FINAL DESIGN REPORT

FOR
JOHNSTOWN RESERVOIR
WELD COUNTY, COLORADO
WATER DISTRICT NO. 4
WATER DIVISION 1
DAM ID – 040132
CONSTRUCTION FILE NUMBER C-0625A

JULY 1, 2021

PREPARED FOR:

Johnstown
Colorado

450 S PARISH AVE.
JOHNSTOWN, CO 80534

PREPARED BY:

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Certification Sheet

Johnstown Reservoir Repair

Water Division 1, Water District 4
Weld County, Colorado
DAM ID – 040132
SEO File Number – C-0625A

I, James C. York, a registered professional engineer in the State of Colorado, hereby certify that the Design Report for Johnstown Reservoir was prepared by me or under my direct supervision for the Town of Johnstown.

____
James C. York

Registered Professional Engineer
State of Colorado No. 36846

Approved on this ____ day of ______________, 20__.

____
State Engineer

By:______________________________
Name:
Title:
PE #:

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1. INTRODUCTION

J&T Consulting, Inc. prepared this report to provide the design basis for the repair of the Johnstown Reservoir for the Town of Johnstown. Johnstown Reservoir has a high hazard classification as determined for the existing reservoir by the State Engineers Office.

2. PROJECT DESCRIPTION

The property is located on the west side of the Town of Johnstown, just north of state route highway 60. See Figure 1 for the vicinity map. The property is currently being used for recreation and water storage. There is a water treatment plant for the Town of Johnstown that uses water stored in this reservoir. The land adjacent to the reservoir is comprised of a residential neighborhood, a church, and a park. There is gravel walking path that currently surrounds the reservoir. Vegetation around the reservoir is sparse to heavy growth of native and landscaping grasses. The ground surface the reservoir is positioned on slopes towards the east. J&T Consulting has been tasked with designing and implementing a new outlet structure in accordance with current state rules and regulations.

2.1. Project Location and Ownership

The Johnstown Reservoir is owned and operated by the Town of Johnstown. The reservoir is located in Johnstown, Weld County, Colorado north of State Route Highway 60, between High Plains Blvd. and Carlson Blvd. The outlet will be constructed on the east side of the reservoir, the location of the outlet structures are shown in Figure 1. The use for the reservoir will be storage of raw water for the town's water treatment facility. The water currently entering the reservoir comes from the Home Supply Ditch just south of State Route Highway 60 and the water exits into a ditch just north-east of the reservoir.

2.2. Project Size, Type, and Hazard Classification

2.2.1. Size

Johnstown Reservoir has a 14.7 foot embankment height. The top of the embankment is at an elevation of 4,986 feet with the toe of the dam sitting at 4,971.3 feet. The reservoir covers an area of 35.78 acres. The dam is classified as 'small'

2.2.2. Type

The outlet structures will consist of an emergency spillway composed of gravel and a concrete outlet structure.

2.2.3. Hazard Classification

Hydrologic Hazard is separated into four categories as described by the State of Colorado's Department of Natural Resources in their document titled, "*Rules and Regulations for Dam Safety and Dam Construction*". The categories are as follows:

Extreme: Life loss potential of 1 or more.

High: Life loss potential of less than 1.

Significant: No life loss potential but significant damage is expected to occur.

Low: No life loss potential or significant damage is expected to occur.

The same document above that classifies Hydrologic Hazard also classifies overall dam hazard. These categories are as follows:

High hazard: A dam for which life loss is expected to result from failure of the dam.

Significant Hazard: A dam for which significant damage, but no life loss is expected to result from failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, including public and private facilities. Significant damage is determined to be damage sufficient to render structures or facilities uninhabitable or inoperable.

Low Hazard: A dam for which neither life loss nor significant damage as defined for a Significant hazard dam are expected to result from failure of the dam.

No Public Hazard (NPH): A dam for which minimal damage, with no life loss, is expected to result from failure of the dam.

The Johnstown Reservoir is classified as an extreme hydraulic hazard dam and an extreme hazard dam due to structures that are located downstream of a potential breach. There is a significant risk of loss of life and damage to property. The design storm for a small dam of these hazard classifications is the PMP (Probable Maximum Precipitation).

2.3. Basin Description

Since the reservoir boundary is elevated above the surrounding land, one basin was used for the calculation of storm water runoff. Basin A incorporates the area within the high point of the gravel path directly surrounding the reservoir. A map of Basin A is included in Figure 2 below. There is no detention other than the reservoir.

The table below shows the area of Basin A along with the average flow released for the PMP (Probable Maximum Precipitation) and the PMP with the AMF (Atmospheric Moisture Factor).

Basin Flow Summary

Basin	Area (acre)	Flow Q_{100} (cfs)	Flow Q_{107} (cfs)
A	64.43	10.77	11.52

2.4. Downstream Floodplain

The FEMA mapped floodplain is on Panel #08069C1405G. The panel is printed and shown in Appendix G; there are no special flood hazard areas for this area.

3. HYDROLOGY

According to regulations of the State Engineer's Office (SEO), the Inflow Design Flood (IDF) for a small, Extreme Hazard dam is equivalent to 100% of the Probable Maximum Precipitation (PMP) for the tributary basin. The regulations further specify the dam spillway must be able to "pass" or route the IDF through the reservoir with one foot of freeboard against the dam overtopping. This Hydrology Report demonstrates the proposed dam, spillway and reservoir configuration are capable of meeting the requirements of the SEO regulations.

The Probable Maximum Precipitation (PMP) rainfall data was determined by the Regional Extreme Precipitation Study (REPS) from the State of Colorado's Department of Natural Resources. The Surveyed, Basin A, boundary was imported into ArcGIS and the REPS toolbox was used to perform analysis. In accordance to the Guidelines for REPS, analysis of the basin was completed for 2-hr, 6-hr, and 24-hr local storms, along with a 72-hr general storm. A 72-hr Tropical Storm Synthetic Distribution was not used because the Reservoir is north of 38.5 degrees latitude.

The probable maximum precipitation event of the "72-hr General Storm Synthetic Distribution" was determined to control for the Johnstown Reservoir because it was the critical case that yielded the highest PMP value. The "local storm" depths for all durations are less than the general storm event. Areal reduction factors are not used since the basin is less than one square mile in area.

General Storm Probable Maximum Precipitation

Depth-Duration Values 100% PMP

Duration	15 min	1 hr	2 hrs	3 hrs	6 hrs	12 hrs	24 hrs	48 hrs	72 hrs
Depth (inches)	0.195	0.078	0.156	0.234	0.468	0.935	1.87	19.58	20.6

The table above displays the cumulative precipitation at defined time intervals over the duration of the 72 hour storm. This data was determined through analysis in REPS.

The PMP data for the Basin A was then converted into a flow for every 15 minute interval. This was done by taking the incremental PMP and multiplying it by the area of the basin and dividing the result by the time interval in seconds. This flow was then multiplied by 1.07 to account for the 7% atmospheric moisture factor (AMF) as per the 2020 Dam Safety Rule 7.2.4.

Since the basin has an approximate longest flow path of 0.4 miles, it was determined that there will be no approximate lag time. There are also two other possible sources of inflow other than the PMP, these include the flow from the Home Supply Ditch just south of State Route Highway 60 and the flow from the water treatment plant back into the reservoir. These flows were included in the calculations to simulate a worst case scenario. Once these inflows were determined, the total sum of the inflows was determined to be the maximum flow that would need to be routed through the reservoir.

The maximum inflow into the reservoir from the water treatment plant was provided by the Town of Johnstown as 500,000 gallons per day or 0.77 cfs. The maximum inflow from the Home Supply Ditch was calculated using Hydraflow with a water surface elevation of 5003.3 feet, which was determined to be the maximum water surface height of the ditch going into the system. The maximum inflow from the Home Supply Ditch was calculated to be 20.1 cfs.

For the PMP event, an infiltration rate of zero was used because the majority of the surface of Basin A is water and because no infiltration is conservative.

A stage-discharge table was developed for the overflow spillway and emergency spillway; they are both located below. The overflow spillways and emergency spillway are capable of discharging 15.3 cfs each for a total of 30.6 cfs and 30.0 cfs respectfully at stage 4985.0, this provides the required one foot of residual freeboard.

The volume of water from the PMP is 110.6 acre-feet with 192.8 acre-feet total with the addition of the base flow. Through routing of the event a maximum storage of 69.2 acre-feet is stored in the reservoir. The total precipitation during the 72-hour PMP storm is 20.6 inches. The contributing area, Basin A, to the dam is 64.43 acres.

The main outflow is routed through an outlet tower with a 24x24 inch sluice gate at an invert elevation of 4971 feet. The sluice gate is placed at this elevation in order to reduce the dead storage of the reservoir as much as possible. The main outflow has two 20 inch effective width weirs at elevations of 4983 feet, this elevation allowed for the maintaining of the 3 foot of normal freeboard required. The sizing of the weirs were done to maximize flow into the outlet pipe without overcoming the capacity of the pipe. Flow exiting the outlet tower is directed through pipes towards a ditch to the north-east of the reservoir.

There is also a 40 foot wide emergency spillway that has side slopes at 10:1 and an elevation of 4984.6 feet. Design of the emergency spillway ensured the base flow would not overtop the spillway. The main outlet tower is positioned on the east side of the reservoir, this water will be then directed north-east of the reservoir towards the Home Supply Ditch. The emergency spillway will remain where it currently is, on the south-east corner of the reservoir; flow through the emergency spillway will be directed into a field south-east of the reservoir and eventually back into the Home Supply Ditch that the inflow came from.

The hydrograph is located in Appendix A.

In accordance with State Engineers Office guidelines, the reservoir routing criterion is for the spillway to pass the IDF, in this case the PMF, with one foot of residual freeboard remaining at peak flood stage. The emergency overflow pipe and grating is sized to pass this. See the spreadsheet in Appendix A.

3.1. Outflow Structure

The proposed outflow structure will be composed of two 28 inch wide weirs at an elevation of 4,983 feet and a 24 inch diameter pipe at an invert elevation of 4967.97 feet. These 28 inch wide weirs are treated as 20 inch wide weirs since they have effective lengths of 20 inches when factoring in the 4, 2 inch trash rack bars covering the opening. The water will overtop the weir and enter a chamber attached to the outlet tower. Through routing it was determined that the pool elevation will reach a maximum height of 4985.0 feet. Throughout the range of elevations between, 4983.0 feet to 4985.0 feet, the weir will control the structure. Attached to the weir will be a trash rack with bar sizes of 2 inches and a spacing of 6 inches.

Four concrete caissons will be attached to the four corners directly beneath the walls of the main outflow structure. These caissons will extend 10 feet into bedrock in order to limit settlement. The outflow structure will also have a slab 1 foot thick that will extend past the walls of the structure by 6 inches on all sides.

Flow through the outflow structure will be routed through a 24 inch diameter ductile iron pipe. This pipe extends a distance of 90.76 feet with 0.5% slope. In order to limit settlement and stresses on the pipe, the pipe will be encased in concrete. This concrete will encompass the pipe throughout the length to the junction and will extend to bedrock to maintain a firm foundation.

Appendix E contains the stage discharge curve for the outlet pipe while Table 2 contains the discharge curve values. The discharge is calculated using the lesser of flow between the water that flows through the weir or the capacity of the pipe. Through analysis it was determined that in order to keep the hydraulic grade line below the top of the junction of the outlet structure, the junction should be extended upwards 4 feet. The hydraulic grade line in this case is shown in Appendix F.

3.2. Emergency Outlet Spillway

The proposed emergency spillway will be composed of a 40 foot bottom width weir at a starting elevation of 4985 feet that has side slopes of 10:1. The elevation discharge table for the emergency spillway weir is displayed in Appendix E below.

Routing of the reservoir was done using the HEC-HMS computer program of the U S Army Corps of Engineers Hydrologic Engineering Center. Using the stage-storage of the reservoir, combined with the predicted inflow as determined earlier, with the elevation discharge tables of the outflow of the emergency spillway and outflow structure, a maximum pool elevation as determined. This maximum pool elevation was determined to be 4985.0, this elevation leads to a total combined outflow of 30.6 cfs from the main outflow structure, and an outflow of 30.0 cfs from the emergency spillway.

3.3. Reservoir Stage-Area-Storage-Discharge Relationship

The stage-storage relationship for the Johnstown Reservoir is shown in Table 1. The discharge rate available from the gravity outlet pipe is shown in Table 2.

3.4. Dam Freeboard

The State required minimum normal freeboard during a PMP event is the greater of 3 feet or the wave setup and runup from a 100 mph wind. The minimum residual freeboard during a PMP event is the greater of 1 foot or the wave setup and runup from a 10% AEP probability wind. The defining freeboard for the normal and residual situations were 3 feet and 1 foot respectively, both of these values were maintained throughout the analysis.

4. PROJECT GEOLOGY

4.1. Regional Geology

The site is located approximately 20 miles to the East of the Rocky Mountains, in a broad area occupied by the South Platte River. The property is situated on the northern part of the Dakota-Cheyenne aquifer near the border between the Dakota-Cheyenne aquifer and the Denver aquifer.

According to Cesare, “It is located in the Great Plains Physiographic province on the Colorado Piedmont section. It is characterized by dissected bluffs, gently sloping pediments, benched alluvial terraces with valleys, and low lying interfluvial hills. Bedrock in the area is comprised of sedimentary rocks from the fluvial and lacustrine systems during the mountain building event during the

Paleogene and from the continental seaway during the Cretaceous."

4.2. Site Geology

Cesare describes the soil on as "eolian sediment, windblown deposits comprised of loess, clay, and silt mixtures. These sediments are Quaternary Middle Holocene and Upper Pleistocene in age, and are generally 3 to 15 feet think."

5. GEOTECHNICAL INVESTIGATION & LABORATORY ANALYSES

Cesare, Inc. performed field investigations in December 2020. The data is included with this report. Bore holes were located in the location of the toe, dam crest, and interior of the proposed reservoir location. Three bore holes were drilled to an approximate depth of 40 feet along the dam centerline. One boring was drilled to a depth of 25 feet at the downstream toe of the dam embankment.

5.1. Geotechnical Investigation

A total of four boreholes were dug to depths of 26 to 40 feet. The material consisted of clay, clayey sand, and claystone. Bedrock was encountered at 14 to 23 feet deep and extended to the full depth of the bore holes. Bedrock was consistently a hard claystone.

5.2. Ground Water

Groundwater was encountered during drilling at 8 to 18 feet deep. One day after drilling, the water level was measured 5 to 16 feet deep. The geotechnical analysis is included in Appendix H.

5.3. Laboratory Data

The subsurface data was analyzed by Cesare, Inc. for potential seepage loss and slope stability parameters. The borings were located in the field by a surveyor prior to drilling. Samples were taken at set intervals to be able to classify the material in all bore holes.

6. GEOTECHNICAL ANALYSIS & DESIGN

6.1.1. Wave Run-up

Wave Run-up for the reservoir was determined based on multiple factors, including, fetch distance and wind velocity over the water. Analysis used the prescriptive design standard wind velocity of 100 mph and a fetch length of 0.413 miles. The calculated wave run-up was 1.10 feet. The calculations are shown below in Appendix C.

6.1.2. Wind Setup

The wind setup calculations were determined based on the fetch distance, wind velocity, and average depth of water along the fetch. Based on these factors it was determined that there would be 0.23 feet of wide setup. Calculations for the wind setup are shown within Appendix C below.

6.1.3. Freeboard Design

Determination of the required freeboard depths was based off of rules 7.4.2.2.1 and 7.4.2.2.2. For the 100 mph design wind speed, the resulting wind setup and wave run-up was 1.33 feet. This lead to a minimum normal freeboard depth to be 3 feet. For the minimum residual freeboard a 10 percent AEP wind speed of 22 mph was used in the calculations. This led to a total wave run-up and wind setup of 0.25 feet, so the 1 foot minimum residual freeboard depth was used.

6.2. General Embankment

The material used for the construction of the temporary cofferdam will be taken from offsite and will be a clay material. The embankment will be extended to meet the desired slope of 3:1, the material used in this process will be the same offsite clay material. Mixing of the material will be conducted to ensure homogeneity in soil composition prior to placement and compaction of the fill. Water will also be added to the soil if necessary. This is to meet the desired water content that will result in the necessary soil compaction as specified by Cesare. It is estimated that there will be approximately 6 inches of consolidation during construction. The in-situ material may settle due to the additional pressure of the dam.

6.3. Project Seismicity

No active faults have been identified in the area of the project that would require consideration for surface rupture. Analysis of seismicity must factor in using at least 50% of the peak acceleration but no less than 0.05g. In order to be conservative, 0.1g was used in the calculations.

6.4. Stability Analysis Maximum Section

The material properties below were used by Cesare, Inc. during the stability analysis at four sections along the dam. These are based on material laboratory testing results from the soils sampled during boring.

Design Hydraulic Conductivities

Material	Saturated Hydraulic Conductivity (cm/sec)	Saturated Hydraulic Conductivity (ft/sec)
Existing embankment fill	1.70 x E-6	5.54 x E-8
New embankment fill	4.97 x E-7	1.64 x E-8
Native clay soils	7.07 x E-7	2.32 x E-8
Weathered claystone	1.0 x E-8	3.3 x E-10
Unweathered claystone	1.0 x E-5*	3.3 x E-7*

*Horizontal conductivity. Vertical is one order of magnitude less.

Stability Analysis Strength Parameters

Material	Friction Angle (degrees)	Cohesion (psf)
Existing embankment fill	30	100
New embankment fill	30	200
Native clay soil	25	50
Weathered claystone	25	100
Unweathered claystone	0	3000
Residual claystone	15	0

Stability Analyses Results

Section	Analysis	Factor of Safety		Required Factor of Safety
		Block	Circular	
Existing	Full, stead state upstream	2.54	2.47	1.5
	Full, steady state upstream, pseudo seismic	1.71	1.67	1.0
	Full, steady state downstream	1.81	1.73	1.5
	Full, steady state downstream, pseudo seismic	1.34	1.27	1.0
	Transient upstream	1.82	1.74	1.2*
Repaired	Full, steady state upstream	3.94	3.78	1.5
	Full, steady state upstream, pseudo seismic	2.68	2.56	1.0
	Full, steady state downstream	3.50	3.29	1.5
	Full, steady state downstream, pseudo seismic	2.56	2.41	1.0
	Full, steady state downstream, residual bedrock strength	2.84	3.07	1.1**
	Transient upstream	2.84	2.67	1.2*

*Lowest factor of safety.
**Case by case determination

7. RESERVOIR FACILITY DESIGN

The reservoir will be filled via gravity up to elevation 4,983 feet. The reservoir can be drained down to an elevation of 4,971.3 feet. Since the reservoir's lowest point is at an elevation of 4970.3 feet, the resulting reservoir dead storage is 0.52 acre-feet. The proposed total storage to the normal high water line is approximately 311.77 acre-feet.

7.1. Outlet Works & Reservoir Fill

The reservoir is filled from two separate pipes, the first being a pipe that flows from the Home Supply Ditch on the south side of State Route Highway 60, this pipeline enters the reservoir on the southwest side. The other inflow to the reservoir comes from backflow from the water treatment plant, this pipeline meets the reservoir on the south east side.

From analysis it was determined that the inflow pipe from the ditch could provide a maximum inflow of 20.1 cfs. The Town of Johnstown also provided the maximum inflow of the water treatment plant into the reservoir of 0.77 cfs.

If the top 5 feet of water in the reservoir needs to be released in 5 days, as a High hazard dam, the required flow rate is 17.1 cfs. This calculation is from the normal water surface level. This is easily achieved through the outlet pipes in the outlet tower. See Table 3 for the 5-day discharge calculations.

The outlet works consists of an outlet tower which has one 24"x24" sluice gate to control the flow of water into the 24 inch diameter outlet pipe. Structural calculations for the tower and baffled rundown structure are included in Appendix I.

8. CONCLUSION

The proposed dam and reservoir has been designed to the standards established by the State Engineer's Office. The following summarizes the Engineer's Opinion of Cost based on expenses from other similar dams and available information:

Phase 1 Cost Summary

Item	Estimated Cost
Reservoir Repair Construction	$662,625
Construction Engineering and Materials Testing	$66,300
Total Phase 1 Construction Cost Estimate	$728,925

Phase 2 Cost Summary

Item	Estimated Cost
Reservoir Repair Construction	$176,330
Construction Engineering and Materials Testing	$17,600
Total Phase 2 Construction Cost Estimate	$193,930

References

Colorado Department of Natural Resources. Division of Water Resources, Office of the State Engineer, Colorado Dam Safety Branch. *Rules and Regulations for Dam Safety and Dam Construction*. Denver, CO. January 1, 2020.

Colorado Department of Natural Resources. Division of Water Resources, Office of the State Engineer, Colorado Dam Safety Branch. *Guidelines for Hazard Classification*. Denver, CO. November 15, 2010

Design Standards No. 13 Embankment Dams Chapter 2, Embankment Design, The United States Department of the Interior, Bureau of Reclamation, December 2012.

Design Standards No. 13 Embankment Dams Chapter 3, Foundation Surface Treatment, The United States Department of the Interior, Bureau of Reclamation, July 2012.

Design Standards No. 13 Embankment Dams Chapter 10, Embankment Construction, The United States Department of the Interior, Bureau of Reclamation, March 1987.

United States Department of the Interior: Bureau of Reclamation. Design of Small Dams, Third Edition. Washington, D.C. 1987.

Table 1. Reservoir Stage Storage

JOHNSTOWN RESERVOIR STAGE STORAGE					
Contour Elevation (ft)	Stage (ft)	Contour Area (ac)	Incremental Volume Conic (ac-ft)	Cumulative Volume Conic (ac-ft)	Notes
4971.3	0	0.03	0	0	
4971.5	0.2	0.36	0.03	0.03	
4972	0.7	2.28	0.21	0.66	
4972.5	1.2	3.89	0.37	2.2	
4973	1.7	17.2	1.69	9.45	
4973.5	2.2	20.07	1.98	18.81	
4974	2.7	22.19	2.2	29.38	
4974.5	3.2	23.96	2.38	40.93	
4975	3.7	25.51	2.54	53.31	
4975.5	4.2	26.91	2.68	66.42	
4976	4.7	28.42	2.82	80.24	
4976.5	5.2	30.2	3	94.88	
4977	5.7	31.46	3.14	110.35	
4977.5	6.2	32.1	3.2	126.25	
4978	6.7	32.53	3.25	142.41	
4978.5	7.2	32.91	3.29	158.78	
4979	7.7	33.19	3.32	175.31	
4979.5	8.2	33.51	3.35	191.98	
4980	8.7	33.77	3.38	208.81	
4980.5	9.2	33.97	3.39	225.74	
4981	9.7	34.15	3.41	242.77	
4981.5	10.2	34.33	3.43	259.89	
4982	10.7	34.5	3.45	277.1	
4982.5	11.2	34.67	3.46	294.39	
4983	11.7	34.83	3.48	311.77	Normal Water Surface
4983.5	12.2	34.99	3.5	329.22	
4984	12.7	35.15	3.51	346.76	
4984.5	13.2	35.31	3.53	364.37	
4985	13.7	35.46	3.54	382.06	Maximum Water Surface
4985.5	14.2	35.62	3.56	399.83	
4986	14.7	35.78	3.58	417.68	

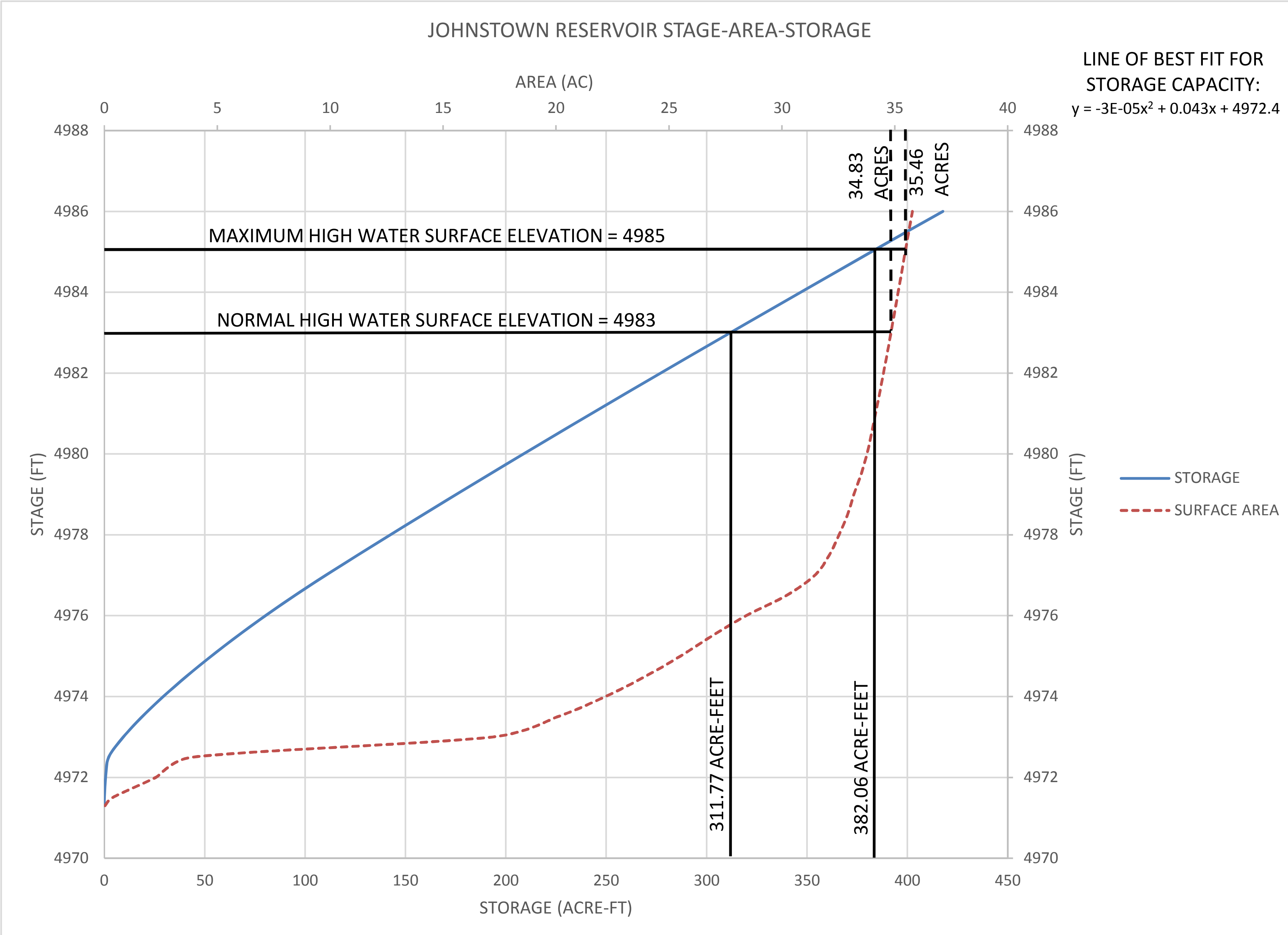

JOHNSTOWN RESERVOIR STAGE-AREA-STORAGE
LINE OF BEST FIT FOR STORAGE CAPACITY:
$y = -3E\text{-}05x^2 + 0.043x + 4972.4$
AREA (AC)
0
5
10
15
20
25
30
35
40
STAGE (FT)
4988
4986
4984
4982
4980
4978
4976
4974
4972
4970
34.83 ACRES
35.46 ACRES
MAXIMUM HIGH WATER SURFACE ELEVATION = 4985
NORMAL HIGH WATER SURFACE ELEVATION = 4983
311.77 ACRE-FEET
382.06 ACRE-FEET
STORAGE (ACRE-FT)
0
50
100
150
200
250
300
350
400
450
STORAGE
SURFACE AREA

Table 2. Reservoir 24-inch Diameter Outlet Pipe and Discharge

Johnstown Reservoir Spillway Weirs and Pipe Rating Table

Orifice flow through pipe

Q = 0.6A(2gh)^0.5

Variable	Description	Value	Unit
Q =	flow rate	varies	cfs
A =	24" Ø Spillway Pipe	3.14	sq-ft
g =	gravitational acceleration	32.2	ft/sec^2
h =	height of water above grate	varies	ft

Weir Flow Equation

Q = CLH^1.5

Variable	Description	Value	Unit
Q =	flow rate	varies	cfs
C =	Weir Coefficient	3.33	
L =	Weir Length	varies	ft
H =	Height of Water	varies	ft

Reduction of Weir Lengths for Trash Racks

Bar Spacing =	6 in =	0.5000	ft
Bar Width =	2 in =	0.1667	ft

Weir No.	Weir Length (ft)	Bars Across	Bar Length (ft)	Weir Length Adjusted For Bars (ft)	Reduction For Blockage (%)	Net Weir Length (ft)
1 (W1)	2.33	4	0.667	1.67	0%	1.67
2 (W2)	2.33	4	0.667	1.67	0%	1.67

Johnstown Reservoir Spillway Weirs and Pipe Rating Table

Elevation	H	Q_1 (W1)	Q_2 (W2)	Q_1+Q_2	Q_p (Pipe)	Q (Flow)
4983.0	0.0	0.00	0.00	0.00	58.65	0.00
4983.1	0.1	0.18	0.18	0.35	58.85	0.35
4983.2	0.2	0.50	0.50	0.99	59.04	0.99
4983.3	0.3	0.91	0.91	1.82	59.23	1.82
4983.4	0.4	1.40	1.40	2.81	59.43	2.81
4983.5	0.5	1.96	1.96	3.92	59.62	3.92
4983.6	0.6	2.58	2.58	5.16	59.81	5.16
4983.7	0.7	3.25	3.25	6.50	60.00	6.50
4983.8	0.8	3.97	3.97	7.94	60.19	7.94
4983.9	0.9	4.74	4.74	9.48	60.38	9.48
4984.0	1.0	5.55	5.55	11.10	60.57	11.10
4984.1	1.1	6.40	6.40	12.81	60.76	12.81
4984.2	1.2	7.30	7.30	14.59	60.95	14.59
4984.3	1.3	8.23	8.23	16.45	61.13	16.45
4984.4	1.4	9.19	9.19	18.39	61.32	18.39
4984.5	1.5	10.20	10.20	20.39	61.51	20.39
4984.6	1.6	11.23	11.23	22.46	61.69	22.46
4984.7	1.7	12.30	12.30	24.60	61.88	24.60
4984.8	1.8	13.40	13.40	26.81	62.06	26.81
4984.9	1.9	14.54	14.54	29.07	62.25	29.07
4985.0	2.0	15.70	15.70	31.40	62.43	31.40
4985.1	2.1	16.89	16.89	33.78	62.61	33.78
4985.2	2.2	18.11	18.11	36.22	62.79	36.22
4985.3	2.3	19.36	19.36	38.72	62.98	38.72
4985.4	2.4	20.64	20.64	41.27	63.16	41.27
4985.5	2.5	21.94	21.94	43.88	63.34	43.88
4985.6	2.6	23.27	23.27	46.54	63.52	46.54
4985.7	2.7	24.62	24.62	49.25	63.70	49.25
4985.8	2.8	26.00	26.00	52.01	63.88	52.01
4985.9	2.9	27.41	27.41	54.82	64.06	54.82
4986.0	3.0	28.84	28.84	57.68	64.23	57.68

JOHNSTOWN RESERVOIR

OUTLET PIPE

STAGE-DISCHARGE TABLE

JOHNSTOWN, COLORADO

Stage (ft)	Discharge (cfs)
4,983.0	0.00
4,983.5	3.92
4,984.0	11.10
4,984.5	20.39
4,985.0	31.40
4,985.5	43.88
4,986.0	57.68

Table 3. 5-Day Discharge

5-Day Discharge Table

Sluice Gate Dimensions	Headwater Elevation (ft)	Tailwater Elevation (ft)	Change in Elevation: Δh (ft)	Gate & Pipe Flow: Q (cfs)
24x24	4983	4976.83	6.17	29.29
24x24	4982	4976.23	5.77	28.35
24x24	4981	4975.62	5.38	27.37
24x24	4980	4975.01	4.99	26.35
24x24	4979	4974.41	4.59	25.29
24x24	4978	4973.80	4.20	24.17

Equation: $Q = 0.6A(2g\Delta h)^{0.5}$

Where - $A = 2.45\ ft^2$

$g = 32.2\ ft/s^2$

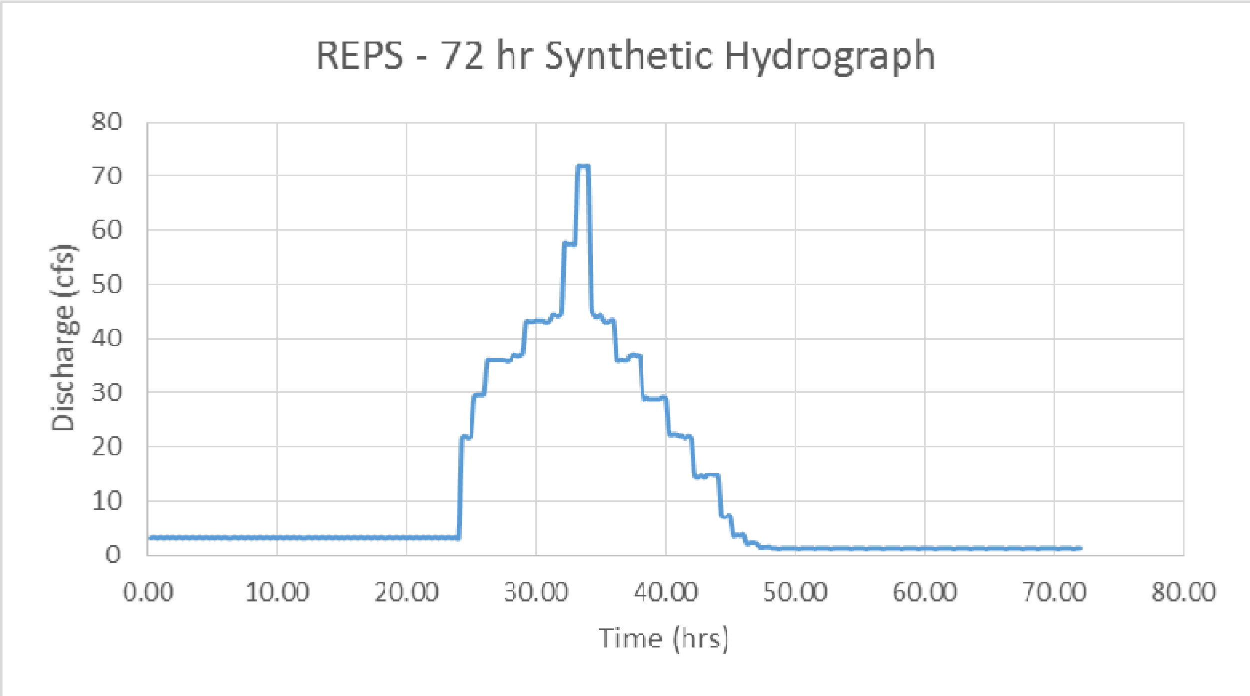
Figure 1. Vicinity Map

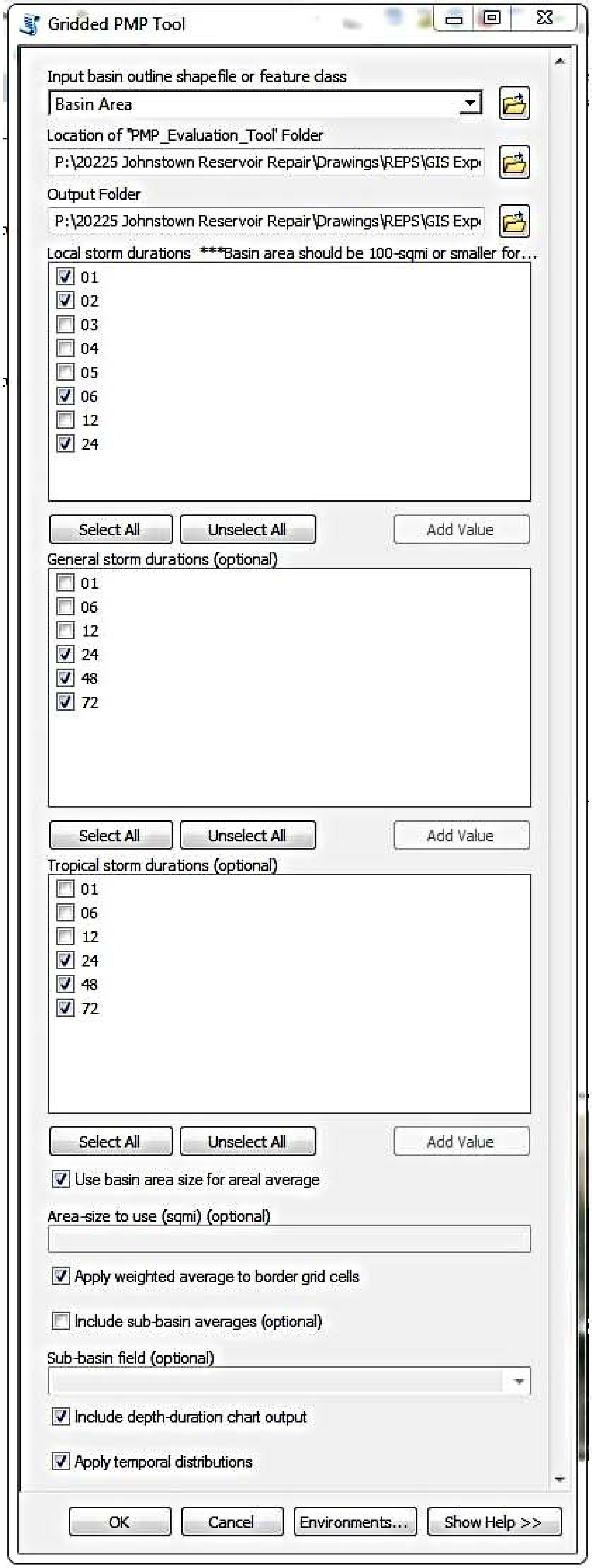

Vicinity Map
25
High Plains Blvd
Johnstown Reservoir
Outflow Structure
Overflow Spillway
Carlson Blvd
60
N
Miles
0
0.5
1

Figure 2. Basin Map


Basin Map
Johnstown Reservoir:
Basin A
64.43 acres
High Plains Blvd
Carlson Blvd
60
N
Legend
Basin Area
Miles
0
0.25
0.5

Appendix A. Hydrology


REPS - 72 hr Synthetic Hydrograph
Discharge (cfs)
80
70
60
50
40
30
20
10
0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
Time (hrs)


Gridded PMP Tool
Input basin outline shapefile or feature class
Basin Area
Location of 'PMP_Evaluation_Tool' Folder
P:\20225 Johnstown Reservoir Repair\Drawings\REPS\GIS Exp
Output Folder
P:\20225 Johnstown Reservoir Repair\Drawings\REPS\GIS Exp
Local storm durations ***Basin area should be 100-sqmi or smaller for...
01
02
03
04
05
06
12
24
Select All
Unselect All
Add Value
General storm durations (optional)
01
06
12
24
48
72
Select All
Unselect All
Add Value
Tropical storm durations (optional)
01
06
12
24
48
72
Select All
Unselect All
Add Value
Use basin area size for areal average
Area-size to use (sqmi) (optional)
Apply weighted average to border grid cells
Include sub-basin averages (optional)
Sub-basin field (optional)
Include depth-duration chart output
Apply temporal distributions
OK
Cancel
Environments...
Show Help >>

Storm Precipitation Totals

Storm Type	PMP 1 Hour (in)	PMP 2 Hour (in)	PMP 6 Hour (in)	PMP 24 Hour (in)	PMP 48 Hour (in)	PMP 72 Hour (in)
Local Storm	9.09	14.29	18.13	19.13	N/A	N/A
General Storm	N/A	N/A	N/A	19.89	19.85	20.6

General 72 Hour Synthetic Storm

Timestep	Time (min)	Time (hr)	Cumulative Precipitation (in)	Incremental Precipitation (in)	Flow (cfs)	Flow with AMF (cfs)
0	0	0	0	0	0	0
1	15	0.25	0.019	0.0190	2.860265278	3.060483847
2	30	0.5	0.039	0.0200	3.010805556	3.221561945
3	45	0.75	0.058	0.0190	2.860265278	3.060483847
4	60	1	0.078	0.0200	3.010805556	3.221561945
5	75	1.25	0.097	0.0190	2.860265278	3.060483847
6	90	1.5	0.117	0.0200	3.010805556	3.221561945
7	105	1.75	0.136	0.0190	2.860265278	3.060483847
8	120	2	0.156	0.0200	3.010805556	3.221561945
9	135	2.25	0.175	0.0190	2.860265278	3.060483847
10	150	2.5	0.195	0.0200	3.010805556	3.221561945
11	165	2.75	0.214	0.0190	2.860265278	3.060483847
12	180	3	0.234	0.0200	3.010805556	3.221561945
13	195	3.25	0.253	0.0190	2.860265278	3.060483847
14	210	3.5	0.273	0.0200	3.010805556	3.221561945
15	225	3.75	0.292	0.0190	2.860265278	3.060483847
16	240	4	0.312	0.0200	3.010805556	3.221561945
17	255	4.25	0.331	0.0190	2.860265278	3.060483847
18	270	4.5	0.351	0.0200	3.010805556	3.221561945
19	285	4.75	0.370	0.0190	2.860265278	3.060483847
20	300	5	0.390	0.0200	3.010805556	3.221561945
21	315	5.25	0.409	0.0190	2.860265278	3.060483847
22	330	5.5	0.429	0.0200	3.010805556	3.221561945
23	345	5.75	0.448	0.0190	2.860265278	3.060483847
24	360	6	0.468	0.0200	3.010805556	3.221561945
25	375	6.25	0.487	0.0190	2.860265278	3.060483847
26	390	6.5	0.506	0.0190	2.860265278	3.060483847
27	405	6.75	0.526	0.0200	3.010805556	3.221561945
28	420	7	0.545	0.0190	2.860265278	3.060483847
29	435	7.25	0.565	0.0200	3.010805556	3.221561945
30	450	7.5	0.584	0.0190	2.860265278	3.060483847
31	465	7.75	0.604	0.0200	3.010805556	3.221561945
32	480	8	0.623	0.0190	2.860265278	3.060483847
33	495	8.25	0.643	0.0200	3.010805556	3.221561945
34	510	8.5	0.662	0.0190	2.860265278	3.060483847
35	525	8.75	0.682	0.0200	3.010805556	3.221561945
36	540	9	0.701	0.0190	2.860265278	3.060483847
37	555	9.25	0.721	0.0200	3.010805556	3.221561945
38	570	9.5	0.740	0.0190	2.860265278	3.060483847
39	585	9.75	0.760	0.0200	3.010805556	3.221561945
40	600	10	0.779	0.0190	2.860265278	3.060483847
41	615	10.25	0.799	0.0200	3.010805556	3.221561945
42	630	10.5	0.818	0.0190	2.860265278	3.060483847
43	645	10.75	0.838	0.0200	3.010805556	3.221561945
44	660	11	0.857	0.0190	2.860265278	3.060483847
45	675	11.25	0.877	0.0200	3.010805556	3.221561945
46	690	11.5	0.896	0.0190	2.860265278	3.060483847
47	705	11.75	0.916	0.0200	3.010805556	3.221561945
48	720	12	0.935	0.0190	2.860265278	3.060483847
49	735	12.25	0.954	0.0190	2.860265278	3.060483847
50	750	12.5	0.974	0.0200	3.010805556	3.221561945
51	765	12.75	0.993	0.0190	2.860265278	3.060483847
52	780	13	1.013	0.0200	3.010805556	3.221561945
53	795	13.25	1.032	0.0190	2.860265278	3.060483847
54	810	13.5	1.052	0.0200	3.010805556	3.221561945
55	825	13.75	1.071	0.0190	2.860265278	3.060483847
56	840	14	1.091	0.0200	3.010805556	3.221561945
57	855	14.25	1.110	0.0190	2.860265278	3.060483847
58	870	14.5	1.130	0.0200	3.010805556	3.221561945
59	885	14.75	1.149	0.0190	2.860265278	3.060483847
60	900	15	1.169	0.0200	3.010805556	3.221561945
61	915	15.25	1.188	0.0190	2.860265278	3.060483847
62	930	15.5	1.208	0.0200	3.010805556	3.221561945
63	945	15.75	1.227	0.0190	2.860265278	3.060483847
64	960	16	1.247	0.0200	3.010805556	3.221561945
65	975	16.25	1.266	0.0190	2.860265278	3.060483847
66	990	16.5	1.286	0.0200	3.010805556	3.221561945
67	1005	16.75	1.305	0.0190	2.860265278	3.060483847
68	1020	17	1.325	0.0200	3.010805556	3.221561945
69	1035	17.25	1.344	0.0190	2.860265278	3.060483847
70	1050	17.5	1.364	0.0200	3.010805556	3.221561945
71	1065	17.75	1.383	0.0190	2.860265278	3.060483847
72	1080	18	1.403	0.0200	3.010805556	3.221561945

General 72 Hour Synthetic Storm

Timestep	Time	Time	Cumulative Precipitation	Incremental Precipitation	Flow	Flow with AMF
73	1095	18.25	1.422	0.0190	2.860265278	3.060483847
74	1110	18.5	1.441	0.0190	2.860265278	3.060483847
75	1125	18.75	1.461	0.0200	3.010805556	3.221561945
76	1140	19	1.480	0.0190	2.860265278	3.060483847
77	1155	19.25	1.500	0.0200	3.010805556	3.221561945
78	1170	19.5	1.519	0.0190	2.860265278	3.060483847
79	1185	19.75	1.539	0.0200	3.010805556	3.221561945
80	1200	20	1.558	0.0190	2.860265278	3.060483847
81	1215	20.25	1.578	0.0200	3.010805556	3.221561945
82	1230	20.5	1.597	0.0190	2.860265278	3.060483847
83	1245	20.75	1.617	0.0200	3.010805556	3.221561945
84	1260	21	1.636	0.0190	2.860265278	3.060483847
85	1275	21.25	1.656	0.0200	3.010805556	3.221561945
86	1290	21.5	1.675	0.0190	2.860265278	3.060483847
87	1305	21.75	1.695	0.0200	3.010805556	3.221561945
88	1320	22	1.714	0.0190	2.860265278	3.060483847
89	1335	22.25	1.734	0.0200	3.010805556	3.221561945
90	1350	22.5	1.753	0.0190	2.860265278	3.060483847
91	1365	22.75	1.773	0.0200	3.010805556	3.221561945
92	1380	23	1.792	0.0190	2.860265278	3.060483847
93	1395	23.25	1.812	0.0200	3.010805556	3.221561945
94	1410	23.5	1.831	0.0190	2.860265278	3.060483847
95	1425	23.75	1.851	0.0200	3.010805556	3.221561945
96	1440	24	1.870	0.0190	2.860265278	3.060483847
97	1455	24.25	2.003	0.1330	20.02185695	21.42338693
98	1470	24.5	2.138	0.1350	20.3229375	21.74554313
99	1485	24.75	2.271	0.1330	20.02185695	21.42338693
100	1500	25	2.406	0.1350	20.3229375	21.74554313
101	1515	25.25	2.586	0.1800	27.09725	28.9940575
102	1530	25.5	2.769	0.1830	27.54887083	29.47729179
103	1545	25.75	2.952	0.1830	27.54887083	29.47729179
104	1560	26	3.136	0.1840	27.69941111	29.63836989
105	1575	26.25	3.359	0.2230	33.57048195	35.92041568
106	1590	26.5	3.582	0.2230	33.57048195	35.92041568
107	1605	26.75	3.805	0.2230	33.57048195	35.92041568
108	1620	27	4.028	0.2230	33.57048195	35.92041568
109	1635	27.25	4.251	0.2230	33.57048195	35.92041568
110	1650	27.5	4.474	0.2230	33.57048195	35.92041568
111	1665	27.75	4.696	0.2220	33.41994167	35.75933758
112	1680	28	4.919	0.2230	33.57048195	35.92041568
113	1695	28.25	5.148	0.2290	34.47372361	36.88688427
114	1710	28.5	5.376	0.2280	34.32318333	36.72580617
115	1725	28.75	5.604	0.2280	34.32318333	36.72580617
116	1740	29	5.835	0.2310	34.77480417	37.20904046
117	1755	29.25	6.102	0.2670	40.19425417	43.00785196
118	1770	29.5	6.369	0.2670	40.19425417	43.00785196
119	1785	29.75	6.636	0.2670	40.19425417	43.00785196
120	1800	30	6.904	0.2680	40.34479445	43.16893006
121	1815	30.25	7.172	0.2680	40.34479445	43.16893006
122	1830	30.5	7.440	0.2680	40.34479445	43.16893006
123	1845	30.75	7.706	0.2660	40.04371389	42.84677386
124	1860	31	7.974	0.2680	40.34479445	43.16893006
125	1875	31.25	8.249	0.2750	41.39857639	44.29647674
126	1890	31.5	8.523	0.2740	41.24803611	44.13539864
127	1905	31.75	8.796	0.2730	41.09749584	43.97432054
128	1920	32	9.073	0.2770	41.69965695	44.61863293
129	1935	32.25	9.431	0.3580	53.89341945	57.66595881
130	1950	32.5	9.787	0.3560	53.59233889	57.34380261
131	1965	32.75	10.144	0.3570	53.74287917	57.50488071
132	1980	33	10.500	0.3560	53.59233889	57.34380261
133	1995	33.25	10.946	0.4460	67.14096389	71.84083136
134	2010	33.5	11.392	0.4460	67.14096389	71.84083136
135	2025	33.75	11.838	0.4460	67.14096389	71.84083136
136	2040	34	12.284	0.4460	67.14096389	71.84083136
137	2055	34.25	12.565	0.2810	42.30181806	45.26294532
138	2070	34.5	12.838	0.2730	41.09749584	43.97432054
139	2085	34.75	13.111	0.2730	41.09749584	43.97432054
140	2100	35	13.386	0.2750	41.39857639	44.29647674
141	2115	35.25	13.654	0.2680	40.34479445	43.16893006
142	2130	35.5	13.920	0.2660	40.04371389	42.84677386
143	2145	35.75	14.188	0.2680	40.34479445	43.16893006
144	2160	36	14.456	0.2680	40.34479445	43.16893006
145	2175	36.25	14.679	0.2230	33.57048195	35.92041568
146	2190	36.5	14.902	0.2230	33.57048195	35.92041568

General 72 Hour Synthetic Storm

Timestep	Time	Time	Cumulative Precipitation	Incremental Precipitation	Flow	Flow with AMF
147	2205	36.75	15.125	0.2230	33.57048195	35.92041568
148	2220	37	15.348	0.2230	33.57048195	35.92041568
149	2235	37.25	15.576	0.2280	34.32318333	36.72580617
150	2250	37.5	15.805	0.2290	34.47372361	36.88688427
151	2265	37.75	16.033	0.2280	34.32318333	36.72580617
152	2280	38	16.259	0.2260	34.02210278	36.40364997
153	2295	38.25	16.437	0.1780	26.79616945	28.67190131
154	2310	38.5	16.617	0.1800	27.09725	28.9940575
155	2325	38.75	16.795	0.1780	26.79616945	28.67190131
156	2340	39	16.973	0.1780	26.79616945	28.67190131
157	2355	39.25	17.151	0.1780	26.79616945	28.67190131
158	2370	39.5	17.329	0.1780	26.79616945	28.67190131
159	2385	39.75	17.509	0.1800	27.09725	28.9940575
160	2400	40	17.687	0.1780	26.79616945	28.67190131
161	2415	40.25	17.825	0.1380	20.77455833	22.22877742
162	2430	40.5	17.962	0.1370	20.62401806	22.06769932
163	2445	40.75	18.099	0.1370	20.62401806	22.06769932
164	2460	41	18.235	0.1360	20.47347778	21.90662122
165	2475	41.25	18.370	0.1350	20.3229375	21.74554313
166	2490	41.5	18.503	0.1330	20.02185695	21.42338693
167	2505	41.75	18.638	0.1350	20.3229375	21.74554313
168	2520	42	18.771	0.1330	20.02185695	21.42338693
169	2535	42.25	18.861	0.0900	13.548625	14.49702875
170	2550	42.5	18.949	0.0880	13.24754445	14.17487256
171	2565	42.75	19.039	0.0900	13.548625	14.49702875
172	2580	43	19.127	0.0880	13.24754445	14.17487256
173	2595	43.25	19.219	0.0920	13.84970556	14.81918495
174	2610	43.5	19.311	0.0920	13.84970556	14.81918495
175	2625	43.75	19.402	0.0910	13.69916528	14.65810685
176	2640	44	19.492	0.0900	13.548625	14.49702875
177	2655	44.25	19.537	0.0450	6.7743125	7.248514375
178	2670	44.5	19.580	0.0430	6.473231945	6.926358181
179	2685	44.75	19.625	0.0450	6.7743125	7.248514375
180	2700	45	19.670	0.0450	6.7743125	7.248514375
181	2715	45.25	19.692	0.0220	3.311886111	3.543718139
182	2730	45.5	19.715	0.0230	3.462426389	3.704796236
183	2745	45.75	19.737	0.0220	3.311886111	3.543718139
184	2760	46	19.760	0.0230	3.462426389	3.704796236
185	2775	46.25	19.773	0.0130	1.957023611	2.094015264
186	2790	46.5	19.787	0.0140	2.107563889	2.255093361
187	2805	46.75	19.801	0.0140	2.107563889	2.255093361
188	2820	47	19.814	0.0130	1.957023611	2.094015264
189	2835	47.25	19.823	0.0090	1.3548625	1.449702875
190	2850	47.5	19.832	0.0090	1.3548625	1.449702875
191	2865	47.75	19.841	0.0090	1.3548625	1.449702875
192	2880	48	19.850	0.0090	1.3548625	1.449702875
193	2895	48.25	19.858	0.0080	1.204322222	1.288624778
194	2910	48.5	19.866	0.0080	1.204322222	1.288624778
195	2925	48.75	19.873	0.0070	1.053781944	1.127546681
196	2940	49	19.881	0.0080	1.204322222	1.288624778
197	2955	49.25	19.889	0.0080	1.204322222	1.288624778
198	2970	49.5	19.897	0.0080	1.204322222	1.288624778
199	2985	49.75	19.905	0.0080	1.204322222	1.288624778
200	3000	50	19.913	0.0080	1.204322222	1.288624778
201	3015	50.25	19.920	0.0070	1.053781944	1.127546681
202	3030	50.5	19.928	0.0080	1.204322222	1.288624778
203	3045	50.75	19.936	0.0080	1.204322222	1.288624778
204	3060	51	19.944	0.0080	1.204322222	1.288624778
205	3075	51.25	19.952	0.0080	1.204322222	1.288624778
206	3090	51.5	19.959	0.0070	1.053781944	1.127546681
207	3105	51.75	19.967	0.0080	1.204322222	1.288624778
208	3120	52	19.975	0.0080	1.204322222	1.288624778
209	3135	52.25	19.983	0.0080	1.204322222	1.288624778
210	3150	52.5	19.991	0.0080	1.204322222	1.288624778
211	3165	52.75	19.998	0.0070	1.053781944	1.127546681
212	3180	53	20.006	0.0080	1.204322222	1.288624778
213	3195	53.25	20.014	0.0080	1.204322222	1.288624778
214	3210	53.5	20.022	0.0080	1.204322222	1.288624778
215	3225	53.75	20.030	0.0080	1.204322222	1.288624778
216	3240	54	20.038	0.0080	1.204322222	1.288624778
217	3255	54.25	20.045	0.0070	1.053781944	1.127546681
218	3270	54.5	20.053	0.0080	1.204322222	1.288624778
219	3285	54.75	20.061	0.0080	1.204322222	1.288624778
220	3300	55	20.069	0.0080	1.204322222	1.288624778

General 72 Hour Synthetic Storm

Timestep	Time	Time	Cumulative Precipitation	Incremental Precipitation	Flow	Flow with AMF
221	3315	55.25	20.077	0.0080	1.204322222	1.288624778
222	3330	55.5	20.084	0.0070	1.053781944	1.127546681
223	3345	55.75	20.092	0.0080	1.204322222	1.288624778
224	3360	56	20.100	0.0080	1.204322222	1.288624778
225	3375	56.25	20.108	0.0080	1.204322222	1.288624778
226	3390	56.5	20.116	0.0080	1.204322222	1.288624778
227	3405	56.75	20.123	0.0070	1.053781944	1.127546681
228	3420	57	20.131	0.0080	1.204322222	1.288624778
229	3435	57.25	20.139	0.0080	1.204322222	1.288624778
230	3450	57.5	20.147	0.0080	1.204322222	1.288624778
231	3465	57.75	20.155	0.0080	1.204322222	1.288624778
232	3480	58	20.163	0.0080	1.204322222	1.288624778
233	3495	58.25	20.170	0.0070	1.053781944	1.127546681
234	3510	58.5	20.178	0.0080	1.204322222	1.288624778
235	3525	58.75	20.186	0.0080	1.204322222	1.288624778
236	3540	59	20.194	0.0080	1.204322222	1.288624778
237	3555	59.25	20.202	0.0080	1.204322222	1.288624778
238	3570	59.5	20.209	0.0070	1.053781944	1.127546681
239	3585	59.75	20.217	0.0080	1.204322222	1.288624778
240	3600	60	20.225	0.0080	1.204322222	1.288624778
241	3615	60.25	20.233	0.0080	1.204322222	1.288624778
242	3630	60.5	20.241	0.0080	1.204322222	1.288624778
243	3645	60.75	20.248	0.0070	1.053781944	1.127546681
244	3660	61	20.256	0.0080	1.204322222	1.288624778
245	3675	61.25	20.264	0.0080	1.204322222	1.288624778
246	3690	61.5	20.272	0.0080	1.204322222	1.288624778
247	3705	61.75	20.280	0.0080	1.204322222	1.288624778
248	3720	62	20.288	0.0080	1.204322222	1.288624778
249	3735	62.25	20.295	0.0070	1.053781944	1.127546681
250	3750	62.5	20.303	0.0080	1.204322222	1.288624778
251	3765	62.75	20.311	0.0080	1.204322222	1.288624778
252	3780	63	20.319	0.0080	1.204322222	1.288624778
253	3795	63.25	20.327	0.0080	1.204322222	1.288624778
254	3810	63.5	20.334	0.0070	1.053781944	1.127546681
255	3825	63.75	20.342	0.0080	1.204322222	1.288624778
256	3840	64	20.350	0.0080	1.204322222	1.288624778
257	3855	64.25	20.358	0.0080	1.204322222	1.288624778
258	3870	64.5	20.366	0.0080	1.204322222	1.288624778
259	3885	64.75	20.373	0.0070	1.053781944	1.127546681
260	3900	65	20.381	0.0080	1.204322222	1.288624778
261	3915	65.25	20.389	0.0080	1.204322222	1.288624778
262	3930	65.5	20.397	0.0080	1.204322222	1.288624778
263	3945	65.75	20.405	0.0080	1.204322222	1.288624778
264	3960	66	20.413	0.0080	1.204322222	1.288624778
265	3975	66.25	20.420	0.0070	1.053781944	1.127546681
266	3990	66.5	20.428	0.0080	1.204322222	1.288624778
267	4005	66.75	20.436	0.0080	1.204322222	1.288624778
268	4020	67	20.444	0.0080	1.204322222	1.288624778
269	4035	67.25	20.452	0.0080	1.204322222	1.288624778
270	4050	67.5	20.459	0.0070	1.053781944	1.127546681
271	4065	67.75	20.467	0.0080	1.204322222	1.288624778
272	4080	68	20.475	0.0080	1.204322222	1.288624778
273	4095	68.25	20.483	0.0080	1.204322222	1.288624778
274	4110	68.5	20.491	0.0080	1.204322222	1.288624778
275	4125	68.75	20.498	0.0070	1.053781944	1.127546681
276	4140	69	20.506	0.0080	1.204322222	1.288624778
277	4155	69.25	20.514	0.0080	1.204322222	1.288624778
278	4170	69.5	20.522	0.0080	1.204322222	1.288624778
279	4185	69.75	20.530	0.0080	1.204322222	1.288624778
280	4200	70	20.538	0.0080	1.204322222	1.288624778
281	4215	70.25	20.545	0.0070	1.053781944	1.127546681
282	4230	70.5	20.553	0.0080	1.204322222	1.288624778
283	4245	70.75	20.561	0.0080	1.204322222	1.288624778
284	4260	71	20.569	0.0080	1.204322222	1.288624778
285	4275	71.25	20.577	0.0080	1.204322222	1.288624778
286	4290	71.5	20.584	0.0070	1.053781944	1.127546681
287	4305	71.75	20.592	0.0080	1.204322222	1.288624778
288	4320	72	20.600	0.0080	1.204322222	1.288624778

Appendix B: Soil Type Map

United States Department of Agriculture

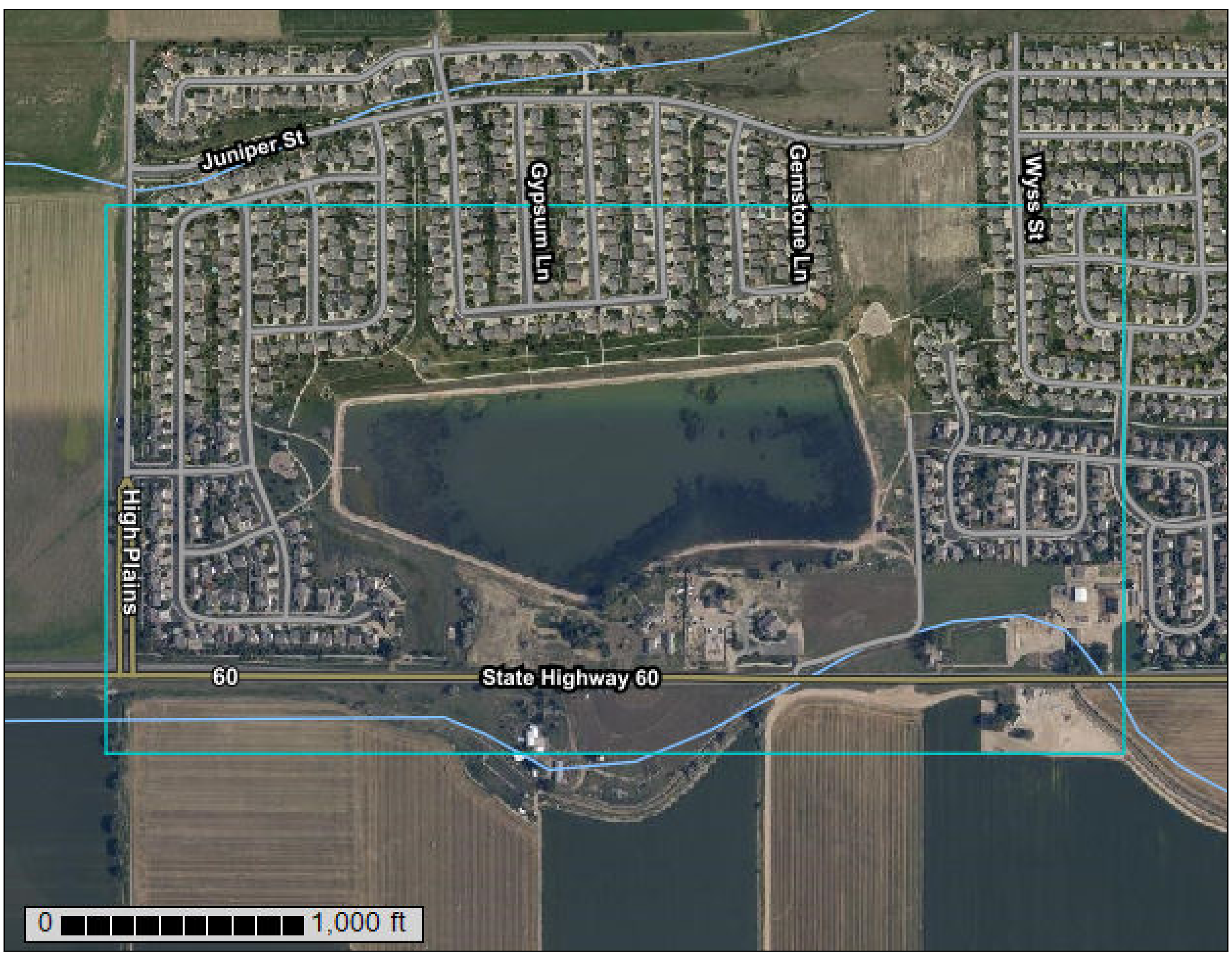
NRCS

Natural Resources Conservation Service

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

Custom Soil Resource Report for Weld County, Colorado, Southern Part

Johnstown Reservoir



March 3, 2021

Soil Map

Map Scale: 1:7,030 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 100, 200, 400, 600

Feet: 0, 300, 600, 1200, 1800

Map projection: Web Mercator   Corner coordinates: WGS84   Edge tics: UTM Zone 13N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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

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

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

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

Soil Survey Area: Weld County, Colorado, Southern Part
Survey Area Data: Version 19, Jun 5, 2020

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

Date(s) aerial images were photographed: Jul 19, 2018—Aug 12, 2018

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
15	Colby loam, 1 to 3 percent slopes	4.9	2.3%
16	Colby loam, 3 to 5 percent slopes	25.6	11.8%
42	Nunn clay loam, 1 to 3 percent slopes	0.0	0.0%
79	Weld loam, 1 to 3 percent slopes	152.6	70.2%
82	Wiley-Colby complex, 1 to 3 percent slopes	0.1	0.0%
85	Water	34.2	15.7%
Totals for Area of Interest		**217.5**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

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

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

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

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

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

Appendix C. Wave Run-up and Wind Setup Calculations

USBR DESIGN STD 13, CHAPTER 6, APPENDIX B: WAVE RUNUP + SETUP ANALYSIS FOR FREEBOARD DESIGN

[ ] =user entry

bold red = spreadsheet calculation based on DS 13 Ch. 6, Appendix B

B.1 Determine resrevoir fetch and avaerage depth, B.3 Determine design wind speed (ref: Rule 7.4.2.2)

D=	13.1	ft, average depth of water along fetch (reasonable appoximation with more emphasis given to depths close to the dam)
VMPH=	100	(mi/hr) wind velocity over water. User can input any desired windspeed. Prescriptive design standard 100 mph per Rule 7.2.2.1, see Table 1 for 10% Pwh per Rule 7.2.2.2)
F=	0.413	miles, fetch. See App. B.1, pg. B-1 & B-2

B.3.6 Determine minimum duration required to generate maximum wave height

t_{min}= **0.22** **hours** [DS 13 Ch 6 App. B, Eq 1] (NOTE: PFARA returns likelihood of a given over-water wind speed for this duration)

B.4.1. Calculate significant wave height (Eq. 2): defined as the average of the highest one-third of the waves in a wave field

H_s= **2.57** ft

B.4.2 Calculate wave period (Eq. 4):

T= **1.89** sec

B.4.2 Calculate deep water wave length (Eq. 3):

L= **18.25** ft NOTE: Assumes reservoir depth > 1/2*L.

B.4.3 Determine wave runup: vertical distance between the maximum level attained by the rush of water up the slope and the still water elevation

upstream slope (xH:1v)= 3.0

alpha=	**0.322**	radians, upstream slope angle
sp=	**0.14**	steepness of the peak waves (Eq. 6)
epsilon_p=	**0.89**	surf similarity factor, (Eq. 5)

The computation of runup, R, follows the following equation:

$$R = H_s\left(A\xi_p + C\right)\gamma_r\gamma_b\gamma_h\gamma_\beta \qquad \text{[Equation 8]}$$

A=	**1.6**	Coeficient depending on epsilon_p (see Table B-4)
C=	**0**	Coeficient depending on epsilon_p (see Table B-4)
Upsream slope mat'l=	riprap	**Drop down list**
gamma-r	**0.55**	Table B-3, pg B-11
gamma-b	0.55	for non-bermed slope, see pg B-11
gamma-h	1	for Rayleigh distributed waves, reduction factor for influence of shallow water conditions (1.0 is conservative)
gamma-beta	1	reduction factor for direction of fetch incident to dam axis (1.0 for fetch perpendicular to dam axis)

R= **1.10** ft, wave runup (Eq. 8)

B.4.4 Determine wind setup: vertical rise in the stillwater level on the leeward side of a water body due to wind stresses on the surface of the water

S= **0.23** ft, wind setup (Eq. 9)

Calculate Total wave runup + wind setup:

R+S= **1.33** ft Spreadsheet calcs checked against USBR DS 13 Ch. 6 App. C example - OK.

Table 1: 10% Probability of Non-Excedence (PWH)

PFARA Station	*Station I.D.*	*Over Water Wind Velocity (mph) 10% Probability of Non-Excedence (Pwh)*			
		Fetch Length			
		0.5 mile	*1.0 mile*	*1.5 mile*	*2 mile*
Aurora/Buckley	CO23036	18	18.5	19	19
Alamosa	CO23061	22.5	23	23.5	24
Denver/Sta Gage	CO23062	22	23	24.6	26
Eagle	CO23062	23	24	25	26
Grand Junction	CO23066	19.5	20	21	22
La Junta	CO23067	18	19	20	21
Pueblo	CO23068	18	19	20	20
Trinidad	CO23070	22	23	24	24
Akron	CO24015	26	27	28	29
Denver	CO93032	19	20	21	21
Colorado Springs	CO93037	20	21	23	23
Pueblo	CO93058	20	20.2	21	22
USAFA	CO93065	21	22	22.5	23
Fort Carson	CO93065	20	20.5	21	22

** Wind Velocity Calucated using PRARA Program*

Table B-2. Common wave height relationships

Percent of total number of waves in series averaged to compute specific wave height (H)	Ratio of specific wave height, H, to average wave height, H_{ave} (H/H_{ave})	Ratio of specific wave height, H, to significant wave height H_s (H/H_s)	Percent of waves exceeding specific wave height (H)
1	2.66	1.67	0.4
5	2.24	1.40	2
10	2.03	1.27	4
20	1.80	1.12	8
25	1.71	1.07	10
30	1.64	1.02	12
33.33	1.60	1.00	13
40	1.52	0.95	16
50	1.42	0.89	20
75	1.20	0.75	32
100	1.00	0.62	46

concrete
riprap

Table B-4. Values for variables *A* and *C* of the runup equation [16b]

ξ-Limits	*A*	*C*
$\xi_p \le 2.5$	1.6	0
$2.5 < \xi_p < 9$	-0.2	4.5

Table B-3. Surface roughness reduction factor (valid for $1 < \xi_p < 3$-4) [16b]

Type of slope surface	γ_r
Smooth, concrete, asphalt	1.0
Smooth block revetment	1.0
Grass (3 centimeters in length)	0.90 – 1.0
One layer of rock, diameter *D*, (H_s/D = 1.5 – 3.0)	0.55 – 0.6
Two or more layers of rock, (H_s/D = 1.5 – 6.0)	0.50 – 0.55

USBR DESIGN STD 13, CHAPTER 6, APPENDIX B: WAVE RUNUP + SETUP ANALYSIS FOR FREEBOARD DESIGN

[ ] =user entry

bold red = spreadsheet calculation based on DS 13 Ch. 6, Appendix B

B.1 Determine resrevoir fetch and avaerage depth, B.3 Determine design wind speed (ref: Rule 7.4.2.2)

D=	13.1	ft, average depth of water along fetch (reasonable appoximation with more emphasis given to depths close to the dam)
VMPH=	22	(mi/hr) wind velocity over water. User can input any desired windspeed. Prescriptive design standard 100 mph per Rule 7.2.2.1, see Table 1 for 10% Pwh per Rule 7.2.2.2)
F=	0.413	miles, fetch. See App. B.1, pg. B-1 & B-2

B.3.6 Determine minimum duration required to generate maximum wave height

t_{min}= **0.36** **hours** [DS 13 Ch 6 App. B, Eq 1] (NOTE: PFARA returns likelihood of a given over-water wind speed for this duration)

B.4.1. Calculate significant wave height (Eq. 2): defined as the average of the highest one-third of the waves in a wave field

H_s= **0.42** ft

B.4.2 Calculate wave period (Eq. 4):

T= **1.03** sec

B.4.2 Calculate deep water wave length (Eq. 3):

L= **5.42** ft NOTE: Assumes reservoir depth > 1/2*L.

B.4.3 Determine wave runup: vertical distance between the maximum level attained by the rush of water up the slope and the still water elevation

upstream slope (xH:1v)= 3.0

alpha=	**0.322**	radians, upstream slope angle
sp=	**0.08**	steepness of the peak waves (Eq. 6)
epsilon_p=	**1.20**	surf similarity factor, (Eq. 5)

The computation of runup, R, follows the following equation:

$$R = H_s\left(A\xi_p + C\right)\gamma_r\gamma_b\gamma_h\gamma_\beta \qquad \text{[Equation 8]}$$

A=	**1.6**	Coeficient depending on epsilon_p (see Table B-4)
C=	**0**	Coeficient depending on epsilon_p (see Table B-4)
Upsream slope mat'l=	riprap	**Drop down list**
gamma-r	**0.55**	Table B-3, pg B-11
gamma-b	0.55	for non-bermed slope, see pg B-11
gamma-h	1	for Rayleigh distributed waves, reduction factor for influence of shallow water conditions (1.0 is conservative)
gamma-beta	1	reduction factor for direction of fetch incident to dam axis (1.0 for fetch perpendicular to dam axis)

R= **0.24** ft, wave runup (Eq. 8)

B.4.4 Determine wind setup: vertical rise in the stillwater level on the leeward side of a water body due to wind stresses on the surface of the water

S= **0.01** ft, wind setup (Eq. 9)

Calculate Total wave runup + wind setup:

R+S= **0.25** ft Spreadsheet calcs checked against USBR DS 13 Ch. 6 App. C example - OK.

Table 1: 10% Probability of Non-Excedence (PWH)

PFARA Station	*Station I.D.*	*Over Water Wind Velocity (mph) 10% Probability of Non-Excedence (Pwh)*			
		Fetch Length			
		0.5 mile	*1.0 mile*	*1.5 mile*	*2 mile*
Aurora/Buckley	CO23036	18	18.5	19	19
Alamosa	CO23061	22.5	23	23.5	24
Denver/Sta Gage	CO23062	22	23	24.6	26
Eagle	CO23062	23	24	25	26
Grand Junction	CO23066	19.5	20	21	22
La Junta	CO23067	18	19	20	21
Pueblo	CO23068	18	19	20	20
Trinidad	CO23070	22	23	24	24
Akron	CO24015	26	27	28	29
Denver	CO93032	19	20	21	21
Colorado Springs	CO93037	20	21	23	23
Pueblo	CO93058	20	20.2	21	22
USAFA	CO93065	21	22	22.5	23
Fort Carson	CO93065	20	20.5	21	22

** Wind Velocity Calucated using PRARA Program*

Table B-2. Common wave height relationships

Percent of total number of waves in series averaged to compute specific wave height (H)	Ratio of specific wave height, H, to average wave height, H_{ave} (H/H_{ave})	Ratio of specific wave height, H, to significant wave height H_s (H/H_s)	Percent of waves exceeding specific wave height (H)
1	2.66	1.67	0.4
5	2.24	1.40	2
10	2.03	1.27	4
20	1.80	1.12	8
25	1.71	1.07	10
30	1.64	1.02	12
33.33	1.60	1.00	13
40	1.52	0.95	16
50	1.42	0.89	20
75	1.20	0.75	32
100	1.00	0.62	46

concrete

riprap

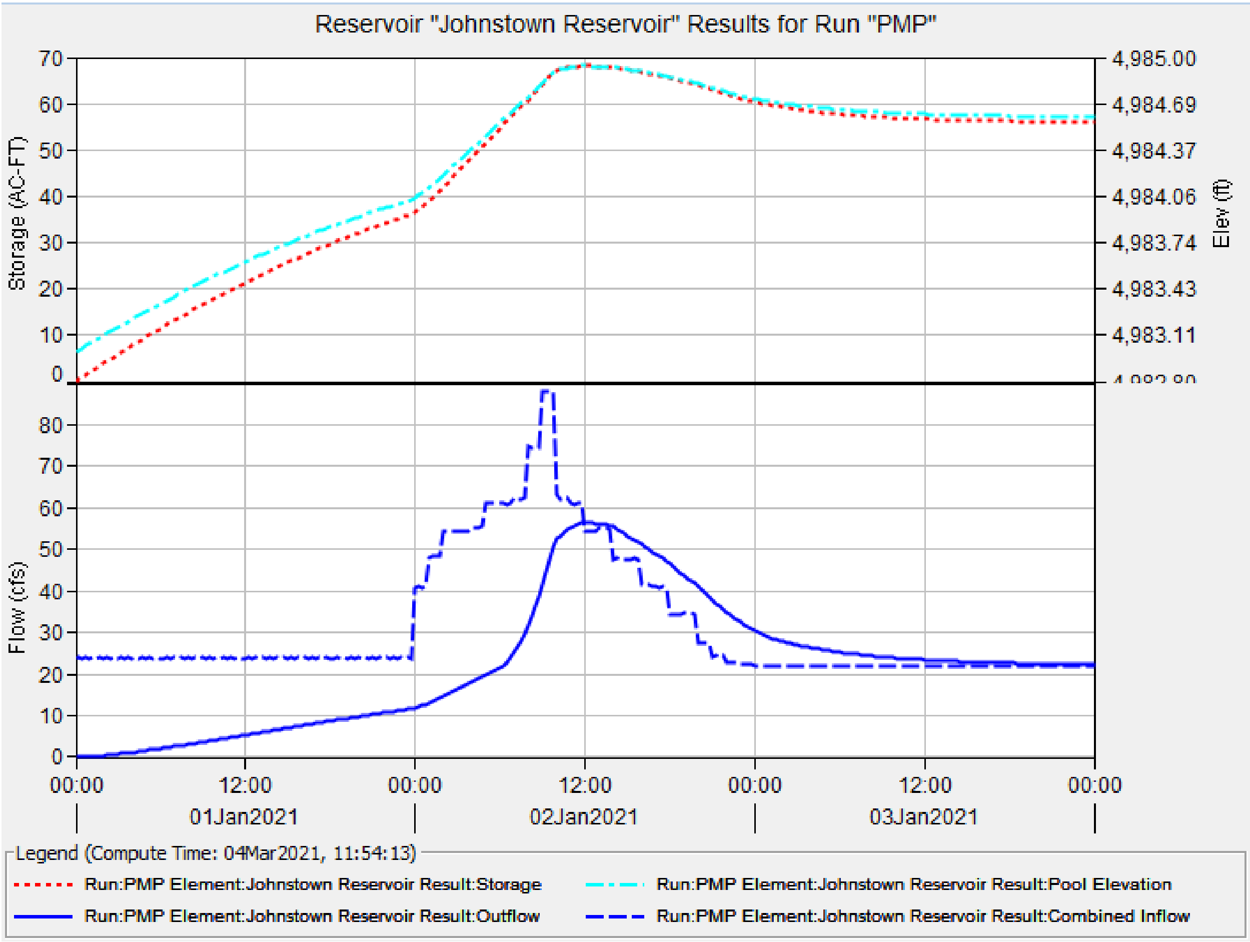
Table B-4. Values for variables *A* and *C* of the runup equation [16b]

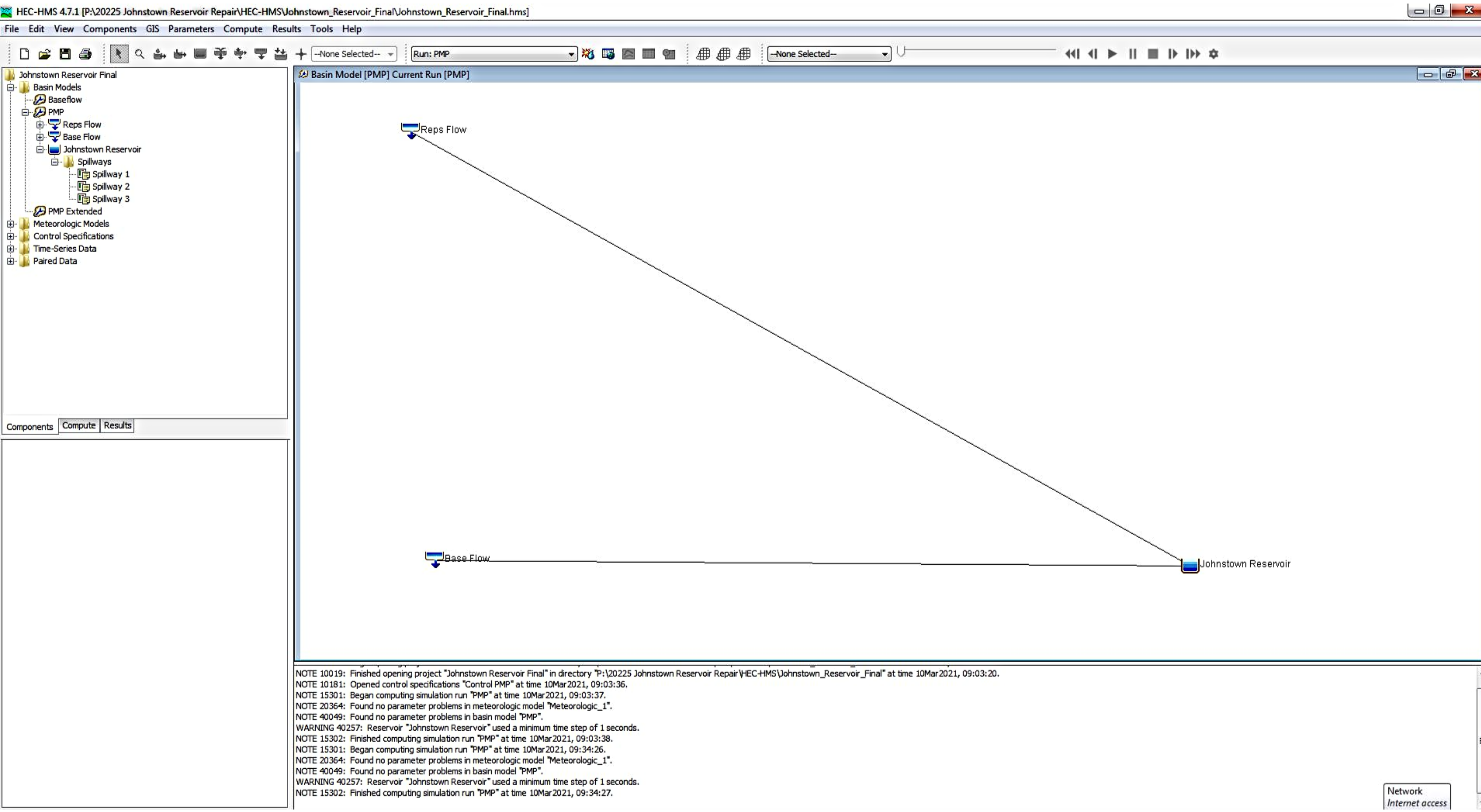
ξ-Limits	*A*	*C*
$\xi_p \le 2.5$	1.6	0
$2.5 < \xi_p < 9$	-0.2	4.5

Table B-3. Surface roughness reduction factor (valid for $1 < \xi_p < 3\text{-}4$) [16b]

Type of slope surface	γ_r
Smooth, concrete, asphalt	1.0
Smooth block revetment	1.0
Grass (3 centimeters in length)	0.90 – 1.0
One layer of rock, diameter *D*, (H_s/D = 1.5 – 3.0)	0.55 – 0.6
Two or more layers of rock, (H_s/D = 1.5 – 6.0)	0.50 – 0.55

Appendix D. HEC-HMS Results


Reservoir "Johnstown Reservoir" Results for Run "PMP"
Storage (AC-FT)
Elev (ft)
Flow (cfs)
4,985.00
4,984.69
4,984.37
4,984.06
4,983.74
4,983.43
4,983.11
01Jan2021
02Jan2021
03Jan2021
Legend (Compute Time: 04Mar2021, 11:54:13)
Run:PMP Element:Johnstown Reservoir Result:Storage
Run:PMP Element:Johnstown Reservoir Result:Pool Elevation
Run:PMP Element:Johnstown Reservoir Result:Outflow
Run:PMP Element:Johnstown Reservoir Result:Combined Inflow


HEC-HMS 4.7.1 [P:\20225 Johnstown Reservoir Repair\HEC-HMS\Johnstown_Reservoir_Final\Johnstown_Reservoir_Final.hms]
File Edit View Components GIS Parameters Compute Results Tools Help
--None Selected--
Run: PMP
--None Selected--
Johnstown Reservoir Final
Basin Models
Baseflow
PMP
Reps Flow
Base Flow
Johnstown Reservoir
Spillways
Spillway 1
Spillway 2
Spillway 3
PMP Extended
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Components
Compute
Results
Basin Model [PMP] Current Run [PMP]
Reps Flow
Base Flow
Johnstown Reservoir
NOTE 10019: Finished opening project "Johnstown Reservoir Final" in directory "P:\20225 Johnstown Reservoir Repair\HEC-HMS\Johnstown_Reservoir_Final" at time 10Mar2021, 09:03:20.
NOTE 10181: Opened control specifications "Control PMP" at time 10Mar2021, 09:03:36.
NOTE 15301: Began computing simulation run "PMP" at time 10Mar2021, 09:03:37.
NOTE 20364: Found no parameter problems in meteorologic model "Meteorologic_1".
NOTE 40049: Found no parameter problems in basin model "PMP".
WARNING 40257: Reservoir "Johnstown Reservoir" used a minimum time step of 1 seconds.
NOTE 15302: Finished computing simulation run "PMP" at time 10Mar2021, 09:03:38.
NOTE 15301: Began computing simulation run "PMP" at time 10Mar2021, 09:34:26.
NOTE 20364: Found no parameter problems in meteorologic model "Meteorologic_1".
NOTE 40049: Found no parameter problems in basin model "PMP".
WARNING 40257: Reservoir "Johnstown Reservoir" used a minimum time step of 1 seconds.
NOTE 15302: Finished computing simulation run "PMP" at time 10Mar2021, 09:34:27.
Network
Internet access

Project: Johnstown_Reservoir_Final
Simulation Run: PMP
Simulation Start: 31 December 2020, 24:00
Simulation End: 3 January 2021, 24:00

HMS Version: 4.7.1
Executed: 08 March 2021, 19:05

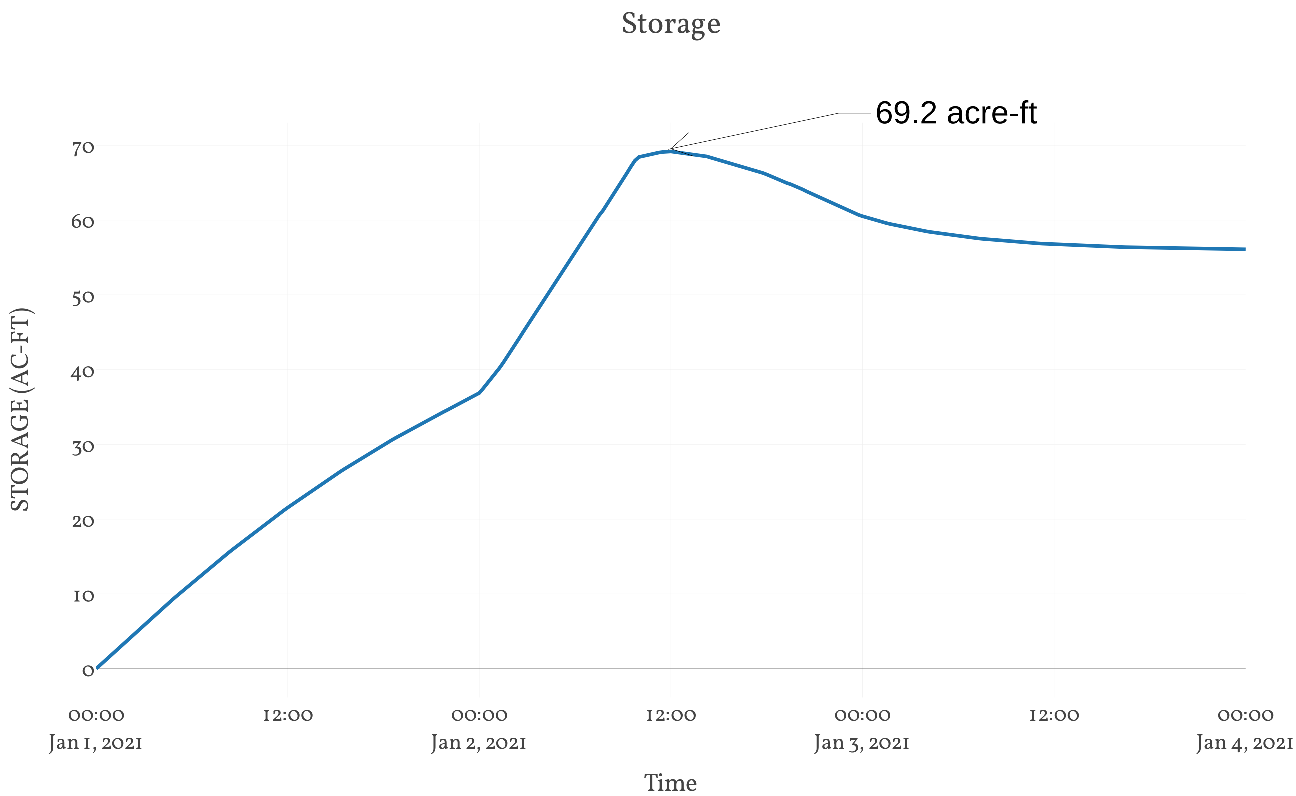
Global Results Summary

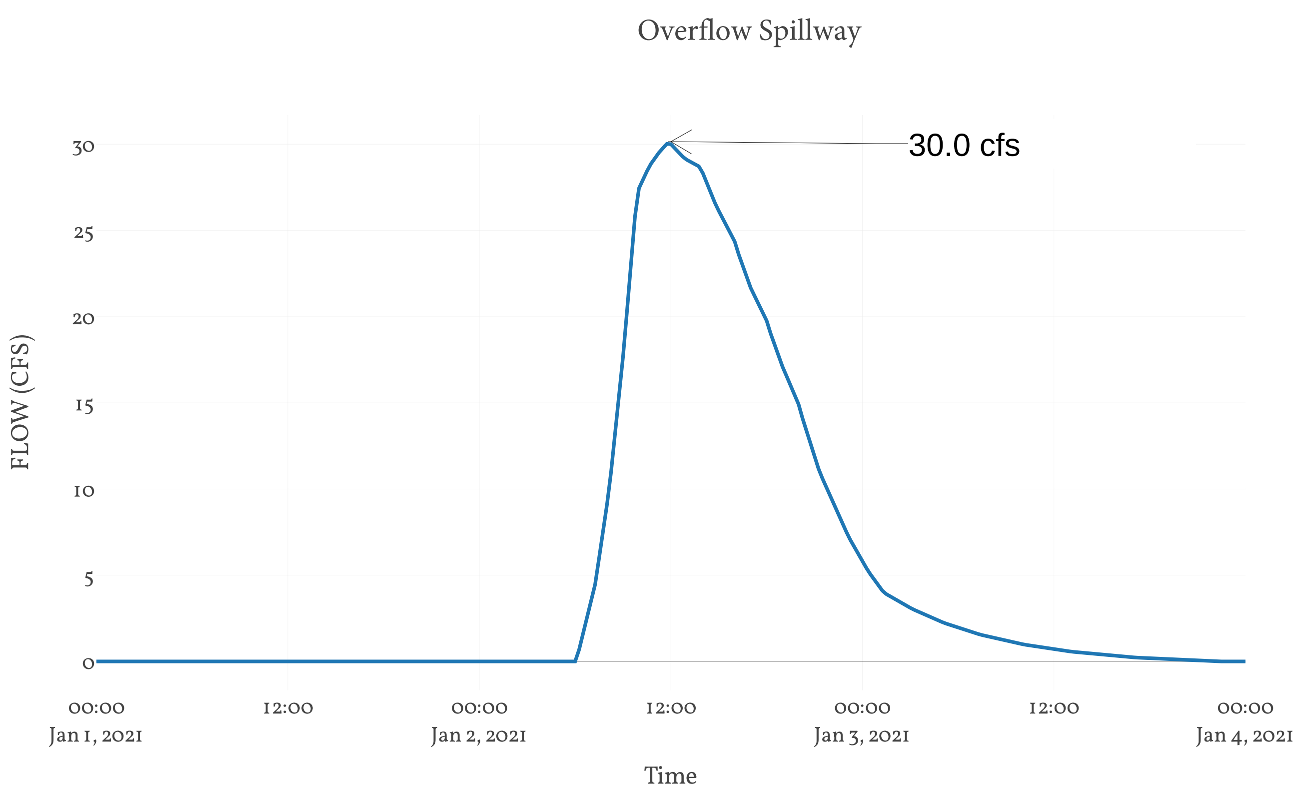
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume ()
Reps Flow	Not specified	71.84	02Jan2021, 09:00	Not specified
Base Flow	Not specified	20.88	31Dec2020, 24:00	Not specified
Johnstown Reservoir	Not specified	60.69	02Jan2021, 11:45	Not specified

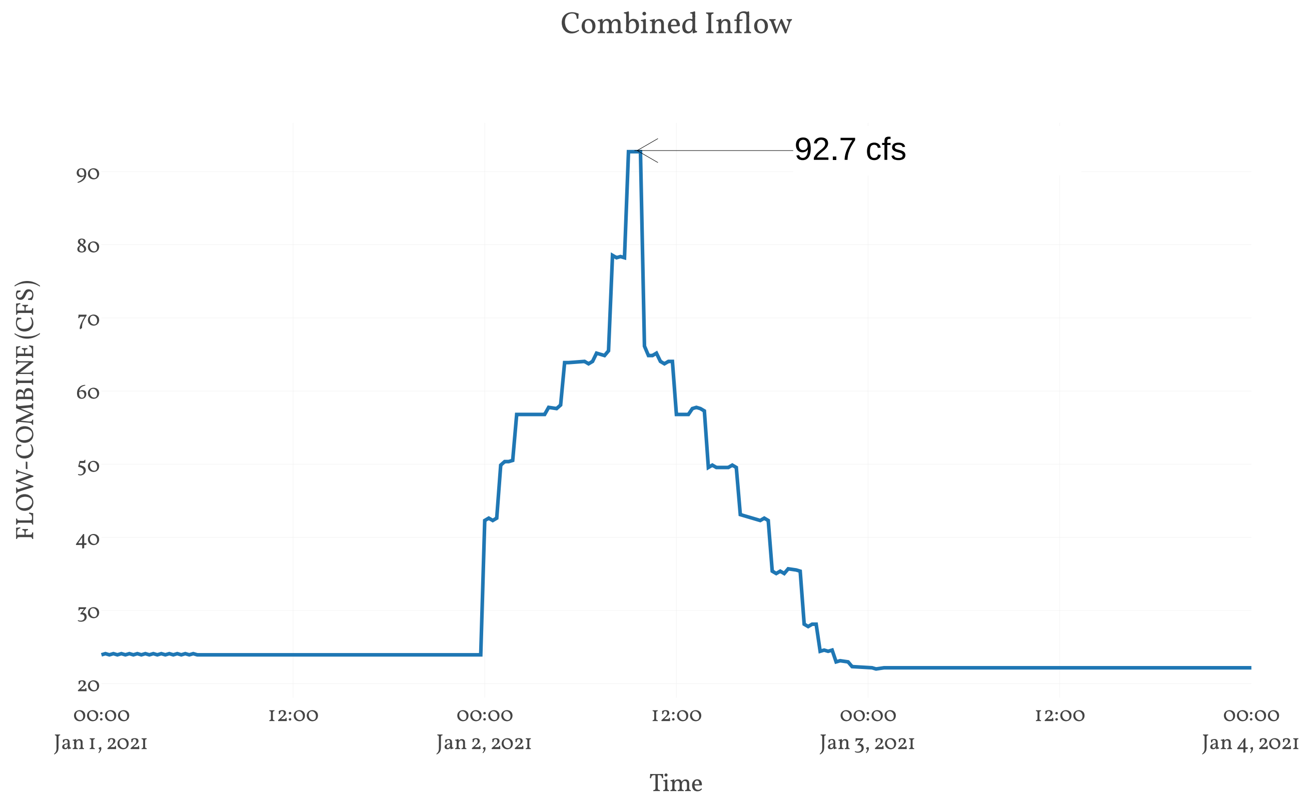
Reservoir: Johnstown Reservoir

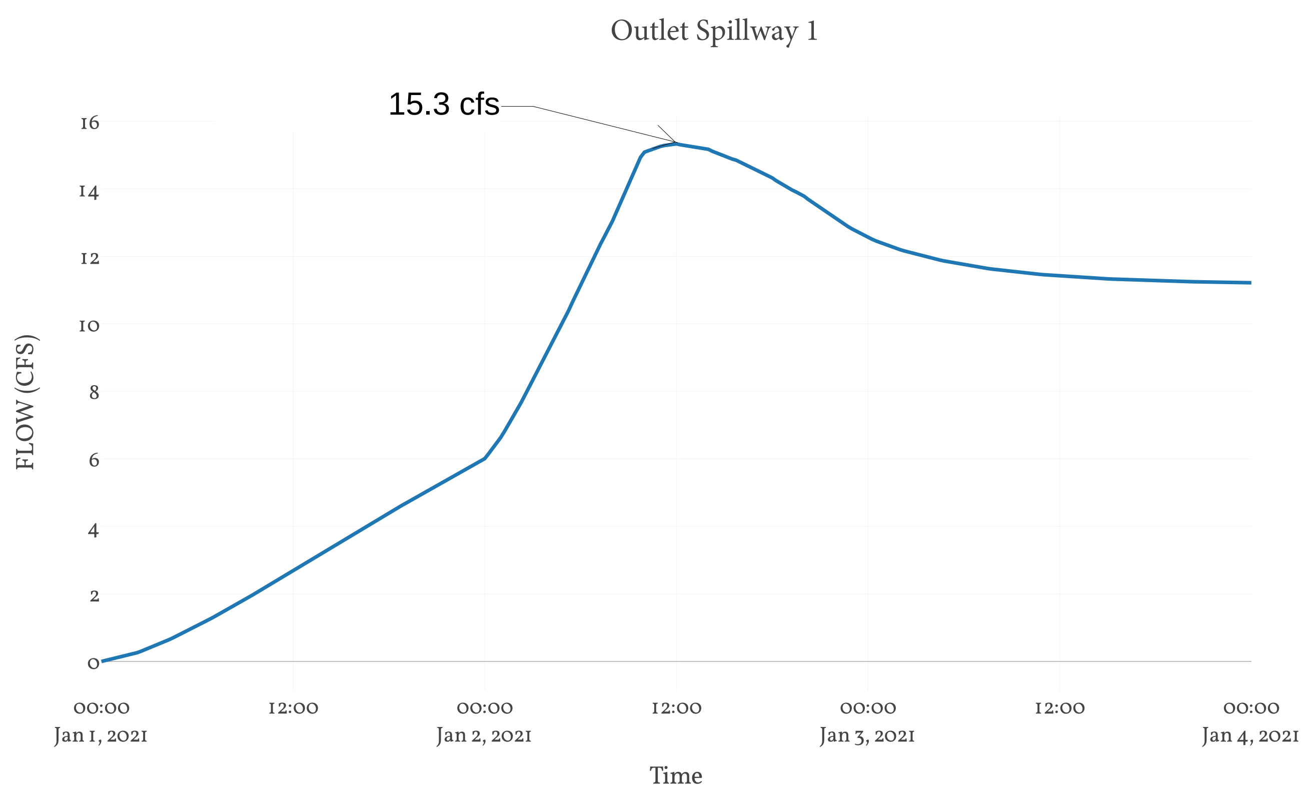
Results: Johnstown Reservoir

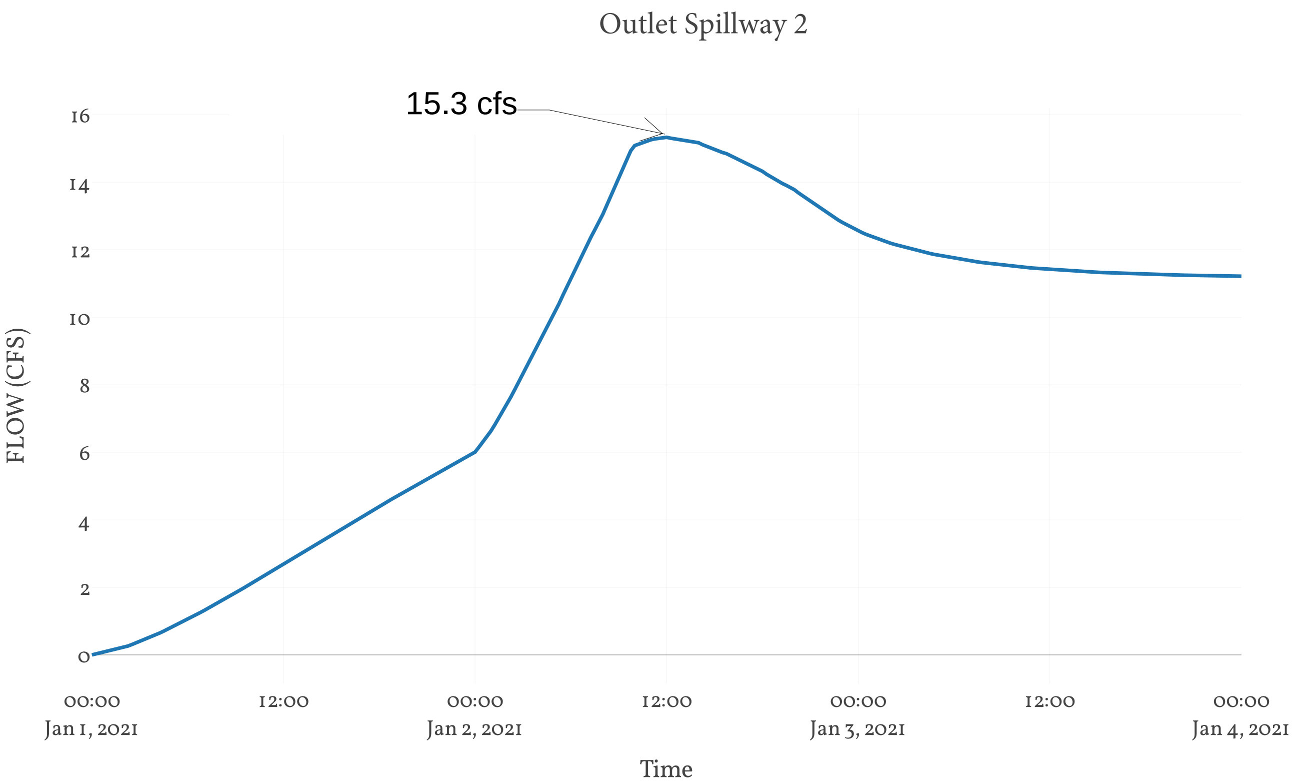
Peak Discharge (CFS)	60.69
Time of Peak Discharge	02Jan2021, 11:45
Peak Inflow (CFS)	92.72
Time of Peak Inflow	02Jan2021, 09:00
Inflow Volume (AC - FT)	192.78
Maximum Storage (AC - FT)	69.18
Peak Elevation (FT)	4984.97
Discharge Volume (AC - FT)	136.69

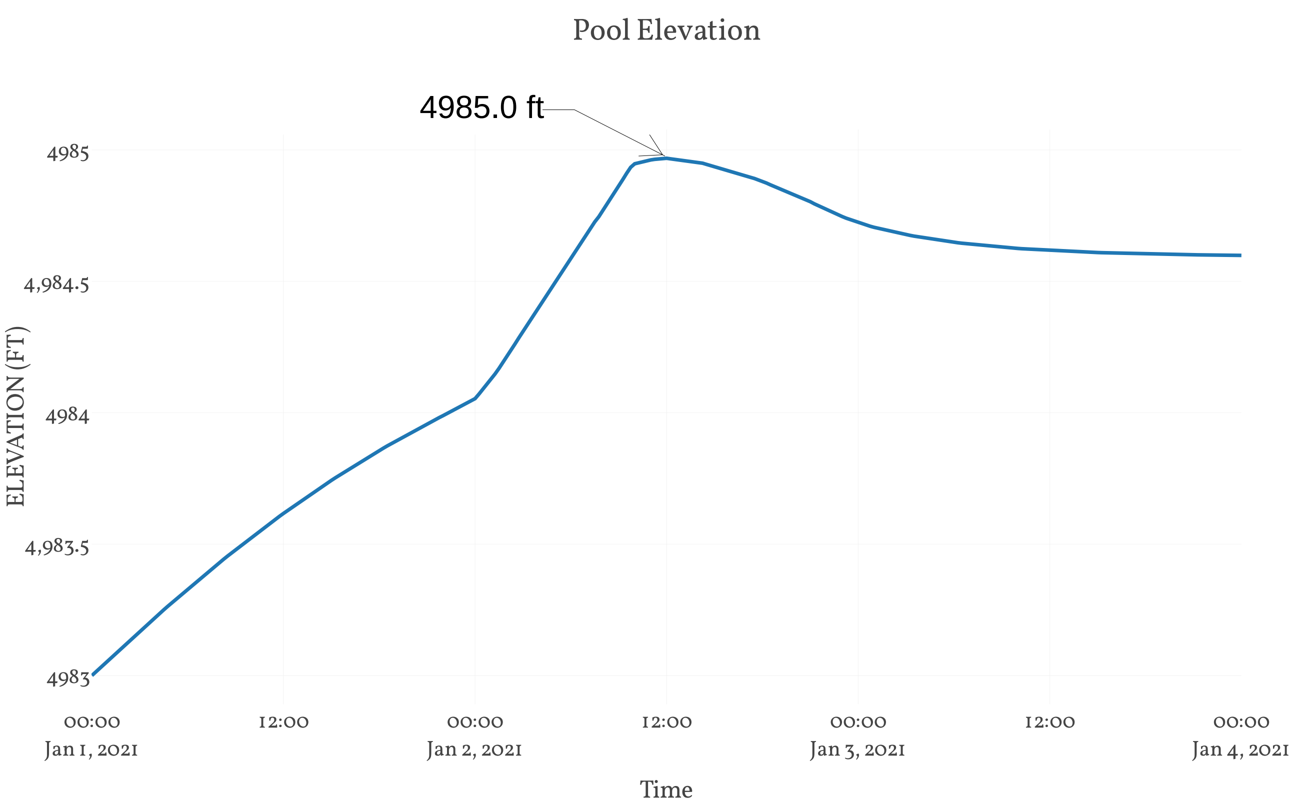

Storage
69.2 acre-ft
STORAGE (AC-FT)
70
60
50
40
30
20
10
0
00:00
Jan 1, 2021
12:00
00:00
Jan 2, 2021
12:00
00:00
Jan 3, 2021
12:00
00:00
Jan 4, 2021
Time

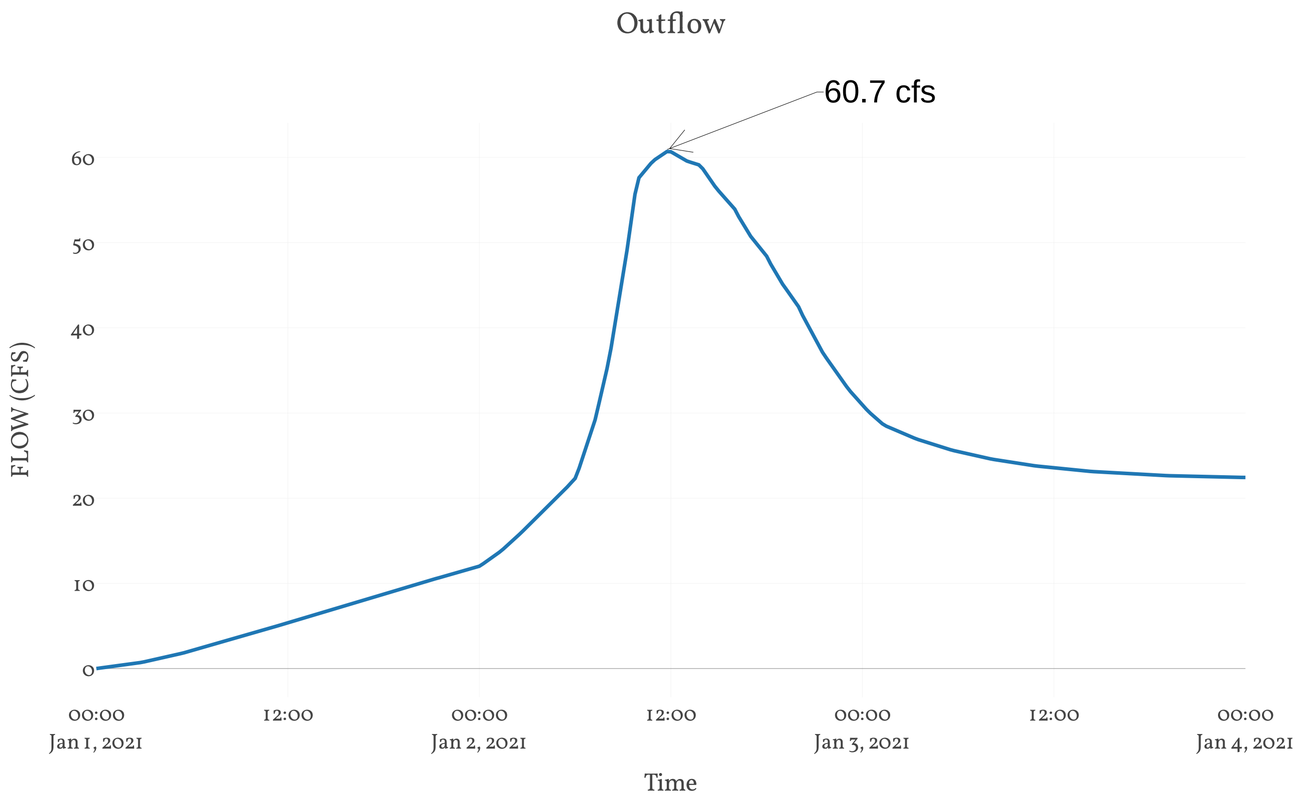

Overflow Spillway
30.0 cfs
FLOW (CFS)
30
25
20
15
10
5
0
00:00
Jan 1, 2021
12:00
00:00
Jan 2, 2021
12:00
00:00
Jan 3, 2021
12:00
00:00
Jan 4, 2021
Time


Combined Inflow
92.7 cfs
FLOW-COMBINE (CFS)
90
80
70
60
50
40
30
20
00:00
Jan 1, 2021
12:00
00:00
Jan 2, 2021
12:00
00:00
Jan 3, 2021
12:00
00:00
Jan 4, 2021
Time


Outlet Spillway 1
15.3 cfs
FLOW (CFS)
16
14
12
10
8
6
4
2
0
00:00
Jan 1, 2021
12:00
00:00
Jan 2, 2021
12:00
00:00
Jan 3, 2021
12:00
00:00
Jan 4, 2021
Time


Outlet Spillway 2
15.3 cfs
FLOW (CFS)
16
14
12
10
8
6
4
2
0
00:00
Jan 1, 2021
12:00
00:00
Jan 2, 2021
12:00
00:00
Jan 3, 2021
12:00
00:00
Jan 4, 2021
Time


Pool Elevation
4985.0 ft
ELEVATION (FT)
4985
4,984.5
4984
4,983.5
4983
00:00
Jan 1, 2021
12:00
00:00
Jan 2, 2021
12:00
00:00
Jan 3, 2021
12:00
00:00
Jan 4, 2021
Time


Outflow
60.7 cfs
FLOW (CFS)
0
10
20
30
40
50
60
00:00
Jan 1, 2021
12:00
00:00
Jan 2, 2021
12:00
00:00
Jan 3, 2021
12:00
00:00
Jan 4, 2021
Time

Time	Hour	Spillway 1 Outflow	Spillway 2 Outflow	Combined Outflow	PMP Inflow	Baseflow Inflow	Combined Inflow	Reservoir Stage Storage	Storage
0:00	0	0	0	0	2.9	20.9	23.7	4983	0
0:15	0.25	0	0	0	3	20.9	23.9	4983	0.5
0:30	0.5	0.1	0	0.1	2.9	20.9	23.7	4983	1
0:45	0.75	0.1	0	0.1	3	20.9	23.9	4983	1.5
1:00	1	0.2	0	0.2	2.9	20.9	23.7	4983.1	2
1:15	1.25	0.2	0	0.2	3	20.9	23.9	4983.1	2.4
1:30	1.5	0.3	0	0.3	2.9	20.9	23.7	4983.1	2.9
1:45	1.75	0.3	0	0.3	3	20.9	23.9	4983.1	3.4
2:00	2	0.4	0	0.4	2.9	20.9	23.7	4983.1	3.9
2:15	2.25	0.5	0	0.5	3	20.9	23.9	4983.1	4.4
2:30	2.5	0.6	0	0.6	2.9	20.9	23.7	4983.1	4.9
2:45	2.75	0.7	0	0.7	3	20.9	23.9	4983.2	5.3
3:00	3	0.8	0	0.8	2.9	20.9	23.7	4983.2	5.8
3:15	3.25	0.8	0	0.8	3	20.9	23.9	4983.2	6.3
3:30	3.5	0.9	0	0.9	2.9	20.9	23.7	4983.2	6.8
3:45	3.75	1	0	1	3	20.9	23.9	4983.2	7.2
4:00	4	1.1	0	1.1	2.9	20.9	23.7	4983.2	7.7
4:15	4.25	1.2	0	1.2	3	20.9	23.9	4983.2	8.2
4:30	4.5	1.4	0	1.4	2.9	20.9	23.7	4983.2	8.6
4:45	4.75	1.5	0	1.5	3	20.9	23.9	4983.3	9.1
5:00	5	1.6	0	1.6	2.9	20.9	23.7	4983.3	9.6
5:15	5.25	1.7	0	1.7	3	20.9	23.9	4983.3	10
5:30	5.5	1.8	0	1.8	2.9	20.9	23.7	4983.3	10.5
5:45	5.75	1.9	0	1.9	3	20.9	23.9	4983.3	10.9
6:00	6	2	0	2	2.9	20.9	23.7	4983.3	11.4
6:15	6.25	2.2	0	2.2	2.9	20.9	23.7	4983.3	11.8
6:30	6.5	2.3	0	2.3	3	20.9	23.9	4983.4	12.3
6:45	6.75	2.4	0	2.4	2.9	20.9	23.7	4983.4	12.7
7:00	7	2.5	0	2.5	3	20.9	23.9	4983.4	13.2
7:15	7.25	2.6	0	2.6	2.9	20.9	23.7	4983.4	13.6
7:30	7.5	2.8	0	2.8	3	20.9	23.9	4983.4	14
7:45	7.75	2.9	0	2.9	2.9	20.9	23.7	4983.4	14.5
8:00	8	3	0	3	3	20.9	23.9	4983.4	14.9
8:15	8.25	3.2	0	3.2	2.9	20.9	23.7	4983.4	15.3
8:30	8.5	3.3	0	3.3	3	20.9	23.9	4983.5	15.8
8:45	8.75	3.4	0	3.4	2.9	20.9	23.7	4983.5	16.2
9:00	9	3.6	0	3.6	3	20.9	23.9	4983.5	16.6
9:15	9.25	3.7	0	3.7	2.9	20.9	23.7	4983.5	17
9:30	9.5	3.8	0	3.8	3	20.9	23.9	4983.5	17.4
9:45	9.75	4	0	4	2.9	20.9	23.7	4983.5	17.8
10:00	10	4.1	0	4.1	3	20.9	23.9	4983.5	18.3
10:15	10.25	4.2	0	4.2	2.9	20.9	23.7	4983.5	18.7
10:30	10.5	4.4	0	4.4	3	20.9	23.9	4983.5	19.1
10:45	10.75	4.5	0	4.5	2.9	20.9	23.7	4983.6	19.5
11:00	11	4.7	0	4.7	3	20.9	23.9	4983.6	19.9
11:15	11.25	4.8	0	4.8	2.9	20.9	23.7	4983.6	20.3
11:30	11.5	4.9	0	4.9	3	20.9	23.9	4983.6	20.6
11:45	11.75	5.1	0	5.1	2.9	20.9	23.7	4983.6	21
12:00	12	5.2	0	5.2	2.9	20.9	23.7	4983.6	21.4
12:15	12.25	5.3	0	5.3	3	20.9	23.9	4983.6	21.8
12:30	12.5	5.5	0	5.5	2.9	20.9	23.7	4983.6	22.2

Time	Hour	Spillway 1 Outflow	Spillway 2 Outflow	Combined Outflow	PMP Inflow	Baseflow Inflow	Combined Inflow	Reservoir Stage Storage	Storage
12:45	12.75	5.6	0	5.6	3	20.9	23.9	4983.6	22.6
13:00	13	5.8	0	5.8	2.9	20.9	23.7	4983.7	22.9
13:15	13.25	5.9	0	5.9	3	20.9	23.9	4983.7	23.3
13:30	13.5	6	0	6	2.9	20.9	23.7	4983.7	23.7
13:45	13.75	6.2	0	6.2	3	20.9	23.9	4983.7	24
14:00	14	6.3	0	6.3	2.9	20.9	23.7	4983.7	24.4
14:15	14.25	6.5	0	6.5	3	20.9	23.9	4983.7	24.8
14:30	14.5	6.6	0	6.6	2.9	20.9	23.7	4983.7	25.1
14:45	14.75	6.7	0	6.7	3	20.9	23.9	4983.7	25.5
15:00	15	6.9	0	6.9	2.9	20.9	23.7	4983.7	25.8
15:15	15.25	7	0	7	3	20.9	23.9	4983.7	26.2
15:30	15.5	7.2	0	7.2	2.9	20.9	23.7	4983.8	26.5
15:45	15.75	7.3	0	7.3	3	20.9	23.9	4983.8	26.9
16:00	16	7.4	0	7.4	2.9	20.9	23.7	4983.8	27.2
16:15	16.25	7.6	0	7.6	3	20.9	23.9	4983.8	27.5
16:30	16.5	7.7	0	7.7	2.9	20.9	23.7	4983.8	27.9
16:45	16.75	7.8	0	7.8	3	20.9	23.9	4983.8	28.2
17:00	17	8	0	8	2.9	20.9	23.7	4983.8	28.5
17:15	17.25	8.1	0	8.1	3	20.9	23.9	4983.8	28.9
17:30	17.5	8.3	0	8.3	2.9	20.9	23.7	4983.8	29.2
17:45	17.75	8.4	0	8.4	3	20.9	23.9	4983.8	29.5
18:00	18	8.5	0	8.5	2.9	20.9	23.7	4983.9	29.8
18:15	18.25	8.7	0	8.7	2.9	20.9	23.7	4983.9	30.1
18:30	18.5	8.8	0	8.8	3	20.9	23.9	4983.9	30.4
18:45	18.75	8.9	0	8.9	2.9	20.9	23.7	4983.9	30.8
19:00	19	9.1	0	9.1	3	20.9	23.9	4983.9	31.1
19:15	19.25	9.2	0	9.2	2.9	20.9	23.7	4983.9	31.4
19:30	19.5	9.3	0	9.3	3	20.9	23.9	4983.9	31.7
19:45	19.75	9.5	0	9.5	2.9	20.9	23.7	4983.9	32
20:00	20	9.6	0	9.6	3	20.9	23.9	4983.9	32.3
20:15	20.25	9.7	0	9.7	2.9	20.9	23.7	4983.9	32.5
20:30	20.5	9.9	0	9.9	3	20.9	23.9	4983.9	32.8
20:45	20.75	10	0	10	2.9	20.9	23.7	4983.9	33.1
21:00	21	10.1	0	10.1	3	20.9	23.9	4984	33.4
21:15	21.25	10.2	0	10.2	2.9	20.9	23.7	4984	33.7
21:30	21.5	10.4	0	10.4	3	20.9	23.9	4984	34
21:45	21.75	10.5	0	10.5	2.9	20.9	23.7	4984	34.2
22:00	22	10.6	0	10.6	3	20.9	23.9	4984	34.5
22:15	22.25	10.7	0	10.7	2.9	20.9	23.7	4984	34.8
22:30	22.5	10.9	0	10.9	3	20.9	23.9	4984	35.1
22:45	22.75	11	0	11	2.9	20.9	23.7	4984	35.3
23:00	23	11.1	0	11.1	3	20.9	23.9	4984	35.6
23:15	23.25	11.2	0	11.2	2.9	20.9	23.7	4984	35.9
23:30	23.5	11.4	0	11.4	3	20.9	23.9	4984	36.1
23:45	23.75	11.5	0	11.5	2.9	20.9	23.7	4984	36.4
0:00	24	11.7	0	11.7	20	20.9	40.9	4984.1	36.8
0:15	24.25	12	0	12	20.3	20.9	41.2	4984.1	37.4
0:30	24.5	12.2	0	12.2	20	20.9	40.9	4984.1	38
0:45	24.75	12.5	0	12.5	20.3	20.9	41.2	4984.1	38.6
1:00	25	12.9	0	12.9	27.1	20.9	48	4984.1	39.3
1:15	25.25	13.2	0	13.2	27.5	20.9	48.4	4984.1	40

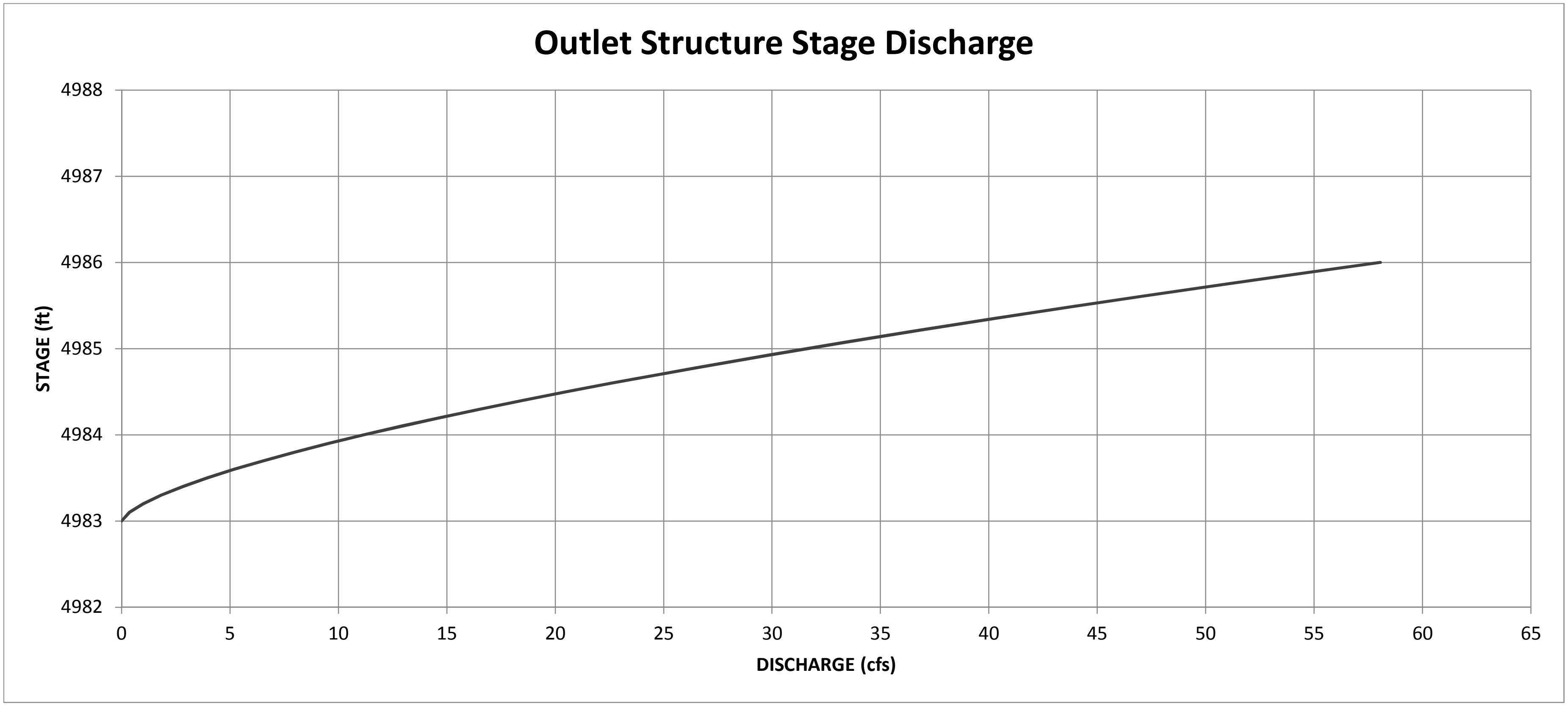
Time	Hour	Spillway 1 Outflow	Spillway 2 Outflow	Combined Outflow	PMP Inflow	Baseflow Inflow	Combined Inflow	Reservoir Stage Storage	Storage
1:30	25.5	13.6	0	13.6	27.5	20.9	48.4	4984.2	40.7
1:45	25.75	13.9	0	13.9	27.7	20.9	48.6	4984.2	41.4
2:00	26	14.3	0	14.3	33.6	20.9	54.4	4984.2	42.2
2:15	26.25	14.7	0	14.7	33.6	20.9	54.4	4984.2	43
2:30	26.5	15.2	0	15.2	33.6	20.9	54.4	4984.3	43.8
2:45	26.75	15.6	0	15.6	33.6	20.9	54.4	4984.3	44.6
3:00	27	16	0	16	33.6	20.9	54.4	4984.3	45.4
3:15	27.25	16.4	0	16.4	33.6	20.9	54.4	4984.3	46.2
3:30	27.5	16.8	0	16.8	33.4	20.9	54.3	4984.3	47
3:45	27.75	17.2	0	17.2	33.6	20.9	54.4	4984.4	47.8
4:00	28	17.7	0	17.7	34.5	20.9	55.4	4984.4	48.6
4:15	28.25	18.1	0	18.1	34.3	20.9	55.2	4984.4	49.3
4:30	28.5	18.5	0	18.5	34.3	20.9	55.2	4984.4	50.1
4:45	28.75	18.9	0	18.9	34.8	20.9	55.7	4984.5	50.9
5:00	29	19.4	0	19.4	40.2	20.9	61.1	4984.5	51.7
5:15	29.25	19.8	0	19.8	40.2	20.9	61.1	4984.5	52.5
5:30	29.5	20.3	0	20.3	40.2	20.9	61.1	4984.5	53.4
5:45	29.75	20.8	0	20.8	40.3	20.9	61.2	4984.5	54.2
6:00	30	21.3	0	21.3	40.3	20.9	61.2	4984.6	55
6:15	30.25	21.7	0	21.7	40.3	20.9	61.2	4984.6	55.9
6:30	30.5	22.2	0.6	22.8	40	20.9	60.9	4984.6	56.7
6:45	30.75	22.7	1.5	24.1	40.3	20.9	61.2	4984.6	57.4
7:00	31	23.1	2.3	25.4	41.4	20.9	62.3	4984.7	58.2
7:15	31.25	23.6	3.2	26.7	41.2	20.9	62.1	4984.7	58.9
7:30	31.5	24	4	28	41.1	20.9	62	4984.7	59.7
7:45	31.75	24.4	5.4	29.8	41.7	20.9	62.6	4984.7	60.4
8:00	32	24.9	7.1	32	53.9	20.9	74.8	4984.7	61.1
8:15	32.25	25.4	8.9	34.3	53.6	20.9	74.5	4984.8	62
8:30	32.5	25.9	10.7	36.6	53.7	20.9	74.6	4984.8	62.8
8:45	32.75	26.4	12.5	38.9	53.6	20.9	74.5	4984.8	63.6
9:00	33	26.9	14.9	41.8	67.1	20.9	88	4984.8	64.4
9:15	33.25	27.5	17.6	45	67.1	20.9	88	4984.9	65.3
9:30	33.5	28	20	48	67.1	20.9	88	4984.9	66.2
9:45	33.75	28.5	22.4	50.9	67.1	20.9	88	4984.9	67
10:00	34	28.8	24.1	52.9	42.3	20.9	63.2	4984.9	67.5
10:15	34.25	28.9	24.8	53.7	41.1	20.9	62	4984.9	67.7
10:30	34.5	29	25.3	54.4	41.1	20.9	62	4984.9	67.8
10:45	34.75	29.1	25.9	55	41.4	20.9	62.3	4984.9	68
11:00	35	29.2	26.3	55.5	40.3	20.9	61.2	4984.9	68.1
11:15	35.25	29.3	26.7	56	40	20.9	60.9	4984.9	68.2
11:30	35.5	29.4	27.1	56.4	40.3	20.9	61.2	4984.9	68.3
11:45	35.75	29.4	27.4	56.8	40.3	20.9	61.2	4984.9	68.4
12:00	36	29.4	27.5	56.9	33.6	20.9	54.4	4984.9	68.4
12:15	36.25	29.4	27.3	56.7	33.6	20.9	54.4	4984.9	68.4
12:30	36.5	29.4	27.1	56.5	33.6	20.9	54.4	4984.9	68.3
12:45	36.75	29.3	27	56.3	33.6	20.9	54.4	4984.9	68.3
13:00	37	29.3	26.9	56.2	34.3	20.9	55.2	4984.9	68.3
13:15	37.25	29.3	26.8	56.1	34.5	20.9	55.4	4984.9	68.3
13:30	37.5	29.3	26.8	56.1	34.3	20.9	55.2	4984.9	68.2
13:45	37.75	29.3	26.7	56	34	20.9	54.9	4984.9	68.2
14:00	38	29.2	26.4	55.6	26.8	20.9	47.7	4984.9	68.1

Time	Hour	Spillway 1 Outflow	Spillway 2 Outflow	Combined Outflow	PMP Inflow	Baseflow Inflow	Combined Inflow	Reservoir Stage Storage	Storage
14:15	38.25	29.1	25.8	55	27.1	20.9	48	4984.9	68
14:30	38.5	29	25.4	54.4	26.8	20.9	47.7	4984.9	67.8
14:45	38.75	29	24.9	53.8	26.8	20.9	47.7	4984.9	67.7
15:00	39	28.9	24.5	53.3	26.8	20.9	47.7	4984.9	67.6
15:15	39.25	28.8	24.1	52.9	26.8	20.9	47.7	4984.9	67.5
15:30	39.5	28.7	23.7	52.5	27.1	20.9	48	4984.9	67.4
15:45	39.75	28.7	23.4	52.1	26.8	20.9	47.7	4984.9	67.3
16:00	40	28.6	22.9	51.5	20.8	20.9	41.7	4984.9	67.1
16:15	40.25	28.5	22.2	50.7	20.6	20.9	41.5	4984.9	66.9
16:30	40.5	28.3	21.6	49.9	20.6	20.9	41.5	4984.9	66.7
16:45	40.75	28.2	21.1	49.4	20.5	20.9	41.4	4984.9	66.6
17:00	41	28.1	20.7	48.8	20.3	20.9	41.2	4984.9	66.4
17:15	41.25	28	20.2	48.3	20	20.9	40.9	4984.9	66.3
17:30	41.5	28	19.8	47.8	20.3	20.9	41.2	4984.9	66.1
17:45	41.75	27.9	19.4	47.3	20	20.9	40.9	4984.9	66
18:00	42	27.7	18.9	46.6	13.5	20.9	34.4	4984.9	65.8
18:15	42.25	27.6	18.2	45.8	13.2	20.9	34.1	4984.9	65.5
18:30	42.5	27.5	17.5	45	13.5	20.9	34.4	4984.9	65.3
18:45	42.75	27.3	16.9	44.2	13.2	20.9	34.1	4984.9	65.1
19:00	43	27.2	16.4	43.6	13.9	20.9	34.7	4984.8	64.9
19:15	43.25	27.1	15.9	43	13.9	20.9	34.7	4984.8	64.7
19:30	43.5	27	15.4	42.4	13.7	20.9	34.6	4984.8	64.6
19:45	43.75	26.9	15	41.8	13.5	20.9	34.4	4984.8	64.4
20:00	44	26.8	14.3	41.1	6.8	20.9	27.7	4984.8	64.2
20:15	44.25	26.6	13.6	40.2	6.5	20.9	27.4	4984.8	63.9
20:30	44.5	26.4	12.9	39.3	6.8	20.9	27.7	4984.8	63.7
20:45	44.75	26.3	12.2	38.5	6.8	20.9	27.7	4984.8	63.4
21:00	45	26.1	11.5	37.6	3.3	20.9	24.2	4984.8	63.2
21:15	45.25	26	10.9	36.9	3.5	20.9	24.3	4984.8	62.9
21:30	45.5	25.8	10.4	36.2	3.3	20.9	24.2	4984.8	62.7
21:45	45.75	25.7	9.9	35.5	3.5	20.9	24.3	4984.8	62.4
22:00	46	25.5	9.4	34.9	2	20.9	22.8	4984.8	62.2
22:15	46.25	25.4	8.8	34.2	2.1	20.9	23	4984.8	61.9
22:30	46.5	25.2	8.4	33.6	2.1	20.9	23	4984.8	61.7
22:45	46.75	25.1	7.9	33	2	20.9	22.8	4984.8	61.5
23:00	47	25	7.5	32.4	1.4	20.9	22.2	4984.7	61.3
23:15	47.25	24.8	7	31.9	1.4	20.9	22.2	4984.7	61.1
23:30	47.5	24.7	6.6	31.3	1.4	20.9	22.2	4984.7	60.9
23:45	47.75	24.6	6.2	30.8	1.4	20.9	22.2	4984.7	60.7
0:00	48	24.5	5.8	30.4	1.2	20.9	22.1	4984.7	60.5
0:15	48.25	24.4	5.5	29.9	1.2	20.9	22.1	4984.7	60.4
0:30	48.5	24.3	5.1	29.5	1.1	20.9	21.9	4984.7	60.2
0:45	48.75	24.2	4.8	29	1.2	20.9	22.1	4984.7	60.1
1:00	49	24.1	4.5	28.7	1.2	20.9	22.1	4984.7	59.9
1:15	49.25	24.1	4.2	28.3	1.2	20.9	22.1	4984.7	59.8
1:30	49.5	24	4	28	1.2	20.9	22.1	4984.7	59.7
1:45	49.75	23.9	3.9	27.8	1.2	20.9	22.1	4984.7	59.5
2:00	50	23.8	3.7	27.6	1.1	20.9	21.9	4984.7	59.4
2:15	50.25	23.8	3.6	27.4	1.2	20.9	22.1	4984.7	59.3
2:30	50.5	23.7	3.5	27.2	1.2	20.9	22.1	4984.7	59.2
2:45	50.75	23.7	3.4	27	1.2	20.9	22.1	4984.7	59.1

Time	Hour	Spillway 1 Outflow	Spillway 2 Outflow	Combined Outflow	PMP Inflow	Baseflow Inflow	Combined Inflow	Reservoir Stage Storage	Storage
3:00	51	23.6	3.2	26.8	1.2	20.9	22.1	4984.7	59
3:15	51.25	23.5	3.1	26.7	1.1	20.9	21.9	4984.7	58.9
3:30	51.5	23.5	3	26.5	1.2	20.9	22.1	4984.7	58.8
3:45	51.75	23.4	2.9	26.3	1.2	20.9	22.1	4984.7	58.7
4:00	52	23.4	2.8	26.2	1.2	20.9	22.1	4984.7	58.6
4:15	52.25	23.3	2.7	26.1	1.2	20.9	22.1	4984.7	58.6
4:30	52.5	23.3	2.6	25.9	1.1	20.9	21.9	4984.7	58.5
4:45	52.75	23.2	2.5	25.8	1.2	20.9	22.1	4984.7	58.4
5:00	53	23.2	2.5	25.7	1.2	20.9	22.1	4984.7	58.3
5:15	53.25	23.1	2.4	25.5	1.2	20.9	22.1	4984.7	58.2
5:30	53.5	23.1	2.3	25.4	1.2	20.9	22.1	4984.7	58.2
5:45	53.75	23.1	2.2	25.3	1.2	20.9	22.1	4984.7	58.1
6:00	54	23	2.2	25.2	1.1	20.9	21.9	4984.7	58
6:15	54.25	23	2.1	25.1	1.2	20.9	22.1	4984.7	58
6:30	54.5	23	2	25	1.2	20.9	22.1	4984.7	57.9
6:45	54.75	22.9	1.9	24.9	1.2	20.9	22.1	4984.6	57.9
7:00	55	22.9	1.9	24.8	1.2	20.9	22.1	4984.6	57.8
7:15	55.25	22.9	1.8	24.7	1.1	20.9	21.9	4984.6	57.7
7:30	55.5	22.8	1.8	24.6	1.2	20.9	22.1	4984.6	57.7
7:45	55.75	22.8	1.7	24.5	1.2	20.9	22.1	4984.6	57.6
8:00	56	22.8	1.6	24.4	1.2	20.9	22.1	4984.6	57.6
8:15	56.25	22.7	1.6	24.3	1.2	20.9	22.1	4984.6	57.5
8:30	56.5	22.7	1.5	24.2	1.1	20.9	21.9	4984.6	57.5
8:45	56.75	22.7	1.5	24.2	1.2	20.9	22.1	4984.6	57.5
9:00	57	22.7	1.4	24.1	1.2	20.9	22.1	4984.6	57.4
9:15	57.25	22.6	1.4	24	1.2	20.9	22.1	4984.6	57.4
9:30	57.5	22.6	1.3	24	1.2	20.9	22.1	4984.6	57.3
9:45	57.75	22.6	1.3	23.9	1.2	20.9	22.1	4984.6	57.3
10:00	58	22.6	1.3	23.8	1.1	20.9	21.9	4984.6	57.3
10:15	58.25	22.5	1.2	23.8	1.2	20.9	22.1	4984.6	57.2
10:30	58.5	22.5	1.2	23.7	1.2	20.9	22.1	4984.6	57.2
10:45	58.75	22.5	1.1	23.6	1.2	20.9	22.1	4984.6	57.2
11:00	59	22.5	1.1	23.6	1.2	20.9	22.1	4984.6	57.1
11:15	59.25	22.5	1.1	23.5	1.1	20.9	21.9	4984.6	57.1
11:30	59.5	22.4	1	23.5	1.2	20.9	22.1	4984.6	57.1
11:45	59.75	22.4	1	23.4	1.2	20.9	22.1	4984.6	57
12:00	60	22.4	1	23.4	1.2	20.9	22.1	4984.6	57
12:15	60.25	22.4	0.9	23.3	1.2	20.9	22.1	4984.6	57
12:30	60.5	22.4	0.9	23.3	1.1	20.9	21.9	4984.6	56.9
12:45	60.75	22.4	0.9	23.2	1.2	20.9	22.1	4984.6	56.9
13:00	61	22.4	0.9	23.2	1.2	20.9	22.1	4984.6	56.9
13:15	61.25	22.3	0.8	23.2	1.2	20.9	22.1	4984.6	56.9
13:30	61.5	22.3	0.8	23.1	1.2	20.9	22.1	4984.6	56.9
13:45	61.75	22.3	0.8	23.1	1.2	20.9	22.1	4984.6	56.8
14:00	62	22.3	0.8	23.1	1.1	20.9	21.9	4984.6	56.8
14:15	62.25	22.3	0.7	23	1.2	20.9	22.1	4984.6	56.8
14:30	62.5	22.3	0.7	23	1.2	20.9	22.1	4984.6	56.8
14:45	62.75	22.3	0.7	23	1.2	20.9	22.1	4984.6	56.8
15:00	63	22.3	0.7	22.9	1.2	20.9	22.1	4984.6	56.7
15:15	63.25	22.2	0.7	22.9	1.1	20.9	21.9	4984.6	56.7
15:30	63.5	22.2	0.6	22.9	1.2	20.9	22.1	4984.6	56.7

Time	Hour	Spillway 1 Outflow	Spillway 2 Outflow	Combined Outflow	PMP Inflow	Baseflow Inflow	Combined Inflow	Reservoir Stage Storage	Storage
15:45	63.75	22.2	0.6	22.8	1.2	20.9	22.1	4984.6	56.7
16:00	64	22.2	0.6	22.8	1.2	20.9	22.1	4984.6	56.7
16:15	64.25	22.2	0.6	22.8	1.2	20.9	22.1	4984.6	56.7
16:30	64.5	22.2	0.6	22.8	1.1	20.9	21.9	4984.6	56.6
16:45	64.75	22.2	0.5	22.7	1.2	20.9	22.1	4984.6	56.6
17:00	65	22.2	0.5	22.7	1.2	20.9	22.1	4984.6	56.6
17:15	65.25	22.2	0.5	22.7	1.2	20.9	22.1	4984.6	56.6
17:30	65.5	22.2	0.5	22.7	1.2	20.9	22.1	4984.6	56.6
17:45	65.75	22.2	0.5	22.6	1.2	20.9	22.1	4984.6	56.6
18:00	66	22.1	0.5	22.6	1.1	20.9	21.9	4984.6	56.6
18:15	66.25	22.1	0.5	22.6	1.2	20.9	22.1	4984.6	56.5
18:30	66.5	22.1	0.4	22.6	1.2	20.9	22.1	4984.6	56.5
18:45	66.75	22.1	0.4	22.6	1.2	20.9	22.1	4984.6	56.5
19:00	67	22.1	0.4	22.5	1.2	20.9	22.1	4984.6	56.5
19:15	67.25	22.1	0.4	22.5	1.1	20.9	21.9	4984.6	56.5
19:30	67.5	22.1	0.4	22.5	1.2	20.9	22.1	4984.6	56.5
19:45	67.75	22.1	0.4	22.5	1.2	20.9	22.1	4984.6	56.5
20:00	68	22.1	0.4	22.5	1.2	20.9	22.1	4984.6	56.5
20:15	68.25	22.1	0.4	22.5	1.2	20.9	22.1	4984.6	56.5
20:30	68.5	22.1	0.4	22.5	1.1	20.9	21.9	4984.6	56.5
20:45	68.75	22.1	0.4	22.4	1.2	20.9	22.1	4984.6	56.4
21:00	69	22.1	0.3	22.4	1.2	20.9	22.1	4984.6	56.4
21:15	69.25	22.1	0.3	22.4	1.2	20.9	22.1	4984.6	56.4
21:30	69.5	22.1	0.3	22.4	1.2	20.9	22.1	4984.6	56.4
21:45	69.75	22.1	0.3	22.4	1.2	20.9	22.1	4984.6	56.4
22:00	70	22.1	0.3	22.4	1.1	20.9	21.9	4984.6	56.4
22:15	70.25	22.1	0.3	22.4	1.2	20.9	22.1	4984.6	56.4
22:30	70.5	22.1	0.3	22.4	1.2	20.9	22.1	4984.6	56.4
22:45	70.75	22.1	0.3	22.3	1.2	20.9	22.1	4984.6	56.4
23:00	71	22.1	0.3	22.3	1.2	20.9	22.1	4984.6	56.4
23:15	71.25	22	0.3	22.3	1.1	20.9	21.9	4984.6	56.4
23:30	71.5	22	0.3	22.3	1.2	20.9	22.1	4984.6	56.4
23:45	71.75	22	0.3	22.3	1.2	20.9	22.1	4984.6	56.4
0:00	72	22	0.3	22.3	1.2	20.9	22.1	4984.6	56.4

Appendix E. Stage Discharge

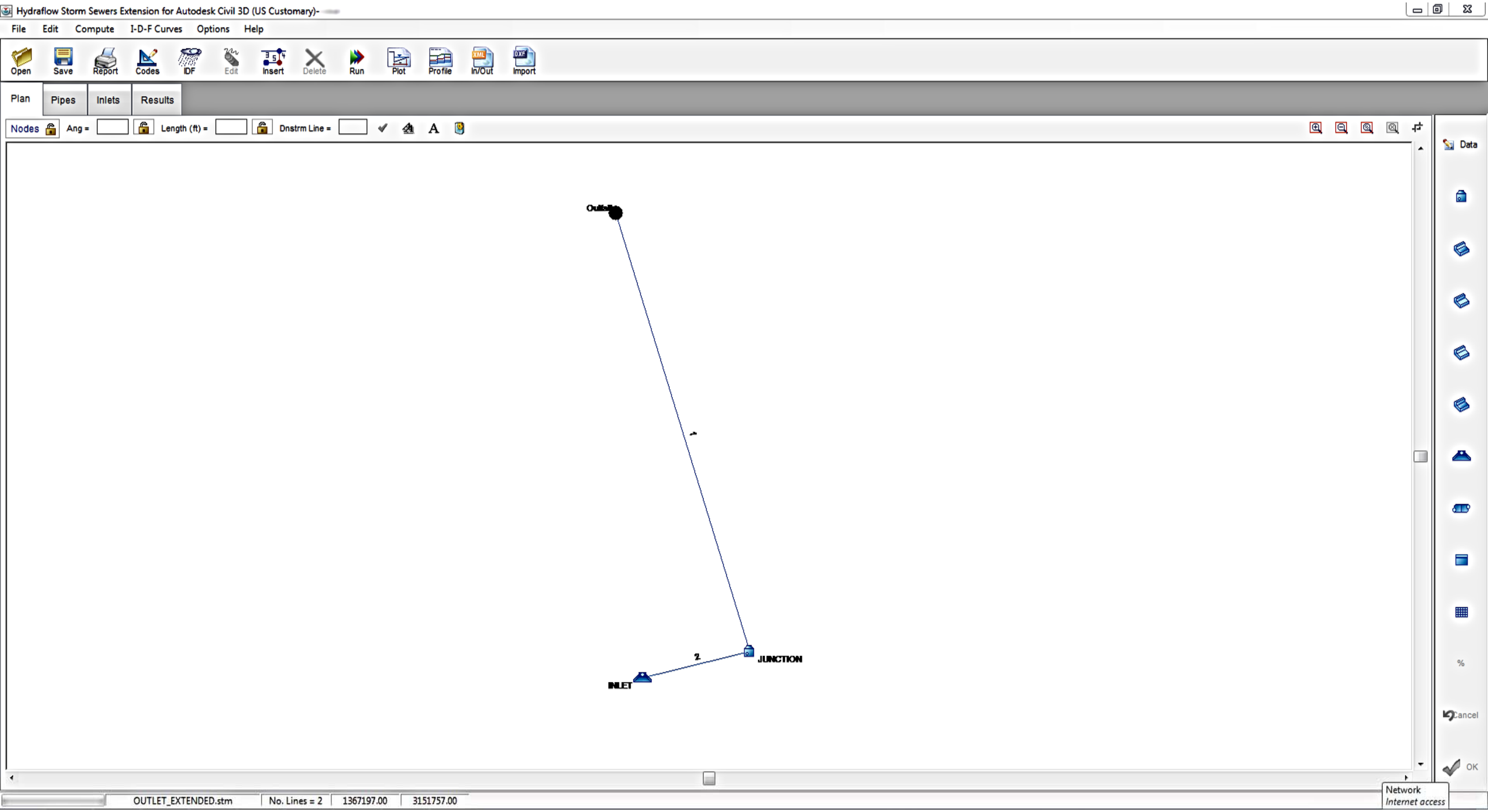


Outlet Structure Stage Discharge
STAGE (ft)
4988
4987
4986
4985
4984
4983
4982
0
5
10
15
20
25
30
35
40
45
50
55
60
65
DISCHARGE (cfs)

20 Inch Wide Weir Discharge Table			
Stage (ft)	Depth (ft)	Q (cfs)	A (sqft)
4983	0	0.000	0
4983.1	0.1	0.175	0.17
4983.2	0.2	0.496	0.33
4983.3	0.3	0.912	0.5
4983.4	0.4	1.404	0.67
4983.5	0.5	1.962	0.83
4983.6	0.6	2.579	1
4983.7	0.7	3.25	1.17
4983.8	0.8	3.971	1.33
4983.9	0.9	4.738	1.5
4984	1	5.55	1.67
4984.1	1.1	6.403	1.83
4984.2	1.2	7.295	2
4984.3	1.3	8.226	2.17
4984.4	1.4	9.193	2.33
4984.5	1.5	10.2	2.5
4984.6	1.6	11.23	2.67
4984.7	1.7	12.3	2.83
4984.8	1.8	13.4	3
4984.9	1.9	14.53	3.17
4985	2	15.7	3.33
4985.1	2.1	16.89	3.5
4985.2	2.2	18.11	3.67
4985.3	2.3	19.36	3.83
4985.4	2.4	20.63	4
4985.5	2.5	21.94	4.17
4985.6	2.6	23.27	4.33
4985.7	2.7	24.62	4.5
4985.8	2.8	26	4.67
4985.9	2.9	27.41	4.83
4986	3	28.84	5

40 Foot Wide Weir Discharge Table			
Stage (ft)	Depth (ft)	Q (cfs)	A (sqft)
4984.6	0	0.000	0
4984.7	0.1	4.000	4.1
4984.8	0.2	11.535	8.4
4984.9	0.3	21.598	12.9
4985	0.4	33.879	17.6
4985.1	0.5	48.225	22.5
4985.2	0.6	64.546	27.6
4985.3	0.7	82.789	32.9
4985.4	0.8	102.924	38.4
4985.5	0.9	124.930	44.1
4985.6	1	148.800	50
4985.7	1.1	174.530	56.1
4985.8	1.2	202.123	62.4
4985.9	1.3	231.583	68.9
4986	1.4	262.920	75.6

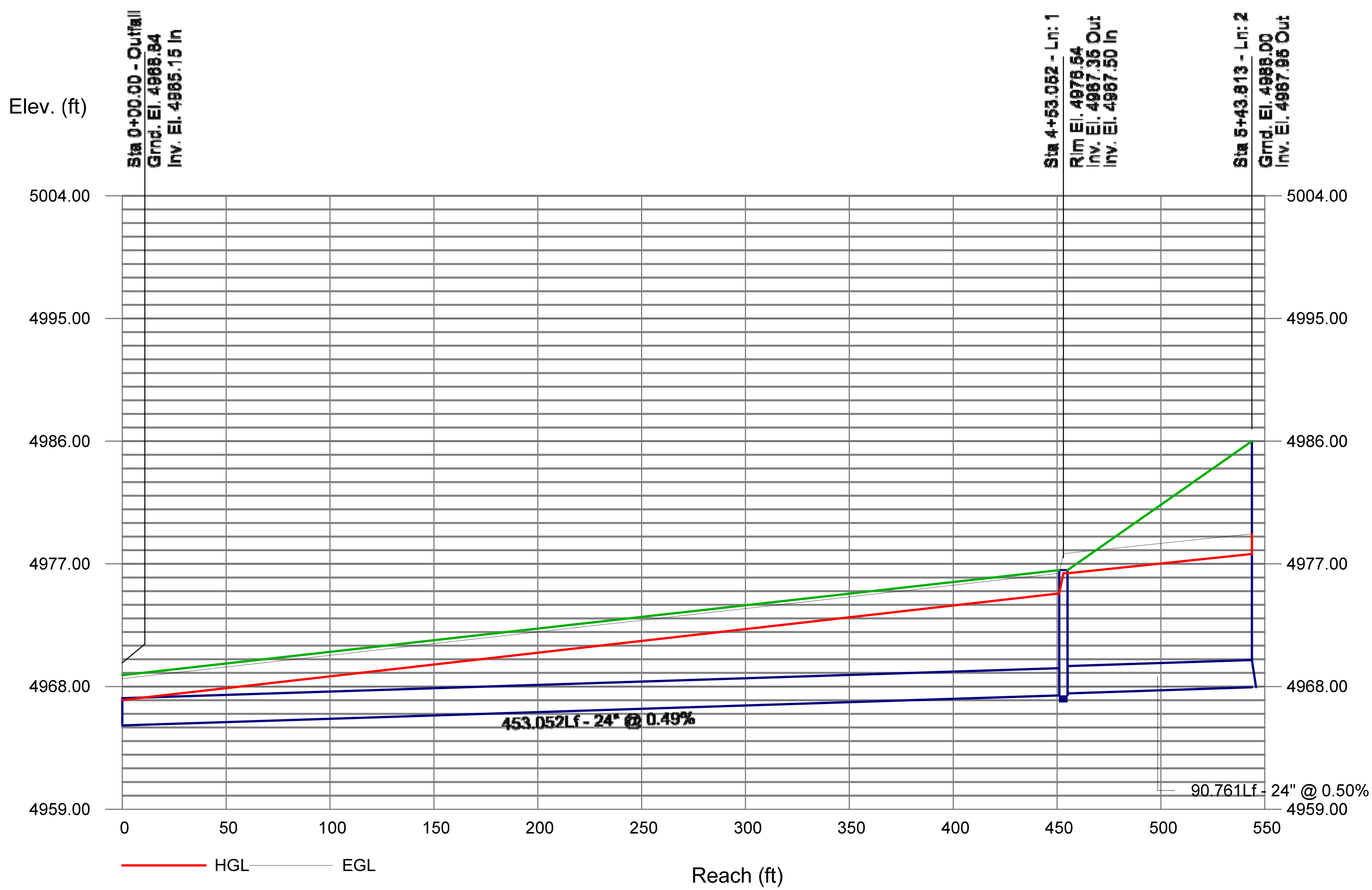
Appendix F. Storm Sewer Calculations



Hydraflow Storm Sewers Extension for Autodesk Civil 3D (US Customary)-
File
Edit
Compute
I-D-F Curves
Options
Help
Open
Save
Report
Codes
IDF
Edit
Insert
Delete
Run
Plot
Profile
In/Out
Import
Plan
Pipes
Inlets
Results
Nodes
Ang =
Length (ft) =
Dnstrm Line =
Data
Cancel
OK
2
JUNCTION
INLET
OUTLET_EXTENDED.stm
No. Lines = 2
1367197.00
3151757.00
Network
Internet access

Storm Sewer Profile

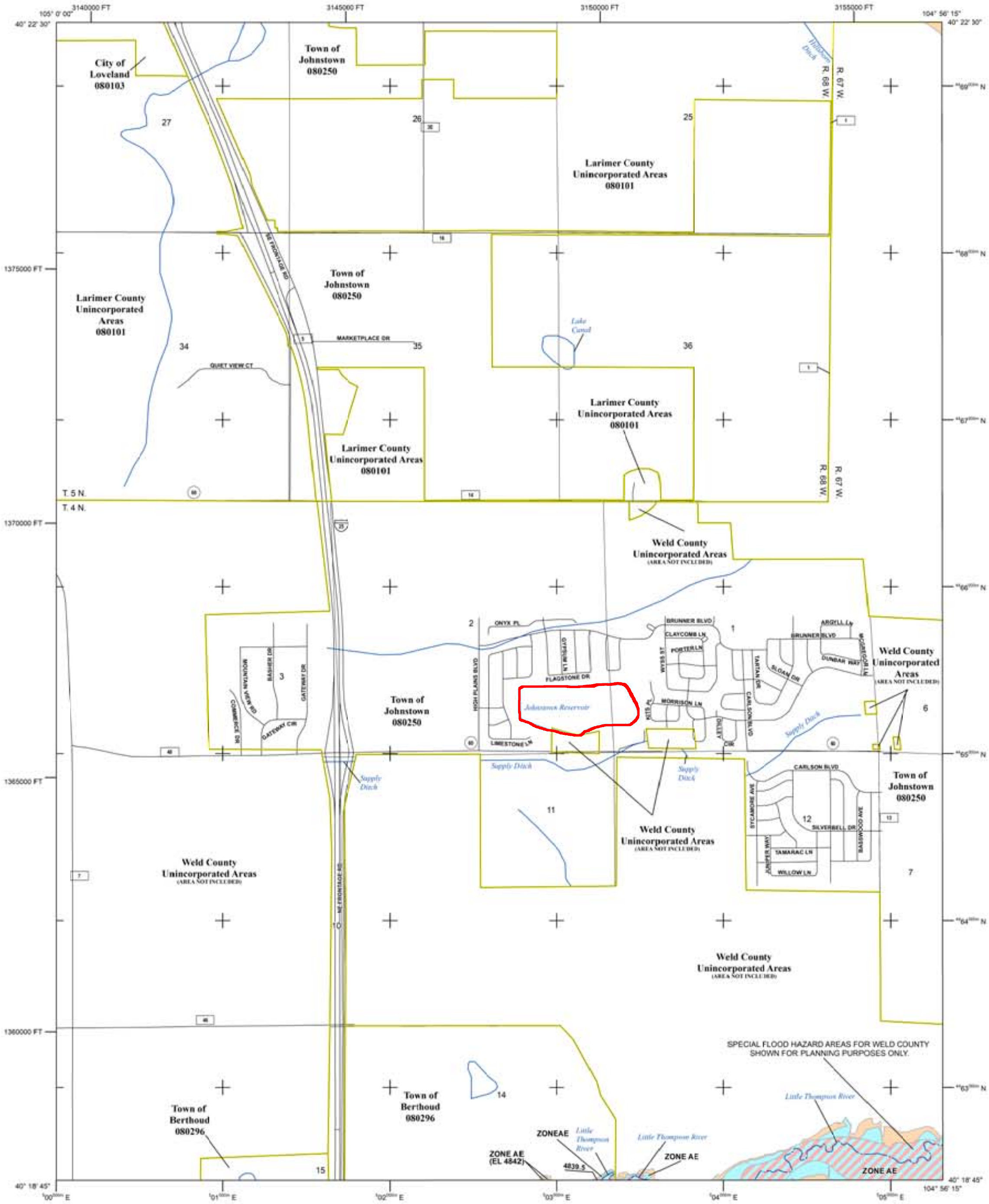
Proj. file: OUTLET24.stm



Line No.	Line ID	Flow Rate	Line Size (Rise x Span)	Line Type	Line Length	Invert Elev. Down	Invert Elev. Up	Line Slope	HGL Down	HGL Up	Minor Loss
		(cfs)	(in)		(ft)	(ft)	(ft)	(%)	(ft)	(ft)	(ft)
1	Pipe - (4)	30.60	24	Cir	453.052	4965.15	4967.35	0.49	4967.02	4974.83*	1.48
2	Pipe - (3)	30.60	24	Cir	90.761	4967.50	4967.95	0.50	4976.31	4977.73*	1.48
	Notes: *Surcharged (HGL above crown).										

Line No.	HGL Junct	Dn Str Line No.
	(ft)	
1	4976.31	Outfall
2	4979.20	1

Appendix G. FEMA Floodplain



Area of Interest:

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

THE INFORMATION DEPICTED ON THIS MAP AND SUPPORTING DOCUMENTATION ARE ALSO AVAILABLE IN DIGITAL FORMAT AT HTTPS://MSC.FEMA.GOV

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) Zone A, V, A99
	With BFE or Depth Zone AE, AO, AH, VE, AR
	Regulatory Floodway
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile Zone X
	Future Conditions 1% Annual Chance Flood Hazard Zone X
	Area with Reduced Flood Risk due to Levee See Notes. Zone X
	Area with Flood Risk due to Levee Zone D
OTHER AREAS	NO SCREEN Area of Minimal Flood Hazard Zone X
	Area of Undetermined Flood Hazard Zone D
GENERAL STRUCTURES	Channel, Culvert, or Storm Sewer
	Levee, Dike, or Floodwall
OTHER FEATURES	Cross Sections with 1% Annual Chance Water Surface Elevation (18.2, 17.5)
	Coastal Transect
	Coastal Transect Baseline
	Profile Baseline
	Hydrographic Feature
	Base Flood Elevation Line (BFE)
	Limit of Study
	Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at https://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Base map information shown on this FIRM was derived from the National Flood Hazard Layer (NFHL), dated 2013 and digital data provided by Larimer County GIS Department, dated 2018.

SCALE

N

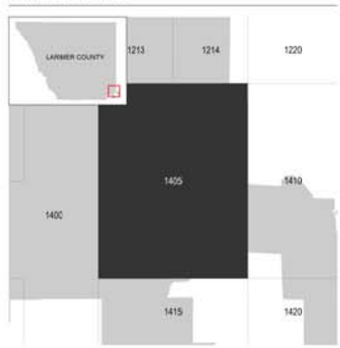
Map Projection:
Universal Transverse Mercator (UTM) Zone 13N; North American Datum 1983; Western Hemisphere; Vertical Datum: NAVD 88

1 inch = 1,000 feet 1:12,000

0 1,000 2,000 4,000 feet

0 250 500 1,000 meters

PANEL LOCATOR



FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM
FLOOD INSURANCE RATE MAP

LARIMER COUNTY, COLORADO
and Incorporated Areas

PANEL 1405 OF 1420

FEMA

Panel Contains:

COMMUNITY	NUMBER	PANEL	SUFFIX
BERTHOUD, TOWN OF	080296	1405	G
JOHNSTOWN, TOWN OF	080250	1405	G
LOVELAND, CITY OF	080103	1405	G
LARIMER COUNTY	080101	1405	G

VERSION NUMBER
2.5.3.6

MAP NUMBER
08069C1405G

MAP REVISED
JANUARY 15, 2021

Appendix H. Geotechnical Report

GEOTECHNICAL EVALUATION

Johnstown Reservoir Outlet Structure
Weld County, Colorado

Report Prepared for:

J.C. York, P.E.
J&T Consulting, Inc.
305 Denver Avenue, Suite D
Fort Lupton, CO 80621

Project No. 20.3062
February 19, 2021

Corporate Office: 7108 South Alton Way, Building B • Centennial, CO 80112
Locations: Centennial • Frederick • Silverthorne • Salida/Crested Butte
Phone 303-220-0300 • www.cesareinc.com

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GEOTECHNICAL EVALUATION

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February 19, 2021

Report Prepared by:

COLORADO REGISTERED PROFESSIONAL ENGINEER DARIN R. DURAN 33919 02/19/21

Jonathan A. Crystal, P.E.
Project Engineer

Darin R. Duran, P.E.
Principal, Manager - Salida and Crested Butte

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FIGURE

VICINITY MAP .... FIGURE 1

APPENDICES

FIELD EXPLORATION .... APPENDIX A
LABORATORY TESTING .... APPENDIX B
SLOPE STABILITY RESULTS .... APPENDIX C

COMMON ABBREVIATIONS

AASHTO .... **American Association of State Highway and Transportation Officials**
ABC .... **aggregate base course**
ACI .... **American Concrete Institute**
ADA .... **Americans with Disabilities Act**
ADSC .... **Association of Drilled Contractors**
AI .... **Asphalt Institute**
APM .... **asphalt paving material**
ASCE .... **American Society of Civil Engineers**
ASTM .... **American Society for Testing and Materials**
AWWA .... **American Water Works Association**
bgs .... **below ground surface**
CDOT .... **Colorado Department of Transportation**
CBR .... **California Bearing Ratio**
CFR .... **Code of Federal Regulations**
CGS .... **Colorado Geological Survey**
CKD .... **cement of kiln dust stabilized subgrade**
CMU .... **concrete masonry unit**
CSEO .... **Colorado State Engineer's Office**
CTB .... **cement treated base course**
deg .... **degree**
EDLA .... **equivalent daily load application**
e_m .... **edge moisture variation distance**
EPS .... **expanded polystyrene**
ESAL .... **equivalent single axle loads**
f'c .... **specified compressive strength of concrete at the age of 28 days**
F_a .... **seismic site coefficient**
FHWA .... **Federal Highway Administration**
FS .... **factor of safety**
F_v .... **seismic site coefficient**
GSA .... **global stability analysis**
GVW .... **gross vehicle weight**
IBC .... **International Building Code**
ICC-ES .... **International Code Council Evaluation Services, Inc.**
IRC .... **International Residential Code**
kip .... **1,000 pounds-force**
km .... **kilometer**
LTS .... **lime treated subgrade**
MDD .... **maximum dry density**
mg/L .... **milligrams per liter**
MGPEC .... **Metropolitan Government Pavement Engineers Council**
mm .... **millimeter**
Mr .... **resilient modulus**
MSE .... **mechanically stabilized earth**
mV .... **millivolts**
NAPA .... **National Asphalt Pavement Association**
N_{DESIGN} .... **design gyrations**

OSHA .... **Occupational Safety and Health Administration**
OMC .... **optimum moisture content**
OWTS .... **onsite wastewater treatment system**
PCA .... **Portland Cement Association**
PCC .... **portland cement concrete**
pcf .... **pounds per cubic foot**
pci .... **pounds per cubic inch**
pH .... **power of hydrogen**
psf .... **pounds per square foot**
psi .... **pounds per square inch**
PT .... **post-tension**
RAP .... **recycled asphalt pavement**
S_s .... **mapped spectral accelerations for short periods**
UBC .... **Uniform Building Code**
USGS .... **United States Geological Survey**

1. PURPOSE

1.1 GENERAL

Cesare, Inc. (Cesare) completed a geotechnical evaluation of the outlet structure replacement location of the existing Johnstown Reservoir in Weld County, Colorado. The purpose of the project is to replace the existing outlet structure due to leakage in the fall of 2020.

1.2 SCOPE OF SERVICES

Cesare's proposed scope of services is detailed in Cesare's Proposal Agreement No. F201001.

2. SUMMARY OF FINDINGS AND CONCLUSIONS

This section is intended as a summary only and does not include design details. The report should be read in its entirety and utilized for design.

- Cesare encountered a surface layer of granular material about 1 foot thick, which was likely base course used for a travel surface on the dam. Below the base course, the borings encountered about 8 to 16 feet of fill overlying weathered claystone in Borings B-1, B-2, and B-4 or native clays in Boring B-3. Claystone bedrock was encountered below the weathered claystone and clays at a depth of about 23 feet in B-1, B-2, and B-3 and 13 feet in B-4, extending to the remaining depths explored. A zone of about 1 foot of granular material was encountered in B-4 at a depth of about 9 feet, directly overlying the weathered claystone. The granular material may be pipe or structure bedding.
- The embankment is over 100 years old and little is known of its design or construction.
- The new outlet is anticipated to be a cast iron pipe (CIP) encased in concrete bearing on undisturbed competent claystone bedrock.

3. RESERVOIR HISTORY

Cesare understands the reservoir is on the order of 100 years old. Little is known of its design or construction. A new outlet was constructed in about 1952 for emergency discharge. Design documents for the new outlet were available; however, as-built documents were not available. The outlet began leaking in the fall of 2020, requiring emergency repair of the outlet.

4. PROJECT DESCRIPTION

The project consists of open cut excavating through the existing embankment, removing the existing outlet works, and constructing a more vigorous outlet structure. In addition, the repair will include localized grading to direct ponded water to the outlet structure intake. The grading will require excavating the existing soil up to an estimated 3 feet at the upstream dam toe. Some regrading of the existing embankment is planned, with a planned crest elevation of 4,984 feet and the maximum storage elevation of 4,981 feet. An outlet tower inside the reservoir will allow discharge from the reservoir.

Cesare understands normal operation is providing water for the treatment plant, which is understood to be low discharge rates CSEO requires a minimum design rapid drawdown of 1 foot, per day, for 5 days.

5. GEOLOGIC CONDITIONS

The soil onsite is described as eolian sediment, windblown deposits comprised of loess, clay, and silt mixtures. These sediments are Quaternary Middle Holocene and Upper Pleistocene in age, and generally 3 to 15 feet thick[1].

6. SITE CONDITIONS

Johnstown Reservoir is about 38 acres in area, roughly rectangular, and located in the southwest quarter of Section 1 and extends into the southeast quarter of Section 2, Township 4 North, and Range 68 West in Weld County. More specifically, the reservoir is north of State Highway 60 (SH60) and about 1 mile east of the Interstate Highway 25 (I25) intersection with SH60 and about 2-1/2 miles west of Johnstown, Colorado. The site location is shown in the vicinity map presented in Figure 1. The reservoir is bounded by an open space setback, with residential properties and a church bordering the outer open space perimeter on all sides.

The reservoir is positioned on an east sloping, low topographic ridge with the ground surface to the north and south sloping downwards to the northeast and southeast. Vegetation consists of a sparse to heavy growth of native and landscaping grasses. Cesare noted no bodies of water outside the reservoir in the vicinity of the site at the time of its field exploration. The reservoir water surface level was low, only a few feet deep, due to the leakage and subsequent CSEO decree.

7. FIELD EXPLORATION

Subsurface conditions were explored on December 2, 2020 by drilling four borings at the locations indicated in the boring location plan presented in Appendix A. Three borings were drilled to about 40 feet in depth along the existing dam centerline. One boring at the embankment downstream toe near the existing outlet was drilled to about 25 feet in depth. Graphical logs of the subsurface conditions observed, locations of sampling, and further explanation of the exploration performed are presented in the boring logs and accompanying key to symbols contained in Appendix A.

8. LABORATORY TESTING

Cesare personnel returned samples obtained during field exploration to its laboratory where professional staff visually classified them and assigned testing to selected samples to evaluate pertinent engineering properties. Laboratory tests performed are listed in Table 8.1. Further discussion of laboratory testing and laboratory test results are presented in Appendix B.

TABLE 8.1. Laboratory Testing Performed

Laboratory Test	To Evaluate
Grain size analysis	Grain size distribution for classification purposes.
Atterberg limits	Soil plasticity for classification purposes.
Moisture density relationships	Evaluate the relationship of moisture content, compactive effort, and compacted density.
In situ moisture and density	Evaluate in situ moisture content and density
Water soluble sulfate content	Potential reaction of the soil with cementitious material.

[1] Palkovic, M.J., Morgan, M.L., 2017, Geologic Map of the Johnstown Quadrangle, Larimer and Weld Counties, Colorado, Colorado Geologic Survey.

9. SUBSURFACE CONDITIONS

Cesare's borings encountered:

- Existing embankment fill to depths of about 8 to 16 feet in Borings B-1 through B-3.
- Existing fill, likely pipe backfill for the outlet installed in 1953, to 9 feet in B-4. Granular material found at the bottom of the fill and directly overlying weathered bedrock is likely pipe bedding for the outlet.
- Native clay below the fill in B-3 that extended to a depth of 23 feet.
- Weathered claystone bedrock in B-1, B-2, and B-4 below the fill.
- Claystone bedrock at depths of about 23 feet in B-1 through B-3 and about 13 feet in B-4.
- Groundwater at depths of 15, 18, 14 and 8 feet in Borings B-1 through B-4, respectively, at the time of drilling.
- Groundwater at depths of 15, 14-1/2, 13, and 4-1/2 feet in Borings B-1 through B-4, respectively, 1 day after drilling,.
- Borings B-1 through B-4 caved to depths of 38, 37, 27, and 16-1/2 feet immediately after drilling.

These observations represent conditions at the time of field exploration and may not be indicative of other times or other locations. Groundwater in the embankment can be expected to fluctuate and will be primarily influenced by height of water in the reservoir. Regional groundwater can be influenced by variations in seasons, weather, precipitation, drainage, vegetation, landscaping, and irrigation. Discontinuous zones of perched water may exist or develop within the overburden material and/or upper zones of the bedrock. Cesare's field explorations were performed during the fall when regional groundwater levels are usually lowest. Regional groundwater levels may be higher in the spring and early summer.

10. EMBANKMENT ANALYSIS

The CSEO considers the embankment as stable in its present configuration. Cesare's evaluation is intended to verify the embankment's stability at the repair location, considering the existing conditions and post repair conditions.

10.1 EMBANKMENT CONFIGURATIONS

10.1.1 Existing Configuration

The existing embankment at the outlet repair location has a crest width of about 12 feet wide at an elevation of about 4,986 feet. The upstream and downstream embankment slopes are about 3:1, horizontal to vertical. The upstream slope is about 11 feet high from its present toe and the downstream slope is about 13 feet high. The present downstream slope has a localized steepened slope of about 1-1/2:1 at its toe.

10.1.2 Repair Configuration

The final embankment will have a 12 foot wide crest width at an elevation of 4,986 feet. The upstream and downstream slopes are planned for 3:1. Excavation planned for the pond bottom at the embankment toe at the outlet is expected to extend to about elevation 4,971 feet, about 15 feet from the crest at that location.

10.2 MATERIAL PARAMETERS

Cesare based the stability analysis and seepage parameters on its field and laboratory test results, and experience with similar projects.

10.2.1 Seepage Analysis

Cesare used permeability values based on its experience and the laboratory classification, moisture density relationship, and in situ physical characteristics results. Due to the dam's age, the seepage parameters for the various materials will remain consistent, with the only modification being the fill placed in the repair section. The fill is expected to be of lower permeability than the existing material considering its compaction by modern earthwork equipment, as opposed to the equipment likely used when the embankment was first constructed.

No in situ permeability testing was performed. The upper portion of claystone in the Front Range typically exhibits permeabilities somewhat higher than expected for this material. This higher permeability is likely relating to fracture flow, at least in the unweathered claystone. Packer tests in unweathered claystone typically exhibit nonuniform permeability, indicating fracture flow in the fresher claystone is unlikely to be uniform below the embankment. Work by Zhang[2] (2013) and others indicates claystone fractures tend to close under increased loading and when wetted. Although the upper bedrock has likely gained the maximum moisture it is capable of under the existing conditions, Cesare believes a conservative approach considering fracture flow during the reservoir life is appropriate.

The material requiring seepage parameters for analysis includes the existing and new fill soil, native soil, weathered bedrock, and unweathered bedrock; the values for which are presented in Table 10.1. The values presented for embankment material and weathered bedrock are based on laboratory test results previously described. The permeability of the unweathered bedrock considers Packer test results from similar projects and research into published rates for the local claystone bedrock.

TABLE 10.1. Design Hydraulic Conductivities

Material	Saturated Hydraulic Conductivity (cm/sec)	Saturated Hydraulic Conductivity (ft/sec)
Existing embankment fill	1.70 x E-6	5.54 x E-8
New embankment fill	4.97 x E -7	1.64 x E-8
Native clay soils	7.07 x E-7	2.32 x E-8
Weathered claystone	1.0 x E-8	3.3 x E-10
Unweathered claystone	1.0 x E-5*	3.3 x E-7*

* Horizontal conductivity. Vertical is one order of magnitude less.

10.2.2 Strength Parameters

Based on Cesare's testing and judgement, strength parameters assigned to embankment material are presented in Table 10.2.

[2] Zhang, C.L., Experimental evidence for self-sealing of fractures in claystone. J. Phys. Chem. Earth (2011), doi:10.1016/ j.pce.2011.07.030.

TABLE 10.2. Stability Analysis Strength Parameters

Material	Friction Angle (degrees)	Cohesion (psf)
Existing embankment fill	30	100
New embankment fill	30	200
Native clay soil	25	50
Weathered claystone	25	100
Unweathered claystone	0	3000
Residual claystone	15	0

10.3 SEISMIC DESIGN

The "*Rules and Regulations for Dam Safety and Dam Construction"* (2007) indicate a pseudostatic analysis for embankment dams is acceptable, for the following cases:

> *"5.9.2.3.1 The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D698, or at least 90% of the maximum modified Proctor density, ASTM D1557 or at least 70% relative density per ASTM D4253 and ASTM D4254, if Proctor testing is not appropriate; no materials prone to liquefaction are present in the foundation and the design peak bedrock acceleration is 0.20g or less; or*
>
> *5.9.2.3.2 The embankment is to be mechanically compacted to at least 95% of the maximum standard Proctor density, ASTM D698, or at least 90% of the maximum modified Proctor density, ASTM D1557; potentially submerged portions of the embankment except for internal drain elements are constructed of clayey material; the dam is constructed on clayey soil or bedrock foundation and peak bedrock acceleration is 0.35g or less; and*
>
> *5.9.2.3.3 All static stability safety factor requirements of these Rules are met; minimum freeboard requirements of these Rules are met; and the pseudostatic coefficient selected for analysis must be at least 50% of the design peak bedrock acceleration, but not less than 0.05g and the factor of safety under pseudostatic analysis shall be 1.0 or greater. In determining the factor of safety for pseudostatic analysis, a search for the critical failure surface shall be made."*

The analysis requirement includes using at least 50% of the peak acceleration, but not less than 0.05g. Cesare used 0.1g in that this value is customarily used and is suitably conservative.

10.4 STABILITY AND SEEPAGE RESULTS

Cesare analyzed the repair zone for seepage and stability, considering both existing and repaired conditions. Analysis included steady state seepage at full pool surface elevation for both upstream and downstream slopes and rapid drawdown on the upstream face by means of a transient analysis. The rapid drawdown discharge rate was 17 cfs, which has a relative equivalence of 1 foot of drawdown, per day. Cesare also analyzed the downstream slope at full pool, considering a pseudo seismic force and considering residual bedrock strength. These scenarios meet the CSEO requirements (2020). Results of Cesare's stability analyses are presented in Table 10.3 and include the CSEO's requirements.

TABLE 10.3. Stability Analyses Results

Section	Analysis	Factor of Safety		Required Factor of Safety
		Block	Circular	
Existing	Full, steady state upstream	2.54	2.47	1.5
	Full, steady state upstream, pseudo seismic	1.71	1.67	1.0
	Full, steady state downstream	1.81	1.73	1.5
	Full, steady state downstream, pseudo seismic	1.34	1.27	1.0
	Transient upstream	1.82	1.74	1.2*
Repaired	Full, steady state upstream	3.94	3.78	1.5
	Full, steady state upstream, pseudo seismic	2.68	2.56	1.0
	Full, steady state downstream	3.50	3.29	1.5
	Full, steady state downstream, pseudo seismic	2.56	2.41	1.0
	Full, steady state downstream, residual bedrock strength	2.84	3.07	1.1**
	Transient upstream	2.84	2.67	1.2*

* Lowest factor of safety.
**Case by case determination.

10.5 SETTLEMENT

Cesare did not perform a settlement analysis on the embankment. The embankment at the repair section is estimated to be about 33 feet from the embankment crest to its contact with competent bedrock. Considering this and Cesare's experience with timed consolidation results, Cesare estimates less than about 1/2 foot of embankment consolidation during construction. This consolidation typically occurs rapidly in clays with sand contents similar to the clays encountered at this site in both existing embankment and native soil. Settlement may be complete by the end of embankment construction, however, Cesare recommends a minimum of 1/2 foot of camber to account for unforeseen conditions. The bedrock supporting the embankment is unlikely to consolidate or deflect.

11. CONSTRUCTION CONSIDERATIONS

11.1 GROUNDWATER CONTROL

Groundwater was measured within the lower portion of existing fill in Boring B-1, in the weathered bedrock in Boring B-2, and in the native clay soil in B-3. Boring B-2 was located within the anticipated repair zone; thus, will likely represent the groundwater conditions during construction. All water levels appear within the anticipated vertical extent of the repair zone. The nature of the subsurface material may result in variable rates of inflow into the open excavation; however, the difference between the existing embankment, native clays, and weathered bedrock is not expected to be large. The contractor should implement groundwater control that will minimize disturbance to foundation material, all excavation activities, and fill placement. The groundwater appeared to be within the lower portion of the area to receive fill, such that groundwater control will be required for at least a portion of the fill placement. Saturated borrow material may require wasting. The contractor should be responsible for designing and maintaining dewatering systems. Localized sumps may be adequate.

Surface drainage should be prevented from entering or flooding excavations and from causing uncontrolled erosion on excavated slopes. The contractor should be responsible for controlling surface drainage and meeting applicable local, state, and federal regulations.

11.2 EXCAVATIONS

11.2.1 General Considerations

The relative ease or difficultly of the excavation of the material onsite is not anticipated to vary greatly, both horizontally and with depth. Material ranged from existing embankment fill, unconsolidated native deposits, and weathered bedrock exhibiting single digit blow counts that should be readily excavated. Excavation should stop at competent bedrock contact. Excavation using rippers or tracked vehicles should stop before reaching final foundation surface as discussed in Section **11.3 FOUNDATION PREPARATION**. Blasting of foundation material will not be allowed.

11.2.2 Embankment Foundations

Soil and weathered bedrock should be excavated to remove soft and compressible material to contact of competent bedrock to provide proper support for the new outlet pipe and its encasement. The excavated soil and weathered bedrock may be used as fill for these areas, provided it is free of organics or other deleterious material. The side slopes excavated into the existing embankment should be benched at minimum vertical intervals of 1 foot and horizontal intervals of 2 feet, as fill is placed. At least the upper 6 inches of exposed embankment soil on the excavation slope benches should be moistened and compacted similar to the repair fill soil.

11.2.3 Fill Material

The soil excavated from the repair area is intended for use as repair embankment construction. The weathered claystone bedrock can also be used for embankment.

11.2.4 Moisture Conditioning

The embankment material should be conditioned in the required excavation area to within ±2% of optimum moisture content according to ASTM D698. Based on laboratory results, Cesare estimates most of the soil to be excavated is well over its optimum moisture content. Moistening material may be required and can be accomplished through mixing on grade; however, drying of the excavated material will likely be required. Variable moisture contents exist naturally and the contractor should design a program to moisten or dry the material to produce uniform moisture contents in the embankment material. Application of water should be carefully controlled to avoid overwatering or drying of the borrow material.

11.2.5 Temporary Cuts

Temporary cuts in the existing embankment, native soil, and weathered bedrock material should not exceed slopes of 2 horizontal to 1 vertical (2:1). Construction materials should not be stored adjacent to the slope crest, which would result in surcharging the slope and reducing its stability. Temporary cuts in competent bedrock material should not exceed slopes of 1:1. Steeper slopes may require bracing or other stabilization methods to provide safe working conditions. The contractor should be responsible for designing and maintaining construction slopes. All slopes should be protected from runoff due to precipitation events. Methods of slope stabilization should comply with applicable state, local, and federal regulations.

11.3 FOUNDATION PREPARATION

Where claystone bedrock will be used for embankment and outlet pipe foundation, precautions should be considered for construction. Claystone bedrock tends to air slake upon exposure and drying. The foundation in the outlet line alignment and outlet structure should be protected from losing moisture, freezing, and effects of weathering. To accomplish this, Cesare recommends that a temporary cover of a few feet of unexcavated material be left in place until construction is ready to proceed. Final excavation, preparation, and backfilling must be done in small sections so that work can be completed before the foundation is damaged from drying. Within 10 hours of exposing the final foundation surface, surveying, inspection, foundation preparation, and placement of protective coatings or fill should take place. Experience gained during construction may allow for variations in this. Use of concrete mud mats should be considered for bedrock protection in outlet structure and other structure areas that must be left open for extended periods of time.

Exposed finished surfaces should be kept from drying or slaking. Temporary plastic may be effective in limited areas. If exposed surfaces dry out, become desiccated, slake, or are loosened or disturbed, the affected material should be removed just prior to fill or structure placement. Cesare’s experience has shown that metal tracked equipment should be kept off the final excavated surface. Rubber tired equipment should be used for the final excavation to foundation grade.

11.4 OUTLET PIPE

The outlet pipe should bear on competent bedrock encased in reinforced concrete. The depth to bedrock in the outlet location will require on the order of 2 to 6 feet of excavation below the pipe invert to contact competent bedrock. The bedrock will likely be exposed for sufficient time to allow desiccation and cracking. Thus, a mud mat should be placed on it and below the encasement. The encasement’s longitudinal sides should have slopes of 1 to 10, horizontal to vertical, from the bearing surface. A collar should surround the encasement on all four sides by at least 12 inches of filter material meeting the project requirements. The filter material should extend along the encasement at least 5 feet.

12. SOLUBLE SULFATE CONTENT

Water soluble sulfate contents of 0.01% and 0.0% were measured on samples of native and fill clays. Results are summarized in Appendix B. The PCA publication titled, *Design and Control of Concrete Mixtures* 2002 and the ACI publication titled *Building Code Requirements for Structural Concrete and Commentary* consider this range negligible for water soluble sulfate exposure. Recommendations for all concrete which will be in contact with or within 6 inches of these soils are shown in Table 12.1.

TABLE 12.1. Information from ACI 318-08 - Table 4.3.1

Water Soluble Sulfates (%)	Exposure Class	Maximum (w/cm)*	Minimum f'_c, (psi)	Cementitious materials† (types)			Calcium Chloride Admixture
				ASTM C150	ASTM C595	ASTM C1157	
<0.10	S0	N/A	2,500	No type restriction	No type restriction	No type restriction	No restriction
0.10≤ to <0.20	S1 Moderate	0.50	4,000	II[‡]	IP (MS) IS (<70) (MS)	MS	No restriction
≤0.20 to ≤2.00	S2 Severe	0.45	4,500	V[§]	IP (HS) IS (<70) (HS)	HS	Not permitted
>2.00	S3 Very Severe	0.45	4,500	V + pozzolan or slag[II]	IP (HS)+pozzolan or slag[II] or IS (<70) (HS)+pozzolan or slag[II]	HS+pozzolan or slag[II]	Not permitted

*For lightweight concrete, see ACI 318-08 4.1.2.

†Alternative combinations of cementitious materials of those listed in Table 4.3.1 shall be permitted when tested for sulfate resistance and meeting the criteria in ACI 318-08 4.5.1.

‡For seawater exposure, other types of Portland cements with tricalcium aluminate (C_3A) contents up to 10 percent are permitted if the w/cm does not exceed 0.40.

§Other available types of cement such as Type III or Type I are permitted in Exposure Classes S1 or S2 if the C_3A contents are less than 8 or 5 percent, respectively.

II The amount of the specific source of the pozzolan or slag to be used shall not be less than the amount that has been determined by service record to improve sulfate resistance when used in concrete containing Type V cement. Alternatively, the amount of the specific source of the pozzolan or slag to be used shall not be less than the amount tested in accordance with ASTM C1012 and meeting the criteria in ACI 318-08 4.5.1.

Refer to ACI 318-08 R4.3.1 for further interpretation of this table.

13. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical evaluation. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical evaluation should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute Cesare's best estimate of those measures that are necessary to help the structure perform in a satisfactory manner based on the information generated during this evaluation, training, and experience in working with these conditions.

14. LIMITATIONS

This document has been prepared as an instrument of service for the exclusive use of J&T Consulting, Inc. for the specific application to the project as discussed herein and has been prepared in accordance with geotechnical engineering practices generally accepted in the state of Colorado at the date of its preparation. No warranties, either expressed or implied, are intended or made. This document should not be assumed to contain information for other parties or other purposes.

The findings of this evaluation are valid as of the date its preparation. Changes in the conditions of a property can occur with the passage of time, whether due to natural processes or the works of people on this or adjacent properties. Standards of practice evolve in engineering and changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this evaluation may be invalidated wholly or partially by changes outside of Cesare's control, therefore, this evaluation is subject to review and should not be relied upon without such review after a period of 3 years.

In the event that changes, including but not limited to, the nature, type, design, size, elevation, or location of the project or project elements as outlined in this report are made, the conclusions and recommendations contained in this report shall not be considered valid unless Cesare reviews the changes and either confirms or modifies the conclusions of this report in writing.

Cesare should be retained to review final plans and specifications that are developed for proposed construction to judge whether the recommendations presented in this report and any addenda have been appropriately interpreted and incorporated in the project plans and specifications as intended.

The exploration locations for this evaluation were selected to obtain a reasonably accurate depiction of underground conditions for design purposes and these locations are often modified based on accessibility and the presence of underground or overhead utility conflicts. Variations from the soil conditions encountered are possible. These variations may necessitate modifications to Cesare's design recommendations, therefore, Cesare should be retained to observe subsurface conditions, once exposed, to evaluate whether they are consistent with the conditions encountered during Cesare's exploration and that the recommendations of this evaluation remain valid. If parties other than Cesare perform these observations and judgements, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

Cesare's scope of services for this report did not include either specifically, or by implication, any environmental assessment of the site or identification of contaminated or hazardous material or conditions.

Cesare should be retained during construction to observe and/or test the following:

- completed excavations.
- placement and compaction of fill.
- proposed import or onsite fill material.

Cesare offers many other construction observations, materials engineering, and testing services and can be contacted to discuss further.

BASEMAP FROM GOOGLE EARTH PRO©.

PROJECT NO:	20.3062		
PROJECT NAME:	Johnstown Reservoir Outlet Structure		
DRAWN BY:	RCK	CHECKED BY:	JAC2
DWG DATE:	12.15.2020	REV. DATE:	--

FIGURE 1
Vicinity Map

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APPENDIX A

Field Exploration

FIELD EXPLORATION

Samples of the subsoil were obtained at this site using a modified California sampler which was driven into the soil by dropping a 140 pound hammer through a free fall of 30 inches. The modified California sampler is a 2-1/2 inch outside diameter by 2 inch inside diameter device lined with brass tubes. The procedure to drive the modified California sampler into the soil and to record the number of blows required to do so is known as a penetration test. The number of blows required for the sampler to penetrate 12 inches gives an indication of the relative stiffness of cohesive soil, relative density of non-cohesive soil, and relative hardness of sedimentary bedrock material encountered. Bulk samples were collected from cuttings generated during drilling. Locations of sampling and penetration test results are presented on the boring logs and key to symbols/legend contained in this appendix.

LEGEND: B-1 ● BORING LOCATIONS

0 70' 140'
Scale in Feet

BASEMAP FROM GOOGLE EARTH PRO©.

PROJECT NO:	20.3062		
PROJECT NAME:	Johnstown Reservoir Outlet Structure		
DRAWN BY:	RCK	CHECKED BY:	JAC2
DWG DATE:	12.16.2020	REV. DATE:	--

BORING LOCATION PLAN

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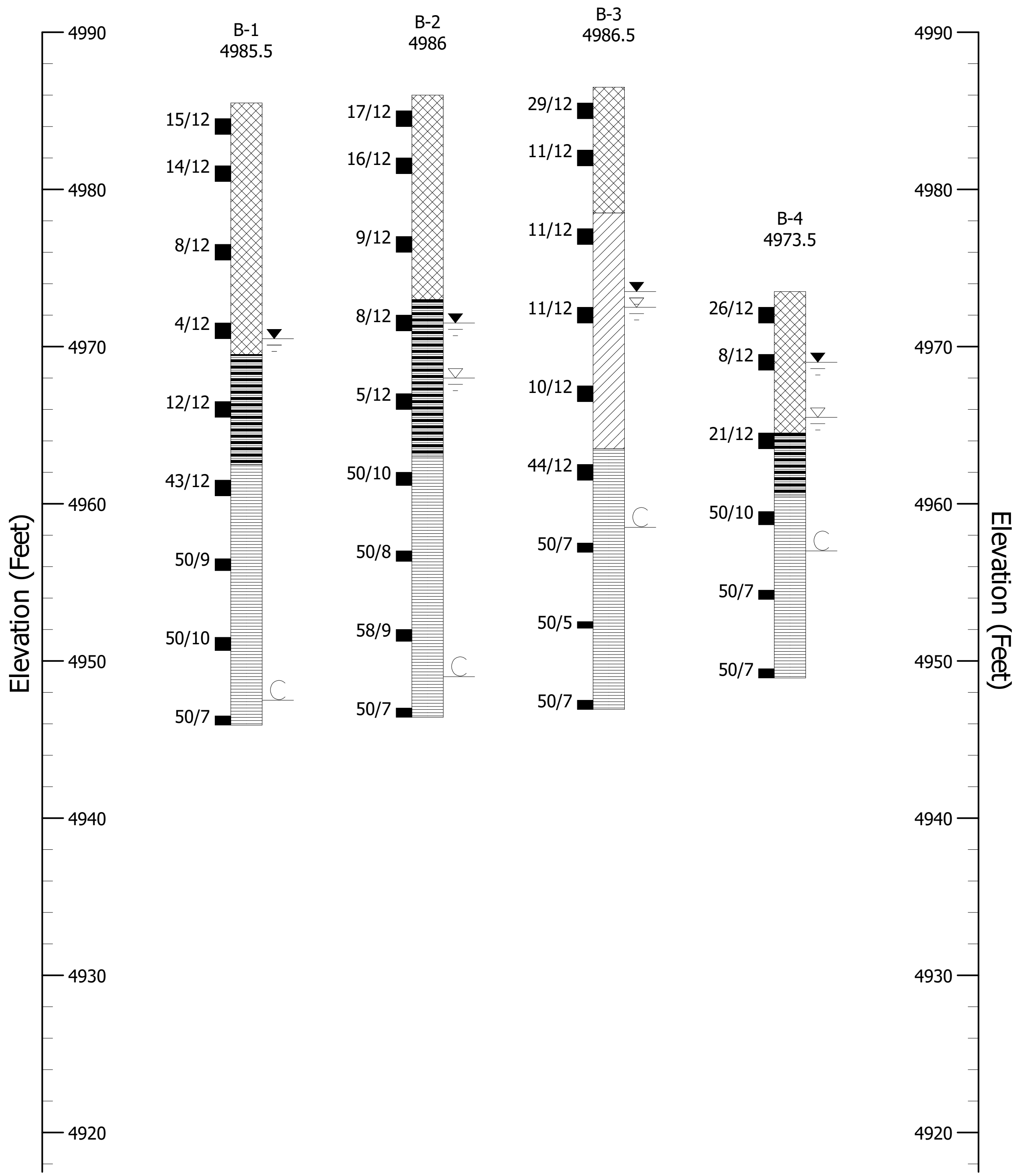

BORING LOGS

PROJECT NO:	20.3062
PROJECT NAME:	Johnstown Reservoir Outlet Structure
DWG DATE:	2/10/2021

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KEY TO SYMBOLS

Symbol Description

Strata symbols

FILL: CLAY, lean, to with sand, stiff to very stiff, moist, brown, olive (CL, A-7-6, A-6); POSSIBLE PIPE BEDDING: SAND, open graded medium sand size, wet, medium dense, dark gray (SP, A-1-b); SURFACE TRAVEL COURSE: SAND, clayey, with gravel, slightly moist, dense, (SC, A-6).

CLAY, moist, stiff, brown (CL, A-6, A-7-6).

WEATHERED CLAYSTONE, moist to very moist, soft to very stiff, light to dark olive.

CLAYSTONE, moist, hard to very hard, light to dark olive, olive tan, olive brown, olive gray.

Misc. Symbols

Water level during drilling

Water level 1 day after drilling.

Soil Samplers

Modified California sample

Notes:

1. 15/12 indicates 15 blows with a 140-pound hammer falling 30 inches were required to drive a modified California barrel sampler 12 inches.

2. Exploratory borings B-1 through B-4 were drilled on December 2, 2020 using a CME-55 drill rig equipped with 4-inch diameter continuous flight solid stem auger.

3. Relative elevations of borings B-1 through B-4 were provided by J&T Consulting from project survey.

4. Groundwater was encountered at depths of 15, 18, 14, and 8 feet below ground surface in borings B-1 through B-4, respectively, during drilling. Groundwater was measured at depths of 15, 14-1/2, 13, and 4-1/2 feet below ground surface in borings B-1 through B-4, respectively, 1 day after drilling. Borings were grouted solid at the completion of the latter groundwater measurement.

5. Contacts between soil units are approximate and may be gradational.

6. These logs are subject to the limitations, conclusions, and recommendations in this report.

Project No. 20.3062.

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APPENDIX B

Laboratory Testing

SUMMARY OF LABORATORY TEST RESULTS
Johnstown Reservoir Outlet Structure
Project No. 20.3062

Sample Location		Natural Dry Density (pcf)	Natural Moisture Content (%)	Standard Proctor		Water Soluble Sulfates (%)	Gradation			Atterberg Limits		Material Type
Boring	Depth (feet)			Maximum Dry Density (pcf)	Optimum Moisture Content (%)		Gravel (%)	Sand (%)	Silt/ Clay (%)	Liquid Limit (%)	Plasticity Index (%)	
B-1	0 to 5		2.6	114.4	15.2		3	30	64.8	38	24	FILL: CLAY, sandy, lean (A-6(13))
B-1	1	109.0	17.7				2	8	90.3	47	32	FILL: CLAY, lean (A-7-6(30))
B-1	4	109.2	19.1					12	88.0	37	24	FILL: CLAY, lean (A-6(20))
B-1	9	94.8	27.5					8	91.9	43	28	FILL: CLAY, lean (A-7-6(26))
B-2	0 to 5		2.0	120.2	11.9		9	39	47.3	30	16	FILL: SAND, clayey (A-6(4))
B-2	1	106.2	20.0				2	8	89.6	47	33	FILL: CLAY, lean (A-7-6(30))
B-2	4	109.6	19.5					12	87.8	43	29	FILL: CLAY, lean (A-7-6(25))
B-2	9	99.6	25.5					8	91.7	44	29	FILL: CLAY, lean (A-7-6(27))
B-2	14	96.6	27.3			0.01						WEATHERED CLAYSTONE: CLAY, lean (A-7-6)
B-3	1	116.5	15.4				6	12	82	44	29	FILL: CLAY, lean, with sand (CL, A-7-6(23))
B-3	4	103.7	18.4				2	19	79	46	30	FILL: CLAY, lean, with sand (CL, A-7-6(23))
B-3	9	96.4	27.5					10	90	42	27	CLAY, lean (A-7-6(24))
B-3	14	101.9	24.9									WEATHERED CLAYSTONE: CLAY, lean (A-7-6)
B-4	4					0.00						FILL: CLAY, lean (CL, A-7-6)

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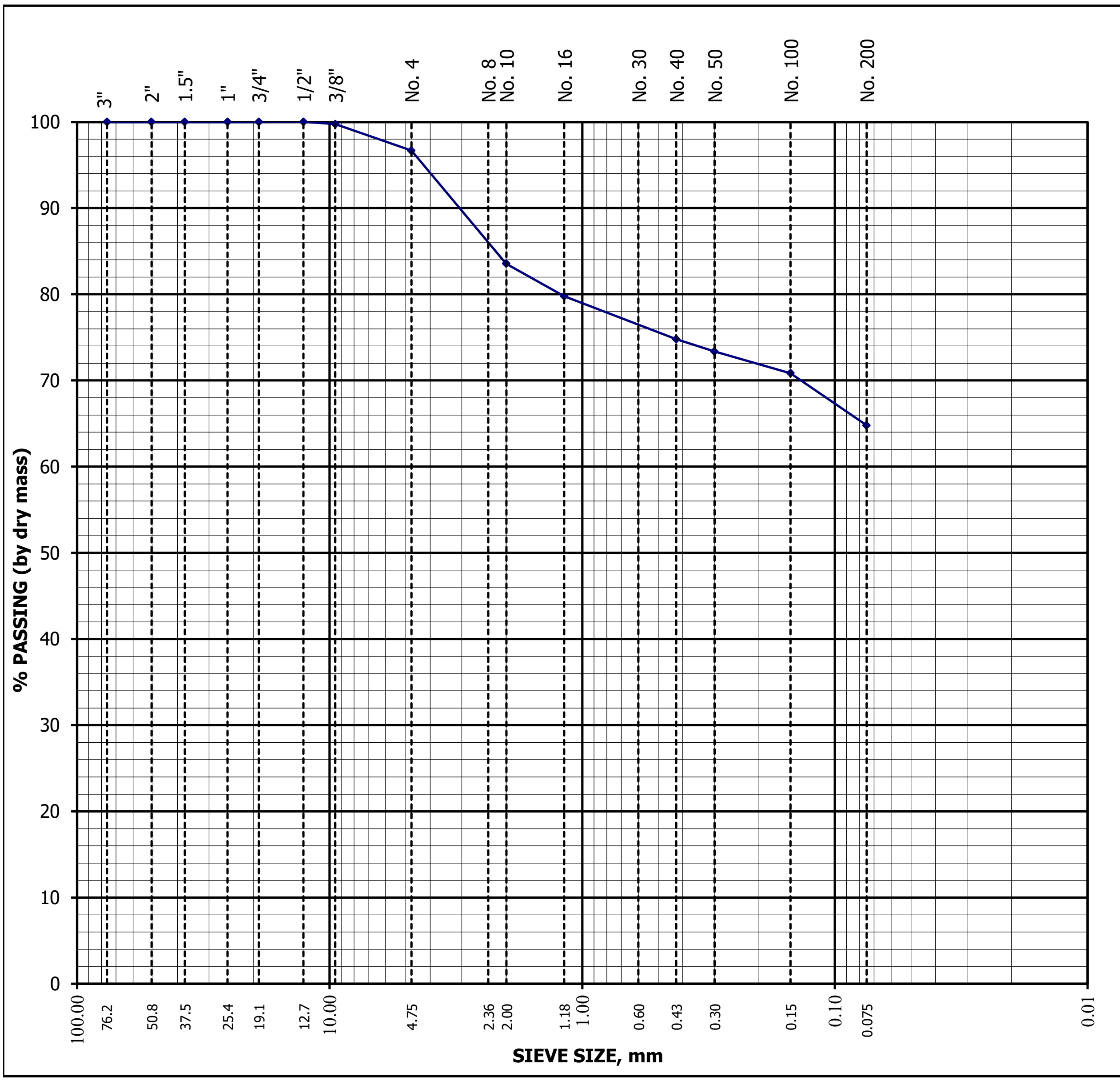
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	20.3062, J&T Consulting, Inc.	Date:	16-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. De Los Santos
Lab ID Number:	2021425	Reviewer:	J. Crystal
Sample Location:	B-1 at 0' to 5'		
Visual Description:	CLAY, sandy, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **13**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Sandy lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	100
3/8"	100
#4	97
#8	
#10	84
#16	80
#30	
#40	75
#50	73
#100	71
#200	64.8

Moisture (M) & Density (D)	
M, %:	2.6
D, pcf:	

LL	38
PL	14
PI	24

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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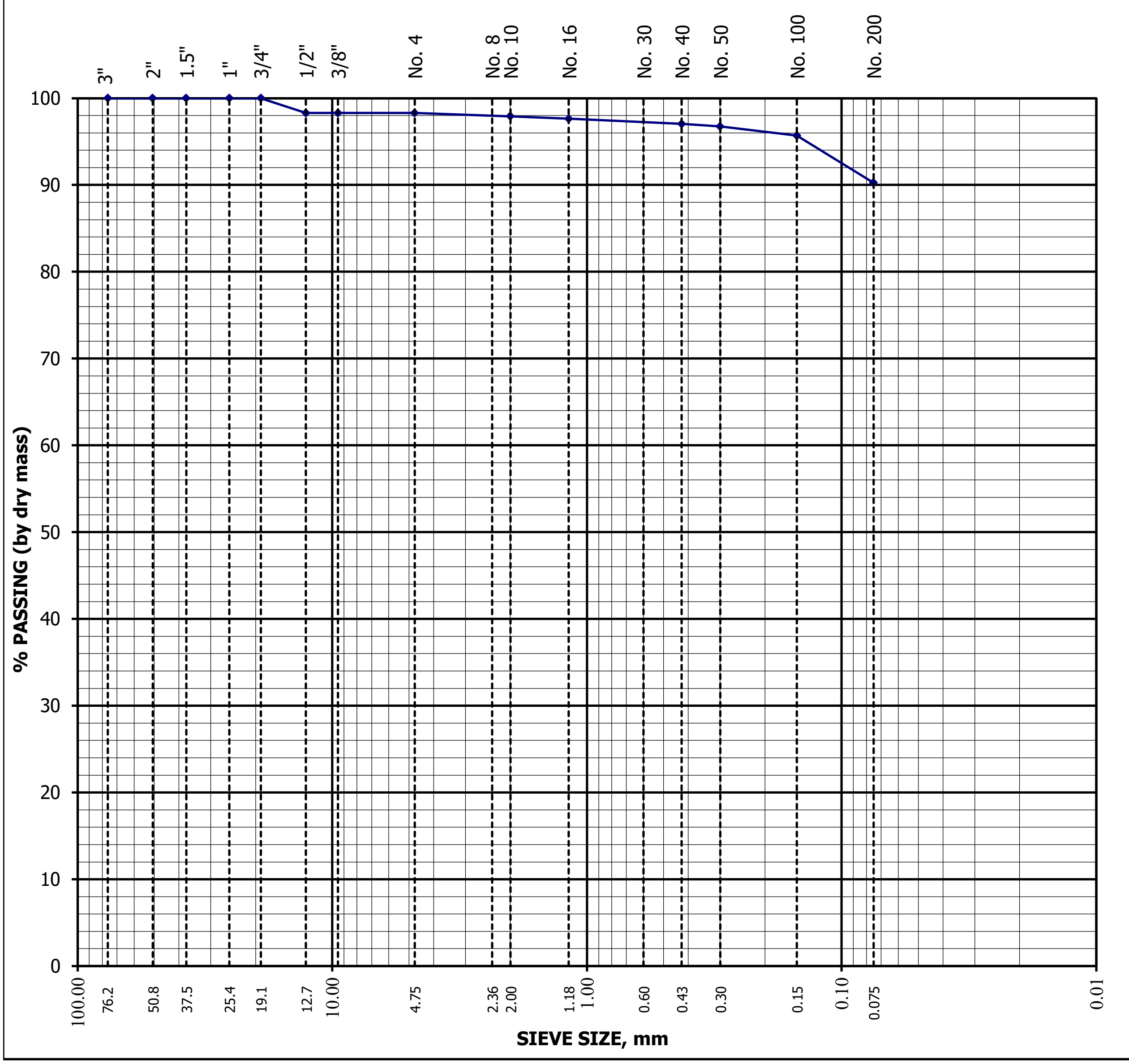
Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021426	Reviewer:	J. Crystal
Sample Location:	B-1 at 1'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **30**
Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	100
1/2"	98
3/8"	98
#4	98
#8	
#10	98
#16	98
#30	
#40	97
#50	97
#100	96
#200	90.3

Moisture (M) & Density (D)	
M, %:	17.7
D, pcf:	109.0

LL	47
PL	15
PI	32

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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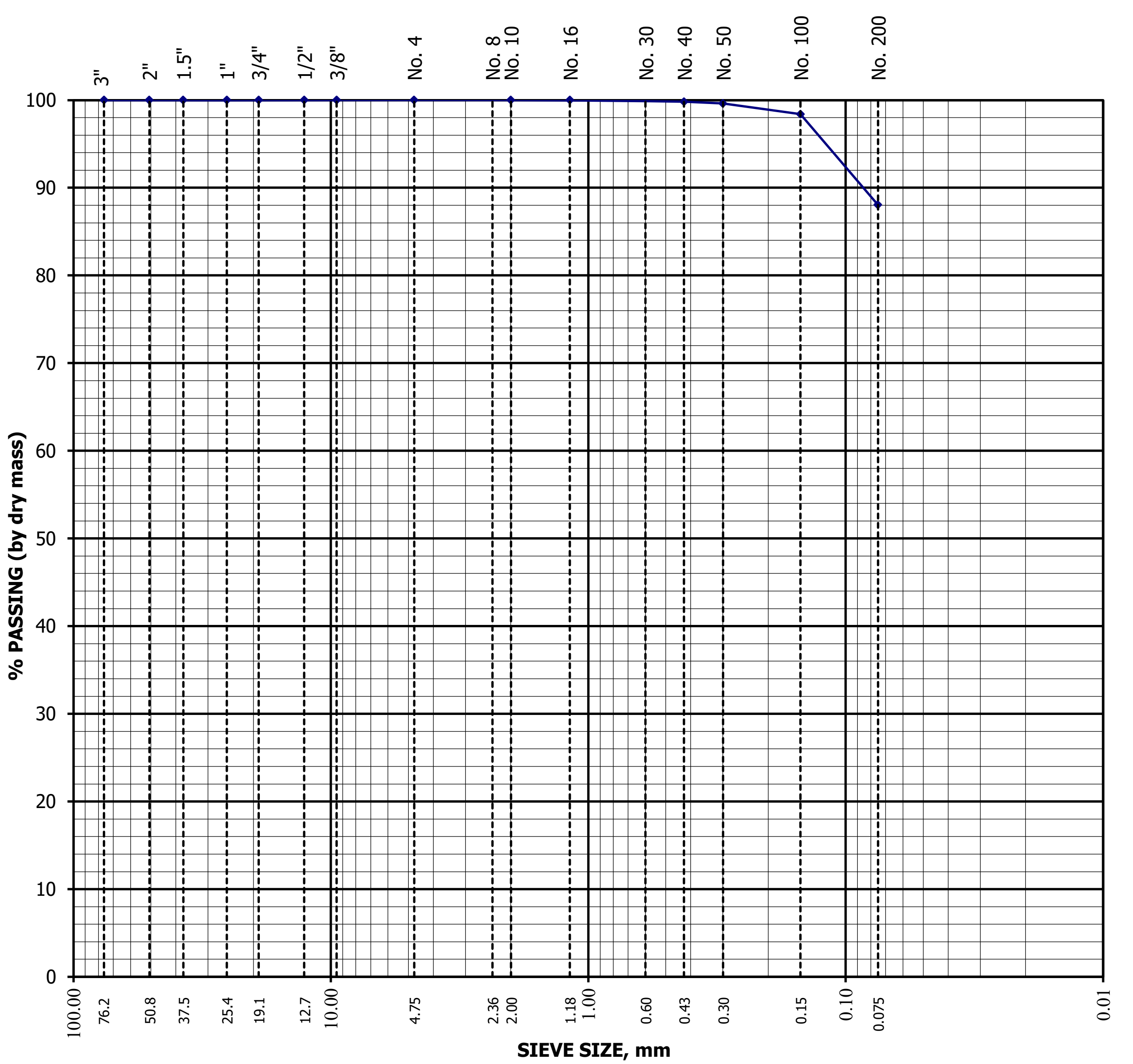
Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021427	Reviewer:	J. Crystal
Sample Location:	B-1 at 4'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **20**

Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	
#8	
#10	
#16	100
#30	
#40	100
#50	100
#100	98
#200	88.0

Moisture (M) & Density (D)	
M, %:	19.1
D, pcf:	109.2

LL	37
PL	13
PI	24

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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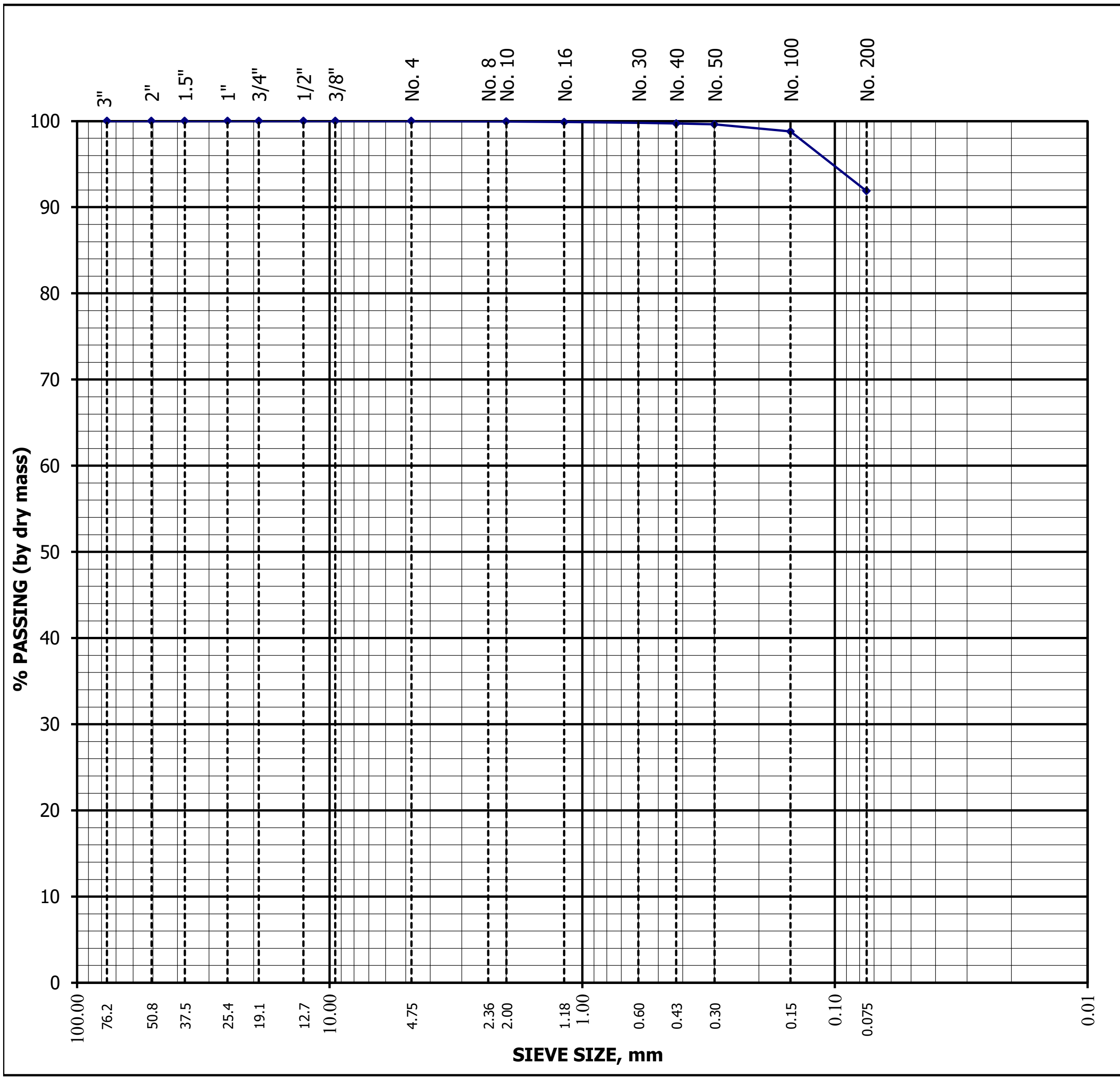
Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021428	Reviewer:	J.Crystal
Sample Location:	B-1 at 9'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **26**
Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	100
#30	
#40	100
#50	100
#100	99
#200	91.9

Moisture (M) & Density (D)	
M, %:	27.5
D, pcf:	94.8

LL	43
PL	15
PI	28

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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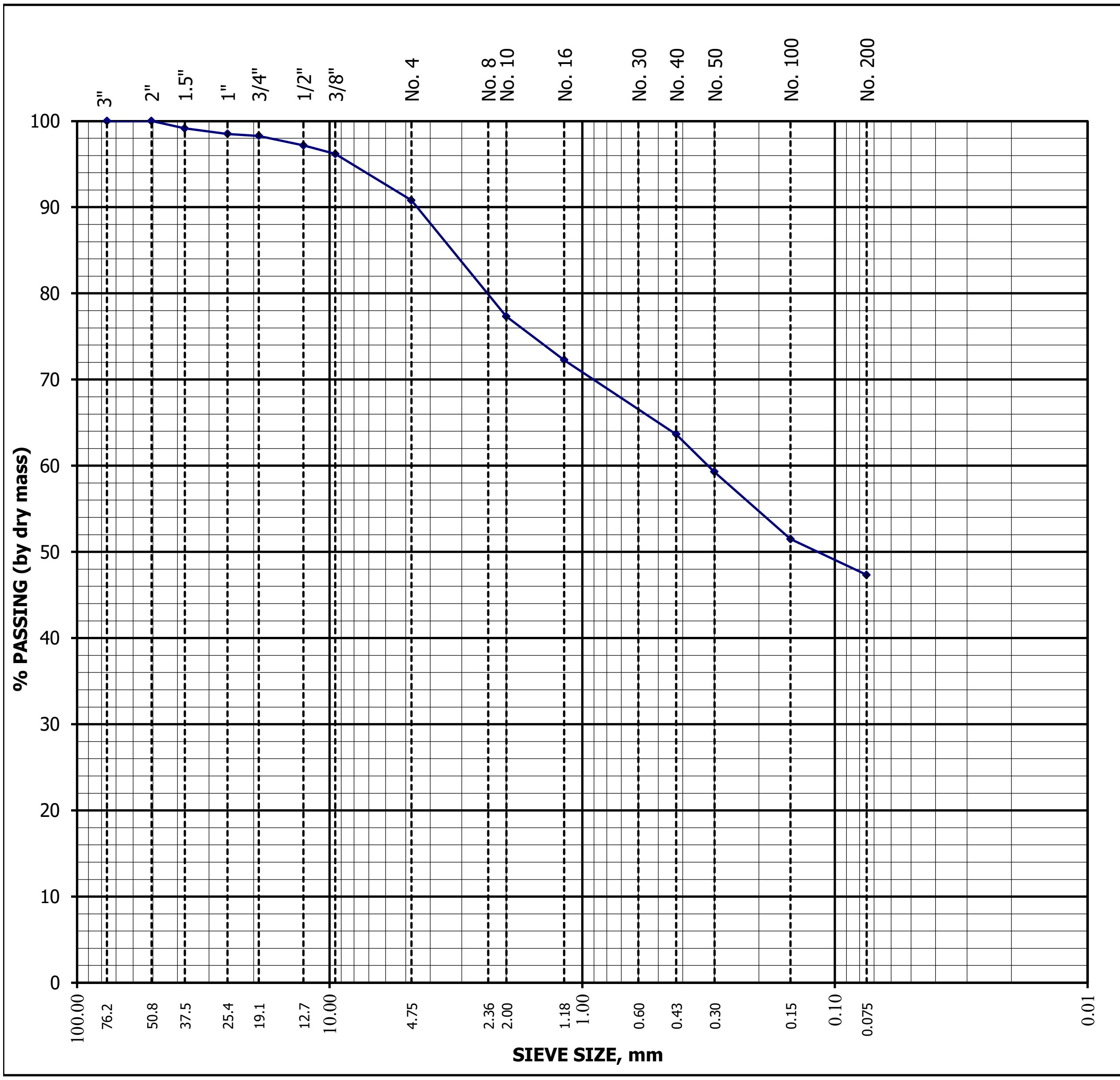
Project Number:	20.3062, J&T Consulting, Inc.	Date:	16-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. De Los Santos
Lab ID Number:	2021429	Reviewer:	J. Crystal
Sample Location:	B-2 at 0' to 5'		
Visual Description:	SAND, clayey, brown		

AASHTO M 145 Classification: **A-6** **Group Index:** **4**
Unified Soil Classification System (ASTM D 2487): **(SC)** **Clayey Sand**



Sieve Size	% Passing
3"	
2"	100
1.5"	99
1"	99
3/4"	98
1/2"	97
3/8"	96
#4	91
#8	
#10	77
#16	72
#30	
#40	64
#50	59
#100	51
#200	47.3

Moisture (M) & Density (D)	
M, %:	2.0
D, pcf:	

LL	30
PL	14
PI	16

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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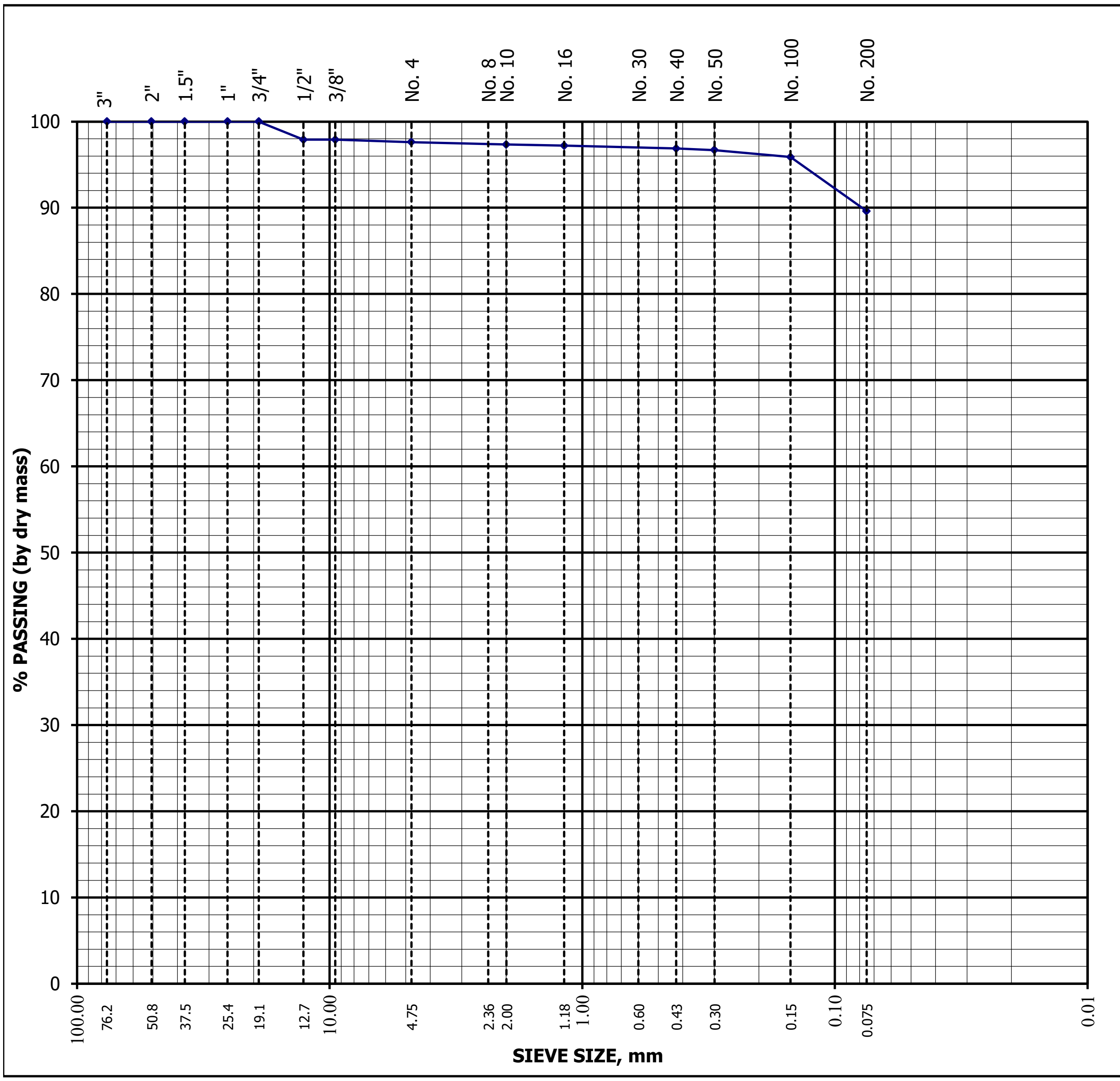
Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021430	Reviewer:	J. Crystal
Sample Location:	B-2 at 1'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **30**
Unified Soil Classification System (ASTM D 2487): **(CL)** **Lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	98
3/8"	98
#4	98
#8	
#10	97
#16	97
#30	
#40	97
#50	97
#100	96
#200	89.6

Moisture (M) & Density (D)	
M, %:	20.2
D, pcf:	106.2

LL	47
PL	14
PI	33

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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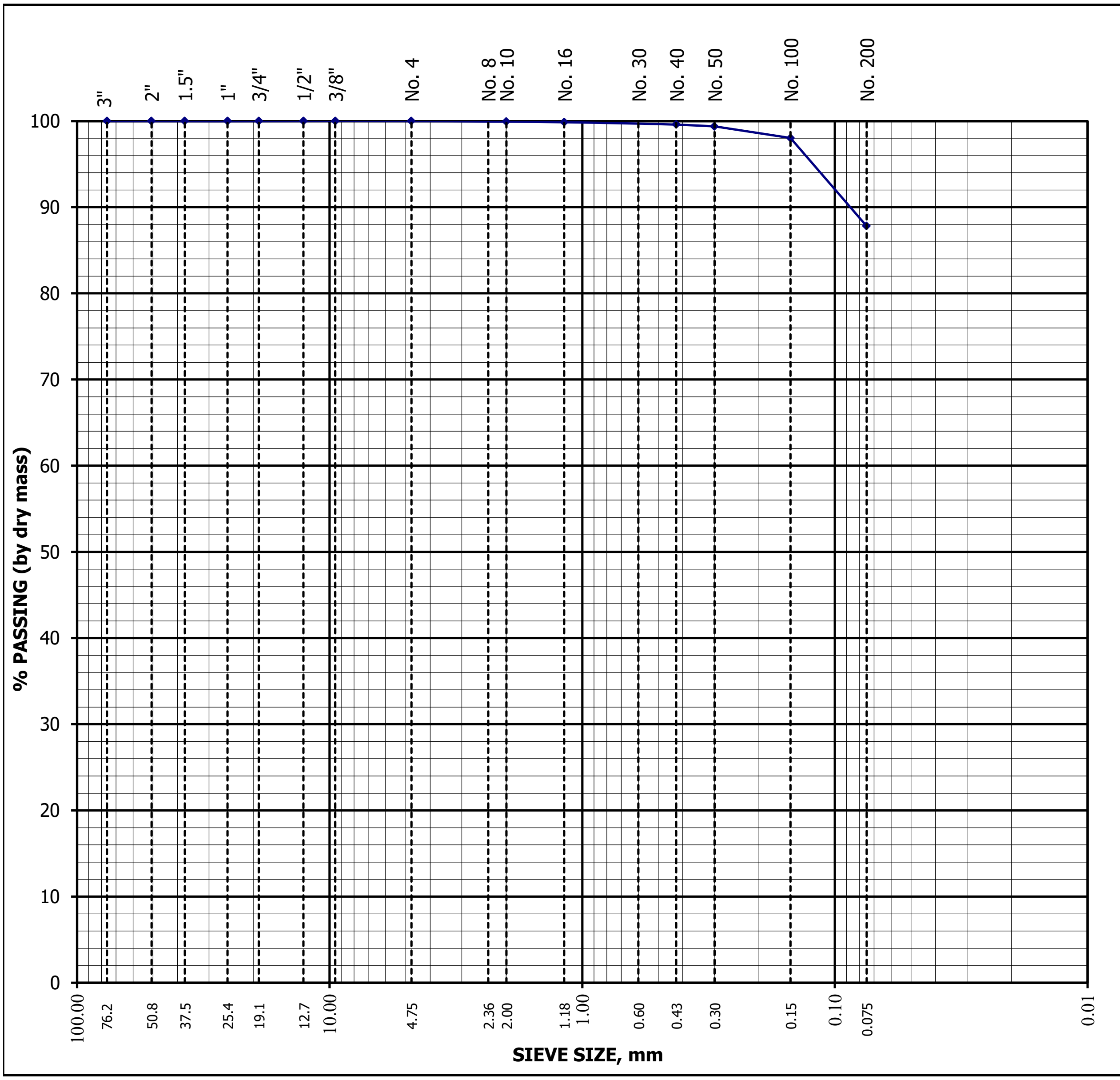
Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021431	Reviewer:	J. Crystal
Sample Location:	B-2 at 4'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **25**
Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	100
#30	
#40	100
#50	99
#100	98
#200	87.8

Moisture (M) & Density (D)	
M, %:	19.5
D, pcf:	109.6

LL	43
PL	14
PI	29

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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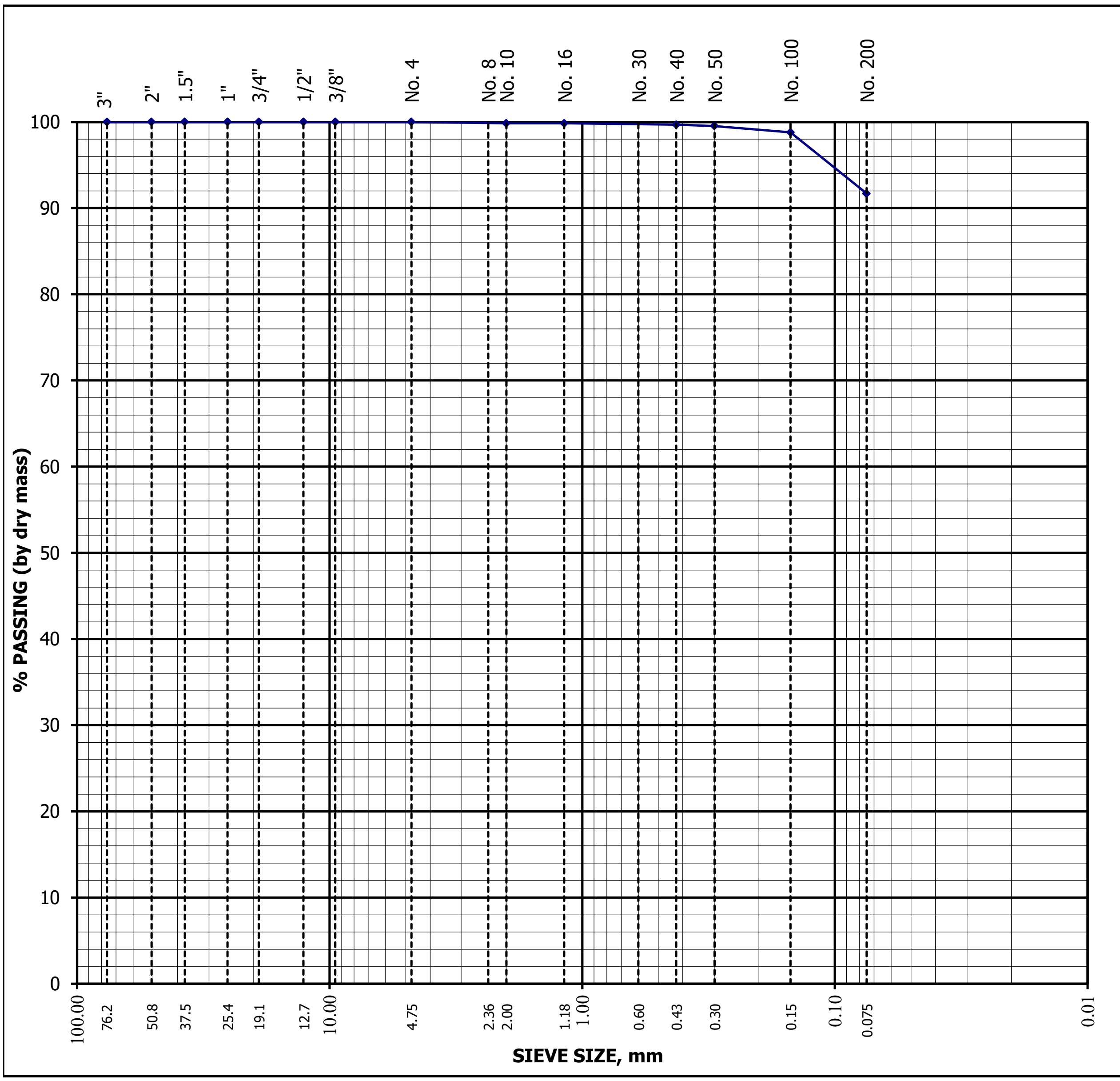
Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021432	Reviewer:	J. Crystal
Sample Location:	B-2 at 9'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **27**
Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	100
#30	
#40	100
#50	100
#100	99
#200	91.7

Moisture (M) & Density (D)	
M, %:	25.5
D, pcf:	99.6

LL	44
PL	15
PI	29

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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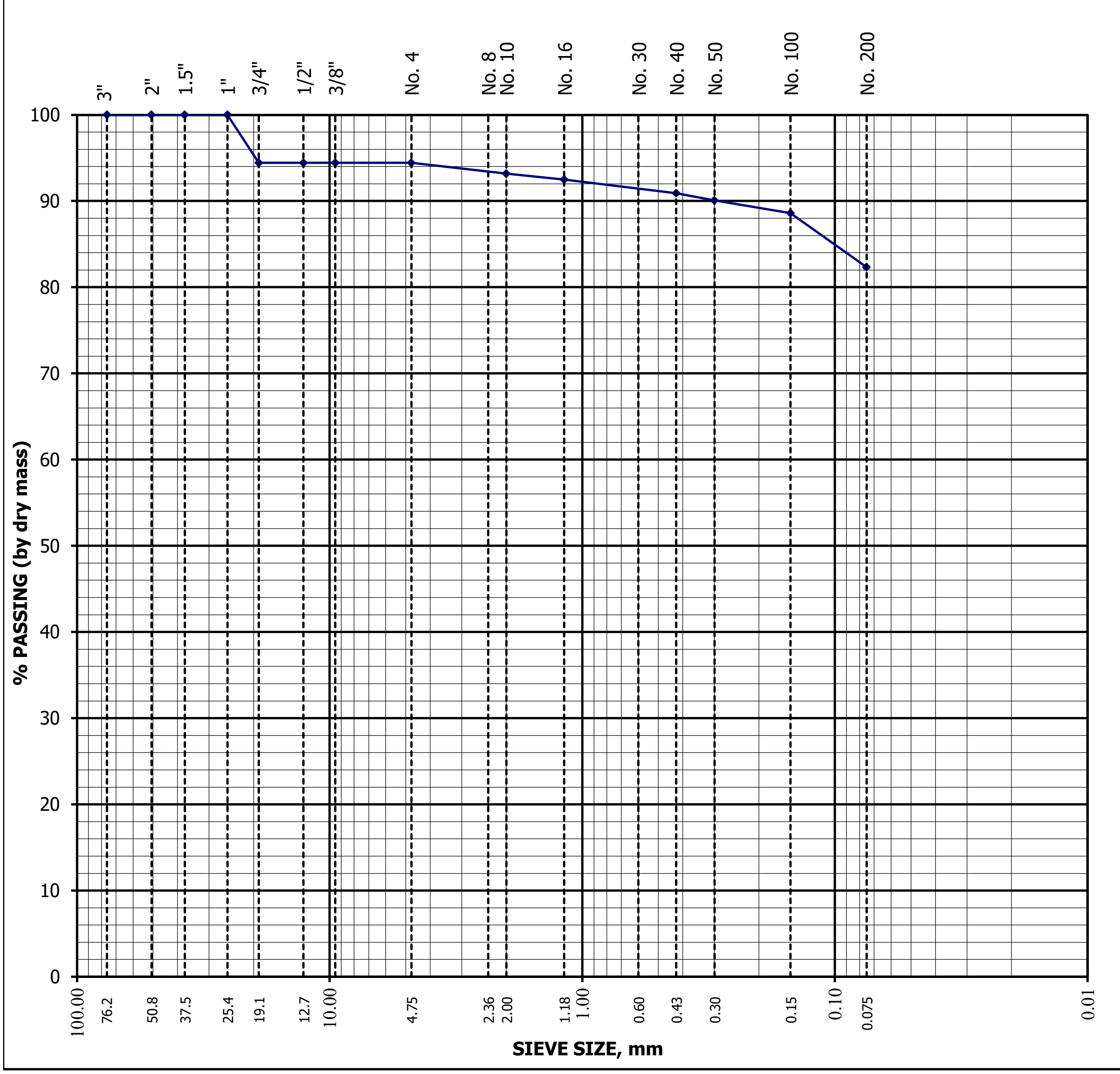
Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021435	Reviewer:	J. Crystal
Sample Location:	B-3 at 1'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **23**

Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay with sand**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	100
3/4"	94
1/2"	94
3/8"	94
#4	94
#8	
#10	93
#16	92
#30	
#40	91
#50	90
#100	89
#200	82.3

Moisture (M) & Density (D)	
M, %:	15.4
D, pcf:	116.5

LL	44
PL	15
PI	29

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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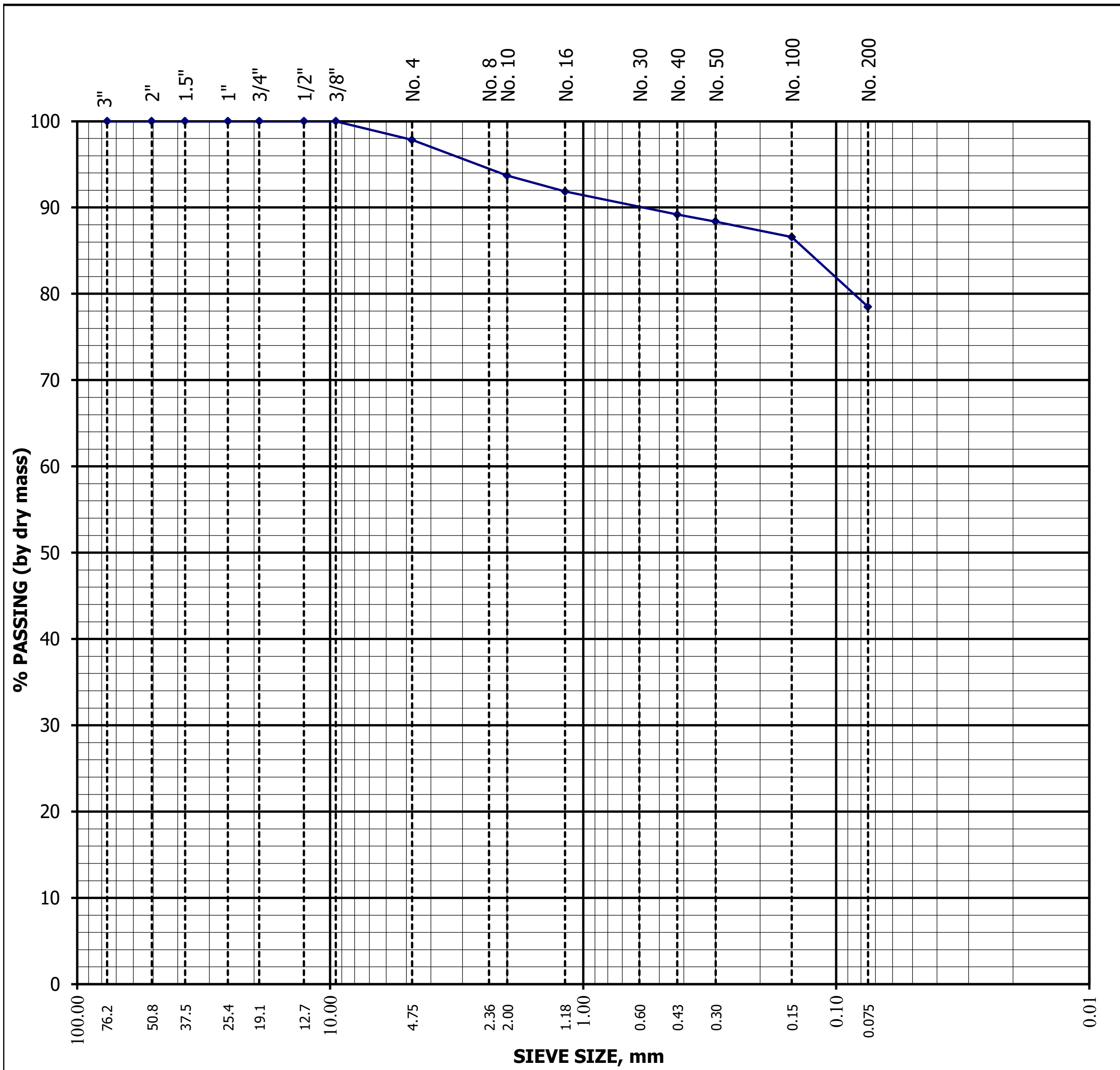
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021435	Reviewer:	J. Crystal
Sample Location:	B-3 at 4'		
Visual Description:	CLAY, with sand, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **23**

Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay with sand**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	100
#4	98
#8	
#10	94
#16	92
#30	
#40	89
#50	88
#100	87
#200	78.5

Moisture (M) & Density (D)	
M, %:	18.4
D, pcf:	103.7

LL	46
PL	16
PI	30

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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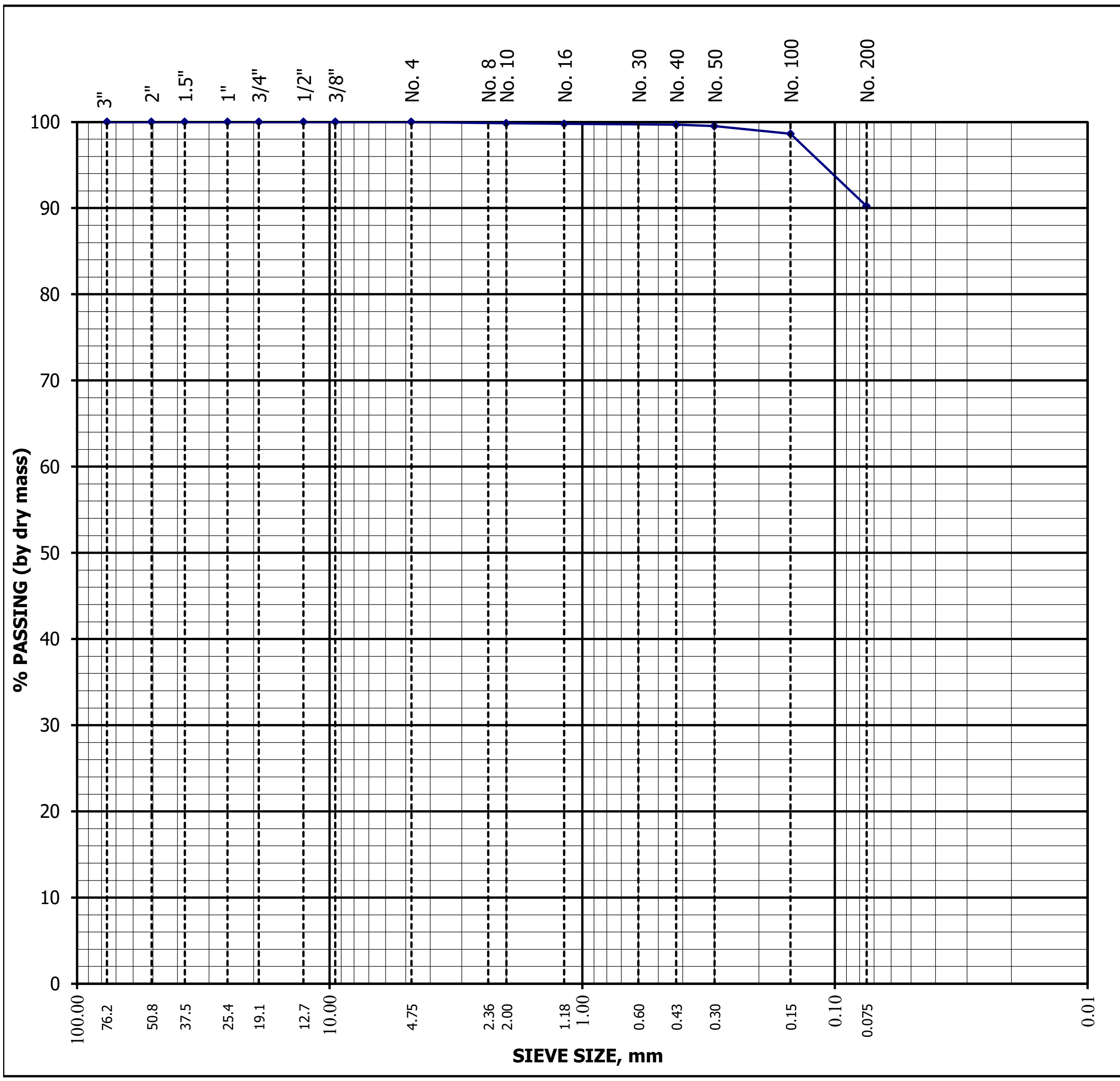
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	20.3062, J&T Consulting, Inc.	Date:	9-Dec-20
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	J. Holiman
Lab ID Number:	2021436	Reviewer:	J. Crystal
Sample Location:	B-3 at 9'		
Visual Description:	CLAY, brown		

AASHTO M 145 Classification: **A-7-6** **Group Index:** **24**

Unified Soil Classification System (ASTM D 2487): **(CL) Lean clay**



Sieve Size	% Passing
3"	
2"	
1.5"	
1"	
3/4"	
1/2"	
3/8"	
#4	100
#8	
#10	100
#16	100
#30	
#40	100
#50	100
#100	99
#200	90.2

Moisture (M) & Density (D)	
M, %:	27.5
D, pcf:	96.4

LL	42
PL	15
PI	27

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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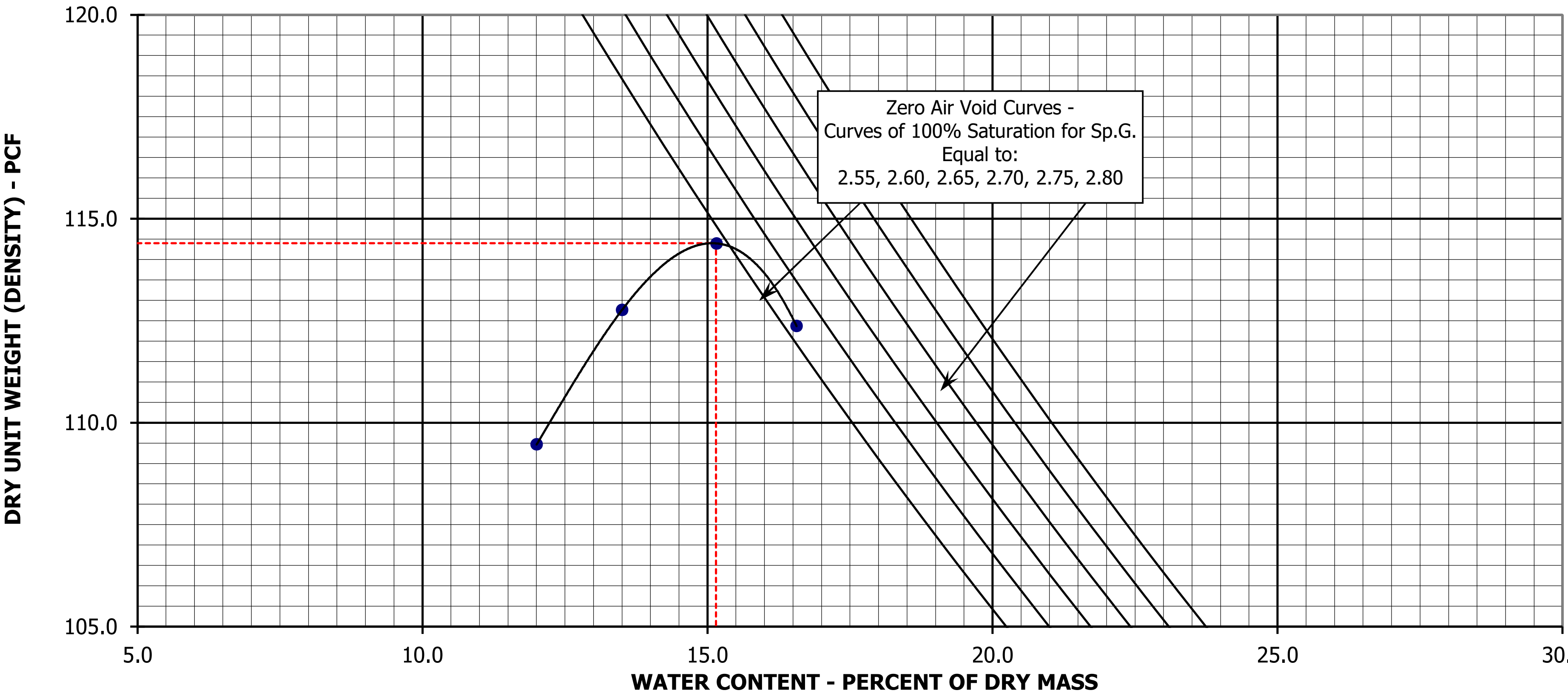
ASTM/AASHTO Compaction

Test Procedure Designation: ASTM D698 (Standard)

Method: A

Laboratory Maximum Dry Unit Weight (Density): 114.4 pcf

Laboratory Optimum Moisture Content (OMC): 15.2 %



Sample Location	Depth (ft)	**LL**	PL	**PI**	**-#200 (%)**	Soil Description & Classification	
B-1	0 to 5	**38**	14	**24**	**64.8**	Visual:	CLAY, sandy, brown
						AASHTO:	A-6(13)
						USCS:	CLAY, sandy, lean

Moisture/Density Relationship (Proctor) Test

Project Number:	20.3062, J&T Consulting, Inc.		
Project Name:	Johnstown Reservoir Outlet Structure		
Drawn By:	K. Lang	Tested by:	J. De Los Santos
Checked By:	J. Crystal	Date:	18-Dec-20
Date:	21-Dec-20	Lab ID Number:	2021425

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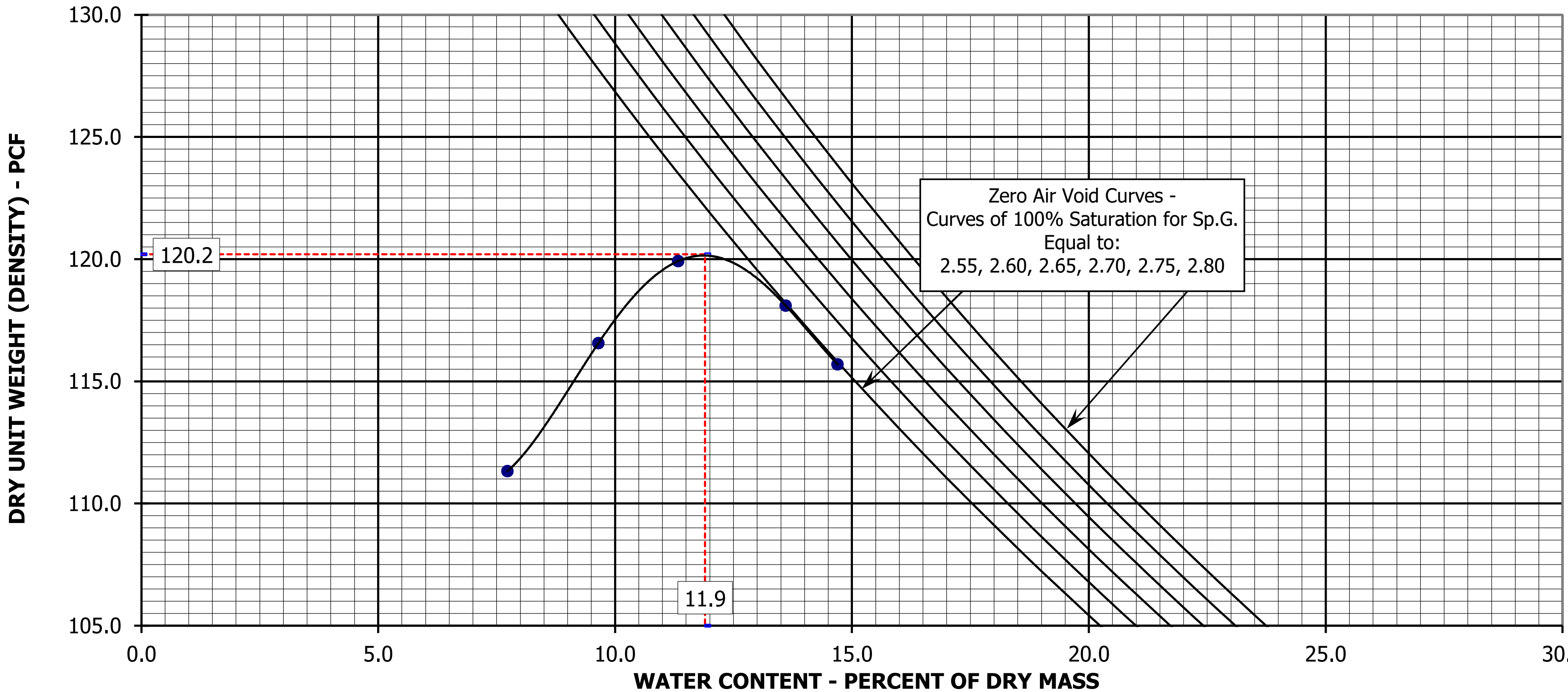
ASTM/AASHTO Compaction
Test Procedure Designation: ASTM D698 (Standard)
Method: A

Laboratory Maximum Dry Unit Weight (Density): 120.2 pcf
Laboratory Optimum Moisture Content (OMC): 11.9 %



Sample Location	Depth (ft)	LL	PL	PI	-#200 (%)	Soil Description & Classification	
B-2	0 to 5	30	14	16	47.3	Visual:	SAND, clayey, brown
						AASHTO:	A-6(4)
						USCS:	(SC) Sandy clay

Moisture/Density Relationship (Proctor) Test

Project Number:	20.3062, J&T Consulting, Inc.		
Project Name:	Johnstown Reservoir Outlet Structure		
Drawn By:	K. Lang	Tested by:	J. De Los Santos
Checked By:	J. Crystal	Date:	18-Dec-20
Date:	21-Dec-20	Lab ID Number:	2021429

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SOIL CHEMICAL TESTS

Project Number:	20.3062, J&T Consulting, Inc.	Date:	11-Feb-21
Project Name:	Johnstown Reservoir Outlet Structure	Technician:	G. Hoyos
Lab ID Number:	212211	Reviewer:	J. Crystal
Sample Location:	B-2 at 14'		
Visual Description:	CLAY, sandy, brown		

Dish+Wet Soil (g): ________
Dish+Dry Soil (g): ________
Dish Wt. (g): ________
Air Dried Moisture Content (%): ________

Water Soluble Sulfate (Colorado Procedure CP-L-2103)

Dilution	Reading, mg/L	Concentration, ppm	Concentration, %
100:1	1.0	100	0.01

pH (ASTM D 4972, 20g of -#10)

pH Meter Reading: ________

Water Soluble Chloride (HACH Method 8113, 100g of -#10)

Dilution	Reading (mg/L)	Result (mg/L)

Resistivity (AASHTO T 288, -#10)

Readings (ohm*cm)

Lowest Resistivity

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SOIL CHEMICAL TESTS

Project Number: 20.3062, J&T Consulting, Inc.
Project Name: Johnstown Reservoir Outlet Structure
Lab ID Number: 212212
Sample Location: B-4 at 4'
Visual Description: CLAYSTONE, sandy, brown

Date: 11-Feb-21
Technician: G. Hoyos
Reviewer: J. Crystal

Dish+Wet Soil (g): ______
Dish+Dry Soil (g): ______
Dish Wt. (g): ______
Air Dried Moisture Content (%): ______

Water Soluble Sulfate (Colorado Procedure CP-L-2103)

Dilution	Reading, mg/L	Concentration, ppm	Concentration, %
100:1	0.0	0	0.00

pH (ASTM D 4972, 20g of -#10)

pH Meter Reading: ______

Water Soluble Chloride (HACH Method 8113, 100g of -#10)

Dilution	Reading (mg/L)	Result (mg/L)

Resistivity (AASHTO T 288, -#10)

Readings (ohm*cm)

Lowest Resistivity

CESARE, INC.
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APPENDIX C

Slope Stability Results

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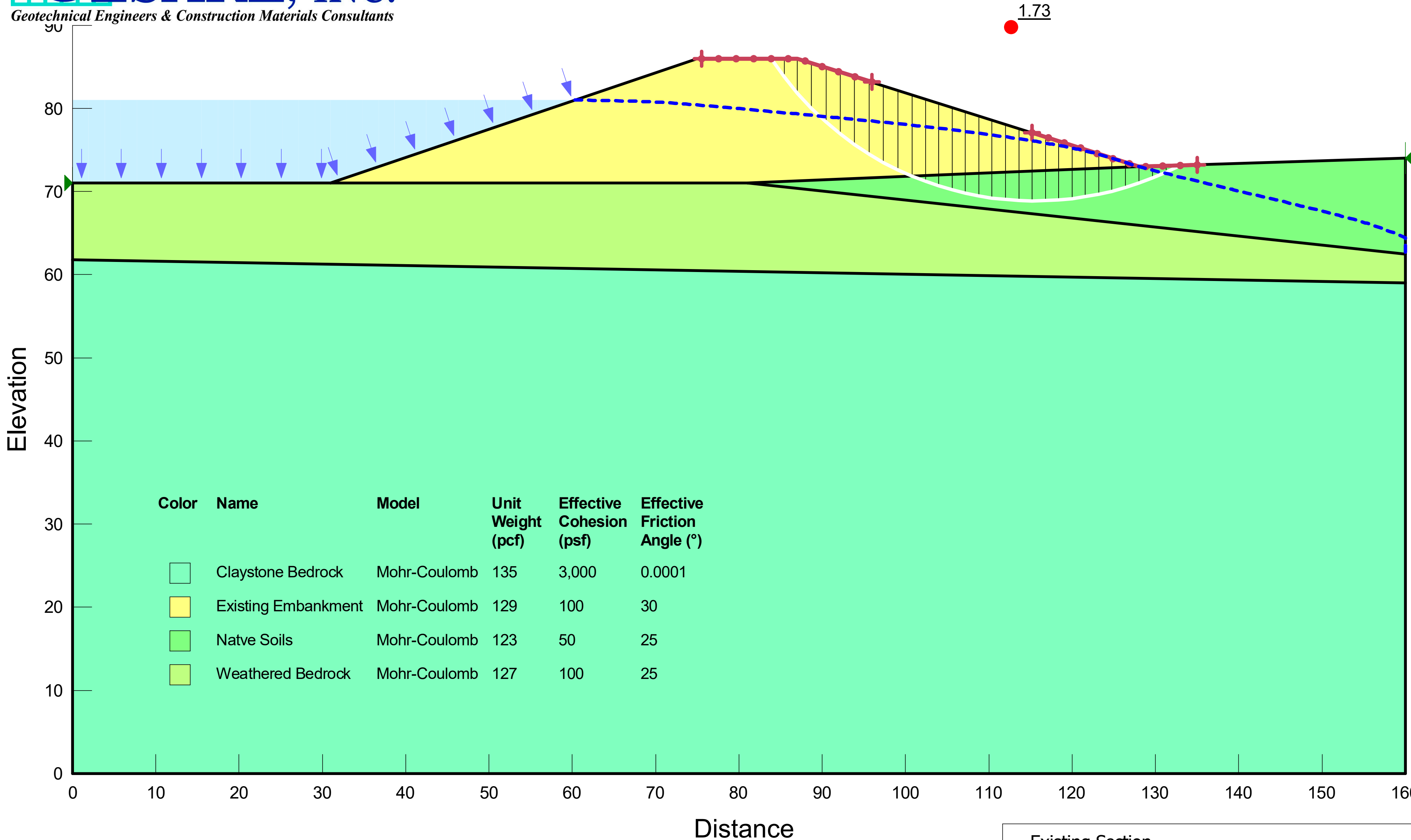
APPENDIX C

Slope Stability Results
Existing

CESARE, INC.

Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Existing Embankment	Mohr-Coulomb	129	100	30
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section

Full Reservoir Steady State Seepage

Downstream Circular Failure

Critical Failure Surface

CESARE, INC.
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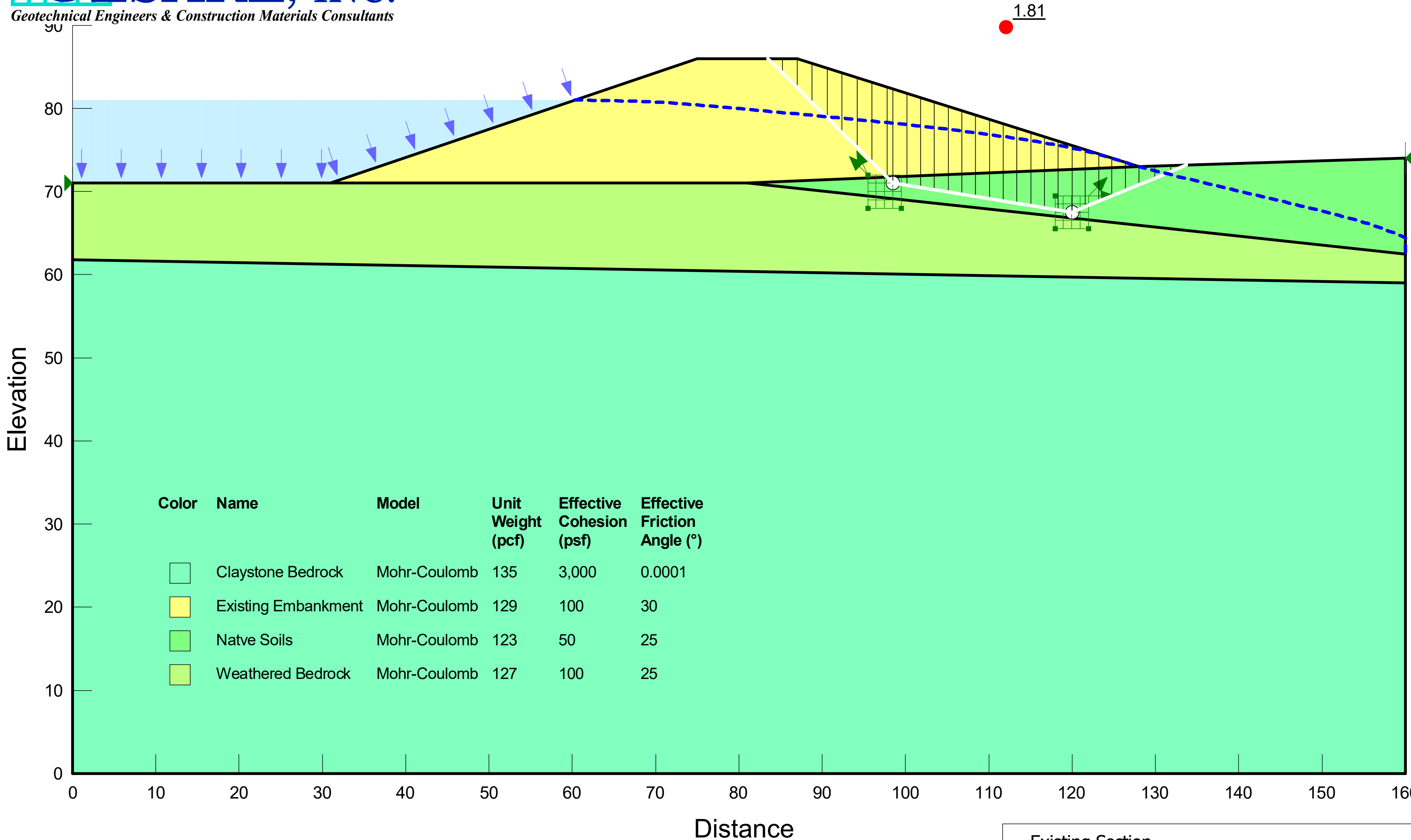
Johnstown Reservoir Outlet Structure
Project No. 20.3062



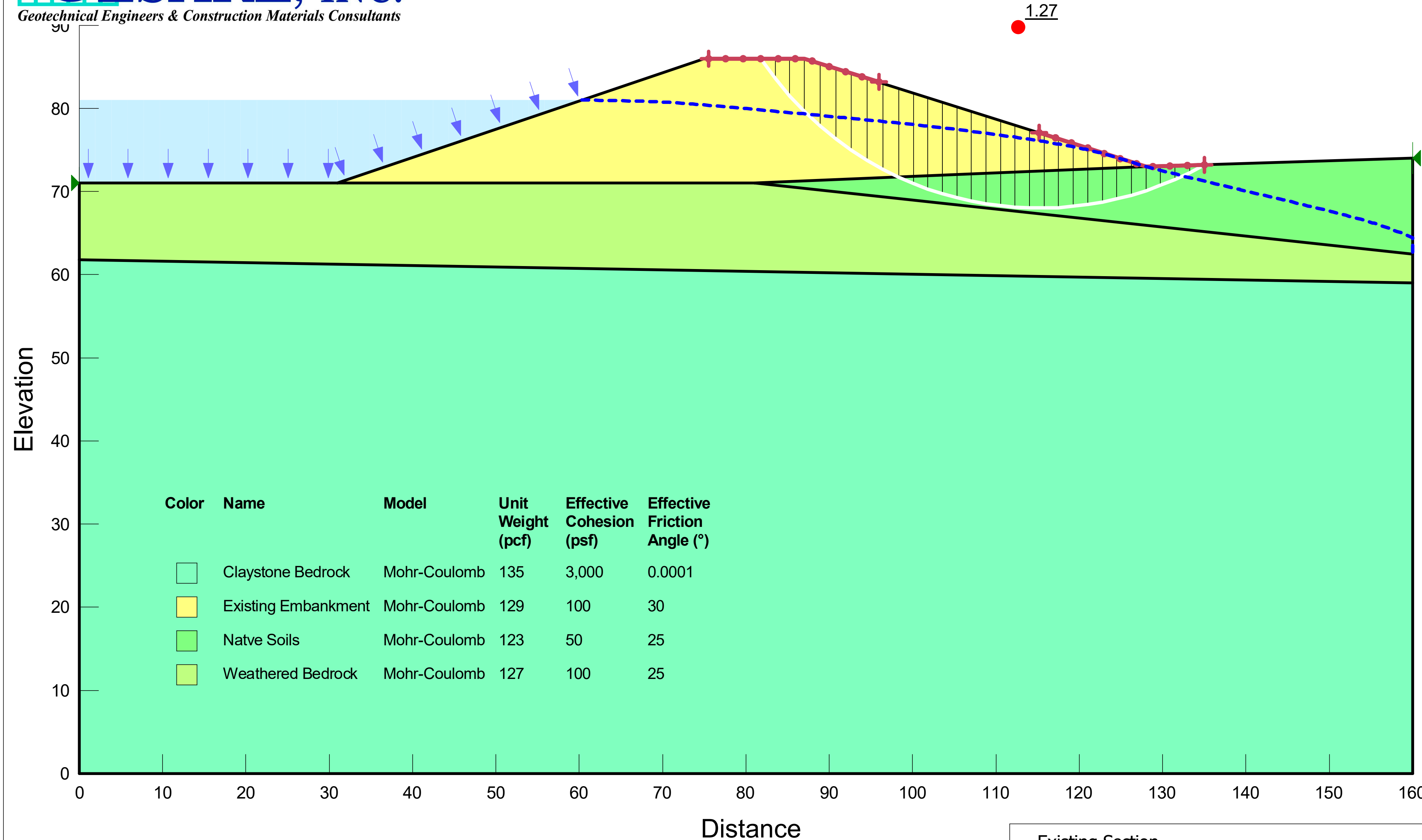
Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Existing Embankment	Mohr-Coulomb	129	100	30
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section
Full Reservoir Steady State Seepage
Downstream Block Failure
Critical Failure Surface

CESARE, INC.

Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



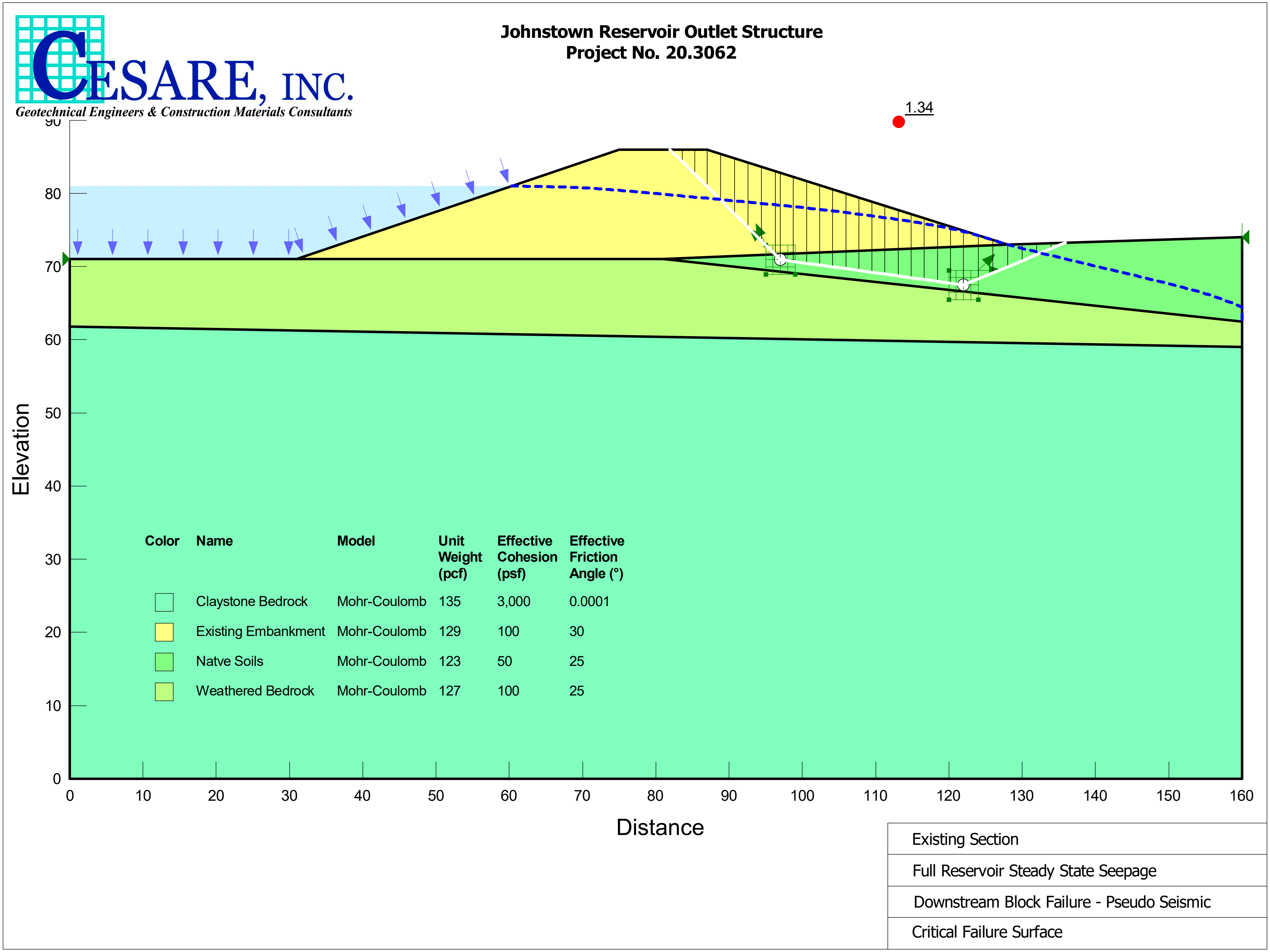
Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Existing Embankment	Mohr-Coulomb	129	100	30
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section

Full Reservoir Steady State Seepage

Downstream Circular Failure - Pseudo Seismic

Critical Failure Surface



CESARE, INC.
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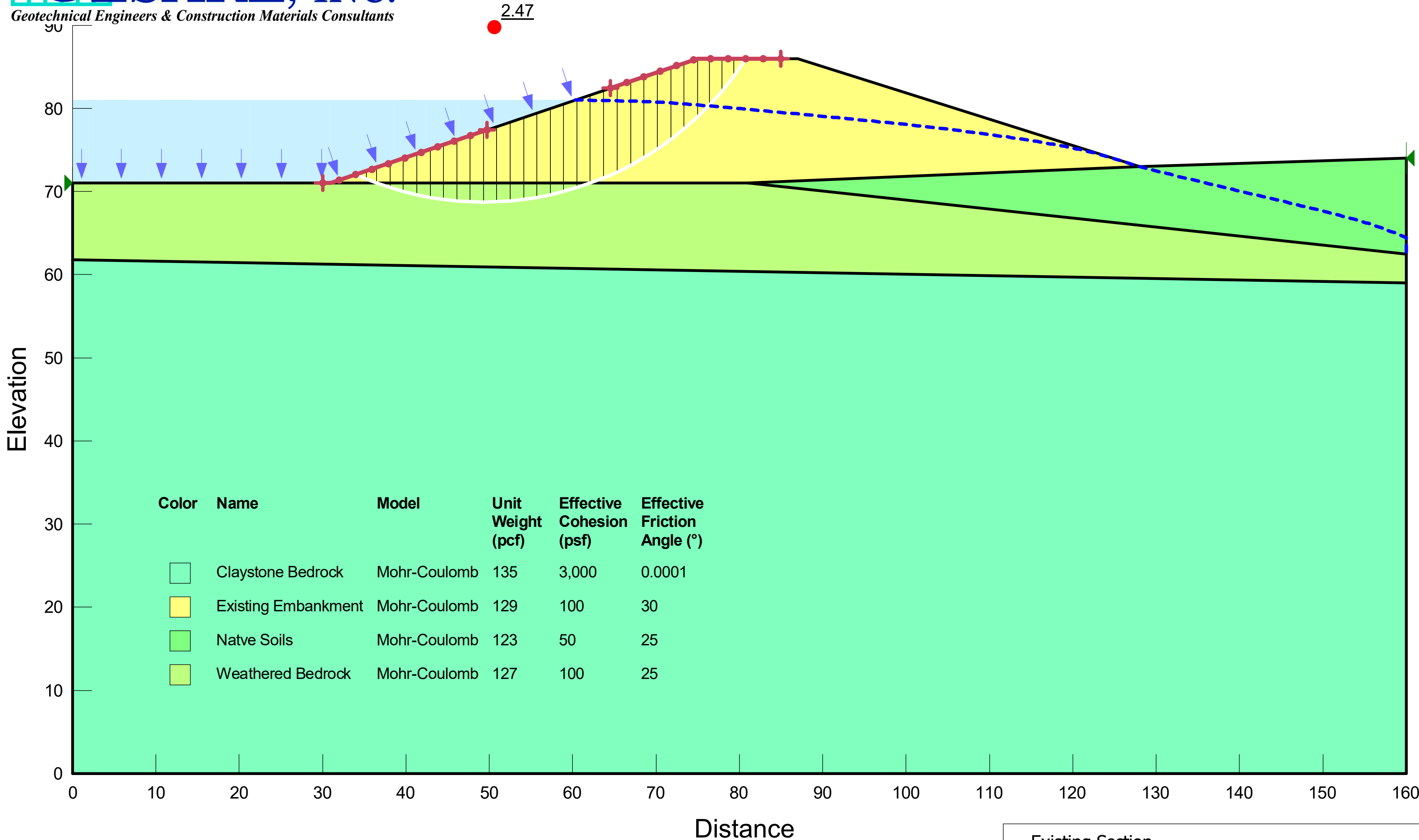
Johnstown Reservoir Outlet Structure
Project No. 20.3062
1.34
Elevation
Distance
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
Color
Name
Model
Unit Weight (pcf)
Effective Cohesion (psf)
Effective Friction Angle (°)
Claystone Bedrock
Mohr-Coulomb
135
3,000
0.0001
Existing Embankment
Mohr-Coulomb
129
100
30
Natve Soils
Mohr-Coulomb
123
50
25
Weathered Bedrock
Mohr-Coulomb
127
100
25
Existing Section
Full Reservoir Steady State Seepage
Downstream Block Failure - Pseudo Seismic
Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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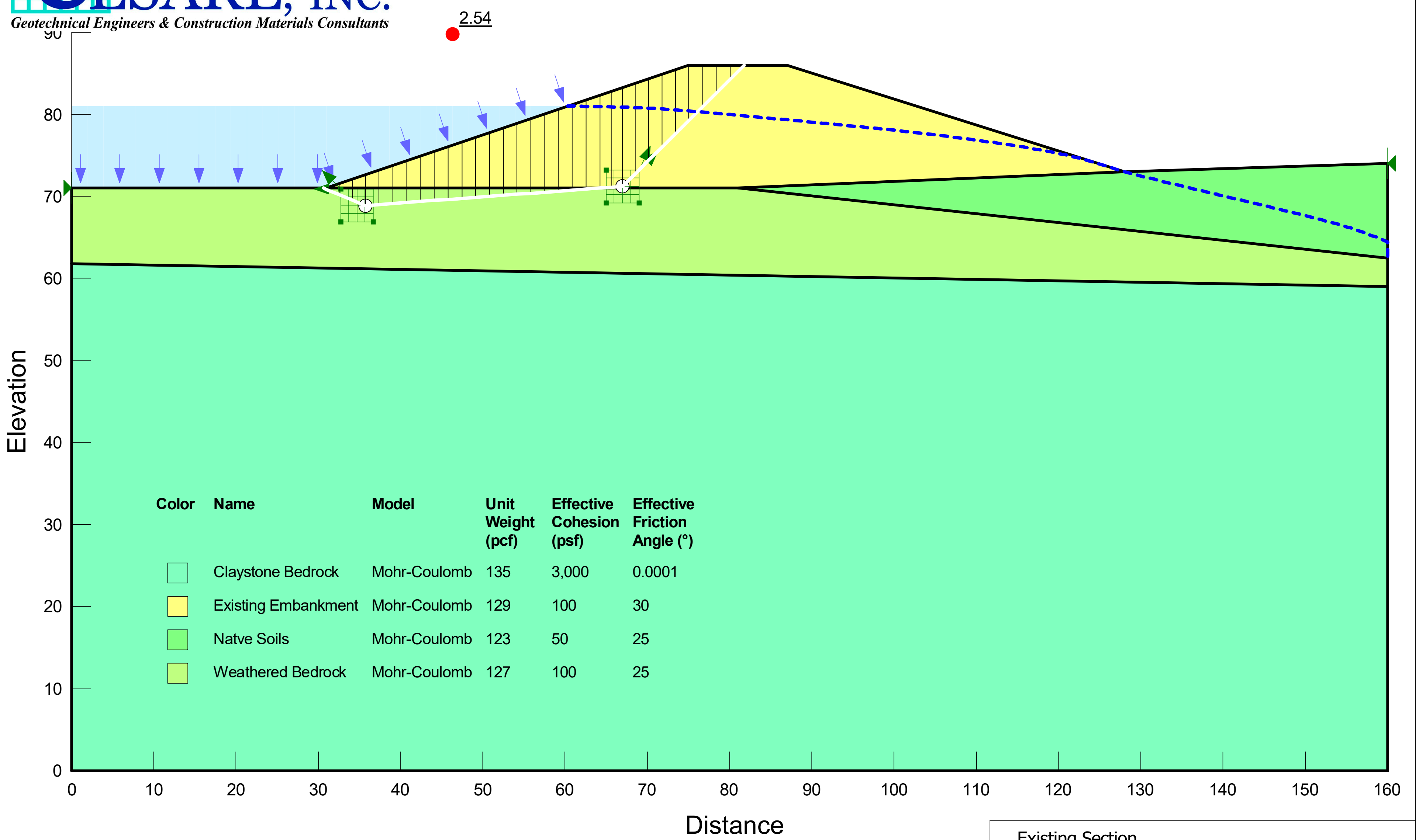
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section
Full Reservoir Steady State Seepage
Upstream Circular Failure
Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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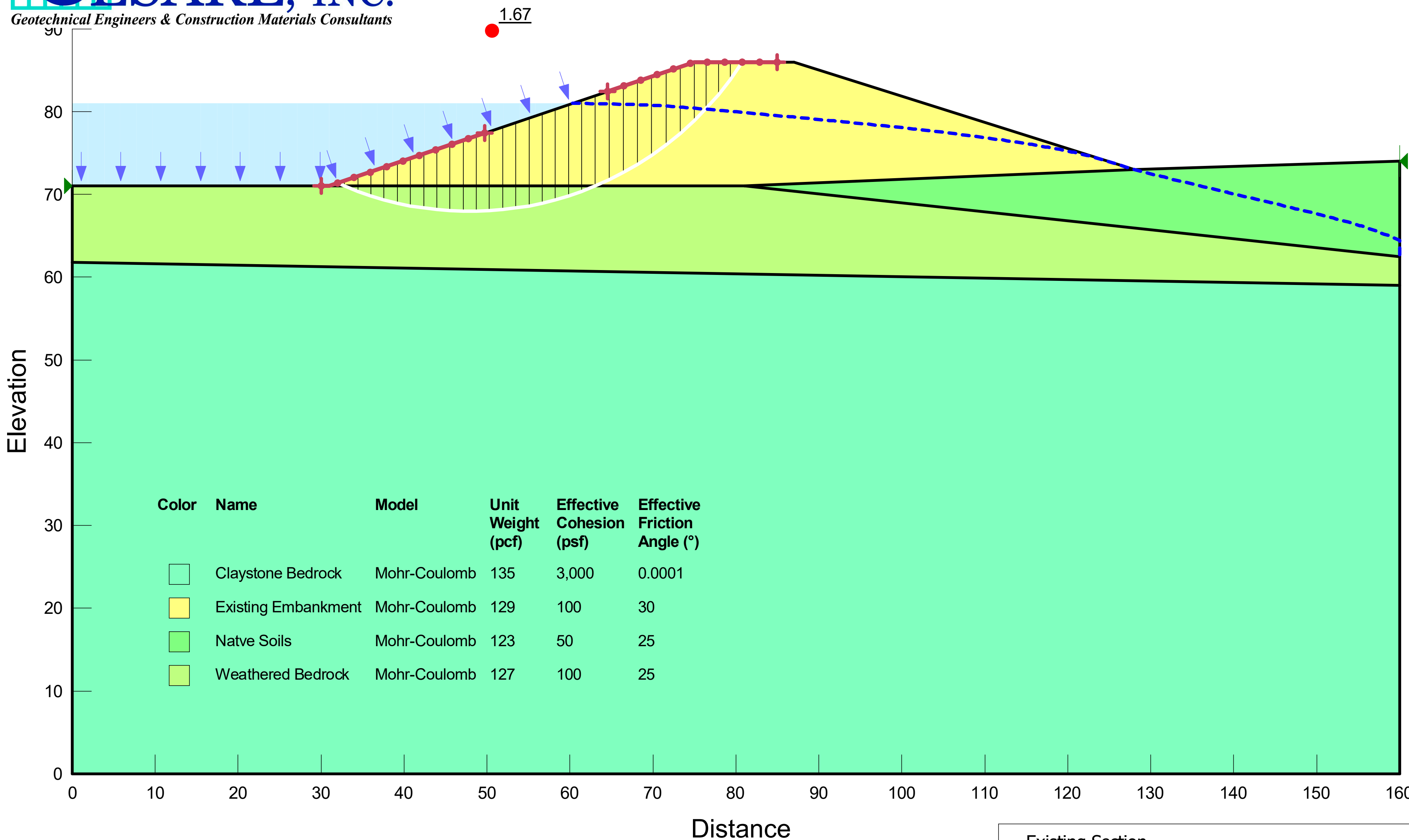
	Existing Embankment	Mohr-Coulomb	129	100	30
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section
Full Reservoir Steady State Seepage
Upstream Block Failure
Critical Failure Surface

Johnstown Reservoir Outlet Structure
Project No. 20.3062

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants



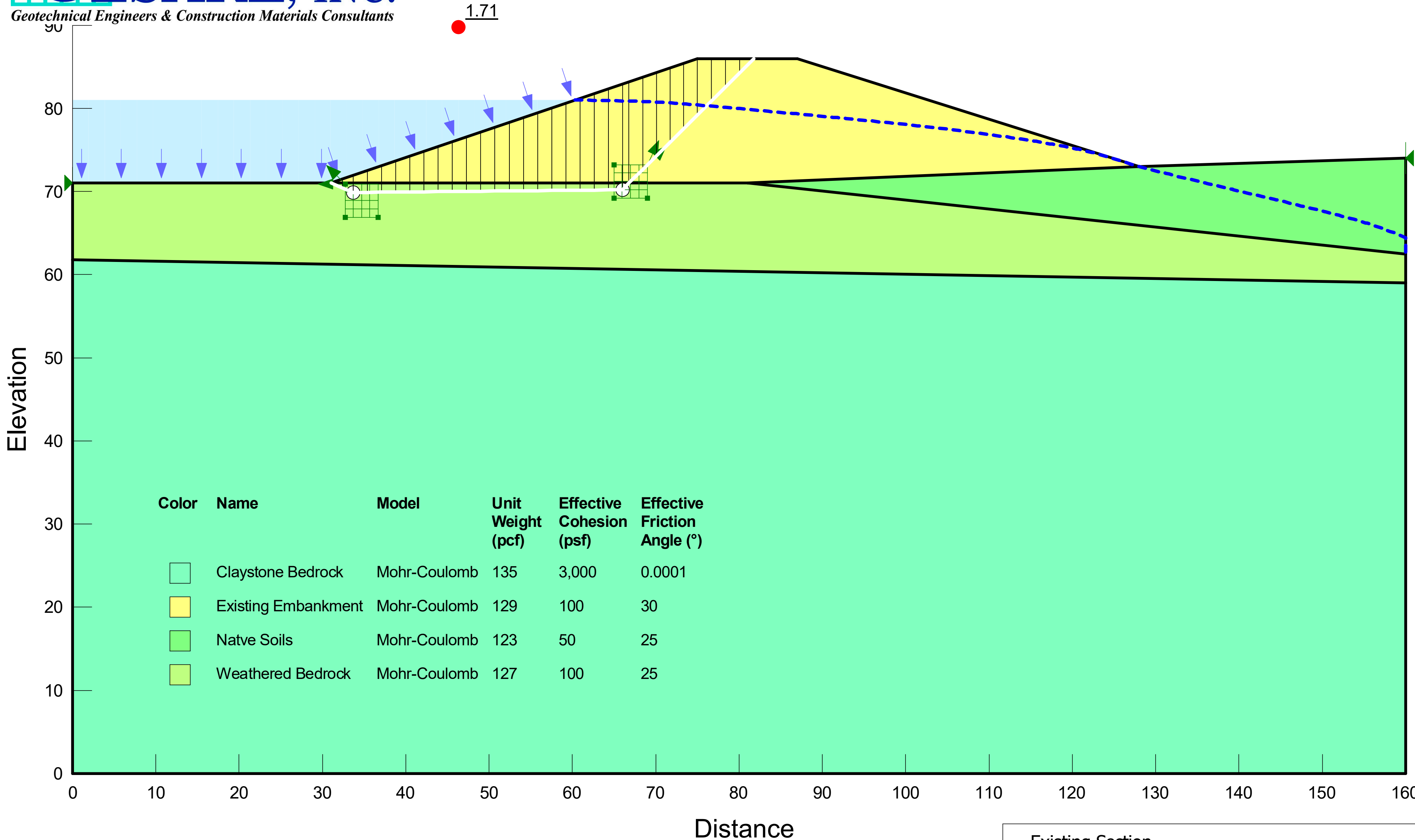
Existing Section

Steady State Seepage

Upstream Circular Failure - Pseudo Seismic

Critical Failure Surface

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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	Existing Embankment	Mohr-Coulomb	129	100	30
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section
Steady State Seepage
Upstream Block Failure - Pseudo Seismic
Critical Failure Surface

CESARE, INC.
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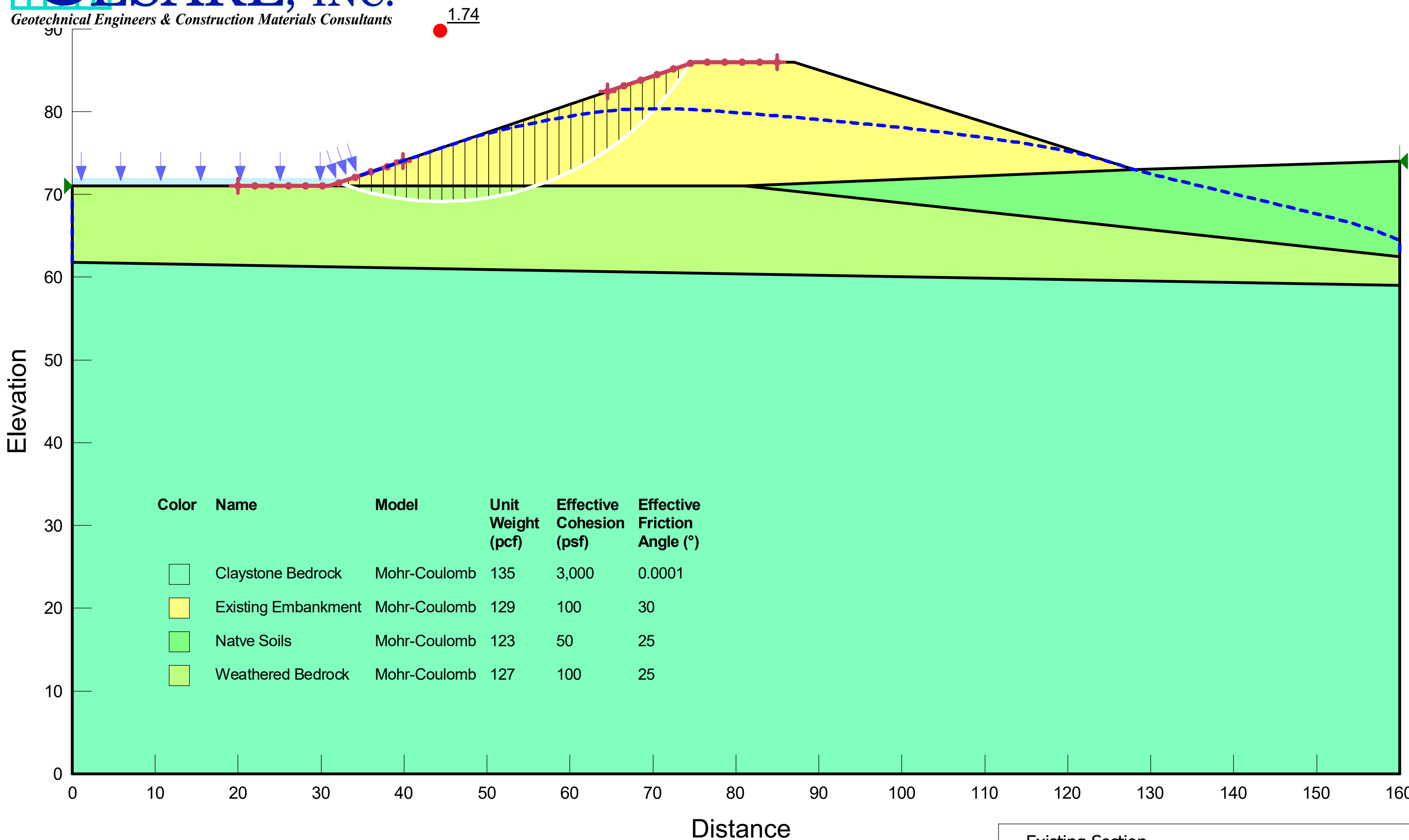
Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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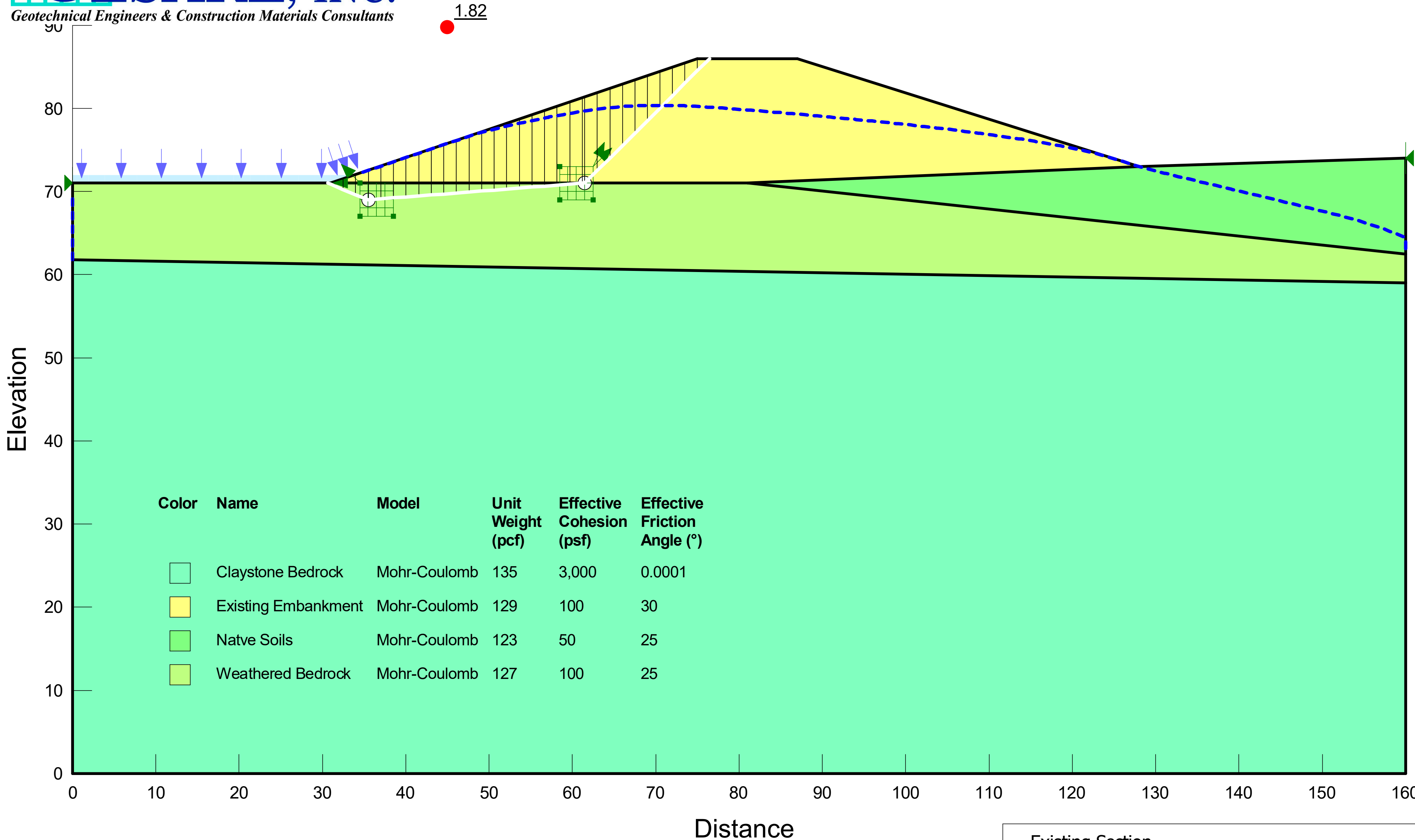
	Existing Embankment	Mohr-Coulomb	129	100	30
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section
Rapid Drawdown Transient Seepage
Upstream Circular Failure
Lowest Critical Failure Surface of All Time Steps

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Existing Embankment	Mohr-Coulomb	129	100	30
	Natve Soils	Mohr-Coulomb	123	50	25
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Existing Section
Rapid Drawdown Transient Seepage
Upstream Block Failure
Lowest Critical Failure Surface of All Time Steps

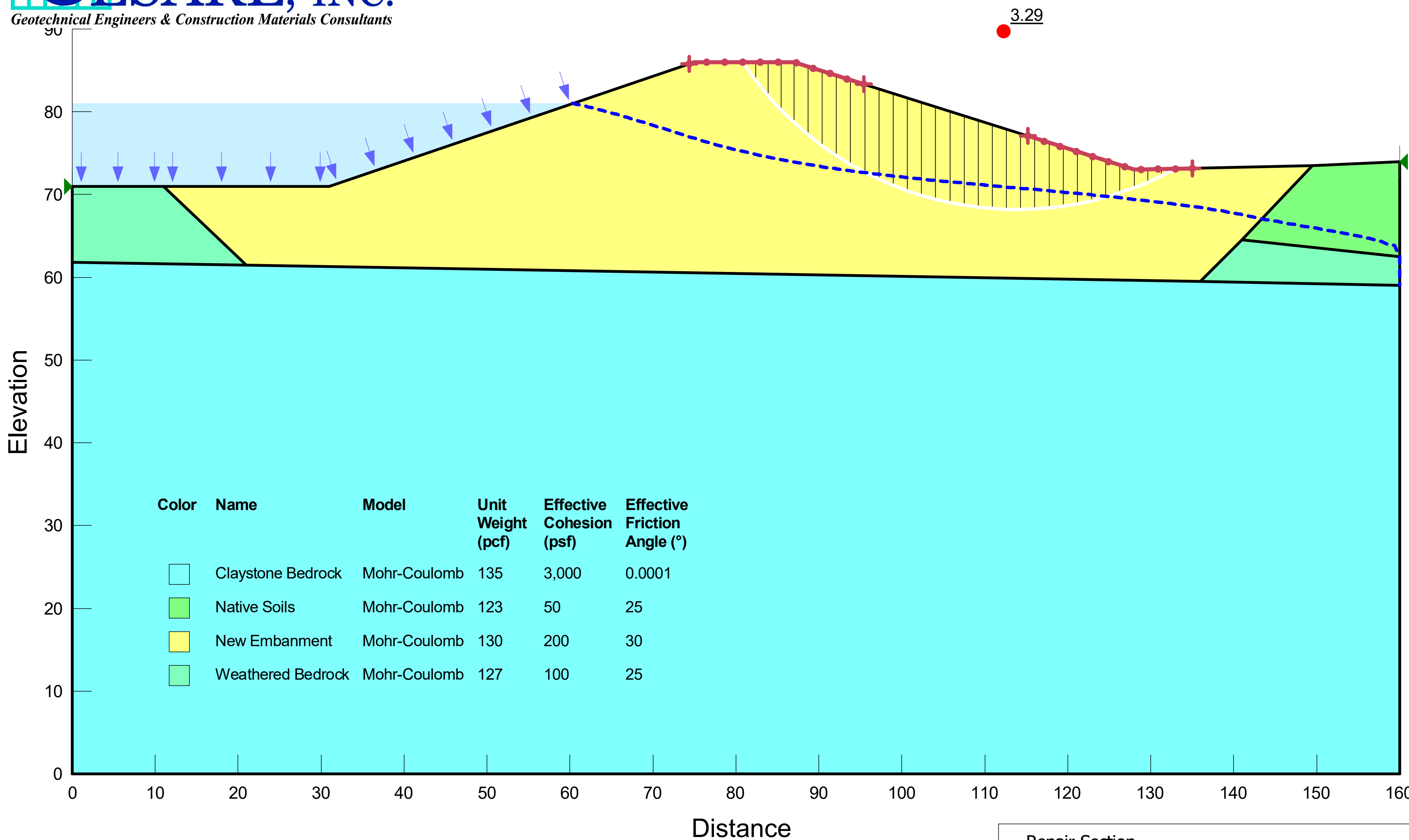
CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

APPENDIX C

Slope Stability Results
Repaired

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

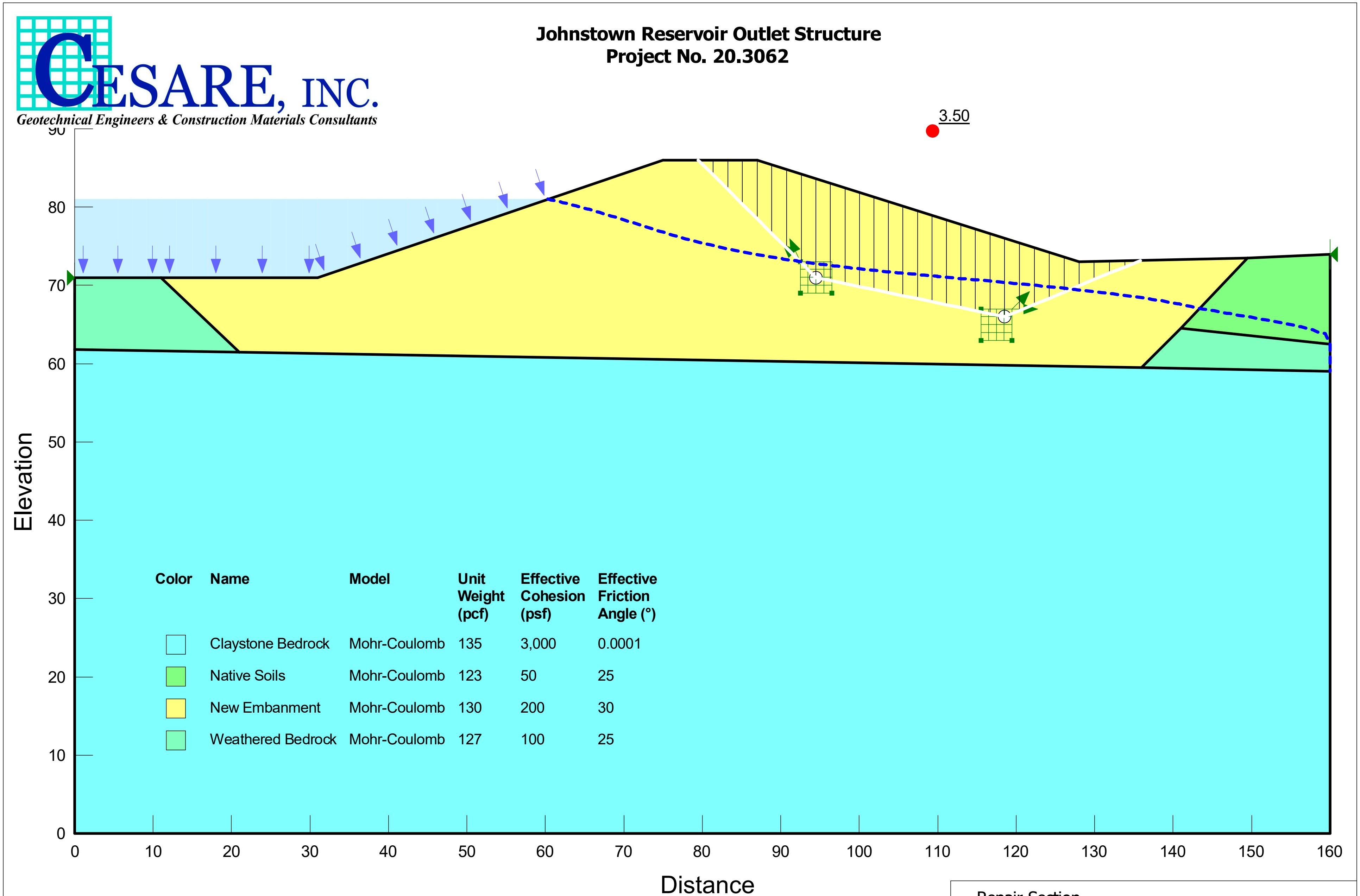
Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Native Soils	Mohr-Coulomb	123	50	25
	New Embanment	Mohr-Coulomb	130	200	30
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Repair Section
Full Steady State Seepage
Downstream Circular Failure
Critical Failure Surface

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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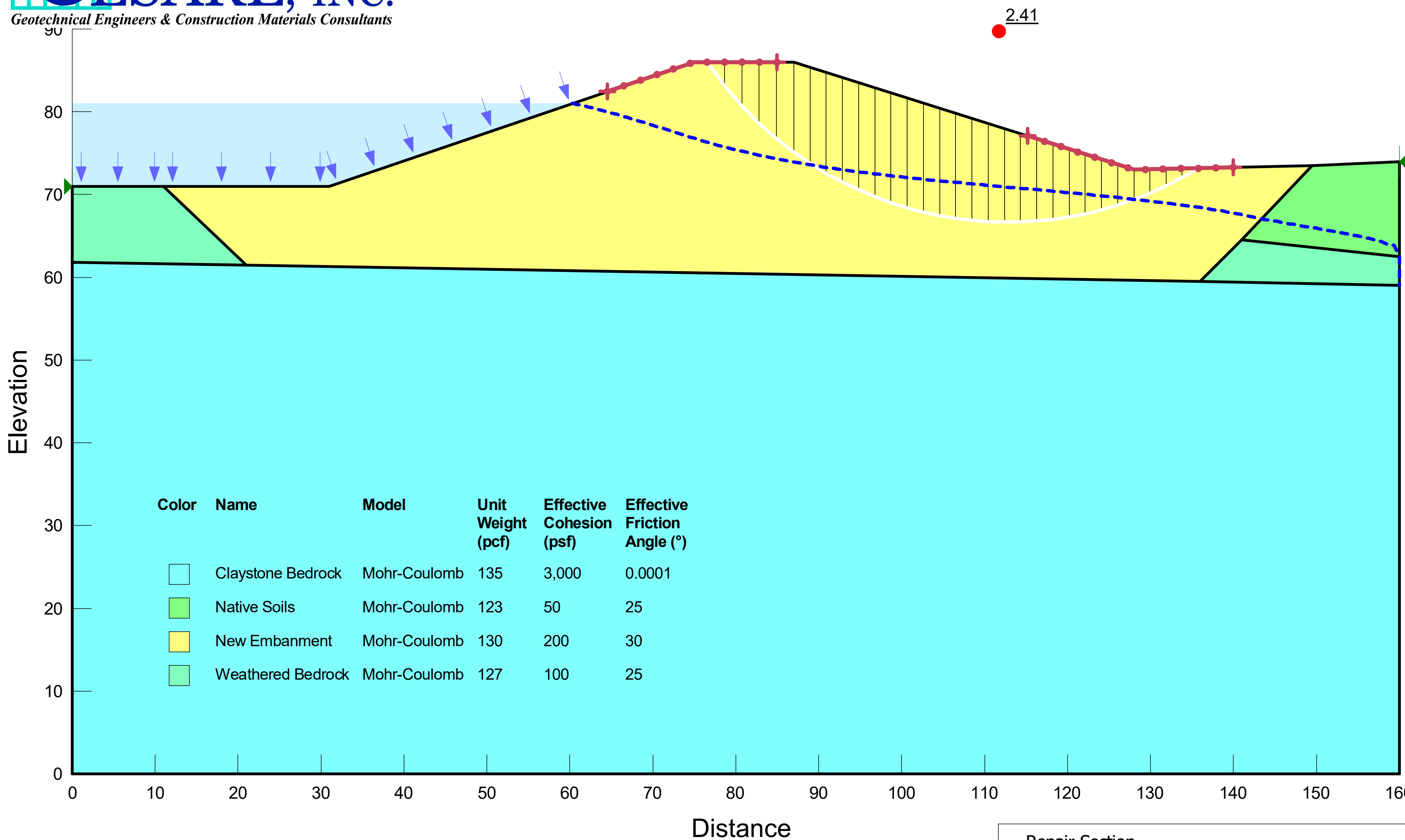
	Native Soils	Mohr-Coulomb	123	50	25
	New Embanment	Mohr-Coulomb	130	200	30
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Repair Section
Full Steady State Seepage
Downstream Block Failure
Critical Failure Surface

CESARE, INC.

Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Native Soils	Mohr-Coulomb	123	50	25
	New Embanment	Mohr-Coulomb	130	200	30
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Repair Section

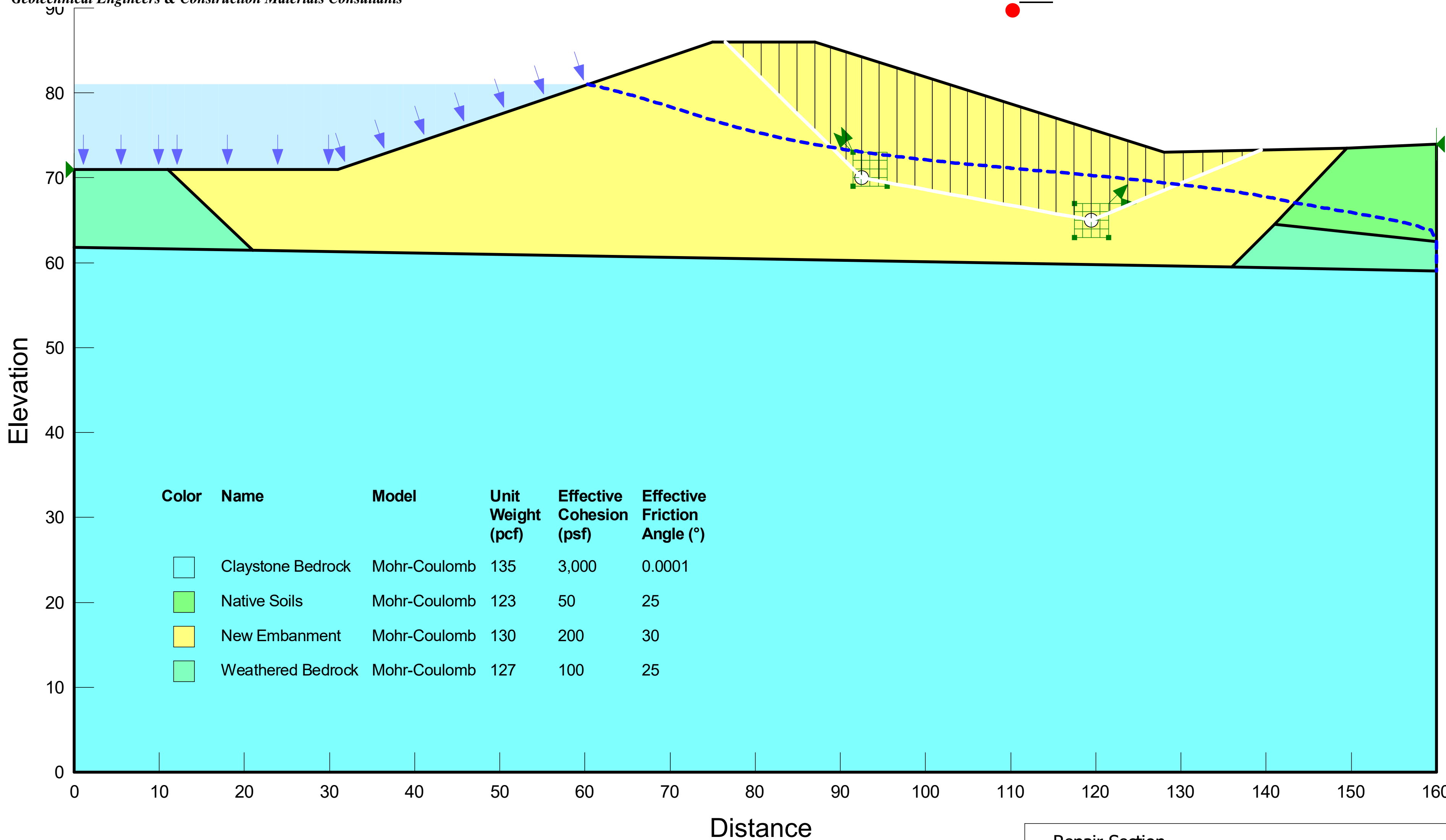
Full Steady State Seepage

Downstream Circular Failure Pseudo Seismic

Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062

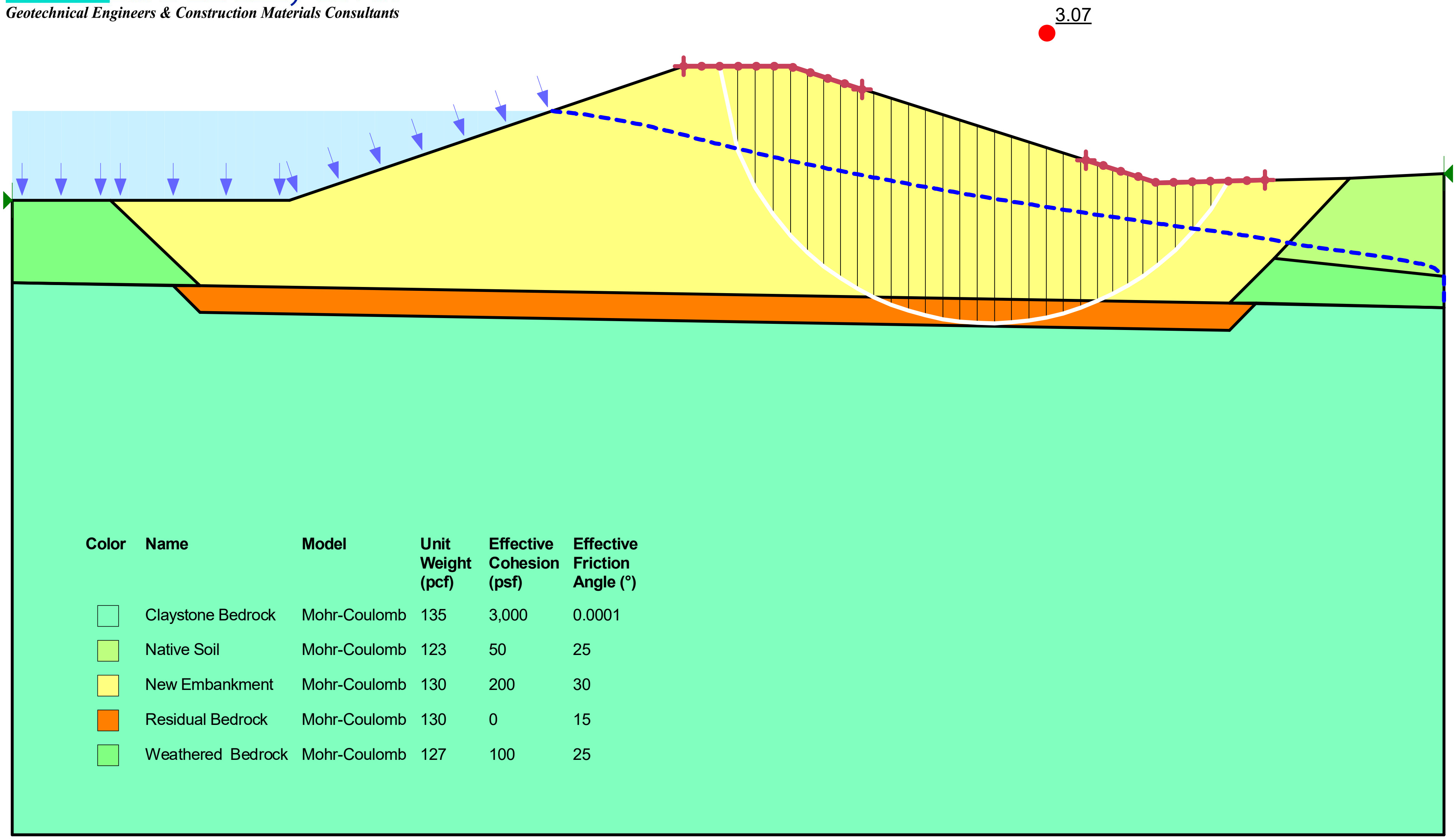


Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Native Soils	Mohr-Coulomb	123	50	25
	New Embanment	Mohr-Coulomb	130	200	30
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Repair Section
Full Steady State Seepage
Downstream Block Failure Pseudo Seismic
Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Native Soil	Mohr-Coulomb	123	50	25
	New Embankment	Mohr-Coulomb	130	200	30
	Residual Bedrock	Mohr-Coulomb	130	0	15
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Repair Section

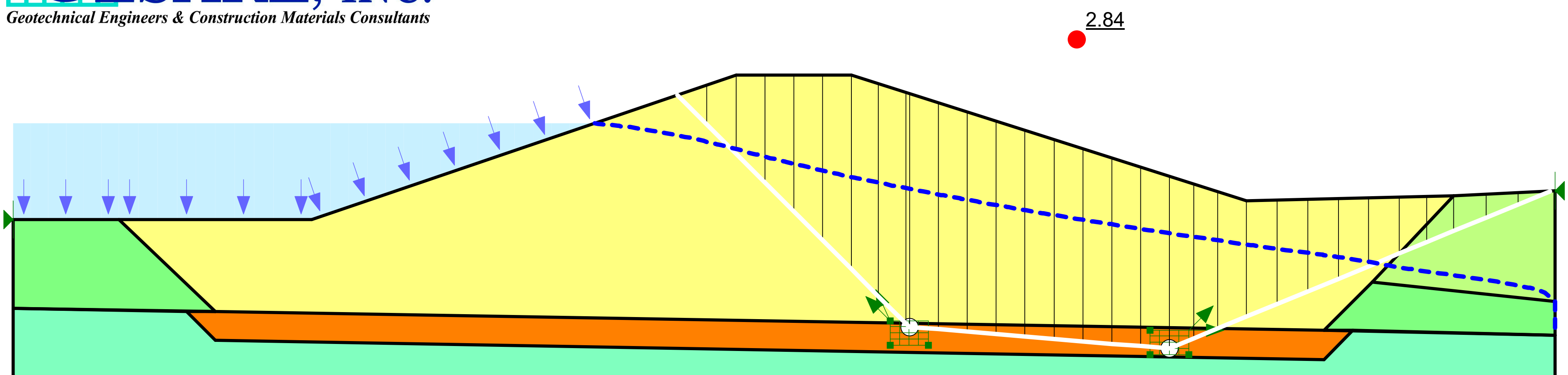
Full Steady State Seepage

Downstream Circular Failure - Residual Bedrock

Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Native Soil	Mohr-Coulomb	123	50	25
	New Embankment	Mohr-Coulomb	130	200	30
	Residual Bedrock	Mohr-Coulomb	130	0	15
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Repair Section

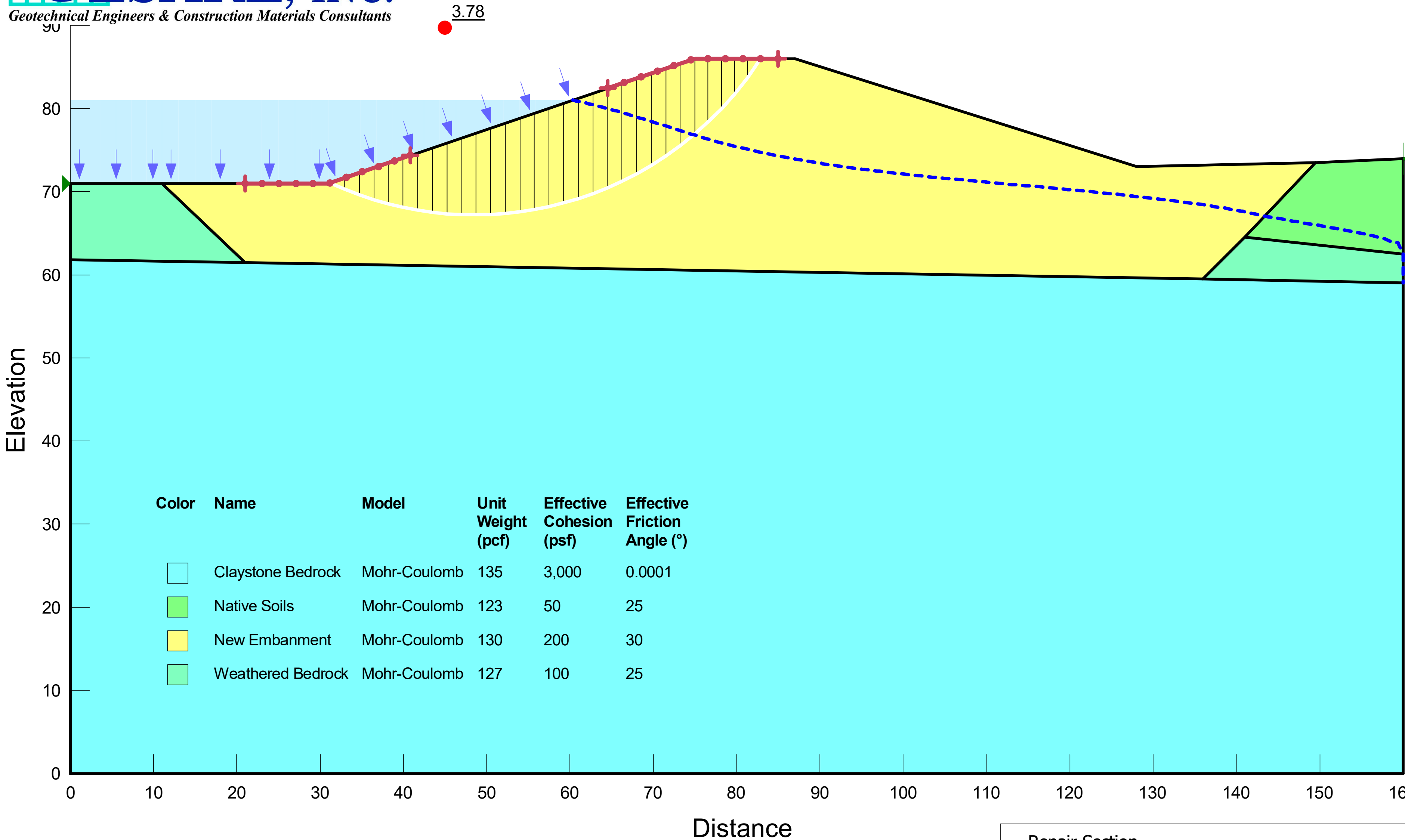
Full Steady State Seepage

Downstream Block Failure - Residual Bedrock

Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Color	Name	Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Claystone Bedrock	Mohr-Coulomb	135	3,000	0.0001
	Native Soils	Mohr-Coulomb	123	50	25
	New Embankment	Mohr-Coulomb	130	200	30
	Weathered Bedrock	Mohr-Coulomb	127	100	25

Repair Section

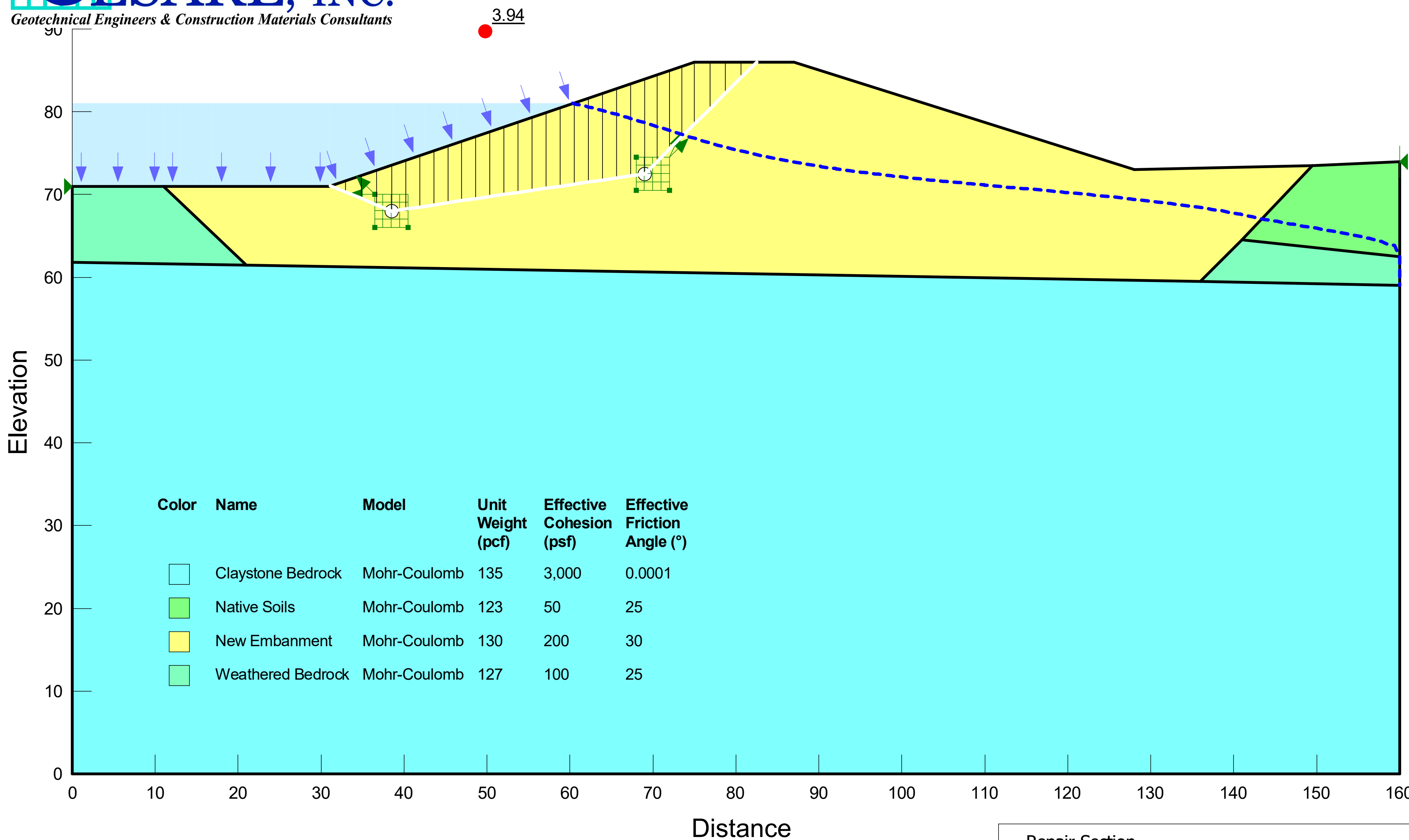
Full Steady State Seepage

Upstream Circular Failure

Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

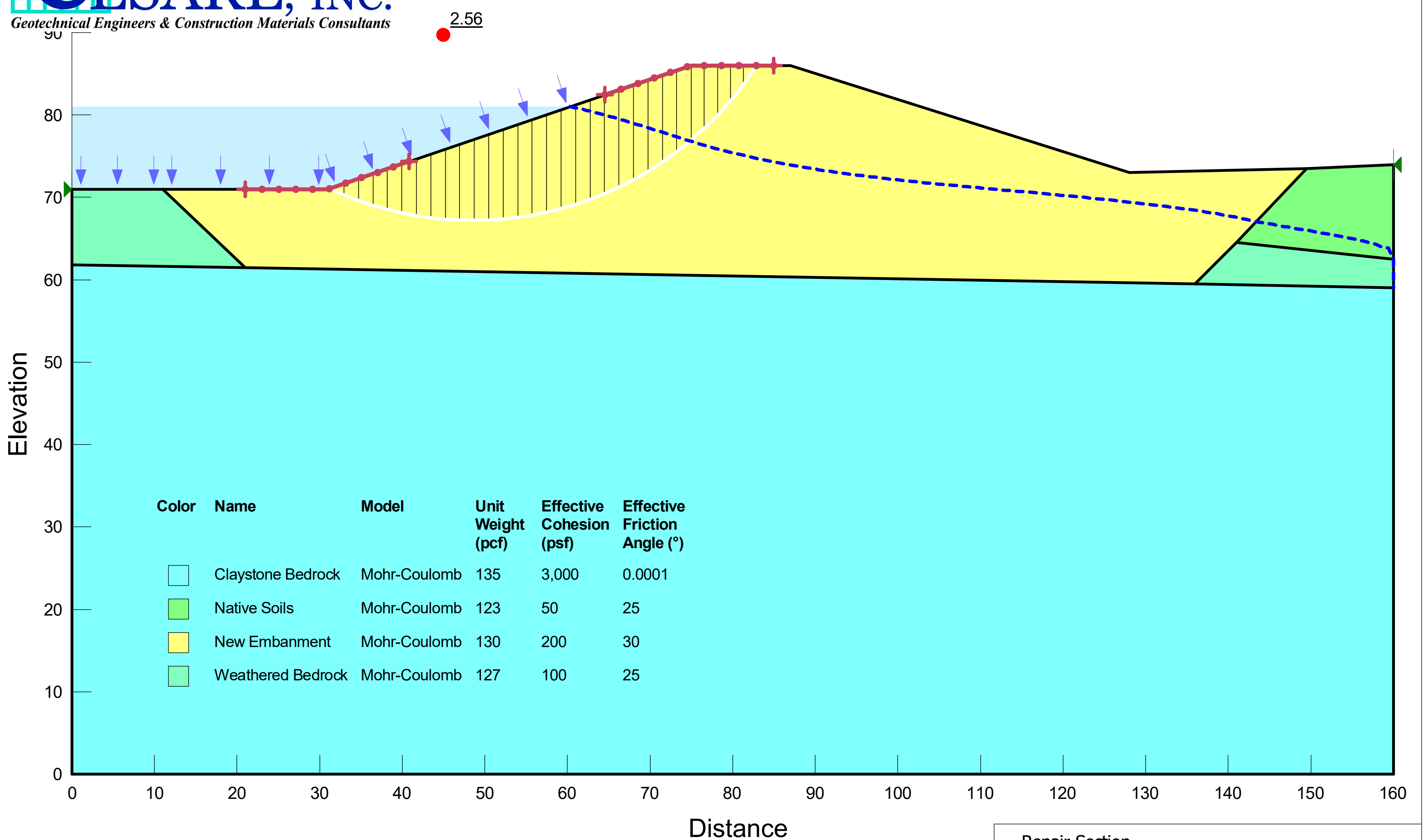
Johnstown Reservoir Outlet Structure
Project No. 20.3062



Repair Section
Full Steady State Seepage
Upstream Block Failure
Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062

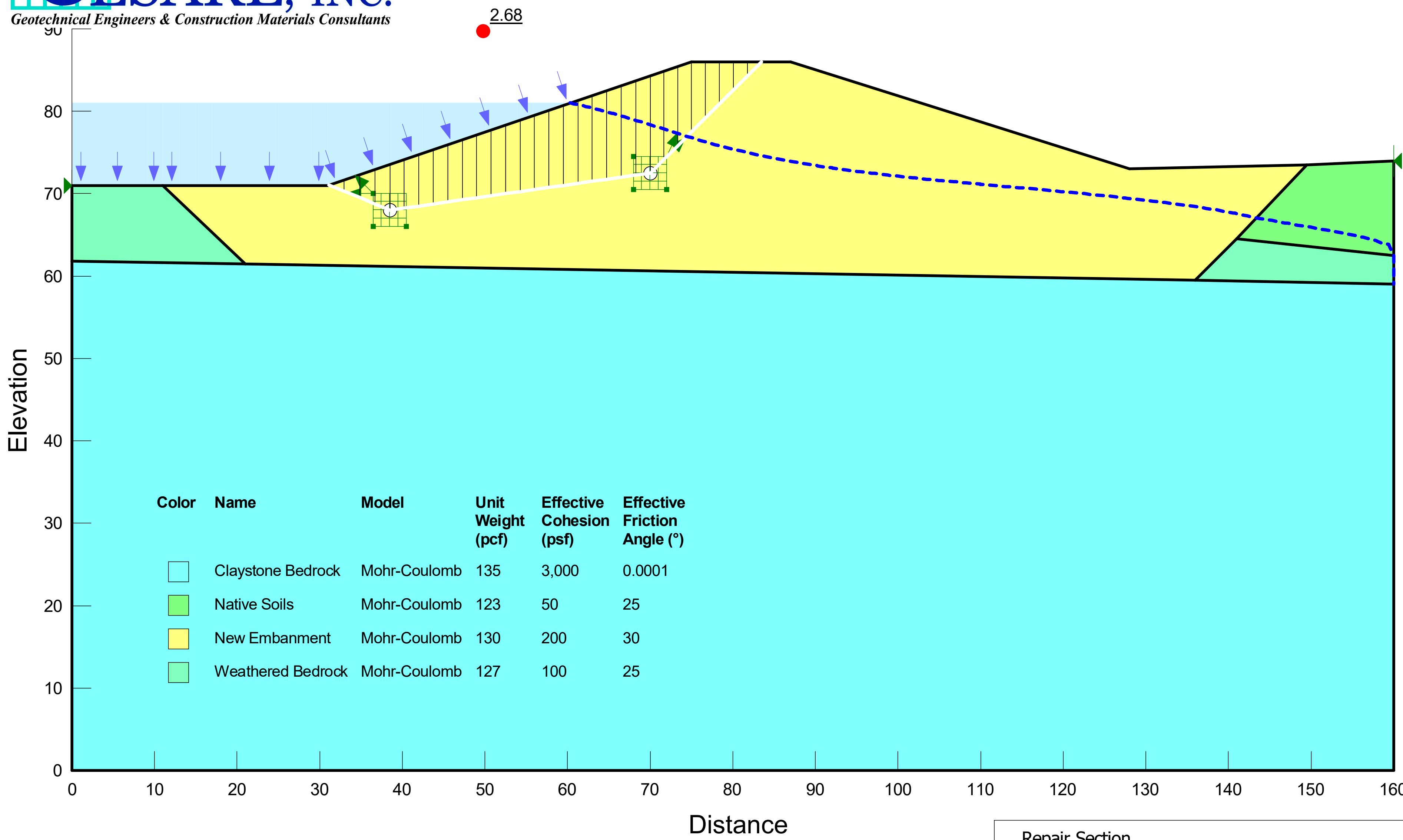


Repair Section
Full Steady State Seepage
Upstream Circular Failure - Pseudo Seismic
Critical Failure Surface

CESARE, INC.

Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Repair Section

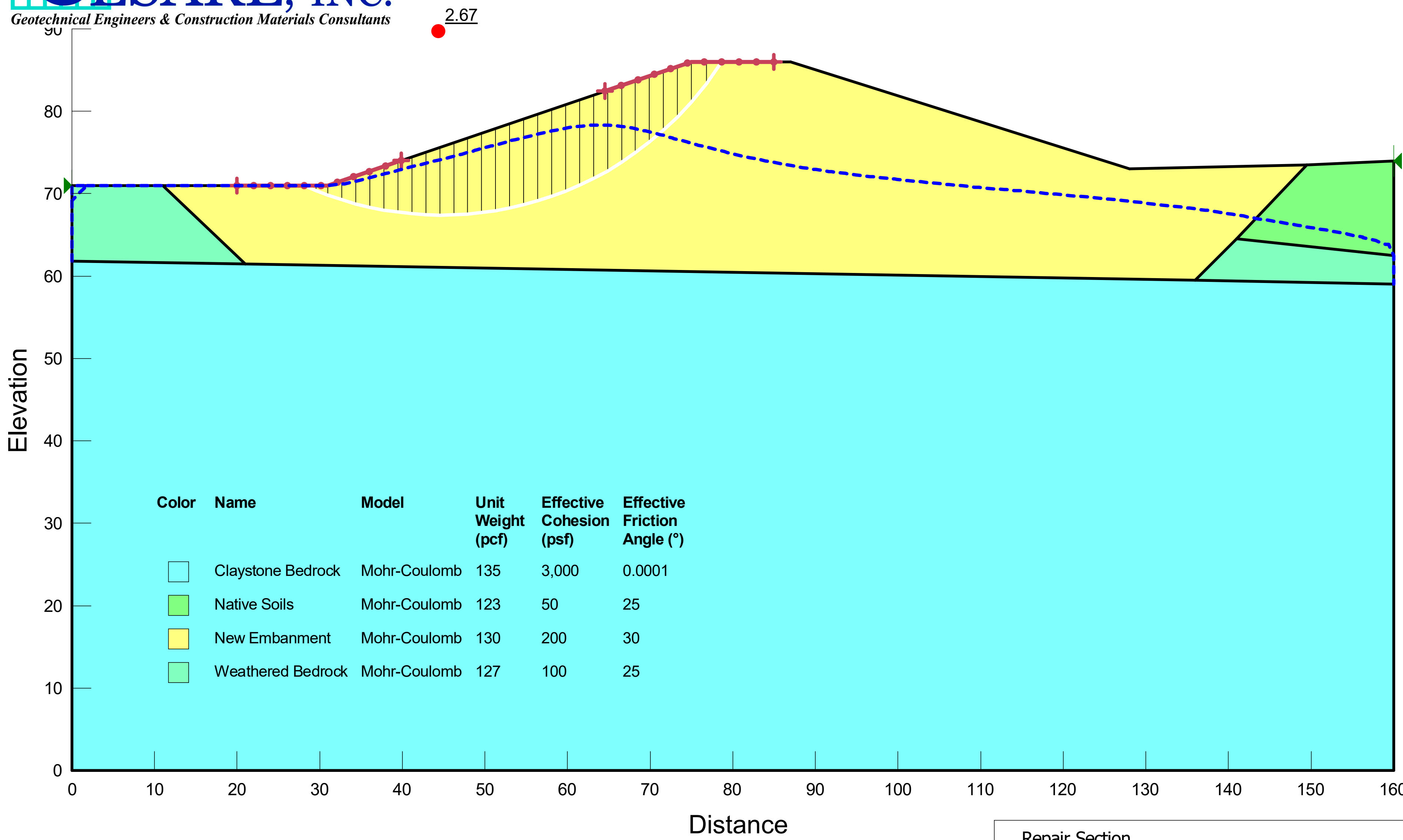
Full Steady State Seepage

Upstream Block Failure - Pseudo Seismic

Critical Failure Surface

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062

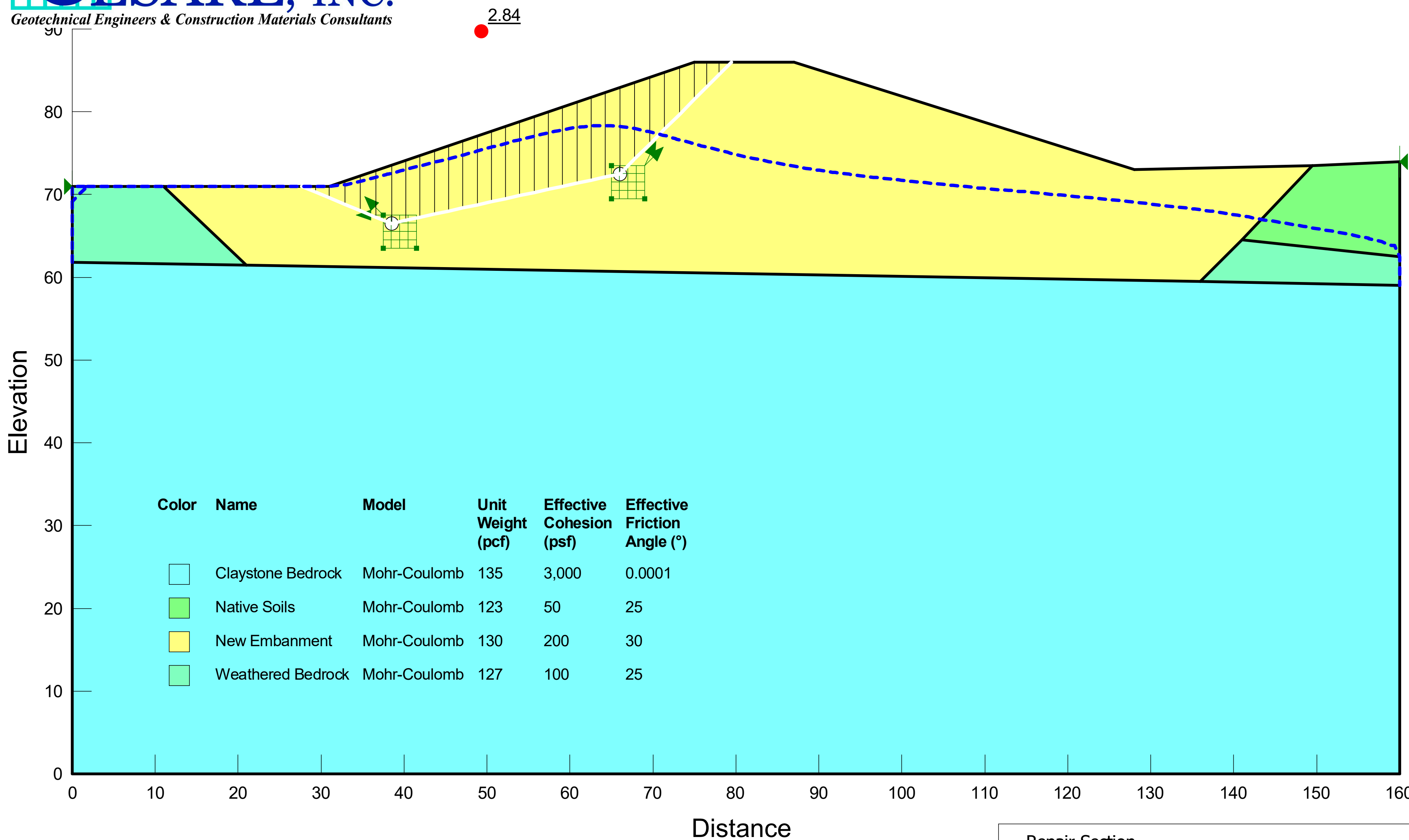


Repair Section
Rapid Drawdown Transient Seepage
Upstream Circular Failure
Lowest Critical Failure Surface of All Time Steps

CESARE, INC.

Geotechnical Engineers & Construction Materials Consultants

Johnstown Reservoir Outlet Structure
Project No. 20.3062



Repair Section
Rapid Drawdown Transient Seepage
Upstream Block Failure
Lowest Critical Failure Surface of All Time Steps

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

May 6, 2021

J.C. York, P.E.
J&T Consulting, Inc.
305 Denver Avenue, Suite D
Fort Lupton, CO 80261

Subject: Johnstown Reservoir Outlet Structure
Outlet Structure and Access Ramp Foundations
Weld County, Colorado
Addendum No. 1
Project No. 20.3062

Dear Mr. York:

Mr. Todd Yee with J&T Consulting, Inc. (J&T) requested recommendations for a foundation design for a proposed outlet tower and access ramp for the subject project. Cesare, Inc. (Cesare) reviewed its original geotechnical engineering evaluation for the project to provide recommendation appropriate to the structures.

The outlet tower will be constructed of cast-in-place concrete located within the embankment near its upstream toe and will have a single discharge elevation within the reservoir. It will bear on straight shaft drill pier foundations embedded in competent bedrock. Cesare understands the top of piers will be at or near the contact of the competent bedrock.

A discharge pipe will extend from the outlet tower below the embankment to a water treatment plant intake pipe downstream of the embankment. The discharge pipe will be encased in concrete bearing on competent bedrock its entire length below the embankment. The existing embankment and its supporting soil will be excavated to competent bedrock contact for the discharge pipe structure.

The proposed access ramp configuration will be two parallel cast-in-place concrete cantilever retaining walls with a space of 11 feet between them. The walls will be cast in lifts and the space between will be backfilled with soil prior to the next lift being cast. The walls are planned to bear on spread footings stepping up from an elevation near the tower pier cap to the embankment crest. Since the embankment will be reconstructed from the competent bedrock contact, wall footings will bear on reconstructed embankment fill.

FOUNDATIONS

OUTLET TOWER

The proposed structure can be supported by straight shaft drilled piers designed in accordance with the following recommendations:

a) The tower floor should be designed as a pier cap.
b) Piers shall have a minimum diameter of 12 inches.

c) Piers shall have a minimum penetration of 26 feet into competent bedrock, which is considered as having blow counts of 50/12 or harder.
d) The minimum pier shaft length is based on measuring from the bottom of the pier cap.
e) Dead load plus full live load of the structure should be used for pier length sizing.
f) Piers shall be designed so that dead loads are as high as reasonably practicable.
g) Maximum allowable end bearing pressure of 25,000 pounds per square foot (psf).
h) Allowable side shear of 2,500 psf for the portion of pier in competent bedrock.
i) No side shear shall be used to resist downward axial load for any portion of the pier in natural soil or manmade fill.
j) No side shear shall be used to resist upward forces within the top 3 feet of the pier shaft.
k) Minimum dead load pressure is assumed to be zero.
l) Piers should be reinforced their full length to resist tension forces.
m) Piers should have a center-to-center spacing of at least 3 pier diameters when designing for vertical loading conditions or be designed as a group.
n) Piers aligned in the direction of lateral forces should have center-to-center spacing of at least 6 pier diameters.
o) Piers should have a maximum length to diameter ratio of about 30 for constructability and observation purposes.
p) It is anticipated that casing will not be needed for most of the drilled shafts. Concrete should be placed as soon as possible after drilling to reduce the potential for caving soil and/or water accumulation. Drilled shafts shall not be allowed to remain open overnight.
q) Concrete should not be placed by freefall through more than 3 inches of water, unless proper tremie techniques are utilized to place concrete from the bottom of the shaft displacing the water or the water is removed.
r) Difficult drilling may be encountered in the hard bedrock. Rock teeth may be required for the bit. Pier penetration may not be decreased unless acceptable by the geotechnical engineer.
s) Concrete for each pier should be formed at the top of the pier, if necessary, to achieve a uniform diameter at the top of the pier. Excess concrete or overpour resulting in enlargement of the pier shall be removed.
t) Proper concrete mixture design for drilled shafts varies with the design stress intensity, anticipated concrete placement procedures, and spacing of the reinforcement. It is recommended that current design and construction procedures outlined by the American Concrete Institute (ACI) and the International Association of Drilled Contractors (ADSC) be followed. Per these guidelines, current practice is to use a concrete mixture design slump in the range of 5 to 7 inches if casing is to be utilized or the shaft is heavily reinforced. A design slump in the range of 7 to 9 inches with 3/4 inch maximum size aggregate is recommended if concrete is to be placed by tremie or pumping methods. Additional recommendations as outlined by ACI and ADCS should also be followed.
u) A Cesare representative should observe pier drilling to confirm that actual subsurface conditions are consistent with those presented in this evaluation. If conditions deviate significantly, drilled pier recommendations may require modification.

ACCESS RAMP WALL FOOTINGS

The proposed structure can be supported by continuous spread footings bearing on controlled, structural fill below frost depth in accordance with the following design recommendations:

a) Weld County Building Code requires a design frost depth of 30 inches, as adopted at the time of this evaluation.
b) Footings should be designed for a maximum allowable soil bearing pressure of 3,000 psf based on dead load plus full live load.
c) Continuous footings should have a minimum width of 18 inches. Using the soil pressure recommended above, Cesare estimates the maximum settlement for the walls will be on the order of 1 inch, with differential settlement potentially on the order of 0.5 inches. Footings should be proportioned as much as practicable to reduce differential settlement.
d) The previously presented estimated settlement will likely be differential to the outlet tower. The retaining walls should be structurally independent from the outlet tower.
e) Steel reinforcement for continuous concrete foundation walls should be designed to span localized settlements over a 10 foot length.
f) All soft or loose soil beneath footing areas should be densified in place, or removed and replaced with properly compacted structural fill, suitable flow fill, or concrete prior to placement of footing concrete.
g) A Cesare representative should observe all footing excavations prior to concrete placement to evaluate if bearing conditions are consistent with those assumed to develop its recommendations.

LATERAL EARTH PRESSURES

Lateral pressures on walls depend on the type of wall, hydrostatic pressure behind the wall, type of backfill material, and allowable wall movements. Cesare understands the location and configuration of the access ramp will necessitate design considering backfill with hydrostatic pressures. Where anticipated wall movements are greater than 0.5% of the wall height, lateral earth pressures can be estimated for an "active" condition. Where anticipated wall movement is less than approximately 0.5% of the wall height or wall movement is constrained, lateral earth pressures should be estimated for an "at rest" condition. Recommended lateral earth pressures for onsite material are provided in the following table.

The recommended values for lateral earth pressures provided in the following table are given in terms of equivalent unit weight. The equivalent unit weight multiplied by the depth below the top of the ground surface is the horizontal pressure against the wall at that depth. The resulting pressure distribution is a triangular shape. These soil pressures are for horizontal backfill with no surcharge loading and with hydrostatic pressure. If these criteria cannot be met, Cesare should be contacted for additional criteria.

Lateral Earth Pressures and Coefficients of Sliding Resistance for Onsite Material

Backfill Material Type	Location	Equivalent Unit Weight (pcf)			Coefficient of Sliding Resistance
		Active	At Rest	Passive	
Saturated sandy clay	Between access ramp walls	90	100	285	0.35

This addendum should be attached to the original report[1] and made a part thereof. Please contact Cesare with any questions or comments regarding this information.

Sincerely,
CESARE, INC.

Jonathan A. Crystal, P.E.
Project Engineer

JAC2/ksm

cc: Mr. Todd Yee, J&T Consulting, Inc., toddyee@j-tconsulting.com

[1] Geotechnical Evaluation, Johnstown Reservoir Outlet Structure, Weld County, Colorado, Project No. 20.3062, dated February 19, 2021.

Appendix I. Structural Design Calculations

The Lepetsos Group, Inc.

Structural Engineering Consultants

Tower and Abutment Analyses

Town of Johnstown

Johnstown Reservoir Repair

Weld County, Colorado

Water Division 1, Water District 4

Dam ID - 040132

Job LG-21-2259   June 27, 2021

Prepared for Todd Yee, P.E.

J&T Consulting

305 Denver Boulevard, Suite 105

Fort Lupton, CO.

COLORADO REGISTERED PROFESSIONAL ENGINEER
GREGORY NICHOLAS LEPETSOS
28787

Tower and Abutment Analyses

NOTE: The current revision of this document is REV NEW.
Information contained in this document supercedes all other revisions.

INTRODUCTION

J&T Consulting requested The Lepetsos Group, Inc perform structural analysis of two cast-in-place reinforced concrete structures for this project:

20-foot-tall 6' x 7' Tower

60-foot-long Abutment to support concrete tee bridge (by others)

ANALYSIS APPROACH

Tower

The tower was designed to be supported on four deep concrete piers per J&T Drawing Sheet 13.

The critical load case for structure stability including over-turning, and for pier and soil bearing evaluation was with the reservoir empty and the tower exposed to maximum wind loading.

The maximum over-turning moment was 42,000 ft-lbs
The minimum restoring moment was 283,050 ft-lbs

Since 283,050 ft-lbs > 42,000 ft-lbs, the piers are never in tension under empty reservoir conditions.

The vertical pier capacity was computed to be 200,276 lbs

The max pier load was computed to be 27,088 lbs

Since 200,276 lbs > 27,088 lbs OK

Buoyancy analysis was also performed.

Under a full reservoir condition, the buoyant force was computed to be 52,416 lbs
The weight of the concrete structure was reduced by 10% to determine the weight resisting buoyancy.

Structure wt = (0.9) x 94,350 = 84,915 lbs.

Therefore since 84,915 lbs. > 52,416 lbs, the piers are not in tension under the full reservoir condition.

The critical load case for the tower wall design occurred with the reservoir full of water.

The long wall (20' tall by 7' wide with 5' internal dimension) was modeled using RIAS-3D finite element software.

Ultimate load factors were applied within the RISA analysis, and therefore factors of 1.0 were used in the spreadsheet.

The RISA model showed #5 rebar on 12" centers both faces, both surfaces with all appropriate end and corner splices and hooks was adequate.

The RISA-3D results and hand calculations are provided in the attachment.

Abutment

The Abutment was analyzed using hand methods.

The allowable soil bearing pressure for the continuous footing was 3,000 psf (per the Cesare Report).

The maximum applied soil pressure was computed to be 1,494 psf.

Since 3,000 psf > 1,494 psf OK

CONCLUSIONS

In my opinion, the Tower and Abutment Structures will be capable of withstanding the applied loads.

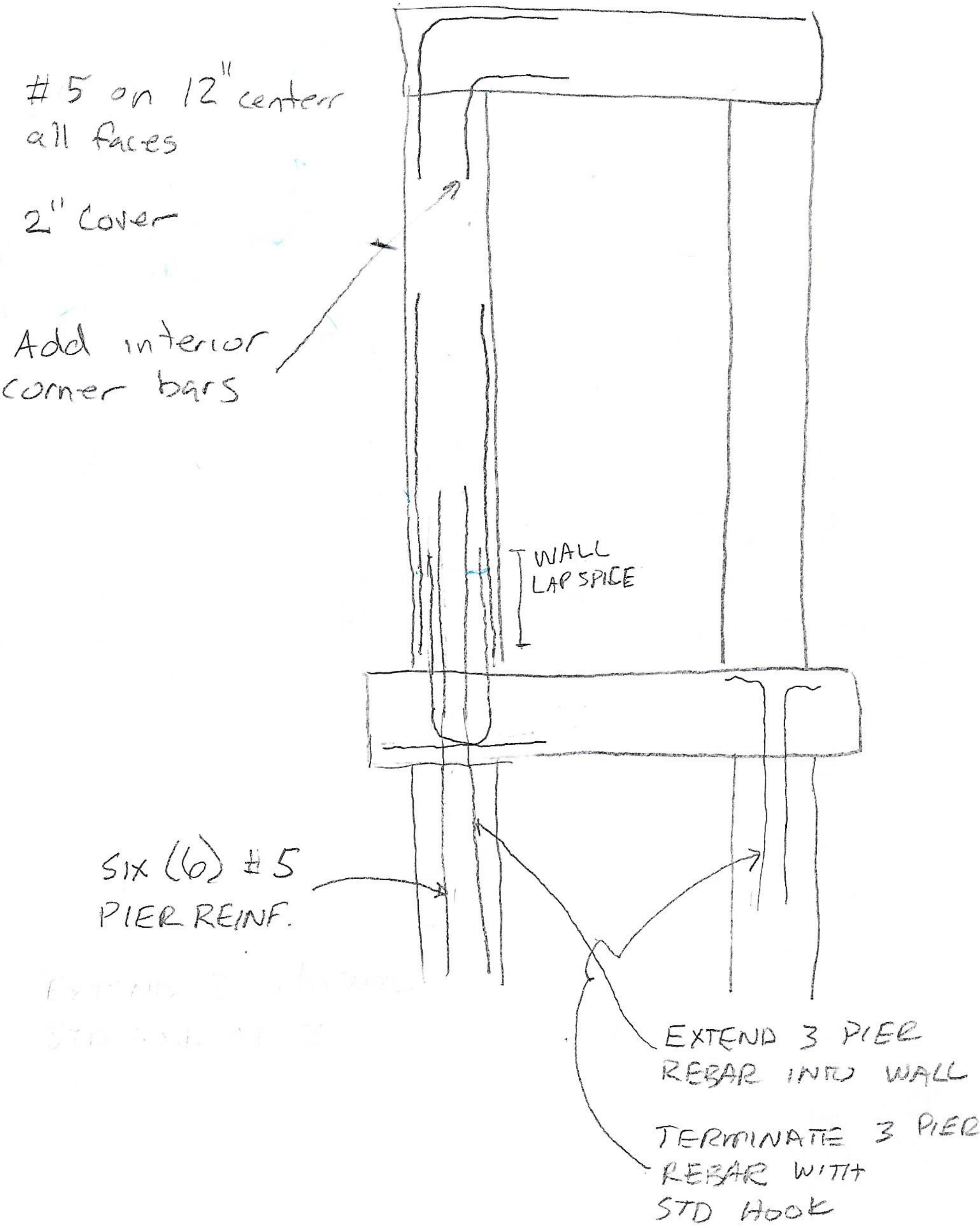
Please contact this office if you have any questions regarding these findings or if I can be of service in any way.

Regards,

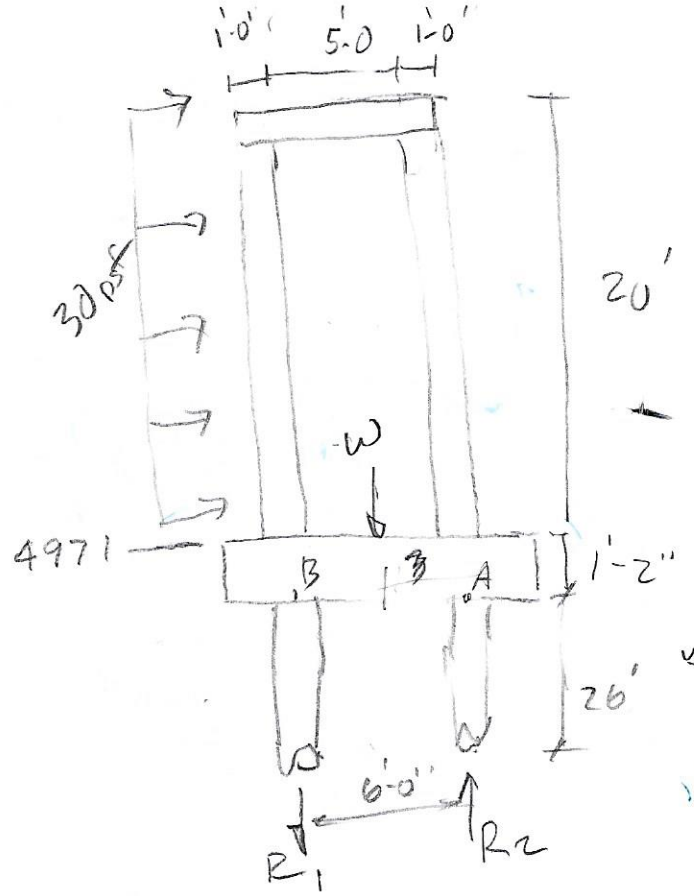
(electronically signed on cover page)

____

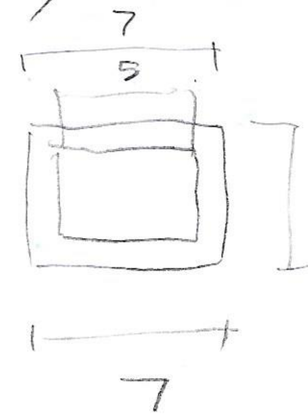
Gregory N. Lepetsos, P.E., M.S.C.E.
President, The Lepetsos Group, Inc.



5 on 12" centers
all faces
2" Cover
Add interior
corner bars
WALL
LAP SPICE
SIX (6) # 5
PIER REINF.
EXTEND 3 PIER
REBAR INTO WALL
TERMINATE 3 PIER
REBAR WITH
STD HOOK



Empty reservoir
Weld County



Mwind

$30(7)(20) \times \frac{20}{2} = 42{,}000$

wt = 4 walls + base + 4 piers + top

walls $2(5)(20) + 2(6)(20) =$
$200 + 240 = 440\ ft^3$

Base $(8 \times 7 \times 1.167) = 65\ ft^3$

piers $\frac{\pi(1)^2}{4} \times 4 \times 26 = 82\ ft^3$

top $6 \times 7 \times 1 = 42\ ft^2$

Total = $629\ ft^3$

wt = $629 \times 150 = 94{,}350$ lb

$M_R = 94{,}350 \times 3 = 283{,}050$ ft-lb

$M_{OT} = 42{,}000$ ft-lb
$M_R = 283{,}050$ ft-lb

∴ piers are never in uplift cond since 283,050 >> 42,000

$\circlearrowleft \Sigma M_B = 0 \quad 42000 + 94350(3) = (2)(6)(R_2)$

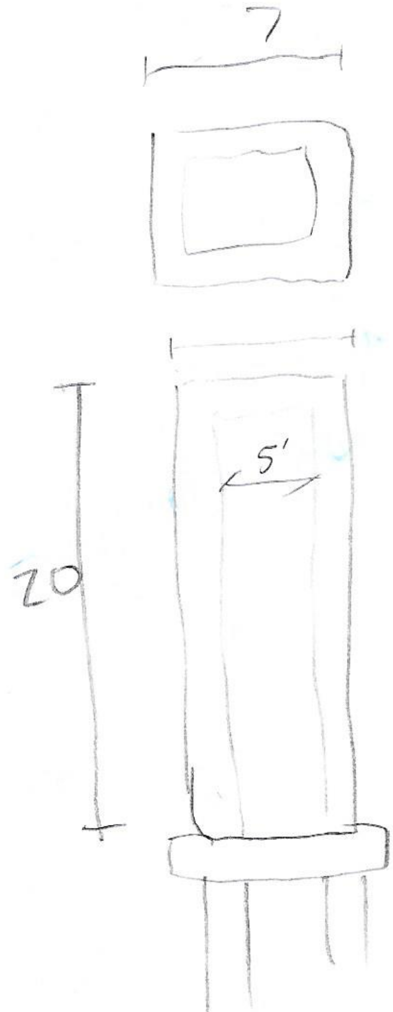
$R_2 = 27{,}088$ lb. $\quad R_1 = 20{,}087$

Pier area = .785 in^2

allowable end bearing = $25{,}000 \times .785 = 19635$ lb

Side shear $= (26-3)(\pi)(1)(2500) = 180641$ lb

Total pier cap = 180641 + 19635 = 200,276
since 200,276 >> 27,088 OK



- Wind governs for overturning and pier design
- water pressure governs for tower wall design

M_x max = 738.9

M_y max = 1,000.6

Ult max mom = 1.6 (1000.6)
= 1601 lb/ft

#5 @ 12" from spread sheet is OK since 13.2 >> 1.6

min steel per section 10.5 is not req'd because As provided is more than 1/3 greater than that req'd by analysis (10.5.3

6-9-21

Johnstown Tower

Bridge Abutment Footing per note 2 LL = 50psf

3000 psf allowable soil bearing pressure (p3)

Section A-A Double Tee 39,530 lb for 59'-4" long

lbs 666 lb/ft

Worst case is snow load

Span = 40'

width = 6'

DL = (40)(666)

+ (5 × 1 × 6) × 150

+ 8 × 1 × 2) × 150

= 26640 + 4500 + 2400 = 33540 lb total

LL = 6 × 40 × 50 = 12,000

Abutment load = $\frac{(33540 + 12000)}{2}$ = 22770 lb

Use 5% for railings

22770 + 5% (22770) = 23909 lb

Footing area = 2 × 8 = 16

Applied soil pressure = $\frac{23909}{16}$ = 1494 psf

Since 1494 < 3000 OK ←

Double tee bearing on Tower

Area = (2 web) × 7" × 6" = 84 in^2

bearing wt = 21388.5

pressure = $\frac{21388.5}{84}$ = 255 psi ← OK

Date: June 27, 2021

Job	Johnstown Reservoir Tower
Client	Todd Yee/ J&T Consulting
Item	***Tower Wall***

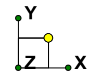
Num of Bars	1		Ultimate Load Factors		
Bar Size	5		DL	1	
Bar Dia	0.625	in	LL	1	
Single Bar Area	0.31	in^2	Applied Moments		
Total Bar Area	0.31	in^2	DL	0	k-ft
			LL	1.60	k-ft
			Mu =	1.6	k-ft
Beam Depth, D	12	in	Material Strengths		
Beam Width, b	12	in	f'c =	4	ksi
Cover, c	2	in	fy =	60	ksi

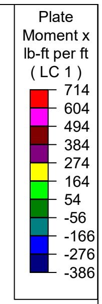
a =	As fy / 0.85 f'c b	=	0.46	in
d =	(D - c - 1/2 bar dia)	=	9.69	in
Md =	0.9 As fy[d-a/2]	=	158.4	k-in
		=	13.2	k-ft

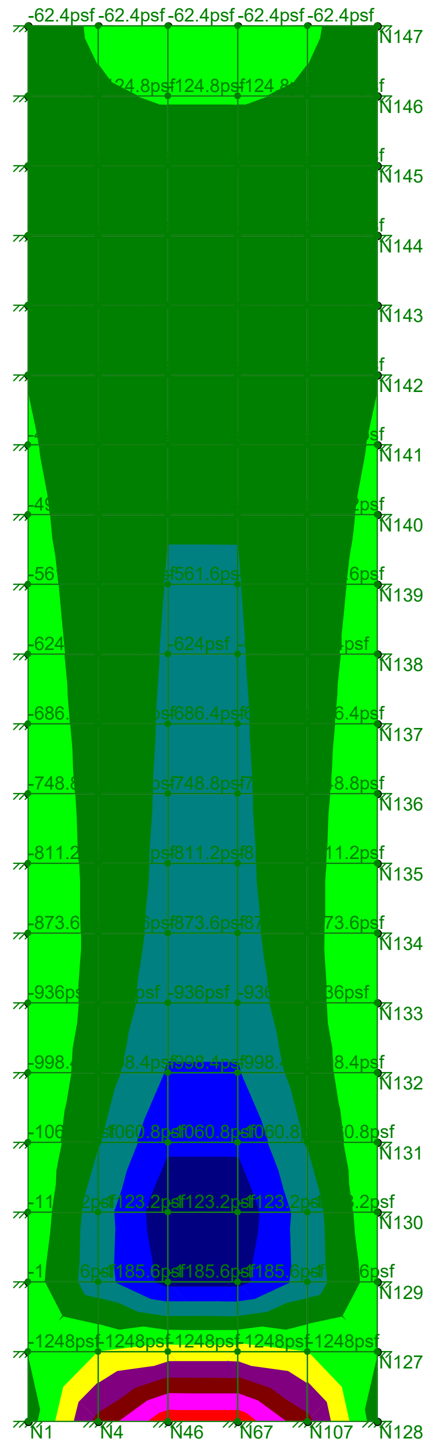
SINCE	13.2	>	1.6	OK

ACI 318 10.5.1 Min Reinf of Flexural Members — $A_{s, min}$ = 0.367615 NO GOOD

if NO GOOD per 10.5.1, check 10.5.3 — OK

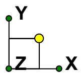


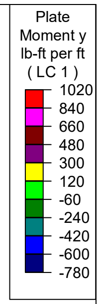


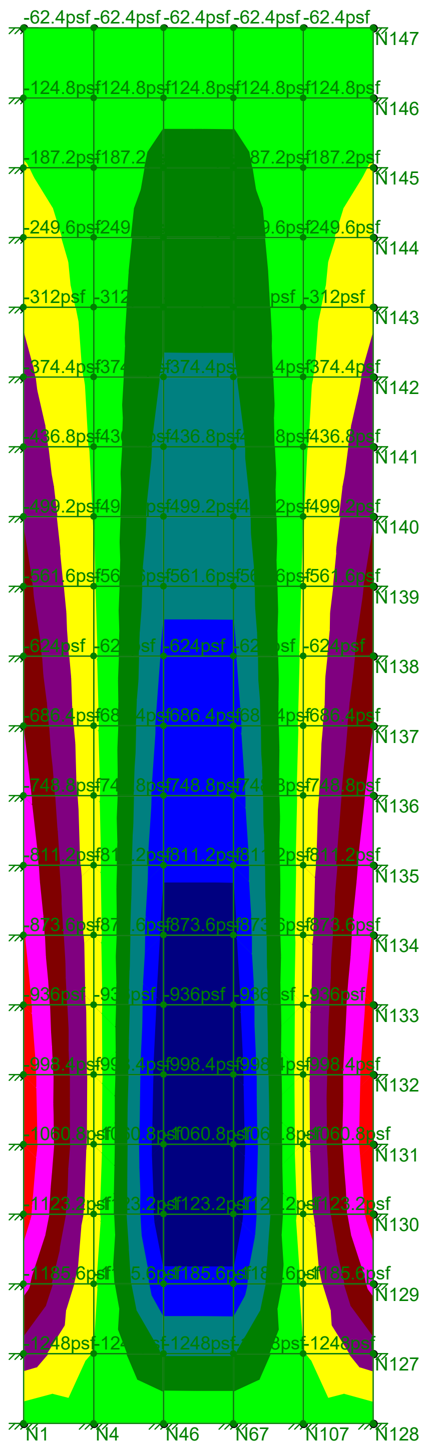


Loads: BLC 1,
Results for LC 1,

		SK - 1
		June 27, 2021 at 11:51 AM
	Mx Moment	untitled.r3d







Loads: BLC 1,
Results for LC 1,

		SK - 2
		June 27, 2021 at 11:51 AM
	My Moment	untitled.r3d

Global

Display Sections for Member Calcs	5
Max Internal Sections for Member Calcs	97
Include Shear Deformation?	Yes
Increase Nailing Capacity for Wind?	Yes
Include Warping?	Yes
Trans Load Btwn Intersecting Wood Wall?	Yes
Area Load Mesh (in^2)	144
Merge Tolerance (in)	.12
P-Delta Analysis Tolerance	0.50%
Include P-Delta for Walls?	Yes
Automatically Iterate Stiffness for Walls?	Yes
Max Iterations for Wall Stiffness	3
Gravity Acceleration (ft/sec^2)	32.2
Wall Mesh Size (in)	24
Eigensolution Convergence Tol. (1.E-)	4
Vertical Axis	Y
Global Member Orientation Plane	XZ
Static Solver	Sparse Accelerated
Dynamic Solver	Accelerated Solver

Hot Rolled Steel Code	AISC 14th(360-10): ASD
Adjust Stiffness?	Yes(Iterative)
RISAConnection Code	AISC 14th(360-10): ASD
Cold Formed Steel Code	AISI S100-12: ASD
Wood Code	AF&PA NDS-12: ASD
Wood Temperature	< 100F
Concrete Code	ACI 318-11
Masonry Code	ACI 530-13: ASD
Aluminum Code	AA ADM1-10: ASD - Building

Number of Shear Regions	4
Region Spacing Increment (in)	4
Biaxial Column Method	Exact Integration
Parme Beta Factor (PCA)	.65
Concrete Stress Block	Rectangular
Use Cracked Sections?	Yes
Use Cracked Sections Slab?	Yes
Bad Framing Warnings?	No
Unused Force Warnings?	Yes
Min 1 Bar Diam. Spacing?	No
Concrete Rebar Set	REBAR_SET_ASTMA615
Min % Steel for Column	1
Max % Steel for Column	8

Global, Continued

Seismic Code	ASCE 7-10
Seismic Base Elevation (ft)	Not Entered
Add Base Weight?	Yes
Ct X	.02
Ct Z	.02
T X (sec)	Not Entered
T Z (sec)	Not Entered
R X	3
R Z	3
Ct Exp. X	.75
Ct Exp. Z	.75
SD1	1
SDS	1
S1	1
TL (sec)	5
Risk Cat	I or II
Om Z	1
Om X	1
Rho Z	1
Rho X	1

General Material Properties

	Label	E [ksi]	G [ksi]	Nu	Therm (\1E5 F)	Density[k/ft^3]
1	gen_Conc3NW	3155	1372	.15	.6	.145
2	gen_Conc4NW	3644	1584	.15	.6	.145
3	gen_Conc3LW	2085	906	.15	.6	.11
4	gen_Conc4LW	2408	1047	.15	.6	.11
5	gen_Alum	10600	4077	.3	1.29	.173
6	gen_Steel	29000	11154	.3	.65	.49
7	RIGID	1e+6		.3	0	0

General Section Sets

	Label	Shape	Type	Material	A [in2]	Iyy [in4]	Izz [in4]	J [in4]
1	GEN1	RE4X4	Beam	gen_Conc3NW	16	21.333	21.333	31.573
2	RIGID		None	RIGID	1e+6	1e+6	1e+6	1e+6

Joint Coordinates and Temperatures

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
1	N1	0	0	0	0	
2	N2	0	1	0	0	
3	N3	1	1	0	0	
4	N4	1	0	0	0	
5	N5	0	2	0	0	
6	N6	1	2	0	0	
7	N7	0	3	0	0	
8	N8	1	3	0	0	
9	N9	0	4	0	0	
10	N10	1	4	0	0	
11	N11	0	5	0	0	
12	N12	1	5	0	0	
13	N13	0	6	0	0	
14	N14	1	6	0	0	
15	N15	0	7	0	0	

Joint Coordinates and Temperatures (Continued)

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
16	N16	1	7	0	0	
17	N17	0	8	0	0	
18	N18	1	8	0	0	
19	N19	0	9	0	0	
20	N20	1	9	0	0	
21	N21	0	10	0	0	
22	N22	1	10	0	0	
23	N23	0	11	0	0	
24	N24	1	11	0	0	
25	N25	0	12	0	0	
26	N26	1	12	0	0	
27	N27	0	13	0	0	
28	N28	1	13	0	0	
29	N29	0	14	0	0	
30	N30	1	14	0	0	
31	N31	0	15	0	0	
32	N32	1	15	0	0	
33	N33	0	16	0	0	
34	N34	1	16	0	0	
35	N35	0	17	0	0	
36	N36	1	17	0	0	
37	N37	0	18	0	0	
38	N38	1	18	0	0	
39	N39	0	19	0	0	
40	N40	1	19	0	0	
41	N41	0	20	0	0	
42	N42	1	20	0	0	
43	N45	2	1	0	0	
44	N46	2	0	0	0	
45	N48	2	2	0	0	
46	N50	2	3	0	0	
47	N52	2	4	0	0	
48	N54	2	5	0	0	
49	N56	2	6	0	0	
50	N58	2	7	0	0	
51	N60	2	8	0	0	
52	N62	2	9	0	0	
53	N64	2	10	0	0	
54	N66	2	11	0	0	
55	N68	2	12	0	0	
56	N70	2	13	0	0	
57	N72	2	14	0	0	
58	N74	2	15	0	0	
59	N76	2	16	0	0	
60	N78	2	17	0	0	
61	N80	2	18	0	0	
62	N82	2	19	0	0	
63	N84	2	20	0	0	
64	N66A	3	1	0	0	
65	N67	3	0	0	0	
66	N69	3	2	0	0	
67	N71	3	3	0	0	
68	N73	3	4	0	0	
69	N75	3	5	0	0	
70	N77	3	6	0	0	
71	N79	3	7	0	0	
72	N81	3	8	0	0	

Joint Coordinates and Temperatures (Continued)

	Label	X [ft]	Y [ft]	Z [ft]	Temp [F]	Detach From Diap...
73	N83	3	9	0	0	
74	N85	3	10	0	0	
75	N87	3	11	0	0	
76	N89	3	12	0	0	
77	N91	3	13	0	0	
78	N93	3	14	0	0	
79	N95	3	15	0	0	
80	N97	3	16	0	0	
81	N99	3	17	0	0	
82	N101	3	18	0	0	
83	N103	3	19	0	0	
84	N105	3	20	0	0	
85	N106	4	1	0	0	
86	N107	4	0	0	0	
87	N108	4	2	0	0	
88	N109	4	3	0	0	
89	N110	4	4	0	0	
90	N111	4	5	0	0	
91	N112	4	6	0	0	
92	N113	4	7	0	0	
93	N114	4	8	0	0	
94	N115	4	9	0	0	
95	N116	4	10	0	0	
96	N117	4	11	0	0	
97	N118	4	12	0	0	
98	N119	4	13	0	0	
99	N120	4	14	0	0	
100	N121	4	15	0	0	
101	N122	4	16	0	0	
102	N123	4	17	0	0	
103	N124	4	18	0	0	
104	N125	4	19	0	0	
105	N126	4	20	0	0	
106	N127	5	1	0	0	
107	N128	5	0	0	0	
108	N129	5	2	0	0	
109	N130	5	3	0	0	
110	N131	5	4	0	0	
111	N132	5	5	0	0	
112	N133	5	6	0	0	
113	N134	5	7	0	0	
114	N135	5	8	0	0	
115	N136	5	9	0	0	
116	N137	5	10	0	0	
117	N138	5	11	0	0	
118	N139	5	12	0	0	
119	N140	5	13	0	0	
120	N141	5	14	0	0	
121	N142	5	15	0	0	
122	N143	5	16	0	0	
123	N144	5	17	0	0	
124	N145	5	18	0	0	
125	N146	5	19	0	0	
126	N147	5	20	0	0	

Plate Primary Data

	Label	A Joint	B Joint	C Joint	D Joint	Material	Thickness[in]
1	P1	N1	N2	N3	N4	gen_Conc3NW	12
2	P2	N2	N5	N6	N3	gen_Conc3NW	12
3	P3	N5	N7	N8	N6	gen_Conc3NW	12
4	P4	N7	N9	N10	N8	gen_Conc3NW	12
5	P5	N9	N11	N12	N10	gen_Conc3NW	12
6	P6	N11	N13	N14	N12	gen_Conc3NW	12
7	P7	N13	N15	N16	N14	gen_Conc3NW	12
8	P8	N15	N17	N18	N16	gen_Conc3NW	12
9	P9	N17	N19	N20	N18	gen_Conc3NW	12
10	P10	N19	N21	N22	N20	gen_Conc3NW	12
11	P11	N21	N23	N24	N22	gen_Conc3NW	12
12	P12	N23	N25	N26	N24	gen_Conc3NW	12
13	P13	N25	N27	N28	N26	gen_Conc3NW	12
14	P14	N27	N29	N30	N28	gen_Conc3NW	12
15	P15	N29	N31	N32	N30	gen_Conc3NW	12
16	P16	N31	N33	N34	N32	gen_Conc3NW	12
17	P17	N33	N35	N36	N34	gen_Conc3NW	12
18	P18	N35	N37	N38	N36	gen_Conc3NW	12
19	P19	N37	N39	N40	N38	gen_Conc3NW	12
20	P20	N39	N41	N42	N40	gen_Conc3NW	12
21	P21	N4	N3	N45	N46	gen_Conc3NW	12
22	P22	N3	N6	N48	N45	gen_Conc3NW	12
23	P23	N6	N8	N50	N48	gen_Conc3NW	12
24	P24	N8	N10	N52	N50	gen_Conc3NW	12
25	P25	N10	N12	N54	N52	gen_Conc3NW	12
26	P26	N12	N14	N56	N54	gen_Conc3NW	12
27	P27	N14	N16	N58	N56	gen_Conc3NW	12
28	P28	N16	N18	N60	N58	gen_Conc3NW	12
29	P29	N18	N20	N62	N60	gen_Conc3NW	12
30	P30	N20	N22	N64	N62	gen_Conc3NW	12
31	P31	N22	N24	N66	N64	gen_Conc3NW	12
32	P32	N24	N26	N68	N66	gen_Conc3NW	12
33	P33	N26	N28	N70	N68	gen_Conc3NW	12
34	P34	N28	N30	N72	N70	gen_Conc3NW	12
35	P35	N30	N32	N74	N72	gen_Conc3NW	12
36	P36	N32	N34	N76	N74	gen_Conc3NW	12
37	P37	N34	N36	N78	N76	gen_Conc3NW	12
38	P38	N36	N38	N80	N78	gen_Conc3NW	12
39	P39	N38	N40	N82	N80	gen_Conc3NW	12
40	P40	N40	N42	N84	N82	gen_Conc3NW	12
41	P41	N46	N45	N66A	N67	gen_Conc3NW	12
42	P42	N45	N48	N69	N66A	gen_Conc3NW	12
43	P43	N48	N50	N71	N69	gen_Conc3NW	12
44	P44	N50	N52	N73	N71	gen_Conc3NW	12
45	P45	N52	N54	N75	N73	gen_Conc3NW	12
46	P46	N54	N56	N77	N75	gen_Conc3NW	12
47	P47	N56	N58	N79	N77	gen_Conc3NW	12
48	P48	N58	N60	N81	N79	gen_Conc3NW	12
49	P49	N60	N62	N83	N81	gen_Conc3NW	12
50	P50	N62	N64	N85	N83	gen_Conc3NW	12
51	P51	N64	N66	N87	N85	gen_Conc3NW	12
52	P52	N66	N68	N89	N87	gen_Conc3NW	12
53	P53	N68	N70	N91	N89	gen_Conc3NW	12
54	P54	N70	N72	N93	N91	gen_Conc3NW	12
55	P55	N72	N74	N95	N93	gen_Conc3NW	12
56	P56	N74	N76	N97	N95	gen_Conc3NW	12

Plate Primary Data (Continued)

	Label	A Joint	B Joint	C Joint	D Joint	Material	Thickness[in]
57	P57	N76	N78	N99	N97	gen_Conc3NW	12
58	P58	N78	N80	N101	N99	gen_Conc3NW	12
59	P59	N80	N82	N103	N101	gen_Conc3NW	12
60	P60	N82	N84	N105	N103	gen_Conc3NW	12
61	P61	N67	N66A	N106	N107	gen_Conc3NW	12
62	P62	N66A	N69	N108	N106	gen_Conc3NW	12
63	P63	N69	N71	N109	N108	gen_Conc3NW	12
64	P64	N71	N73	N110	N109	gen_Conc3NW	12
65	P65	N73	N75	N111	N110	gen_Conc3NW	12
66	P66	N75	N77	N112	N111	gen_Conc3NW	12
67	P67	N77	N79	N113	N112	gen_Conc3NW	12
68	P68	N79	N81	N114	N113	gen_Conc3NW	12
69	P69	N81	N83	N115	N114	gen_Conc3NW	12
70	P70	N83	N85	N116	N115	gen_Conc3NW	12
71	P71	N85	N87	N117	N116	gen_Conc3NW	12
72	P72	N87	N89	N118	N117	gen_Conc3NW	12
73	P73	N89	N91	N119	N118	gen_Conc3NW	12
74	P74	N91	N93	N120	N119	gen_Conc3NW	12
75	P75	N93	N95	N121	N120	gen_Conc3NW	12
76	P76	N95	N97	N122	N121	gen_Conc3NW	12
77	P77	N97	N99	N123	N122	gen_Conc3NW	12
78	P78	N99	N101	N124	N123	gen_Conc3NW	12
79	P79	N101	N103	N125	N124	gen_Conc3NW	12
80	P80	N103	N105	N126	N125	gen_Conc3NW	12
81	P81	N107	N106	N127	N128	gen_Conc3NW	12
82	P82	N106	N108	N129	N127	gen_Conc3NW	12
83	P83	N108	N109	N130	N129	gen_Conc3NW	12
84	P84	N109	N110	N131	N130	gen_Conc3NW	12
85	P85	N110	N111	N132	N131	gen_Conc3NW	12
86	P86	N111	N112	N133	N132	gen_Conc3NW	12
87	P87	N112	N113	N134	N133	gen_Conc3NW	12
88	P88	N113	N114	N135	N134	gen_Conc3NW	12
89	P89	N114	N115	N136	N135	gen_Conc3NW	12
90	P90	N115	N116	N137	N136	gen_Conc3NW	12
91	P91	N116	N117	N138	N137	gen_Conc3NW	12
92	P92	N117	N118	N139	N138	gen_Conc3NW	12
93	P93	N118	N119	N140	N139	gen_Conc3NW	12
94	P94	N119	N120	N141	N140	gen_Conc3NW	12
95	P95	N120	N121	N142	N141	gen_Conc3NW	12
96	P96	N121	N122	N143	N142	gen_Conc3NW	12
97	P97	N122	N123	N144	N143	gen_Conc3NW	12
98	P98	N123	N124	N145	N144	gen_Conc3NW	12
99	P99	N124	N125	N146	N145	gen_Conc3NW	12
100	P100	N125	N126	N147	N146	gen_Conc3NW	12

Joint Boundary Conditions

	Joint Label	X [lb/in]	Y [lb/in]	Z [lb/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
1	N41	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
2	N39	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
3	N37	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
4	N35	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
5	N33	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
6	N31	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
7	N29	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
8	N27	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	

Joint Boundary Conditions (Continued)

	Joint Label	X [lb/in]	Y [lb/in]	Z [lb/in]	X Rot.[k-ft/rad]	Y Rot.[k-ft/rad]	Z Rot.[k-ft/rad]	Footing
9	N25	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
10	N23	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
11	N21	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
12	N19	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
13	N17	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
14	N15	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
15	N13	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
16	N11	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
17	N9	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
18	N7	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
19	N5	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
20	N2	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
21	N1	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
22	N4	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
23	N46	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
24	N67	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
25	N107	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
26	N128	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
27	N127	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
28	N129	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
29	N130	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
30	N131	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
31	N132	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
32	N133	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
33	N134	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
34	N135	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
35	N136	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
36	N137	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
37	N138	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
38	N139	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
39	N140	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
40	N141	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
41	N142	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
42	N143	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
43	N144	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
44	N145	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
45	N146	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
46	N147	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
47	N126	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
48	N105	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
49	N84	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	
50	N42	Reaction	Reaction	Reaction	Reaction	Reaction	Reaction	

Member Distributed Loads

Member Label	Direction	Start Magnitude[lb/ft,F]	End Magnitude[lb/ft,F]	Start Location[ft,%]	End Location[ft,%]
No Data to Print ...					

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Joint	Point	Distribut...	Area(M...	Surface...
1		None								100

Load Combinations

	Description	Solve	PDelta	S...	BLC	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...	B...	Fa...
1		Yes	Y		1	1																		

Joint Reactions

	LC	Joint Label	X [lb]	Y [lb]	Z [lb]	MX [lb-ft]	MY [lb-ft]	MZ [lb-ft]
1	1	N41	0	0	38.341	-29.528	-30.162	0
2	1	N39	0	0	133.845	-41.188	-119.891	0
3	1	N37	0	0	327.341	-52.421	-257.303	0
4	1	N35	0	0	521.474	-52.086	-407.559	0
5	1	N33	0	0	696.053	-48.443	-550.115	0
6	1	N31	0	0	858.424	-45.764	-683.437	0
7	1	N29	0	0	1015.531	-44.404	-811.217	0
8	1	N27	0	0	1171.009	-43.891	-936.546	0
9	1	N25	0	0	1326.269	-43.804	-1061.135	0
10	1	N23	0	0	1481.775	-43.956	-1185.837	0
11	1	N21	0	0	1637.908	-44.364	-1311.294	0
12	1	N19	0	0	1795.58	-45.13	-1438.361	0
13	1	N17	0	0	1956.621	-46.162	-1568.05	0
14	1	N15	0	0	2123.418	-46.492	-1700.198	0
15	1	N13	0	0	2296.061	-42.893	-1829.36	0
16	1	N11	0	0	2463.5	-27.81	-1935.72	0
17	1	N9	0	0	2583.364	11.79	-1970.554	0
18	1	N7	0	0	2549.889	89.284	-1844.719	0
19	1	N5	0	0	2169.745	188.727	-1457.972	0
20	1	N2	0	0	1322.483	230.695	-838.006	0
21	1	N1	0	0	581.957	223.307	-223.334	0
22	1	N4	0	0	1331.279	808.92	-207.894	0
23	1	N46	0	0	2105.318	1286.331	-98.47	0
24	1	N67	0	0	2105.318	1286.331	98.47	0
25	1	N107	0	0	1331.279	808.92	207.894	0
26	1	N128	0	0	581.957	223.307	223.334	0
27	1	N127	0	0	1322.483	230.695	838.006	0
28	1	N129	0	0	2169.745	188.727	1457.972	0
29	1	N130	0	0	2549.889	89.284	1844.719	0
30	1	N131	0	0	2583.364	11.79	1970.554	0
31	1	N132	0	0	2463.5	-27.81	1935.72	0
32	1	N133	0	0	2296.061	-42.893	1829.36	0
33	1	N134	0	0	2123.418	-46.492	1700.198	0
34	1	N135	0	0	1956.621	-46.162	1568.05	0
35	1	N136	0	0	1795.58	-45.13	1438.361	0
36	1	N137	0	0	1637.908	-44.364	1311.294	0
37	1	N138	0	0	1481.775	-43.956	1185.837	0
38	1	N139	0	0	1326.269	-43.804	1061.135	0
39	1	N140	0	0	1171.009	-43.891	936.546	0
40	1	N141	0	0	1015.531	-44.404	811.217	0
41	1	N142	0	0	858.424	-45.764	683.437	0
42	1	N143	0	0	696.053	-48.443	550.115	0
43	1	N144	0	0	521.474	-52.086	407.559	0
44	1	N145	0	0	327.341	-52.421	257.303	0
45	1	N146	0	0	133.845	-41.188	119.891	0
46	1	N147	0	0	38.341	-29.528	30.162	0
47	1	N126	0	0	91.462	-100.768	29.469	0
48	1	N105	0	0	181.351	-166.977	14.619	0
49	1	N84	0	0	181.351	-166.977	-14.619	0
50	1	N42	0	0	91.462	-100.768	-29.469	0

Joint Reactions (Continued)

	LC	Joint Label	X [lb]	Y [lb]	Z [lb]	MX [lb-ft]	MY [lb-ft]	MZ [lb-ft]
51	1	Totals:	0	0	65520			
52	1	COG (ft):	NC	NC	NC			

Joint Deflections

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
1	1	N1	0	0	0	0	0	0
2	1	N2	0	0	0	0	0	0
3	1	N3	0	0	0	-1.082e-5	1.046e-5	0
4	1	N4	0	0	0	0	0	0
5	1	N5	0	0	0	0	0	0
6	1	N6	0	0	0	-7.816e-6	1.868e-5	0
7	1	N7	0	0	0	0	0	0
8	1	N8	0	0	0	-3.212e-6	2.409e-5	0
9	1	N9	0	0	0	0	0	0
10	1	N10	0	0	0	-1.697e-7	2.582e-5	0
11	1	N11	0	0	0	0	0	0
12	1	N12	0	0	0	1.259e-6	2.538e-5	0
13	1	N13	0	0	0	0	0	0
14	1	N14	0	0	0	1.75e-6	2.399e-5	0
15	1	N15	0	0	0	0	0	0
16	1	N16	0	0	0	1.838e-6	2.229e-5	0
17	1	N17	0	0	0	0	0	0
18	1	N18	0	0	0	1.804e-6	2.055e-5	0
19	1	N19	0	0	0	0	0	0
20	1	N20	0	0	0	1.758e-6	1.885e-5	0
21	1	N21	0	0	0	0	0	0
22	1	N22	0	0	0	1.728e-6	1.719e-5	0
23	1	N23	0	0	0	0	0	0
24	1	N24	0	0	0	1.713e-6	1.554e-5	0
25	1	N25	0	0	0	0	0	0
26	1	N26	0	0	0	1.708e-6	1.391e-5	0
27	1	N27	0	0	0	0	0	0
28	1	N28	0	0	0	1.71e-6	1.227e-5	0
29	1	N29	0	0	0	0	0	0
30	1	N30	0	0	0	1.727e-6	1.063e-5	0
31	1	N31	0	0	0	0	0	0
32	1	N32	0	0	0	1.776e-6	8.957e-6	0
33	1	N33	0	0	0	0	0	0
34	1	N34	0	0	0	1.88e-6	7.207e-6	0
35	1	N35	0	0	0	0	0	0
36	1	N36	0	0	0	2.044e-6	5.332e-6	0
37	1	N37	0	0	0	0	0	0
38	1	N38	0	0	0	2.15e-6	3.331e-6	0
39	1	N39	0	0	0	0	0	0
40	1	N40	0	0	0	1.77e-6	1.528e-6	0
41	1	N41	0	0	0	0	0	0
42	1	N42	0	0	0	0	0	0
43	1	N45	0	0	0	-1.774e-5	4.749e-6	0
44	1	N46	0	0	0	0	0	0
45	1	N48	0	0	0	-1.343e-5	8.94e-6	0
46	1	N50	0	0	0	-5.686e-6	1.175e-5	0
47	1	N52	0	0	0	-4.86e-7	1.277e-5	0
48	1	N54	0	0	0	2.017e-6	1.264e-5	0
49	1	N56	0	0	0	2.905e-6	1.198e-5	0
50	1	N58	0	0	0	3.081e-6	1.115e-5	0

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
51	1	N60	0	0	0	3.032e-6	1.028e-5	0
52	1	N62	0	0	0	2.956e-6	9.429e-6	0
53	1	N64	0	0	0	2.905e-6	8.594e-6	0
54	1	N66	0	0	0	2.879e-6	7.771e-6	0
55	1	N68	0	0	0	2.869e-6	6.954e-6	0
56	1	N70	0	0	0	2.873e-6	6.137e-6	0
57	1	N72	0	0	0	2.903e-6	5.314e-6	0
58	1	N74	0	0	0	2.989e-6	4.474e-6	0
59	1	N76	0	0	0	3.169e-6	3.594e-6	0
60	1	N78	0	0	0	3.436e-6	2.652e-6	0
61	1	N80	0	0	0	3.604e-6	1.658e-6	0
62	1	N82	0	0	0	2.966e-6	7.604e-7	0
63	1	N84	0	0	0	0	0	0
64	1	N66A	0	0	0	-1.774e-5	-4.749e-6	0
65	1	N67	0	0	0	0	0	0
66	1	N69	0	0	0	-1.343e-5	-8.94e-6	0
67	1	N71	0	0	0	-5.686e-6	-1.175e-5	0
68	1	N73	0	0	0	-4.86e-7	-1.277e-5	0
69	1	N75	0	0	0	2.017e-6	-1.264e-5	0
70	1	N77	0	0	0	2.905e-6	-1.198e-5	0
71	1	N79	0	0	0	3.081e-6	-1.115e-5	0
72	1	N81	0	0	0	3.032e-6	-1.028e-5	0
73	1	N83	0	0	0	2.956e-6	-9.429e-6	0
74	1	N85	0	0	0	2.905e-6	-8.594e-6	0
75	1	N87	0	0	0	2.879e-6	-7.771e-6	0
76	1	N89	0	0	0	2.869e-6	-6.954e-6	0
77	1	N91	0	0	0	2.873e-6	-6.137e-6	0
78	1	N93	0	0	0	2.903e-6	-5.314e-6	0
79	1	N95	0	0	0	2.989e-6	-4.474e-6	0
80	1	N97	0	0	0	3.169e-6	-3.594e-6	0
81	1	N99	0	0	0	3.436e-6	-2.652e-6	0
82	1	N101	0	0	0	3.604e-6	-1.658e-6	0
83	1	N103	0	0	0	2.966e-6	-7.604e-7	0
84	1	N105	0	0	0	0	0	0
85	1	N106	0	0	0	-1.082e-5	-1.046e-5	0
86	1	N107	0	0	0	0	0	0
87	1	N108	0	0	0	-7.816e-6	-1.868e-5	0
88	1	N109	0	0	0	-3.212e-6	-2.409e-5	0
89	1	N110	0	0	0	-1.697e-7	-2.582e-5	0
90	1	N111	0	0	0	1.259e-6	-2.538e-5	0
91	1	N112	0	0	0	1.75e-6	-2.399e-5	0
92	1	N113	0	0	0	1.838e-6	-2.229e-5	0
93	1	N114	0	0	0	1.804e-6	-2.055e-5	0
94	1	N115	0	0	0	1.758e-6	-1.885e-5	0
95	1	N116	0	0	0	1.728e-6	-1.719e-5	0
96	1	N117	0	0	0	1.713e-6	-1.554e-5	0
97	1	N118	0	0	0	1.708e-6	-1.391e-5	0
98	1	N119	0	0	0	1.71e-6	-1.227e-5	0
99	1	N120	0	0	0	1.727e-6	-1.063e-5	0
100	1	N121	0	0	0	1.776e-6	-8.957e-6	0
101	1	N122	0	0	0	1.88e-6	-7.207e-6	0
102	1	N123	0	0	0	2.044e-6	-5.332e-6	0
103	1	N124	0	0	0	2.15e-6	-3.331e-6	0
104	1	N125	0	0	0	1.77e-6	-1.528e-6	0
105	1	N126	0	0	0	0	0	0
106	1	N127	0	0	0	0	0	0
107	1	N128	0	0	0	0	0	0

Joint Deflections (Continued)

	LC	Joint Label	X [in]	Y [in]	Z [in]	X Rotation [rad]	Y Rotation [rad]	Z Rotation [rad]
108	1	N129	0	0	0	0	0	0
109	1	N130	0	0	0	0	0	0
110	1	N131	0	0	0	0	0	0
111	1	N132	0	0	0	0	0	0
112	1	N133	0	0	0	0	0	0
113	1	N134	0	0	0	0	0	0
114	1	N135	0	0	0	0	0	0
115	1	N136	0	0	0	0	0	0
116	1	N137	0	0	0	0	0	0
117	1	N138	0	0	0	0	0	0
118	1	N139	0	0	0	0	0	0
119	1	N140	0	0	0	0	0	0
120	1	N141	0	0	0	0	0	0
121	1	N142	0	0	0	0	0	0
122	1	N143	0	0	0	0	0	0
123	1	N144	0	0	0	0	0	0
124	1	N145	0	0	0	0	0	0
125	1	N146	0	0	0	0	0	0
126	1	N147	0	0	0	0	0	0

Plate Corner Forces

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
1	1	P1	N1	0	0	581.957	223.307	-223.334	0
2			N2	0	0	450.85	85.519	-211.54	0
3			N3	0	0	-227.914	-121.221	114.14	0
4			N4	0	0	443.108	213.46	-88.073	0
5	1	P2	N2	0	0	871.634	145.177	-626.465	0
6			N5	0	0	990.576	91.709	-555.551	0
7			N6	0	0	-445.261	-94.129	66.604	0
8			N3	0	0	-231.349	-95.272	-153.998	0
9	1	P3	N5	0	0	1179.169	97.019	-902.421	0
10			N7	0	0	1270.074	20.549	-844.085	0
11			N8	0	0	-655.335	-81.686	7.806	0
12			N6	0	0	-670.709	-89.021	-148.942	0
13	1	P4	N7	0	0	1279.814	68.735	-1000.633	0
14			N9	0	0	1318.568	-43.718	-976.616	0
15			N10	0	0	-736.989	-66.631	-17.616	0
16			N8	0	0	-800.593	-9.565	-73.117	0
17	1	P5	N9	0	0	1264.796	55.508	-993.939	0
18			N11	0	0	1265.125	-76.743	-994	0
19			N12	0	0	-739.85	-55.541	-25.376	0
20			N10	0	0	-791.671	50.7	-17.406	0
21	1	P6	N11	0	0	1198.375	48.933	-941.72	0
22			N13	0	0	1179.728	-87.437	-953.698	0
23			N14	0	0	-704.971	-47.844	-26.029	0
24			N12	0	0	-737.132	79.591	11.344	0
25	1	P7	N13	0	0	1116.334	44.545	-875.662	0
26			N15	0	0	1090.738	-86.991	-891.989	0
27			N16	0	0	-657.144	-42.139	-24.932	0
28			N14	0	0	-676.328	87.791	22.311	0
29	1	P8	N15	0	0	1032.68	40.499	-808.209	0
30			N17	0	0	1005.575	-82.427	-825.473	0
31			N18	0	0	-607.012	-37.289	-23.922	0
32			N16	0	0	-620.043	86.254	24.948	0
33	1	P9	N17	0	0	951.047	36.265	-742.577	0

Plate Corner Forces (Continued)

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
34			N19	0	0	924.215	-76.944	-759.663	0
35			N20	0	0	-557.786	-32.697	-23.345	0
36			N18	0	0	-568.675	81.347	24.723	0
37	1	P10	N19	0	0	871.365	31.814	-678.699	0
38			N21	0	0	845.078	-71.599	-695.44	0
39			N22	0	0	-509.776	-28.137	-23.088	0
40			N20	0	0	-520.267	75.82	23.985	0
41	1	P11	N21	0	0	792.831	27.235	-615.853	0
42			N23	0	0	766.928	-66.556	-632.352	0
43			N24	0	0	-462.573	-23.548	-22.994	0
44			N22	0	0	-473.185	70.515	23.441	0
45	1	P12	N23	0	0	714.847	22.6	-553.485	0
46			N25	0	0	689.132	-61.719	-569.866	0
47			N26	0	0	-415.824	-18.906	-22.98	0
48			N24	0	0	-426.555	65.517	23.151	0
49	1	P13	N25	0	0	637.136	17.915	-491.269	0
50			N27	0	0	611.436	-56.979	-507.641	0
51			N28	0	0	-369.364	-14.132	-23.078	0
52			N26	0	0	-380.008	60.724	23.015	0
53	1	P14	N27	0	0	559.573	13.088	-428.905	0
54			N29	0	0	533.652	-52.288	-445.415	0
55			N30	0	0	-323.084	-9.018	-23.458	0
56			N28	0	0	-333.341	56.05	22.953	0
57	1	P15	N29	0	0	481.88	7.884	-365.802	0
58			N31	0	0	455.31	-47.678	-382.72	0
59			N32	0	0	-276.598	-3.195	-24.443	0
60			N30	0	0	-286.192	51.476	22.975	0
61	1	P16	N31	0	0	403.114	1.914	-300.718	0
62			N33	0	0	375.217	-43.29	-318.471	0
63			N34	0	0	-228.6	3.732	-26.378	0
64			N32	0	0	-237.73	47.028	23.236	0
65	1	P17	N33	0	0	320.836	-5.153	-231.644	0
66			N35	0	0	291.011	-39.398	-250.593	0
67			N36	0	0	-175.77	11.422	-28.942	0
68			N34	0	0	-186.477	42.688	24.132	0
69	1	P18	N35	0	0	230.464	-12.688	-156.966	0
70			N37	0	0	200.106	-36.42	-176.461	0
71			N38	0	0	-112.183	16.489	-29.737	0
72			N36	0	0	-131.186	38.297	26.196	0
73	1	P19	N37	0	0	127.235	-16.001	-80.842	0
74			N39	0	0	102.388	-33.688	-96.538	0
75			N40	0	0	-32.246	8.676	-19.177	0
76			N38	0	0	-72.577	33.271	29.334	0
77	1	P20	N39	0	0	31.457	-7.5	-23.352	0
78			N41	0	0	38.341	-29.528	-30.162	0
79			N42	0	0	22.484	-23.426	-9.857	0
80			N40	0	0	-29.883	30.829	24.772	0
81	1	P21	N4	0	0	888.172	595.46	-119.821	0
82			N3	0	0	-165.999	130.163	97.977	0
83			N45	0	0	-439.278	-43.824	18.751	0
84			N46	0	0	965.105	547.478	-95.08	0
85	1	P22	N3	0	0	625.263	86.33	-58.12	0
86			N6	0	0	438.949	258.041	138.099	0
87			N48	0	0	-215.668	110.344	-214.279	0
88			N45	0	0	337.056	-85.196	-337.111	0
89	1	P23	N6	0	0	677.02	-74.891	-55.761	0
90			N8	0	0	741.749	195.204	83.614	0

Plate Corner Forces (Continued)

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
91			N50	0	0	-191.54	109.159	-396.417	0
92			N48	0	0	-104.029	-218.081	-488.605	0
93	1	P24	N8	0	0	714.179	-103.953	-18.302	0
94			N10	0	0	809.072	106.252	29.591	0
95			N52	0	0	-200.008	84.257	-484.601	0
96			N50	0	0	-262.444	-165.221	-519.539	0
97	1	P25	N10	0	0	719.588	-90.322	5.431	0
98			N12	0	0	780.712	48.685	-2.834	0
99			N54	0	0	-207.53	63.111	-503.209	0
100			N52	0	0	-294.371	-95.457	-500.488	0
101	1	P26	N12	0	0	696.269	-72.735	16.866	0
102			N14	0	0	724.35	20.755	-17.206	0
103			N56	0	0	-205.117	50.734	-486.464	0
104			N54	0	0	-279.502	-49.986	-465.814	0
105	1	P27	N14	0	0	656.949	-60.702	20.924	0
106			N16	0	0	666.055	9.762	-21.747	0
107			N58	0	0	-195.053	44.396	-456.184	0
108			N56	0	0	-254.351	-27.658	-429.197	0
109	1	P28	N16	0	0	611.132	-53.877	21.731	0
110			N18	0	0	612.155	5.961	-22.309	0
111			N60	0	0	-181.062	40.997	-422.658	0
112			N58	0	0	-231.024	-18.574	-394.45	0
113	1	P29	N18	0	0	563.533	-50.019	21.508	0
114			N20	0	0	562.154	4.286	-21.794	0
115			N62	0	0	-165.572	38.652	-389.419	0
116			N60	0	0	-211.315	-15.101	-361.582	0
117	1	P30	N20	0	0	515.898	-47.409	21.154	0
118			N22	0	0	514.326	2.782	-21.262	0
119			N64	0	0	-149.734	36.518	-357.096	0
120			N62	0	0	-194.09	-13.283	-329.821	0
121	1	P31	N22	0	0	468.635	-45.16	20.909	0
122			N24	0	0	467.403	.975	-20.941	0
123			N66	0	0	-133.965	34.339	-325.451	0
124			N64	0	0	-178.073	-11.592	-298.554	0
125	1	P32	N24	0	0	421.726	-42.944	20.784	0
126			N26	0	0	420.731	-1.075	-20.799	0
127			N68	0	0	-118.381	32.13	-294.178	0
128			N66	0	0	-162.476	-9.662	-267.463	0
129	1	P33	N26	0	0	375.101	-40.742	20.764	0
130			N28	0	0	374.012	-3.184	-20.784	0
131			N70	0	0	-102.996	30.053	-263.095	0
132			N68	0	0	-146.918	-7.544	-236.398	0
133	1	P34	N28	0	0	328.692	-38.735	20.909	0
134			N30	0	0	327.03	-5.179	-20.917	0
135			N72	0	0	-87.718	28.402	-232.107	0
136			N70	0	0	-131.204	-5.4	-205.207	0
137	1	P35	N30	0	0	282.246	-37.279	21.4	0
138			N32	0	0	279.464	-6.999	-21.312	0
139			N74	0	0	-72.118	27.544	-201.058	0
140			N72	0	0	-115.193	-3.412	-173.541	0
141	1	P36	N32	0	0	234.864	-36.835	22.519	0
142			N34	0	0	230.855	-8.93	-22.128	0
143			N76	0	0	-54.921	27.545	-169.458	0
144			N74	0	0	-98.798	-1.715	-140.652	0
145	1	P37	N34	0	0	184.222	-37.49	24.374	0
146			N36	0	0	181.098	-12.207	-23.349	0
147			N78	0	0	-33.39	26.978	-136.147	0

Plate Corner Forces (Continued)

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
148			N76	0	0	-82.33	-.189	-105.399	0
149	1	P38	N36	0	0	125.858	-37.512	26.095	0
150			N38	0	0	132.185	-20.401	-24.494	0
151			N80	0	0	-3.414	20.493	-99.141	0
152			N78	0	0	-67.429	2.249	-66.902	0
153	1	P39	N38	0	0	52.576	-29.359	24.897	0
154			N40	0	0	85.975	-39.429	-19.333	0
155			N82	0	0	42.925	-6.242	-54.735	0
156			N80	0	0	-56.675	8.529	-26.98	0
157	1	P40	N40	0	0	-23.846	-.076	13.738	0
158			N42	0	0	68.978	-77.342	-19.612	0
159			N84	0	0	78.799	-69.098	-13.716	0
160			N82	0	0	-61.531	29.938	5.658	0
161	1	P41	N46	0	0	1140.212	738.853	-3.39	0
162			N45	0	0	-516.212	89.359	83.062	0
163			N66A	0	0	-516.212	89.359	-83.062	0
164			N67	0	0	1140.212	738.853	3.39	0
165	1	P42	N45	0	0	618.434	39.661	235.299	0
166			N48	0	0	-25.634	282.373	311.6	0
167			N69	0	0	-25.634	282.373	-311.6	0
168			N66A	0	0	618.434	39.661	-235.299	0
169	1	P43	N48	0	0	345.331	-174.636	391.285	0
170			N50	0	0	216.269	239.167	442.51	0
171			N71	0	0	216.269	239.167	-442.51	0
172			N69	0	0	345.331	-174.636	-391.285	0
173	1	P44	N50	0	0	237.715	-183.104	473.446	0
174			N52	0	0	292.685	155.619	491.975	0
175			N73	0	0	292.685	155.619	-491.975	0
176			N71	0	0	237.715	-183.104	-473.446	0
177	1	P45	N52	0	0	201.693	-144.419	493.114	0
178			N54	0	0	297.507	96.512	490.75	0
179			N75	0	0	297.507	96.512	-490.75	0
180			N73	0	0	201.693	-144.419	-493.114	0
181	1	P46	N54	0	0	189.524	-109.638	478.274	0
182			N56	0	0	278.476	65.162	466.301	0
183			N77	0	0	278.476	65.162	-466.301	0
184			N75	0	0	189.524	-109.638	-478.274	0
185	1	P47	N56	0	0	180.993	-88.238	449.36	0
186			N58	0	0	255.807	50.831	434.13	0
187			N79	0	0	255.807	50.831	-434.13	0
188			N77	0	0	180.993	-88.238	-449.36	0
189	1	P48	N58	0	0	170.27	-76.653	416.504	0
190			N60	0	0	235.33	44.123	400.73	0
191			N81	0	0	235.33	44.123	-400.73	0
192			N79	0	0	170.27	-76.653	-416.504	0
193	1	P49	N60	0	0	157.047	-70.02	383.511	0
194			N62	0	0	217.353	39.867	367.995	0
195			N83	0	0	217.353	39.867	-367.995	0
196			N81	0	0	157.047	-70.02	-383.511	0
197	1	P50	N62	0	0	142.31	-65.236	351.245	0
198			N64	0	0	200.89	35.945	336.053	0
199			N85	0	0	200.89	35.945	-336.053	0
200			N83	0	0	142.31	-65.236	-351.245	0
201	1	P51	N64	0	0	126.916	-60.871	319.596	0
202			N66	0	0	185.084	31.788	304.614	0
203			N87	0	0	185.084	31.788	-304.614	0
204			N85	0	0	126.916	-60.871	-319.596	0

Plate Corner Forces (Continued)

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
205	1	P52	N66	0	0	111.357	-56.465	288.3	0
206			N68	0	0	169.443	27.423	273.417	0
207			N89	0	0	169.443	27.423	-273.417	0
208			N87	0	0	111.357	-56.465	-288.3	0
209	1	P53	N68	0	0	95.856	-52.009	257.159	0
210			N70	0	0	153.744	23.065	242.288	0
211			N91	0	0	153.744	23.065	-242.288	0
212			N89	0	0	95.856	-52.009	-257.159	0
213	1	P54	N70	0	0	80.456	-47.718	226.014	0
214			N72	0	0	137.944	18.974	211.038	0
215			N93	0	0	137.944	18.974	-211.038	0
216			N91	0	0	80.456	-47.718	-226.014	0
217	1	P55	N72	0	0	64.966	-43.964	194.609	0
218			N74	0	0	122.234	15.331	179.302	0
219			N95	0	0	122.234	15.331	-179.302	0
220			N93	0	0	64.966	-43.964	-194.609	0
221	1	P56	N74	0	0	48.682	-41.16	162.408	0
222			N76	0	0	107.318	11.842	146.388	0
223			N97	0	0	107.318	11.842	-146.388	0
224			N95	0	0	48.682	-41.16	-162.408	0
225	1	P57	N76	0	0	29.933	-39.199	128.469	0
226			N78	0	0	94.867	6.732	111.318	0
227			N99	0	0	94.867	6.732	-111.318	0
228			N97	0	0	29.933	-39.199	-128.469	0
229	1	P58	N78	0	0	5.952	-35.96	91.731	0
230			N80	0	0	87.648	-4.888	73.643	0
231			N101	0	0	87.648	-4.888	-73.643	0
232			N99	0	0	5.952	-35.96	-91.731	0
233	1	P59	N80	0	0	-27.558	-24.135	52.478	0
234			N82	0	0	89.958	-34.624	36.138	0
235			N103	0	0	89.958	-34.624	-36.138	0
236			N101	0	0	-27.558	-24.135	-52.478	0
237	1	P60	N82	0	0	-71.352	10.927	12.94	0
238			N84	0	0	102.552	-97.879	-.903	0
239			N105	0	0	102.552	-97.879	.903	0
240			N103	0	0	-71.352	10.927	-12.94	0
241	1	P61	N67	0	0	965.105	547.478	95.08	0
242			N66A	0	0	-439.278	-43.824	-18.751	0
243			N106	0	0	-165.999	130.163	-97.977	0
244			N107	0	0	888.172	595.46	119.821	0
245	1	P62	N66A	0	0	337.056	-85.196	337.111	0
246			N69	0	0	-215.668	110.344	214.279	0
247			N108	0	0	438.949	258.041	-138.099	0
248			N106	0	0	625.263	86.33	58.12	0
249	1	P63	N69	0	0	-104.029	-218.081	488.605	0
250			N71	0	0	-191.54	109.159	396.417	0
251			N109	0	0	741.749	195.204	-83.614	0
252			N108	0	0	677.02	-74.891	55.761	0
253	1	P64	N71	0	0	-262.444	-165.221	519.539	0
254			N73	0	0	-200.008	84.257	484.601	0
255			N110	0	0	809.072	106.252	-29.591	0
256			N109	0	0	714.179	-103.953	18.302	0
257	1	P65	N73	0	0	-294.371	-95.457	500.488	0
258			N75	0	0	-207.53	63.111	503.209	0
259			N111	0	0	780.712	48.685	2.834	0
260			N110	0	0	719.588	-90.322	-5.431	0
261	1	P66	N75	0	0	-279.502	-49.986	465.814	0

Plate Corner Forces (Continued)

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
262			N77	0	0	-205.117	50.734	486.464	0
263			N112	0	0	724.35	20.755	17.206	0
264			N111	0	0	696.269	-72.735	-16.866	0
265	1	P67	N77	0	0	-254.351	-27.658	429.197	0
266			N79	0	0	-195.053	44.396	456.184	0
267			N113	0	0	666.055	9.762	21.747	0
268			N112	0	0	656.949	-60.702	-20.924	0
269	1	P68	N79	0	0	-231.024	-18.574	394.45	0
270			N81	0	0	-181.062	40.997	422.658	0
271			N114	0	0	612.155	5.961	22.309	0
272			N113	0	0	611.132	-53.877	-21.731	0
273	1	P69	N81	0	0	-211.315	-15.101	361.582	0
274			N83	0	0	-165.572	38.652	389.419	0
275			N115	0	0	562.154	4.286	21.794	0
276			N114	0	0	563.533	-50.019	-21.508	0
277	1	P70	N83	0	0	-194.09	-13.283	329.821	0
278			N85	0	0	-149.734	36.518	357.096	0
279			N116	0	0	514.326	2.782	21.262	0
280			N115	0	0	515.898	-47.409	-21.154	0
281	1	P71	N85	0	0	-178.073	-11.592	298.554	0
282			N87	0	0	-133.965	34.339	325.451	0
283			N117	0	0	467.403	.975	20.941	0
284			N116	0	0	468.635	-45.16	-20.909	0
285	1	P72	N87	0	0	-162.476	-9.662	267.463	0
286			N89	0	0	-118.381	32.13	294.178	0
287			N118	0	0	420.731	-1.075	20.799	0
288			N117	0	0	421.726	-42.944	-20.784	0
289	1	P73	N89	0	0	-146.918	-7.544	236.398	0
290			N91	0	0	-102.996	30.053	263.095	0
291			N119	0	0	374.012	-3.184	20.784	0
292			N118	0	0	375.101	-40.742	-20.764	0
293	1	P74	N91	0	0	-131.204	-5.4	205.207	0
294			N93	0	0	-87.718	28.402	232.107	0
295			N120	0	0	327.03	-5.179	20.917	0
296			N119	0	0	328.692	-38.735	-20.909	0
297	1	P75	N93	0	0	-115.193	-3.412	173.541	0
298			N95	0	0	-72.118	27.544	201.058	0
299			N121	0	0	279.464	-6.999	21.312	0
300			N120	0	0	282.246	-37.279	-21.4	0
301	1	P76	N95	0	0	-98.798	-1.715	140.652	0
302			N97	0	0	-54.921	27.545	169.458	0
303			N122	0	0	230.855	-8.93	22.128	0
304			N121	0	0	234.864	-36.835	-22.519	0
305	1	P77	N97	0	0	-82.33	-.189	105.399	0
306			N99	0	0	-33.39	26.978	136.147	0
307			N123	0	0	181.098	-12.207	23.349	0
308			N122	0	0	184.222	-37.49	-24.374	0
309	1	P78	N99	0	0	-67.429	2.249	66.902	0
310			N101	0	0	-3.414	20.493	99.141	0
311			N124	0	0	132.185	-20.401	24.494	0
312			N123	0	0	125.858	-37.512	-26.095	0
313	1	P79	N101	0	0	-56.675	8.529	26.98	0
314			N103	0	0	42.925	-6.242	54.735	0
315			N125	0	0	85.975	-39.429	19.333	0
316			N124	0	0	52.576	-29.359	-24.897	0
317	1	P80	N103	0	0	-61.531	29.938	-5.658	0
318			N105	0	0	78.799	-69.098	13.716	0

Plate Corner Forces (Continued)

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
319			N126	0	0	68.978	-77.342	19.612	0
320			N125	0	0	-23.846	-.076	-13.738	0
321	1	P81	N107	0	0	443.108	213.46	88.073	0
322			N106	0	0	-227.914	-121.221	-114.14	0
323			N127	0	0	450.85	85.519	211.54	0
324			N128	0	0	581.957	223.307	223.334	0
325	1	P82	N106	0	0	-231.349	-95.272	153.998	0
326			N108	0	0	-445.261	-94.129	-66.604	0
327			N129	0	0	990.576	91.709	555.551	0
328			N127	0	0	871.634	145.177	626.465	0
329	1	P83	N108	0	0	-670.709	-89.021	148.942	0
330			N109	0	0	-655.335	-81.686	-7.806	0
331			N130	0	0	1270.074	20.549	844.085	0
332			N129	0	0	1179.169	97.019	902.421	0
333	1	P84	N109	0	0	-800.593	-9.565	73.117	0
334			N110	0	0	-736.989	-66.631	17.616	0
335			N131	0	0	1318.568	-43.718	976.616	0
336			N130	0	0	1279.814	68.735	1000.633	0
337	1	P85	N110	0	0	-791.671	50.7	17.406	0
338			N111	0	0	-739.85	-55.541	25.376	0
339			N132	0	0	1265.125	-76.743	994	0
340			N131	0	0	1264.796	55.508	993.939	0
341	1	P86	N111	0	0	-737.132	79.591	-11.344	0
342			N112	0	0	-704.971	-47.844	26.029	0
343			N133	0	0	1179.728	-87.437	953.698	0
344			N132	0	0	1198.375	48.933	941.72	0
345	1	P87	N112	0	0	-676.328	87.791	-22.311	0
346			N113	0	0	-657.144	-42.139	24.932	0
347			N134	0	0	1090.738	-86.991	891.989	0
348			N133	0	0	1116.334	44.545	875.662	0
349	1	P88	N113	0	0	-620.043	86.254	-24.948	0
350			N114	0	0	-607.012	-37.289	23.922	0
351			N135	0	0	1005.575	-82.427	825.473	0
352			N134	0	0	1032.68	40.499	808.209	0
353	1	P89	N114	0	0	-568.675	81.347	-24.723	0
354			N115	0	0	-557.786	-32.697	23.345	0
355			N136	0	0	924.215	-76.944	759.663	0
356			N135	0	0	951.047	36.265	742.577	0
357	1	P90	N115	0	0	-520.267	75.82	-23.985	0
358			N116	0	0	-509.776	-28.137	23.088	0
359			N137	0	0	845.078	-71.599	695.44	0
360			N136	0	0	871.365	31.814	678.699	0
361	1	P91	N116	0	0	-473.185	70.515	-23.441	0
362			N117	0	0	-462.573	-23.548	22.994	0
363			N138	0	0	766.928	-66.556	632.352	0
364			N137	0	0	792.831	27.235	615.853	0
365	1	P92	N117	0	0	-426.555	65.517	-23.151	0
366			N118	0	0	-415.824	-18.906	22.98	0
367			N139	0	0	689.132	-61.719	569.866	0
368			N138	0	0	714.847	22.6	553.485	0
369	1	P93	N118	0	0	-380.008	60.724	-23.015	0
370			N119	0	0	-369.364	-14.132	23.078	0
371			N140	0	0	611.436	-56.979	507.641	0
372			N139	0	0	637.136	17.915	491.269	0
373	1	P94	N119	0	0	-333.341	56.05	-22.953	0
374			N120	0	0	-323.084	-9.018	23.458	0
375			N141	0	0	533.652	-52.288	445.415	0

Plate Corner Forces (Continued)

	LC	Plate Label	Joint	X[lb]	Y[lb]	Z[lb]	MX[lb-ft]	MY[lb-ft]	MZ[lb-ft]
376			N140	0	0	559.573	13.088	428.905	0
377	1	P95	N120	0	0	-286.192	51.476	-22.975	0
378			N121	0	0	-276.598	-3.195	24.443	0
379			N142	0	0	455.31	-47.678	382.72	0
380			N141	0	0	481.88	7.884	365.802	0
381	1	P96	N121	0	0	-237.73	47.028	-23.236	0
382			N122	0	0	-228.6	3.732	26.378	0
383			N143	0	0	375.217	-43.29	318.471	0
384			N142	0	0	403.114	1.914	300.718	0
385	1	P97	N122	0	0	-186.477	42.688	-24.132	0
386			N123	0	0	-175.77	11.422	28.942	0
387			N144	0	0	291.011	-39.398	250.593	0
388			N143	0	0	320.836	-5.153	231.644	0
389	1	P98	N123	0	0	-131.186	38.297	-26.196	0
390			N124	0	0	-112.183	16.489	29.737	0
391			N145	0	0	200.106	-36.42	176.461	0
392			N144	0	0	230.464	-12.688	156.966	0
393	1	P99	N124	0	0	-72.577	33.271	-29.334	0
394			N125	0	0	-32.246	8.676	19.177	0
395			N146	0	0	102.388	-33.688	96.538	0
396			N145	0	0	127.235	-16.001	80.842	0
397	1	P100	N125	0	0	-29.883	30.829	-24.772	0
398			N126	0	0	22.484	-23.426	9.857	0
399			N147	0	0	38.341	-29.528	30.162	0
400			N146	0	0	31.457	-7.5	23.352	0