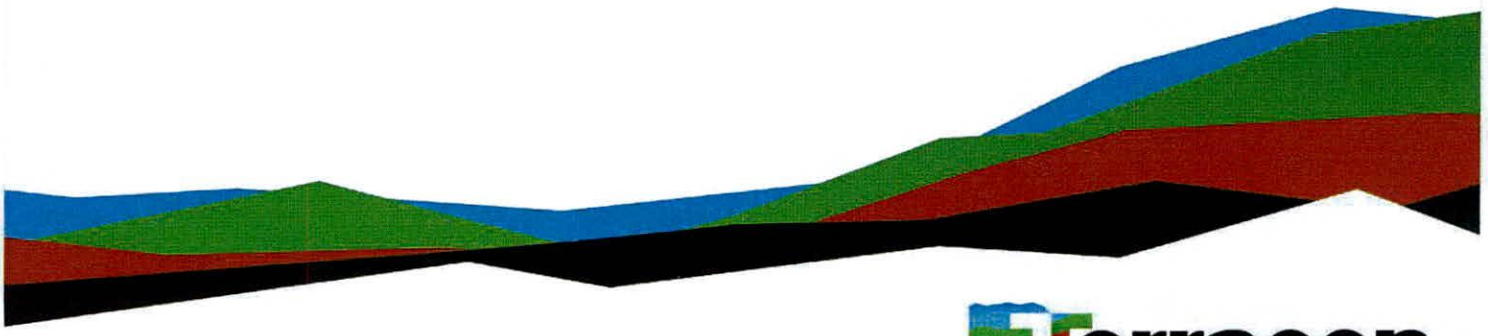
Lake Contrary Dredging Underseepage Evaluation

Geotechnical Engineering Report

July 11, 2024 | Terracon Project No. 02245037

Prepared for:

GDS, LLC/Ambrozi.US
St. Joseph, Missouri 64501



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July 11, 2024

GDS, LLC/Ambrozi.US
1207 S 4th Street
St. Joseph, Missouri 64501

Attn: Lauren Morgan
P: (816) 200-0708
E: lmorgan@ambrozi.com

Re: Geotechnical Engineering Report
Lake Contrary Dredging Underseepage Evaluation
5220 SW Lakefront Lane W
St. Joseph, Missouri
Terracon Project No. 02245037

Dear Ms. Morgan:

We have completed our geotechnical engineering evaluation for the referenced project in general accordance with Terracon Change Order to the original project dated June 26, 2024. This report presents the result of the seepage analysis for the project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,

Terracon

Kevin D. Friedrichs

Kevin D. Friedrichs, P.E.
Project Engineer
Missouri: PE 2013010325

Kole C. Berg

Kole C. Berg, P.E.
Senior Consultant
Missouri: PE 2002016417

Steven Zhou

Steven Z. Zhou, Ph.D., P.E.
Senior Engineer

Table of Contents

Appendixes

Note: This report was originally delivered in a web-based format. **Blue Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the Terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Introduction

This report presents the results of our underseepage analysis performed for the proposed dredging of Lake Contrary in St. Joseph, Missouri. Given that Lake Contrary is adjacent (south) to a levee of the Missouri River, the purpose of these services was to assess the risk of undermining the levee, Lake Contrary, and the Missouri River due to the dredging.

Project Description

Lake Contrary is an abandoned lake located southwest of St. Joseph, Missouri. We understand that the client intends to dredge the lake to a depth of 6 feet from its current condition, with the dredged material to be discharged into the river. The US Army Corps of Engineers (USACE) has requested that Ambrozi provide gradation analyses of the material to be dredged and conduct an underseepage analysis of the adjacent levee in its current and post-dredging conditions. Terracon performed subsurface exploration and issued a data report dated June 14, 2024. In that service, three test borings were drilled along the levee in the proposed dredging area. The subsurface conditions revealed by the test borings were used in our underseepage and slope stability analyses. This report presents their results and our conclusions.

Item	Description
Information Provided	▪ Subsurface Exploration Data Report, prepared by Terracon and dated June 14, 2024 ▪ 455L_boring logs_sta 140+00-220+00, prepared by US Army Corps of engineers ▪ Plan and Profile – Lake Contrary, prepared by US Army Corps of engineers, Kansas City District ▪ Lake Contrary Aerial Lidar, prepared by eTrc
Existing Improvements	The lake is presently dry and filled with silt.
Existing Topography	The site is relatively flat.

Terracon should be notified if any of the above information is inconsistent with the project, especially the dredging plan, as modifications to our conclusions may be necessary.

Site Conditions

Lake Contrary, located southwest of St. Joseph, Missouri, is an abandoned oxbow lake formed from an old channel of the Missouri River. It spans approximately 1,341 feet in width, with a relatively flat bottom elevation ranging from 794 to 797 feet in the project area according to the survey provided by eTrac. The lake features varying depths and accumulated sediment deposits, surrounded by both natural and human-made elements like levees and farmland. The lake's water levels fluctuate due to regional hydrological conditions and proximity to the Missouri River. The adjacent levee on the northern edge of Lake Contrary is part of a larger flood protection system designed to safeguard the land from the Missouri River's floodwaters. This levee, primarily formed from alluvial clay underlain by alluvial silt according to the test borings, has an average width of about 480 feet and a top elevation of approximately 821 feet. The Missouri River, a major North American river, flows next to Lake Contrary and the levee. In the project area, the river is about 2,640 feet wide with a bottom elevation of approximately 797 feet. The hydrological interaction between Lake Contrary, the Missouri River, and the levee system is complex. High river flows can influence Lake Contrary's water levels, especially if the levee experiences seepage or overtopping. Conversely, the lake can act as a temporary floodwater storage basin, mitigating surrounding area impacts. The proposed dredging of Lake Contrary aims to deepen it, necessitating careful assessment of potential impacts on the levee and river, particularly regarding underseepage and structural stability. This project site extends about 19,000 feet from south to north.

Seepage and Slope Stability Analyses

Given that Lake Contrary is adjacent to a levee of the Missouri River and will be dredged 6 feet from the riverbed, with the flood level of the Missouri River potentially reaching as high as elevation 816.4 feet for up to one month, seepage and slope stability analyses are critical to the project. These analyses can provide information related to:

1. **Determining Exit Gradient:** A critical aspect of seepage analysis is calculating the exit gradient, which is the slope at which groundwater exits the soil. If the exit gradient exceeds 1, it indicates that the water pressure is greater than the vertical soil pressure, which can lead to piping and make the river bottom unstable. Conversely, an exit gradient of less than 1 suggests that the river bottom is stable under seepage conditions.

2. **Assessing Slope Stability of the Levee:** Performing a slope stability analysis on the levee is crucial to ensure its stability after dredging Lake Contrary to a depth of 6 feet. This dredging effectively increases the height of the levee by 6 feet, potentially making it more susceptible to failure. Additionally, seepage between the Missouri River and Lake Contrary can further compromise the levee's integrity by increasing pore water pressure within the levee structure, thereby

reducing its overall stability. A coupled seepage and slope stability analysis is essential in these conditions, as it allows for a comprehensive assessment of the combined effects of increased levee height and seepage. This analysis can identify potential failure surfaces and determine if the levee can withstand the increased hydraulic load and maintain its structural integrity. Ensuring the levee's stability under these conditions is critical for preventing catastrophic failures and protecting the surrounding areas from flooding.

Computer software

We utilized the commercially available computer program Visual Slope, which employs the Finite Difference Method (FDM) for our 2D underseepage analysis and the Limit Equilibrium Method for our slope stability analysis. This advanced software provides detailed and sophisticated analysis, allowing us to conduct a comprehensive assessment of seepage and slope stability, including the effects of seepage.

Computational Model

The computational models developed for seepage and slope stability analysis for this project were based on the ground surface topographic conditions presented in Google Earth and the survey data provided by eTrac. Three (3) cross-sections were cut at the locations where the three test borings were drilled, covering the entire widths of Lake Contrary, the levee, and the Missouri River as shown in Appendix A. By overlaying the cross-section images with the corresponding boring log images, we developed detailed soil profiles for these sections. The soil profile for this project mainly consists of alluvial clay (CH), alluvial silt (ML), and alluvial sand (SM). These cross-section images, with their respective soil profiles, were then imported into Visual Slope and converted into computational models for our analysis. This approach enabled us to create accurate and reliable models to assess seepage and slope stability effectively.

Soil Parameters

No hydraulic conductivity tests and soil strength tests were conducted on the soils specific to this project, so the hydraulic conductivities and soil strength parameters used in our analysis were estimated based on published data and our experience with the project site. This data, which forms the basis of our estimations, is included in Appendix A of this report. The table below outlines the hydraulic conductivities and soil strength parameters that were employed in our analysis.

Hydraulic Conductivity and Soil Strength Parameters

Soil Name	Unit Weight (pcf)	Hydraulic Conductivity (ft/s)/(cm/s)	Cohesion (psf)	Friction Angle (deg)
Alluvial Clay (CH/CL)	115	1.64E-08/5.0E-07	1000	0
Alluvial Silt (ML)	115	1.64E-07/5.0E-06	0	30
Alluvial Sand (SM)	120	1.64E-03/1.0E-01	0	32

Flood Level

The underseepage impact of the Missouri River on Lake Contrary in St. Joseph, MO, is significantly influenced by the water level difference (potential) between these two bodies of water, especially after the dredging of Lake Contrary. When the water table in the Missouri River is high and the water table in Lake Contrary is low, the impact is more pronounced. Consequently, historical flood data for the Missouri River is crucial in understanding this dynamic. Our research, utilizing data from the US Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA), highlights a significant historical flood event: on April 29, 1881, the flood level of the Missouri River reached 27 feet, corresponding to an elevation of 816.2 feet as shown in Appendix A. If flood levels surpass this mark, water from the Missouri River will breach the levee and overflow into Lake Contrary, raising its water level and reducing the difference between the two water bodies. For conservative assessment purposes, we have used a water level of 27 feet (elevation 816.2 feet) on the Missouri River side and approximately 0 feet (elevation 795 feet) on the Lake Contrary side for our underseepage and slope stability analyses. This approach ensures a thorough understanding of the potential impact and aids in developing robust mitigation strategies.

Result of Analysis

The evaluation of the project site's seepage and slope stability conditions, considering a flood scenario where the Missouri River reaches an elevation of 816.2 feet and the water table on the Lake Contrary side is at 795 feet over an extended duration, was conducted using Finite Difference Method and Limit Equilibrium Method analyses with Visual Slope. The comprehensive results of these analyses are detailed in Appendix B. To provide a concise overview, the following table summarizes the key findings of our analysis.

Summary of Result

Cross Sections	Vertical Exit Gradient (before dredging) <1	Vertical Exit Gradient (after dredging) <1	FS for Slope Stability (before dredging) >1.5	FS for Slope Stability (after dredging) >1.5
Section 1 (B-1)	0.004	0.004	3.15	4.12
Section 2 (B-2)	0.002	0.002	4.25	3.65
Section 3 (B-3)	0.001	0.001	4.81	3.64

Conclusions

The seepage and slope stability analyses, conducted using the finite difference method and limit equilibrium method with the Visual Slope software, demonstrate that the impacts on both the Missouri River and Lake Contrary will be minimal following a 6-foot dredging of Lake Contrary, even under a worst-case flood scenario. Key findings are as follows:

1. **Exit Gradient:** The exit gradient remains significantly less than 1 before and after the dredging, indicating a low risk of soil erosion or piping. This suggests that the dredging will not adversely affect the seepage conditions.

2. **Slope Stability:** The factor of safety (FS) for slope stability of the levee at three representative locations is greater than 1.5. This indicates that the levee will remain stable and will not be undermined by the dredging, even under the most extreme flood conditions.

Overall, the analyses confirm that the proposed dredging will not negatively impact the structural integrity of the levee or exacerbate seepage issues in the area.

General Comments

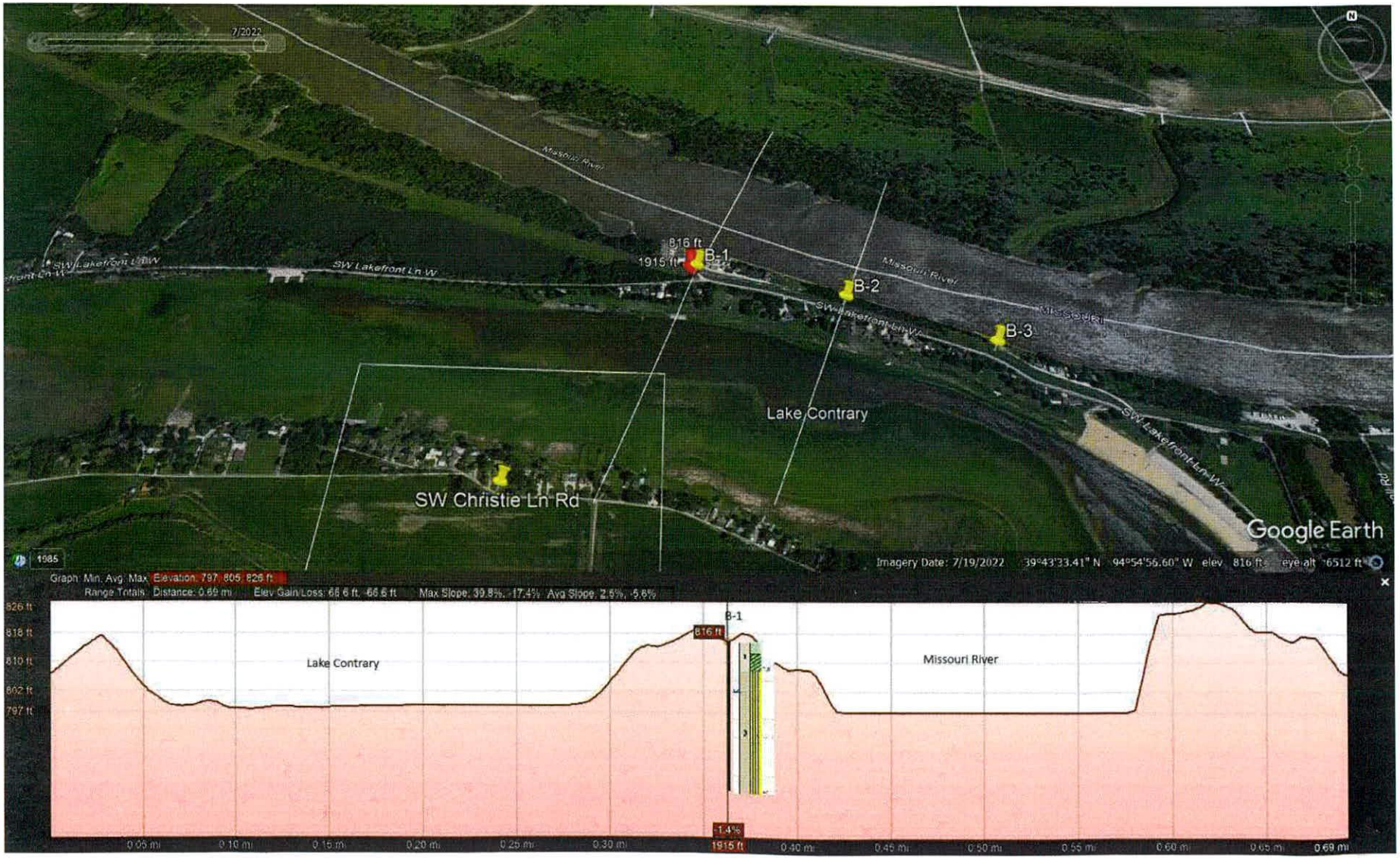
This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted engineering practices and make no warranties, either express or implied, as to the professional advice provided under the terms of our agreement and included in this report.

Appendix A References

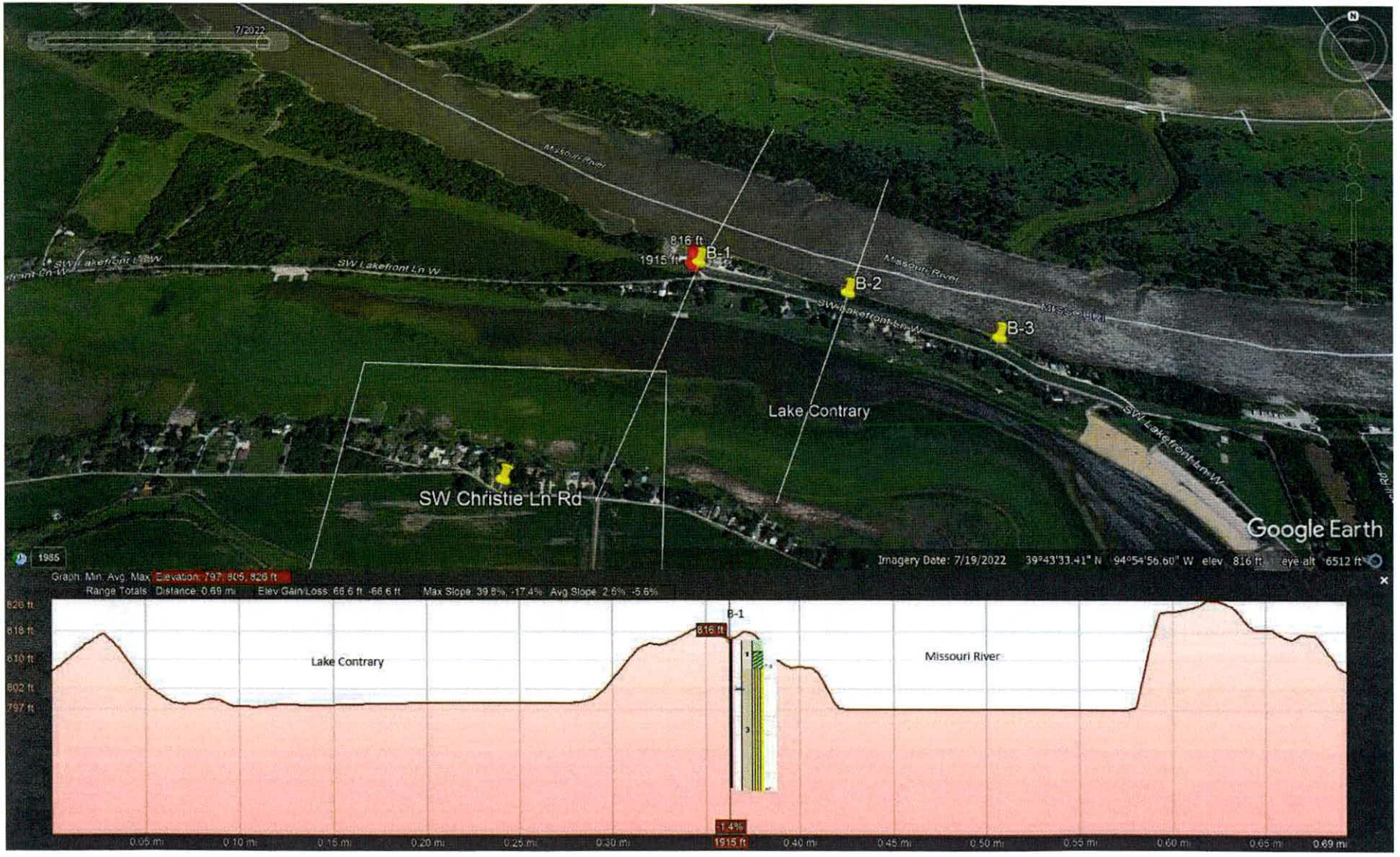
Appendix A

Cross Sections

Section B-1


7/2022
Missouri River
816 ft
1915 ft
B-1
B-2
B-3
SW Lakefront Ln W
Missouri River
Lake Contrary
SW Christie Ln Rd
Google Earth
Imagery Date: 7/19/2022 39°43'33.41" N 94°54'56.60" W elev 816 ft eye alt 6512 ft
Graph: Min, Avg, Max Elevation: 797, 805, 826 ft
Range Totals: Distance: 0.69 mi Elev Gain/Loss: 66.6 ft, -66.6 ft Max Slope: 39.8%, -17.4% Avg Slope: 2.5%, -5.6%
826 ft
818 ft
810 ft
802 ft
797 ft
B-1
816 ft
Lake Contrary
Missouri River
-1.4%
1915 ft
0.05 mi
0.10 mi
0.15 mi
0.20 mi
0.25 mi
0.30 mi
0.40 mi
0.45 mi
0.50 mi
0.55 mi
0.60 mi
0.65 mi
0.69 mi

Section B-2


7/2022
Missouri River
816 ft
1915 ft
B-1
B-2
B-3
SW Lakefront Ln W
Lake Contrary
SW Christie Ln Rd
Google Earth
1985
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826 ft
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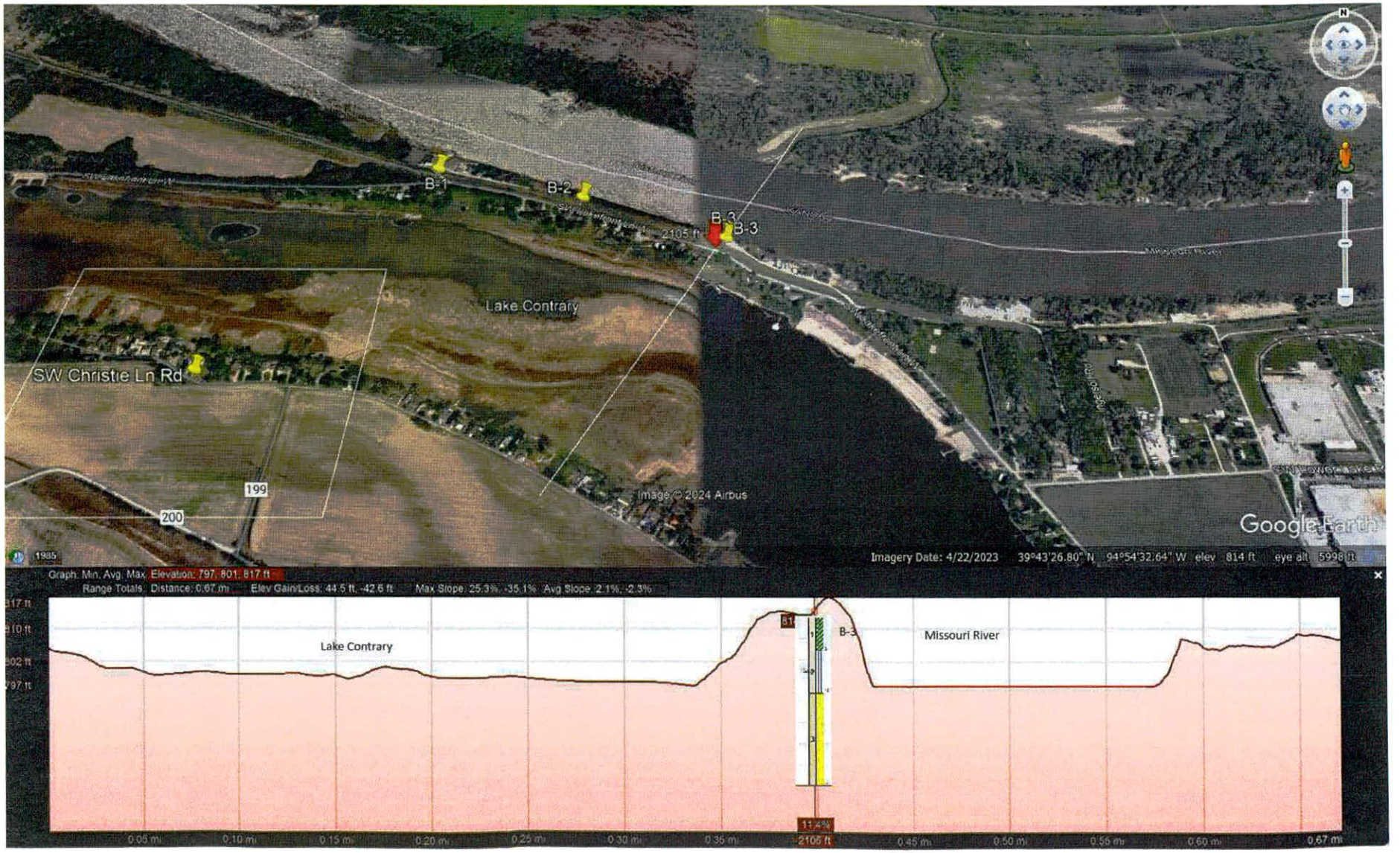
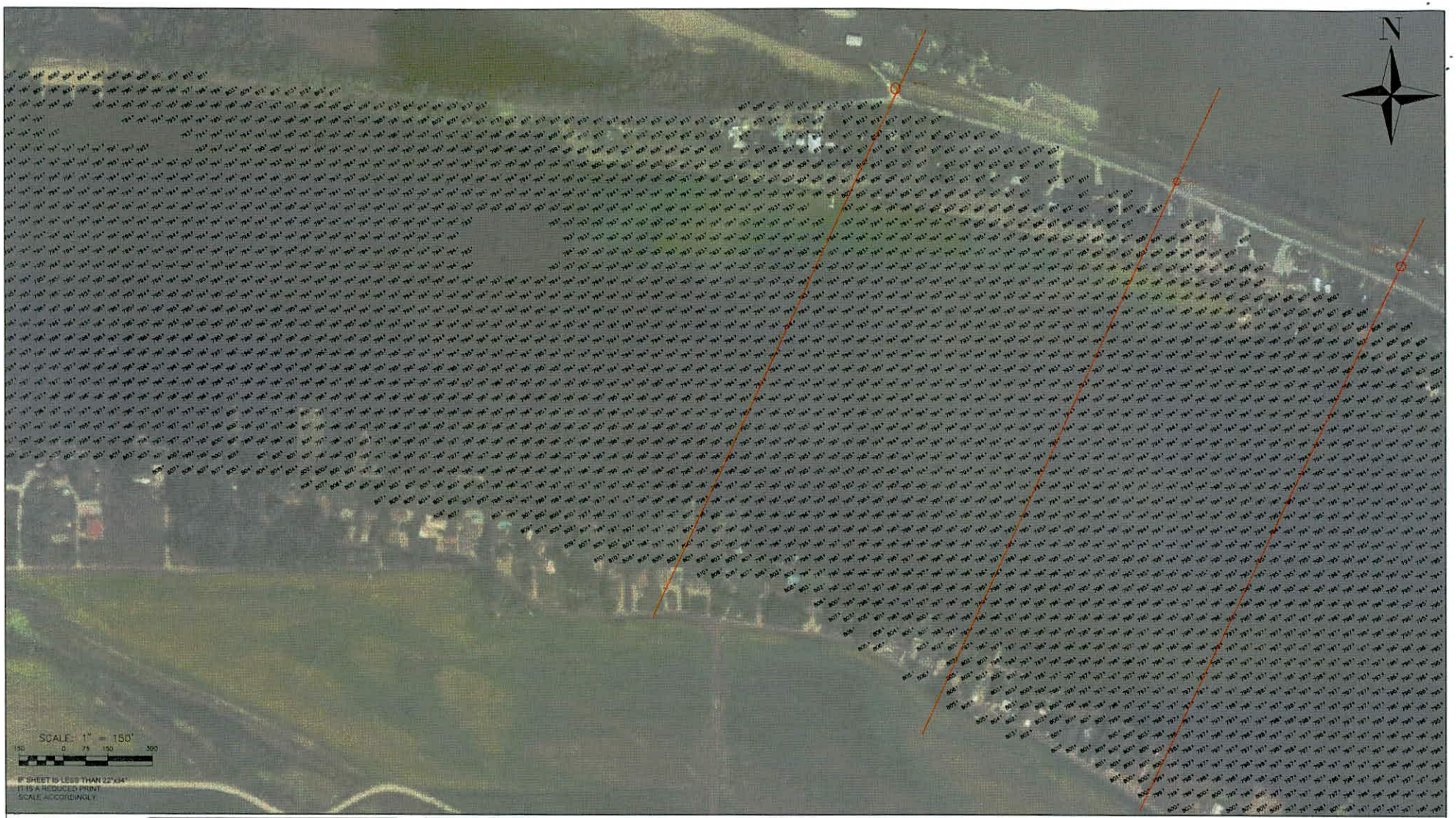
B-1
816 ft
Lake Contrary
Missouri River
-1.4%
1915 ft
0.05 mi
0.10 mi
0.15 mi
0.20 mi
0.25 mi
0.30 mi
0.40 mi
0.45 mi
0.50 mi
0.55 mi
0.60 mi
0.65 mi
0.69 mi

Section B-3


B-1
B-2
B-3
2105 ft
Lake Contrary
SW Christie Ln Rd
199
200
Image © 2024 Airbus
Google Earth
Imagery Date: 4/22/2023 39°43'26.80" N 94°54'32.64" W elev 814 ft eye alt 5998 ft
Graph: Min, Avg, Max Elevation: 797, 801, 817 ft
Range Totals: Distance: 0.67 mi Elev Gain/Loss: 44.5 ft, -42.6 ft Max Slope: 25.3%, -35.1% Avg Slope: 2.1%, -2.3%
Lake Contrary
B-3
Missouri River
11.4%
2105 ft
0.05 mi
0.10 mi
0.15 mi
0.20 mi
0.25 mi
0.30 mi
0.35 mi
0.45 mi
0.50 mi
0.55 mi
0.60 mi
0.67 mi



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ambrozi.com

eTrac Inc.
637 LINDARO STREET
SUITE 100
SAN RAFAEL, CA 94901
415.462.0421
eTracInc.com

SURVEY DATE: NOVEMBER 8 & 9, 2022	PLOT DATE: December 9, 2022
DESIGNED BY: GC	CHECKED BY: JAK
REVISION #	
FILE NAME: AMBR_20221108_LakeContrary_.dwg	

LAKE CONTRARY
AMBROZI CIVIL CONTRACTORS
AERIAL LIDAR

TOPO DATA BINNED AT 50FT

Reference Number:

S3


Flood Level

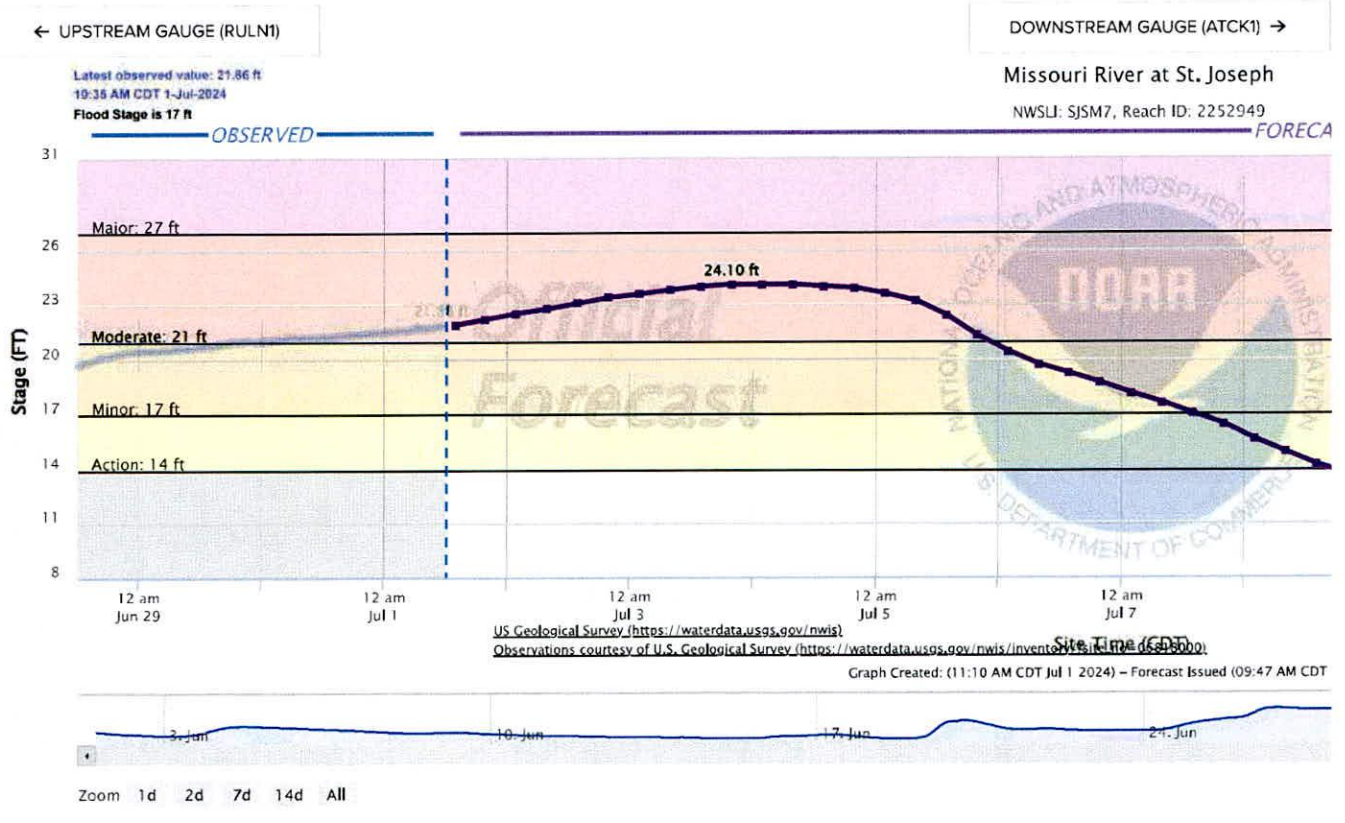
Welcome to the NWPS. If viewing on a mobile device, please try landscape mode. A QUICK START GUIDE IS AVAILABLE (https://www.weather.gov/media/owp/operations/nwps_quick_start_guide.pdf) and includes guidance on accessing the legacy formatted hydrograph. Additional NWPS resources are available HERE (https://www.weather.gov/owp/operations)

(https://www.noaa.gov/) (https://www.weather.gov/)

Missouri River at St. Joseph

Last updated: Jul 1, 2024, 12:10 PM EDT

Official Forecast | National Water Model Guidance



Scale to Flood Categories

Traces and Thresholds Click to turn on/off display

Observed (OBS) 07/01/2024 10:35 AM CDT

Official Forecast (FCST) 07/01/2024 9:47 AM CDT

CATEGORY	STAGE
Major Flooding	27 ft
Moderate Flooding	21 ft
Minor Flooding	17 ft
Action	14 ft

Reliability of the Forecast:

NOTE: Forecasts are issued routinely year-round.

River forecasts for this location take into account past precipitation and the precipitation amounts expected approximately 24 hours into the future from the forecast issuance time.

– none –

Flood Impacts

31.5 - The levee system will likely be overtopped, causing flooding in the town of Elwood and the eastern edge of Wathena.

30 - St. Joseph public works building on 3rd Street floods.

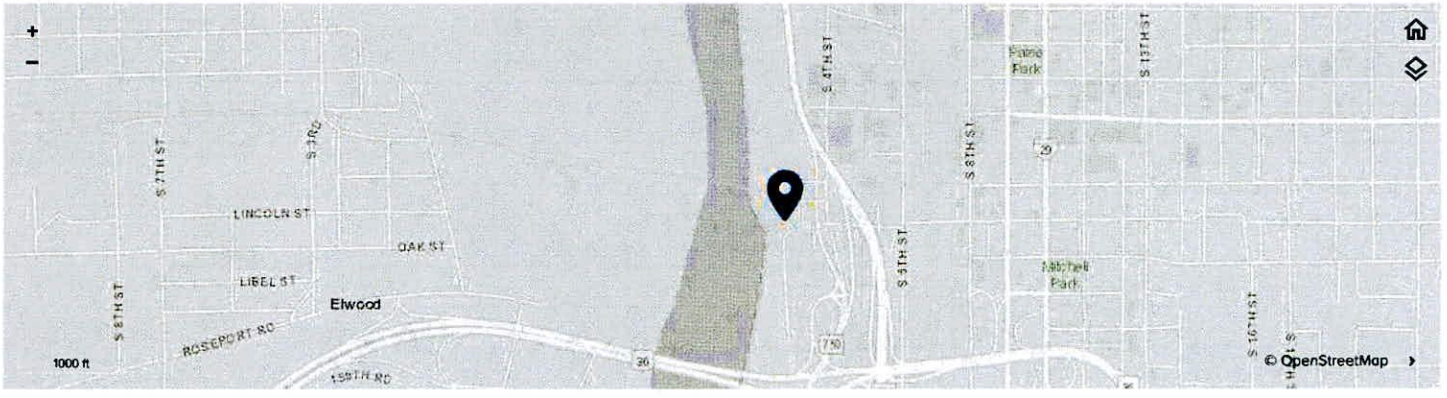
24 - A residential area in northwest St. Joseph begins to flood.

SHOW MORE FLOOD IMPACTS

Gauge Info

Coordinates	39.7533, -94.8568
RFC	MBRFC (/rfc/MBRFC)
State	MO (/state/MO)
WFO	EAX (/wfo/eax)
County	Buchanan
Data Provider(s)	
US Geological Survey	USGS–Water Resources of the United States (https://waterdata.usgs.gov/nwis)
USGS	06818000 (https://waterdata.usgs.gov/nwis/inventory/?site_no=06818000)

Gauge Location



☐ Display SJSM7 marker

☐ Display FEMA's National Flood Hazard Layers

Recent Crests

20.40 ft on 06-25-2021

19.55 ft on 05-27-2020

24.74 ft on 10-03-2019

32.07 ft on 03-22-2019

19.02 ft on 12-02-2018

SHOW ALL

Historic Crests

32.07 ft on 07-26-1993

32.07 ft on 03-22-2019

29.97 ft on 06-28-2011

27.20 ft on 04-29-1881

26.82 ft on 04-22-1952

SHOW ALL

(P) - Preliminary values subject to further review

[1] - Gauge datum changed during this year

Vertical Datum Table

TYPE	NAVD88
Major Flooding	816.27 ft
Moderate Flooding	810.27 ft
Minor Flooding	806.27 ft
Action	803.27 ft
Latest Value	811.08 ft
Gauge Zero	789.27 ft

Gauge Photos

No Images Found

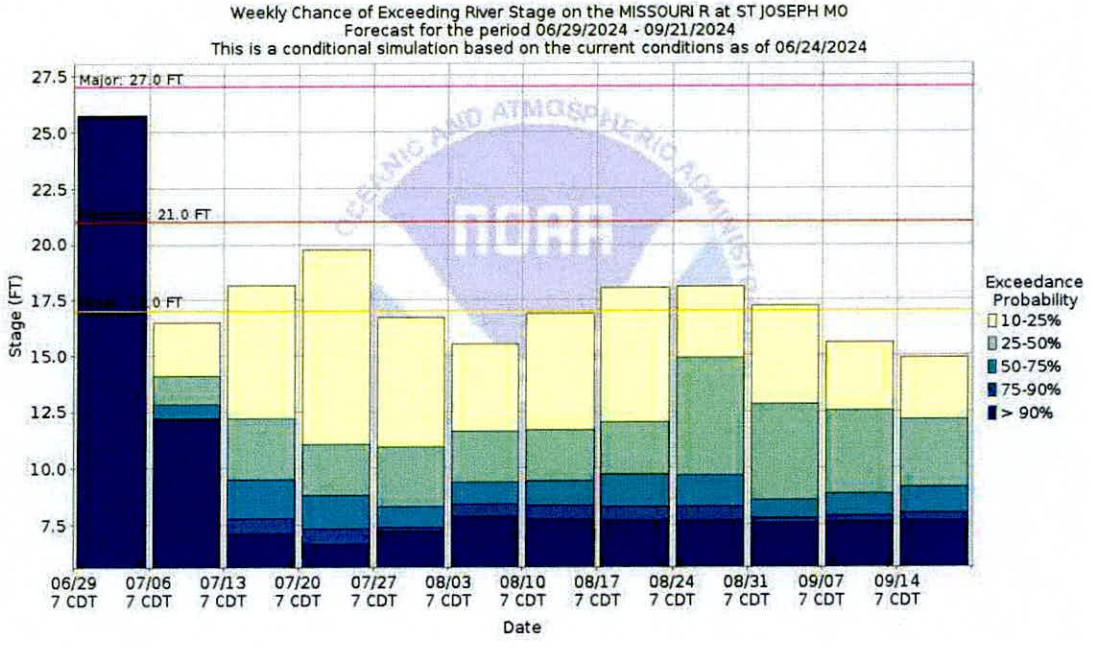
Probability Information

Photo 1 of 3

Weekly Chance of Exceeding Levels

About this graph (/about/weekly-chance-of-exceeding-levels-graphic)

Stage



Soil Parameters

Soil Description	Hydraulic Conductivity, k (cm/s)	Bioremediation Effectiveness
Clean gravel	$1 - 100$	Effective
Sand-gravel	$10^{-2} - 10$	Effective
Clean coarse sand	$10^{-2} - 1$	Effective
Fine sand	$10^{-3} - 10^{-1}$	Moderate
Silty sand	$10^{-3} - 10^{-2}$	Moderate
Clayey sand	$10^{-4} - 10^{-2}$	Limited
Silt	$10^{-8} - 10^{-3}$	Ineffective
Clay	$10^{-10} - 10^{-6}$	Ineffective

Soil Correlations

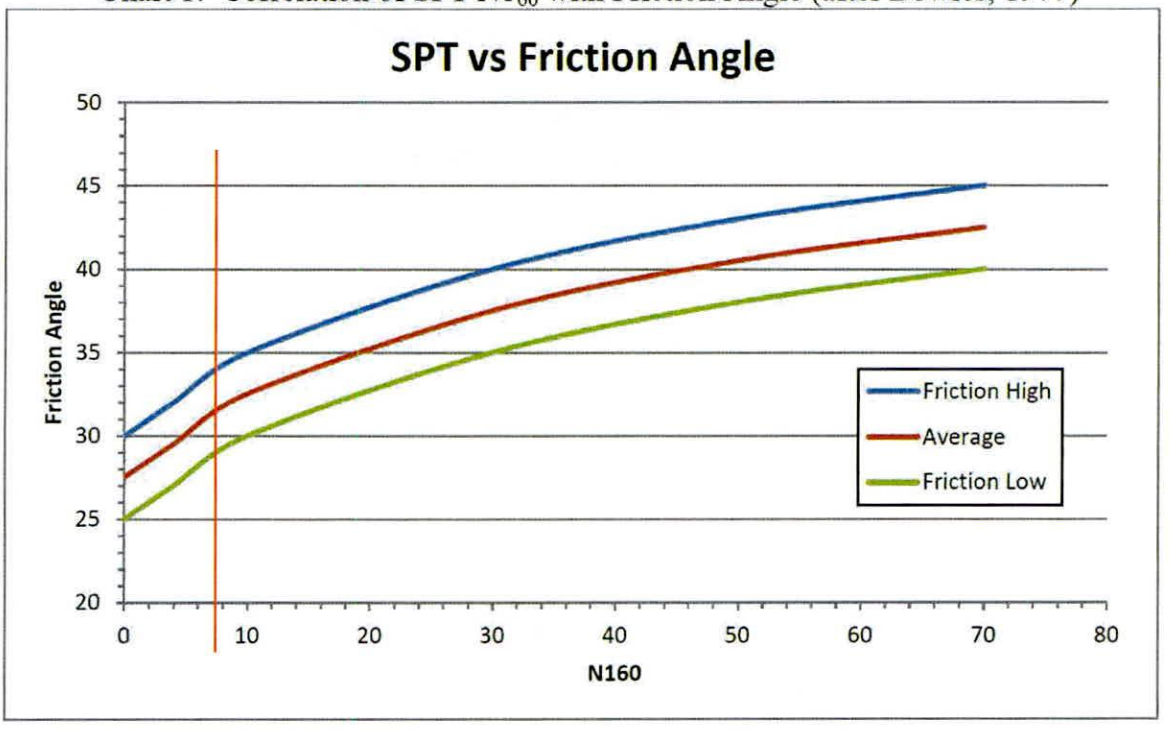
This section of the Geotechnical Manual presents the SPT correlations to be used for friction angle (phi angle) and unit weight. The correlations use Standard Penetration Test (N) values corrected for overburden and hammer efficiency ($N1_{60}$). Usage of correlations for geotechnical design is addressed in the various design sections of the Geotechnical Manual. Other correlations, e.g. CPT correlations and shear wave velocity correlations are found elsewhere in the Geotechnical Manual.

Cohesionless Soil: Friction Angle

Correlations of SPT blow counts to cohesionless soil friction angle and unit weight follow Bowles (1977) and are consistent with many of the NHI manuals used by the department. The correlations use Standard Penetration Test (N) values corrected for overburden and hammer efficiency ($N1_{60}$).

Use Chart 1 to correlate $N1_{60}$ to the friction (phi) angle.

Chart 1: Correlation of SPT $N1_{60}$ with Friction Angle (after Bowles, 1977)



Choose the friction angle (expressed to the nearest degree) based upon the soil type, particle size(s), and rounding or angularity. Experience should be used to select specific values within the ranges. In general, finer materials or materials with significant (about 30+ %) silt-sized material will fall in the lower portion of the range. Coarser materials

with less than 5% fines will fall in the upper portion of the range. The extreme range of phi angles for any $N1_{60}$ is five degrees, so the adjustment factors for particle size and roundness should be only a degree or two. The following bullets provide help in determining which value to select for a given $N1_{60}$ and soil type:

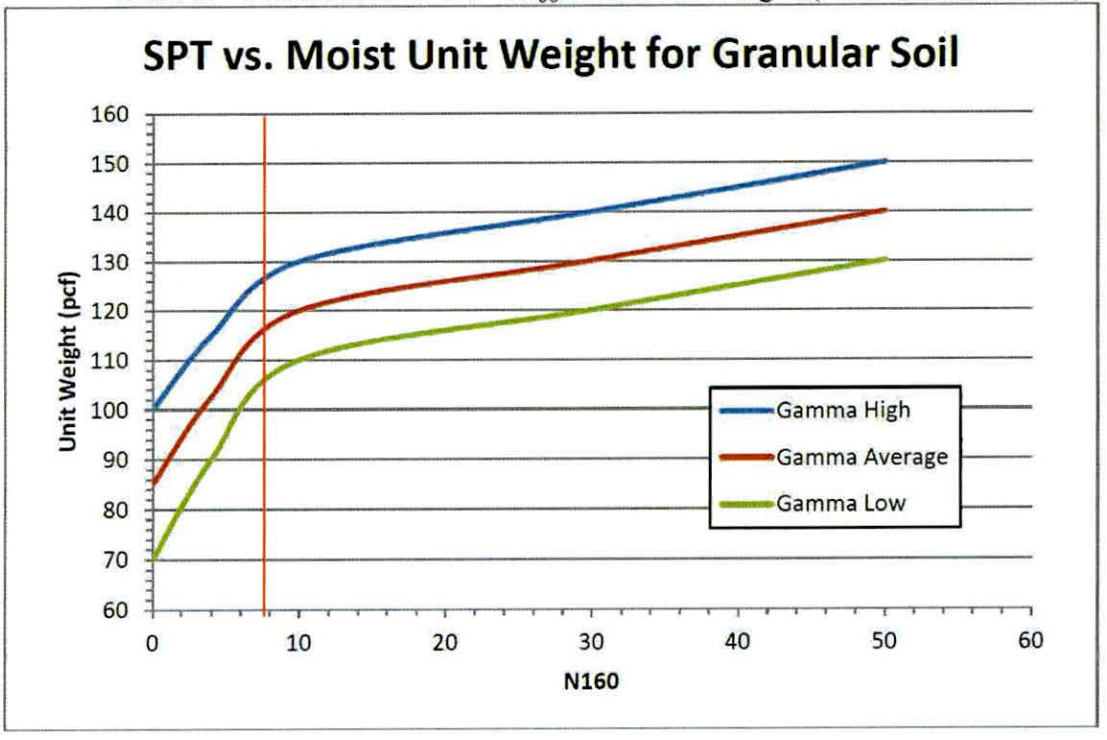
- Use the maximum value for GW
- Use the average for GM and SP
- Use the minimum for SC
- Use the minimum + 0.5 for ML
- Use the average +1 for SW
- Use the average -1 for GC
- Use the Maximum -1 for GP

Values may also be increased with increasing grain size and/or particle angularity and decreased with decreasing grain size and/or increasing roundness. For example, an SP with $N1_{60}$ = 30 could be assigned phi angles of 37, 38 or 39 degrees for fine, medium and coarse grain sizes respectively.

Cohesionless Soil: Unit Weight

Use Chart 2 to correlate $N1_{60}$ to the moist unit weight for cohesionless (Granular) soil.

Chart 2: Correlation of SPT $N1_{60}$ with Unit Weight (after Bowles, 1977).



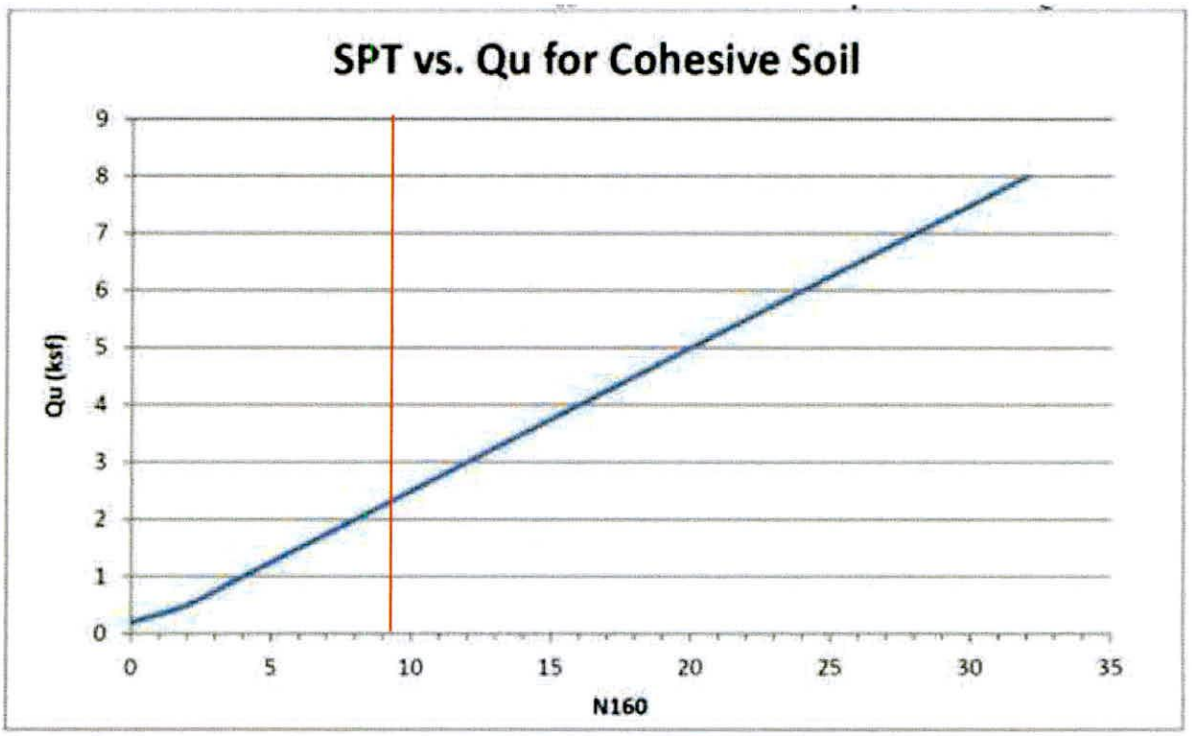
Choose the unit weight expressed to the nearest five pcf for the soil type based on the following guidelines:

- Use the higher values for well-graded sands and gravels and average values for poorly-graded sands and gravels.
- Use lower values for elastic silt, and clayey or silty sands and gravel.
- Deduct up to 20% for dry soils.

Cohesive Soil: Unconfined Compressive Strength (Qu)
Undrained Shear Strength (Su)

The standard practice is to determine shear strength of cohesive soils in the field based on measurements with torvane, pocket penetrometer, or vane shear. It is not acceptable to use SPT correlations to determine shear strength or to assign consistency values. For preliminary studies, use Chart 3 to assign shear strength values when only SPT values are available. Usually this is applicable when data are available from old as-built LOTBs where field or laboratory strength tests are not available.

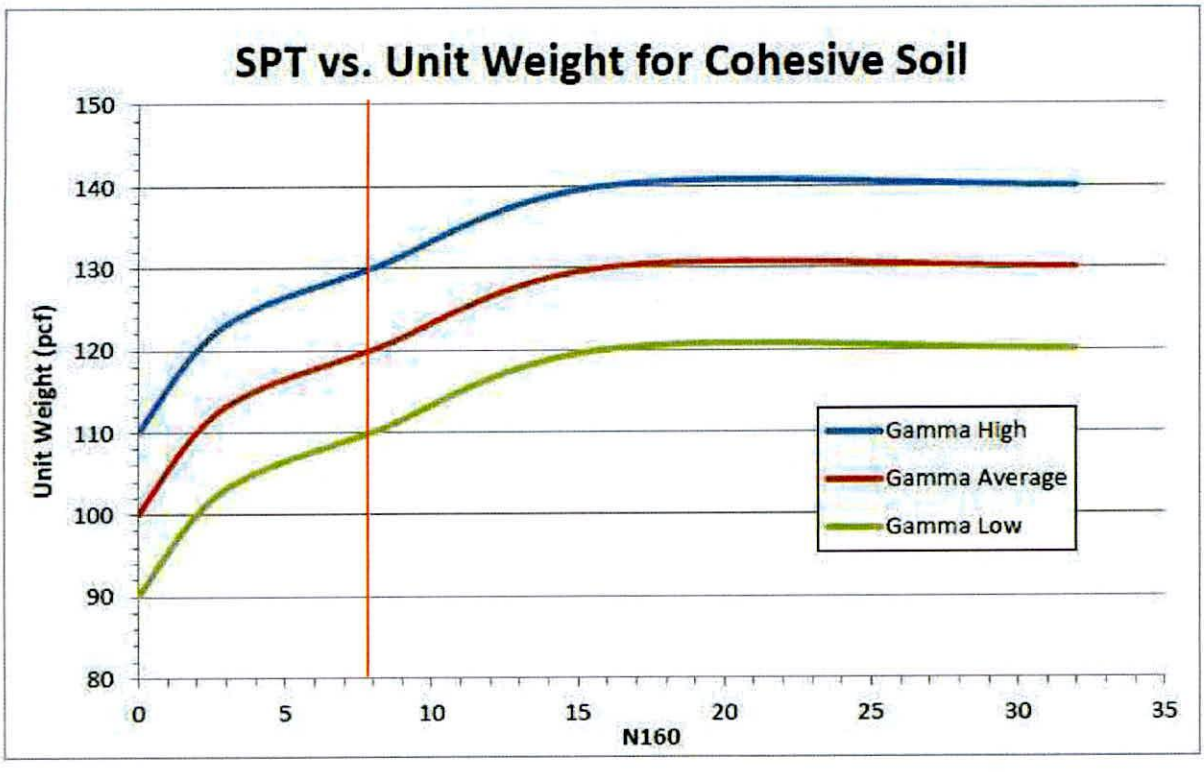
Chart 3: Correlation of SPT $N1_{60}$ to Unconfined Compressive Strength
(after Bowles, 1977)



Cohesive Soil: Unit Weight

Use Chart 4 to correlate $N1_{60}$ with the Unit Weight of cohesive soil.

Chart 4: Correlation of SPT $N1_{60}$ with Unit Weight (after Bowles, 1977).



Comparing field pocket penetrometer and/or torvane readings to Chart 4 is a good way of determining whether high or low values should be used. For example, if the pocket penetrometer reading for a clay with $N1_{60}$ = 10 is about 2.5 ksf (the same as the value shown in Chart 3) the unit weight should correspond to the average value. If the pocket penetrometer reading is higher, the unit weight should be increased from the average, and if the pocket penetrometer reading is lower, the unit weight should be decreased from the average.

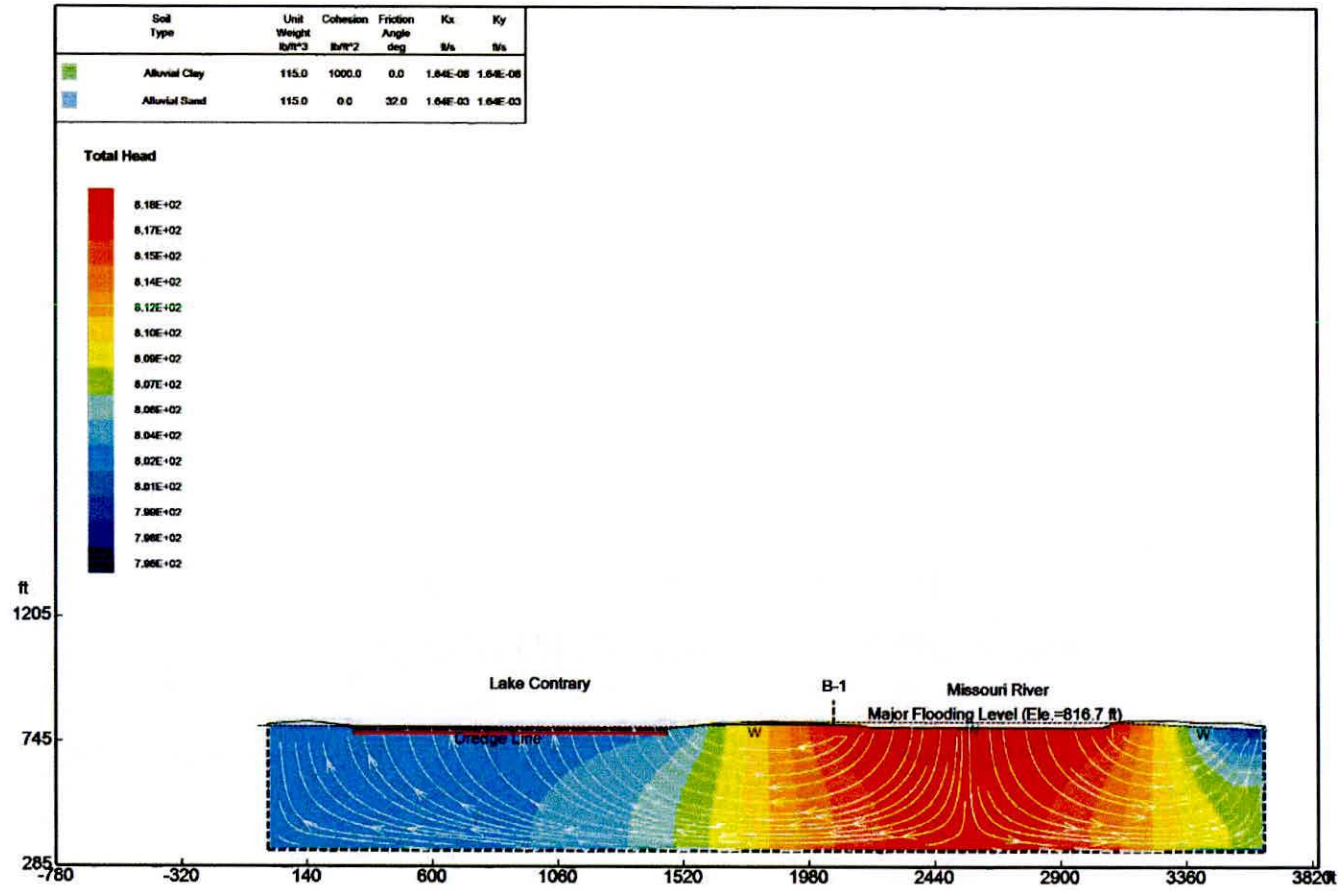
In the absence of SPT data, unit weights can be estimated using Charts 3 and 4 and the strength data (e.g., pocket penetrometer reading). For example, from Chart 3, a pocket penetrometer value of 5 ksf corresponds to an SPT $N1_{60}$ value of 20. Chart 4 shows the average unit weight of a cohesive soil with SPT $N1_{60}$ = 20 is 130 pcf.

Appendix B Result of Analysis

Seepage and Slope Stability Analysis Output

Lake Contrary and Missouri River
St. Joseph, Missouri

Lake Contrary - Missouri River Underseepage Analysis
B-1 Section (Before Dredge)



Discharge Rate: 9.26E-03 ft^3/s/ft Y-exit Gradient: 0.004 Along Specified Section

Seepage Analysis-Equal Potential-Flow Diagram

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-1 Section-0.slp

Seepage Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

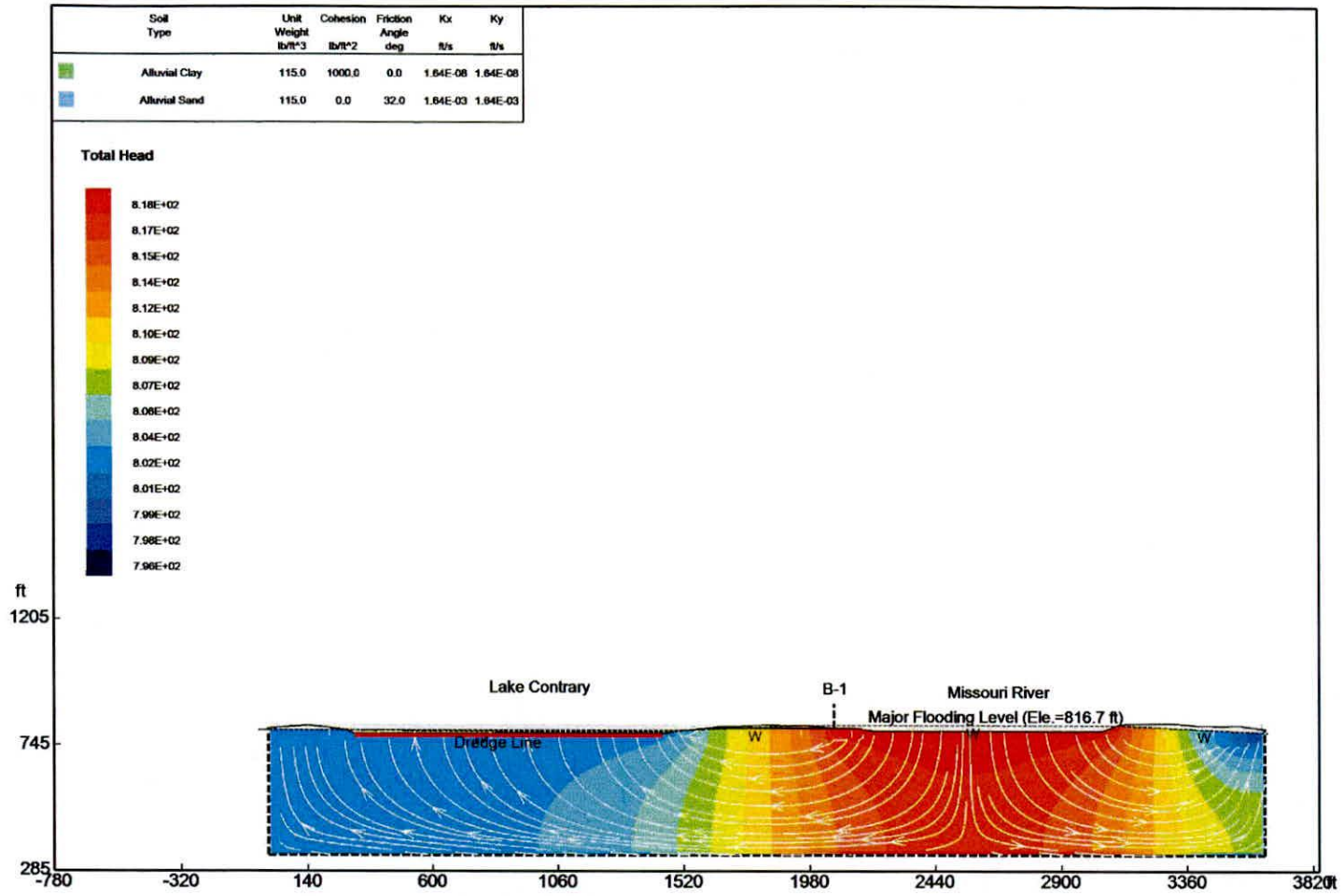
Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-1 (Before Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-1 Section (After Dredge)

Soil Type	Unit Weight lb/ft^3	Cohesion lb/ft^2	Friction Angle deg	Kx ft/s	Ky ft/s
Alluvial Clay	115.0	1000.0	0.0	1.84E-08	1.84E-08
Alluvial Sand	115.0	0.0	32.0	1.84E-03	1.84E-03



Discharge Rate: 4.86E-03 ft^3/s/ft Y-exit Gradient: 0.004 Along Specified Section

Seepage Analysis-Equal Potential-Flow Diagram

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-1 Section-1.slp

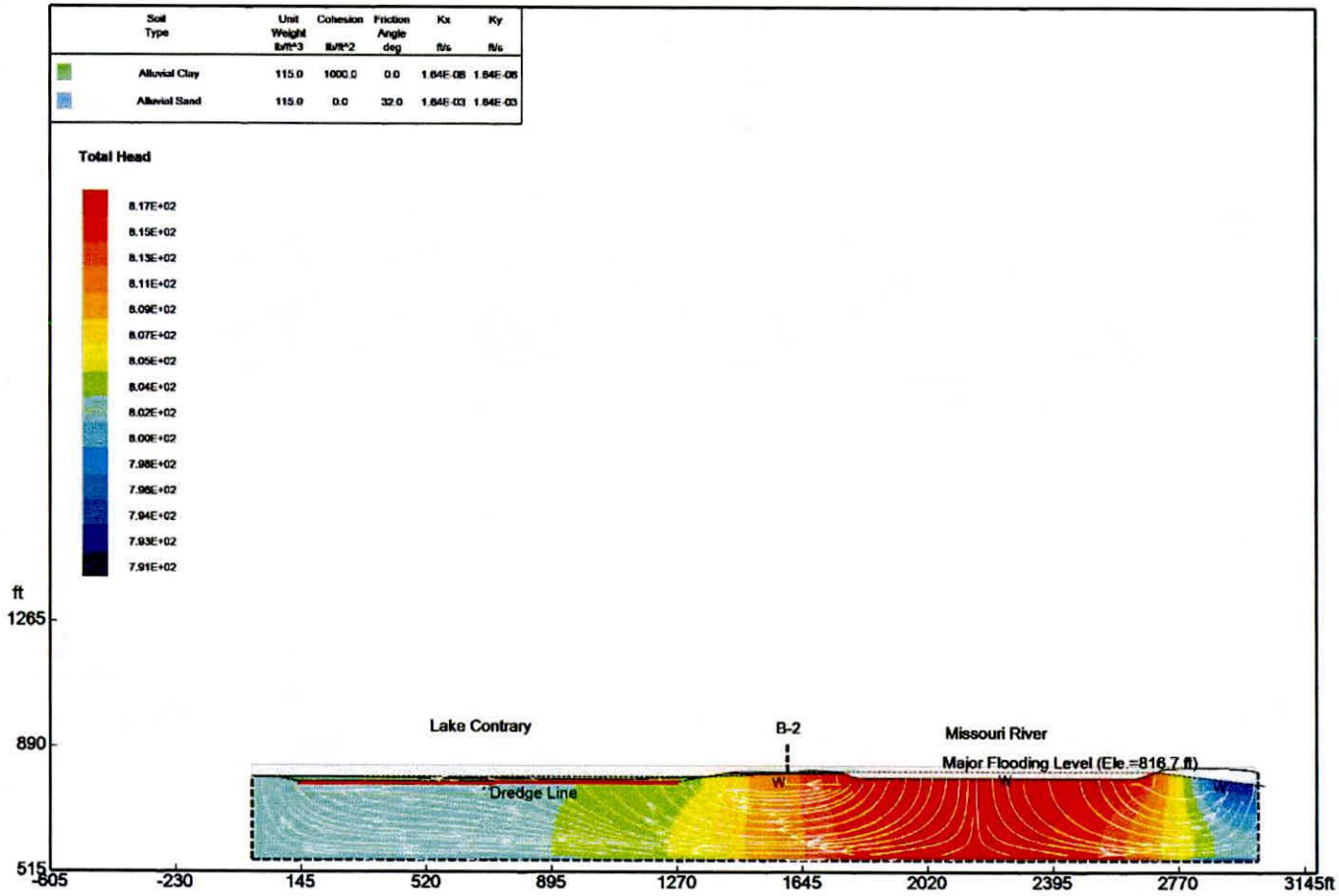
Seepage Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-1 (After Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-2 Section (Before Dredge)



Discharge Rate: 1.13E+00 ft^3/s/ft Y-exit Gradient: 0.002 Along Specified Section

Seepage Analysis-Equal Potential-Flow Diagram

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-2 Section-2-0.slp

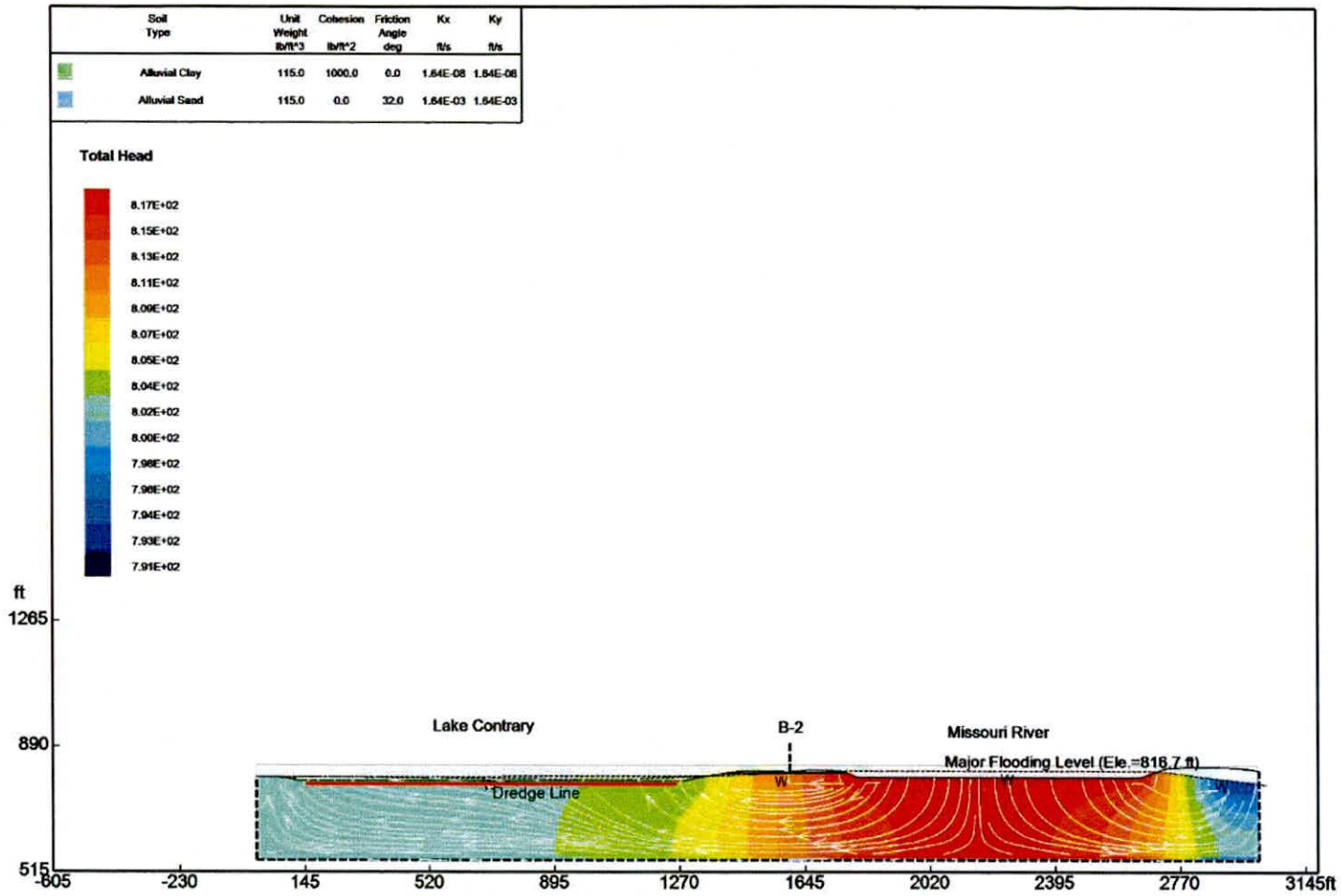
Seepage Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-2 (Before Dredging)

Lake Contrary - Missouri River Underseepage Analysis
B-2 Section (After Dredge)

Soil Type	Unit Weight lb/ft^3	Cohesion lb/ft^2	Friction Angle deg	Kx ft/s	Ky ft/s
Alluvial Clay	115.0	1000.0	0.0	1.64E-08	1.64E-08
Alluvial Sand	115.0	0.0	32.0	1.64E-03	1.64E-03



Discharge Rate: 2.06E-02 ft^3/s/ft Y-exit Gradient: 0.002 Along Specified Section

Seepage Analysis-Equal Potential-Flow Diagram

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-2 Section-2-1.slp

Seepage Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

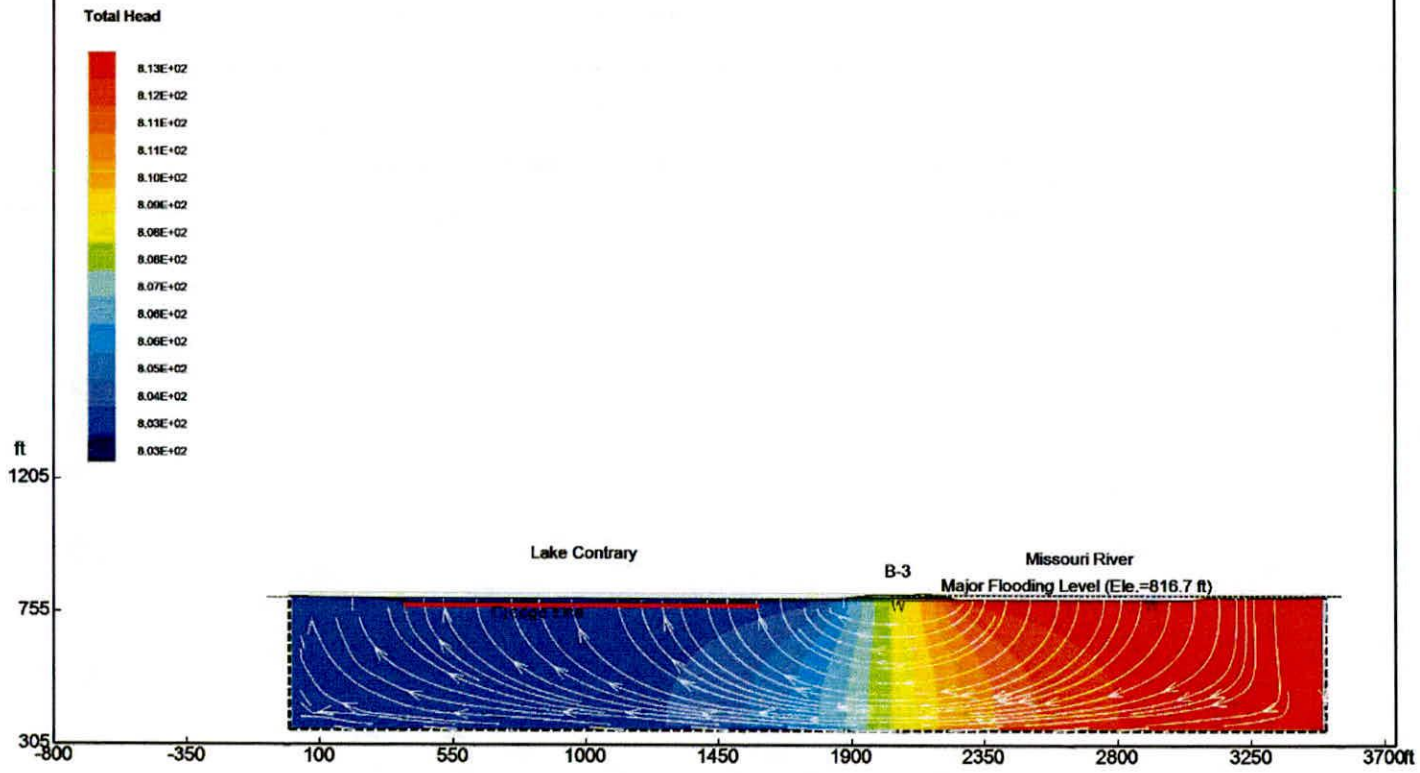
Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-2 (After Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-3 Section (Before Dredge)

Soil Type	Unit Weight lb/ft^3	Cohesion lb/ft^2	Friction Angle deg	Kx ft/s	Ky ft/s
Alluvial Clay	115.0	1000.0	0.0	1.64E-08	1.64E-08
Alluvial Silt	115.0	0.0	30.0	1.64E-07	1.64E-07
Alluvial Sand	115.0	0.0	32.0	1.64E-03	1.64E-03



Discharge Rate: 2.25E-03 ft^3/s/ft Y-exit Gradient: 0.001 Along Specified Section

Seepage Analysis-Equal Potential-Flow Diagram

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-3 Section-0.slp

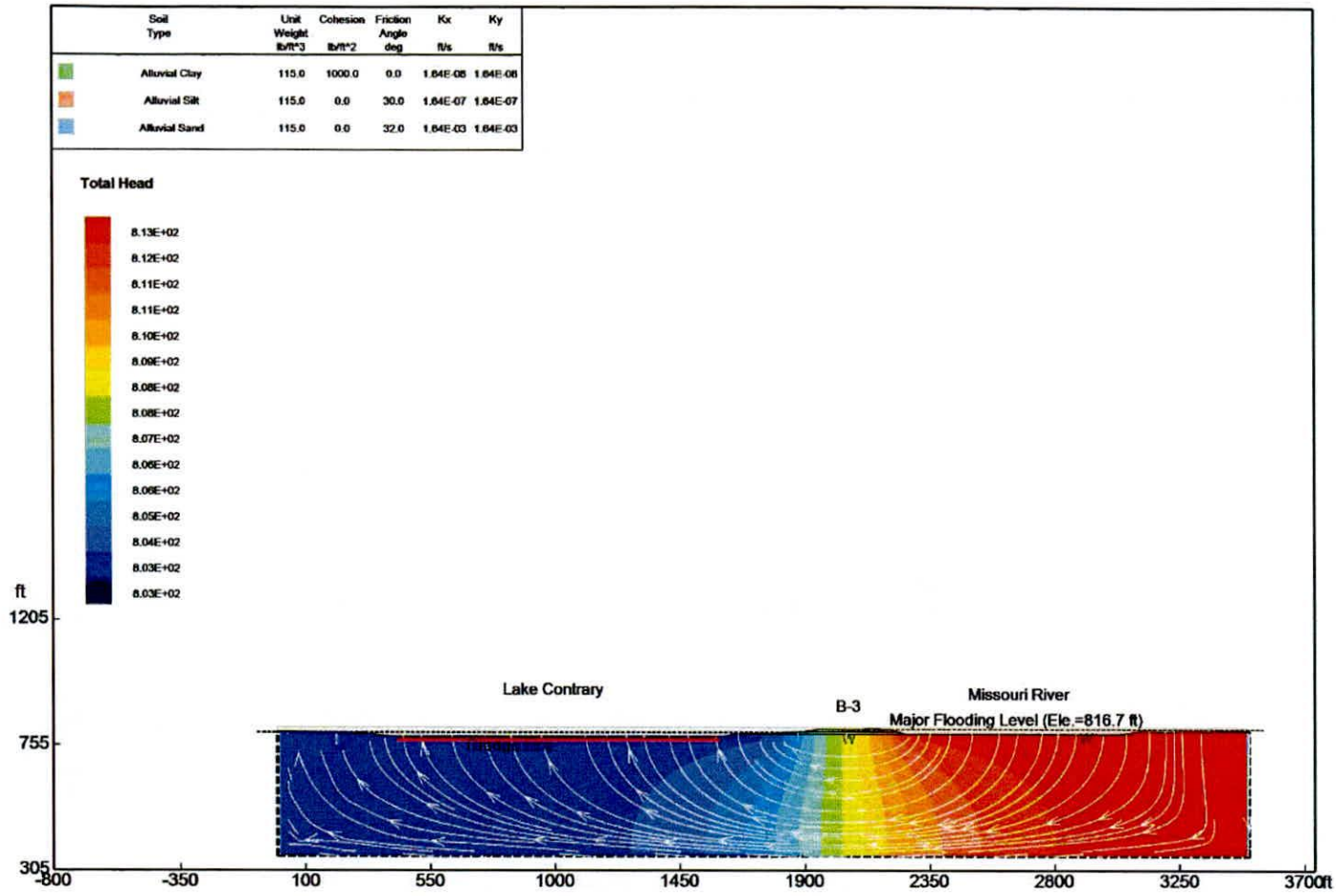
Seepage Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-3 (Before Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-3 Section (After Dredge)



Discharge Rate: 2.29E-03 ft^3/s/ft Y-exit Gradient: 0.001 Along Specified Section

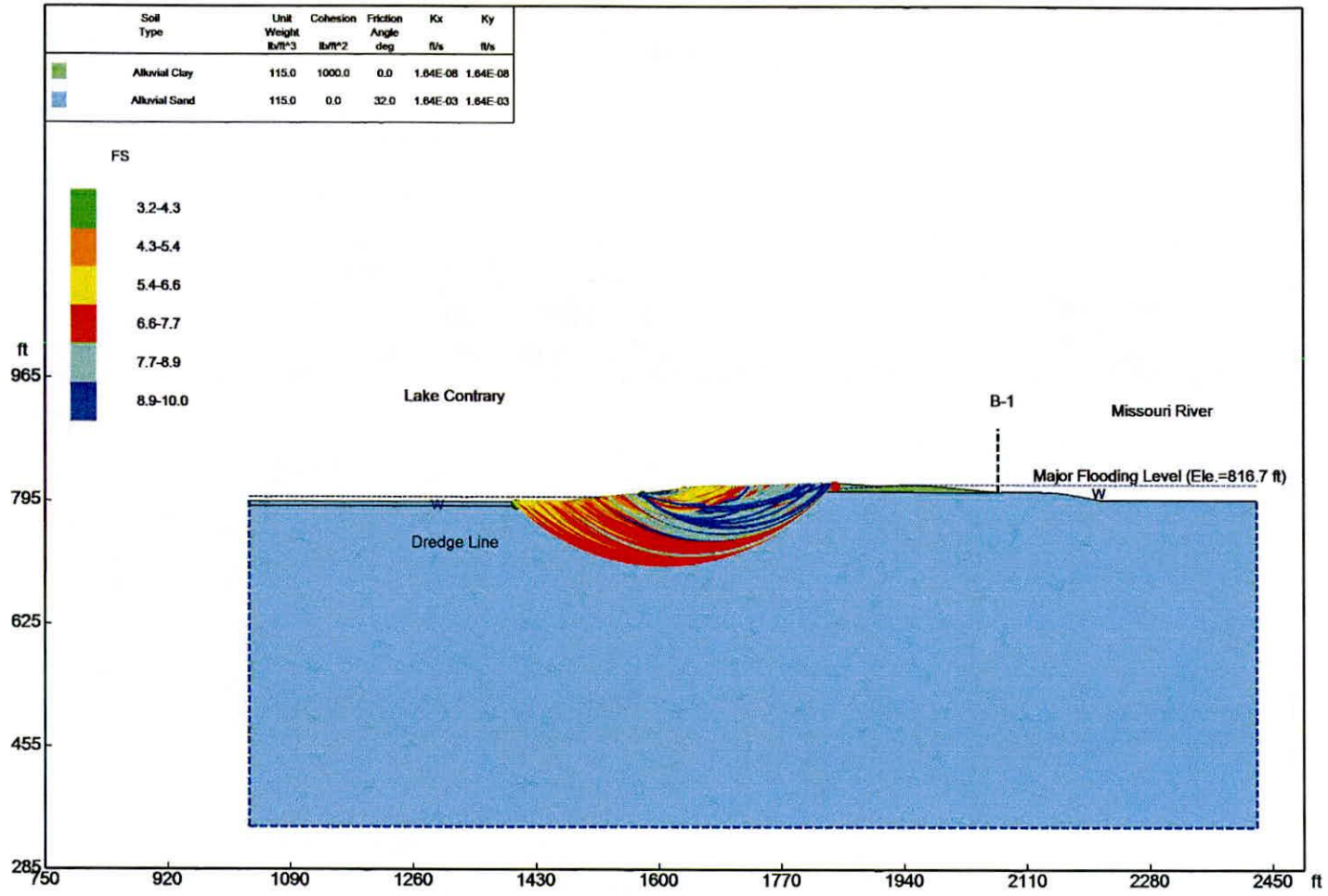
Seepage Analysis-Equal Potential-Flow Diagram

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-3 Section-1.slp

Seepage Analysis Output Lake Contrary and Missouri River St. Joseph, Missouri	Terracon 20401 Seneca Meadows Pkwy Germantown, MD 20876	Section B-3 (After Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-1 Section (Before Dredge)



FSmin = 3.15 Failure Surface Fi/C Reduction= 1.0/1.0

Slope Stability Analysis-Spencer Method

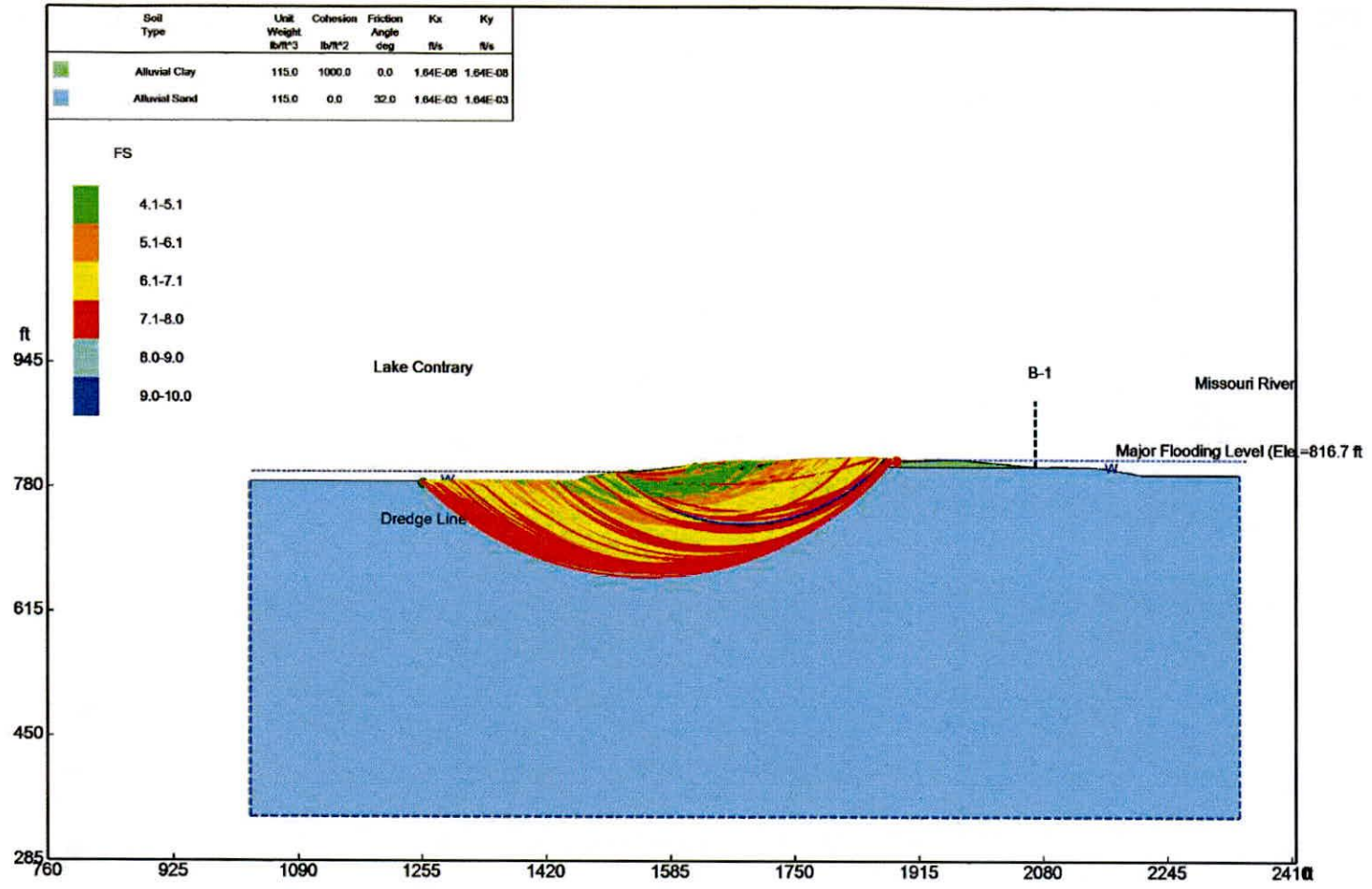
User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-1 Section-0-1.slp

Slope Stability Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-1 (Before Dredging)

Lake Contrary - Missouri River Underseepage Analysis
B-1 Section (After Dredge)



FSmin = 4.12 Failure Surface Fi/C Reduction= 1.0/1.0

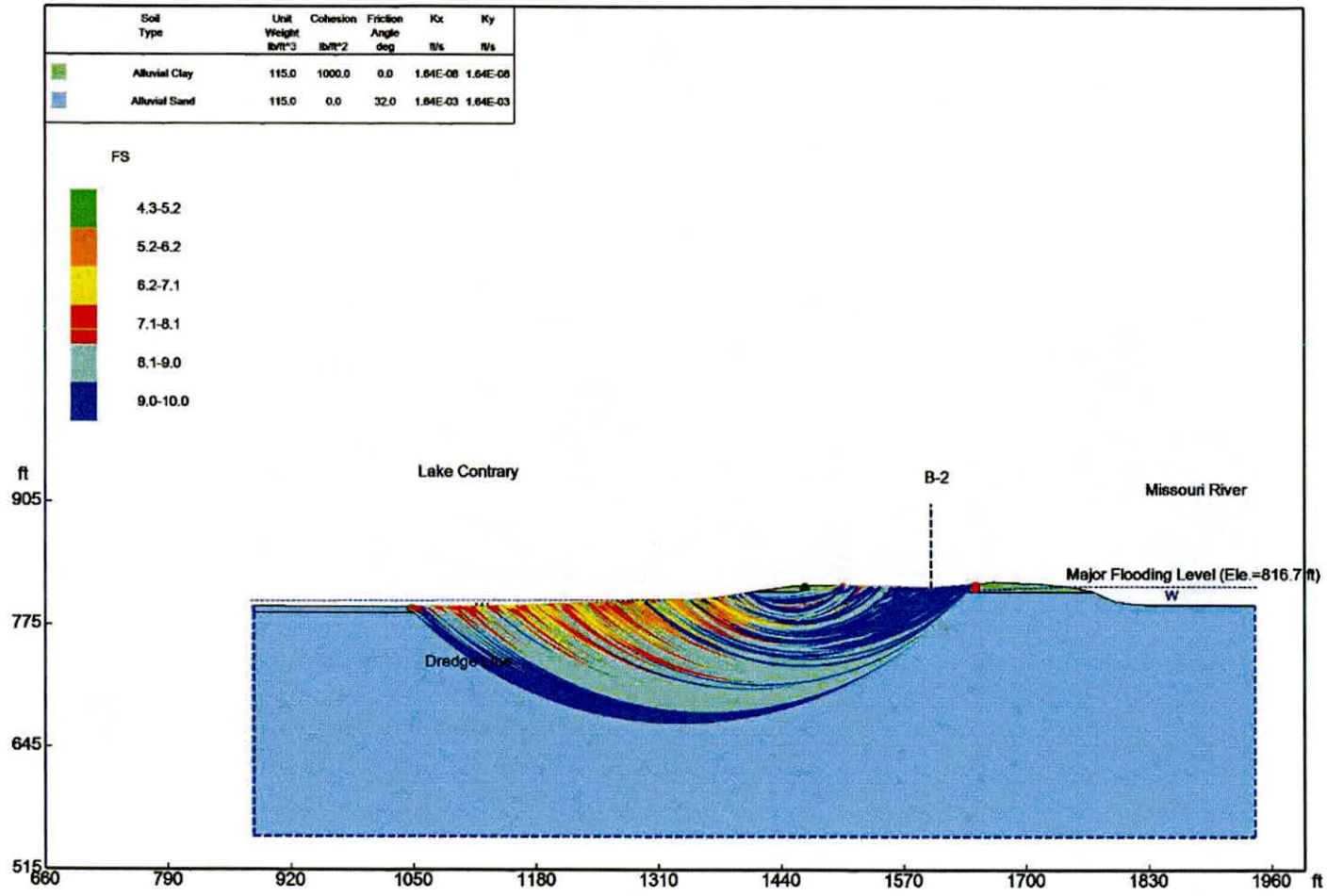
Slope Stability Analysis-Spencer Method

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-1 Section-1-1.slp

Slope Stability Analysis Output Lake Contrary and Missouri River St. Joseph, Missouri	Terracon 20401 Seneca Meadows Pkwy Germantown, MD 20876	Section B-1 (After Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-2 Section (Before Dredge)



FSmin = 4.25 Failure Surface Fi/C Reduction= 1.0/1.0

Slope Stability Analysis-Spencer Method

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-2 Section-0-1.slp

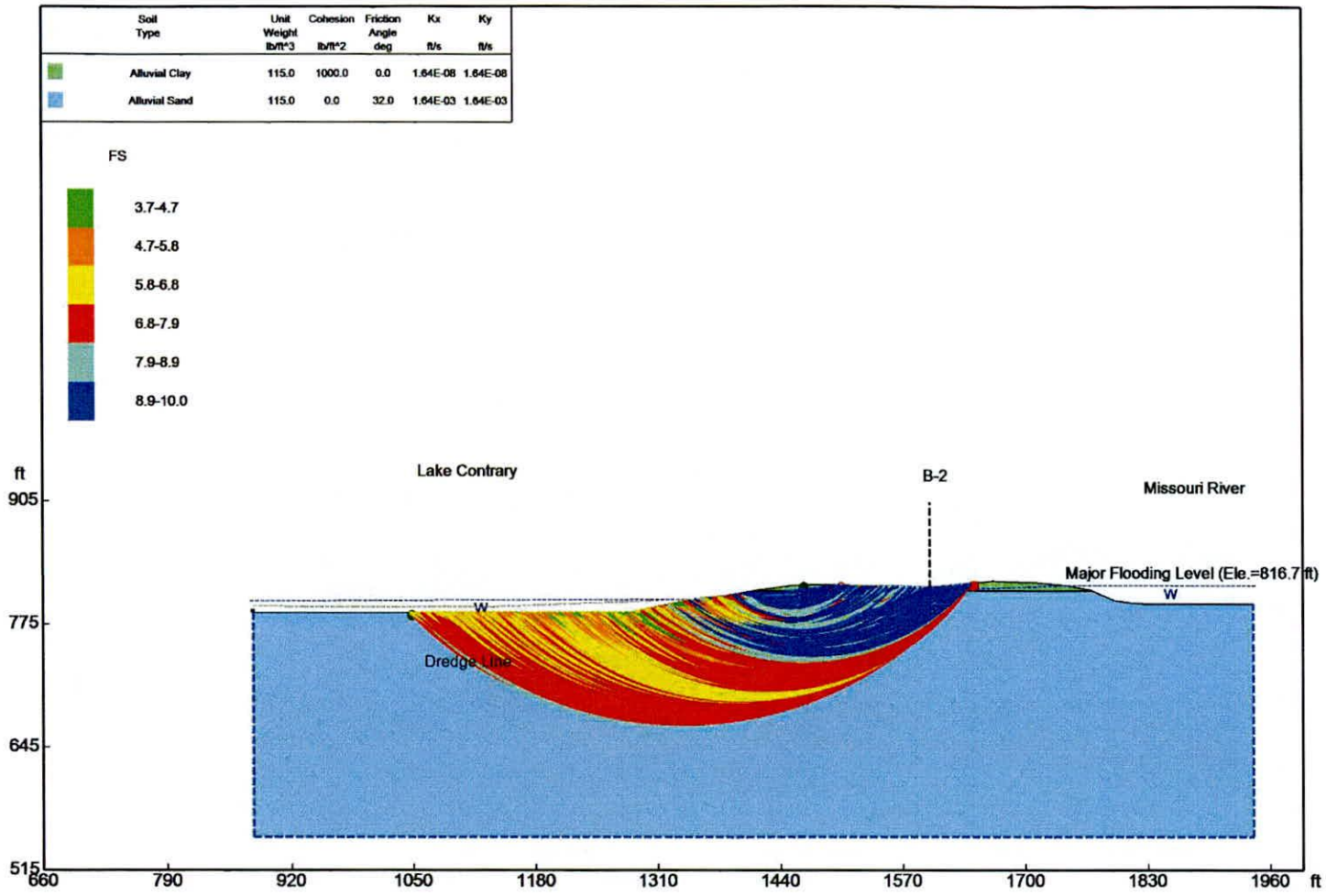
Slope Stability Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-2 (Before Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-2 Section (After Dredge)



FSmin = 3.65 Failure Surface Fi/C Reduction= 1.0/1.0

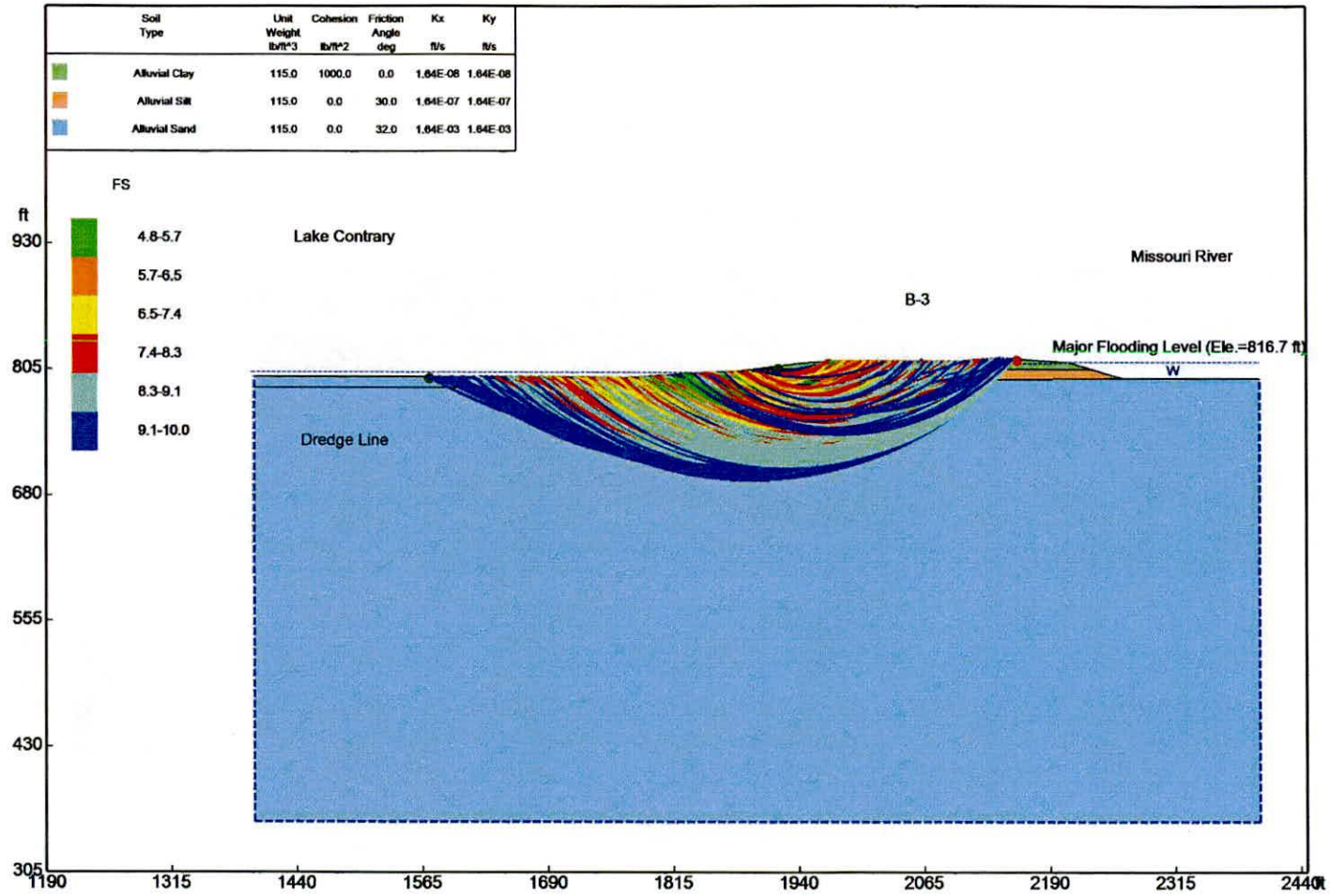
Slope Stability Analysis-Spencer Method

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-2 Section-1-1.slp

Slope Stability Analysis Output Lake Contrary and Missouri River St. Joseph, Missouri	Terracon 20401 Seneca Meadows Pkwy Germantown, MD 20876	Section B-2 (After Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-3 Section (Before Dredge)



FSmin = 4.81 Failure Surface Fi/C Reduction= 1.0/1.0

Slope Stability Analysis-Spencer Method

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-3 Section-0-1.slp

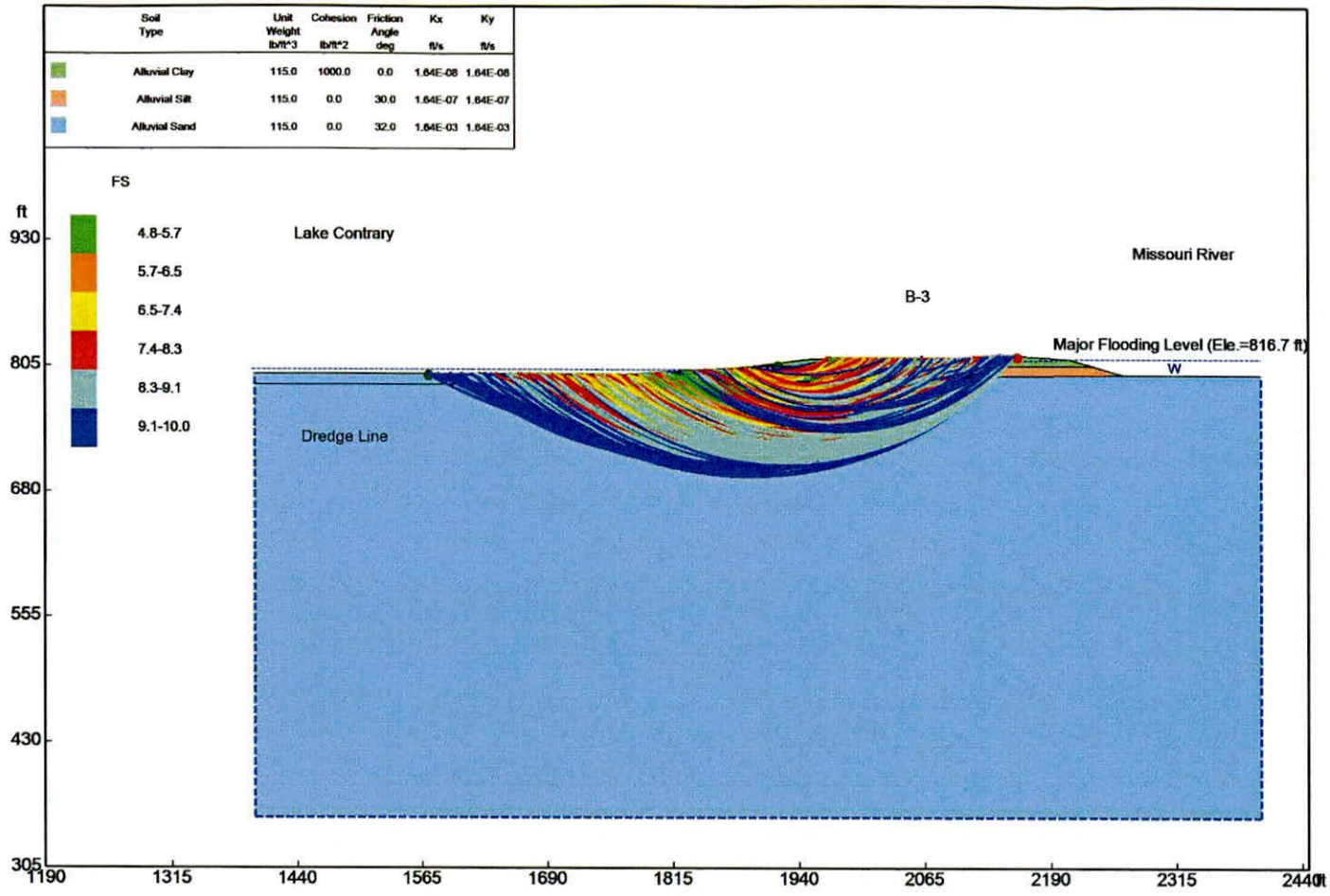
Slope Stability Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-3 (Before Dredging)

Lake Contrary - Missouri River Underseepage Analysis

B-3 Section (Before Dredge)



FSmin = 4.81 Failure Surface Fi/C Reduction= 1.0/1.0

Slope Stability Analysis-Spencer Method

User Name: szzhou C:\Users\szzhou\OneDrive - Terracon Consultants Inc\SZZhou\Lake Contrary Dredging Operation\Analysis\B-3 Section-0-1.slp

Slope Stability Analysis Output
Lake Contrary and Missouri River
St. Joseph, Missouri

Terracon
20401 Seneca Meadows Pkwy
Germantown, MD 20876

Section B-3 (After Dredging)