on Figure 2 through Figure 4 above.

Samples from the 5 borings were analyzed by Northern Technologies, LLC for several key engineering properties including:

- Water content (ASTM D2216)
- Dry density (ASTM D7263-09 Method B)
- Atterberg limits (ASTM D4318)
- Grain size distribution (ASTM D422)
- Hydrometer (ASTM D7928 - 17)
- Unconfined Compressive Test - Triaxial (ASTM D2166)
- Hydraulic Conductivity (ASTM D5084)
- Consolidated Undrained Triaxial (ASTM 4767)

Detailed geotechnical information on the borehole logs and laboratory test results can be found in the Geotechnical Exploration and Engineering Review report and laboratory results provided by Northern Technologies, LLC. (Attachment A).

Subsurface conditions were described in Geotechnical Exploration and Engineering Review report provided by Northern Technologies, LLC. (Attachment A) as follows:

> *The overall subsurface soil profile at the borings consists of approximately 0.2 to 4.5 feet of topsoil and topsoil/fill underlain by relatively thin layers of loose to medium dense Glacial Lake Sediment (GLS) soils followed by medium to stiff Lake Modified Glacial Till (LMGT) which extends to the termination depth of the borings (maximum 46 feet). The GLS soils are comprised of sand and silty sand. LMGT soils are comprised of lean clay, silty clay, silt, occasional layers of sand. The soils have varying color, moisture content and unit weight. The LMGT clay soils have trace amounts of sand and gravel. Additional comment on the evaluation of recovered soil samples is presented within the report appendices and boring logs.*

During drilling, groundwater in BH-06 and BH-10 was encountered at depths of 5.0 and 1.0 feet respectively below ground surface in the sand with silt/silty sand layers. Groundwater was not encountered in BH-07 to BH-09. No long-term groundwater table measurements were made as borings were backfilled immediately after drilling.

Relatively slow draining clay soils are present below the upper sand/silt layer in the boreholes and considerable time may be required for static groundwater levels to be determined. The groundwater readings represent conditions at the time of the borings.

Shallow groundwater may be present, especially in any areas where organics are present. It should be noted that groundwater levels will fluctuate seasonally and in response to climatic conditions.

Subsurface Stratigraphy and Soil Parameters

The materials at the site were characterized based on the available regional data and the field and laboratory testing data. The layers were grouped primarily based on their grain-size distribution and strength behaviors and only pertain to material encountered within the investigated area. The typical stratigraphy included topsoil, followed by sand/silty sand (SP-SM Glacial Lake Sediment), underlain by lean silty clay (Lean Clay-Lake Modified Glacial Till) which is underlain by a higher strength lean sandy clay (Lower Lean Clay-Lake Modified Glacial Till).

Soil parameters used in the geotechnical analysis were obtained from a number of sources and are summarized in Table 2. Details on parameter selection are provided in Table 2 and in the in the following paragraphs. In addition to the soils in the subsurface stratigraphy, soil parameters were estimated for the new embankment.

Soil Strength Design Parameters

Unit Weight

Average laboratory results were utilized for selecting the unit weight for the Lean Clay-Lake Modified Glacial Till and Lower Lean Clay-Lake Modified Glacial Till. Table 1, Typical Properties of Compacted Soils from Chapter 2 of the NAVFAC Foundations and Earthwork Design Manual (NAVFAC 7.02, 1986) was used to select the unit weight for the Embankment Fill material. Table 6 from Chapter 1 of the NAVFAC Soil Mechanics Design Manual (NAVFAC 7.01, 1986) was utilized to select the unit weight for the SP-SM Glacial Lake Sediment.

Drained Strengths

The drained strength for the Lower Lean Clay-Lake Modified Glacial Till layer was developed from average test results for plasticity index (PI) used in conjunction with the plot of peak friction angle vs. PI (Duncan et al., 1989). The drained strength for the Lean Clay-Lake Modified Glacial Till was obtained from Consolidated Undrained testing data. The friction angle for the SP-SM Glacial Lake Sediment layer was selected based on average blow counts (Meyerhof, G. G., 1956). Table 1, Typical Properties of Compacted Soils from Chapter 2 of the NAVFAC Foundations and Earthwork Design Manual (NAVFAC 7.02, 1986) was used to select the long-term friction angle for the Embankment Fill material. All soils were adopted a conservative long-term cohesion of 0 psf.

Undrained Strengths

The undrained strength for the Lower Lean Clay-Lake Modified Glacial Till layer was determined utilizing the average blow count (N) values (Duncan and McGregor, 1998). The undrained strength for the Lean Clay-Lake Modified Glacial Till was obtained from assessing Unconfined Compression and Consolidated Undrained testing data.

An undrained shear strength of 1200 psf was chosen for the Embankment Fill material based on the recommendations for borrow material in Table 1, *Typical Properties of Compacted Soils* from Chapter 2 of the NAVFAC Foundations and Earthwork Design Manual (NAVFAC 7.02, 1986).

Seepage Parameters

Permeability

The primary input parameter in seepage analyses is hydraulic conductivity (or "permeability") of the materials that comprise the embankment and foundation.

The permeability of the SP-SM Glacial Lake Sediment layer was determined by correlation from hydrometer lab data.

A hydraulic conductivity test was completed on one sample from the Lean Clay-Lake Modified Glacial Till and this value was selected for use in the analysis for the Embankment Fill material, Lean Clay-Lake Modified Glacial Till, and Lower Lean Clay-Lake Modified Glacial Till.

Anisotropy Ratio (K_y/K_x), Coefficient of Volume Compressibility (m_v), Saturated Volumetric Water Content (Θ_s,), and Residual Volumetric Water Content (Θr)

K_y/K_x, m_v, Θ_s, *and* Θ_r values and how they were determined are summarized in Table 2. All materials were modeled as saturated/unsaturated materials in SEEP/W requiring the m_v, Θ_s, *and* Θ_r parameters for the soil-water characteristic curve (SWCC). For this project, SWCCs were estimated using Geostudio's SWCC estimating feature.

Table 2. Soil Parameters

<table>
<tr><th rowspan="3">Soil Type</th><th rowspan="3">Moist Unit Weight γ (lbs/ft³)</th><th colspan="3">Shear Strength Parameters</th><th rowspan="3">Horizontal Saturated Permeability, [k_h]</th><th rowspan="3">Anisotropy k_v/k_h (1)</th><th rowspan="3">Coefficient of Volume Compressibility (M_v) /psf(2)</th><th rowspan="3">Saturated Volumetric Water Content, Θs (ft^3/ft^3)(3)</th><th rowspan="3">Residual Volumetric Water Content, Θr (4)</th><th rowspan="3">GeoStudio SWCC Function</th></tr>
<tr><th>End of Construction (Undrained Strength)</th><th colspan="2">Effective Stress Envelope (Drained Strength)</th></tr>
<tr><th>(S_u), psf</th><th>c' (psf)</th><th>ϕ'</th></tr>
<tr><td>SP/SM (Glacial Lake Sediment)</td><td>130</td><td>Drained</td><td>0</td><td>35</td><td>3.47E-05</td><td>0.25</td><td>3.12E-06</td><td>0.35</td><td>0.045</td><td>Silty Sand</td></tr>
<tr><td>Lean Clay (Lake Modified Glacial Till)</td><td>131</td><td>1600</td><td>0</td><td>33</td><td>2.10E-09</td><td>0.25</td><td>1.54E-06</td><td>0.32</td><td>0.068</td><td>Clay</td></tr>
<tr><td>Lower Lean Clay (Lake Modified Glacial Till)</td><td>138</td><td>5000</td><td>0</td><td>33</td><td>2.10E-09</td><td>0.25</td><td>1.54E-06</td><td>0.23</td><td>0.070</td><td>Clay</td></tr>
<tr><td>Embankment Fill</td><td>125</td><td>1200</td><td>0</td><td>28</td><td>2.10E-09</td><td>0.25</td><td>1.54E-06</td><td>0.32</td><td>0.068</td><td>Clay</td></tr>
</table>

Notes:

(1) Table 1, Natomas Levee Improvement Project (January 31, 2010).
(2) Calculated from Young's modulus values from AASHTO 2014.
(3) Calculated from lab moisture content or void ratio results.
(4) Leij et al, 1996.

Seepage Analysis and Slope Stability

Seepage analysis and slope stability was evaluated using SEEP/W and SLOPE/W in Geostudio 2021 R2 software and the adopted strength and drainage parameters summarized in Table 2. In addition to soil parameters, information related to cross section geometry and design water surface was required for the stability models.

Cross Section Geometry and Subsurface Stratigraphy

Four critical embankment cross-sections were selected to evaluate seepage and stability for the proposed embankment based on the estimated height of the embankment and the encountered subsurface conditions at the site. From review of the test borings at the site as well as the existing topography, these critical locations were determined at BH-08 and BH-09 along the existing JD 21 ditch located on the downstream side of the embankment. The existing JD 21 cross section near BH-08 is approximately 7 ft deep with a 20-foot bottom and 3H:1V side slopes. The existing JD 21 cross section near BH-09 is approximately 10 ft deep with a 5-foot bottom and 1.5H:1V side slopes. For the BH-09 cross section, the thicker depth of the silt layer at BH-10 was used to establish a worst-case condition. Figure 5 shows the borehole locations along with embankment heights. Based on existing topography and a crest elevation of 1109 the embankment heights were estimated at 9 and 16 and feet for the BH-08 and BH-09 cross sections respectively. The embankment geometry was based on that provided in the 2019 Preliminary Engineers Report (see Figure 1). A minimum bench of 30 feet was selected for the distance between the downstream embankment toe and the downstream ditch for the BH-08 cross section and 40 feet for the BH-09 cross section. These are the minimum required distances determined based on seepage and slope stability modeling results. The downstream ditch is the existing JD 21 ditch (see Figure 2).

An exterior drainage ditch will be constructed along the downstream toe of the remaining embankment sections (see Figure 2). In order to minimize the bench along the remaining embankment sections the BH 8 and 9 cross sections were modeled with 3 and 4-feet-deep ditch with 4:1 side slopes respectively (these represent the maximum depth of the exterior drainage ditch). A minimum bench of 15 feet was selected.

The maximum interior drainage ditch depth of 8 feet with 4:1 side slope and a 15-foot bench was included in all models.

For all cases the embankment was impounding water in the retention basin and a seepage analysis was completed to assess the anticipated seepage forces and pore water pressures at each cross-section and the results of the seepage analyses were imported into the slope stability models.

The four cross section models are shown in Figure 6 through Figure 9.

Design Criteria and Conditions

Seepage and slope stability criteria and guidance as defined in EM 1110-2-1913, “Design and Construction of Levees” was used to evaluate the retention embankment.

Figure 5. Embankment Height and Borehole Locations

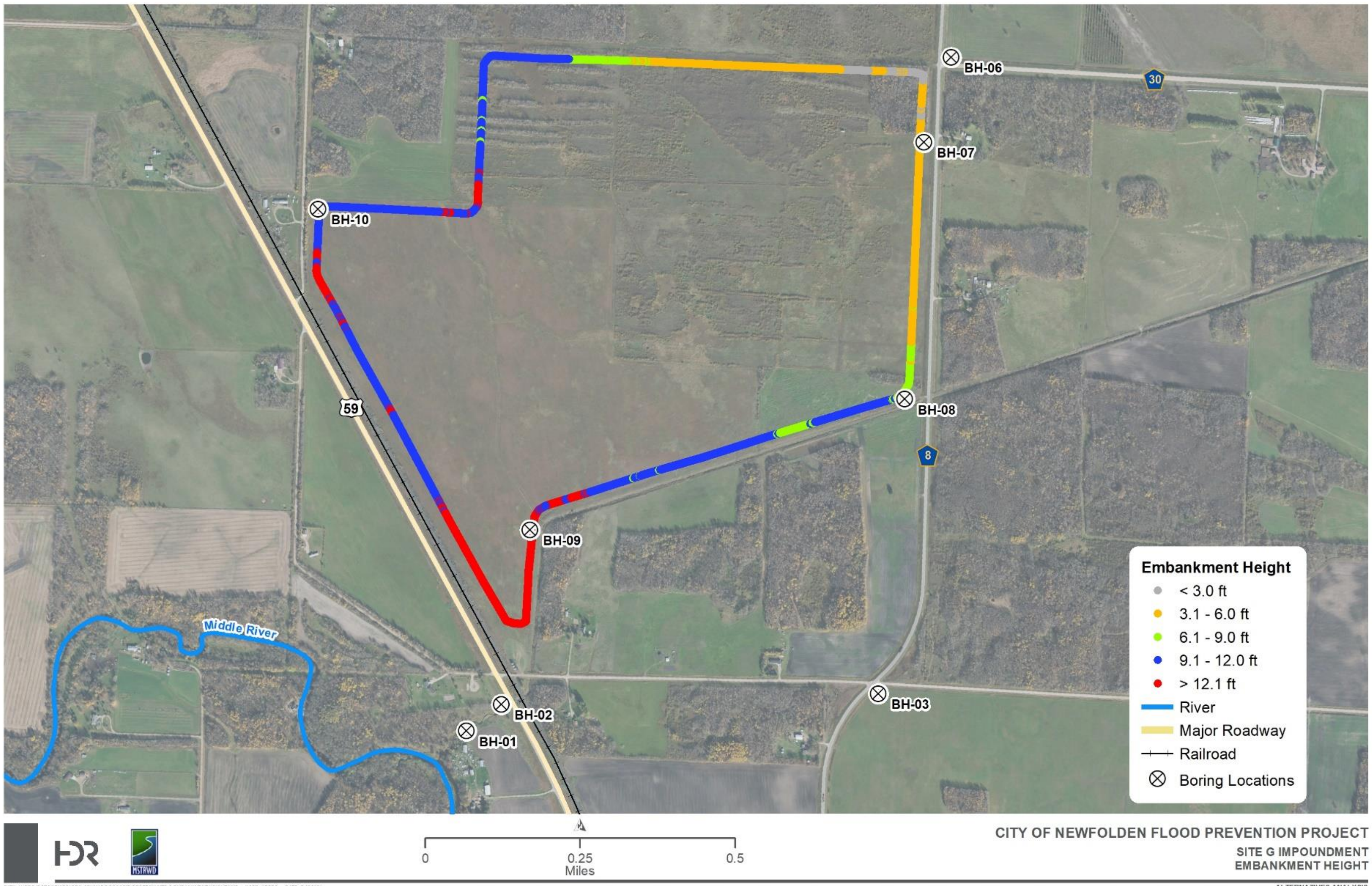


Figure 6. Cross Section at BH-8 with JD 21

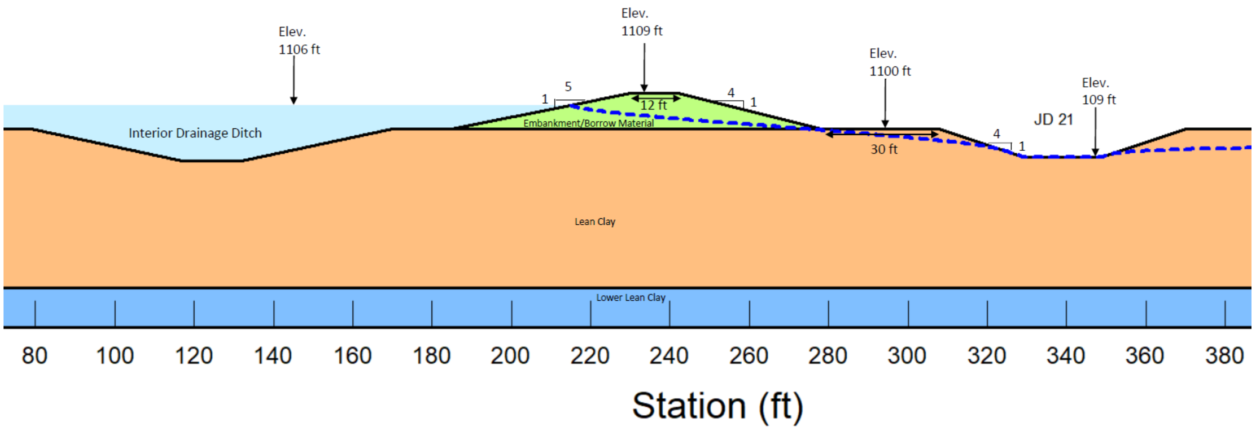


Figure 7. Cross Section at BH-8 with Exterior Drainage Ditch

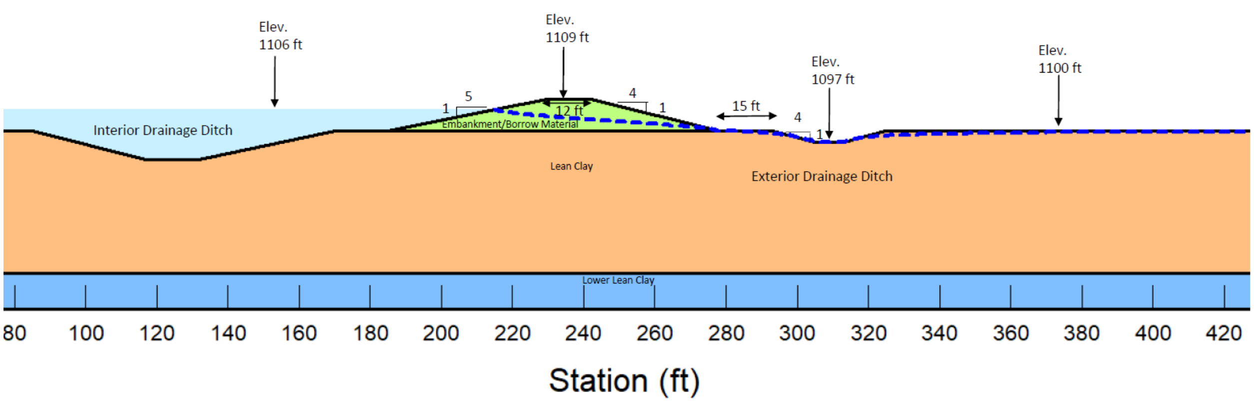


Figure 8. Cross Section at BH-9 with JD 21

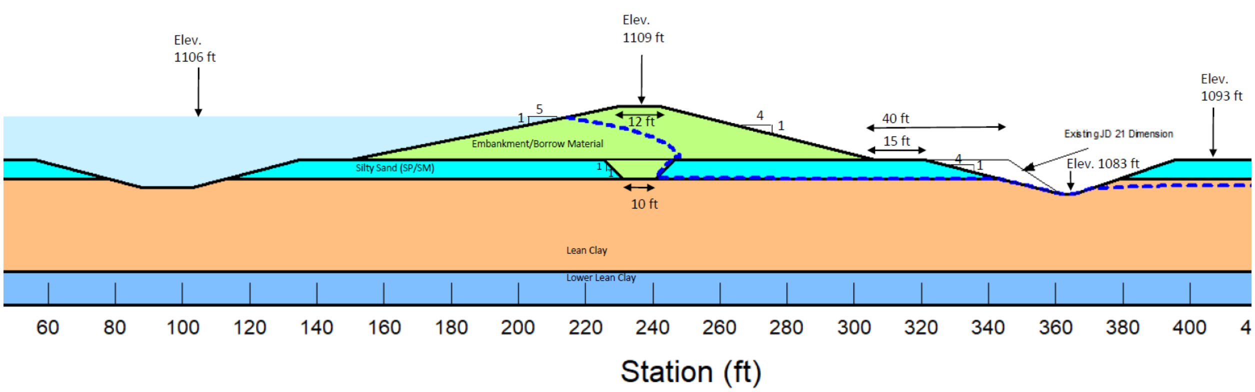
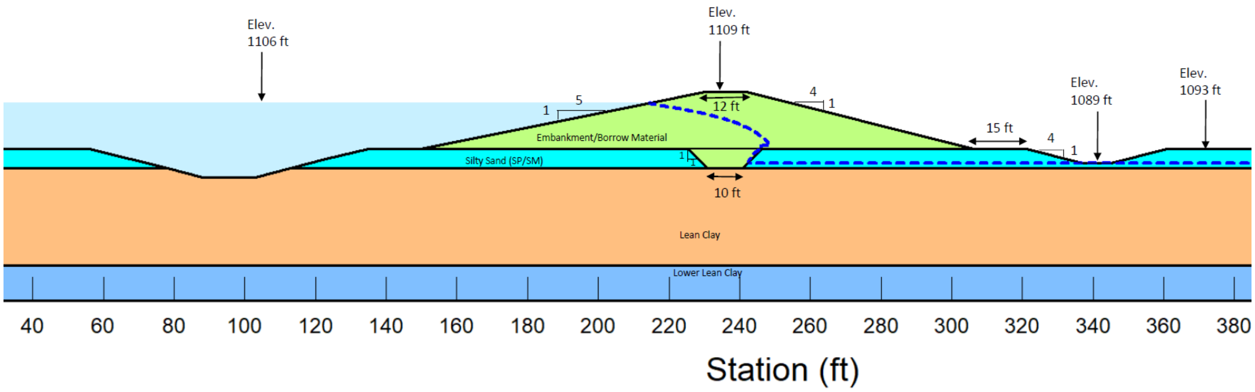


Figure 9. Cross Section at BH-8 with Exterior Drainage Ditch



Seepage and Stability Results

Loading Conditions

The loading conditions considered for the stability analysis are listed below and are based on guidance provided in EM 1110-2-1913, "Design and Construction of Levees".

- Case I- End of Construction
- Case II- Long-Term (Steady Seepage)
- Case III- Rapid Drawdown

The hydraulic boundary conditions for the piezometric lines and seepage models are provided in Table 3.

Table 3. Hydraulic Boundary Conditions for Loading Cases

Loading Case (1)		Analysis Type	Slope analyzed	Retention Site Water Elevations [feet]	Tailwater Elevation [feet]
I	End of Construction	Steady-State Seepage	Upstream and Downstream	Ground Surface	Potential Seepage Face
II	Steady Seepage	Steady-State Seepage	Upstream and Downstream	1106	Potential Seepage Face
III	Rapid Drawdown (RDD)	Transient	Upstream	1109 to Interior Ditch Bottom	Ground Surface

Seepage Analysis Results

Seepage analysis was evaluated per USACE EM 1110-2-1913 manual guidelines, which states the maximum allowable exit hydraulic gradient is limited to 0.5. In addition, USACE EM 1110-2-1913 states that drainage ditches should be located such that the exit gradient in the bottom of the ditch does not exceed 0.5 at the landside levee toe.

Seepage results for all cross sections demonstrate the exit gradient is less than the maximum allowable value of 0.5 at the toe of the embankment and in the downstream ditch (JD 21 or the exterior ditch) indicating seepage design requirements are satisfied (

Table 4).

However, because the exit gradient in the downstream ditch of JD 21 for BH-09 is very close to the limit of 0.5, it is recommended that maintenance checks in the ditch be performed regularly to check for slumps in the ditch. The slumps should be removed to avoid damming up the ditch.

The factor of safety against heave/piping at the toe of the embankment and at the ditch was estimated for the BH-09 cross sections due to the silty sand layer located at ground surface. The analysis was performed using the water pressures from the seepage analysis as input. As specified in ETL 1110-2-569, the factor of safety against heave/piping was greater than 1.6 (Table 4).

See Attachment B for figures of the SEEP/W seepage analysis results.

Table 4. Seepage Analysis Results

Cross Section	Seepage Case	Cohesionless layer present:	Heave at Downstream Embankment Toe (Downstream Ditch result in brackets)		Exit Gradient at toe of slope	Exit Gradient at bottom of ditch
			Check for Heave	Recommended FOS = 1.6 (USACE[1])	Recommended Exit Gradient < 0.5 (USACE)	Recommended Exit Gradient < 0.5 (USACE)
BH-08 at JD 21 with 30 ft Bench	Steady State Seepage	No	No	N/A	<<0.5	0.38
BH-08 with Exterior Drainage Ditch with 15 ft Bench	Steady State Seepage	No	No	N/A	0.06	0.38
BH-09 at JD 21 with 40 ft Bench	Steady State Seepage	Yes, at surface	Yes	>>1.6 (2.25)	<<0.5	0.49
BH-09 with Exterior Drainage Ditch with 15 ft Bench	Steady State Seepage	Yes, at surface	Yes	>>1.6 (>>1.6)	<<0.5	0.03

[1] USACE = United States Army Corps of Engineers

Slope Stability Analysis Results

As per USACE guidance, three loading conditions were modeled:

Short Term - End of Construction

For the short term condition, the water surfaces as described in Table 3 were first used to estimate the pore water pressures in the embankment based on a seepage analysis. The pore water pressures from the seepage analysis were used in the stability analysis. Stability models for this condition simulate the response of the soils immediately after the construction of the embankments. This is considered an unconsolidated and undrained condition since the soils have not had sufficient time to consolidate or to drain off the excess pore pressures that result from the additional loading. Results and output contained in this report are for failures modeled on both the upstream and downstream side of the embankment.

Long Term - Steady State Seepage

For the steady state condition, the water surfaces as described in in Table 3 were first used to estimate the pore water pressures in the embankment based on a seepage analysis. The pore water pressures from the seepage analysis were used in the stability analysis. Drained soil strengths are used for this analysis. Results and output contained in this report are for failures modeled on both the upstream and downstream side of the embankment.

Results also include failures modeled in the downstream JD 21 ditch and exterior ditch. Given the need for regular maintenance regarding the JD 21 and exterior ditch, a minimum slip surface depth of 3 feet was used in the ditch failures (as opposed to less than 1 foot in all locations) when searching for the critical surfaces to exclude the more surficial failure surfaces.

Rapid Drawdown

As stated in EM 1110-2-1913, "Design and Construction of Levees" this case represents the condition whereby a prolonged flood stage saturates at least the major part of the wet embankment portion and then falls faster than the soil can drain. This causes the development of excess pore water pressure which may result in the slope on the upstream side of the embankment becoming unstable. Stability analysis was evaluated on the upstream side.

Results

The cross sections were evaluated using the USACE criteria for levees as defined in EM 1110-2-1913. It states that a minimum factor of safety of 1.3 is required for the short-term condition. For the long-term stability condition, a factor of safety of 1.4 is required. A minimum factor of safety of 1.2 is required for rapid drawdown. All factors of safety determined for the embankment were above or equal to minimum requirements.

The minimum factors of safety calculated for each section under the various loading conditions are shown in **Error! Reference source not found.**Attachment C includes figures of the SLOPE/W slope stability analysis results.

The analyses demonstrate that the proposed cross sections exceed or equal the minimum requirements for each condition.

Note: BH-09 Cross Section

Stability analysis indicated the existing JD 21 ditch at the BH-09 cross section is not stable at the existing 1.5H:1V slope. Although the JD 21 slope will not be modified as part of the proposed project, we have conservatively assumed for analysis purposes that the ditch has sloughed off to a 4H:1V slope within this section (Attachments B and C) and provides less resistance at the toe of the slope. If the JD 21 ditch sloughs to a 4:1 slope, a 15 ft bench will remain between the downstream embankment toe and JD 21 at the BH-09 cross section. Ultimately, we anticipate regular maintenance of the slope will be performed to prevent it from sloughing to a 4H:1V.

Table 5. Slope Stability Results

Case		USACE Recommended Minimum Factor of Safety (EM 1110-2-1913)	BH-08 at JD 21 with 30 ft Bench	BH-08 with Exterior Drainage Ditch with 15 ft Bench	BH-09 at JD 21 with 40 ft Bench	BH-09 with Exterior Drainage Ditch with 15 ft Bench
End of Construction (EOC) – Undrained (short-term) Loading	**Upstream (US)**	1.3	6.6	6.7	4.5	4.5
	Downstream (DS)		5.6	7.1	3.7	4.2
Steady State Seepage-Drained (Long-term) Loading	**Upstream (US)**	1.4	2.7	2.7	2.7	2.7
	Downstream (DS) - Embankment		2.3	2.0	2.2	2.2
	Downstream (DS) - Ditch		1.4	1.8	1.5	2.8
Rapid Drawdown		1.2	2.7	2.7	2.7	2.7

Settlement

Settlement was calculated based on the compression of the foundation soils under the weight of the proposed embankment fill. Settlement calculations are provided in Attachment D. Settlement was calculated at cross sections at BH-08 and BH-09 with embankment heights of 9 and 16 feet respectively. These sections were deemed critical based on embankment height and subsurface conditions (subsurface conditions are BH-08 are all clay and BH-09 is the location of the maximum embankment height). Settlement was also calculated at a cross section at BH-07 with embankment heights of 6, 9, and 12 feet to obtain a settlement estimates for the lower embankments on the north and east sides of the retention basin.

The settlement models include Lean Clay (Lake Modified Glacial Till), and Lower Lean Clay (Lake Modified Glacial Till). Pre-consolidation coefficients were determined from Figure 3 of NAVFAC Design Manual 7.01 Soil Mechanics, page 142 (NAVFAC 1986). Consolidation Coefficients were determined from Figure 4 of NAVFAC Design Manual 7.01 Soil Mechanics, page 144 (NAVFAC 1986). Compression and Recompression Indices were calculated based on Liquidity Index (USDT 2006). The parameters are indicated in

Table *6*.

Table 6. Consolidation Parameters

Soil Layer	Wet Unit Weight (pcf)	Preconsolidation Pressure - P_c (tsf)	Initial Void Ratio – e_0	Consolidation Coefficient - C_v (ft^2/day)	Compression Index - C_c	Recompression Index - C_r
Lean Clay	131	2,600	0.47	0.65	0.19	0.019
Lower Lean Clay	138	10,000	0.30	5.58	0.18	0.018

Based on the analysis, the estimated settlement of the embankments based on primary consolidation are shown in Table 7. It should be noted that any topsoil, organics, or peat (which are highly compressible) is assumed to be completely undercut for these analyses. It is assumed that any compression in the silty sand layer (Glacial Lake Sediment) will take place during construction. The time-rate of settlement of the foundation soils under the embankment loading at the site was estimated to be approximately 6 months.

Table 7. Summary of Settlement Analysis

Location	Embankment Height (feet)	Estimated Total Settlement (inches)	Estimated Time for 90% consolidation (months)
BH-07	6	1.9	6
BH-07	9	2.6	6
BH-07	12	3.3	6
BH-08	9	3.6	6
BH-09	16	4.0	6

Findings and Recommendations

Summary of Findings

The geotechnical investigations and engineering evaluations demonstrate that design requirements are satisfied for the Newfolden impoundment embankments. As mentioned previously in this report, it is recommended maintenance checks in JD 21 and the exterior ditch be performed regularly to check for slumps in the ditch. Any slumps should be removed to avoid damming up the ditch. Based on information from the NRCS Web Soil Survey, peat may be present in the north-east corner of the impoundment. Any peat encountered in the embankment footprint should be completely undercut and replaced with suitable fill material.

The embankment will have a key trench that is 10 feet in width. The key trench will be required to be recessed one foot into the existing clay soils.

Recommendations

Bench Distances

For the embankment section along JD 21, a minimum bench of 40 feet is recommended for the distance between the downstream embankment toe and the start of JD 21.

For the exterior drainage ditch that will be constructed along the downstream toe of the remaining embankment sections a minimum bench of 15 feet is required.

Earthwork and Compaction Requirements

Prior to general fill placement clearing, grubbing, and stripping is required for foundation preparation as per USACE EM 1110-2-1913. All trees, brush, vegetation, topsoil and organics (including peat, if encountered) should be removed from the embankment footprint. Topsoil and organics can be stockpiled for future use on the final embankment surface to promote vegetation growth.

The exposed surface shall be scarified and mixed with the first lift of fill. Fill soils for the embankment levees may be borrowed on-site or imported. All fill should be compacted in place using sheepsfoot compaction equipment. The fill should be placed at 9" lifts (or less) and be compacted to at least 95% of the maximum dry density as determined by ASTM D 698-91 (Standard Proctor test) within moisture contents corresponding from 0 to +5% of the optimum water content as determined by the referenced test. Embankment strain and the potential for cracking will be minimized by placing all fill and backfill soils at a moisture content only slightly wet of optimum moisture content. Frequent in-place density tests (minimum every 2 vertical feet of fill and every 300 linear feet) should be performed to ensure adequate compaction is achieved.

Soils from the on-site excavations are considered suitable for reuse as compacted fill; provided the requirements for organics, moisture content, and compaction level are met. Suitable borrow clay soils for the embankments include those classified in ASTM D2487 as lean clay (CL) and shall be free of ice, snow, frozen earth, trash, debris, organic material, stones larger than three inches in any dimension, and must meet the following requirements:

A. The fill should be compacted to at least 95% of the maximum dry density as determined by ASTM D 698-91 (Standard Proctor test) within moisture contents corresponding from 0 to +5% of the optimum water content as determined by the referenced test.

B. Shall be placed at 6 to 9-inch lifts (or less)

C. Cohesive materials classified as CL accordance with ASTM D2487.

D. Silt (ML) or Sand (SP-SM) soils are not Suitable Soils.

E. Less than 35 percent larger than the No. 4 sieve.

F. Less than 50% larger than the No. 200 sieve.

G. Less than 5% organic content.

H. Free of any rocks with dimensions greater than 3 inches.

I. Soils not meeting these requirements are considered unsuitable soils, regardless of classification.

Soils classified in ASTM D2487 as coarse-grained soils (gravelly and sandy soils) or soils containing organics are not considered suitable for embankment borrow material.

Some drying of the excavated embankment and foundation soils may require scarifying or other processing methods to meet the moisture requirements and achieve necessary compaction.

During construction, embankment fill must be approved by an engineer and must be comprised of impervious cohesive soils (clays) encountered at the site.

Embankment Overbuild

To maintain adequate freeboard for the crest of the earthen embankment, the embankment should be overbuilt a total of 2 to 4 inches above the required profile grades to account for any long-term settlement of the foundation soils.

Limitations

This report presents the findings, conclusions, and recommendations for the seepage, slope stability, settlement, and geotechnical aspects of the proposed Site G retention site and related features. It has been prepared in accordance with generally accepted engineering practice and in a manner consistent with the level of care and skill for this type of project within this geographic area. No warranty, expressed or implied, is made.

The conclusions and recommendations presented herein are based on research and available literature, the results of field exploration and laboratory materials testing, and the results of engineering analyses. Limited laboratory testing was performed for the project. The borings represent the conditions at the explored locations but may not be representative of the conditions throughout the project.

Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our understanding of the proposed construction, partly on our general experience, and on the state-of-the-practice at the time of this writing.

Abbreviations

AASHTO LRFD. American Association of State Highway and Transportation Officials Load-and-Resistance Factor Design.

ASTM. American Society for Testing and Materials.

BH. Borehole.

MGS. Minnesota Geological Survey.

NAVFAC. Naval Facilities Engineering Command

SWCC. Soil-Water Characteristic Curve.

USACE. United States Army Corps of Engineers.

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Attachments

Attachment A – Borehole Logs and Laboratory Test Results

Attachment B – SEEP/W Seepage Analysis Results

Attachment C – SLOPE/W Slope Stability Analysis Results

Attachment D – Settlement Calculations

Attachment A

Borehole Logs and Laboratory Test Results

GEOTECHNICAL EXPLORATION
AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

NTI
NORTHERN TECHNOLOGIES, LLC

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December 10, 2018

Middle-Snake-Tamarac Rivers Watershed District (MSTRWD)
453 North McKinley St.
Warren, MN 56762

Attn: Mr. Joel Praska, Administrator

Subject: Geotechnical Exploration (factual)
Proposed Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota
NTI Project No. 18.FGO.06666

In accordance with your request and subsequent August 31, 2018 authorization, Northern Technologies, LLC (NTI) conducted a Geotechnical Exploration for the above referenced project. Our services included advancement of exploration borings and preparation of a factual engineering report with respect to our geotechnical services. Our work was performed in general accordance with our proposal of August 28, 2018.

Soil samples obtained at the site will be held for 60 days (from issue of report) at which time they will be discarded. Please advise us in writing if you wish to have us retain them for a longer period. You will be assessed an additional fee if soil samples are retained beyond 60 days.

We appreciate the opportunity to have been of service on this project. If there are any questions regarding the soils explored or our review and recommendations, please contact us at your convenience at (701) 232-1822.

Northern Technologies, LLC

Daniel Gibson

Dan Gibson, P.E.
Senior Engineer

Josh Holmes, P.E.
Senior Engineer

cc: HDR

GEOTECHNICAL EXPLORATION
AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

TABLE OF CONTENTS
GEOTECHNICAL EXPLORATION AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

Contents — Page

1.0 INTRODUCTION 1
1.1 Site / Project Description 1
1.2 Scope of Services 1
2.0 EXPLORATION PROGRAM RESULTS 1
2.1 Exploration Scope and Procedures 1
2.2 Surface Conditions 2
2.3 Subsurface Conditions 2
2.4 Groundwater Conditions 2
2.5 Laboratory Test Program 3
3.0 CLOSURE 4

APPENDICES

Appendix A - Geotechnical Evaluation of Recovered Soil Samples, Field Exploration Procedures, General Notes, Classification of Soils for Engineering Purposes

Appendix B - Laboratory Summary, Atterberg Limits Testing, Hydrometer Testing, Proctor Test, Unconfined Compression Tests, Consolidation Test, Hydraulic Conductivity Test, C-U Triaxial Test

Appendix C - Boring Logs, MDH Sealing Records, Site Diagram

GEOTECHNICAL EXPLORATION AND ENGINEERING REVIEW

Newfolden/Middle River Subwatershed Flood Damage Reduction Project
Rural Newfolden, Minnesota

NTI Project No. 18.FGO.06666

1.0 INTRODUCTION

1.1 Site / Project Description

The proposed Newfolden/Middle River Subwatershed Flood Damage Reduction Project is to be constructed in rural areas to the north and east of Newfolden, Minnesota as shown on the appended Borehole Location Plan provided by HDR. The project will consist of a diversion channel and embankments to reduce flood damage in the Newfolden area. The purpose of our investigation was to identify soils and perform laboratory testing as directed by HDR.

1.2 Scope of Services

The purpose of this report is to present a summary of our geotechnical exploration and laboratory testing for founding of the project. Our "scope of services" was limited to the following:

1. Explore the project subsurface by means of fifteen (15) standard penetration borings extending to depths of 16 to 46 feet, and conduct laboratory tests (as directed by HDR) on representative samples to characterize the engineering and index properties of the soils.
2. Prepare a factual report presenting our findings from our field exploration and laboratory testing based on the Scope of Work provided by HDR.

2.0 EXPLORATION PROGRAM RESULTS

2.1 Exploration Scope and Procedures

Site geotechnical drilling occurred on October 16, 17, & 18, 2018 with individual borings advanced at approximate locations as presented on the diagrams and corresponding coordinates within the appendices. Coordinates on the boring logs may differ slightly than the original plan to allow for access or avoidance of utilities. HDR staked the boring locations and provided elevations. NTI performed the borings in relatively close proximity to the staked locations.

NTI and its sub consultant (Soil Engineering Testing) performed the field exploration and laboratory under guidance from ASTM Standards and common practice within the geotechnical engineering field. We provide additional information on field and laboratory procedures within the report appendices.

2.2 Surface Conditions

The property for the proposed Newfolden/Middle River Subwatershed Flood Damage Reduction Project is currently farm fields, grasslands, wooded areas, and roadway ditches. Surfaces consist of grass cover and fallow farm land at the boring locations.

2.3 Subsurface Conditions

Please refer to the boring logs within the appendices for a detailed description and depths of stratum at each boring. The boreholes were abandoned using high solids bentonite grout per Minnesota Department of Health statutes. Minor settlement of upper infill soil and grout will occur with Owner responsible for final closure of the boreholes. The general geologic origin of retained soil samples is listed on the boring logs. The upper portion of the soil profile for each boring was sampled using auger flights and is approximate.

The overall subsurface soil profile at the borings consists of approximately 0.2 to 4.5 feet of topsoil and topsoil/fill underlain by relatively thin layers of loose to medium dense Glacial Lake Sediment (GLS) soils followed by medium to stiff Lake Modified Glacial Till (LMGT) which extends to the termination depth of the borings (maximum 46 feet). The GLS soils are comprised of sand and silty sand. LMGT soils are comprised of lean clay, silty clay, silt, occasional layers of sand. The soils have varying color, moisture content and unit weight. The LMGT clay soils have trace amounts of sand and gravel. Additional comment on the evaluation of recovered soil samples is presented within the report appendices and boring logs.

2.4 Groundwater Conditions

The drill crew observed the borings for groundwater and noted cave-in depth of borings, if any, during and at the completion of drilling activities. These observations and measurements are noted on the boring logs.

Measurable groundwater was encountered from depths of 1 to 15 feet below grade at select boring locations during and / or at the completion of drilling operations. Boring logs noted if samples were saturated during classification of the samples. The groundwater was contained within silt and sand soils that were generally confined by clay soils above and/or below the sand and silt layers. Additionally, occasional silt and sand seems are likely present and may be water bearing during spring thaw or times of heavy precipitation at all boring locations. The moisture content of lens soils and host clays can vary annually and per recent precipitation. Such soils and other regional dependent conditions may produce groundwater entry of project excavations.

2.5 Laboratory Test Program

2.5.1 SPT and Hand Penetrometer – Boring logs include SPT "N"-values and hand penetrometer readings obtained on cohesive soils during laboratory classification of retained soils.

2.5.2 Moisture and Density – We performed moisture and density testing on the samples requested by HDR as well as a number of other samples. Moisture and dry density of the soils ranged from 9 to 24 percent (excluding topsoil) and 108 to 134 lbs/ft^3, respectively. Results of all tests are included within the boring logs and testing summary.

2.5.3 Atterberg Limits (LL/PL) – We performed a total of fifteen (15) Atterberg limit tests on samples selected by HDR. The liquid limits (LL) ranged from 13 to 33 and the plastic limits (PL) ranged from 9 to 19. Results of all tests are included within the boring logs, testing summary, and Appendix B.

2.5.4 Hydrometer / Grain Size Analysis – Four (4) hydrometer / Grain Size Analysis tests were performed on samples chosen by HDR. The results are included in Appendix B of this report.

2.5.5 Standard Proctor Test – A single Standard Proctor test was conducted on a composite sample from augur cuttings of soils encountered from 1 to 10 feet below grade at soil boring SB-13. The test report is included within Appendix B.

2.5.5 Unconfined Compression Tests and CU Test (3 pressures) – We performed two unconfined compression tests and one UU Triaxial Test on samples chosen by HDR. Results are included in the testing summary and/or on individual reports within the appendices of this report. Additional information and data on the compressive strength of soils is included within the pocket pen. column on the boring logs.

2.5.6 Consolidation Test – We performed a single consolidation test on a thin wall tube sample obtained at a depth of 15 feet at soil boring SB-13. The result of the test is in Appendix B.

2.5.7 Hydraulic Conductivity Test – A single hydraulic conductivity or permeability test was performed on a thin wall tube sample obtained at a depth of 15 feet at soil boring SB-9. The result of the test is in Appendix B.

3.0 CLOSURE

The area coverage of borings in relation to the entire project is very small. For this and other reasons, we do not warrant conditions below the depth of our borings, or that the strata logged from our borings are necessarily typical of the site.

This factual report has been prepared for the exclusive use of Middle-Snake-Tamarac Rivers Watershed District (MSTRWD) and HDR for specific application to the proposed Flood Damage Reduction Project in rural Newfolden, Minnesota. Northern Technologies, LLC has endeavored to comply with generally accepted geotechnical engineering practice common to the local area. Northern Technologies, LLC makes no other warranty, expressed or implied.

Northern Technologies, LLC

Daniel Gibson

Dan Gibson, P.E.
Senior Engineer

Josh Holmes, P.E.
Senior Engineer

DG:jh

Attachments

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APPENDIX A

GEOTECHNICAL EVALUATION OF RECOVERED SOIL SAMPLES

We visually examined recovered soil samples to estimate distribution of grain sizes, plasticity, consistency, moisture condition, color, presence of lenses and seams, and apparent geologic origin. We then classified the soils according to the Unified Soil Classification System (ASTM D2488). A chart describing this classification system and general notes explaining soil sampling procedures are presented within the appendices.

The stratification depth lines between soil types on the logs are estimated based on the available data. Insitu, the transition between type(s) may be distinct or gradual in either the horizontal or vertical directions. The soil conditions have been established at our specific boring locations only. Variations in the soil stratigraphy may occur between and around the borings, with the nature and extent of such change not readily evident until exposed by excavation. These variations must be properly assessed when utilizing information presented on the boring logs. We request that you, your design team or contractors contact NTI immediately if local conditions differ from those assumed by this report, as we would need to review how such changes impact our recommendations. Such contact would also allow us to revise our recommendations as necessary to account for the changed site conditions.

FIELD EXPLORATION PROCEDURES

Soil Sampling – Standard Penetration Boring:

Soil sampling was performed according to the procedures described by ASTM D-1586. Using this procedure, a 2 inch O.D. split barrel sampler is driven into the soil by a 140 pound weight falling 30 inches. After an initial set of six inches, the number of blows required to drive the sampler an additional 12 inches is recorded (known as the penetration resistance (i.e. "N-value") of the soil at the point of sampling. The N-value is an index of the relative density of cohesionless soils and an approximation of the consistency of cohesive soils.

Soil Sampling – Power Auger Boring:

The boring(s) was/were advanced with a 6 inch nominal diameter continuous hollow stem flight auger. As a result, samples recovered from the boring are disturbed, and our determination of the depth, extent of various stratum and layers, and relative density or consistency of the soils is approximate.

Soil Classification:

Soil samples were visually and manually classified in general conformance with ASTM D-2488 as they were removed from the sampler(s). Representative fractions of soil samples were then sealed within respective containers and returned to the laboratory for further examination and verification of the field classification. In addition, select samples were submitted for laboratory tests. Individual sample information, identification of sampling methods, method of advancement of the samples and other pertinent information concerning the soil samples are presented on boring logs and related report attachments.

General Notes

DRILLING & SAMPLING SYMBOLS		LABORATORY TEST SYMBOLS	
SYMBOL	**DEFINITION**	**SYMBOL**	**DEFINITION**
C.S.	Continuous Sampling	W	Moisture content-percent of dry weight
P.D.	2-3/8" Pipe Drill	D	Dry Density-pounds per cubic foot
C.O.	Cleanout Tube	LL, PL	Liquid and plastic limits determined in accordance with ASTM D 423 and D 424
3 HSA	3 ¼" I.D. Hollow Stem Auger	Q_u	Unconfined compressive strength-pounds per square foot in accordance with ASTM D 2166-66
4 FA	4" Diameter Flight Auger		
6 FA	6" Diameter Flight Auger		
2 ½ C	2 ½" Casing		
4 C	4" Casing	**Additional insertions in Qu Column**	
D.M.	Drilling Mud	Pq	Penetrometer reading-tons/square foot
J.W.	Jet Water	S	Torvane reading-tons/square foot
H.A.	Hand Auger	G	Specific Gravity – ASTM D 854-58
NXC	Size NX Casing	SL	Shrinkage limit – ASTM 427-61
BXC	Size BX Casing	pH	Hydrogen ion content-meter method
AXC	Size AX casing	O	Organic content-combustion method
SS	2" O.D. Split Spoon Sample	M.A.*	Grain size analysis
2T	2" Thin Wall Tube Sample	C*	One dimensional consolidation
3T	3" Thin Wall Tube Sample	Q_c*	Triaxial Compression
			* See attached data Sheet and/or graph

Water Level Symbol

Water levels shown on the boring logs are the levels measured in the borings at the time and under the conditions indicated. In sand, the indicated levels can be considered reliable groundwater levels. In clay soils, it is not possible to determine the groundwater level within the normal scope of a test boring investigation, except where lenses or layers of more pervious water bearing soil is present and then a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level symbol for cohesive or mixed soils may not indicate the true level of the groundwater table. The available water level information is given at the bottom of the log sheet.

Descriptive Terminology

DENSITY		CONSISTENCY	
TERM	**"N" VALUE**	**TERM**	**"N" VALUE**
Very Loose	0-4	Soft	0-4
Loose	5-8	Medium	5-8
Medium Dense	9 – 15	Rather Stiff	9 – 15
Dense	16 – 30	Stiff	16 – 30
Very Dense	Over 30	Very Stiff	Over 30

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch OD split spoon.

Relative Proportions

TERMS	RANGE
Trace	0-5%
A little	5-15%
Some	15-30%
With	30-50%

Particle Sizes

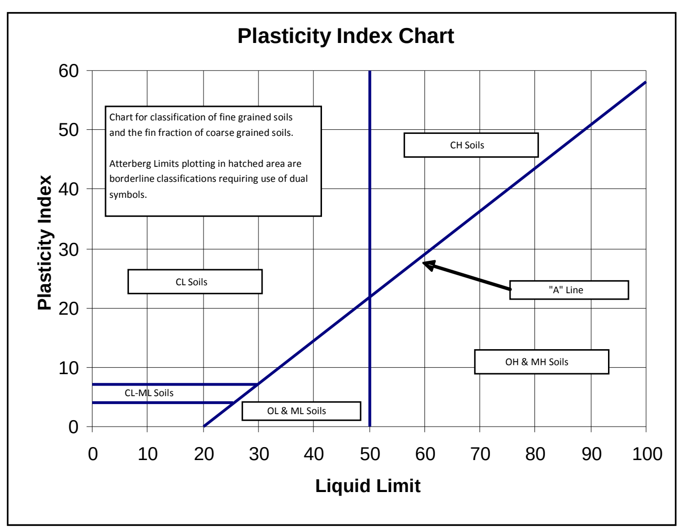
Boulders		Over 3"
Gravel -	Coarse	¾" – 3"
	Medium	#4 – ¾"
Sand -	Coarse	#4 - #10
	Medium	#10 - #40
	Fine	#40 - #200
Silt and Clay		Determined by plasticity characteristics.

Note: Sieve sizes are U.S. Standard.

Classification of Soils for Engineering Purposes

ASTM Designation D-2487 and D 2488 (Unified Soil Classification System)

Major Divisions			Group Symbol	Typical Names	Classification Criteria		
Course Grained Soils More than 50% retained on No. 200 sieve *	***Gravels*** 50% or more of coarse fraction retained on No. 4 sieve.	Clean Gravels	**GW**	Well –graded gravels and gravel-sand mixtures, little or no fines.	***Classification on basis of percentage of fines.*** Less than 5% passing No. 200 Sieve: GW, GP, SW, SP More than 12% passing No. 200 Sieve: GM, GC, SM, SC From 5% to 12% passing No. 200 Sieve: Borderline Classification requiring use of duel symbols.	$C_u = D_{60} / D_{10}$ $C_z = (D_{30})^2 / (D_{10} \times D_{60})$	greater than 4. between 1 & 3.
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines.		Not meeting both criteria for GW materials.	
		Gravels with Fines	**GM**	Silty gravels, gravel-sand-silt mixtures.		Atterberg limits below "A" line, or P.I. less than 4.	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures.		Atterberg limits above "A" line with P.I. greater than 7.	
	Sands More than 50% of coarse fraction passes No 4 sieve.	Clean Sands	**SW**	Well-graded sands and gravelly sands, little or no fines.		$C_u = D_{60} / D_{10}$ greater than 6. $C_z = (D_{30})^2 / (D_{10} \times D_{60})$ between 1 & 3.	
			SP	Poorly-graded sands and gravelly sands, little or no fines.		Not meeting both criteria for SW materials.	
		Sands with Fines	**SM**	Silty sands, sand-silt mixtures.		Atterberg limits below "A" line, or P.I. less than 4.	Atterberg limits plotting in hatched area are *borderline* classifications requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.		Atterberg limits above "A" line with P.I. greater than 7.	
Fine Grained Soils More than 50% passes No. 200 sieve *	***Silts and Clays*** Liquid Limit of 50% or less		**ML**	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands.			
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.			
			OL	Organic silts and organic silty clays of low plasticity.			
	Silts and Clays Liquid Limit greater than 50%.		**MH**	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.			
			CH	Inorganic clays of high plasticity, fat clays.			
			OH	Organic clays of medium to high plasticity.			
	Highly Organic Soils		**Pt**	Peat, muck and other highly organic soils.			



APPENDIX B

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SUMMARY OF LABORATORY RESULTS

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Borehole	Sample #	Depth (ft)	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Maximum Size (mm)	% < #200 Sieve	Unconfined Compression Peak (psf)	Unconfined Compression %	Void Ratio	Other Tests
SB-01	2	2.0	12.0	121.3	33	12						
SB-01	3	4.5	13.1	117.1								
SB-01	4	7.0	12.9	121.1								
SB-01	5	9.5	13.1	124.0								
SB-01	6	12.0	13.7	122.7								
SB-01	8	17.0	13.0	126.4								
SB-01	9	19.5	20.5	114.9								
SB-01	10	24.5	12.7	126.3								
SB-01	11	29.5	14.9	122.5								
SB-02	1	0.0	19.4									
SB-02	2	2.0	16.0	112.4								
SB-02	3	4.5	13.4	122.7								
SB-02	4	7.0	14.1	124.6								
SB-02	5	9.5	15.7	115.7								
SB-02	6	12.0	15.1	121.6	30	12						
SB-02	8	17.0	13.5	125.4								
SB-02	9	19.5	11.8	127.6								
SB-02	10	24.5	13.3	123.3								
SB-02	11	29.5	12.9	127.5								
SB-03	1	0.0	16.7									
SB-03	3	4.5	23.8	107.7								
SB-03	4	7.0	10.0		15	9						
SB-03	5	9.5	13.2	128.0								
SB-03	6	12.0	14.2	130.4								
SB-03	8	17.0	13.3	123.4								
SB-03	9	19.5	12.7	126.7								
SB-03	10	24.5	13.2	125.9								
SB-03	11	29.5	14.4	121.7								
SB-04	1	0.0	20.3									
SB-04	5	9.5	13.3	129.7								
SB-04	6	12.0	13.4	131.7								
SB-04	7	14.5	13.0	129.5								
SB-05	1	0.0	18.8									
SB-05	2	2.0	17.5									
SB-05	3	4.5	21.4	120.1								
SB-05	4	7.0	8.9	133.9								
SB-05	5	9.5	12.2									
SB-05	6	12.0	14.7	119.2								

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SUMMARY OF LABORATORY RESULTS

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Borehole	Sample #	Depth (ft)	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Maximum Size (mm)	% < #200 Sieve	Unconfined Compression		Void Ratio	Other Tests
									Peak (psf)	%		
SB-05	7	14.5	12.5	124.0								
SB-06	3	4.5	22.7				4.75	12				
SB-07	3	4.5	12.9				9.5	63				
SB-08	2	2.0	17.9	109.4	20	11						
SB-08	3	4.5	14.4	121.5								
SB-08	4	7.0	11.7	125.6								
SB-08	5	9.5	13.2	118.2								
SB-08	6	12.0	12.1	130.7								
SB-08	7	14.5	13.2	128.5								
SB-08	8	17.0	14.2	123.9								
SB-08	9	19.5	13.6	125.8								
SB-08	10	24.5	14.9	120.4								
SB-08	11	29.5	17.1	115.5								
SB-09	1	0.0	29.9									
SB-09	2	2.0	12.8				9.5	23				
SB-09	3	4.5	15.7	123.2	25	11			3570	12.6		
SB-09	4	7.0	14.0	126.3								
SB-09	5	9.5	14.2	122.5								
SB-09	6	12.0	13.8	121.3								
SB-09	8	17.0	16.6									
SB-09	9	19.5	13.3	125.3	25	12						
SB-09	10	24.5	14.0	123.3								
SB-09	11	29.5	8.8	130.2								
SB-09	12	34.5	6.4	127.2								
SB-09	13	39.5	6.0		13	10						
SB-09	14	44.5	9.4									
SB-10	2	2.0	24.0				2	19				
SB-11	5	9.5	12.9	126.0	22	11						
SB-12	4	7.0	11.0		23	11						
SB-12	11	29.5	17.3	117.3	22	11						
SB-13	1	0.0	20.4									
SB-13	2	2.0	10.2	116.7								
SB-13	Bag	3.0	11.9	121.6								
SB-13	3	4.5	12.6	125.4								
SB-13	4	7.0	13.4	122.0	25	11						
SB-13	5	9.5	14.0	126.8	24	12			4730	15.0		
SB-13	6	12.0	12.8	122.2								
SB-13	7	14.5	14.7	114.7							0.470	

SUMMARY OF LABORATORY RESULTS

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Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Borehole	Sample #	Depth (ft)	Water Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Maximum Size (mm)	% < #200 Sieve	Unconfined Compression Peak (psf)	Unconfined Compression %	Void Ratio	Other Tests
SB-13	8	17.0	16.6	114.2								
SB-13	9	19.5	12.4	123.5								
SB-13	10	24.5	13.7	120.9								
SB-13	11	29.5	20.6	106.8								
SB-13	12	34.5	13.9	118.3	27	12						
SB-13	13	39.5	8.2	128.8								
SB-13	14	44.5	8.2	128.6								
SB-14	10	24.5	15.7	119.5	31	12						
SB-15	6	12.0	13.2	123.6	26	19						

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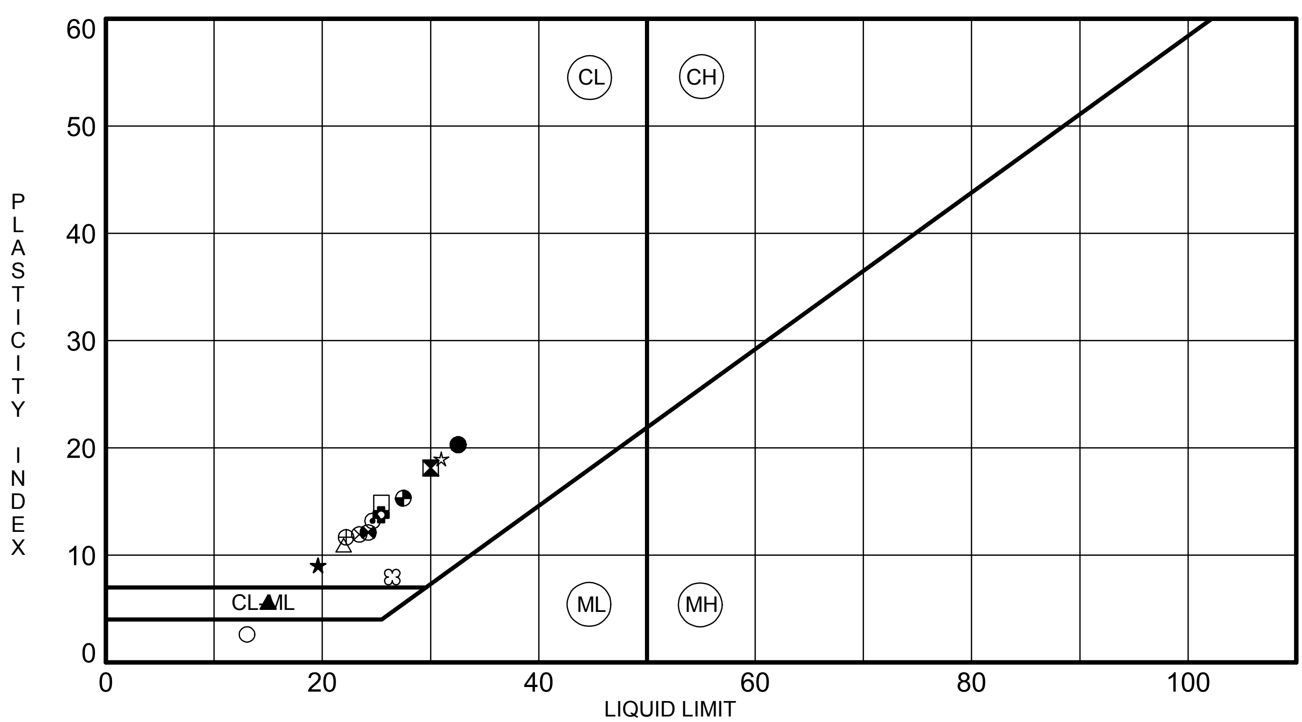
ATTERBERG LIMITS' RESULTS

ASTM D4318

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Data

	BOREHOLE	SAMPLE #	DEPTH	LL	PL	PI	Fines	Classification
	SB-01	2	2.0	33	12	21		LEAN CLAY (CL)
	SB-02	6	12.0	30	12	18		LEAN CLAY (CL)
	SB-03	4	7.0	15	9	6		SILTY LEAN CLAY (CL-ML)
	SB-08	2	2.0	20	11	9		LEAN CLAY (CL)
	SB-09	3	4.5	25	11	14		LEAN CLAY (CL)
	SB-09	9	19.5	25	12	13		LEAN CLAY (CL)
	SB-09	13	39.5	13	10	3		SILT (ML)
	SB-11	5	9.5	22	11	11		LEAN CLAY (CL)
	SB-12	4	7.0	23	11	12		LEAN CLAY (CL)
	SB-12	11	29.5	22	11	11		LEAN CLAY (CL)



Cc:

Submitted by,
Northern Technologies, LLC

Dan Gibson
(12/7/18)

NTI NORTHERN TECHNOLOGIES, LLC

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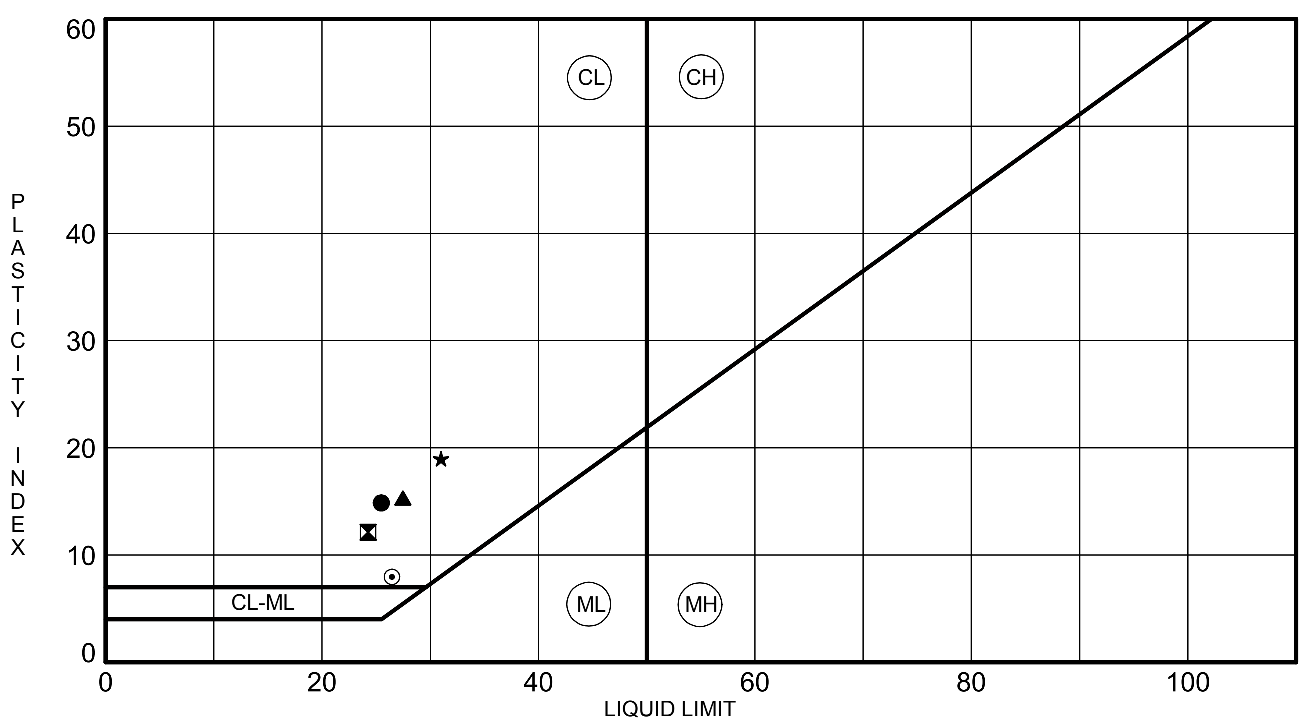
ATTERBERG LIMITS' RESULTS

ASTM D4318

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Data

	BOREHOLE	SAMPLE #	DEPTH	LL	PL	PI	Fines	Classification
●	SB-13	4	7.0	25	11	14		LEAN CLAY (CL)
⊠	SB-13	5	9.5	24	12	12		LEAN CLAY (CL)
▲	SB-13	12	34.5	27	12	15		LEAN CLAY (CL)
★	SB-14	10	24.5	31	12	19		LEAN CLAY (CL)
⊙	SB-15	6	12.0	26	19	7		LEAN CLAY (CL)



Cc:

Submitted by,

Northern Technologies, LLC

Dan Gibson
(12/7/18)

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GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

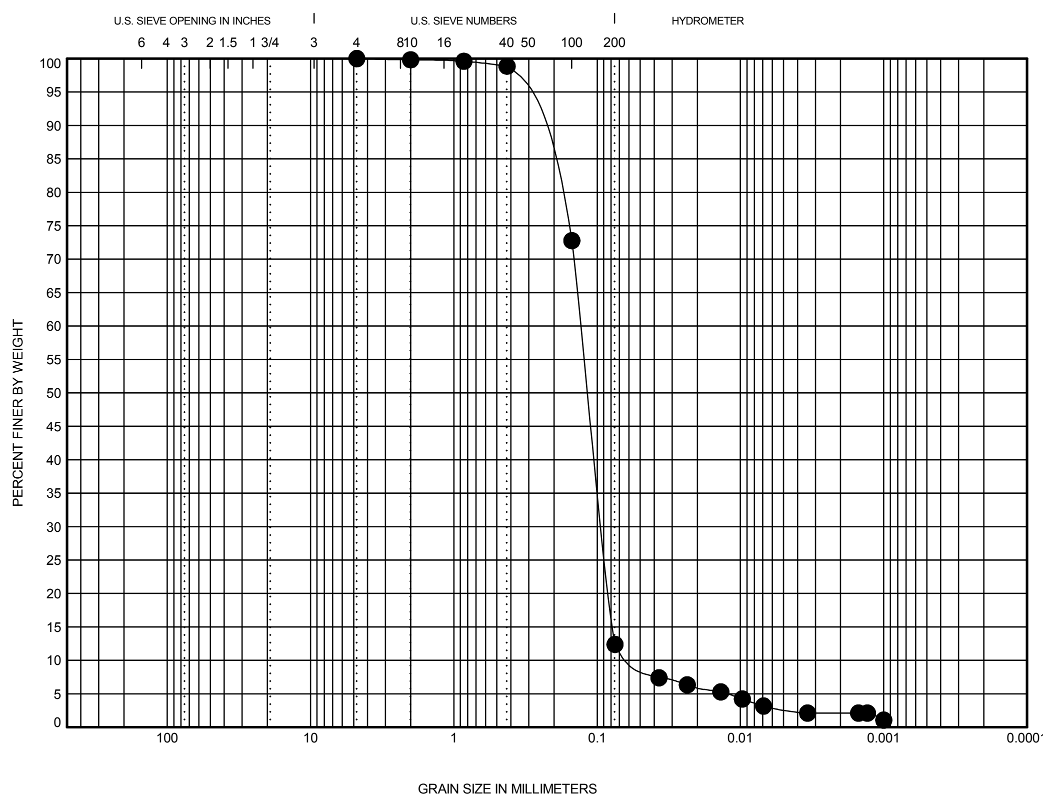
Sample Information

Boring Number:	SB-06	Date Sampled:	10/17/2018
Sample Number:	3	Sampled By:	NTI
Sample Depth (ft):	4.5	Sample Type:	SS
Classification:	SILTY SAND, fine grained		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
1.21	2.42	4.75	0.13	0.092	0.054	0.0	87.6	9.7	2.7

Sieve Name	Percent Finer	Project Specs
#4	100.0	
#10	99.8	
#20	99.6	
#40	98.9	
#100	72.8	
#200	12.4	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	12.3
0.02 mm	6.0
0.005 mm	2.7
0.002 mm	2.1
0.001 mm	1.1

Notes:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

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GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

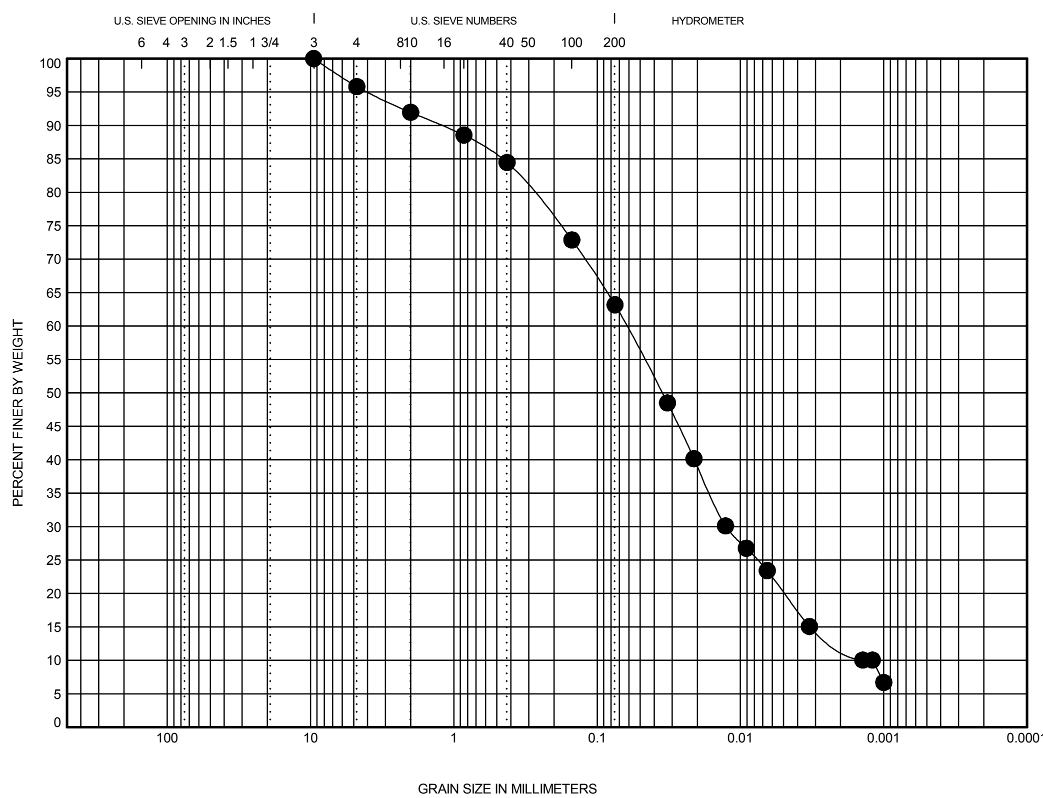
Sample Information

Boring Number:	SB-07	Date Sampled:	10/17/2018
Sample Number:	3	Sampled By:	NTI
Sample Depth (ft):	4.5	Sample Type:	SS
Classification:	SILT, with sand, trace of gravel		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
2.11	52.19	9.5	0.063	0.013	0.001	4.2	32.6	43.0	20.2

Sieve Name	Percent Finer	Project Specs
3/8"	100.0	
#4	95.8	
#10	92.0	
#20	88.6	
#40	84.5	
#100	72.9	
#200	63.2	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	62.9
0.02 mm	39.1
0.005 mm	20.2
0.002 mm	12.1
0.001 mm	6.7

Notes:

Cc:

Submitted by,

Northern Technologies, LLC

Chris Nelson
(12/7/18)

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GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

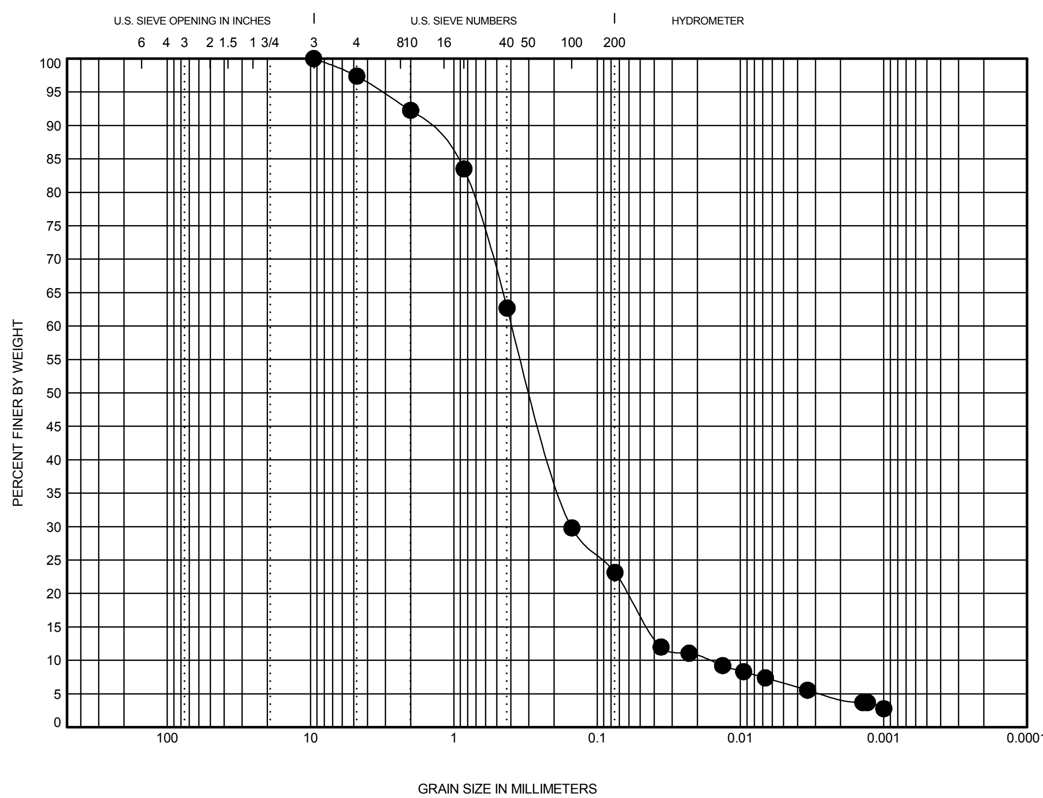
Sample Information

Boring Number:	SB-09	Date Sampled:	10/17/2018
Sample Number:	2	Sampled By:	NTI
Sample Depth (ft):	2	Sample Type:	SS
Classification:	SILTY SAND, fine to coarse grained, trace of gravel		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
3.49	23.36	9.5	0.39	0.151	0.017	2.6	74.2	16.6	6.6

Sieve Name	Percent Finer	Project Specs
3/8"	100.0	
#4	97.4	
#10	92.3	
#20	83.5	
#40	62.7	
#100	29.8	
#200	23.1	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	22.9
0.02 mm	10.6
0.005 mm	6.6
0.002 mm	4.4
0.001 mm	2.8

Notes:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

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GRAIN SIZE DISTRIBUTION

ASTM C136 & D422

Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

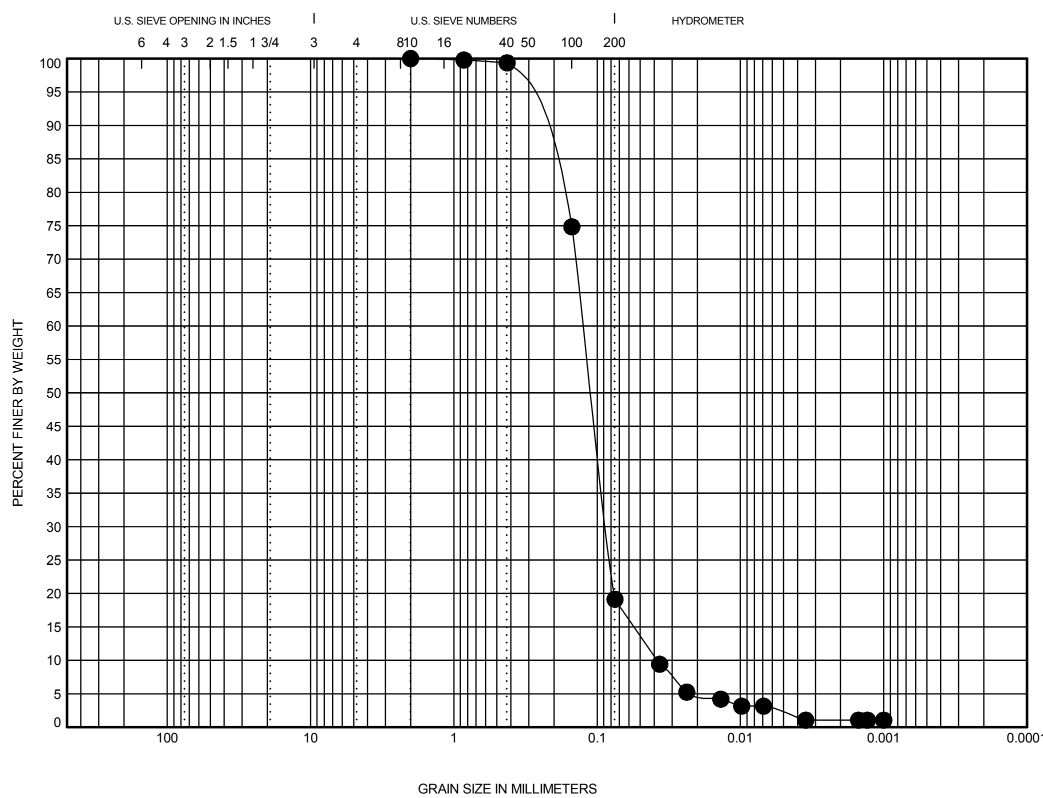
Sample Information

Boring Number:	SB-10	Date Sampled:	10/17/2018
Sample Number:	2	Sampled By:	NTI
Sample Depth (ft):	2	Sample Type:	SS
Classification:	SILTY SAND, fine to medium grained		

Sample Data

Cc	Cu	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
1.55	3.26	2	0.125	0.086	0.038	0.0	80.9	17.0	2.1

Sieve Name	Percent Finer	Project Specs
#10	100.0	
#20	99.8	
#40	99.4	
#100	74.8	
#200	19.1	



Hydrometer

Particle Size (mm)	Percent Finer
0.074 mm	18.9
0.02 mm	4.9
0.005 mm	2.1
0.002 mm	1.0
0.001 mm	1.0

Notes:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

LABORATORY COMPACTION CHARACTERISTICS OF SOIL

NTI NORTHERN TECHNOLOGIES, LLC

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Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

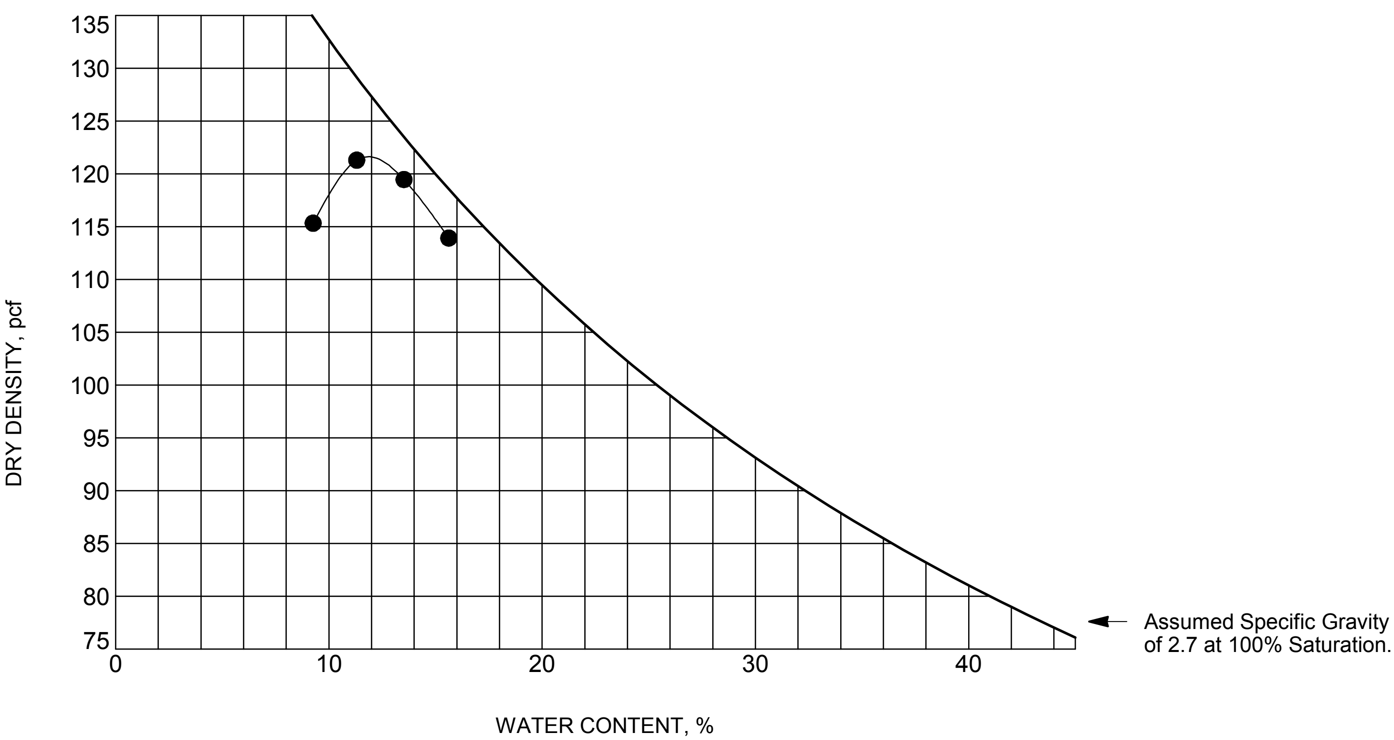
Sample Location:	SB-13	Date Sampled:	10/17/2018
Sample Number:	NA	Sample Type:	Bag Samples
Soil Description:	Lean Clay, trace of gravel, light brown		

Laboratory Information

Test Method:	ASTM D698 Method A	Rammer Type:	Manual
Preparation Method:	Dry		

Sample Data

Maximum Dry Density:	121.6 pcf	Liquid Limit:	
Optimum Water Content:	11.9 %	Plastic Limit:	



Comments:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/10/18)

UNCONFINED COMPRESSION TEST
ASTM D2166

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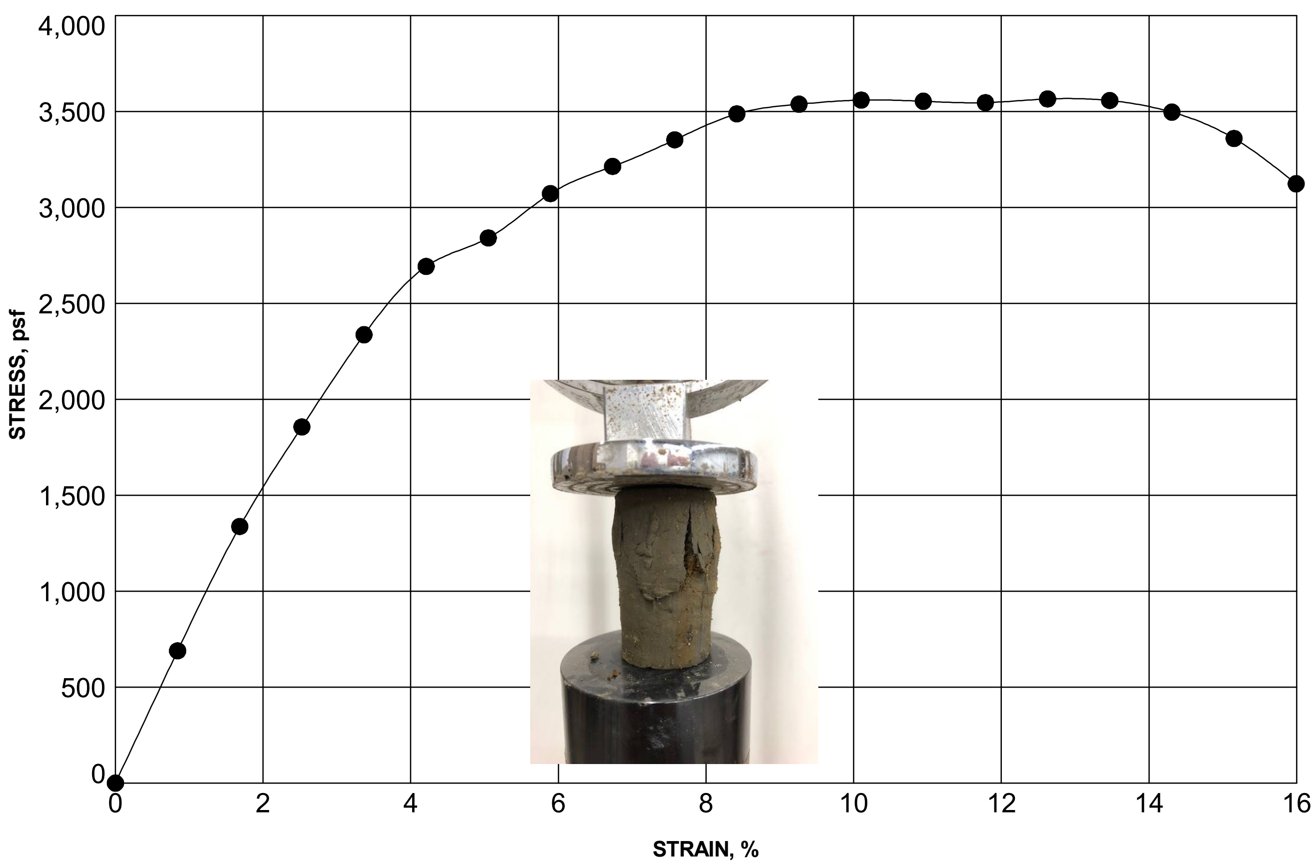
Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

Borehole:	SB-09	Sample Number:	3	Depth (ft):	4.5
Classification:	LEAN CLAY (CL)				

Sample Data

Dry Density:	123	Liquid Limit:	25	Peak (psf):	3570 @ 12.6%
Moisture Content (%):	16	Plastic Limit:	11		



Comments:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

UNCONFINED - BASIC - NTI 2015-01-15.GDT - 12/7/18 11:28 - C:\USERS\CHRISN\DESKTOP\DESKTOP PROJECTS\NEWFOLDEN MIDDLE RIVER FLOOD REDUCTION\NEWFOLDEN MIDDLE RIVER FLOOD REDUCTION.GPJ

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UNCONFINED COMPRESSION TEST

ASTM D2166

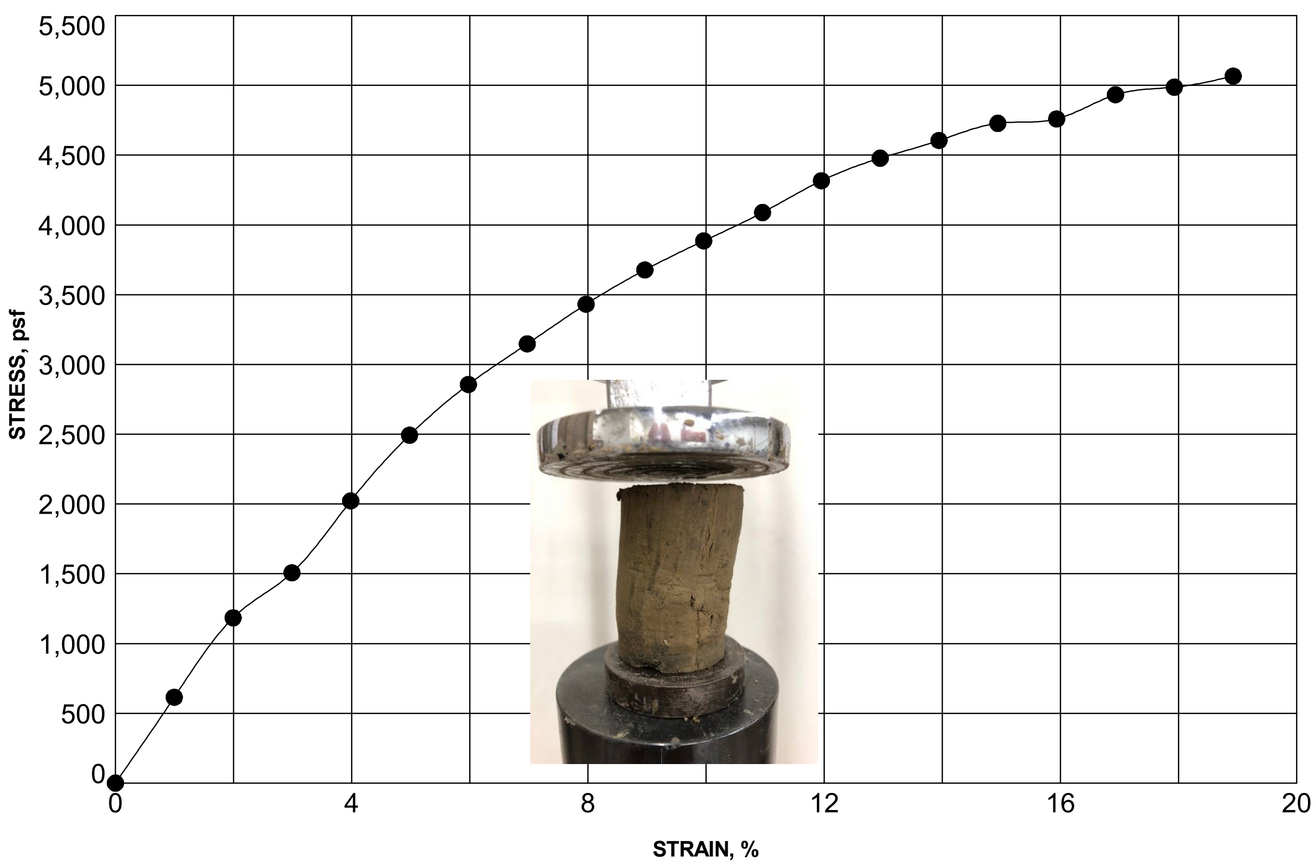
Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

Borehole:	SB-13	Sample Number:	5	Depth (ft):	9.5
Classification:	LEAN CLAY (CL)				

Sample Data

Dry Density:	127	Liquid Limit:	24	Peak (psf):	4730 @ 15.0%
Moisture Content (%):	14	Plastic Limit:	12		



Comments:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/7/18)

CONSOLIDATION TEST

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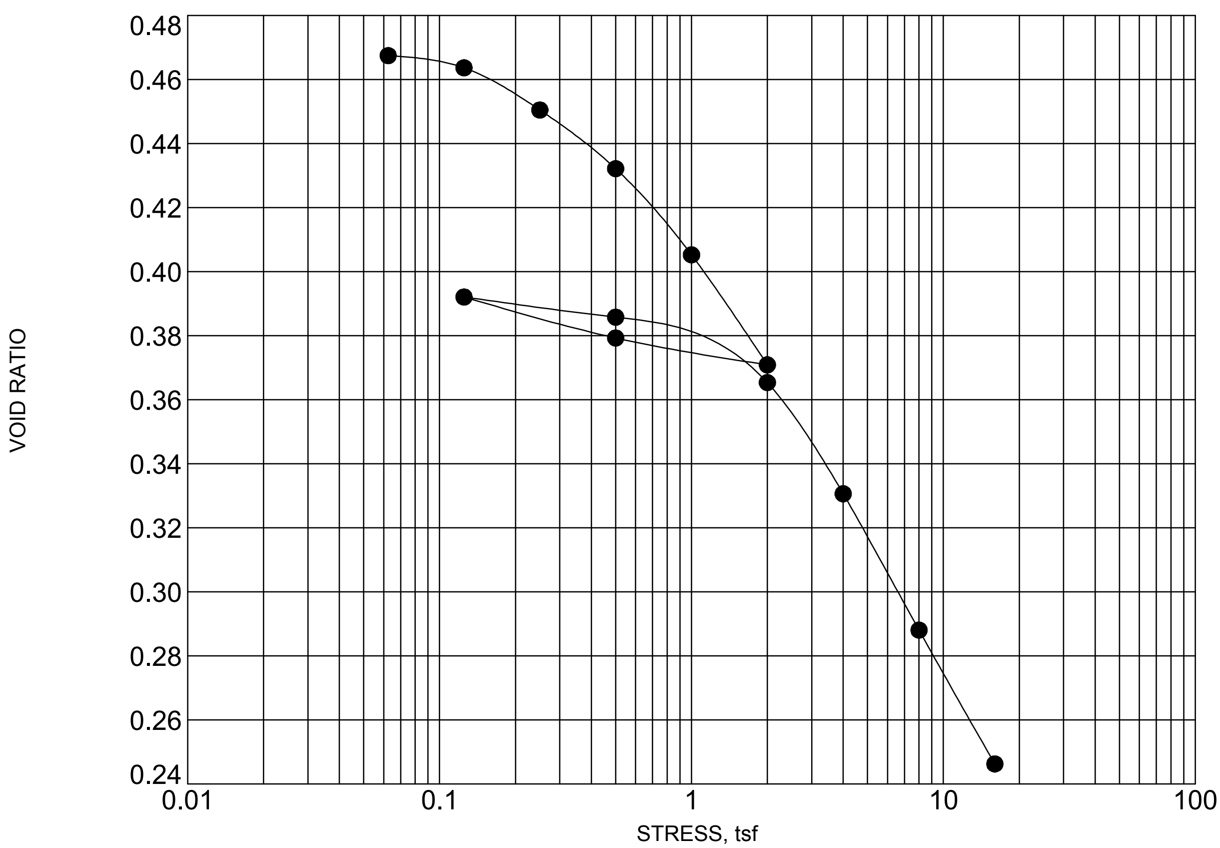
Report To:	MSTRWD 453 North McKinley St. Warren, MN 56762	Project:	Newfolden / MR Subwatershed Flood Damage Reduction
		Project Number:	18.FGO06666.000
Attention:	Joel Praska	Location:	Newfolden, Minnesota

Sample Information

Borehole:	SB-13	Sample Number:	7	Depth (ft):	14.5
Soil Classification:	SANDY LEAN CLAY (CLS)				

Sample Data

Deg of Sat (%)	MC (%)	γ_d	LL	PI	Sp Gravity	Overburden (tsf)	Pc (tsf)	Cc	Cr	Initial Void Ratio
	15	115			2.70					0.470



Comments:

Cc:

Submitted by,
Northern Technologies, LLC

Chris Nelson
(12/10/18)

Hydraulic Conductivity Test Data ASTM D5084

Project: Newfolden — Date: 11/26/2018

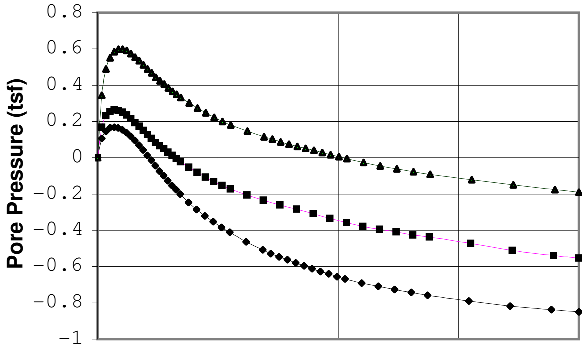
Client: Northern Technologies, LLC — Job No.: 11715

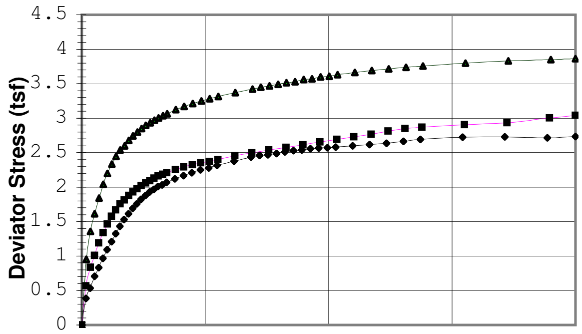
Boring No.:	9						
Sample No.:	7						
Depth (ft):	15						
Location:							
Sample Type:	TWT						
Soil Type:	Clayey Sand w/gravel (SC)						
Atterberg Limits							
LL							
PL							
PI							
Permeability Test	Intact						
Before Test Conditions: Saturation %:							
Porosity:							
Ht. (in):	2.81						
Dia. (in):	2.87						
Dry Density (pcf):	136.4						
Water Content:	8.1%						
Test Type:	Falling						
Max Head (ft):	5.0						
Confining press. (Effective-psi):	2.0						
Trial No.:	8-12						
Water Temp °C:	22.0						
% Compaction							
% Saturation (After Test)	100.7%						
Coefficient of Permeability							
K @ 20 °C (cm/sec)	**1.6×10^{-8}**						
K @ 20 °C (ft/min)	**3.3×10^{-8}**						
Notes:							

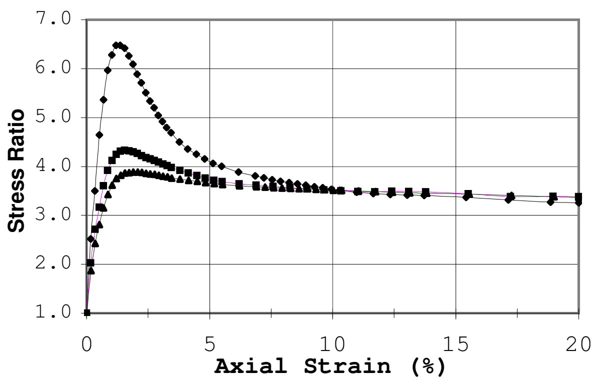
TRIAXIAL TEST ASTM: D 4767

Job No. **11715**
Date: **11/28/18**

Project: **Newfolden / Northern Technologies, LLC**
Boring #: **7** Sample #: **7** Type: **3T** Depth (ft): **14.5-16**
Soil Type: **Sandy Lean Clay w/a little gravel (CL)**







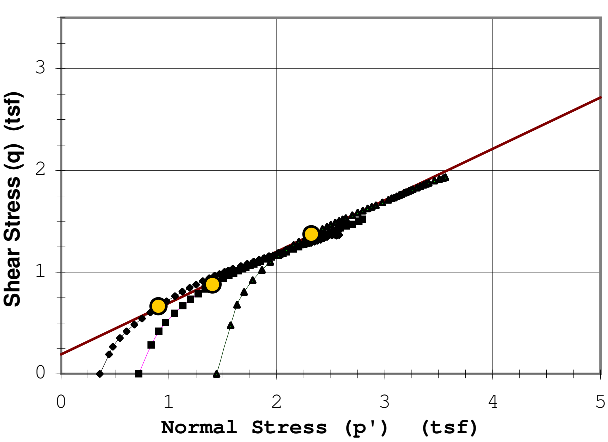
Failure Criterion:	Max. Stress Ratio
Angle of internal friction, ϕ' =	30.3 °
Apparent Cohesion, c' =	0.22 (tsf)

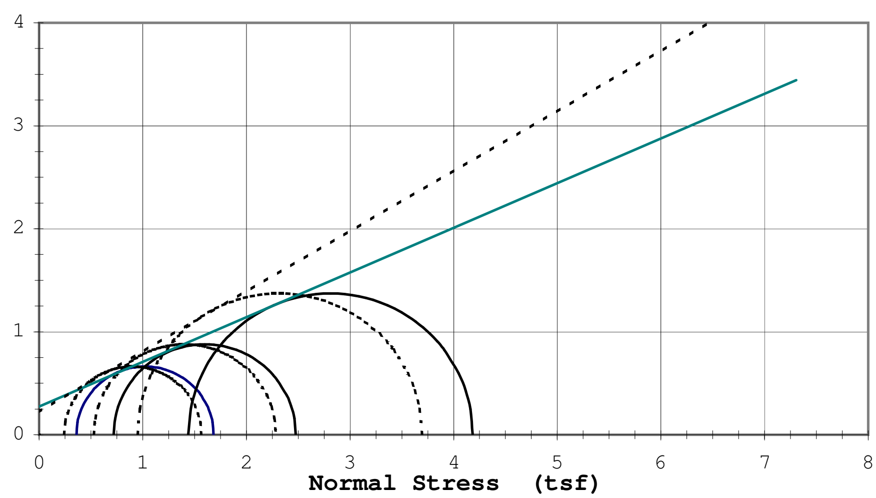
Test Date:	11/16/18	Liquid Limit:	
Test Type:	CU w/pp	Plastic Limit:	
Strain Rate (in/min):	0.00073	Plasticity Index:	
Strain Rate (%/min):	0.025	Spec. Gravity (Assumed):	2.69

Before Consolidation	A	B	C	D	E
Diameter (in)	1.44	1.44	1.44		
Height (in)	2.92	2.92	2.92		
Water Content (%)	17.5	16.7	16.5		
Dry Density (pcf)	112.6	113.2	113.6		
Void Ratio	0.49	0.48	0.48		
After Consolidation					
Diameter (in)	1.44	1.43	1.43		
Height (in)	2.92	2.90	2.90		
Water Content (%)	18.0	17.0	16.2		
Dry Density (pcf)	113.1	115.3	117.0		
Void Ratio	0.48	0.46	0.43		
Back Pressure (tsf)	4.4	8.5	6.6		
Minor Principal Stress (tsf)	0.36	0.72	1.44		
Max. Deviator Stress (tsf)	2.73	3.04	3.87		
Ultimate Deviator Stress (tsf)	2.73	3.04	3.87		
Deviator Stress at Failure (tsf)	1.32	1.76	2.74		
Max. Pore Pressure Buildup (tsf)	0.17	0.26	0.60		
Pore Pressure Parameter "B"	0.95	0.95	0.95		
Pct. Axial Strain at Failure	1.4	1.6	2.1		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





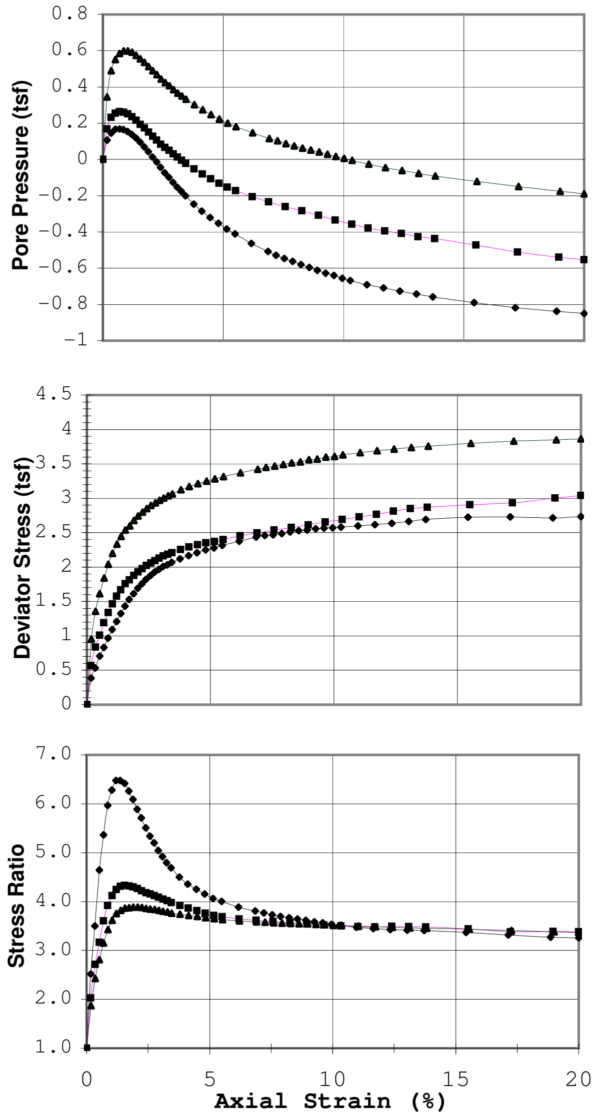
Rupture Envelope at Failure	
α = 26.8 °	a = 0.2 (tsf)

------------	Effective ϕ': 30.3 °	c'=	0.22 (tsf)
________	Total ϕ: 23.5 °	c=	0.27 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. **11715**
Date: **11/28/18**

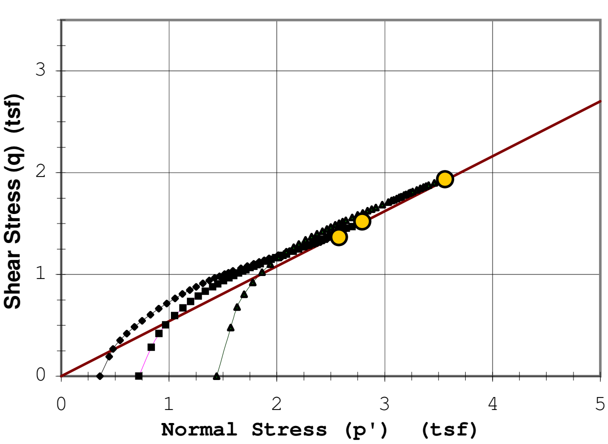
Project: **Newfolden / Northern Technologies, LLC**
Boring #: **7** Sample #: **7** Type: **3T** Depth (ft): **14.5-16**
Soil Type: **Sandy Lean Clay w/a little gravel (CL)**



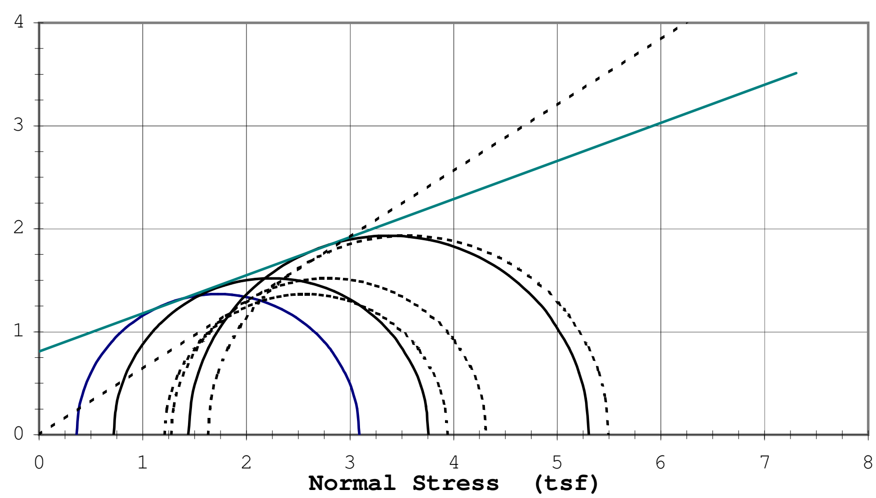
Failure Criterion:	**Max. Deviator Stress**				
Angle of internal friction, ϕ' =	**32.7 °**				
Apparent Cohesion, **c'** =	**0.00 (tsf)**				
Test Date: 11/16/18	Liquid Limit:				
Test Type: CU w/pp	Plastic Limit:				
Strain Rate (in/min): 0.00073	Plasticity Index:				
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69				
Before Consolidation	**A**	**B**	**C**	**D**	**E**
Diameter (in)	1.44	1.44	1.44		
Height (in)	2.92	2.92	2.92		
Water Content (%)	17.5	16.7	16.5		
Dry Density (pcf)	112.6	113.2	113.6		
Void Ratio	0.49	0.48	0.48		
After Consolidation					
Diameter (in)	1.44	1.43	1.43		
Height (in)	2.92	2.90	2.90		
Water Content (%)	18.0	17.0	16.2		
Dry Density (pcf)	113.1	115.3	117.0		
Void Ratio	0.48	0.46	0.43		
Back Pressure (tsf)	4.4	8.5	6.6		
Minor Principal Stress (tsf)	0.36	0.72	1.44		
Max. Deviator Stress (tsf)	2.73	3.04	3.87		
Ultimate Deviator Stress (tsf)	2.73	3.04	3.87		
Deviator Stress at Failure (tsf)	2.73	3.04	3.87		
Max. Pore Pressure Buildup (tsf)	0.17	0.26	0.60		
Pore Pressure Parameter "B"	0.95	0.95	0.95		
Pct. Axial Strain at Failure	20.0	20.0	20.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.



Rupture Envelope at Failure	
α = 28.4 °	a = 0.0 (tsf)

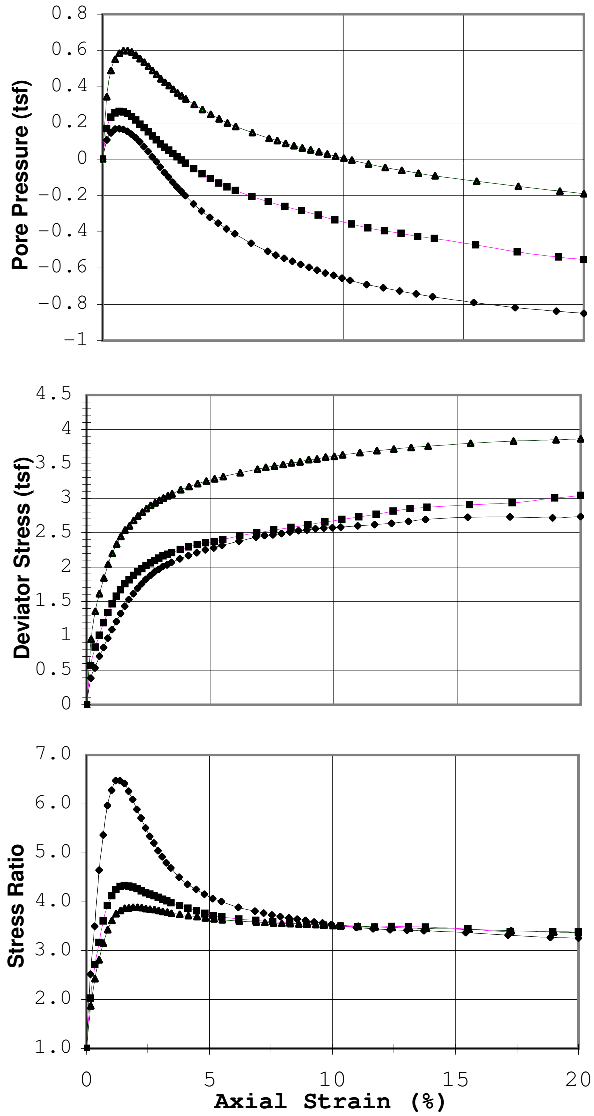


------------	Effective ϕ':	32.7 °	c'=	0.00 (tsf)
________	Total ϕ:	20.3 °	c=	0.81 (tsf)

TRIAXIAL TEST ASTM: D 4767

Job No. **11715**
Date: **11/28/18**

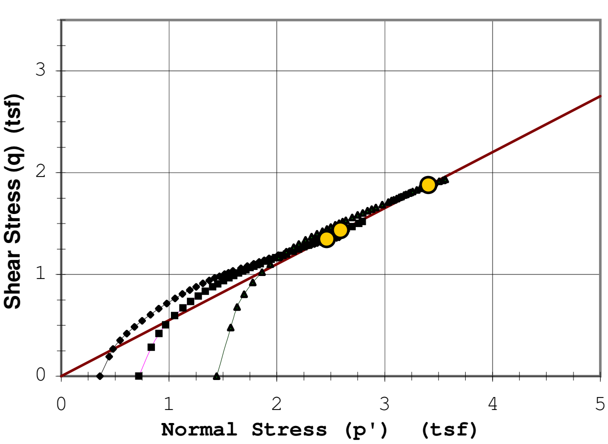
Project: **Newfolden / Northern Technologies, LLC**
Boring #: **7** Sample #: **7** Type: **3T** Depth (ft): **14.5-16**
Soil Type: **Sandy Lean Clay w/a little gravel (CL)**

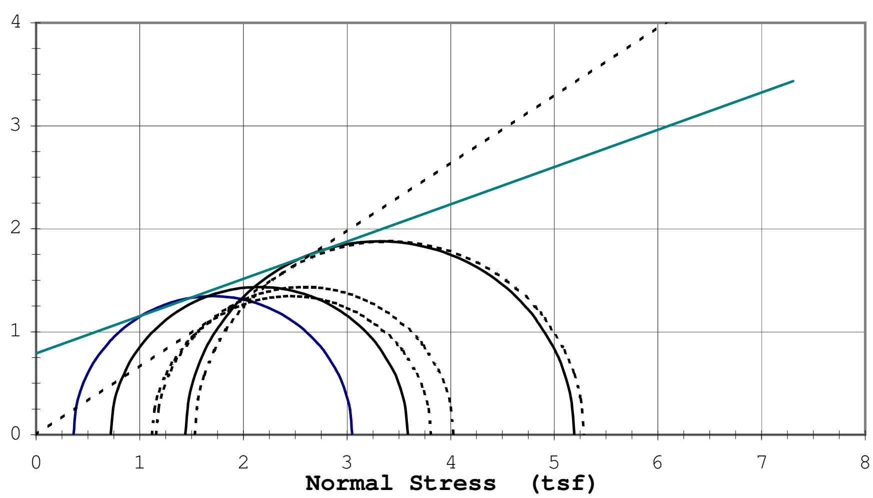


Failure Criterion:	Given Strain of: 15%					
Angle of internal friction, ϕ' =	33.4 °					
Apparent Cohesion, c' =	0.00 (tsf)					
Test Date: 11/16/18	Liquid Limit:					
Test Type: CU w/pp	Plastic Limit:					
Strain Rate (in/min): 0.00073	Plasticity Index:					
Strain Rate (%/min): 0.025	Spec. Gravity (Assumed): 2.69					
Before Consolidation		**A**	**B**	**C**	**D**	**E**
Diameter (in)		1.44	1.44	1.44		
Height (in)		2.92	2.92	2.92		
Water Content (%)		17.5	16.7	16.5		
Dry Density (pcf)		112.6	113.2	113.6		
Void Ratio		0.49	0.48	0.48		
After Consolidation						
Diameter (in)		1.44	1.43	1.43		
Height (in)		2.92	2.90	2.90		
Water Content (%)		18.0	17.0	16.2		
Dry Density (pcf)		113.1	115.3	117.0		
Void Ratio		0.48	0.46	0.43		
Back Pressure (tsf)		4.4	8.5	6.6		
Minor Principal Stress (tsf)		0.36	0.72	1.44		
Max. Deviator Stress (tsf)		2.73	3.04	3.87		
Ultimate Deviator Stress (tsf)		2.73	3.04	3.87		
Deviator Stress at Failure (tsf)		2.69	2.87	3.75		
Max. Pore Pressure Buildup (tsf)		0.17	0.26	0.60		
Pore Pressure Parameter "B"		0.95	0.95	0.95		
Pct. Axial Strain at Failure		15.0	15.0	15.0		

"These test results are for informational purposes only and must be reviewed by a qualified professional engineer to verify that the test parameters shown are appropriate for any particular design"

Remarks: Radial drainage strips applied to trimmed specimen; Saturated, backpressured until "B" response was 0.95 to 1.00; Consolidated; All Drainage valves closed and immediately sheared.





Rupture Envelope at Failure	
α = 28.8 °	a = 0.0 (tsf)

------------	Effective ϕ': 33.4 °	c'=	0.00 (tsf)
________	Total ϕ: 19.9 °	c=	0.79 (tsf)

Triaxial Data

Job: **11715**

Boring: 7 Sample: 7 Depth: 14.5-16 Date: 11/28/18

Sample 1			**Sample 2**			**Sample 3**			**Sample 4**			**Sample 5**		
Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)	Strain (%)	Deviator Stress (tsf)	Pore Pressure (tsf)
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
0.17	0.38	0.11	0.17	0.57	0.17	0.18	0.95	0.34						
0.34	0.54	0.15	0.34	0.84	0.23	0.35	1.36	0.49						
0.51	0.71	0.17	0.52	1.01	0.25	0.52	1.61	0.55						
0.69	0.83	0.17	0.69	1.19	0.26	0.69	1.84	0.58						
0.86	0.97	0.16	0.86	1.34	0.26	0.87	2.04	0.60						
1.03	1.09	0.15	1.03	1.46	0.25	1.04	2.20	0.60						
1.20	1.21	0.14	1.21	1.57	0.23	1.21	2.33	0.59						
1.37	1.32	0.12	1.38	1.67	0.22	1.39	2.44	0.57						
1.54	1.43	0.10	1.55	1.76	0.19	1.56	2.54	0.55						
1.71	1.53	0.07	1.72	1.81	0.17	1.73	2.60	0.54						
1.89	1.61	0.04	1.90	1.88	0.15	1.90	2.68	0.51						
2.06	1.69	0.01	2.07	1.93	0.13	2.08	2.74	0.49						
2.23	1.76	-0.01	2.24	1.98	0.11	2.25	2.80	0.47						
2.40	1.82	-0.04	2.41	2.02	0.08	2.42	2.85	0.44						
2.57	1.88	-0.07	2.58	2.06	0.07	2.59	2.89	0.42						
2.74	1.93	-0.10	2.76	2.09	0.05	2.77	2.93	0.41						
2.91	1.96	-0.13	2.93	2.13	0.03	2.94	2.97	0.39						
3.09	2.01	-0.15	3.10	2.16	0.01	3.11	3.00	0.37						
3.26	2.03	-0.18	3.27	2.19	0.00	3.28	3.04	0.35						
3.43	2.07	-0.20	3.45	2.21	-0.02	3.46	3.06	0.33						
3.77	2.12	-0.25	3.79	2.25	-0.05	3.80	3.12	0.30						
4.11	2.17	-0.28	4.14	2.29	-0.08	4.15	3.17	0.27						
4.46	2.21	-0.32	4.48	2.32	-0.11	4.49	3.21	0.25						
4.80	2.25	-0.35	4.82	2.35	-0.13	4.84	3.25	0.22						
5.14	2.28	-0.38	5.17	2.37	-0.15	5.18	3.28	0.20						
5.49	2.32	-0.41	5.51	2.40	-0.17	5.53	3.32	0.18						
6.17	2.38	-0.46	6.20	2.45	-0.21	6.22	3.37	0.15						
6.86	2.44	-0.51	6.89	2.50	-0.23	6.91	3.42	0.12						
7.20	2.46	-0.53	7.58	2.54	-0.26	7.26	3.45	0.10						
7.54	2.47	-0.55	8.27	2.57	-0.28	7.60	3.47	0.09						
7.89	2.49	-0.56	8.96	2.61	-0.31	7.95	3.49	0.08						
8.23	2.51	-0.58	9.65	2.65	-0.33	8.29	3.52	0.06						
8.57	2.53	-0.60	10.34	2.69	-0.36	8.64	3.53	0.05						
8.91	2.54	-0.61	11.03	2.73	-0.38	8.98	3.56	0.04						
9.26	2.55	-0.63	11.72	2.76	-0.39	9.33	3.57	0.03						
9.60	2.56	-0.64	12.41	2.81	-0.41	9.67	3.60	0.02						
9.94	2.57	-0.66	13.10	2.85	-0.43	10.02	3.61	0.01						
10.29	2.58	-0.67	13.79	2.87	-0.44	10.37	3.63	0.00						
10.97	2.60	-0.69	15.51	2.91	-0.47	11.06	3.66	-0.03						
11.66	2.62	-0.71	17.23	2.93	-0.51	11.75	3.69	-0.04						
12.34	2.64	-0.73	18.96	3.00	-0.54	12.44	3.72	-0.06						
13.03	2.66	-0.74	20.00	3.04	-0.55	13.13	3.74	-0.08						
13.71	2.69	-0.76				13.82	3.75	-0.09						
15.43	2.72	-0.79				15.55	3.80	-0.12						
17.14	2.73	-0.82				17.27	3.83	-0.15						
18.86	2.71	-0.84				19.00	3.85	-0.18						
20.00	2.73	-0.85				20.00	3.87	-0.19						

APPENDIX C

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-01

Long: -96° 20' 12.876"
Lat: 48° 22' 5.16"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1093.266 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 15.50 ft / Elev 1077.77 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.9	ORGANIC SILTY SAND, (OL) black, fine grained	1092.3	AU 1									
	LEAN CLAY, (CL) light brown to light gray, stiff, trace sand		SS 2	100	5-7-9 (16)	6.0	121	12	33	12	21	
			SS 3	94	5-8-9 (17)	4.0	117	13				
7.0	LEAN CLAY, (CL) light brown to light gray, stiff, trace sand, trace gravel	1086.3	SS 4	100	6-8-9 (17)	5.7	121	13				
9.0	LEAN CLAY, (CL) brown, stiff, trace sand, trace gravel	1084.3	SS 5	100	5-7-9 (16)	4.6	124	13				
12.5	LEAN CLAY, (CL) dark gray, stiff, trace sand, trace gravel	1080.8	SS 6	100	6-8-8 (16)	4.1	123	14				
15.5 ▽	POORLY GRADED SAND, (SP) brown, fine to coarse grained, wet, dense	1077.8	SS 7	67	8-12-11 (23)							
18.0	LEAN CLAY, (CL) dark gray, stiff, trace sand, trace gravel	1075.3	SS 8	67	3-5-12 (17)	2.0	126	13				
19.0	SILTY FAT CLAY, (CH/CL) dark gray, rather stiff	1074.3	SS 9	83	5-5-7 (12)	1.0	115	21				
23.0	LEAN CLAY, (CL) dark gray, stiff, trace sand	1070.3	SS 10	100	4-7-9 (16)	2.1	126	13				
31.0		1062.3	SS 11	111	5-8-9 (17)	2.2	123	15				

Bottom of borehole at 31.0 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-02

Long: -96° 20' 8.52"
Lat: 48° 22' 6.708"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1093.013 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.7	ORGANIC SILTY SAND, (OL) dark brown, fine grained	1092.3	AU 1					19				
	LEAN CLAY, (CL) light brown to light gray, rather stiff, trace sand, trace gravel		SS 2	67	4-5-6 (11)	6.0	112	16				
			SS 3	89	3-4-7 (11)	4.1	123	13				
9.5		1083.5	SS 4	100	4-5-6 (11)	2.5	125	14				
11.5	LEAN CLAY, (CL) dark brown, rather stiff, trace sand, trace gravel	1081.5	SS 5	56	4-6-10 (16)	2.4	116	16				
	LEAN CLAY, (CL) brown, rather stiff, trace sand, trace gravel		SS 6	44	3-4-6 (10)	1.9	122	15	30	12	18	
16.5		1076.5	ST 7									
	LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel		SS 8	100	2-3-6 (9)	1.7	125	13				
			SS 9	89	2-6-8 (14)	2.8	128	12				
			SS 10	56	6-10-11 (21)	1.9	123	13				
31.0		1062.0	SS 11	89	6-10-10 (20)	2.9	127	13				

Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-03

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: -96° 19' 21.468"
Lat: 48° 22' 9.876"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1100.962 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.8	ORGANIC SILTY SAND, (OL) black, fine grained	1100.2	AU 1					17				
5.5	POORLY GRADED SAND WITH SILT, (SP-SM) brown, fine to coarse grained, medium dense	1095.5	SS 2	83	4-5-7 (12)							
			SS 3	67	1-3-3 (6)	2.5	108	24				
6.5	LEAN CLAY, (CL/CH) light brown to light gray, medium	1094.5										
10.5	SILTY LEAN CLAY, (CL-ML) light brown, rather stiff, trace sand, trace gravel	1090.5	SS 4	56	2-5-6 (11)	4.1		10	15	9	6	
			SS 5	100	3-6-8 (14)	3.5	128	13				
31.0	LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel	1070.0	SS 6	94	2-4-6 (10)	0.6	130	14				
			ST 7									
			SS 8	89	2-4-7 (11)	2.7	123	13				
			SS 9	67	7-9-9 (18)	2.7	127	13				
			SS 10	111	6-10-11 (21)	1.6	126	13				
			SS 11	122	7-10-10 (20)	2.7	122	14				

Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-04

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: 96° 18' 10.44"
Lat: 48° 22' 9.048"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1107.192 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 1.00 ft / Elev 1106.19 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0		0.8 ORGANIC SILTY SAND, (OL) black 1106.4	AU 1					20				
		▽ POORLY GRADED SAND, (SP) light brown, fine grained, wet, medium dense	SS 2	56	1-4-6 (10)							
5		4.5 1102.7 SILTY SAND, (SM) gray, fine grained, moist, medium dense	SS 3	67	2-4-6 (10)							
		6.5 1100.7 POORLY GRADED SAND, (SP) gray, fine grained, wet, loose	SS 4	78	3-3-3 (6)							
10		10.0 1097.2 LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel	SS 5	94	2-4-6 (10)	2.3	130	13				
			SS 6	89	2-4-6 (10)	1.8	132	13				
15		16.0 1091.2	SS 7	89	2-4-7 (11)	2.1	130	13				

Bottom of borehole at 16.0 feet.
Borehole grouted.

BORING NUMBER SB-05

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: -96° 17' 9.528"
Lat: 48° 22' 8.508"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1104.952 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 5.00 ft / Elev 1099.95 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0 – 0.4		ORGANIC CLAY WITH SAND, (OL) dark brown, trace gravel	1104.5	AU 1					19				
0.4 – 5.0		LEAN CLAY, (CL) light brown, rather stiff, trace sand, trace gravel	1100.0	SS 2	44	3-5-9 (14)	4.2		18				
5.0 ▽ – 7.0		SILT, (ML) light brown, moist, rather stiff, trace sand	1098.0	SS 3	100	3-6-9 (15)	1.5	120	21				
7.0 – 11.5		LEAN CLAY, (CL) light brown, rather stiff to stiff, trace sand, trace gravel	1093.5	SS 4	89	3-5-7 (12)	4.8	134	9				
				SS 5	44	7-9-15 (24)			12				
11.5 – 15.5		LEAN CLAY, (CL) brown to dark gray, stiff, trace sand, trace gravel	1089.5	SS 6	89	7-9-13 (22)	3.9	119	15				
15.5 – 16.0		LEAN CLAY, (CL) dark gray, stiff, trace sand, trace gravel	1089.0	SS 7	111	5-7-11 (18)	4.4	124	13				

Bottom of borehole at 16.0 feet.
Borehole grouted.

BORING NUMBER SB-06

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: -96° 19' 16.14"
Lat: 48° 23' 3.264"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1106.683 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 5.00 ft / Elev 1101.68 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0–0.8	ORGANIC SILTY SAND, (OL) black, fine grained	1105.9	AU 1									
0.8–5.0	POORLY GRADED SAND WITH SILT, (SP-SM) light brown, fine grained, medium dense	1101.7	SS 2	72	3-4-7 (11)							
5.0 ▽ –8.0	SILTY SAND, (SM) brown, fine grained, wet, medium dense	1098.7	SS 3	78	3-5-7 (12)			23				12
8.0–11.5	FAT CLAY, (CH) gray, medium, trace sand	1095.2	SS 4	78	3-2-3 (5)	1.4						
			SS 5	94	2-3-5 (8)	1.3						
11.5–17.5	SILT, (ML) gray, moist, rather stiff	1089.2	SS 6	78	2-4-7 (11)	4.9						
			SS 7	78	3-4-9 (13)	3.3						
17.5–23.0	FAT CLAY, (CH) gray, rather stiff, trace sand	1083.7	SS 8	89	2-4-6 (10)	2.0						
			SS 9	122	2-4-7 (11)	2.0						
23.0–30.5	LEAN CLAY, (CL) gray, stiff, trace sand, trace gravel	1076.2	SS 10	111	4-6-11 (17)	1.7						
			SS 11	183	4-6-10/0"	1.9						

Bottom of borehole at 30.5 feet.
Borehole grouted.

NTI NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-07

Long: -96° 19' 19.1136"
Lat: 48° 22' 55.9344"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1104.681 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0	0.8	ORGANIC SILTY SAND, (OL) black 1103.9	AU 1									
		SILT, (ML) brown to light brown, rather stiff, with sand, trace gravel	SS 2	89	3-5-6 (11)							
5	5.0	1099.7 LEAN CLAY, (CL) gray to dark gray, medium to stiff, with sand, trace gravel	SS 3	83	2-3-3 (6)	1.4		13				63
			SS 4	72	2-3-5 (8)	1.6						
10			SS 5	100	1-3-6 (9)	2.0						
			SS 6	100	3-6-8 (14)	2.4						
15			ST 7			1.8						
			SS 8	94	3-5-8 (13)	2.4						
20			SS 9	100	3-5-8 (13)							
25			SS 10	100	4-9-10 (19)	1.2						
30	31.0	1073.7	SS 11	100	4-9-10 (19)	2.1						

Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-08

NTI NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: -96° 19' 19.164"
Lat: 48° 22' 34.608"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1100.469 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
0.7	ORGANIC SILTY SAND, (OL) black	1099.8	AU 1									
	LEAN CLAY, (CL) light brown, soft to rather stiff, trace sand, trace gravel		SS 2	67	3-2-1 (3)	0.6	109	18	20	11	9	
			SS 3	78	2-3-5 (8)	1.4	121	14				
			SS 4	94	3-4-6 (10)	3.0	126	12				
10.0		1090.5										
	LEAN CLAY, (CL) dark brown, rather stiff, trace sand, trace gravel		SS 5	100	4-5-7 (12)	3.8	118	13				
12.0		1088.5										
	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel		SS 6	89	3-4-6 (10)	3.3	131	12				
			SS 7	89	2-4-5 (9)	1.9	129	13				
			SS 8	111	3-4-6 (10)	2.0	124	14				
			SS 9	111	2-4-6 (10)	2.2	126	14				
			SS 10	111	3-6-8 (14)	5..2	120	15				
31.0		1069.5	SS 11	111	3-7-8 (15)	2.7	116	17				

Bottom of borehole at 31.0 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-09

Long: -96° 20' 6.864"
Lat: 48° 22' 14.232"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1093.245 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0											
0.6	ORGANIC SILTY SAND, (OL) black 1092.7	AU 1					30				
	SILTY SAND, (SM) light brown to light gray, fine to coarse grained, loose, trace gravel	SS 2	56	1-2-4 (6)			13				23
4.0	LEAN CLAY, (CL) gray, rather stiff, trace sand, trace gravel 1089.2										
5		SS 3	67	3-4-5 (9)	2.0	123	16	25	11	14	
7.0	LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel 1086.2	SS 4	111	2-4-6 (10)	2.2	126	14				
10		SS 5	83	4-4-5 (9)	1.3	123	14				
		SS 6	89	3-4-6 (10)	2.6	121	14				
15		ST 7									
		SS 8	44	6-9-12 (21)	1.1		17				
20		SS 9	100	4-6-10 (16)	2.4	125	13	25	12	13	
25		SS 10	89	3-6-9 (15)	2.1	123	14				

(Continued Next Page)

Long: -96° 20' 6.864"
Lat: 48° 22' 14.232"

CLIENT MSTRWD **PROJECT NAME** Newfolden / MR Subwatershed Flood Damage Reduction

PROJECT NUMBER 18.FGO06666.000 **PROJECT LOCATION** Newfolden, Minnesota

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
		LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel *(continued)*										
30			SS 11	89	12-20-28 (48)	6.0	130	9				
33.0		1060.2										
		SANDY LEAN CLAY, (CL) gray, very stiff, trace gravel										
35			SS 12	111	20-55-46 (101)	6.0	127	6				
40			SS 13	100	47-70			6	13	10	3	
45			SS 14	100	52-68	3.6		9				
45.5		1047.7										

Bottom of borehole at 45.5 feet.
Borehole grouted.

NTI NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-10

PAGE 1 OF 1
Long: -96° 20' 34.944"
Lat: 48° 22' 47.856"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1095.869 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING 1.00 ft / Elev 1094.87 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.4	ORGANIC SILTY SAND, (OL) black	1095.4	AU 1									
5.5	SILTY SAND, (SM) light brown, fine to medium grained, wet, medium dense	1090.4	SS 2	56	2-5-5 (10)			24				19
			SS 3	67	2-3-2 (5)							
11.5	LEAN CLAY, (CL) gray, medium to rather stiff, trace sand	1084.4	SS 4	89	1-2-4 (6)	2.4						
			SS 5	94	2-4-7 (11)	4.8						
31.0	LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel	1064.9	SS 6	89	2-4-6 (10)	1.4						
			SS 7	100	2-4-5 (9)	2.0						
			SS 8	122	3-4-6 (10)	1.8						
			SS 9	100	3-4-6 (10)	1.7						
			SS 10	111	3-7-10 (17)	4.4						
			SS 11	122	3-7-10 (17)	2.3						

Bottom of borehole at 31.0 feet.
Borehole grouted.

NTI NORTHERN TECHNOLOGIES, LLC

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-11

Long: -96° 13' 51.276"
Lat: 48° 21' 28.044"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1131.395 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.
0 – 2.5	FILL, FAT CLAY, brown to black	1128.9
2.5 – 4.5	BURIED TOPSOIL, ORGANIC CLAY WITH SAND, (OL) black	1126.9
4.5 – 13.0	LEAN CLAY, (CL) brown, medium to stiff, trace sand, trace gravel	1118.4
13.0 – 14.0	LEAN CLAY, (CL) olive gray, stiff, trace sand, trace gravel	1117.4
14.0 – 23.0	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel	1108.4
23.0 – 31.0	LEAN CLAY, (CL) light brown, rather stiff, trace sand, trace gravel	1100.4

SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
AU 1									
SS 2	78	2-4-7 (11)							
SS 3	89	2-3-5 (8)	2.5						
SS 4	100	3-4-7 (11)	3.3						
SS 5	89	3-9-13 (22)	4.7	126	13	22	11	11	
SS 6	133	3-13-13 (26)	6.0						
SS 7	56	4-7-8 (15)	2.0						
SS 8	89	3-4-7 (11)	3.4						
SS 9	100	3-4-6 (10)	2.7						
SS 10	100	3-5-8 (13)	2.0						
SS 11	111	3-5-8 (13)	5.5						

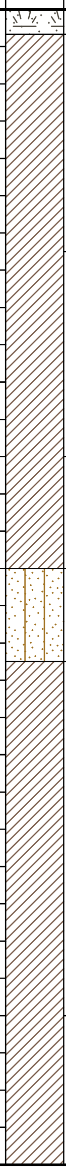
Bottom of borehole at 31.0 feet.
Borehole grouted.

BORING NUMBER SB-12

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

Long: -96° 15' 30.636"
Lat: 48° 21' 27.216"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1120.968 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
▽ **AT TIME OF DRILLING** 15.00 ft / Elev 1105.97 ft
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES



DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.7	ORGANIC SILTY SAND, (OL) black, fine grained	1120.3	AU 1									
	LEAN CLAY, (CL) light brown, soft to medium, trace sand, trace gravel		SS 2	56	2-2-2 (4)	1.5						
6.5		1114.5	SS 3	78	2-3-5 (8)	2.1						
	LEAN CLAY, (CL) brown, stiff, trace sand, trace gravel		SS 4	94	5-8-13 (21)	6.0		11	23	11	12	
12.0		1109.0	SS 5	89	5-9-11 (20)	6.0						
	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel		SS 6	89	2-4-6 (10)	2.6						
15.0 ▽		1106.0										
	SILTY SAND, (SM) gray, fine grained, moist, very dense		SS 7	78	5-16-17 (33)							
17.5		1103.5										
	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel		SS 8	94	5-5-8 (13)	1.2						
			SS 9	94	2-4-7 (11)	2.2						
27.0		1094.0	SS 10	100	2-4-6 (10)	1.3						
	LEAN CLAY, (CL) dark gray, rather stiff, trace sand, trace gravel											
31.0		1090.0	SS 11	100	2-5-6 (11)	2.0	117	17	22	11	11	

Bottom of borehole at 31.0 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-13

Long: -95° 16' 48.144"
Lat: 48° 21' 25.812"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1109.352 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.8	ORGANIC CLAY WITH SAND, (OL) black	1108.6	AU 1					20				
	LEAN CLAY, (CL) light brown to light gray, rather stiff, trace sand		SS 2	67	3-5-7 (12)	6.0	117	10				
			SS 3	78	2-4-5 (9)	2.5	125	13				
9.0		1100.4	SS 4	78	3-4-5 (9)	2.5	122	13	25	11	14	
11.5	LEAN CLAY, (CL) brown, rather stiff, trace sand, trace gravel	1097.9	SS 5	89	3-4-6 (10)	2.6	127	14	24	12	12	
	SANDY LEAN CLAY, (CL) brown, stiff, trace gravel		SS 6	89	3-6-10 (16)	2.5	122	13				
16.5		1092.9	ST 7	52		1.6	115	15				
	LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel		SS 8	89	3-6-10 (16)	2.4	114	17				
			SS 9	89	5-6-8 (14)	2.5	123	12				
			SS 10	94	2-5-8 (13)	3.4	121	14				

(Continued Next Page)

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-13

Long: -95° 16' 48.144"
Lat: 48° 21' 25.812"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES
		LEAN CLAY, (CL) dark gray, rather stiff to very stiff, trace sand, trace gravel *(continued)*										
30			SS 11	100	5-7-12 (19)	3.5	107	21				
35			SS 12	111	6-8-14 (22)	4.2	118	14	27	12	15	
40			SS 13	111	10-26-36 (62)	6.0	129	8				
45			SS 14	111	12-22-35 (57)	6.0	129	8				
46.0		1063.4										

Bottom of borehole at 46.0 feet.
Borehole grouted.

NTI LOG - GENERAL WITH PHOTOS - NTI-2018-02-23.GDT - 12/7/18 11:16 - C:\USERS\CHRISN\DESKTOP\DESKTOP PROJECTS\NEWFOLDEN MIDDLE RIVER FLOOD REDUCTION\NEWFOLDEN MIDDLE RIVER FLOOD REDUCTION.GPJ

NTI NORTHERN TECHNOLOGIES, LLC
Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-14

Long: -96° 16' 47.928"
Lat: 48° 20' 35.016"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1110.355 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0	ORGANIC CLAY WITH SAND, (OL) black		AU 1									
0.4	LEAN CLAY, (CL) brown, medium to rather stiff, trace sand, trace gravel	1109.9	SS 2	67	1-3-5 (8)	2.1						
			SS 3	83	3-4-5 (9)	3.9						
7.0	LEAN CLAY, (CL) brown to dark gray, rather stiff, trace sand, trace gravel	1103.4	SS 4	100	3-5-7 (12)	4.4						
9.0	LEAN CLAY, (CL) dark brown, stiff, trace sand, trace gravel	1101.4	SS 5	100	4-6-11 (17)	4.4						
12.0	LEAN CLAY, (CL) dark gray, rather stiff to stiff, trace sand, trace gravel	1098.4	SS 6	89	3-7-10 (17)	3.0						
			SS 7	11	6-7-8 (15)	1.5						
			SS 8	67	6-10-10 (20)	1.5						
19.0	SANDY LEAN CLAY, (CL) light brown, rather stiff, trace gravel	1091.4	SS 9	89	3-5-8 (13)	6.0						
23.0	LEAN CLAY, (CL) dark gray, rather stiff, trace sand	1087.4	SS 10	39	4-5-5 (10)	0.9	120	16	31	12	19	
			SS 11	67	5-6-4 (10)	1.5						
31.0		1079.4										

Bottom of borehole at 31.0 feet.
Borehole grouted.

Fargo
3522 4th Ave S
Fargo, North Dakota 58103

BORING NUMBER SB-15

Long: -96° 15' 31.032"
Lat: 48° 21' 2.448"

CLIENT MSTRWD
PROJECT NAME Newfolden / MR Subwatershed Flood Damage Reduction
PROJECT NUMBER 18.FGO06666.000
PROJECT LOCATION Newfolden, Minnesota
DATE STARTED 10/17/18 **COMPLETED** 10/17/18
GROUND ELEVATION 1117.051 feet **HOLE SIZE** 6 1/2 in.
DRILLING CONTRACTOR NTI
GROUND WATER LEVELS:
DRILLING METHOD 3 1/4 in H.S.A
AT TIME OF DRILLING --- No Groundwater Encountered
LOGGED BY Chris Nelson **CHECKED BY** Dan Gibson
AT END OF DRILLING ---
CAVE IN (ft) NR **FROST DEPTH (ft)** NA
AFTER DRILLING ---
NOTES

DEPTH (ft)	MATERIAL DESCRIPTION	Elev.	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	FINES
0.2	ORGANIC CLAY WITH SAND, (OL) dark brown	1116.9	AU 1									
	LEAN CLAY, (CL) brown, rather stiff to stiff, trace sand, trace gravel		SS 2	89	2-5-7 (12)	4.0						
			SS 3	22	4-8-10 (18)							
			SS 4	78	3-6-9 (15)	4.0						
			SS 5	100	3-7-9 (16)	2.9						
14.0		1103.1	SS 6	89	5-8-10 (18)	3.0	124	13	26	19	7	
	LEAN CLAY, (CL) dark gray, stiff to rather stiff, trace sand, trace gravel		SS 7	100	4-7-9 (16)	2.4						
			SS 8	100	5-7-9 (16)	2.4						
			SS 9	133	5-6-8 (14)	1.6						
27.0		1090.1	SS 10	111	2-4-6 (10)	1.4						
31.0	SILTY FAT CLAY, (CH/CL) dark gray, rather stiff, trace sand, trace gravel	1086.1	SS 11	111	3-5-6 (11)	1.6						

Bottom of borehole at 31.0 feet.
Borehole grouted.

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. **H 362967**

Minnesota Unique Well No. or W-series No. (Leave blank if not known)

WELL OR BORING LOCATION

County Name: Marshall

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)	Date Sealed	Date Well or Boring Constructed
New Maine	157 N	44 W	33	NE ¼ SE ¼ SW ¼	10/17/2018	10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)

Latitude ____ Longitude ____

Depth at Time of Sealing 30 ft. Original Depth 30 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location: Various Locations in New Maine Twp.

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water-Supply Well ☐ Monit. Well ☒ Env. Bore Hole ☐ Other____

STATIC WATER LEVEL: ☒ Measured Date Measured 10/17/2018 ☐ Estimated

DRY ft. ☒ below ☐ above land surface

Show exact location of well or boring in section grid with "X." Sketch map of well or boring location, showing property lines, roads, and buildings.

N / W / E / S — ½ Mile — 1 Mile

See Attached Map

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile ☒ Other N/A

WELLHEAD COMPLETION

Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ☒ Other____

Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ☒ Other____

PROPERTY OWNER'S NAME/COMPANY NAME: Middle-Snake-Tamarac Rivers Watershed District

Property owner's mailing address if different than well location address indicated above:

453 N McKinley St.
Warren, MN 56762

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

WELL OWNER'S NAME/COMPANY NAME: Same as above

Well owner's mailing address if different than property owner's address indicated above: Same as above

SCREEN/OPEN HOLE: Screen from N/A to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTIONS: ☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ☒ No Obstruction

Type of Obstructions (Describe) ____

Obstructions removed? ☐ Yes ☐ No Describe ____

PUMP: ☒ Not Present ☐ Present, Removed Prior to Sealing ☐ Other____

Type ____

If not known, indicate estimated formation log from nearby well or boring.

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
Glacial Drift			0	End

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE

☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ☒ Casing Perforation/Removal

Casing Diameter

N/A in. from ____ to ____ ft. ☐ Perforated ☐ Removed

____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed

Type of Perforator N/A

VARIANCE: Was a variance granted from the MDH for this well? ☐ Yes ☒ No TN#____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)

Grouting Material Bentonite Grout from 0 to End ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

____ from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS: Other unsealed and unused well or boring on property? ☐ Yes ☒ No How many?____

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Newfolden Flood Redux
(FGO06666)
BH-06 through BH-10

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

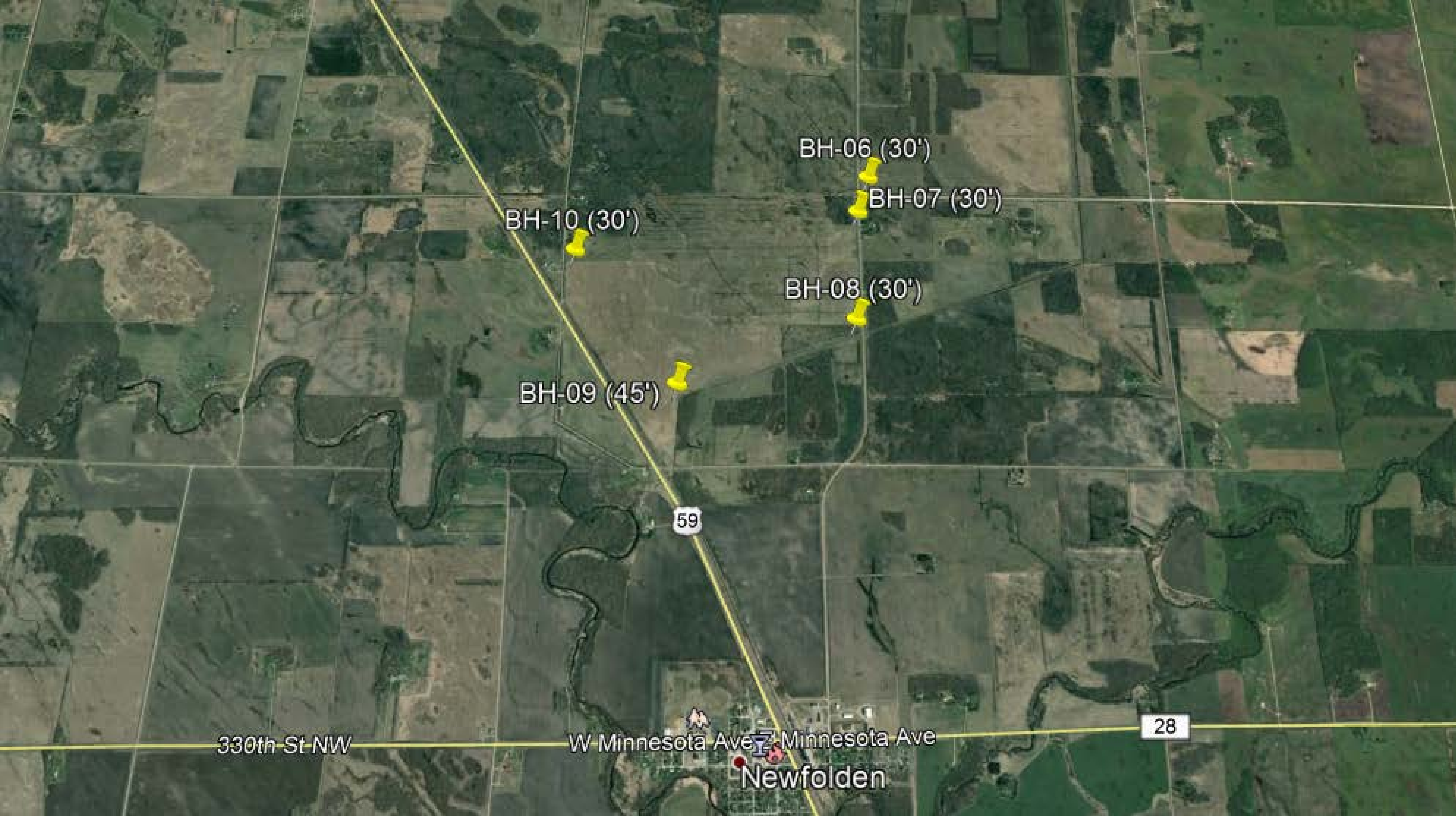
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — *Licensee Business Name*; 3574 — *License or Registration No.*

Christopher Kaiser for Bill Canty — *Certified Representative Signature*; *Certified Rep. No.*; 11/16/2018 — *Date*

Bradley Halvorson — *Name of Person Sealing Well or Boring*

MINN. DEPT OF HEALTH COPY **H 362967**


BH-06 (30')
BH-07 (30')
BH-10 (30')
BH-08 (30')
BH-09 (45')
59
28
330th St NW
W Minnesota Ave
Minnesota Ave
Newfolden

WELL OR BORING LOCATION	MINNESOTA DEPARTMENT OF HEALTH	Minnesota Well and Boring Sealing No.	H 362968
County Name: Marshall	**WELL AND BORING SEALING RECORD** *Minnesota Statutes, Chapter 103I*	Minnesota Unique Well No. or W-series No. (Leave blank if not known)	

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)	Date Sealed	Date Well or Boring Constructed
New Folden	156 N	44 W	4	NE ¼ SW ¼ NW ¼	10/17/2018	10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)

Latitude________ Longitude________

Depth at Time of Sealing 46 ft. Original Depth 45 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location

Various Locations in New Folden Twp.

AQUIFER(S)
☐ Single Aquifer ☐ Multiaquifer

WELL/BORING
☐ Water-Supply Well ☐ Monit. Well
■ Env. Bore Hole ☐ Other______

STATIC WATER LEVEL
■ Measured Date Measured 10/17/2018 ☐ Estimated
15.00 ft. ■ below ☐ above land surface

Show exact location of well or boring in section grid with "X."

N / W / E / S — ½ Mile — 1 Mile

Sketch map of well or boring location, showing property lines, roads, and buildings.

See Attached Map

CASING TYPE(S)
☐ Steel ☐ Plastic ☐ Tile ■ Other N/A

WELLHEAD COMPLETION
Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ■ Other______
Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ■ Other______

PROPERTY OWNER'S NAME/COMPANY NAME
Middle-Snake-Tamarac Rivers Watershed District
Property owner's mailing address if different than well location address indicated above
453 N McKinley St.
Warren, MN 56762

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from____	to____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from____	to____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from____	to____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

WELL OWNER'S NAME/COMPANY NAME
Same as above
Well owner's mailing address if different than property owner's address indicated above
Same as above

SCREEN/OPEN HOLE
Screen from N/A to____ ft. Open Hole from____ to____ ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ■ No Obstruction
Type of Obstructions (Describe)______
Obstructions removed? ☐ Yes ☐ No Describe______

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

PUMP
■ Not Present ☐ Present, Removed Prior to Sealing ☐ Other______
Type______

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE
☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ■ Casing Perforation/Removal
Casing Diameter
N/A in. from____ to____ ft. ☐ Perforated ☐ Removed
____ in. from____ to____ ft. ☐ Perforated ☐ Removed
Type of Perforator N/A

VARIANCE
Was a variance granted from the MDH for this well? ☐ Yes ■ No TN#____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material Bentonite Grout from 0 to End ft.____ yards____ bags
____ from____ to____ ft.____ yards____ bags
____ from____ to____ ft.____ yards____ bags

OTHER WELLS AND BORINGS
Other unsealed and unused well or boring on property? ☐ Yes ■ No How many?____

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Newfolden Flood Redux
(FGO06666)
BH-1, 02 and BH-12 through
BH-15

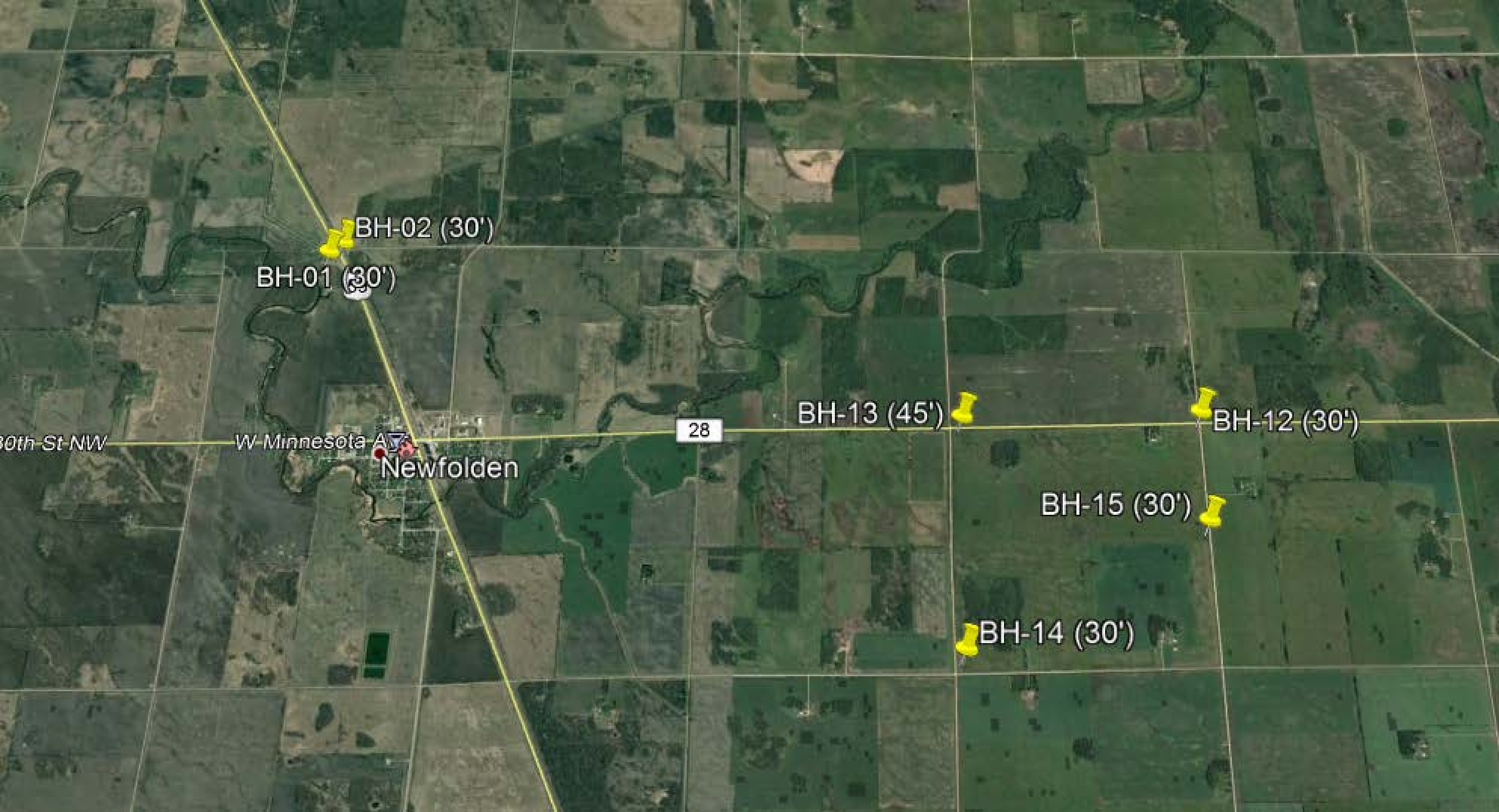
LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — 3574
Licensee Business Name — *License or Registration No.*

Christopher Kaiser for Bill Canty — 11/16/2018
Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson
Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 362968


BH-02 (30')
BH-01 (30')
BH-13 (45')
BH-12 (30')
28
30th St NW
W Minnesota A
Newfolden
BH-15 (30')
BH-14 (30')

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. / Minnesota Unique Well No. or W-series No. (Leave blank if not known): H 362969

WELL OR BORING LOCATION

County Name: Marshall

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)	Date Sealed	Date Well or Boring Constructed
New Folden	156 N	44 W	3	NE ¼ NW ¼ NE ¼	10/17/2018	10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)

Latitude ______ Longitude ______

Depth at Time of Sealing 16 ft. Original Depth 15 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location: Near 340th St NW and 130th Ave NW

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water-Supply Well ☐ Monit. Well ☒ Env. Bore Hole ☐ Other

STATIC WATER LEVEL: ☒ Measured Date Measured 10/17/2018 ☐ Estimated

1.00 ft. ☒ below ☐ above land surface

Show exact location of well or boring in section grid with "X."

Sketch map of well or boring location, showing property lines, roads, and buildings.

N / W / E / S — ½ Mile — 1 Mile

See Attached Map

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile ☒ Other N/A

WELLHEAD COMPLETION

Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ☒ Other

Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ☒ Other

PROPERTY OWNER'S NAME/COMPANY NAME: Middle-Snake-Tamarac Rivers Watershed District

Property owner's mailing address if different than well location address indicated above:

453 N McKinley St.
Warren, MN 56762

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ___	to ___ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
___ in. from ___	to ___ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
___ in. from ___	to ___ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

WELL OWNER'S NAME/COMPANY NAME: Same as above

Well owner's mailing address if different than property owner's address indicated above: Same as above

SCREEN/OPEN HOLE: Screen from N/A to ___ ft. Open Hole from ___ to ___ ft.

OBSTRUCTIONS: ☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ☒ No Obstruction

Type of Obstructions (Describe) ______

Obstructions removed? ☐ Yes ☐ No Describe ______

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

PUMP: ☒ Not Present ☐ Present, Removed Prior to Sealing ☐ Other

Type ______

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE

☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ☒ Casing Perforation/Removal

Casing Diameter

N/A in. from ___ to ___ ft. ☐ Perforated ☐ Removed

___ in. from ___ to ___ ft. ☐ Perforated ☐ Removed

Type of Perforator N/A

VARIANCE

Was a variance granted from the MDH for this well? ☐ Yes ☒ No TN# ______

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)

Grouting Material Bentonite Grout from 0 to End ft. ___ yards ___ bags

___ from ___ to ___ ft. ___ yards ___ bags

___ from ___ to ___ ft. ___ yards ___ bags

OTHER WELLS AND BORINGS

Other unsealed and unused well or boring on property? ☐ Yes ☒ No How many? ______

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING

Newfolden Flood Redux
(FGO06666)
BH-04, 05

LICENSED OR REGISTERED CONTRACTOR CERTIFICATION

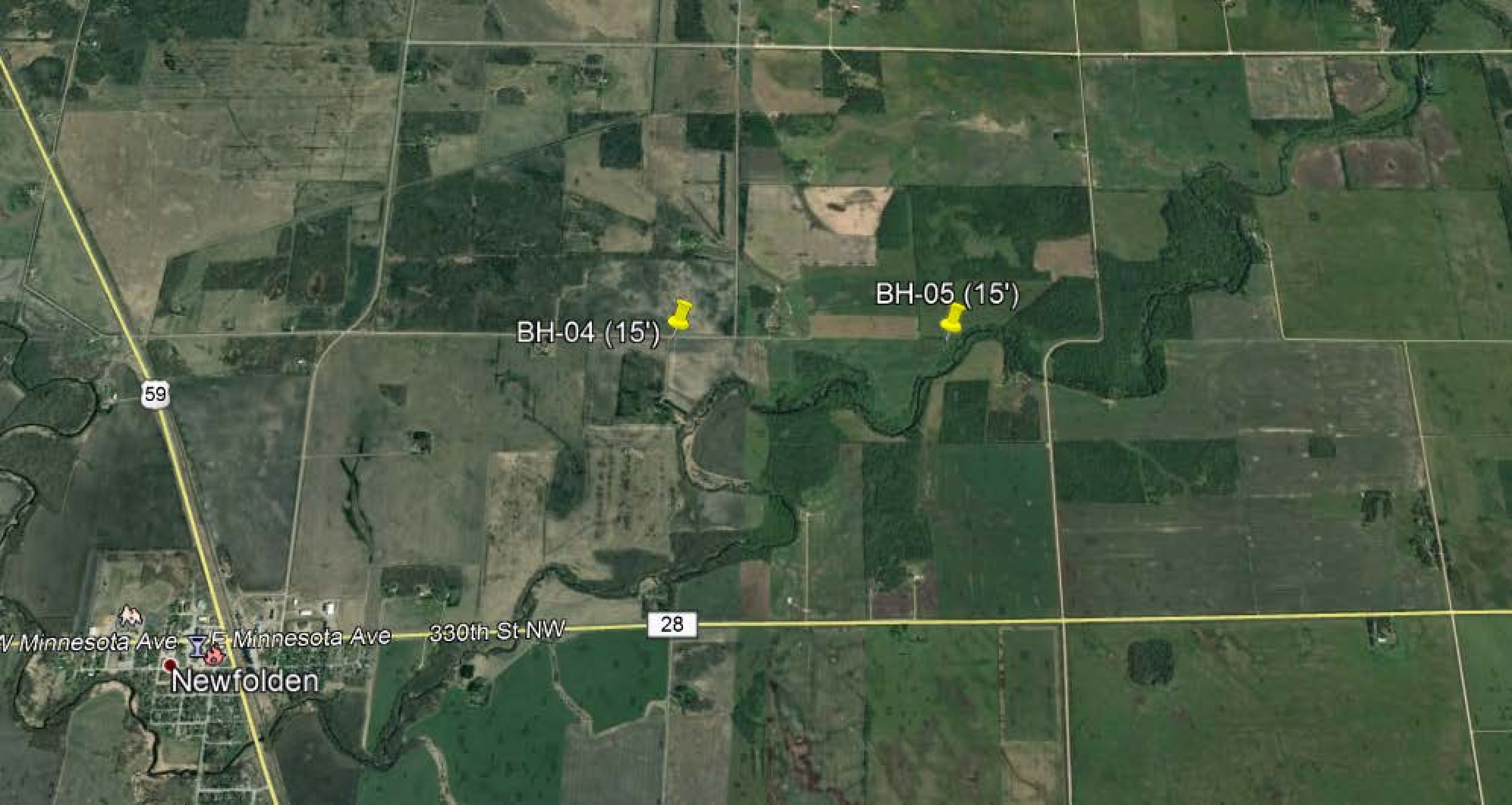
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — 3574
Licensee Business Name — *License or Registration No.*

Christopher Kaiser for Bill Canty — 11/16/2018
Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson
Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 362969



BH-05 (15')
BH-04 (15')
59
28
330th St NW
W Minnesota Ave
E Minnesota Ave
Newfolden

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING SEALING RECORD
Minnesota Statutes, Chapter 103I

Minnesota Well and Boring Sealing No. / Minnesota Unique Well No. or W-series No. (Leave blank if not known): H 362970

WELL OR BORING LOCATION

County Name: Marshall

Township Name	Township No.	Range No.	Section No.	Fraction (sm. → lg.)	Date Sealed	Date Well or Boring Constructed
Holt	156 N	43 W	7	NE ¼ NW ¼ NW ¼	10/17/2018	10/17/2018

GPS LOCATION – decimal degrees (to four decimal places)
Latitude ____ Longitude ____

Depth at Time of Sealing 31 ft. Original Depth 30 ft.

Numerical Street Address or Fire Number and City of Well or Boring Location: Near 110th Ave NE and 330th St NE

AQUIFER(S): ☐ Single Aquifer ☐ Multiaquifer

WELL/BORING: ☐ Water-Supply Well ☐ Monit. Well ■ Env. Bore Hole ☐ Other ____

STATIC WATER LEVEL: ■ Measured Date Measured 10/17/2018 ☐ Estimated
DRY ft. ■ below ☐ above land surface

Show exact location of well or boring in section grid with "X."
Sketch map of well or boring location, showing property lines, roads, and buildings.

N / W / E / S — ½ Mile — 1 Mile

See Attached Map

CASING TYPE(S): ☐ Steel ☐ Plastic ☐ Tile ■ Other N/A

WELLHEAD COMPLETION
Outside: ☐ Pitless Adapter/Unit ☐ At Grade ☐ Well Pit ☐ Buried ■ Other ____
Inside: ☐ Basement Offset ☐ Well House ☐ Well Pit ☐ Buried ■ Other ____

PROPERTY OWNER'S NAME/COMPANY NAME
Middle-Snake-Tamarac Rivers Watershed District
Property owner's mailing address if different than well location address indicated above
453 N McKinley St.
Warren, MN 56762

CASING(S)

Diameter	Depth	Set in oversize hole?	Annular space initially grouted?
N/A in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown
____ in. from ____	to ____ ft.	☐ Yes ☐ No	☐ Yes ☐ No ☐ Unknown

WELL OWNER'S NAME/COMPANY NAME
Same as above
Well owner's mailing address if different than property owner's address indicated above
Same as above

SCREEN/OPEN HOLE
Screen from N/A to ____ ft. Open Hole from ____ to ____ ft.

OBSTRUCTIONS
☐ Rods/Drop Pipe ☐ Check Valve(s) ☐ Debris ☐ Fill ■ No Obstruction
Type of Obstructions (Describe) ____
Obstructions removed? ☐ Yes ☐ No Describe ____

GEOLOGICAL MATERIAL	COLOR	HARDNESS OR FORMATION	FROM	TO
If not known, indicate estimated formation log from nearby well or boring.				
Glacial Drift			0	End

PUMP
■ Not Present ☐ Present, Removed Prior to Sealing ☐ Other ____
Type ____

METHOD USED TO SEAL ANNULAR SPACE BETWEEN 2 CASINGS, OR CASING AND BORE HOLE
☐ No Annular Space Exists ☐ Annular Space Grouted with Tremie Pipe ■ Casing Perforation/Removal
Casing Diameter
N/A in. from ____ to ____ ft. ☐ Perforated ☐ Removed
____ in. from ____ to ____ ft. ☐ Perforated ☐ Removed
Type of Perforator N/A

VARIANCE
Was a variance granted from the MDH for this well? ☐ Yes ■ No TN# ____

GROUTING MATERIAL(S) (One bag of cement = 94 lbs., one bag of bentonite = 50 lbs.)
Grouting Material Bentonite Grout from 0 to End ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags
____ from ____ to ____ ft. ____ yards ____ bags

OTHER WELLS AND BORINGS
Other unsealed and unused well or boring on property? ☐ Yes ■ No How many? ____

REMARKS, SOURCE OF DATA, DIFFICULTIES IN SEALING
Newfolden Flood Redux
(FGO06666)
BH-11

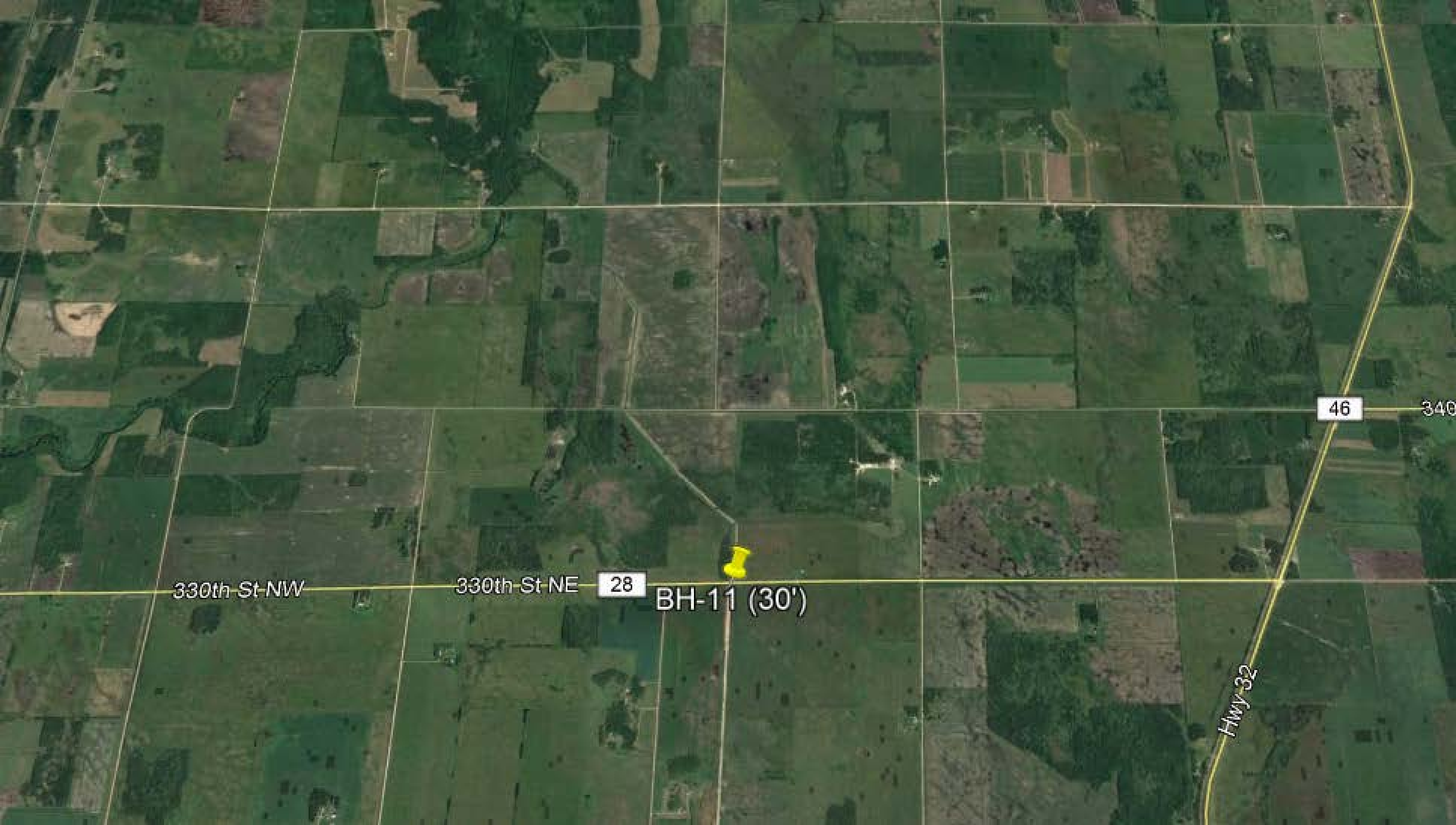
LICENSED OR REGISTERED CONTRACTOR CERTIFICATION
This well or boring was sealed in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Northern Technologies, LLC — 3574
Licensee Business Name — *License or Registration No.*

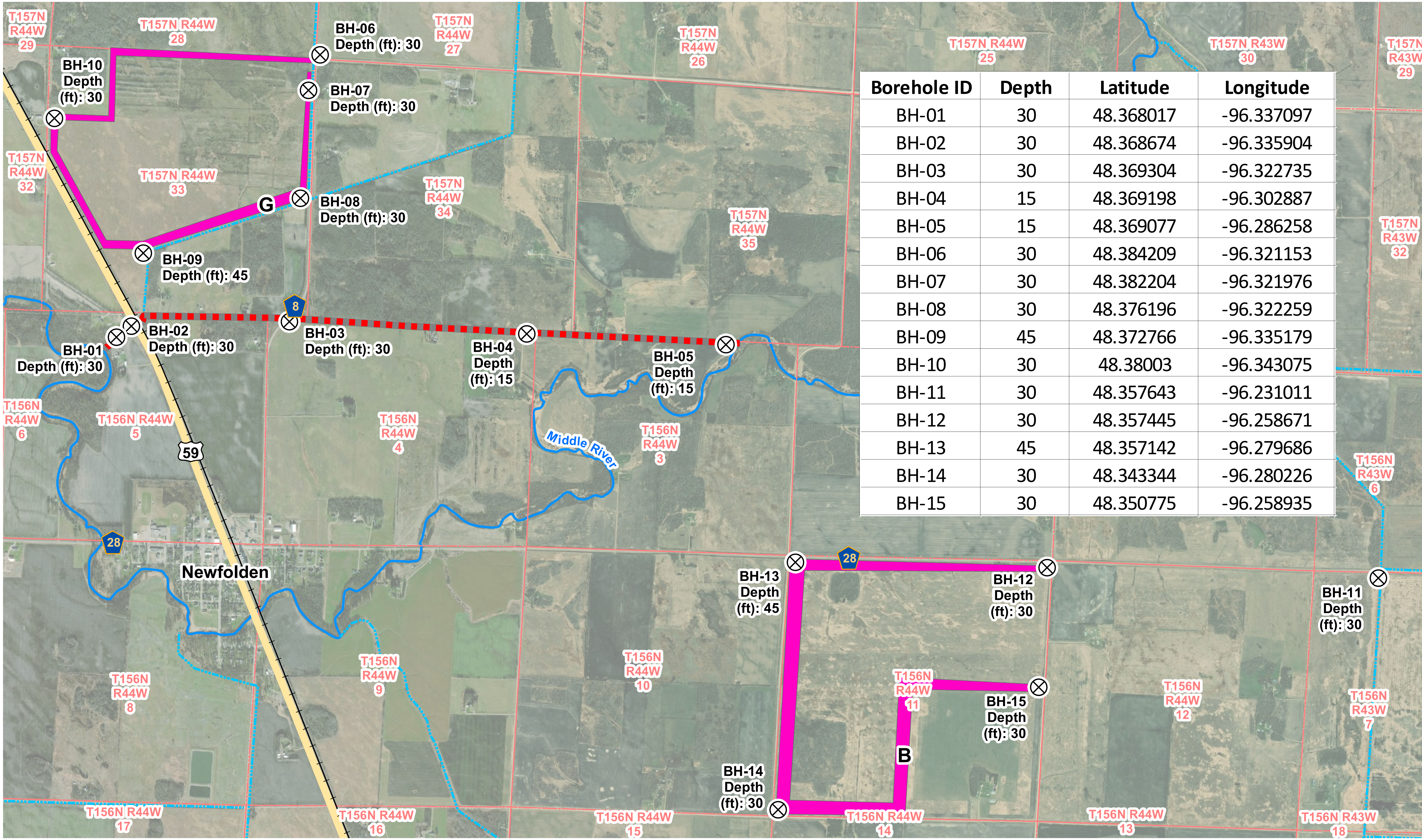
Christopher Kaiser for Bill Canty — 11/16/2018
Certified Representative Signature — *Certified Rep. No.* — *Date*

Bradley Halvorson
Name of Person Sealing Well or Boring

MINN. DEPT OF HEALTH COPY H 362970



330th St NW
330th St NE
28
BH-11 (30')
46
340
Hwy 32



Borehole ID	Depth	Latitude	Longitude
BH-01	30	48.368017	-96.337097
BH-02	30	48.368674	-96.335904
BH-03	30	48.369304	-96.322735
BH-04	15	48.369198	-96.302887
BH-05	15	48.369077	-96.286258
BH-06	30	48.384209	-96.321153
BH-07	30	48.382204	-96.321976
BH-08	30	48.376196	-96.322259
BH-09	45	48.372766	-96.335179
BH-10	30	48.38003	-96.343075
BH-11	30	48.357643	-96.231011
BH-12	30	48.357445	-96.258671
BH-13	45	48.357142	-96.279686
BH-14	30	48.343344	-96.280226
BH-15	30	48.350775	-96.258935

0 0.25 0.5
Miles

Proposed Boring Locations
Potential Embankment Footprint
Diversion Ditch
MSTRWD Ditch
River
Major Roadway
Railroad
Section Lines

BOREHOLE LOCATION PLAN
NEWFOLDEN / MIDDLE RIVER SUBWATERSHED FLOOD DAMAGE REDUCTION PROJECT

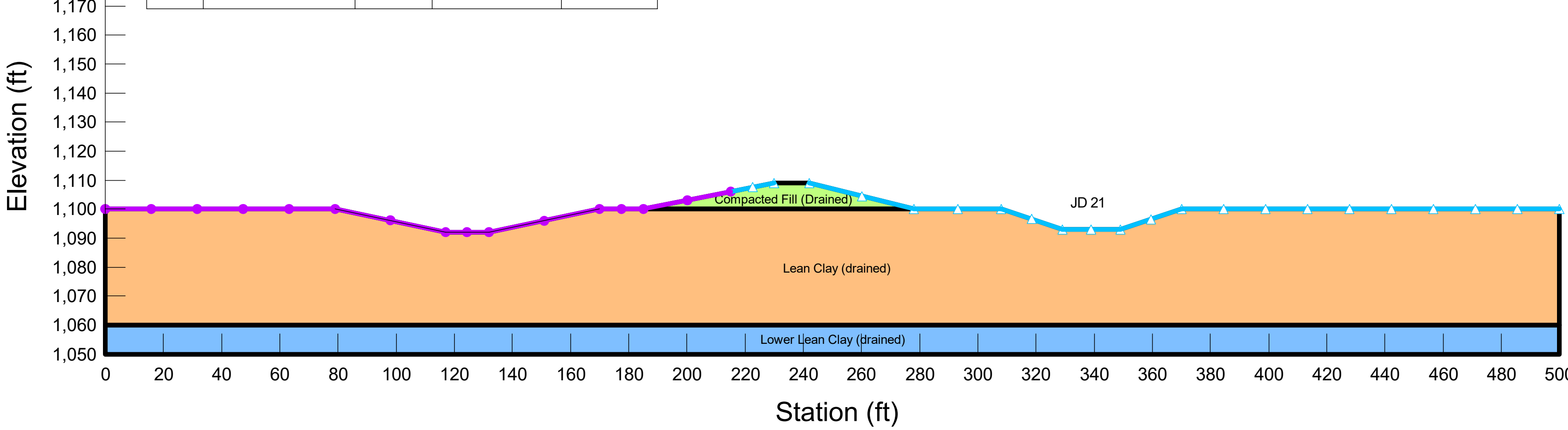
Attachment B

SEEP/W Seepage Analysis Results

Name: Steady State Seepage
File Name: Newfolden_BH8_JD21.gsz
Kind: SEEP/W
Method: Steady-State
Date: 07/12/2021

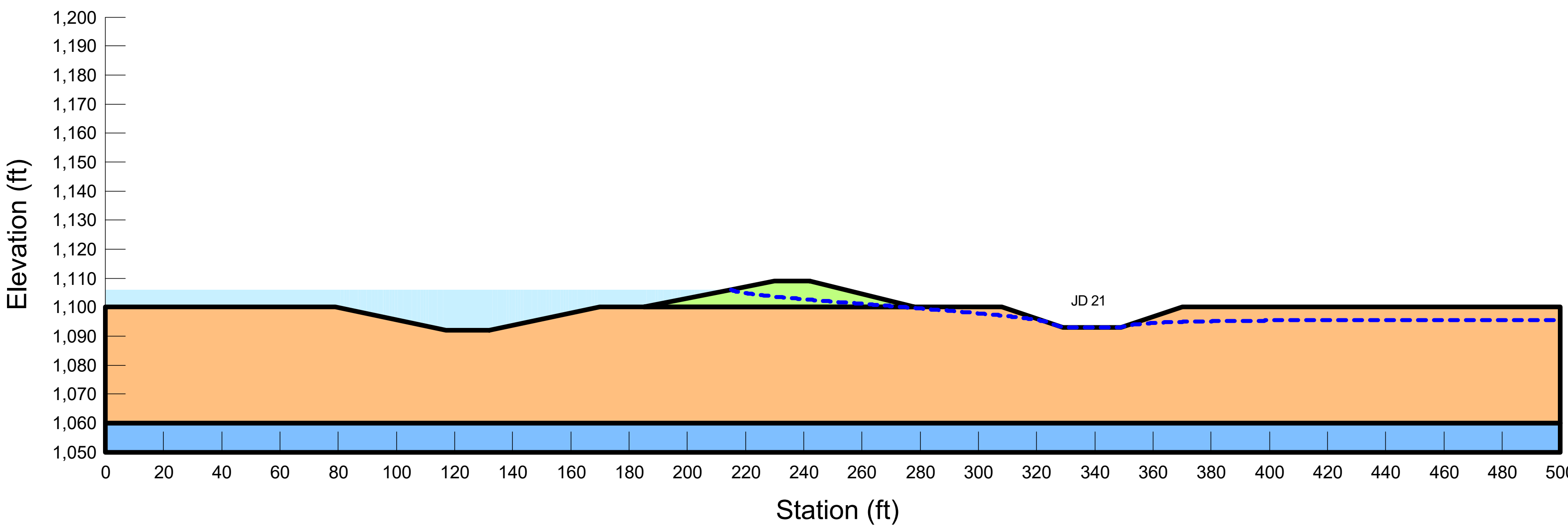
Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0

Color	Name	Category	Kind	Parameters
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/d
	Upstream Boundary Condition 1106	Hydraulic	Water Total Head	1,106 ft



Name: Steady State Seepage
File Name: Newfolden_BH8_JD21.gsz
Kind: SEEP/W
Method: Steady-State
Date: 06/15/2021

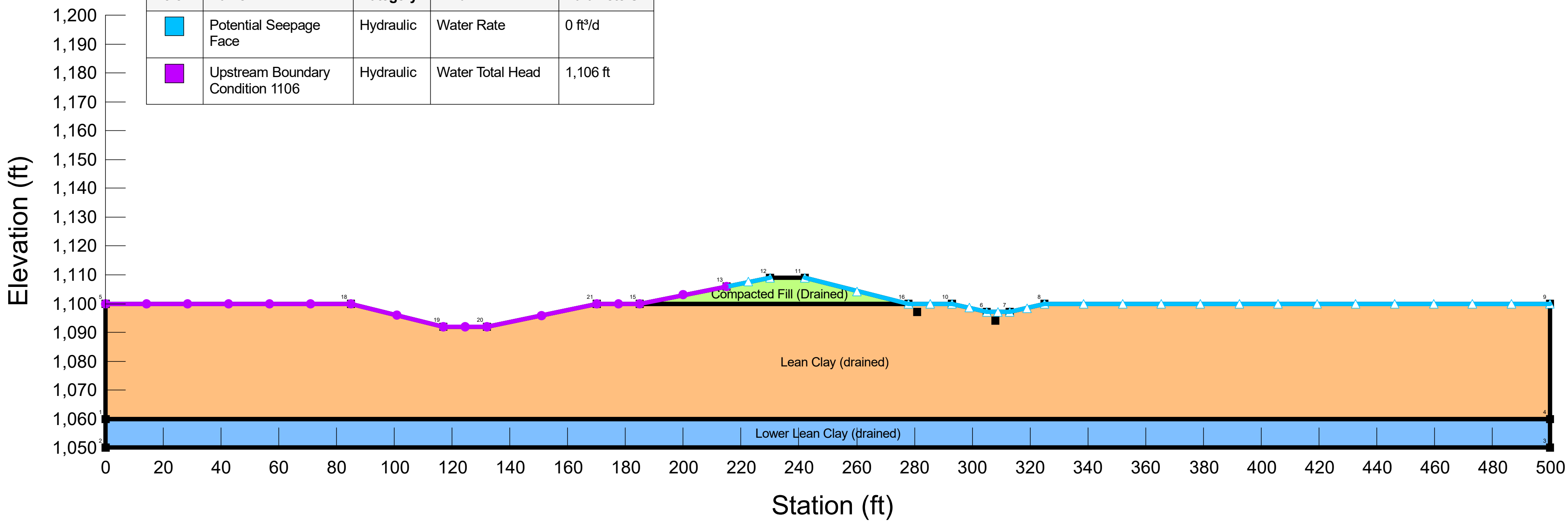
Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0



Name: Steady State Seepage
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SEEP/W
Method: Steady-State
Date: 07/12/2021

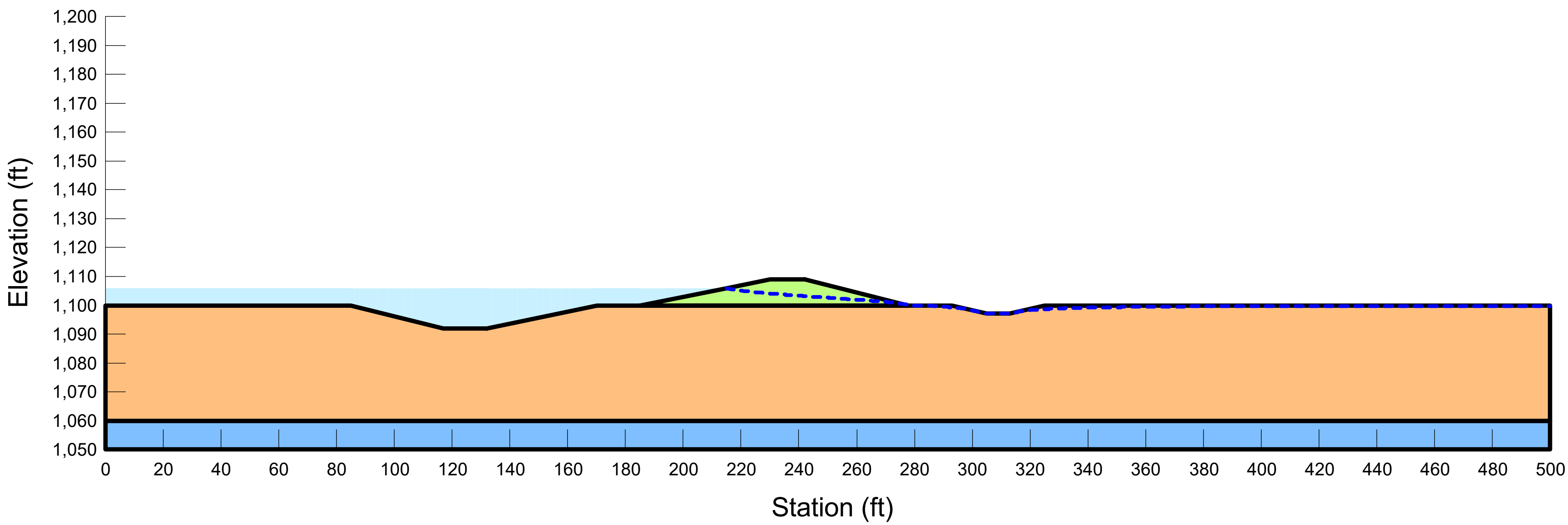
Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0

Color	Name	Category	Kind	Parameters
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/d
	Upstream Boundary Condition 1106	Hydraulic	Water Total Head	1,106 ft



Name: Steady State Seepage
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SEEP/W
Method: Steady-State
Date: 06/15/2021

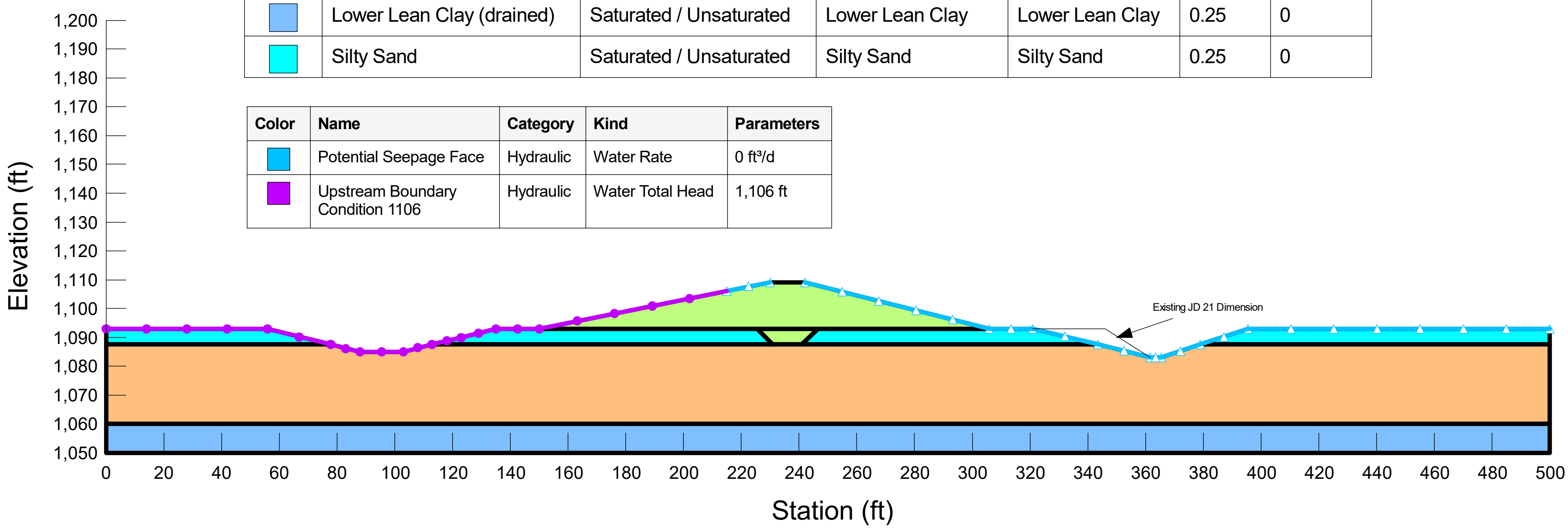
Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0



Name: Steady State Seepage
File Name: Newfolden BH9_JD 21.gsz
Kind: SEEP/W
Method: Steady-State
Date: 07/12/2021

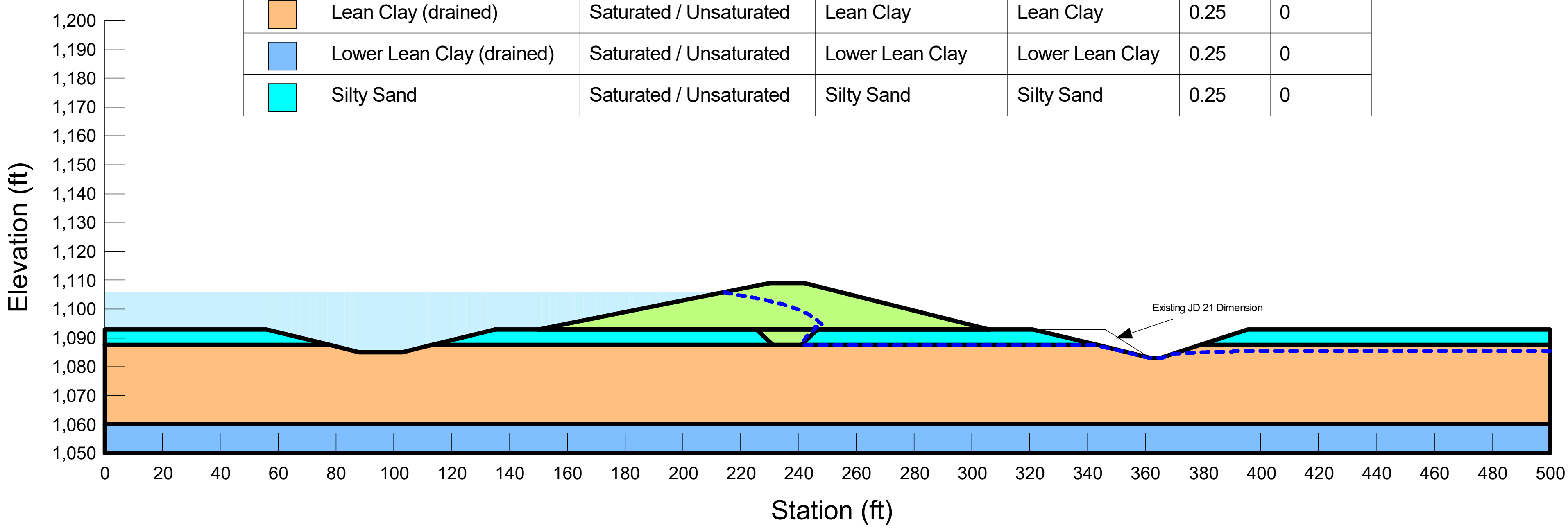
Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0
	Silty Sand	Saturated / Unsaturated	Silty Sand	Silty Sand	0.25	0

Color	Name	Category	Kind	Parameters
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/d
	Upstream Boundary Condition 1106	Hydraulic	Water Total Head	1,106 ft



Name: Steady State Seepage
File Name: Newfolden BH9_JD 21.gsz
Kind: SEEP/W
Method: Steady-State
Date: 06/16/2021

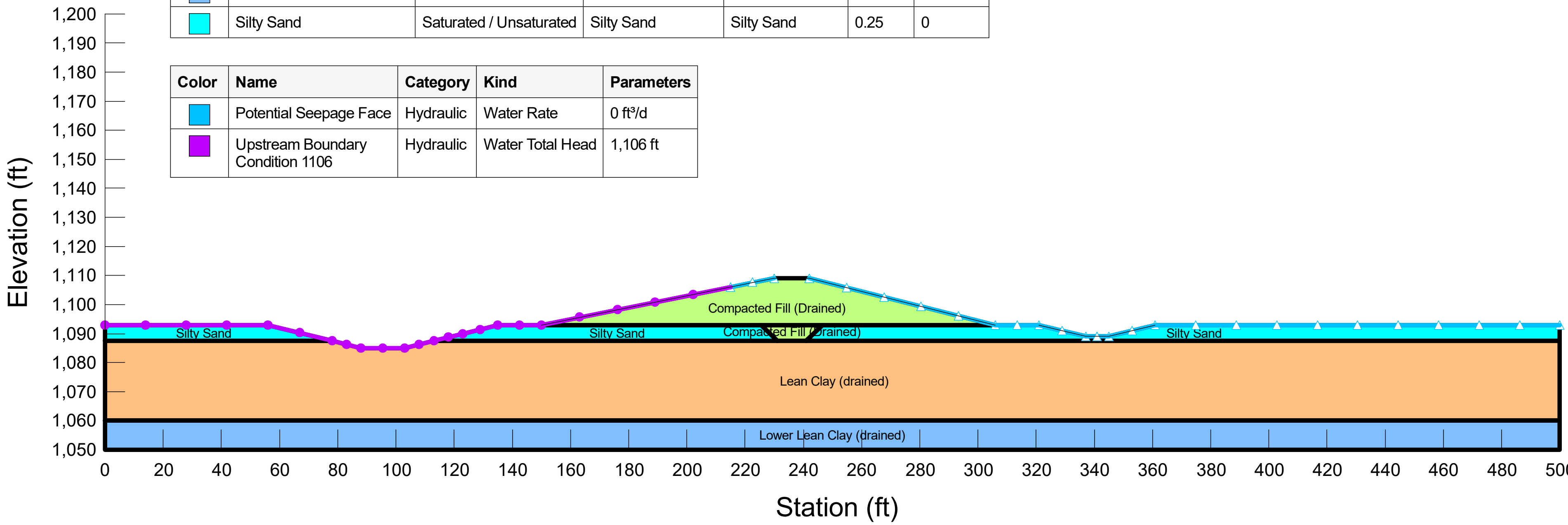
Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0
	Silty Sand	Saturated / Unsaturated	Silty Sand	Silty Sand	0.25	0



Name: Steady State Seepage
File Name: Newfolden BH9_Exterior Ditch.gsz
Kind: SEEP/W
Method: Steady-State
Date: 06/16/2021

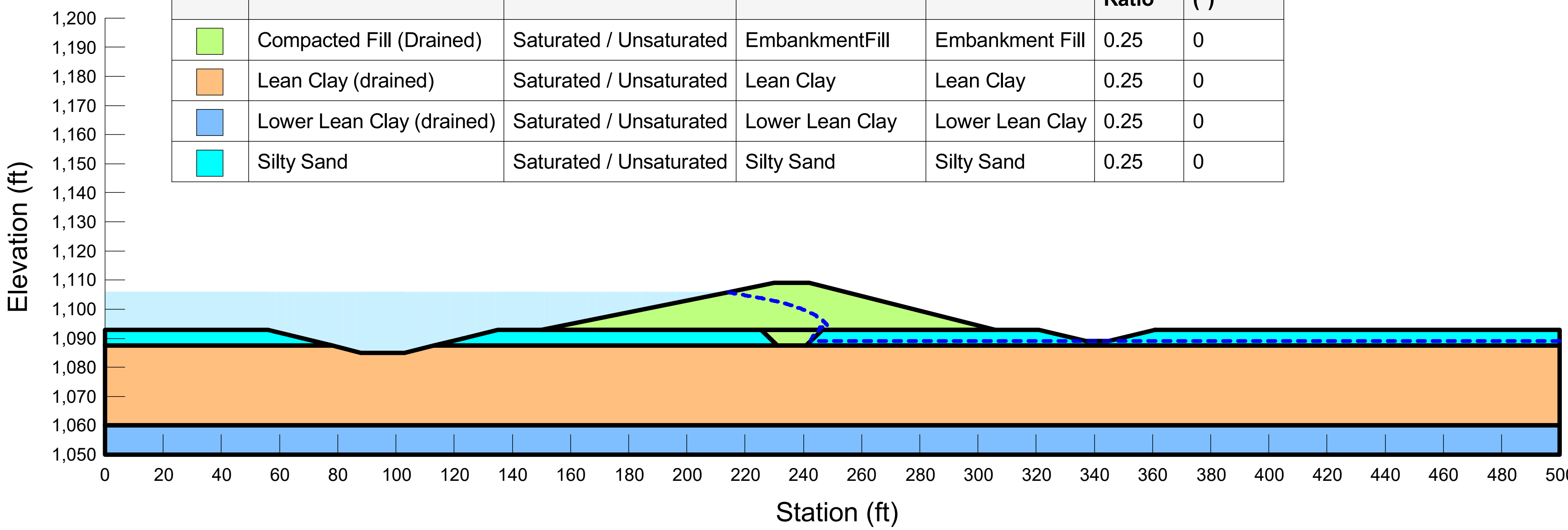
Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0
	Silty Sand	Saturated / Unsaturated	Silty Sand	Silty Sand	0.25	0

Color	Name	Category	Kind	Parameters
	Potential Seepage Face	Hydraulic	Water Rate	0 ft³/d
	Upstream Boundary Condition 1106	Hydraulic	Water Total Head	1,106 ft



Name: Steady State Seepage
File Name: Newfolden BH9_Exterior Ditch.gsz
Kind: SEEP/W
Method: Steady-State
Date: 06/15/2021

Color	Name	Material Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio	Rotation (°)
	Compacted Fill (Drained)	Saturated / Unsaturated	EmbankmentFill	Embankment Fill	0.25	0
	Lean Clay (drained)	Saturated / Unsaturated	Lean Clay	Lean Clay	0.25	0
	Lower Lean Clay (drained)	Saturated / Unsaturated	Lower Lean Clay	Lower Lean Clay	0.25	0
	Silty Sand	Saturated / Unsaturated	Silty Sand	Silty Sand	0.25	0

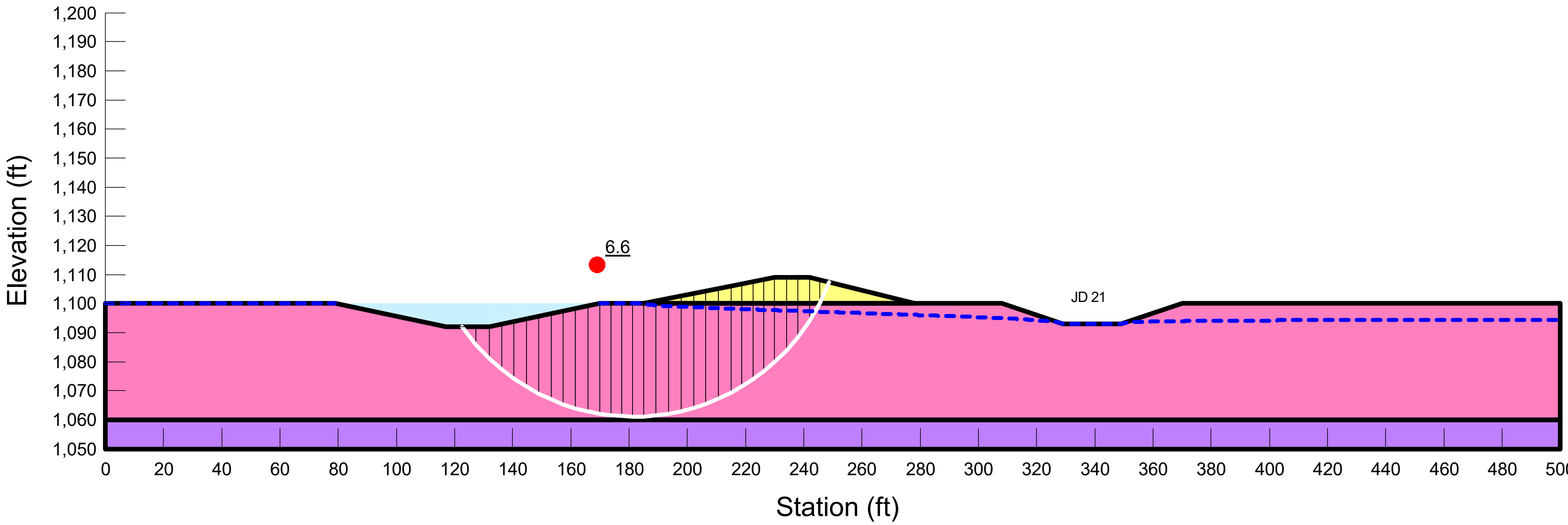


Attachment C

SLOPE/W Slope Stability Analysis Results

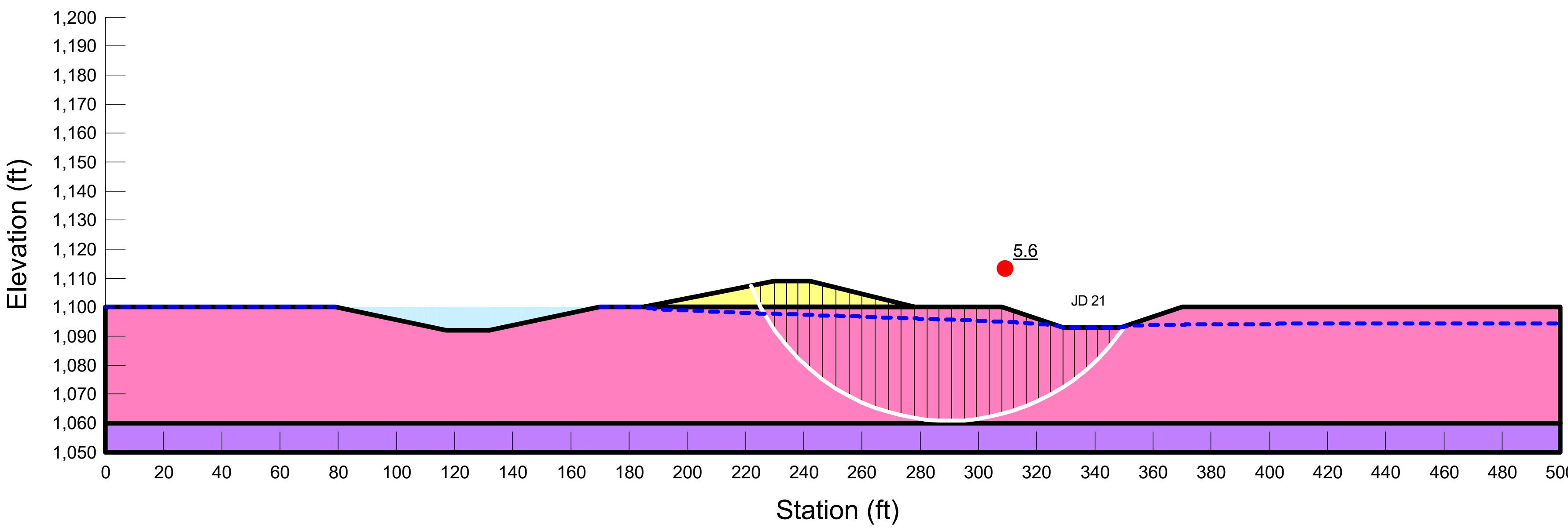
Name: Slope Stability - Short Term EOC US
File Name: Newfolden_BH8_JD21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Cohesion (psf)
Yellow	Compacted Fill (Undrained)	Undrained (Phi=0)	125	1,200
Pink	Lean Clay (Undrained)	Undrained (Phi=0)	131	1,600
Purple	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138	5,000



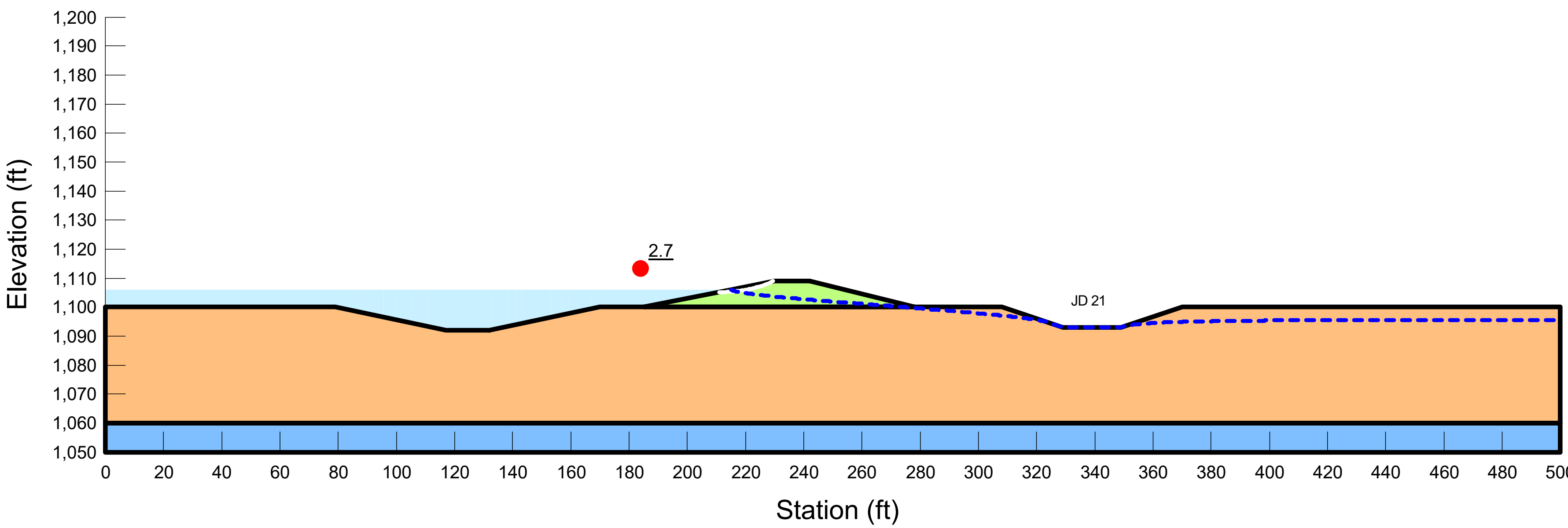
Name: Slope Stability - Short Term EOC DS
File Name: Newfolden_BH8_JD21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Cohesion (psf)
	Compacted Fill (Undrained)	Undrained (Phi=0)	125	1,200
	Lean Clay (Undrained)	Undrained (Phi=0)	131	1,600
	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138	5,000



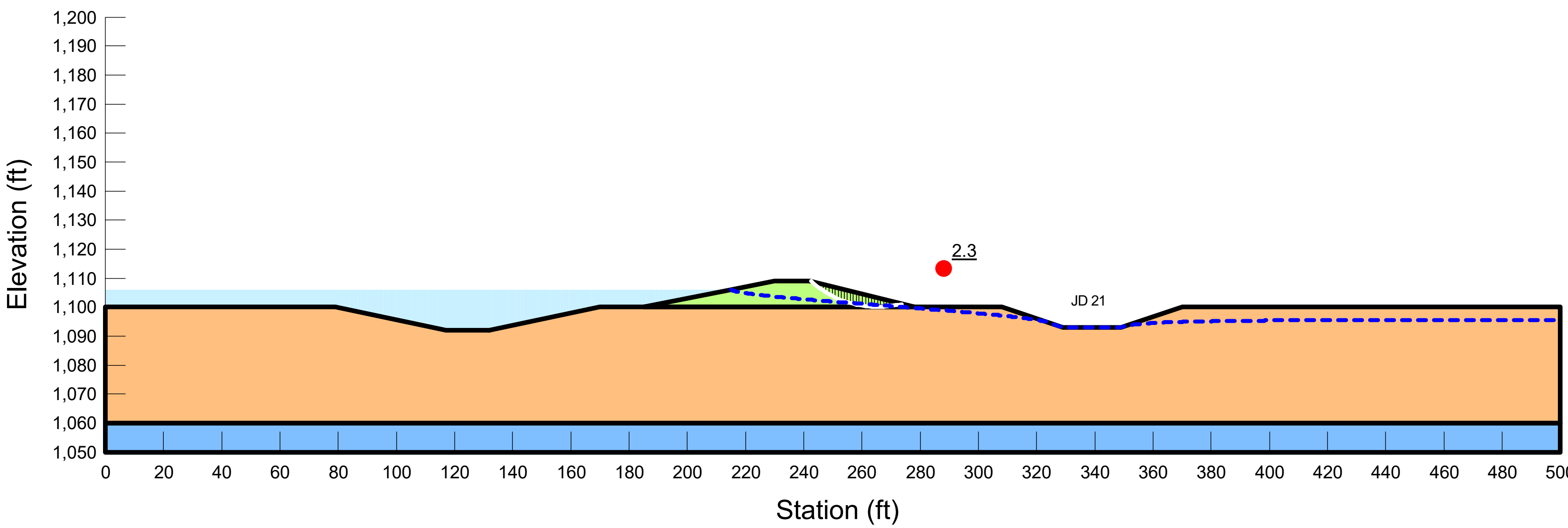
Name: Slope - Long Term (drained) US
File Name: Newfolden_BH8_JD21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0



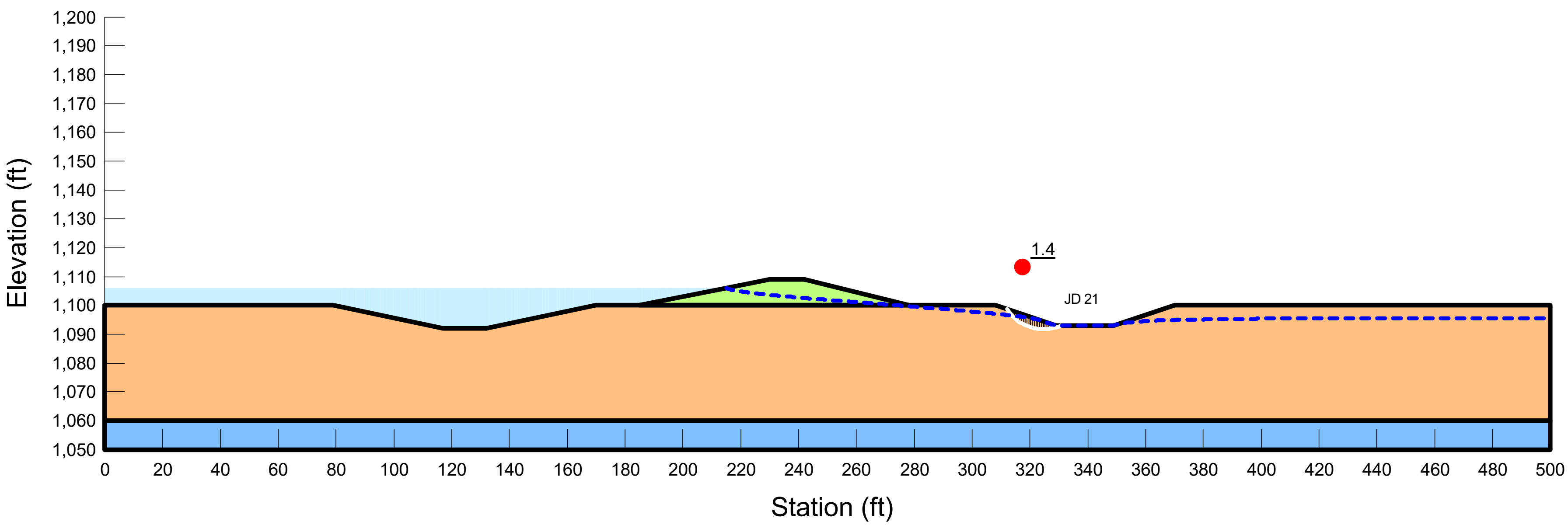
Name: Slope - Long Term (drained) DS
File Name: Newfolden_BH8_JD21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0



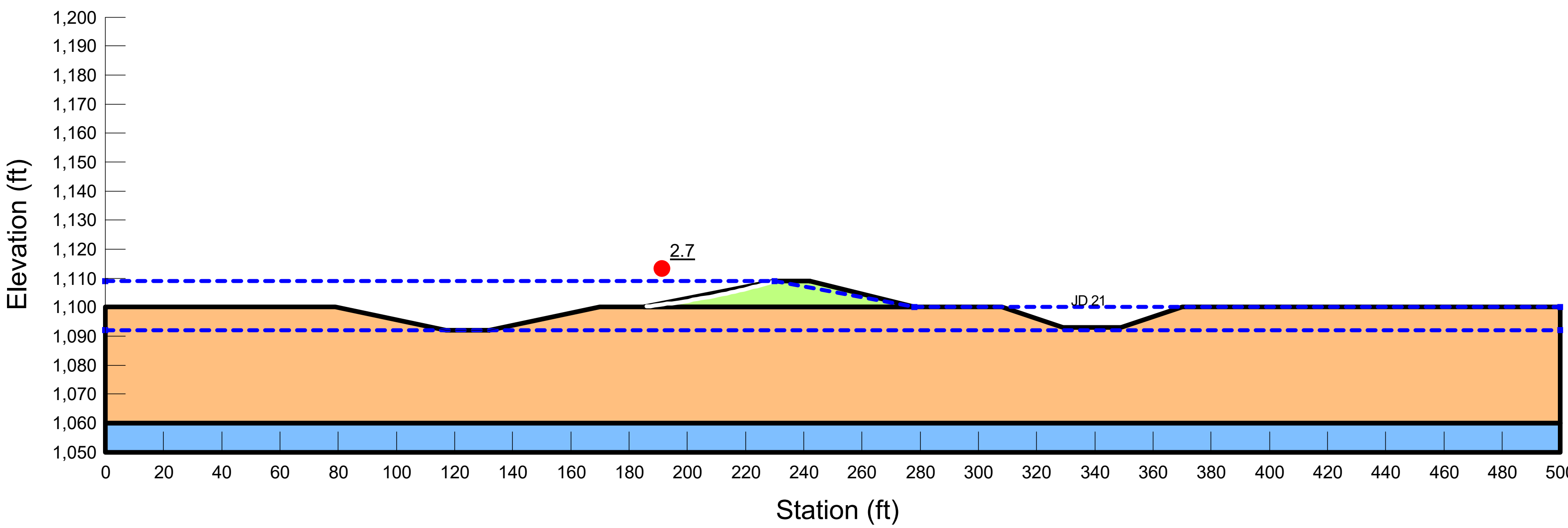
Name: Slope - Long Term (drained) ditch
File Name: Newfolden_BH8_JD21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0



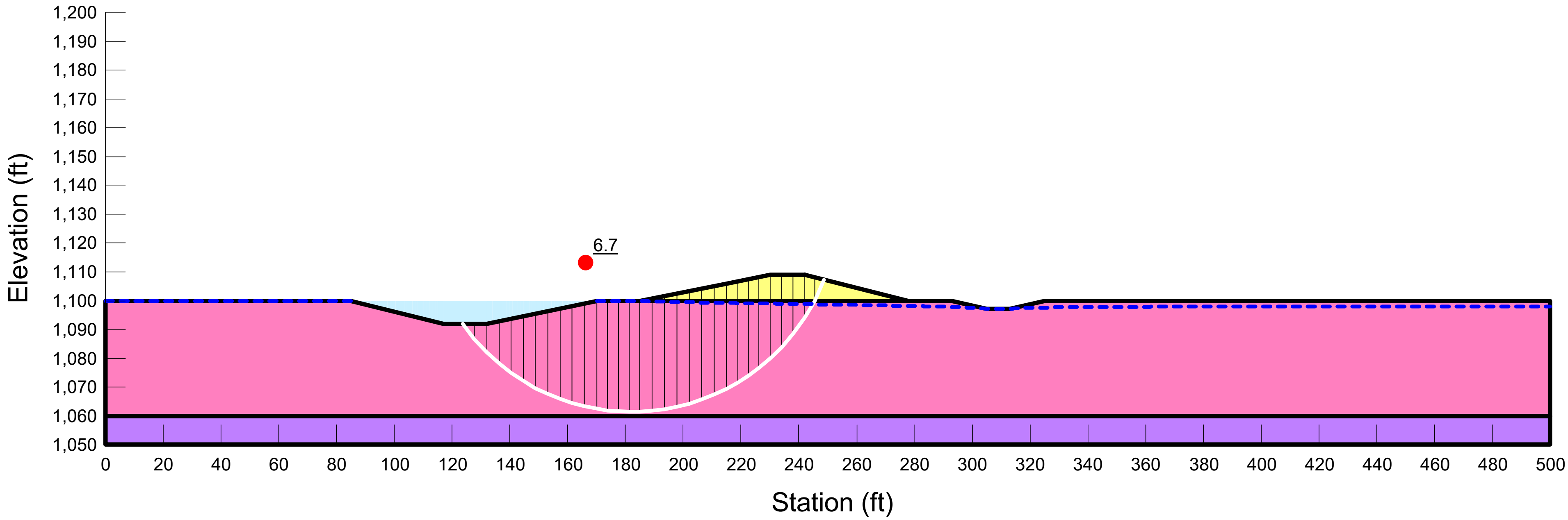
Name: Slope Stability - Rapid Draw Down
File Name: Newfolden_BH8_JD21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0	1,200	0	1	2
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0	1,600	0	1	2
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0	5,000	0	1	2



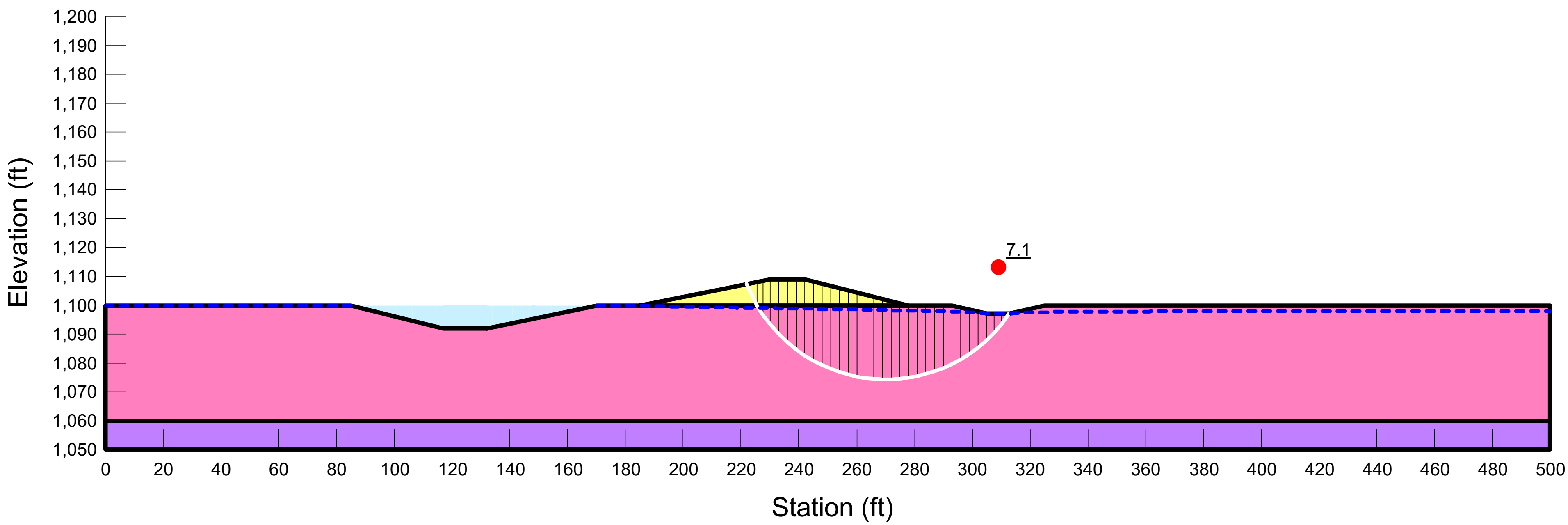
Name: Slope Stability - Short Term EOC US
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Cohesion (psf)
	Compacted Fill (Undrained)	Undrained (Phi=0)	125	1,200
	Lean Clay (Undrained)	Undrained (Phi=0)	131	1,600
	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138	5,000



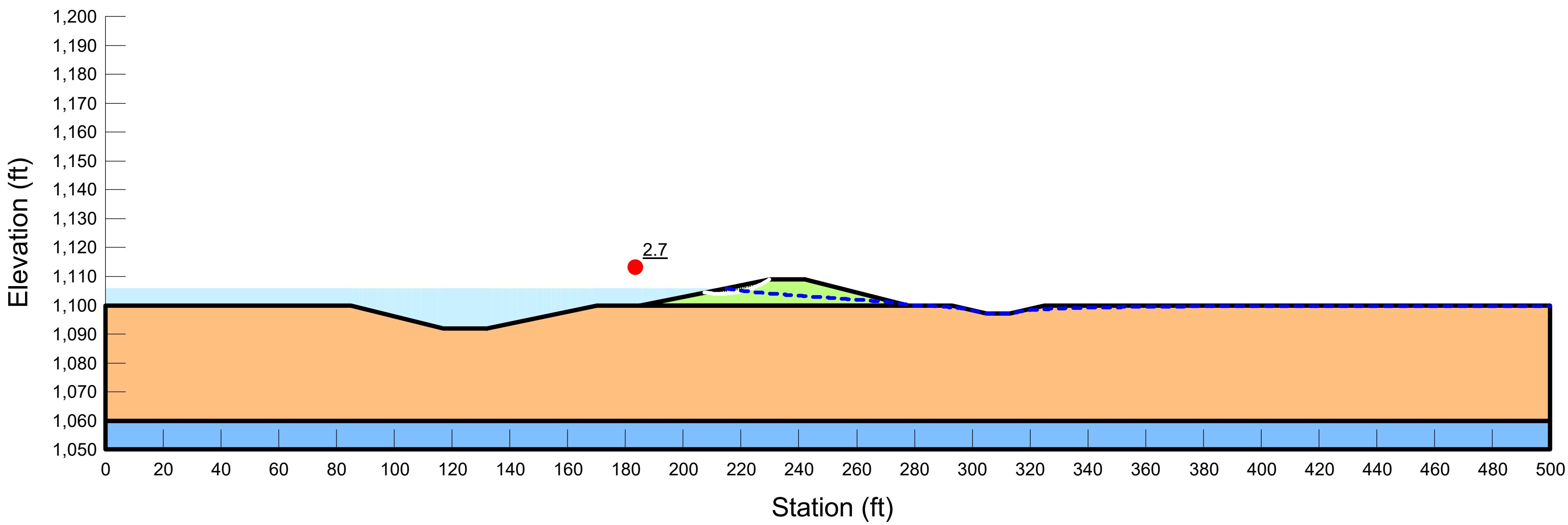
Name: Slope Stability - Short Term EOC DS
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Cohesion (psf)
	Compacted Fill (Undrained)	Undrained (Phi=0)	125	1,200
	Lean Clay (Undrained)	Undrained (Phi=0)	131	1,600
	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138	5,000



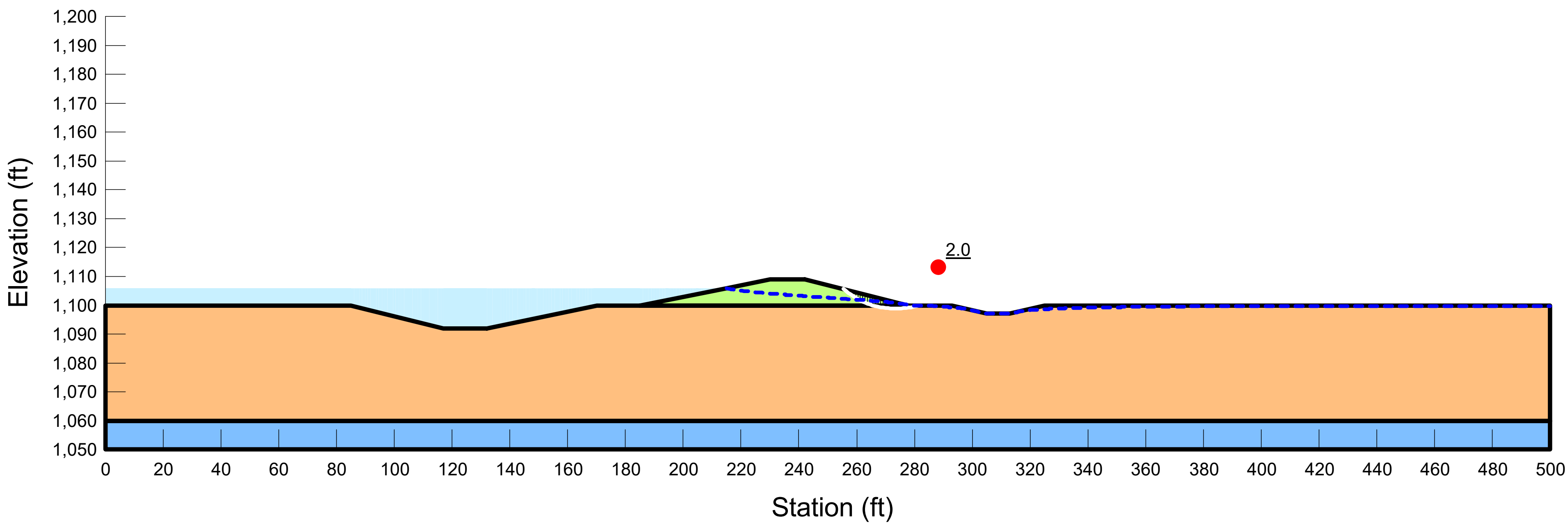
Name: Slope - Long Term (drained) US
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0



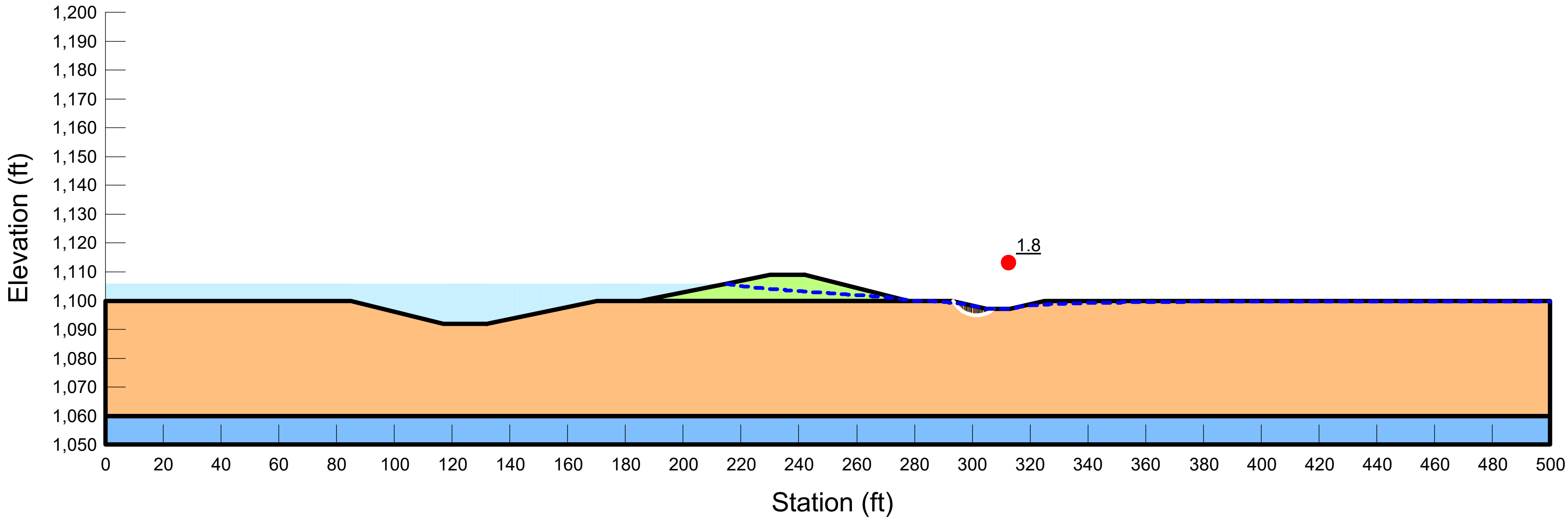
Name: Slope - Long Term (drained) DS
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0



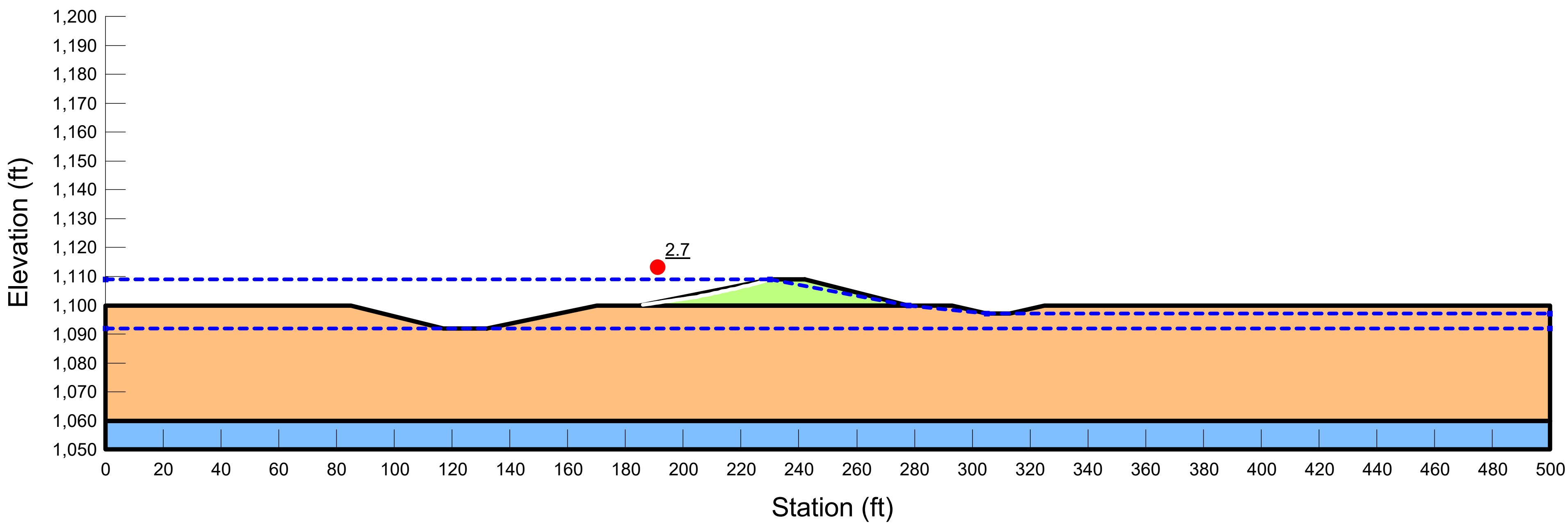
Name: Slope - Long Term (drained) ditch
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/16/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0



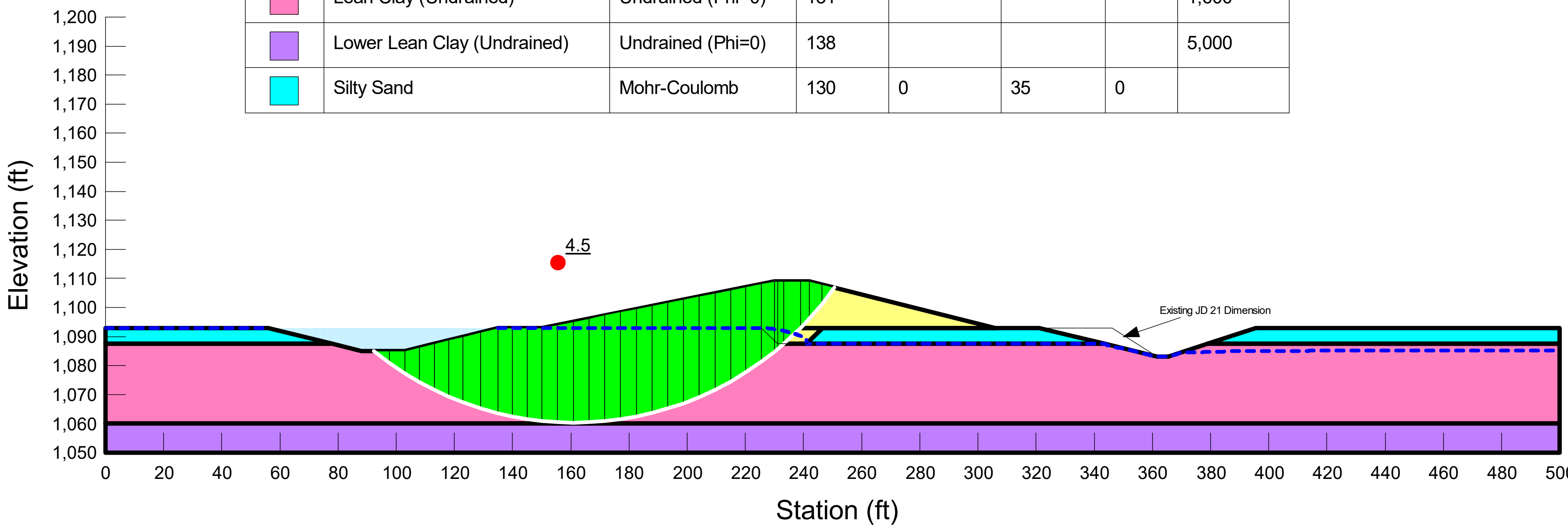
Name: Slope Stability - Rapid Draw Down
File Name: Newfolden_BH8_Exterior Ditch.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezomet Line Afte Drawdow
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0	1,200	0	1	2
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0	1,600	0	1	2
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0	5,000	0	1	2



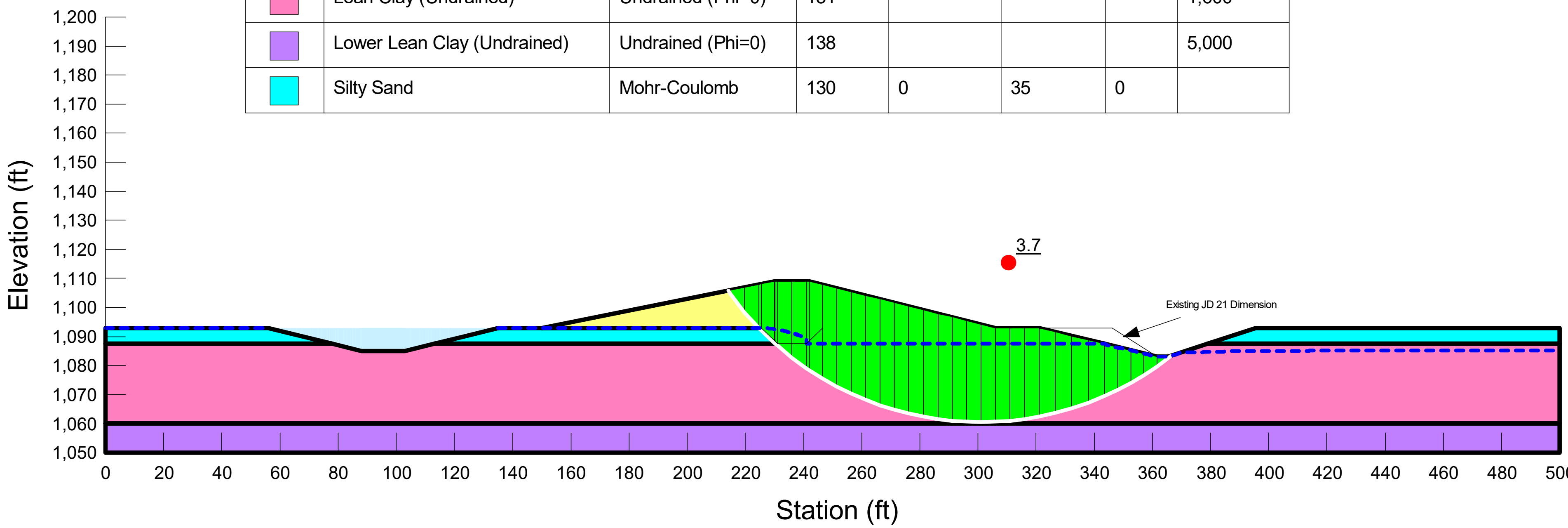
Name: Slope Stability - Short Term EOC US
File Name: Newfolden BH9_JD 21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion (psf)
	Compacted Fill (Undrained)	Undrained (Phi=0)	125				1,200
	Lean Clay (Undrained)	Undrained (Phi=0)	131				1,600
	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138				5,000
	Silty Sand	Mohr-Coulomb	130	0	35	0	



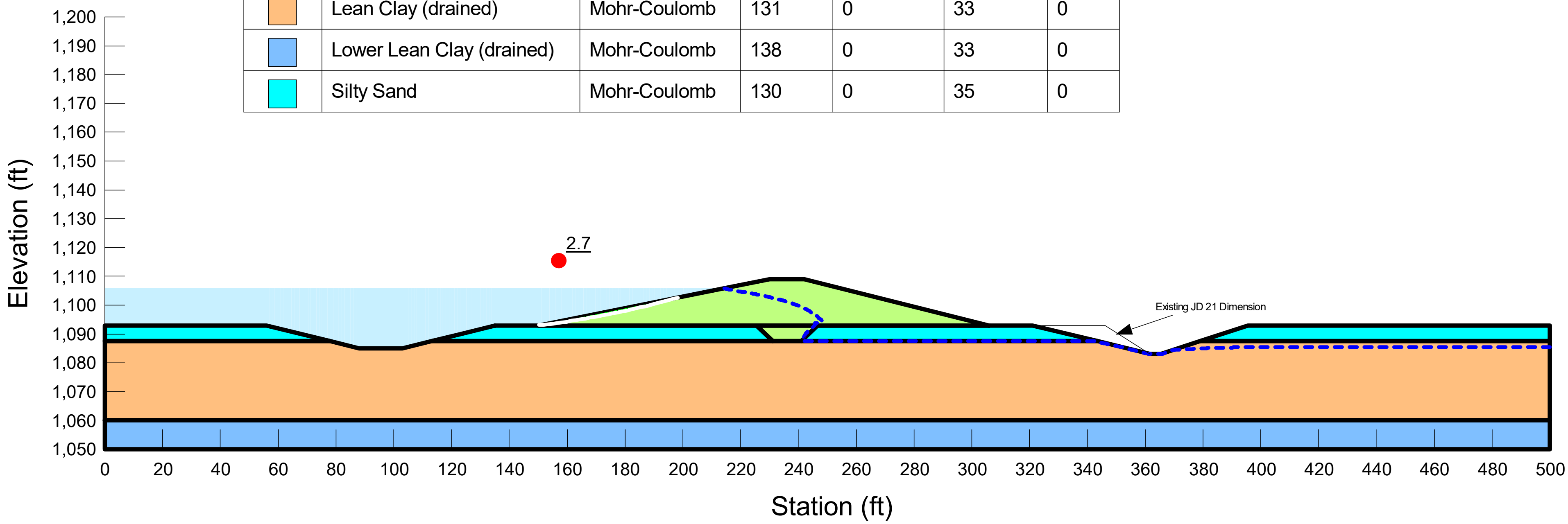
Name: Slope Stability - Short Term EOC DS
File Name: Newfolden BH9_JD 21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion (psf)
	Compacted Fill (Undrained)	Undrained (Phi=0)	125				1,200
	Lean Clay (Undrained)	Undrained (Phi=0)	131				1,600
	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138				5,000
	Silty Sand	Mohr-Coulomb	130	0	35	0	



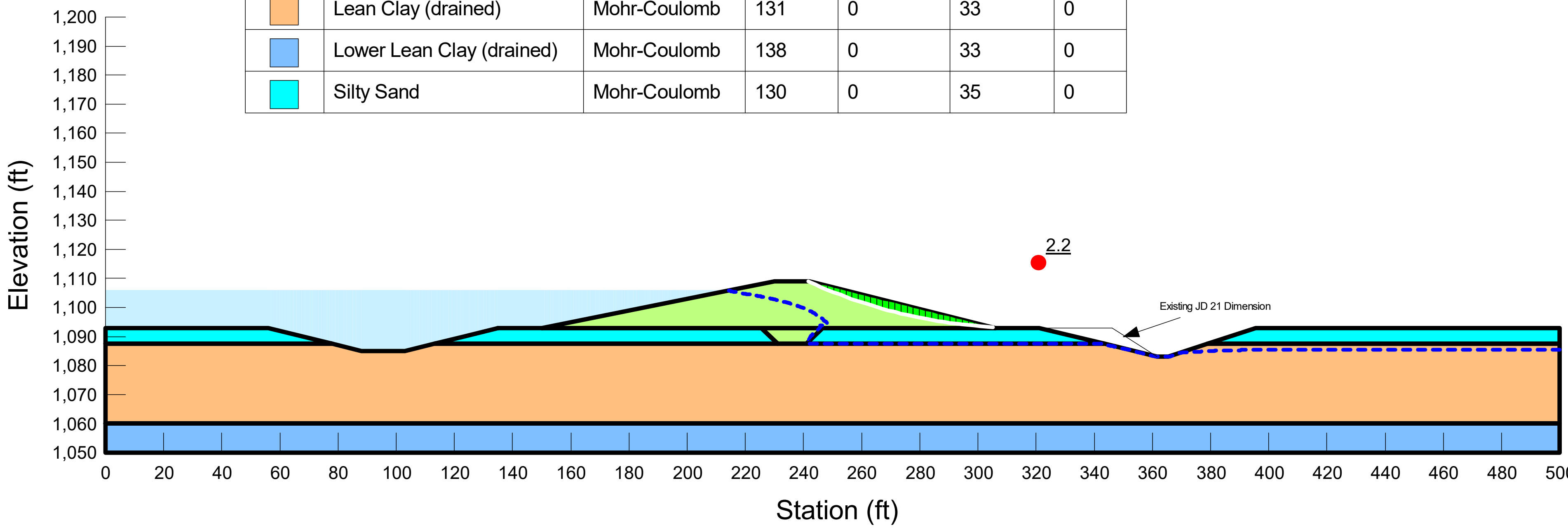
Name: Slope - Steady State Seepage, Long Term (drained) US
File Name: Newfolden BH9_JD 21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0
	Silty Sand	Mohr-Coulomb	130	0	35	0



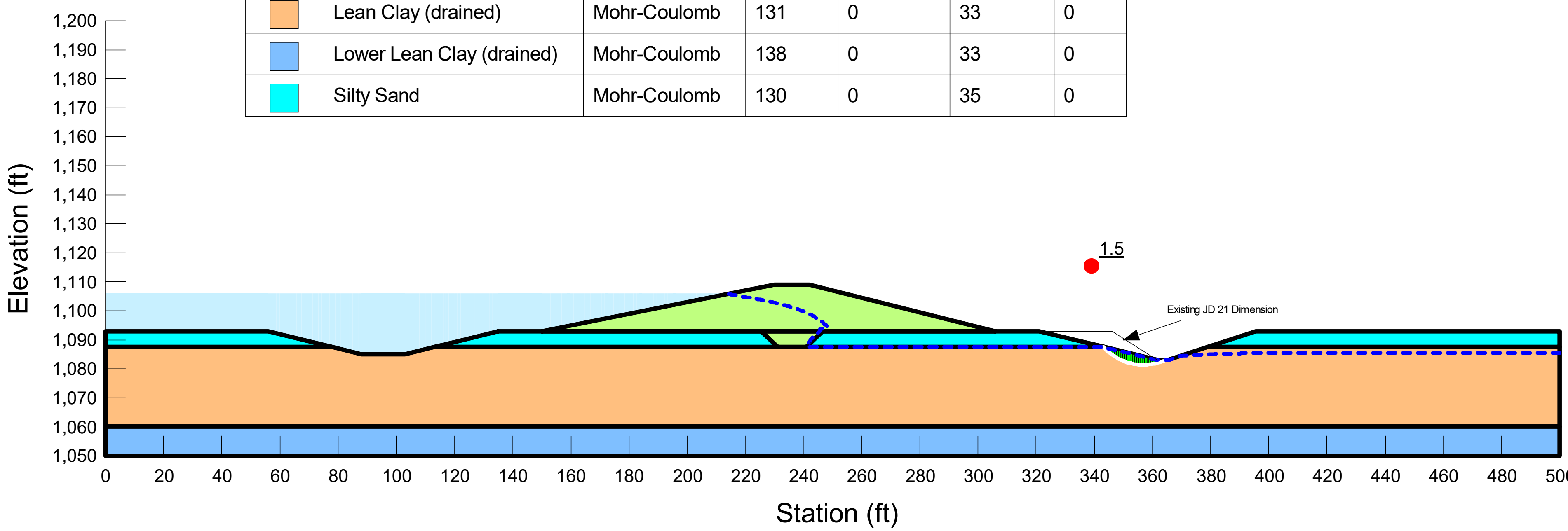
Name: Slope - Steady State Seepage, Long Term (drained) DS
File Name: Newfolden BH9_JD 21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0
	Silty Sand	Mohr-Coulomb	130	0	35	0



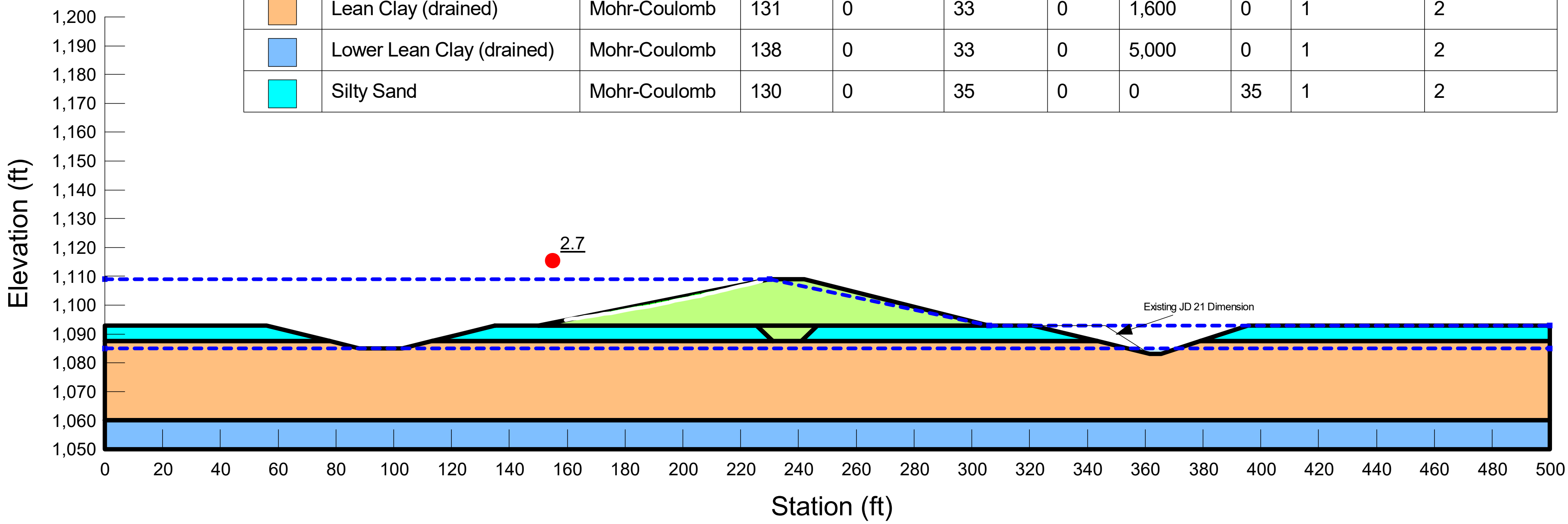
Name: Slope - Steady State Seepage, Long Term (drained) ditch
File Name: Newfolden BH9_JD 21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0
	Silty Sand	Mohr-Coulomb	130	0	35	0



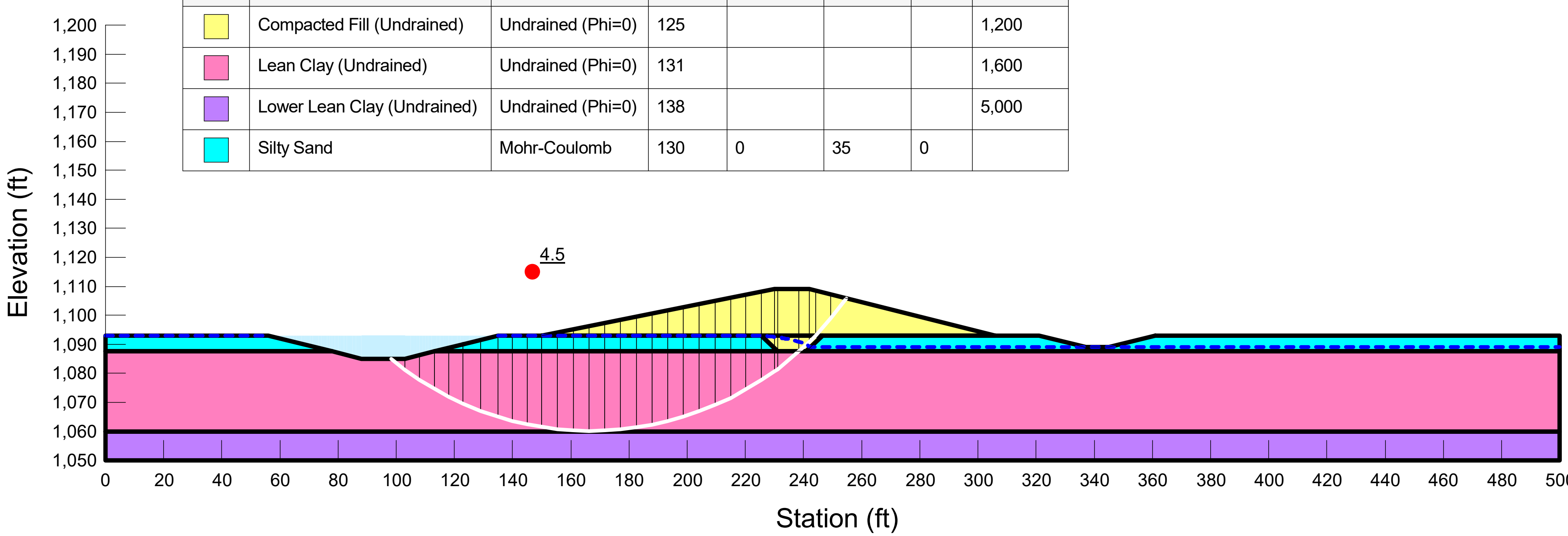
Name: Slope Stability - Rapid Draw Down
File Name: Newfolden BH9_JD 21.gsz
Kind: SLOPE/W
Method: Spencer
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0	1,200	0	1	2
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0	1,600	0	1	2
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0	5,000	0	1	2
	Silty Sand	Mohr-Coulomb	130	0	35	0	0	35	1	2



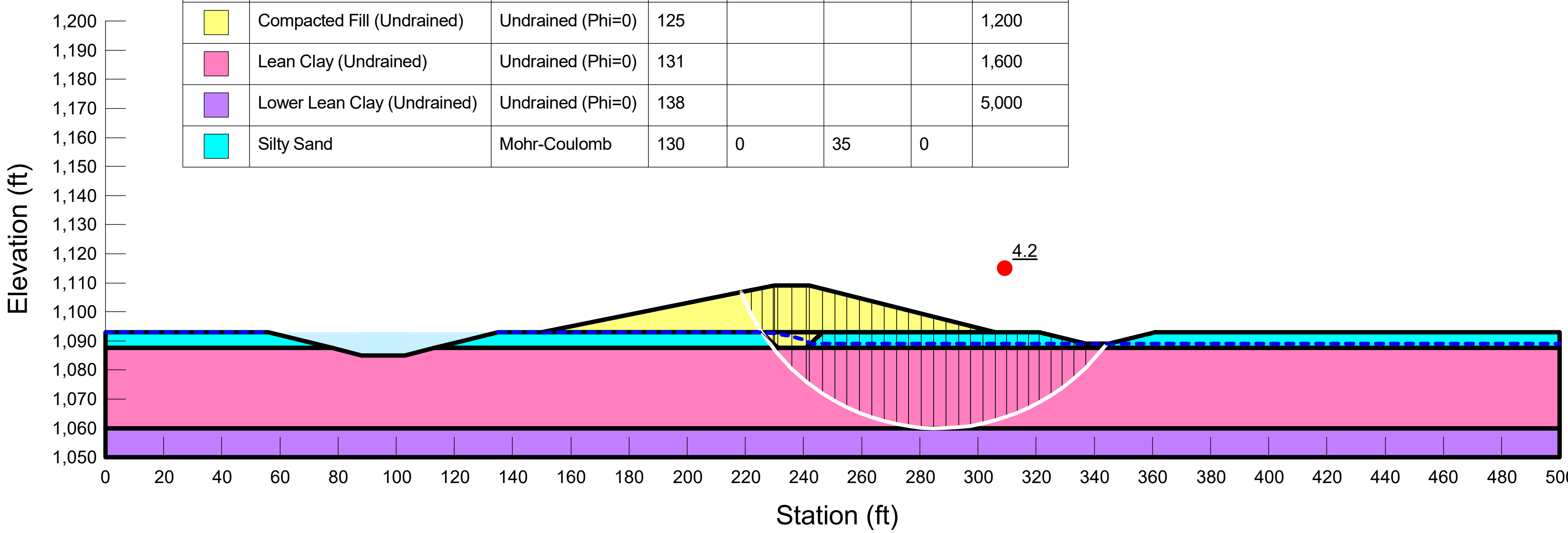
File Name: Newfolden BH9_Exterior Ditch.gsz
Name: Slope Stability - Short Term EOC US
Description:
F of S: 4.5
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion (psf)
	Compacted Fill (Undrained)	Undrained (Phi=0)	125				1,200
	Lean Clay (Undrained)	Undrained (Phi=0)	131				1,600
	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138				5,000
	Silty Sand	Mohr-Coulomb	130	0	35	0	



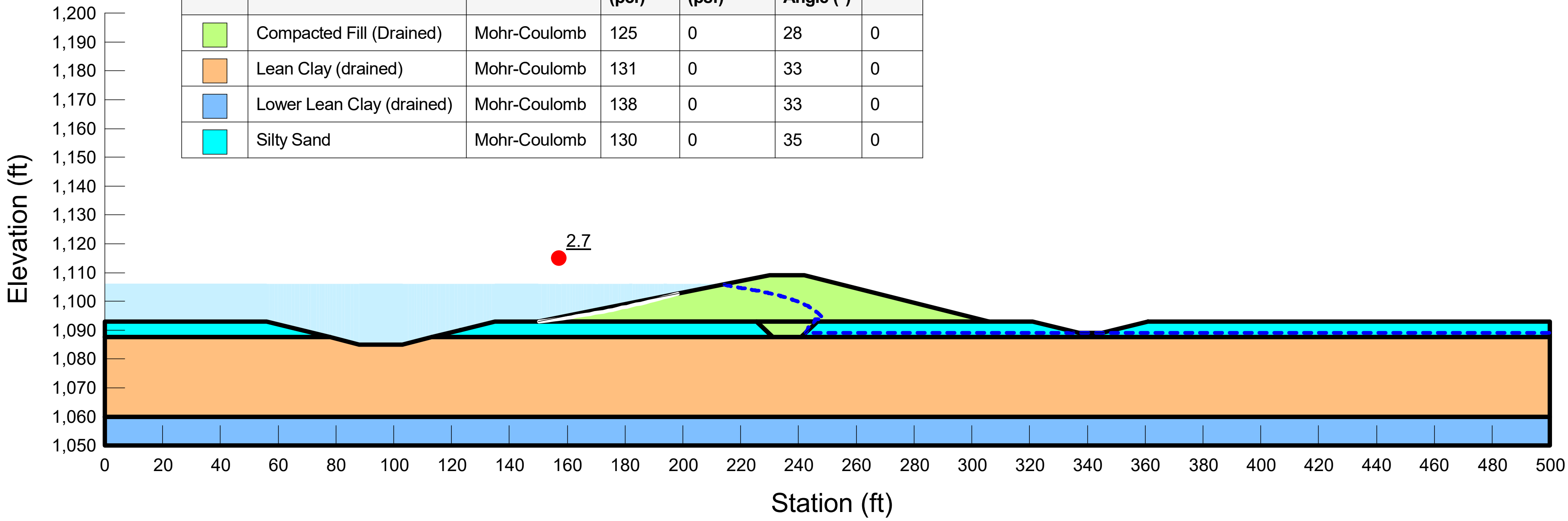
File Name: Newfolden BH9_Exterior Ditch.gsz
Name: Slope Stability - Short Term EOC DS
Description:
F of S: 4.2
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion (psf)
	Compacted Fill (Undrained)	Undrained (Phi=0)	125				1,200
	Lean Clay (Undrained)	Undrained (Phi=0)	131				1,600
	Lower Lean Clay (Undrained)	Undrained (Phi=0)	138				5,000
	Silty Sand	Mohr-Coulomb	130	0	35	0	



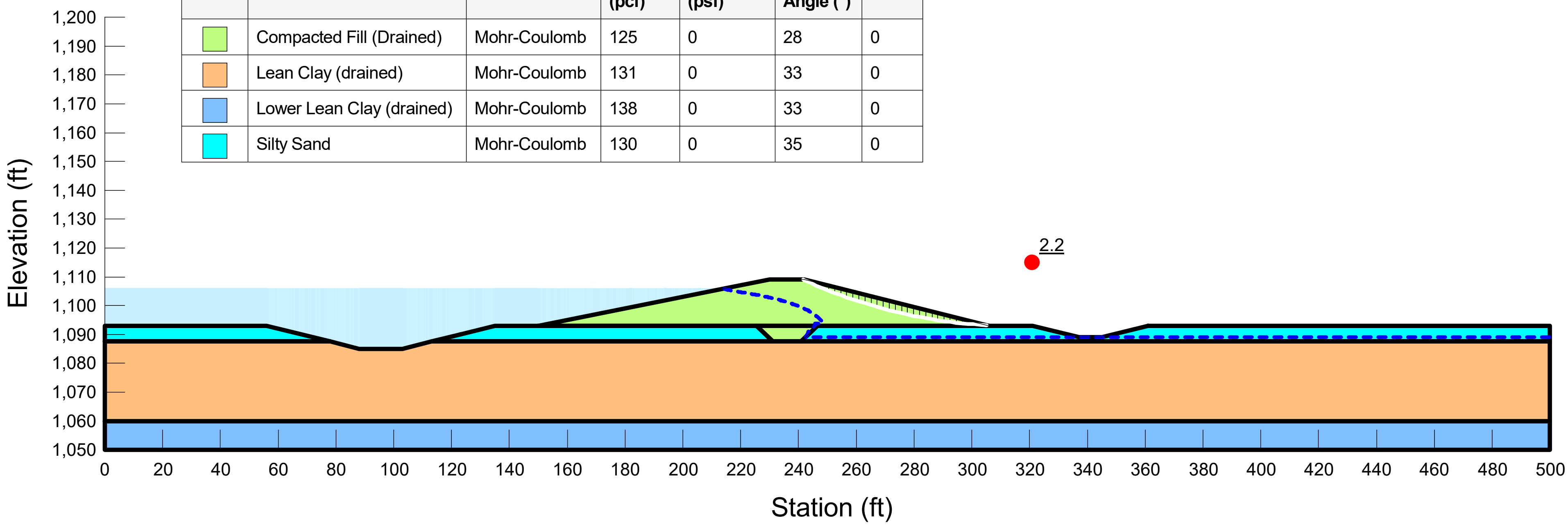
File Name: Newfolden BH9_Exterior Ditch.gsz
Name: Slope - Steady State Seepage, Long Term (drained) US
Description: Long-Term Stability Analysis_Steady State Seepage
F of S: 2.7
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0
	Silty Sand	Mohr-Coulomb	130	0	35	0



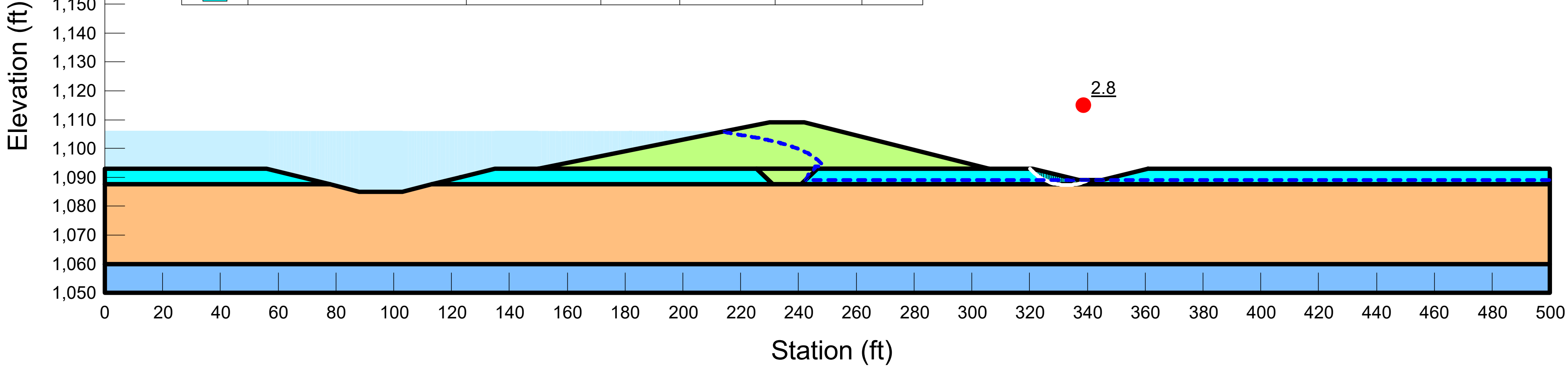
File Name: Newfolden BH9_Exterior Ditch.gsz
Name: Slope - Steady State Seepage, Long Term (drained) DS
Description: Long-Term Stability Analysis_Steady State Seepage
F of S: 2.2
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0
	Silty Sand	Mohr-Coulomb	130	0	35	0



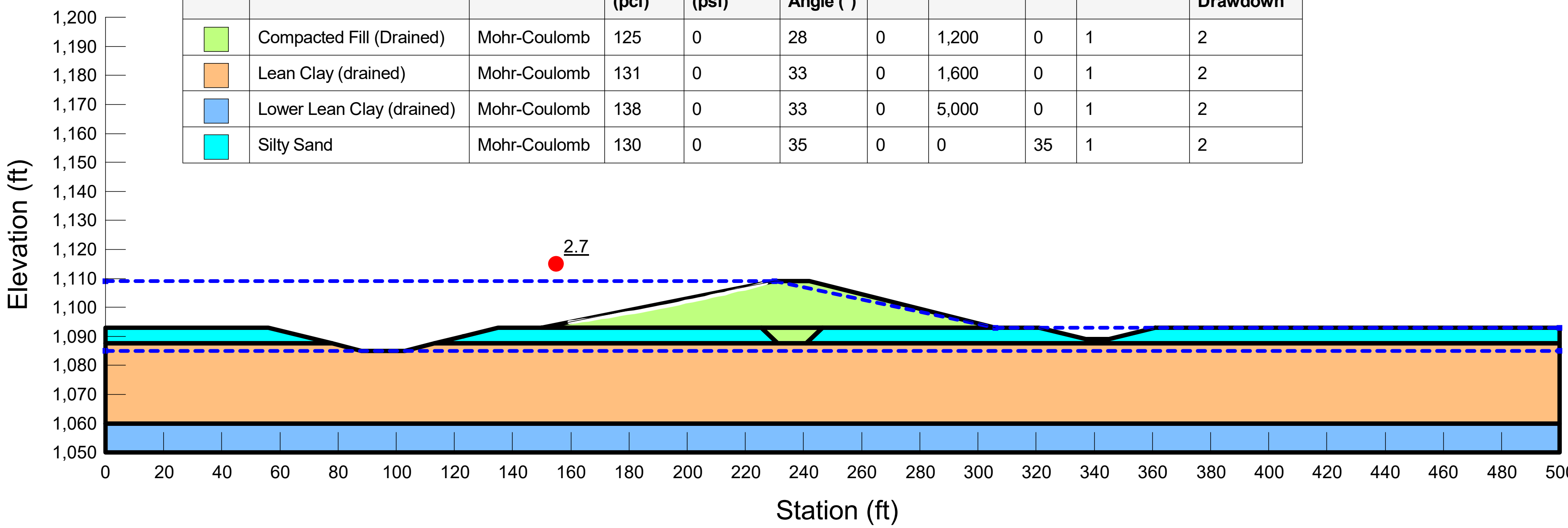
File Name: Newfolden BH9_Exterior Ditch.gsz
Name: Slope - Steady State Seepage, Long Term (drained) ditch
Description: Long-Term Stability Analysis_Steady State Seepage
F of S: 2.8
Date: 06/16/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0
	Silty Sand	Mohr-Coulomb	130	0	35	0



File Name: Newfolden BH9_Exterior Ditch.gsz
Name: Slope Stability - Rapid Draw Down
Description: Drawdown Analysis
F of S: 2.7
Date: 06/15/2021

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Phi-B (°)	Cohesion R (psf)	Phi R (°)	Piezometric Line	Piezometric Line After Drawdown
	Compacted Fill (Drained)	Mohr-Coulomb	125	0	28	0	1,200	0	1	2
	Lean Clay (drained)	Mohr-Coulomb	131	0	33	0	1,600	0	1	2
	Lower Lean Clay (drained)	Mohr-Coulomb	138	0	33	0	5,000	0	1	2
	Silty Sand	Mohr-Coulomb	130	0	35	0	0	35	1	2



Attachment D

Settlement Calculations

COMBINED SETTLEMENT ANALYSIS FOR CLAYS AND SANDS

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21

EXISTING AND PROPOSED EMBANKMENT GEOMETRY

Existing Embankment

Load Type	t	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	0	ft
Unit Wt	120	pcf
Slope	1	H:V
Width	1	ft (for uniform/triangular/slope loads)

Proposed Embankment

Load Type	Tr	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	6	ft
Unit Wt	125	pcf
Slope	4.5	H:V (enter 0.01 for uniform strip/semi-infinite uniform load)
Widening	0	ft (toe to toe)
Width	0	ft (for triangular load; Width = 0.01 for Slope)

Point of Interest (in relation to toe of proposed embankment)

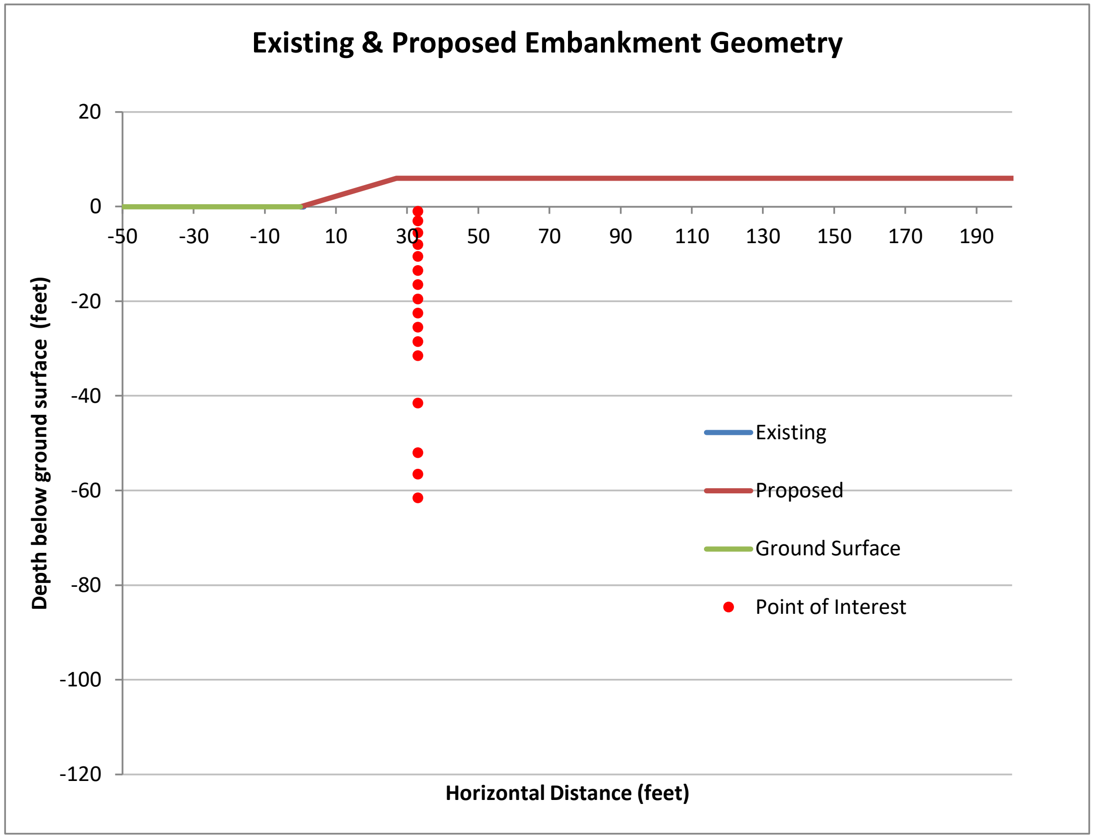
x	33	ft

Depth of Groundwater Table

D_w	0	ft

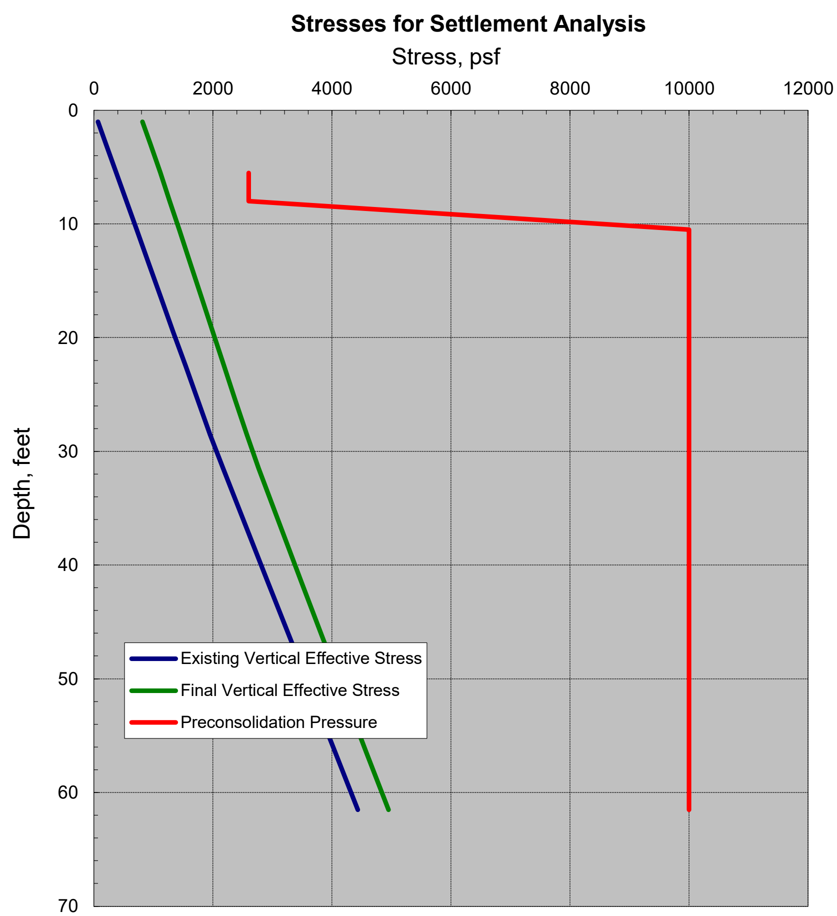
EMBANKMENT GEOMETRY

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21



EXISTING AND FINAL STRESSES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21



SOIL PROFILE AND MATERIAL PROPERTIES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21

	ELEVATION OF LAYER		SOIL LAYER AND MATERIAL PROPERTIES		
LAYER	TOP feet	BOTTOM feet	MATERIAL TYPE	N-VALUE BPF	SOIL UNIT WEIGHT (γ), pcf
1	1104	1102	Graded Silty Sand and Gr	6	130
1	1102	1100	Graded Silty Sand and Gr	6	130
1	1100	1097	Clay	10	131
2	1097	1095	Clay	10	131
2	1095	1092	Clay	10	131
2	1092	1089	Clay	10	131
2	1089	1086	Clay	15	131
3	1086	1083	Clay	15	131
3	1083	1080	Clay	15	131
3	1080	1077	Clay	15	131
3	1077	1074	Clay	15	131
3	1074	1071	Clay	50	138
13	1071	1054	Clay	70	138
14	1054	1050	Clay	70	138
15	1050	1045	Clay	70	138
16	1045	1040	Clay	70	138
17					
18					
19					
20					

CONSOLIDATION PROPERTIES OF SOIL LAYER

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21

	SAND AND CLAY CONSOLIDATION PARAMETERS							
LAYER	Compression Ratio CR	Recompression Ratio RR	cient of Consolidation c_v	nt of Consolidat c_{vr}	p'c psf	Drainage	H_{dr} ft	Sand Compressibility Coefficient ($C_{\varepsilon c}$)
1						both	1.000	0.021
1						both	1.000	0.021
1	0.19	0.019	0.650	5.580	2600	top	30.000	
2	0.19	0.019	0.650	5.580	2600	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
13	0.18	0.018	0.650	5.580	10000	None	30.000	
14	0.18	0.018	0.650	5.580	10000	None	30.000	
15	0.18	0.018	0.650	5.580	10000	None	30.000	
16	0.18	0.018	0.650	5.580	10000	Bottom	30.000	
17								
18								
19								
20								

STRESS DISTRIBUTION AND SETTLEMENT CALCULATIONS

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21

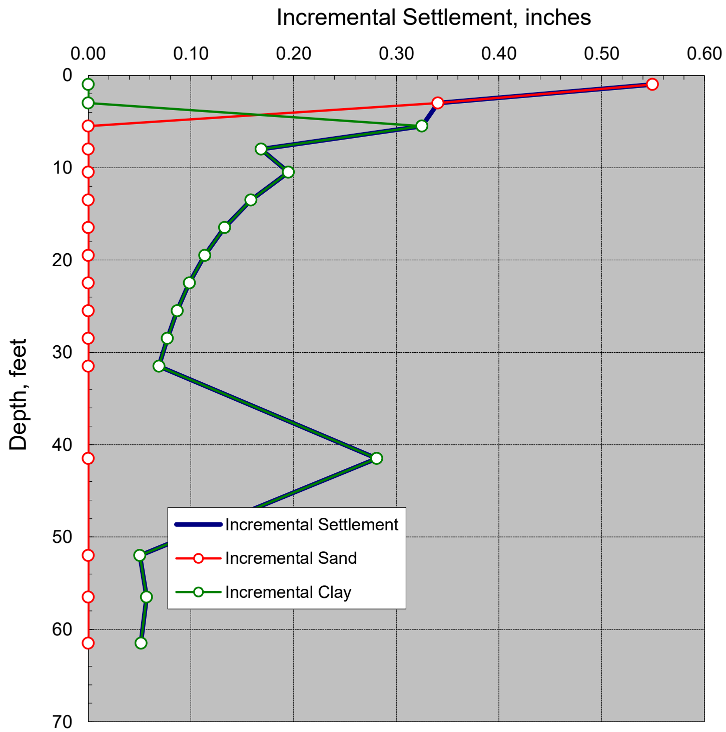
	BOUSSINESQ STRESS DISTRIBUTION			SAND	CLAY			
LAYER	INITIAL EFFECTIVE STRESS (σ'v), psf	CHANGE IN STRESS (Δσ'v), psf	FINAL EFFECTIVE STRESS	SETTLEMENT (ΔH), ft.	**OC Strain %**	**NC Strain %**	**Total Strain %**	**Settlement feet**
1	68	750	818	0.05	0.000	0.000	0.00	0.000
1	203	748	951	0.03	0.000	0.000	0.00	0.000
1	373	741	1114	0.00	0.009	0.000	0.01	0.027
2	545	730	1275	0.00	0.007	0.000	0.01	0.014
2	716	716	1432	0.00	0.005	0.000	0.01	0.016
2	922	698	1620	0.00	0.004	0.000	0.00	0.013
2	1128	680	1807	0.00	0.004	0.000	0.00	0.011
3	1334	662	1995	0.00	0.003	0.000	0.00	0.009
3	1540	645	2184	0.00	0.003	0.000	0.00	0.008
3	1745	629	2374	0.00	0.002	0.000	0.00	0.007
3	1951	614	2566	0.00	0.002	0.000	0.00	0.006
3	2167	601	2768	0.00	0.002	0.000	0.00	0.006
13	2923	563	3487	0.00	0.001	0.000	0.00	0.023
14	3717	534	4251	0.00	0.001	0.000	0.00	0.004
15	4057	524	4581	0.00	0.001	0.000	0.00	0.005
16	4435	514	4949	0.00	0.001	0.000	0.00	0.004
17								
18								
19								
20								
		TOTAL SETTLEMENT OF SAND (ft)=		**0.07**	**TOTAL SETTLEMENT OF CLAY (ft)=**			**0.16**

Settlement Results		
Sand	0.9	inches
Clay	1.9	inches
Total	**2.8**	**inches**

INCREMENTAL SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21

Settlement Beneath Footing



COMBINED SETTLEMENT ANALYSIS FOR CLAYS AND SANDS

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21

EXISTING AND PROPOSED EMBANKMENT GEOMETRY

Existing Embankment

Load Type	t	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	0	ft
Unit Wt	120	pcf
Slope	1	H:V
Width	1	ft (for uniform/triangular/slope loads)

Proposed Embankment

Load Type	Tr	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	9	ft
Unit Wt	125	pcf
Slope	4.5	H:V (enter 0.01 for uniform strip/semi-infinite uniform load)
Widening	0	ft (toe to toe)
Width	0	ft (for triangular load; Width = 0.01 for Slope)

Point of Interest (in relation to toe of proposed embankment)

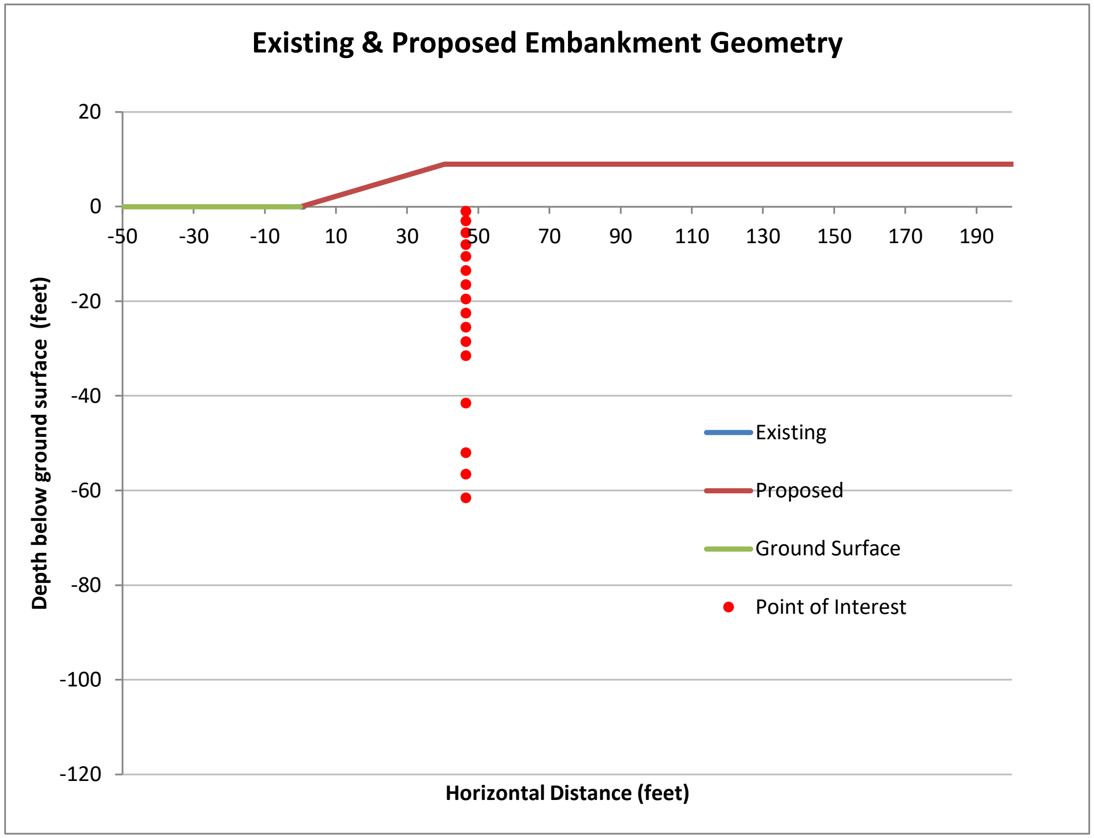
x	46.5	ft

Depth of Groundwater Table

D_w	0	ft

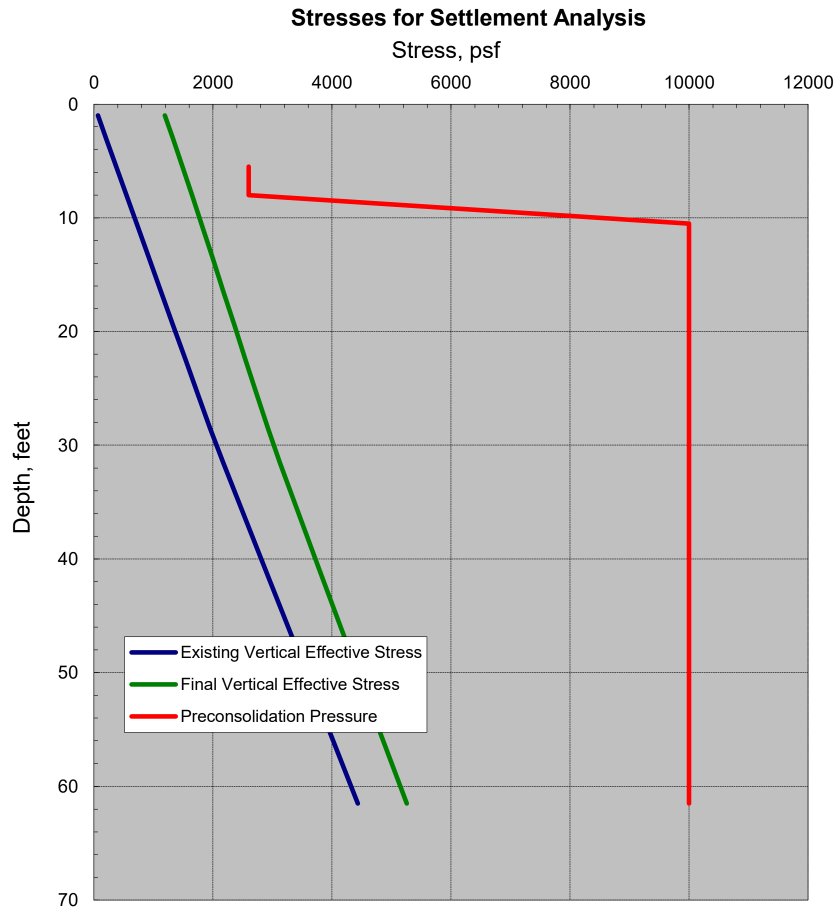
EMBANKMENT GEOMETRY

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21



EXISTING AND FINAL STRESSES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21



SOIL PROFILE AND MATERIAL PROPERTIES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21

	ELEVATION OF LAYER		SOIL LAYER AND MATERIAL PROPERTIES		
LAYER	TOP feet	BOTTOM feet	MATERIAL TYPE	N-VALUE BPF	SOIL UNIT WEIGHT (γ), pcf
1	1104	1102	Graded Silty Sand and Gr	6	130
1	1102	1100	Graded Silty Sand and Gr	6	130
1	1100	1097	Clay	10	131
2	1097	1095	Clay	10	131
2	1095	1092	Clay	10	131
2	1092	1089	Clay	10	131
2	1089	1086	Clay	15	131
3	1086	1083	Clay	15	131
3	1083	1080	Clay	15	131
3	1080	1077	Clay	15	131
3	1077	1074	Clay	15	131
3	1074	1071	Clay	50	138
13	1071	1054	Clay	70	138
14	1054	1050	Clay	70	138
15	1050	1045	Clay	70	138
16	1045	1040	Clay	70	138
17					
18					
19					
20					

CONSOLIDATION PROPERTIES OF SOIL LAYER

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21

	SAND AND CLAY CONSOLIDATION PARAMETERS							
LAYER	Compression Ratio CR	Recompression Ratio RR	cient of Consolidation c_v	nt of Consolidat c_{vr}	p'c psf	Drainage	H_{dr} ft	Sand Compressibility Coefficient ($C_{\varepsilon c}$)
1						both	1.000	0.021
1						both	1.000	0.021
1	0.19	0.019	0.650	5.580	2600	top	30.000	
2	0.19	0.019	0.650	5.580	2600	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
13	0.18	0.018	0.650	5.580	10000	None	30.000	
14	0.18	0.018	0.650	5.580	10000	None	30.000	
15	0.18	0.018	0.650	5.580	10000	None	30.000	
16	0.18	0.018	0.650	5.580	10000	Bottom	30.000	
17								
18								
19								
20								

STRESS DISTRIBUTION AND SETTLEMENT CALCULATIONS

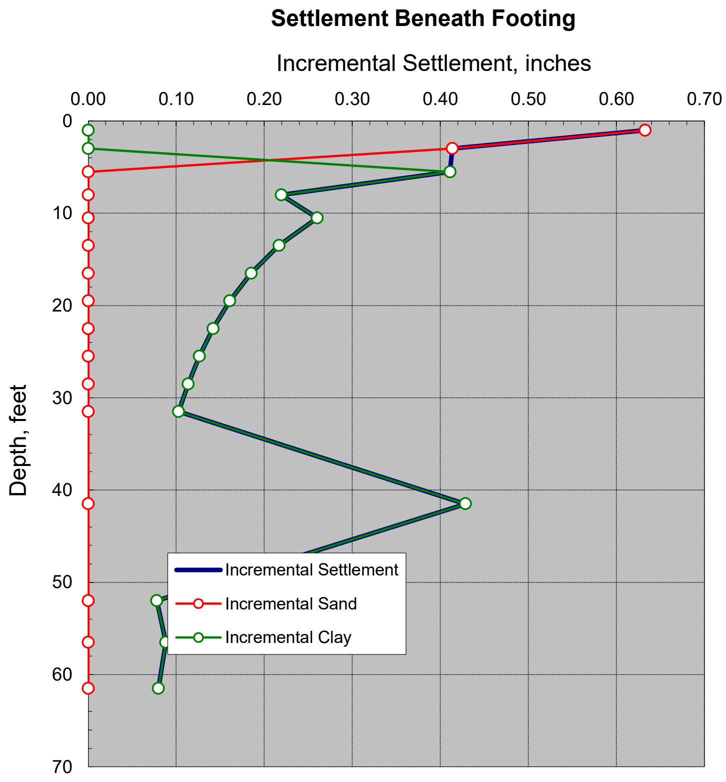
Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21

	BOUSSINESQ STRESS DISTRIBUTION			SAND	CLAY			
LAYER	INITIAL EFFECTIVE STRESS (σ'v), psf	CHANGE IN STRESS (Δσ'v), psf	FINAL EFFECTIVE STRESS	SETTLEMENT (ΔH), ft.	**OC Strain %**	**NC Strain %**	**Total Strain %**	**Settlement feet**
1	68	1125	1193	0.05	0.000	0.000	0.00	0.000
1	203	1123	1326	0.03	0.000	0.000	0.00	0.000
1	373	1116	1489	0.00	0.011	0.000	0.01	0.034
2	545	1104	1649	0.00	0.009	0.000	0.01	0.018
2	716	1089	1806	0.00	0.007	0.000	0.01	0.022
2	922	1070	1992	0.00	0.006	0.000	0.01	0.018
2	1128	1050	2178	0.00	0.005	0.000	0.01	0.015
3	1334	1029	2363	0.00	0.004	0.000	0.00	0.013
3	1540	1009	2549	0.00	0.004	0.000	0.00	0.012
3	1745	990	2735	0.00	0.004	0.000	0.00	0.011
3	1951	971	2922	0.00	0.003	0.000	0.00	0.009
3	2167	954	3121	0.00	0.003	0.000	0.00	0.009
13	2923	901	3825	0.00	0.002	0.000	0.00	0.036
14	3717	856	4574	0.00	0.002	0.000	0.00	0.006
15	4057	840	4897	0.00	0.001	0.000	0.00	0.007
16	4435	824	5259	0.00	0.001	0.000	0.00	0.007
17								
18								
19								
20								
		TOTAL SETTLEMENT OF SAND (ft)=		**0.09**	**TOTAL SETTLEMENT OF CLAY (ft)=**			**0.22**

Settlement Results		
Sand	1.0	inches
Clay	2.6	inches
Total	**3.7**	**inches**

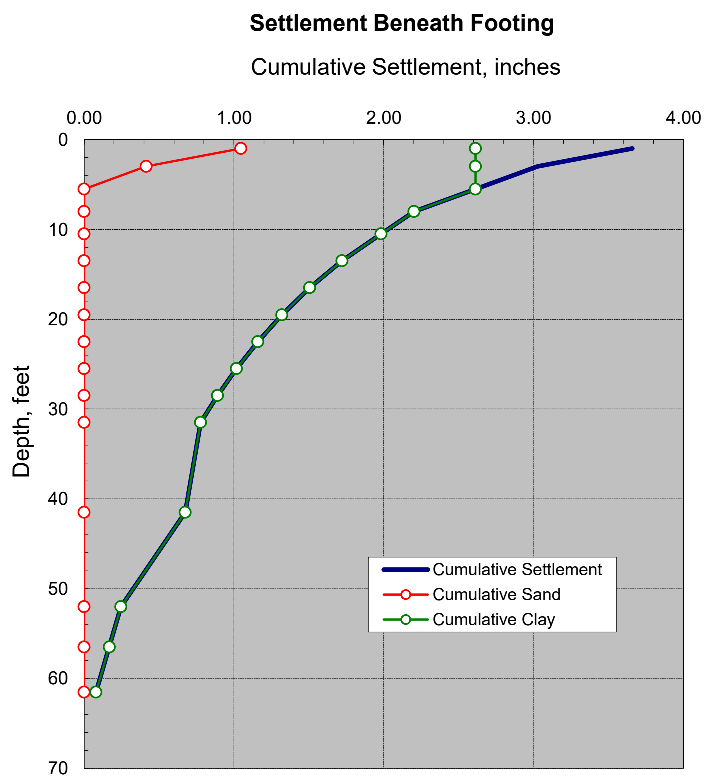
INCREMENTAL SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21



CUMULATIVE SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 9ft High Embankment	Date:	7/12/21



COMBINED SETTLEMENT ANALYSIS FOR CLAYS AND SANDS

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21

EXISTING AND PROPOSED EMBANKMENT GEOMETRY

Existing Embankment

Load Type	t	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	0	ft
Unit Wt	120	pcf
Slope	1	H:V
Width	1	ft (for uniform/triangular/slope loads)

Proposed Embankment

Load Type	Tr	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	12	ft
Unit Wt	125	pcf
Slope	4.5	H:V (enter 0.01 for uniform strip/semi-infinite uniform load)
Widening	0	ft (toe to toe)
Width	0	ft (for triangular load; Width = 0.01 for Slope)

Point of Interest (in relation to toe of proposed embankment)

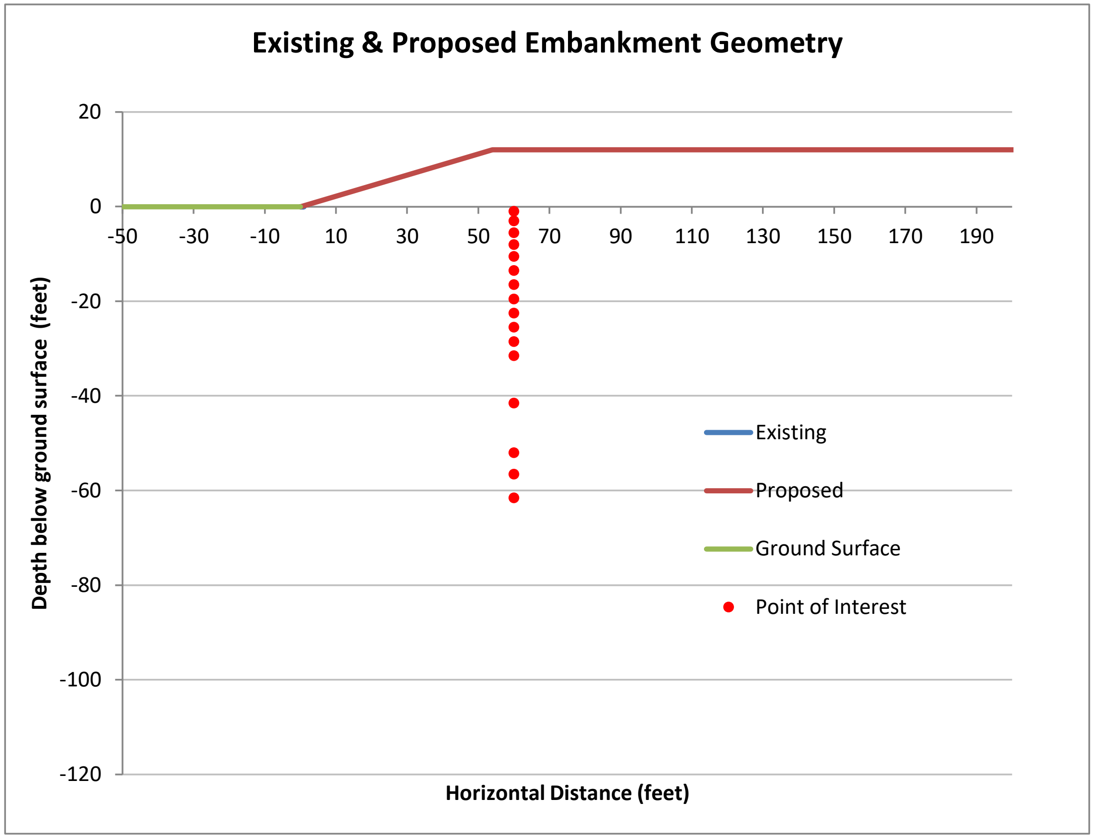
x	60	ft

Depth of Groundwater Table

D_w	0	ft

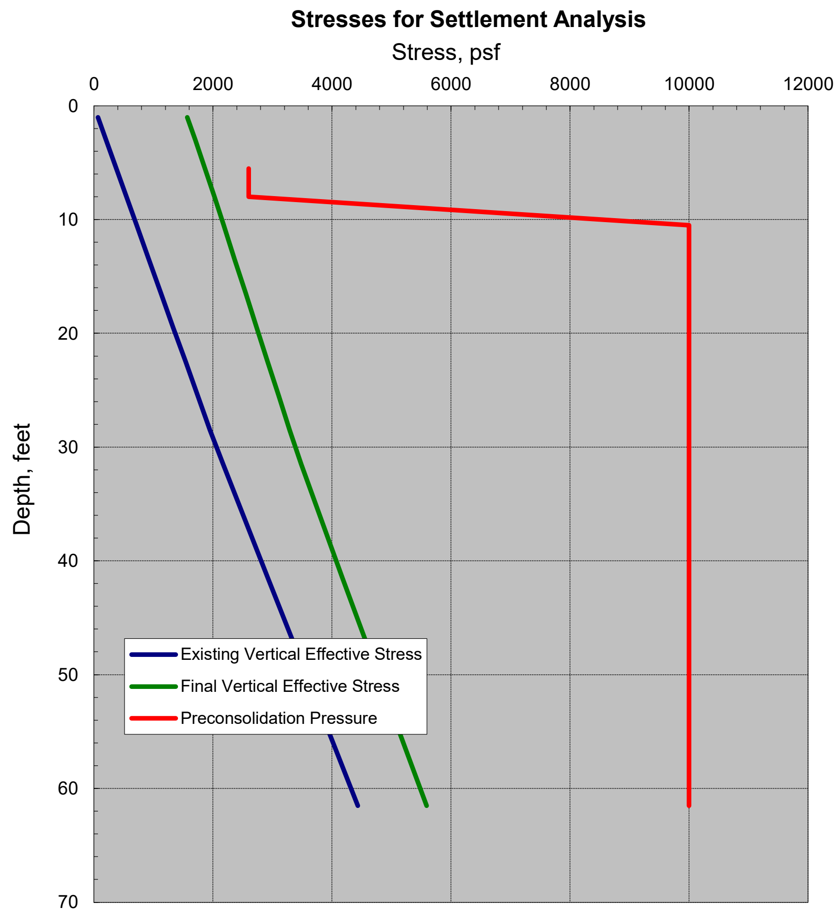
EMBANKMENT GEOMETRY

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21



EXISTING AND FINAL STRESSES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21



SOIL PROFILE AND MATERIAL PROPERTIES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21

	ELEVATION OF LAYER		SOIL LAYER AND MATERIAL PROPERTIES		
LAYER	TOP feet	BOTTOM feet	MATERIAL TYPE	N-VALUE BPF	SOIL UNIT WEIGHT (γ), pcf
1	1104	1102	Graded Silty Sand and Gr	6	130
1	1102	1100	Graded Silty Sand and Gr	6	130
1	1100	1097	Clay	10	131
2	1097	1095	Clay	10	131
2	1095	1092	Clay	10	131
2	1092	1089	Clay	10	131
2	1089	1086	Clay	15	131
3	1086	1083	Clay	15	131
3	1083	1080	Clay	15	131
3	1080	1077	Clay	15	131
3	1077	1074	Clay	15	131
3	1074	1071	Clay	50	138
13	1071	1054	Clay	70	138
14	1054	1050	Clay	70	138
15	1050	1045	Clay	70	138
16	1045	1040	Clay	70	138
17					
18					
19					
20					

CONSOLIDATION PROPERTIES OF SOIL LAYER

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21

	SAND AND CLAY CONSOLIDATION PARAMETERS							
LAYER	Compression Ratio CR	Recompression Ratio RR	cient of Consolidation c_v	nt of Consolidat c_{vr}	p'c psf	Drainage	H_{dr} ft	Sand Compressibility Coefficient ($C_{\epsilon c}$)
1						both	1.000	0.021
1						both	1.000	0.021
1	0.19	0.019	0.650	5.580	2600	top	30.000	
2	0.19	0.019	0.650	5.580	2600	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
2	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
13	0.18	0.018	0.650	5.580	10000	None	30.000	
14	0.18	0.018	0.650	5.580	10000	None	30.000	
15	0.18	0.018	0.650	5.580	10000	None	30.000	
16	0.18	0.018	0.650	5.580	10000	Bottom	30.000	
17								
18								
19								
20								

STRESS DISTRIBUTION AND SETTLEMENT CALCULATIONS

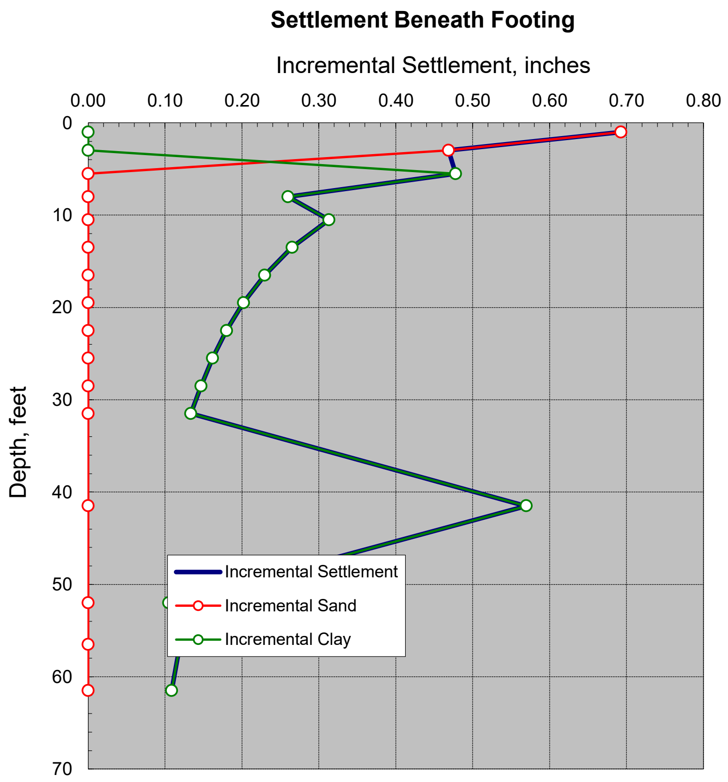
Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21

	BOUSSINESQ STRESS DISTRIBUTION			SAND	CLAY			
LAYER	INITIAL EFFECTIVE STRESS (σ'v), psf	CHANGE IN STRESS (Δσ'v), psf	FINAL EFFECTIVE STRESS	SETTLEMENT (ΔH), ft.	**OC Strain %**	**NC Strain %**	**Total Strain %**	**Settlement feet**
1	68	1500	1568	0.06	0.000	0.000	0.00	0.000
1	203	1498	1701	0.04	0.000	0.000	0.00	0.000
1	373	1491	1864	0.00	0.013	0.000	0.01	0.040
2	545	1479	2024	0.00	0.011	0.000	0.01	0.022
2	716	1464	2180	0.00	0.009	0.000	0.01	0.026
2	922	1444	2366	0.00	0.007	0.000	0.01	0.022
2	1128	1422	2550	0.00	0.006	0.000	0.01	0.019
3	1334	1401	2734	0.00	0.006	0.000	0.01	0.017
3	1540	1379	2919	0.00	0.005	0.000	0.01	0.015
3	1745	1358	3103	0.00	0.004	0.000	0.00	0.013
3	1951	1337	3288	0.00	0.004	0.000	0.00	0.012
3	2167	1317	3484	0.00	0.004	0.000	0.00	0.011
13	2923	1255	4178	0.00	0.003	0.000	0.00	0.047
14	3717	1198	4916	0.00	0.002	0.000	0.00	0.009
15	4057	1177	5234	0.00	0.002	0.000	0.00	0.010
16	4435	1155	5590	0.00	0.002	0.000	0.00	0.009
17								
18								
19								
20								
		TOTAL SETTLEMENT OF SAND (ft)=		**0.10**	**TOTAL SETTLEMENT OF CLAY (ft)=**			**0.27**

Settlement Results		
Sand	1.2	inches
Clay	3.3	inches
Total	**4.4**	**inches**

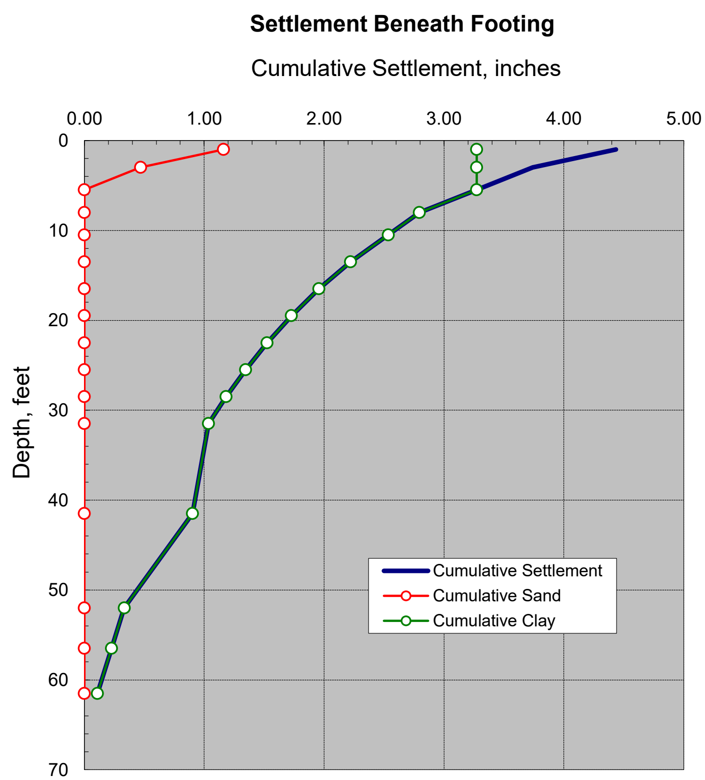
INCREMENTAL SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21



CUMULATIVE SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07, 12ft High Embankment	Date:	7/12/21



COMBINED SETTLEMENT ANALYSIS FOR CLAYS AND SANDS

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21

EXISTING AND PROPOSED EMBANKMENT GEOMETRY

Existing Embankment

Load Type	t	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	0	ft
Unit Wt	120	pcf
Slope	1	H:V
Width	1	ft (for uniform/triangular/slope loads)

Proposed Embankment

Load Type	Tr	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	9	ft
Unit Wt	125	pcf
Slope	4.5	H:V (enter 0.01 for uniform strip/semi-infinite uniform load)
Widening	0	ft (toe to toe)
Width	0	ft (for triangular load; Width = 0.01 for Slope)

Point of Interest (in relation to toe of proposed embankment)

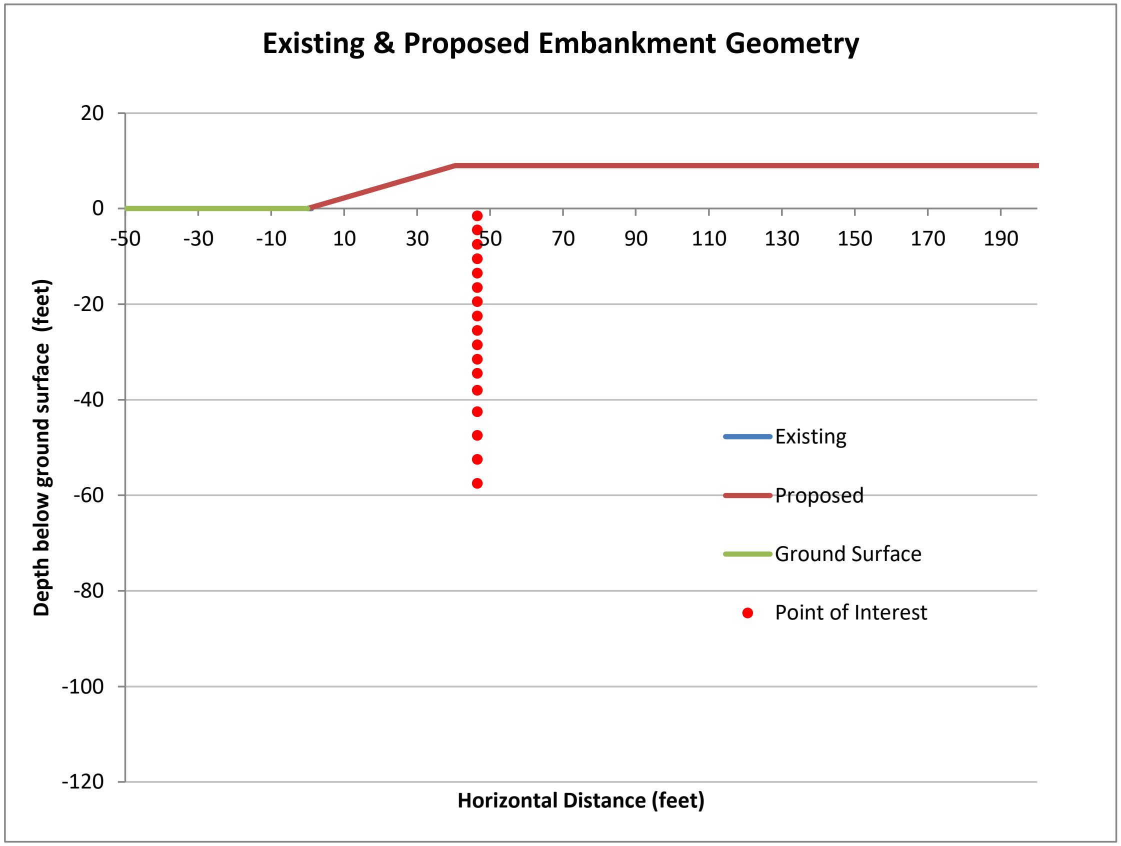
x	46.5	ft

Depth of Groundwater Table

D_w	0	ft

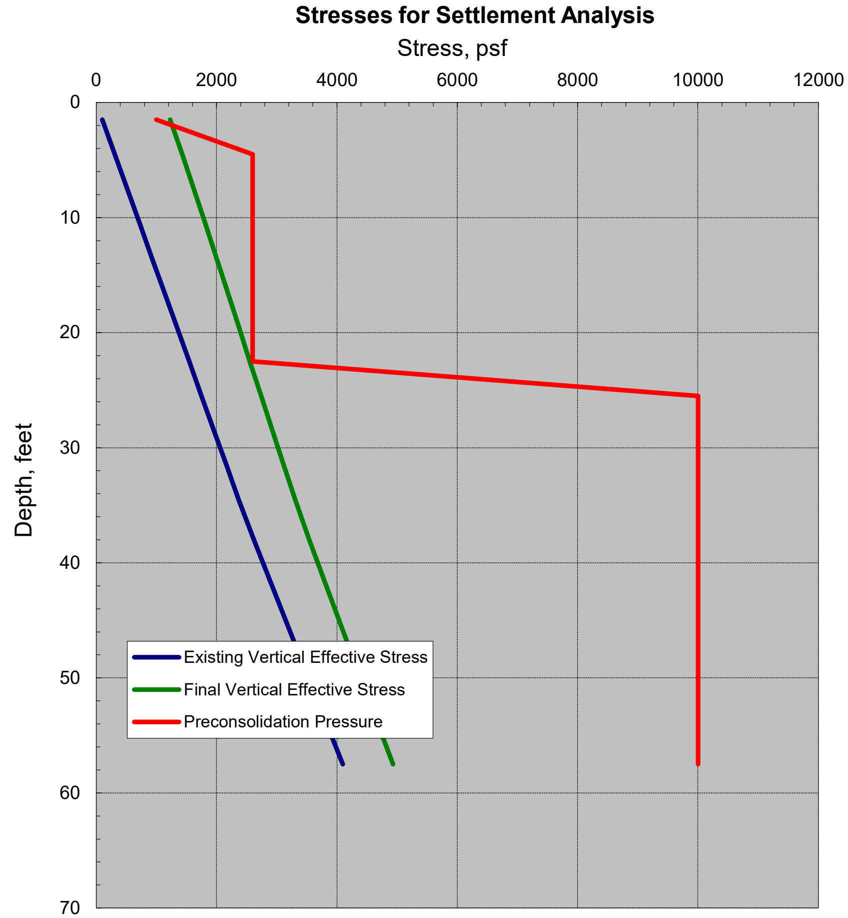
EMBANKMENT GEOMETRY

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21



EXISTING AND FINAL STRESSES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21



SOIL PROFILE AND MATERIAL PROPERTIES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21

	ELEVATION OF LAYER		SOIL LAYER AND MATERIAL PROPERTIES		
LAYER	TOP feet	BOTTOM feet	MATERIAL TYPE	N-VALUE BPF	SOIL UNIT WEIGHT (γ), pcf
1	1100	1097	Clay	3	131
1	1097	1094	Clay	8	131
1	1094	1091	Clay	10	131
2	1091	1088	Clay	10	131
2	1088	1085	Clay	10	131
2	1085	1082	Clay	10	131
2	1082	1079	Clay	10	131
3	1079	1076	Clay	10	131
3	1076	1073	Clay	15	131
3	1073	1070	Clay	15	131
3	1070	1067	Clay	15	131
3	1067	1064	Clay	15	131
13	1064	1060	Clay	70	138
14	1060	1055	Clay	70	138
15	1055	1050	Clay	70	138
16	1050	1045	Clay	70	138
17	1045	1040	Clay	70	138
18					
19					
20					

CONSOLIDATION PROPERTIES OF SOIL LAYER

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21

	SAND AND CLAY CONSOLIDATION PARAMETERS							
LAYER	Compression Ratio CR	Recompression Ratio RR	icient of Consolidation c_v	nt of Consolidati c_{vr}	p'c psf	Drainage	H_{dr} ft	Sand Compressibility Coefficient ($C_{\varepsilon c}$)
1	0.12	0.012	0.930	7.440	1000	top	30.000	
1	0.19	0.019	0.650	5.580	2600	None	30.000	
1	0.19	0.019	0.650	5.580	2600	None	30.000	
2	0.19	0.019	0.650	5.580	2600	None	30.000	
2	0.19	0.019	0.650	5.580	2600	None	30.000	
2	0.19	0.019	0.650	5.580	2600	None	30.000	
2	0.19	0.019	0.650	5.580	2600	None	30.000	
3	0.19	0.019	0.650	5.580	2600	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
3	0.18	0.018	0.650	5.580	10000	None	30.000	
13	0.18	0.018	0.650	5.580	10000	None	30.000	
14	0.18	0.018	0.650	5.580	10000	None	30.000	
15	0.18	0.018	0.650	5.580	10000	None	30.000	
16	0.18	0.018	0.650	5.580	10000	None	30.000	
17	0.18	0.018	0.650	5.580	10000	Bottom	30.000	
18								
19								
20								

STRESS DISTRIBUTION AND SETTLEMENT CALCULATIONS

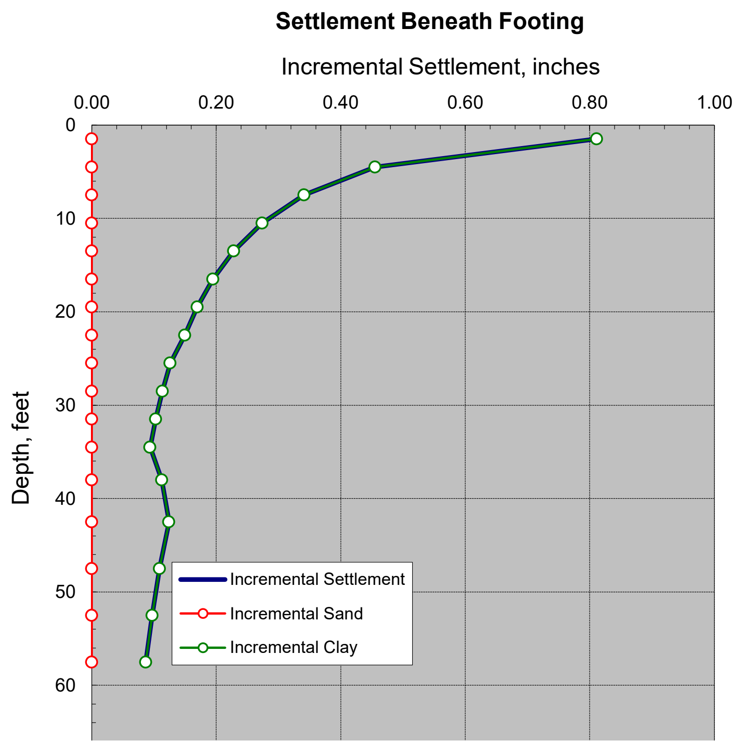
Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21

	BOUSSINESQ STRESS DISTRIBUTION			SAND	CLAY			
LAYER	INITIAL EFFECTIVE STRESS (σ'v), psf	CHANGE IN STRESS (Δσ'v), psf	FINAL EFFECTIVE STRESS	SETTLEMENT (ΔH), ft.	**OC Strain %**	**NC Strain %**	**Total Strain %**	**Settlement feet**
1	103	1125	1228	0.00	0.012	0.011	0.02	0.068
1	309	1119	1428	0.00	0.013	0.000	0.01	0.038
1	515	1107	1621	0.00	0.009	0.000	0.01	0.028
2	720	1089	1810	0.00	0.008	0.000	0.01	0.023
2	926	1070	1996	0.00	0.006	0.000	0.01	0.019
2	1132	1050	2182	0.00	0.005	0.000	0.01	0.016
2	1338	1029	2367	0.00	0.005	0.000	0.00	0.014
3	1544	1009	2553	0.00	0.004	0.000	0.00	0.012
3	1749	990	2739	0.00	0.004	0.000	0.00	0.011
3	1955	971	2926	0.00	0.003	0.000	0.00	0.009
3	2161	954	3114	0.00	0.003	0.000	0.00	0.009
3	2367	937	3303	0.00	0.003	0.000	0.00	0.008
13	2621	918	3539	0.00	0.002	0.000	0.00	0.009
14	2961	896	3857	0.00	0.002	0.000	0.00	0.010
15	3339	874	4213	0.00	0.002	0.000	0.00	0.009
16	3717	854	4571	0.00	0.002	0.000	0.00	0.008
17	4095	837	4932	0.00	0.001	0.000	0.00	0.007
18								
19								
20								
		TOTAL SETTLEMENT OF SAND (ft)=		**0.00**	**TOTAL SETTLEMENT OF CLAY (ft)=**			**0.30**

Settlement Results		
Sand	0.0	inches
Clay	3.6	inches
Total	**3.6**	**inches**

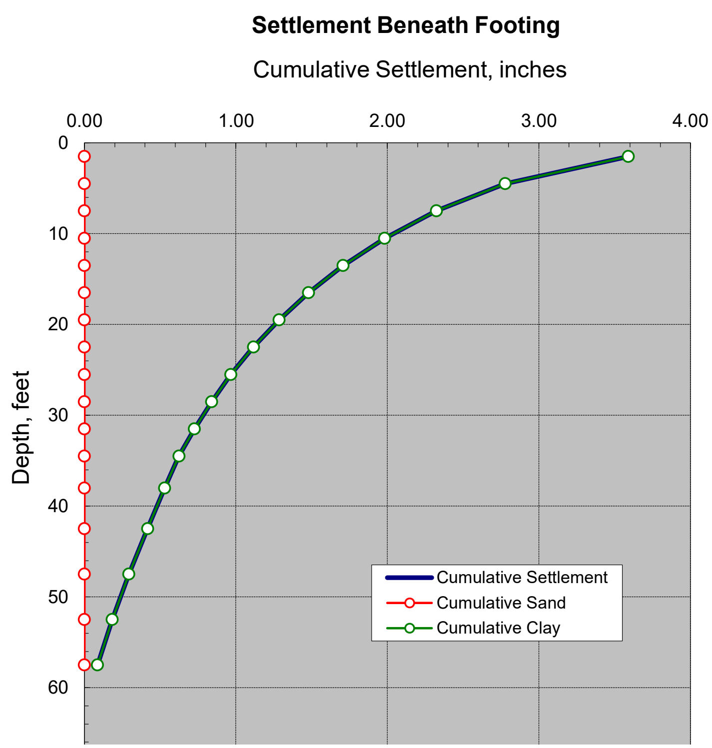
INCREMENTAL SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21



CUMULATIVE SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-08, 9ft High Embankment	Date:	7/12/21



COMBINED SETTLEMENT ANALYSIS FOR CLAYS AND SANDS

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21

EXISTING AND PROPOSED EMBANKMENT GEOMETRY

Existing Embankment

Load Type	t	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	0	ft
Unit Wt	120	pcf
Slope	1	H:V
Width	1	ft (for uniform/triangular/slope loads)

Proposed Embankment

Load Type	Tr	(U=Uniform, Tr=terrace/semi-infinite, t=triangular/slope)
Height	16	ft
Unit Wt	125	pcf
Slope	4.5	H:V (enter 0.01 for uniform strip/semi-infinite uniform load)
Widening	0	ft (toe to toe)
Width	0	ft (for triangular load; Width = 0.01 for Slope)

Point of Interest (in relation to toe of proposed embankment)

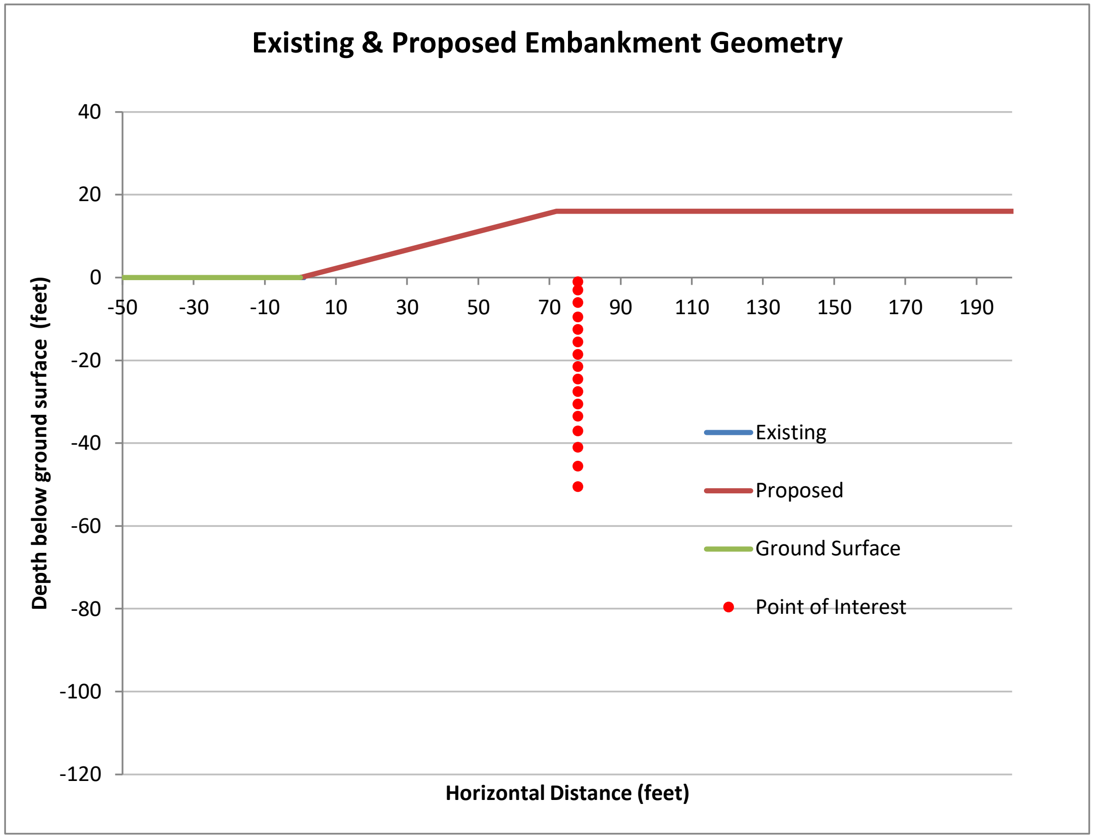
x	78	ft

Depth of Groundwater Table

D_w	0	ft

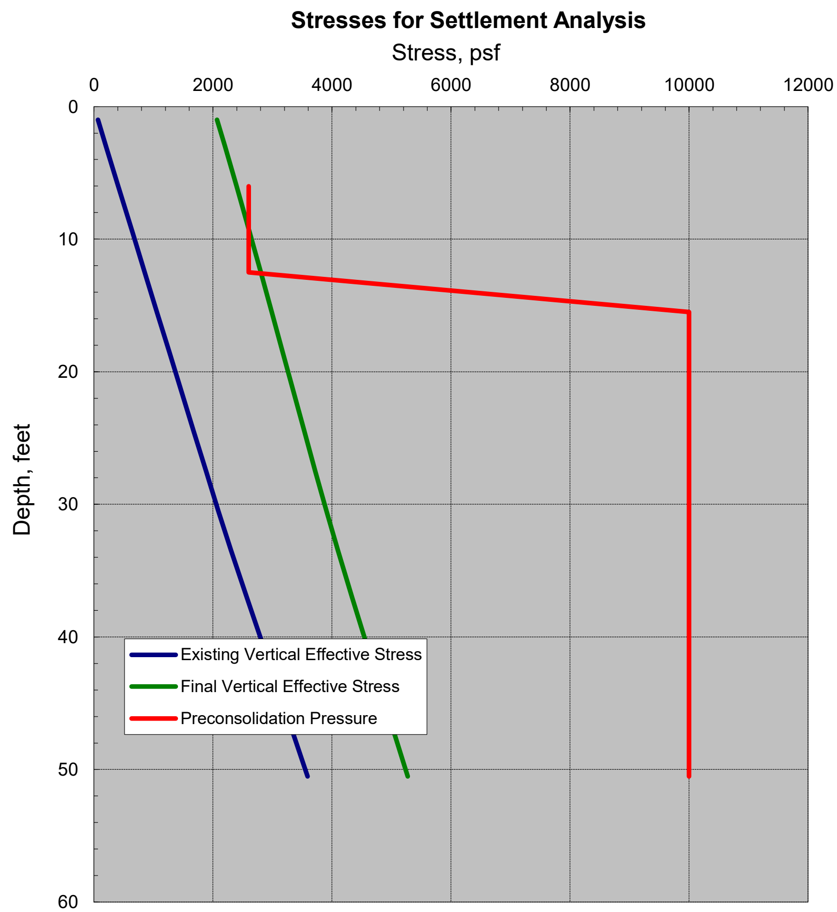
EMBANKMENT GEOMETRY

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21



EXISTING AND FINAL STRESSES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21



SOIL PROFILE AND MATERIAL PROPERTIES

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21

	ELEVATION OF LAYER		SOIL LAYER AND MATERIAL PROPERTIES		
LAYER	TOP feet	BOTTOM feet	MATERIAL TYPE	N-VALUE BPF	SOIL UNIT WEIGHT (γ), pcf
1	1093	1091	Graded Silty Sand and Gr	6	130
1	1091	1089	Graded Silty Sand and Gr	6	130
1	1089	1085	Clay	10	131
2	1085	1082	Clay	10	131
2	1082	1079	Clay	10	131
2	1079	1076	Clay	10	131
2	1076	1073	Clay	15	131
3	1073	1070	Clay	15	131
3	1070	1067	Clay	15	131
3	1067	1064	Clay	15	131
3	1064	1061	Clay	15	131
3	1061	1058	Clay	50	138
13	1058	1054	Clay	70	138
14	1054	1050	Clay	70	138
15	1050	1045	Clay	70	138
16	1045	1040	Clay	70	138
17					
18					
19					
20					

CONSOLIDATION PROPERTIES OF SOIL LAYER

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21

	SAND AND CLAY CONSOLIDATION PARAMETERS							
LAYER	Compression Ratio CR	Recompression Ratio RR	cient of Consolidation c_v	nt of Consolidat c_{vr}	p'c psf	Drainage	H_{dr} ft	Sand Compressibility Coefficient ($C_{\varepsilon c}$)
1						both	1.000	0.021
1						both	1.000	0.021
1	0.19	0.019	0.650	5.580	2600	top	24.500	
2	0.19	0.019	0.650	5.580	2600	None	24.500	
2	0.19	0.019	0.650	5.580	2600	None	24.500	
2	0.18	0.018	0.650	5.580	10000	None	24.500	
2	0.18	0.018	0.650	5.580	10000	None	24.500	
3	0.18	0.018	0.650	5.580	10000	None	24.500	
3	0.18	0.018	0.650	5.580	10000	None	24.500	
3	0.18	0.018	0.650	5.580	10000	None	24.500	
3	0.18	0.018	0.650	5.580	10000	None	24.500	
3	0.18	0.018	0.650	5.580	10000	None	24.500	
13	0.18	0.018	0.650	5.580	10000	None	24.500	
14	0.18	0.018	0.650	5.580	10000	None	24.500	
15	0.18	0.018	0.650	5.580	10000	None	24.500	
16	0.18	0.018	0.650	5.580	10000	Bottom	24.500	
17								
18								
19								
20								

STRESS DISTRIBUTION AND SETTLEMENT CALCULATIONS

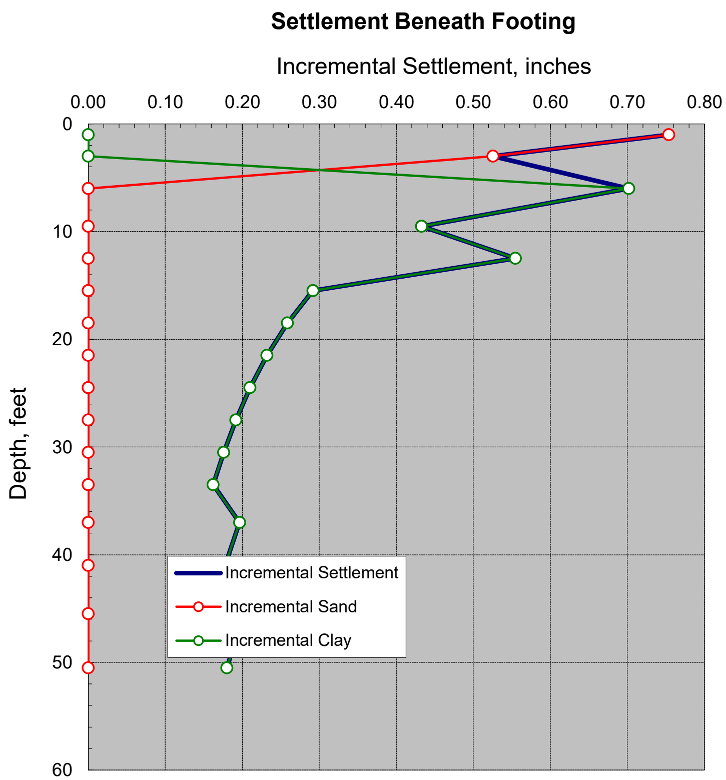
Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21

	BOUSSINESQ STRESS DISTRIBUTION			SAND	CLAY			
LAYER	INITIAL EFFECTIVE STRESS (σ'v), psf	CHANGE IN STRESS (Δσ'v), psf	FINAL EFFECTIVE STRESS	SETTLEMENT (ΔH), ft.	**OC Strain %**	**NC Strain %**	**Total Strain %**	**Settlement feet**
1	68	2000	2068	0.06	0.000	0.000	0.00	0.000
1	203	1998	2201	0.04	0.000	0.000	0.00	0.000
1	408	1989	2396	0.00	0.015	0.000	0.01	0.058
2	648	1970	2618	0.00	0.011	0.001	0.01	0.036
2	854	1950	2803	0.00	0.009	0.006	0.02	0.046
2	1059	1928	2988	0.00	0.008	0.000	0.01	0.024
2	1265	1906	3171	0.00	0.007	0.000	0.01	0.022
3	1471	1883	3354	0.00	0.006	0.000	0.01	0.019
3	1677	1861	3537	0.00	0.006	0.000	0.01	0.018
3	1883	1838	3721	0.00	0.005	0.000	0.01	0.016
3	2088	1816	3904	0.00	0.005	0.000	0.00	0.015
3	2305	1794	4099	0.00	0.005	0.000	0.00	0.014
13	2569	1769	4339	0.00	0.004	0.000	0.00	0.016
14	2872	1742	4613	0.00	0.004	0.000	0.00	0.015
15	3212	1712	4924	0.00	0.003	0.000	0.00	0.017
16	3590	1681	5271	0.00	0.003	0.000	0.00	0.015
17								
18								
19								
20								
		TOTAL SETTLEMENT OF SAND (ft)=		**0.11**	**TOTAL SETTLEMENT OF CLAY (ft)=**			**0.33**

Settlement Results		
Sand	1.3	inches
Clay	4.0	inches
Total	**5.2**	**inches**

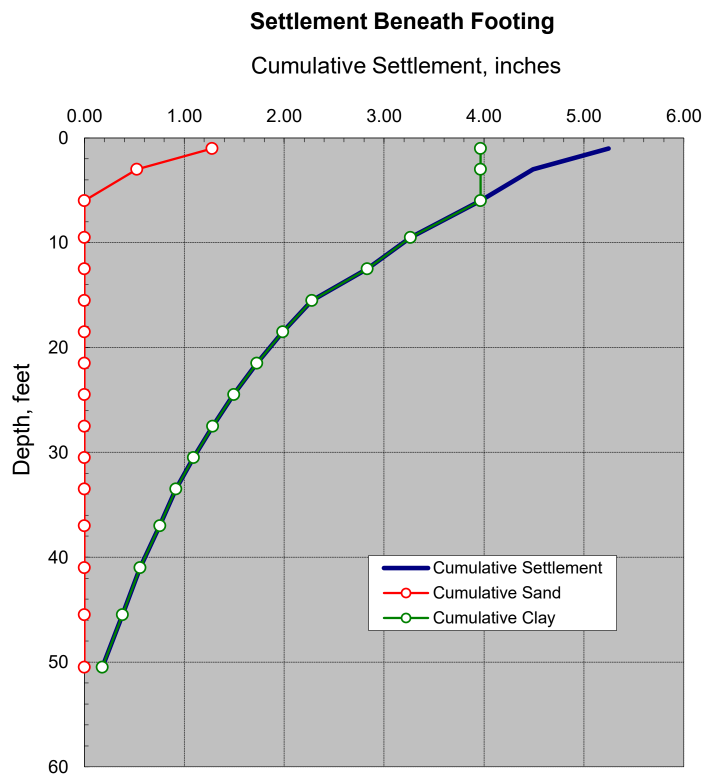
INCREMENTAL SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21



CUMULATIVE SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-09, 16ft High Embankment	Date:	7/12/21



CUMULATIVE SETTLEMENT PROFILE

Project Number:	10254300	Computed by:	KB
Project Name:	Newfolden	Checked by:	SO
Location:	Newfolden, MN, BH-07 - 6ft High Embankment	Date:	7/12/21