RECOVERY IMPLEMENTATION PROGRAM
PLATTE RIVER

Final Report of Geotechnical Investigation and Design

Platte River Recovery Implementation Program
Cottonwood Ranch
Broad-Scale Recharge Project
Phelps County, Nebraska

December 2017

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December 6, 2017

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Nebraska.

December 6, 2017

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My license renewal date is December 31, 2017.

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1.0 Introduction

This report presents the results of the geotechnical investigation and design analyses performed for the proposed Cottonwood Ranch Broad-Scale Recharge (BSR) project. The proposed BSR project would be located in Phelps County, Nebraska, southwest of the Village of Elm Creek, Nebraska. The proposed BSR project site is bounded on the north by 747 Road, on the south by 748 Road, on the east by H Road, and on the west by J Road. A vicinity map showing the overall location of the BSR project is included as Figure 1.

The proposed BSR project consists of the construction of infiltration basins and compacted earthen structures for the purpose of groundwater recharge and establishing whooping crane (*Grus americana*) habitat. The conveyance system to bring water to the infiltration basins, infiltration analyses, and groundwater modeling is not included in this scope of work.

This report presents HDR’s findings, conclusions, and recommendations regarding:

- Geologic setting
- Subsurface soil and groundwater conditions
- Engineering characteristics of the foundation and embankment soils
- Foundation underseepage and embankment through-seepage
- Slope stability of embankment and foundation soils
- Foundation settlement
- Bearing capacity
- Lateral earth pressures
- Construction observations

Professional engineers registered in the State of Nebraska prepared this report. The recommendations presented herein are based on the applicable standards of the profession at the time of this report within this geographic area. This report was prepared for the exclusive use of the Platte River Recovery Implementation Program (PRRIP) for specific application to the proposed BSR project, in accordance with generally accepted soil and foundation engineering practices.

2.0 Project Description

The project consists of eight earthen berm infiltration basins as shown on Figure 2. The basins would temporarily store run-off during high run-off times of the year. The goals being for the stored water to recharge the aquifer through infiltration and provide habitat for the whooping crane.

Based on the results of the preliminary design (HDR, 2017), the berm section would have a maximum height less than 6 feet to avoid being classified as a dam in accordance with Nebraska Department of Natural Resources – Dam Safety Division (NeDNR) criteria (NeDNR 2008) and Natural Resources Conservation Service (NRCS) *Earth Dams and Reservoirs* (TR-60) (NRCS 2005). The berm section would have 6 horizontal to 1 vertical (6H:1V) side slopes and a 12-foot wide crest. Underseepage mitigation, where necessary, would consist of a supplemental downstream seepage berms for Cells 1 through 4, which are not impacted by right-of-way (ROW) restrictions, and a downstream toe drains for Cells 5 through 8, which are impacted by ROW restrictions.

The earthen berms and supplemental downstream seepage berms would be constructed using soils obtained from on-site excavations. The on-site excavations would be used to either maximize recharge potential or establish whooping crane habitat within each basin.

Conveyance channels would be provided to move water from cell to cell and to allow for run-off to pass through the system, when a cell is not in use. A concrete flume with a gate would be provided at each berm to convey water through the berm to the adjacent cell.

Away from the conveyance channel, each berm would include an auxiliary spillway to discharge large run-off events that exceed the storage capacity of each cell. The auxiliary spillway would consist of an earthen structure that directs run-off outside of the system, with the exception of Cell 4, which would discharge into Cell 5.

3.0 Subsurface Investigation

3.1 Field Exploration

The field work for the BSR project consisted of drilling 31 exploratory test borings and excavating nine test pits at the approximate locations shown on the boring location plan included as Figure 3. The boring depths ranged from 20 to 50 feet below existing grade. The test pit depths ranged from 3 to 6 feet below existing grades. The schedule of borings and groundwater data, the boring logs, and test pit logs are provided in Appendix A.

The borings were advanced with a truck-mounted drill rig manufactured by Diedrich Drill, equipped with 3.25-inch ID hollow stem augers. Water was added to the augers during drilling of the 15-foot deep borings, below the water table. Bentonite slurry was added to the augers during drilling of the 35- and 50-foot deep borings, below the water table. The drill rig was equipped with an automatic hammer manufactured by Boart Longyear™ with an efficiency of about 61 percent. The field exploration was conducted by Mid-State Engineering & Testing, Inc. of Kearney, Nebraska, at the direction of HDR. The locations and elevations of the borings were surveyed by Miller & Associates Consulting Engineers, P.C. of Kearney, Nebraska.

Soil samples from the borings were obtained using push and drive sampling at intervals shown on the boring logs.

Undisturbed samples, designated as “U” samples on the logs, were obtained with thin-walled tube samplers, 3-inch outside diameter, hydraulically pushed in general accordance with ASTM D1587 “Standard Practice for Thin Walled Tube Sampling of Soils for Geotechnical

Purposes". Pocket penetrometer readings were taken at the end of some of the cohesive samples. Both ends of the sampler were capped and sealed in the field. The samples were then protected for transportation to the laboratory.

Split-barrel samples, designated as "S" samples on the logs, were obtained while performing standard penetration tests (SPTs) with a thick-walled sampler, 1.5-inch inside diameter, driven in general accordance with ASTM D1586 "Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils". The N-value, reported in blows per foot (bpf), represents the number of blows required to drive the sampler over the last 12 inches of the 18-inch sample interval. The samples were then placed in sealed plastic bags for transportation to the laboratory.

The field boring logs were prepared in general accordance with ASTM D2488 "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)". Stratification lines represent the approximate boundary between soil types and the transition may be gradual. Water level readings were made in the drill holes at times and under conditions stated on the boring logs.

3.2 Laboratory Testing

The field boring logs were reviewed to outline the depths, thicknesses, and lateral extent of the various soil strata. A testing program was developed by HDR to evaluate the engineering properties of the recovered samples and to substantiate the soil classifications made in the field. Tests were conducted by Mid-State Engineering & Testing, Inc. in general accordance with current ASTM or state-of-the-practice test procedures. Laboratory test results are presented in Appendix B.

Selected soil samples were tested to determine moisture content, dry density, plasticity, grain size distribution, undrained shear strength (unconfined compression tests), consolidation properties, and dispersive potential.

3.3 Field Percolation Tests

Field Percolation tests were performed adjacent to each test pit. The percolation tests depths were between 1 and 2 feet below existing grades and were selected by HDR, based on the soil conditions identified in the adjacent test pit.

The percolation tests were performed by Mid-State Engineering & Testing, Inc. at the direction of HDR. The test consisted of:

1. Excavating a 4-inch diameter hole
2. Filling the hole with water
3. Allowing the hole to saturate overnight
4. Refilling the hole with water 1 hour before testing
5. Filling the hole with 6-inches of water
6. Measuring the water drop versus time

Each test was run until the hole ran dry or for a maximum of 1 hour, with the exception of the percolation test adjacent to Test Pit No. 3. The percolation test at Test Pit No. 3 was run for 8 minutes with 2.75 inches of water remaining in the hole. The percolation rate was determined for each time increment by dividing the elapsed time by the drop in water level. The percolation rate for the last time increment is provided in Table 1. The test reports are provided in Appendix C.

Table 1. Percolation Test Results

Location	Test Depth (feet)	Material Description at Bottom of Hole	Depth to Clean Sand (feet)	Depth to Water (feet)	Percolation Rate (min/in)
TP-1	2.0	Sandy Lean Clay	2.5	2.5	16.0
TP-2	1.0	Sand	0.8	2.0	25.3
TP-3	2.0	Clayey Sand	3.5	3.0	9.2
TP-4	2.0	Clayey Sand	4.0	3.0	2.2
TP-5	1.7	Sandy Lean Clay	6.0	4.5	32.7
TP-6	1.0	Sandy Lean Clay	3.0	1.5	40.0
TP-7	1.0	Sandy Lean Clay	2.5	1.5	30.0
TP-8	1.0	Sandy Lean Clay	1.5	1.5	15.5
TP-9	2.0	Sandy Lean Clay	4.0	4.0	2.8

3.4 Previous Subsurface Investigations

The Investigation of Recharge Potential at the Cottonwood Ranch Complex: Infiltration Rates & Geotechnical Surveys (PRRIP 2017), was prepared by the PRRIP and was available for HDR review. This document includes data collected from:

- Two pilot-scale recharge basin infiltration tests
- Ten test borings and associated laboratory testing
- Four monitoring wells
- Ohm-Mapper resistivity testing

Pertinent data from *The Investigation of Recharge Potential at the Cottonwood Ranch Complex: Infiltration Rates & Geotechnical Surveys* (PRRIP 2017) is provided in Appendix D.

4.0 Site Conditions

4.1 Site Characteristics

The BSR project site is situated in the Platte River Valley. Existing site grades are fairly flat and uniform. The site grades appear to vary about 5 feet across the site, with several existing ponds, swales, and excavated drainage ditches. The Platte River is located approximately 1 to 2 miles north of the planned recharge area and the Phelps County Canal is located approximately 2 miles southwest of the planned recharge area.

According to the NRCS Web Soil Survey (NRCS 2017) for this area of Phelps County, the near-surface soils within the Platte River Valley belong primarily to the Leshara-Wann series. The Leshara-Wann series consist of somewhat poorly-drained soils on bottom lands that were formed from alluvium, including silty loam, sandy loam, loamy sand, silty clay loam, silty clay, loam, sand and sandy clay loam. Figure 4 provides the soil survey regions overlaid on the site plan.

4.2 Subsurface Conditions

4.2.1 Geologic Setting

The BSR project site is situated in South Central Nebraska within the Central Loess Plains Physiographic Region. The loess plains have been dissected locally by the Platte River Valley where the site is located. Alluvial deposits are present within the Platte River floodplain as described in Section 4.1 and are formed by deposition in flowing water. The site is located on the first alluvial terrace above and immediately south of the Platte River floodplain (USGS 2005). The alluvial deposits extend down to the Ogallala Formation (predominately sandstone) at a depth of about 40 to 50 feet.

4.2.2 Site Stratigraphy

General

The generalized soil stratigraphy at the BSR project site is presented on the subsurface profiles for each earthen berm alignment in Appendix A. The general subsurface stratigraphy consists of about 1 to 6 feet of fine-grained alluvium (blanket layer), overlying about 33 to 35 feet of course-grained alluvium (sand layer), overlying the Ogallala Formation. About 6 inches of topsoil was present at the surface of the fine-grained alluvium. The topsoil was logged as a developed zone and generally matched the classification of the underling fine-grained alluvium.

Alluvium

These soils generally consisted of a blanket layer of sandy lean clay and clayey sand overlying coarse-grained poorly graded sand. At the boring locations, the alluvium generally consisted of:

- **An alluvial blanket layer** (ground surface to about 1 to 6 feet below grade; averaging 3.5 feet below grade) was described as gray to very dark gray, light grayish brown to dark grayish brown, and very dark brownish gray, moist to saturated, very soft to stiff, sandy lean clay (CL), sandy silt (ML), clayey sand (SC), and silty sand (SM). The test results on samples recovered from this stratum indicate the following general ranges in engineering properties:
    - Moisture contents from 6 to 28 percent
    - Dry densities from 84 to 127 pounds per cubic foot (pcf)
    - Fines content from 30 to 70 percent
    - Liquid limits from non-plastic to 45
    - Plasticity indices from non-plastic to 23

  - Unconfined compressive strengths from 0.3 to 1.6 tons per square foot (tsf)
  - Pocket penetrometer readings from less than 0.25 to 1.75 tsf
  - SPT values from 2 to 14 bpf
- **An alluvial sand layer** (bottom of alluvial blanket layer to bottom of borings at 15 to 50 feet below grade or Ogallala Formation at 40 to 42 feet below grade) was described as light gray to very dark gray, light grayish brown to dark grayish brown, and light brown, very moist to saturated, very loose to dense, poorly graded sand (SP), poorly graded to well graded sand (SP/SW), silty sand (SM), and clayey sand (SC). The test results on samples recovered from this stratum indicate the following general ranges in engineering properties:
  - Moisture contents from 7 to 21 percent;
  - Fines content from 1 to 24 percent; and
  - SPT values from 2 to 54 bpf.

Ogallala Formation

The Ogallala Formation was encountered in several of the deeper borings below the alluvial sand at depths ranging from 40 to 42 feet below existing grade (Elevation 2,238.1 to 2,245.5 feet). It was described as light gray, light brown, pale brown, brown and gray, saturated and moist, very stiff to hard and dense to very dense, clayey sand (SC) and lean clay/clayey sand (CL/SC). Some amount of weathering was noted near the surface. SPT blow counts in the material ranged from 33 to 121 bpf and averaged 68 bpf.

Groundwater

Groundwater was encountered at the depths and times noted on the boring logs and test pits. A summary of recorded groundwater data at the boring locations at the time of our investigation is provided in Appendix A.

Depth to groundwater in the borings ranged from 1.6 to 8.8 feet below existing ground at the time of the investigation. These depths corresponded to a groundwater elevation between 2,275.1 and 2,285.0 feet.

During excavation of some of the test pits, the excavation through the clay blanket layer remained dry until the excavation came within a couple inches of the underlying sand layer. Within a couple of inches of the underlying sand layer, groundwater ruptured through the clay blanket. This indicates that portions of the groundwater are under pressure and confined by the clay blanket.

Fluctuations in the level of the groundwater may occur due to seasonal variations in local and regional precipitation and other factors not evident at the time of measurement.

4.2.3 Surficial Soil Characteristics

The soils present at the site in the top 1 to 6 feet generally consist of soft to firm, sandy lean clay to clayey sand soils from predominantly alluvial deposits. These soils are generally considered: (1) competent to support the proposed embankment and structural loads and (2) a good source of embankment fill for earthen berms, if properly processed and compacted with moisture and density control.

Summaries of the classification and strength test data for the various materials at the site are provided in Appendix B.

4.3 Geologic Investigations

4.3.1 Seismic Assessment

According to the Seismic Zone Map (Figure 4-1 in TR-60), the BSR project site is located near Seismic Zone 1, which corresponds to a low seismic exposure. This designation indicates that the BSR project would not require special investigations to assess the potential for liquefaction or faulting at the site. Based on Figure 4-1 in TR-60, the corresponding seismic horizontal coefficient for the site is 0.05g, which will be used in the pseudo-static analysis of slope stability analyses.

4.3.2 Collapsible Soils

The collapse potential of the fine-grained alluvium was evaluated using the criteria developed by the United States Department of the Interior Bureau of Reclamation (USBR) *Design of Small Dams* (1987), which is based on dry densities and liquid limits of the in situ soils. The results of this evaluation indicate that the fine-grained alluvial soils have dry densities and liquid limits near or above the threshold to exhibit potential for collapse upon wetting, suggesting that the material is marginally collapsible. The shallow groundwater elevation and relatively high water contents suggest that the material has been wetted and any future collapse is likely to occur during placement of the fill. Based on these assessments, no mitigation will be necessary.

4.3.3 Dispersive Soils

Mid-States Engineering & Testing, Inc. performed a series of pin-hole dispersion tests on the fine-grained alluvium. The results of the test indicate that the fine-grained alluvium is non-dispersive. Based on these assessments, no mitigation will be necessary.

4.3.4 Corrosive Soils

According to the soil survey (NRCS, 2017), the site soils are moderately corrosive to concrete and severely corrosive to steel. The designer of the concrete flumes and other below grade structures should include mitigation measures to protect the concrete and steel exposed to soil and water.

5.0 Engineering Analyses

Seepage, slope stability, and settlement analyses were performed for the earthen berms. Bearing capacity and lateral earth pressure analyses were performed for the concrete flumes.

5.1 Seepage Analyses

5.1.1 General

Seepage analyses of the foundation and embankment were conducted to estimate the location of the phreatic surface for use in the stability analyses, estimate average vertical exit gradient at the downstream toe of the embankment, estimate factor of safety against piping at the downstream toe of the embankment, and evaluate mitigation measures, if needed.

5.1.2 Design Criteria

Design criteria for dams were used for design of the earthen berms. Design criteria for seepage are discussed in TR-60. According to TR-60, seepage analyses made for anticipated seepage rates and pressures through the embankment, foundation, abutments, and reservoir perimeter must show that that the dam can accomplish the intended reservoir function, provide a safe operating structure, and prevent damage to downstream property. For the purpose of this BSR project, the vertical exit gradient and the factor of safety for piping at the downstream toe of the earthen berm were evaluated. TR-60 does not provide specific guidance on acceptable vertical exit gradient and factor of safety for piping.

United States Army Corps of Engineers (USACE) “Design Guidance for Levee Underseepage” (USACE 2005) provides the information in Table 2 comparing vertical exit gradient to seepage condition at the downstream toe of a levee.

Table 2. Vertical Exit Gradient versus Seepage Condition Trends

Vertical Exit Gradient	Seepage Condition
0 to 0.5	Light/No Seepage
0.2 to 0.6	Medium Seepage
0.4 to 0.7	Heavy Seepage
0.5 to 0.8	Sand Boils

Source: USACE 2005

USACE guidance for *Seepage Analysis and Control for Dams* (USACE 1986) states that acceptable piping factor of safety for a dam ranges from 1.5 to 15 and is generally in the range of 2.5 to 5. Piping is a process where seepage through the embankment or under the embankment is at a high enough rate to erode the embankment or foundation soil. The eroded soil discharges on the downstream side of the embankment. Erosion through the embankment would lead to an eventual washout of the embankment. Erosion through the foundation would lead to sinking of the embankment crest and eventual overtopping.

Because the earthen berms do not classify as dams and the consequence of failure is unlikely to result in the loss of life or damage to property, it is HDR’s opinion that the design of the earthen berms can be based on a maximum vertical exit gradient of 0.5 and a minimum factor of safety for piping of 1.5. Medium seepage and some seepage maintenance at the downstream toe should be expected with this factor of safety.

5.1.3 Method of Evaluation

The evaluation of underseepage was performed based on the thickness and permeability of the natural blanket layer, the thickness and permeability of the foundation sands, and the maximum head acting on the earthen berm section. The average vertical exit gradient through the blanket layer material was calculated at the downstream toe of the earthen berm section. The piping factor of safety was calculated by dividing the critical vertical exit gradient for the blanket layer material by the average vertical exit gradient.

Seepage analyses were completed using the computer software SEEP/W, which is part of the GeoStudio 2016 software suite copyrighted by GEO-SLOPE International Ltd. SEEP/W is a two-dimensional finite element analysis program that calculates gradients of flow, equipotential lines, head drops, seepage pressures, and quantities for the flow of water through a layered, porous, and anisotropic material.

5.1.4 Assumptions and Design Parameters

The primary assumptions made for the underseepage analyses are presented in the following.

- The berms will be constructed from soil borrowed from the blanket layer upstream of each berm.
- The maximum berm height is 5.9 feet.
  - Critical condition for the berm design is a water level 1.5 feet below the maximum berm height and no water downstream of the berm.
  - Berms will have 6H:1V (Horizontal:Vertical) side slopes with a 12-foot wide crest.
- The soil layers are continuous upstream and downstream of the berm alignment.

The critical sections for seepage analysis were established by reviewing the boring logs and subsurface profiles along each berm alignment and determining were the thinnest blanket layer is located near the tallest section of the berm. Subsurface profiles along the earthen berm alignments are provided in Appendix A. Based on this review, two critical sections were identified.

The first section represents the berms located away from the conveyance channels. The borings located near the berm alignment indicate that the critical thickness of the blanket layer is about 3 feet and the sand layer is about 35 feet thick. The berm thickness at this critical section ranges from 0 to 5.9 feet

The second section represents the concrete flume located at the conveyance channels. These locations are at the existing drainage ditches. No borings were obtained at the bottom of the ditches to provide information on the thickness of the blanket layer. It is likely that only a thin blanket exists at the bottom of the ditch, since the existing ditches at the site were primarily man-made and about 3 feet deep. Additionally, the portions of the ditches located channel downstream of the concrete flume will include embedded riprap, which is expected to remove any remaining remnants of the blanket layer. The selected critical section is no blanket layer and a 35-foot-thick sand layer. A gate in the concrete flume will have a height of 5.9 feet above the flume floor.

The values of effective permeability that were used in the SEEP/W analysis are provided in Table 3. Derivation of these values is provided in Appendix E.

Table 3. Permeability Values for Seepage Analyses

Material Description	k_h (ft/s)	k_v/k_h
Berm Fill	$4x10^{-7}$	0.25
Blanket Layer	$4x10^{-6}$	0.25
Sand Layer	$1x10^{-3}$	0.25

Notes:
1 k_v = coefficient of vertical permeability.
2 k_h= coefficient of horizontal permeability.

5.1.5 Results of Underseepage Analysis

A summary of the underseepage analyses for the berm alignments are provided in Tables 4 and 5. Bold numbers indicate that the allowable average vertical exit gradient or minimum factor of safety is exceeded. Calculations for the underseepage analyses are provided in Appendix F.

Table 4. Summary of Underseepage Analyses for Berms without Mitigation Measures

Critical Section	Pool Height (feet)	Average Vertical Exit Gradient at Downstream Toe	Factor of Safety For Piping at Downstream Toe	Comments
Berms Located Away from Conveyance Channels	4.4	0.90	0.8	i >0.5 and FS<1.5, NG
	4	0.80	1.0	i >0.5 and FS<1.5, NG
	3	0.63	1.2	i >0.5 and FS<1.5, NG
	2	0.43	1.8	OK
Concrete Flumes Located at Conveyance Channels	4.4	0.25	3.0	OK

Notes:
1 NG = Not Good.
2 FS = Factor of Safety.
3 Critical Exit Gradient = 0.76.

Based on these results, mitigation is needed for berm alignments that have pool heights greater than 2 feet, which is in agreement with the results of the preliminary design analyses (HDR, 2017). Based on direction from the PRRIP, mitigation will consist of a supplemental downstream seepage berm for Cells 1 through 4, which are not impacted by ROW restrictions, and a downstream toe drain for Cells 5 through 8, which are impacted by ROW restrictions.

Based on these results, no mitigation is need for the concrete flumes, provided there is no blanket present downstream of the concrete flumes. However, a perimeter wall drain should be provided along the downstream perimeter of the concrete flume walls to collect seepage along any preferential seepage paths, which are common along the interface of the concrete flume wall and the earthen berm.

The following assumptions were made in the underseepage analyses for the earthen berm mitigation measures:

- Seepage berms will be constructed from soil borrowed from the sand layer upstream of the berm alignment.

- Toe drains will consist of a slotted pipe fitted with a filter sock and an outlet 6 inches above the surface of the blanket.

The average vertical exit gradient through the blanket layer material was calculated at the downstream toe of the corresponding mitigation measure. Table 5 provides a summary of the underseepage analyses for the different mitigation scenarios.

Table 5. Summary of Underseepage Analyses for Berms Alternative with Mitigation Measures

Location	Mitigation Measure	Maximum Pool Height (feet)	Average Vertical Exit Gradient at Downstream Toe	Factor of Safety for Piping at Downstream Toe	Comments
Berms 1 through 4	Install 250-Foot Wide Downstream Seepage Berm with a Maximum Thickness of 3 Feet	4.4	0.50	1.5	OK
	Install 200-Foot Wide Downstream Seepage Berm with a Maximum Thickness of 2.5 Feet	4	0.50	1.5	OK
	Install 75-Foot Wide Downstream Seepage Berm with a Maximum Thickness of 1.5 Feet	3	0.50	1.5	OK
Berms 5 through 8	Install Toe Drain at Downstream Toe of Berm at a Depth of 4 Feet	4.4	0.33	2.3	OK

Notes:
1 NG = Not Good.
2 FS = Factor of Safety.
3 Critical Exit Gradient = 0.76.

The results of these analyses demonstrate a stable embankment can be constructed for pool heights greater than 2 feet with the implementation of mitigation measures consisting of downstream seepage berms for Berms 1 through 4 and downstream toe drains for Berms 5 through 8. Seepage berm widths are shorter than what was reported in the preliminary report.

5.2 Slope Stability Analyses

5.2.1 General

The slope stability analyses were performed using the limit equilibrium option in the program SLOPE/W, which is part of the GeoStudio 2016 software suite copyrighted by GEO-SLOPE International Ltd. The limit equilibrium method analyzes individual slices of the potential sliding mass with force and moment equilibrium to determine a factor of safety for all of the slices. The program searches for the location of the critical failure surface that produces the minimum factor of safety. The Spencer method of analysis for circular arc surfaces was selected for the analysis. The slip surfaces were then optimized to find the lowest factor of safety for different slip surface shapes (non-geometrically definable shape) (GEO-SLOPE International Ltd. 2016).

5.2.2 Design Criteria

Design criteria for slope stability are discussed in TR-60. According to TR-60, the minimum required factors of safety for a low hazard dam subjected to various loading conditions are provided in Table 6.

Table 6. Minimum Required Factors of Safety

Loading Case	Minimum Factor of Safety
End of Construction	1.4
Rapid Drawdown	1.2
Steady Seepage	1.5
Steady Seepage w/ Seismic	1.1

5.2.3 Evaluation of Soil Strengths

The critical section for seepage analysis was determined by reviewing the subsurface profile along each berm alignment. Subsurface profiles along the earthen berm alignments are provided in Appendix A. The critical section was selected as the location where the thickest blanket layer is located near the tallest section of the berm. At this location, the blanket layer is about 6 feet thick and the sand layer is about 35 feet thick. The results of the slope stability analysis for the critical berm section should be applied to each berm alignment.

The design shear strength parameters listed in Table 7 were developed for the BSR project based on the laboratory testing, pocket penetrometer readings, and SPT data completed for this BSR project. Derivation of these values is provided in Appendix E.

A summary of the strength parameters used in the stability analyses are presented in Table 8.

Table 7. Design Shear Strength Parameters

Material	Unit Weight	UU Strengths		CU Strengths		CD Strengths	
	γ_{total} (pcf)	c (psf)	**Φ (degrees)**	c (psf)	**Φ (degrees)**	c' (psf)	**Φ'** (degrees)
Berm Fill	125	1,000	0	500	12	50	28
Blanket Layer	110	600	0	300	12	50	28
Sand Layer	115	0	30	0	30	0	30

where: c, c' = total and effective cohesion or undrained shear strength.
Φ, Φ' = total and effective angle of internal friction.
UU = Unconsolidated Undrained triaxial
CU = Consolidated Undrained triaxial
CD = Consolidated Drained triaxial

5.2.4 Results of Stability Analyses

Calculations for the stability analyses are provided in Appendix G. The results of the slope stability analyses are presented in Table 8.

Table 8. Summary of Slope Stability Analyses without Mitigation Measures

Berm Height (feet)	Loading Case	Slope	Phreatic Surface	Factor of Safety	Comments
5.9	End of Construction	Upstream/Downstream Downstream	3 Feet Below Existing Grade	5.4	OK
	Rapid Drawdown	Upstream	Normal Pool to Existing Grade	3.1	OK
	Steady Seepage	Downstream	From Seepage Analysis at Normal Pool (4.4-FT Pool)	2.5	OK
	Steady Seepage w/Seismic (ah=0.05g)	Downstream	From Seepage Analysis at Normal Pool (4.4-FT Pool)	1.9	OK

Based on these results, a stable embankment can be constructed and no mitigation is needed for berm heights of 5.9 feet or less.

5.3 Settlement Analyses

Based on review of the subsurface profile along each berm and dam alignment, the critical section where the thickest blanket layer is located near the tallest section of the berm or dam, the blanket layer is about 6 feet thick and the sand layer is about 35 feet thick.

Because an 8-foot-wide inspection trench would be excavated near the dam or berm centerline completely removing the blanket layer, and would be backfilled with compacted fill, there would be no compressible soil beneath the tallest portion of the embankment. HDR recommends that the berm alignments be overbuilt 3 inches, where the fill is at maximum height, to offset any long-term settlement that may occur.

5.4 Foundation Analyses

The flume walls are expected to bear on undisturbed soils consisting of sand. Continuous footings a minimum of 3.5 feet below grade can be sized for a maximum net soil bearing pressure of 1,000 psf. The maximum net soil bearing pressure is based on a factor of safety of 3. Bearing capacity calculations are provided in Appendix H.

Some differential settlement is likely across the concrete flume. Continuous footing/foundation wall combinations should be designed to function as grade beams. Top and bottom reinforcement should provide the capacity to span at least 10 feet when acting as a continuous beam under foundations loads.

5.5 Lateral Earth Pressure Analyses

The flume walls will be required to support differential soil heights of up to about 6 feet. The lateral pressures developed against these walls are a function of the properties of the retained soils, placement procedures of the wall backfill, hydrostatic pressure, frost action, and wall movements. The magnitude and distribution of the lateral pressures on such walls can vary widely. Experience has shown that these lateral earth pressures can be approximated for design using an equivalent fluid pressure. Design should be based on groundwater behind the wall at a height of 4.4 feet above the flume floor and groundwater in front of the wall at the flume floor.

We recommend that the lateral pressure used for structural design of the walls within the active zone be based on an equivalent fluid pressure of 45 pcf above the groundwater and 85 pcf below the groundwater for the sandy clay fill placed behind the wall above the berm floor elevation. For normal conditions, the groundwater should be assumed to be 1.5 feet below the top of the wall and for extreme conditions, the groundwater should be assumed to be at the top of the wall. Below the berm floor elevation within the active zone, lateral pressure should be based on an equivalent fluid pressure of 80 pcf for the undisturbed sand or compacted sand fill. Passive resistance below the berm floor elevation should be based on an equivalent fluid pressure of 220 pcf for the undisturbed sand or compacted sand fill. A lateral pressure diagram is provided in Appendix I.

6.0 Findings and Recommendations

6.1 Summary of Findings

The geotechnical investigations and engineering analyses conducted for the proposed BSR project demonstrate that a stable embankment can be constructed with appropriate mitigation measures.

- Supplemental downstream seepage berms would be necessary for Berms 1 through 4. This mitigation would consists of constructing a minimum 3-foot high (at the berm slope), 250-foot wide (from berm toe to seepage berm toe) downstream seepage berm, where the berm height would be 5.9 feet (4.4-foot pool) down to a minimum 1-foot high, 75-foot wide downstream seepage berm, where the berm height would be 4.5 feet (3-foot pool) and transition to zero height and width, where the berm height would be less than or equal to 3.5 feet (2-foot pool). A typical section is provided as Exhibit No. 1 in Appendix J. A maximum of 6 inches of topsoil could be placed over the seepage berm to allow for a seed bed and grass cover.
- Supplemental downstream toe drains would be necessary for Berms 5 through 8. This mitigation would consist of installing a slotted drain pipe fitted with a filter sock a depth of 4 feet below the ground surface. The toe drain would be necessary where the berm height is 3.5 feet (2-foot pool) or higher. Minimum drain diameter should be 6 inches. A typical section is provided as Exhibit No. 2 in Appendix J.

- Blanket layer mitigation would be necessary for Berms 1 through 8. Where the berms cross swales, ponds, or other lower areas, and where the blanket layer may not be present due to erosion or excavation, the blanket layer would need to be restored by filling in the low areas with sandy lean clay for a distance of 100 feet upstream and 500 feet downstream of the berms. No blanket layer mitigation would be necessary where a toe drain is present along the downstream toe.
- Excavations for pool enhancements would need to be restricted for a distance of 100 feet upstream and 500 feet downstream of the berms.
- The berm sections would need to be overbuilt 3 inches, where the fill is at maximum height, to offset any long-term settlement that may occur.
- Groundwater dewatering would be necessary to construct the concrete flumes and other below grade structures along each berm alignment.
- A wall drain would need to be provided along the downstream perimeter of the concrete flume walls to collect seepage from preferential seepage paths, which are common along the interface of the concrete flume wall and the earthen berm.
- The site soils are moderately corrosive to concrete and severely corrosive to steel. The designer of the concrete flume and other below grade structures would need to include mitigation measures to protect the concrete and steel exposed to soil and water.

6.2 Recommendations for Construction

6.2.1 Berm Inspection Trench

An inspection trench should be excavated along the entire embankment centerline for each berm alignment. The excavation depth can be stopped when the underlying clean sand is encountered, which is expected to be between 3 and 6 feet below existing grades. The trench should be a minimum of 8 feet wide at the bottom. The side slopes of the trench should be inclined at 2H:1V.

A geotechnical engineer should observe the inspection trench and document the depth to the underlying clean sand and any anomalies, such as drain tile, rubbish, organics, sand lenses, or other material that could adversely impact the performance of the berm. A report should be prepared by the geotechnical engineer that provides the depth to the underlying sand versus berm alignment station every 100 feet and the location and description of any anomalies.

6.2.2 Earthwork

Prior to embankment placement, all topsoil, organic matter, shrubs, trees and large roots, and any debris encountered should be removed from areas to receive fill. The exposed surface should be scarified and mixed with the first lift of fill.

The berms and blanket layer restoration areas should be constructed from the on-site sandy lean clay to clayey sand soils with a minimum of 35 percent passing the number 200 sieve. The material should be placed in 8-inch loose lifts and compacted using sheepsfoot compaction equipment. All fill should be compacted to a minimum of 95 percent of the maximum dry density as determined by ASTM D698 “Method A” (standard Proctor test) within 0 percent and +4 percent of the optimum water content as determined by the referenced test.

The supplemental seepage berm should be constructed from the on-site silty sand and clean sand with a maximum of 15 percent passing the number 200 sieve. The material should be placed in 12-inch loose lifts and lightly compacted using controlled movement of the hauling and spreading equipment to create a stable surface for each lift of fill, such that rut depths are no greater than 4 inches in a single pass.

6.2.3 Borrow Areas

Borrow material is expected to come from on-site excavations made to enlarge the pool areas and establish whooping crane habitat. The top 1 foot to 3 feet of excavation is expected to encounter primarily sandy lean clay to clayey sand, which would be suitable for berm embankment and blanket layer restoration. Silty sand to clean sand was encountered below the upper sandy lean clay to clayey sand. This silty sand to clean sand which would be suitable for seepage berm construction is expected to be encountered primarily below depths of about 5 feet.

Groundwater was generally encountered about 3 feet below grade and was generally located at the base of upper sandy lean clay to clayey sand. Excavations to mine the silty sand to clean sand suitable for seepage berm construction will likely require dewatering or excavation below the groundwater table.

Water content of the sandy lean clay to clayey sand blanket layer ranged from about 16 percent to 28 percent, which is expected to be above the optimum water content for compaction. These soils will likely need to be moisture conditioned prior to compaction within the berm embankment or blanket layer restoration. Typically, moisture conditioning consists of periodic disking and allowing the sun and wind to dry-out the soil before compaction.

Soils excavated below the water table to mine the silty sand to clean sand suitable for seepage berm construction will likely need to be drained before placement. This can typically be accomplished by placing the material in a stockpile and allowing the excess water to drain-out before placing it at the seepage berm.

6.2.4 Dewatering

Excavations to construct the concrete flumes and toe drains are expected to encounter groundwater and will need to be dewatered to a depth of 3 feet below the bottom of the excavation prior to beginning the excavation. This will likely require installing a series of continuously pumped wells. A minimum of 1 piezometer should be installed at each excavation and monitored before and during excavation to verify that the dewatering system has lowered the groundwater to the required depth.

6.2.5 Concrete Flume Wall Drain

A wall drain should be provided along the perimeter of the concrete flume walls that are located downstream of the berm centerline to collect seepage from any preferential seepage paths common along the interface of the concrete flume wall and the earthen berm. The wall drain trench should extend to a minimum depth of 12 inches below the bottom of flume wall footings, have a minimum width of 3 feet, and extend to a height of 2 feet below the top of the flume wall.

The wall drain trench should be backfilled with free-draining aggregate meeting the gradation requirements provided in Table 9. Nebraska Department of Transportation 47B Fine Aggregate for Portland Cement Concrete generally meets this gradation. Filter gradation calculations are provided in Appendix K.

Table 9. Wall Drain Free-Draining Aggregate Gradation

Sieve Size	Percent Passing
2”	100
½”	80 to 100
#4	65 to 95
#10	45 to 75
#30	15 to 60
#200	0 to 5

The slotted collector pipe should be installed on the backside of the flume wall footing. The collector pipes should discharge into a collector box that has an outlet through the concrete flume downstream headwall, 6 inches above the flume floor and a secondary outlet 6 inches above the top of the adjacent grade. The discharge pipe into the concrete flume should have a check valve to prevent sediment from entering the end of the pipe.

Maximum flow into the collector pipe is estimated to be 0.5 gallons per minute per foot of pipe. Pipe size should be design to accommodate twice the estimated maximum flow, should be a minimum of 6 inches in diameter, and have a maximum slot width of 0.05 inches.

6.2.6 Toe Drain

Due to shallow groundwater and the need for dewatering to maintain a stable trench, traditional open excavation with free-draining aggregate backfill toe drain construction would be cost prohibitive. To avoid the need for dewatering along the entire length of each toe drain, the toe drain located along Berms 5 through 8 could consist of a slotted collector pipe fitted with a filter sock that is directly embedded a minimum of 1 foot into the native clean sand. This could be accomplished using a plow equipped with an internal feed tube to place the pipe and sock directly behind the plow as it is pulled along the alignment. Only the excavation for installing the plow to the required depth would require dewatering, which could correspond with the dewatering required for the concrete flume construction. United States Bureau of Reclamation (USBR) research has shown good performance for a slotted collector pipe fitted with a filter sock when surrounded by sand (USBR, 1999).

The depth of installation of the drain pipe can be estimated at 4 feet. Actual installation depth should be determined by a geotechnical engineering after determining the depth to clean sand observed in the inspection trench.

After installation of the toe drain, the ground surface disturbed by the plow would need be restored by running a sheepsfoot compactor over the plow scar. Once surface restoration is complete, the inside of the pipe should be inspected with a camera to verify the pipe was not damaged or experienced significant deformation. This inspection can be eliminated if the Contractor is able to demonstrate that the first three pipe installations do not result in damage to the pipe.

Alternatively, the toe drain could be installed using traditional open excavation and free-draining granular backfill, which would likely require dewatering the entire length of each toe drain to lower the groundwater 3 feet below the bottom of the excavation. The minimum trench width should be 3 feet and the trench should be backfilled with free-draining aggregate meeting the gradation requirements provided in Table 10. Filter gradation calculations are provided in Appendix K.

Table 10. Toe Drain Free-Draining Aggregate Gradation

Sieve Size	Percent Passing
2”	100
½”	35 to 100
#4	10 to 50
#10	8 to 10
#200	0 to 5

The slotted collector pipe should be installed 12 inches above the bottom of the trench. A maximum of 6 inches of topsoil could be placed over the free-draining granular material to allow for a seed bed.

Each collector pipe should discharge into a collector box located adjacent to the conveyance channel. The collector box should have a solid pipe that discharges into the conveyance channel about 6 inches above the bottom of the channel and a secondary outlet that discharges 6 inches above the grade adjacent to the collector box. The discharge pipe into the conveyance channel should have a check valve to prevent sediment from entering the end of the pipe.

Maximum flow into the collector pipe is estimated to be 0.2 gallons per minute per foot of pipe. Pipe sizes would need to be designed to accommodate twice the estimated maximum flow, be a minimum of 6 inches in diameter, and have a maximum slot width of 0.05 inches.

6.2.7 Instrumentation

Geotechnical instrumentation (settlement plates, piezometers, and inclinometers) are not required to monitor performance of the berm embankments, due to the relatively low embankment heights proposed for the BSR project.

6.3 Recommendations for Operations and Maintenance

HDR recommends storing a stockpile of sand and equipment near the site to quickly move and place the sand in the event of excessive seepage or sand boils. The downstream toe of the berms and supplemental seepage berms should be routinely observed for seepage or instability during operation of each basin. Sand blankets should be added to areas that experience excessive seepage or piping (sand boils or slope erosion). The flow into the wall drain and toe drain collector boxes should be routinely monitored for flow rate and sediment transport. Unusual changes in flow rate or an increase in sediment transport should be investigated by running a camera through the pipe to identify the cause.

7.0 Limitations

This report presents the findings, conclusions, and recommendations for the geotechnical aspects of the proposed containment berms for the BSR project. It has been prepared in accordance with generally accepted engineering practice and in a manner consistent with the level of care and skill for this type of project within this geographic area. No warranty, expressed or implied, is made.

The conclusions and recommendations presented herein are based on field reconnaissance, research and available literature, the results of field exploration and laboratory materials testing, the results of engineering analyses, experience, and judgment.

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

8.0 References

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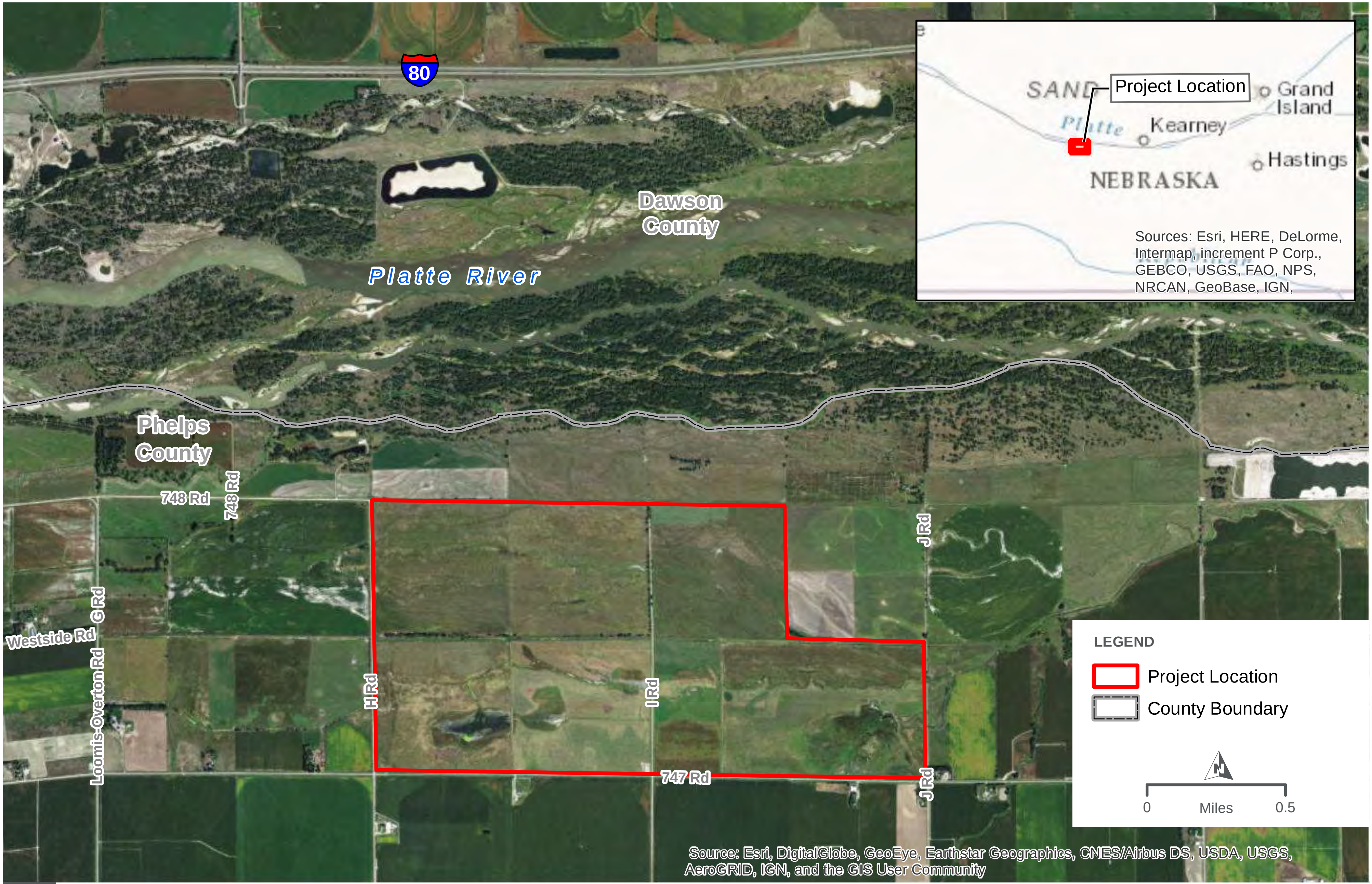

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN,

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

COTTONWOOD RANCH

PROJECT LOCATION

FIGURE 1

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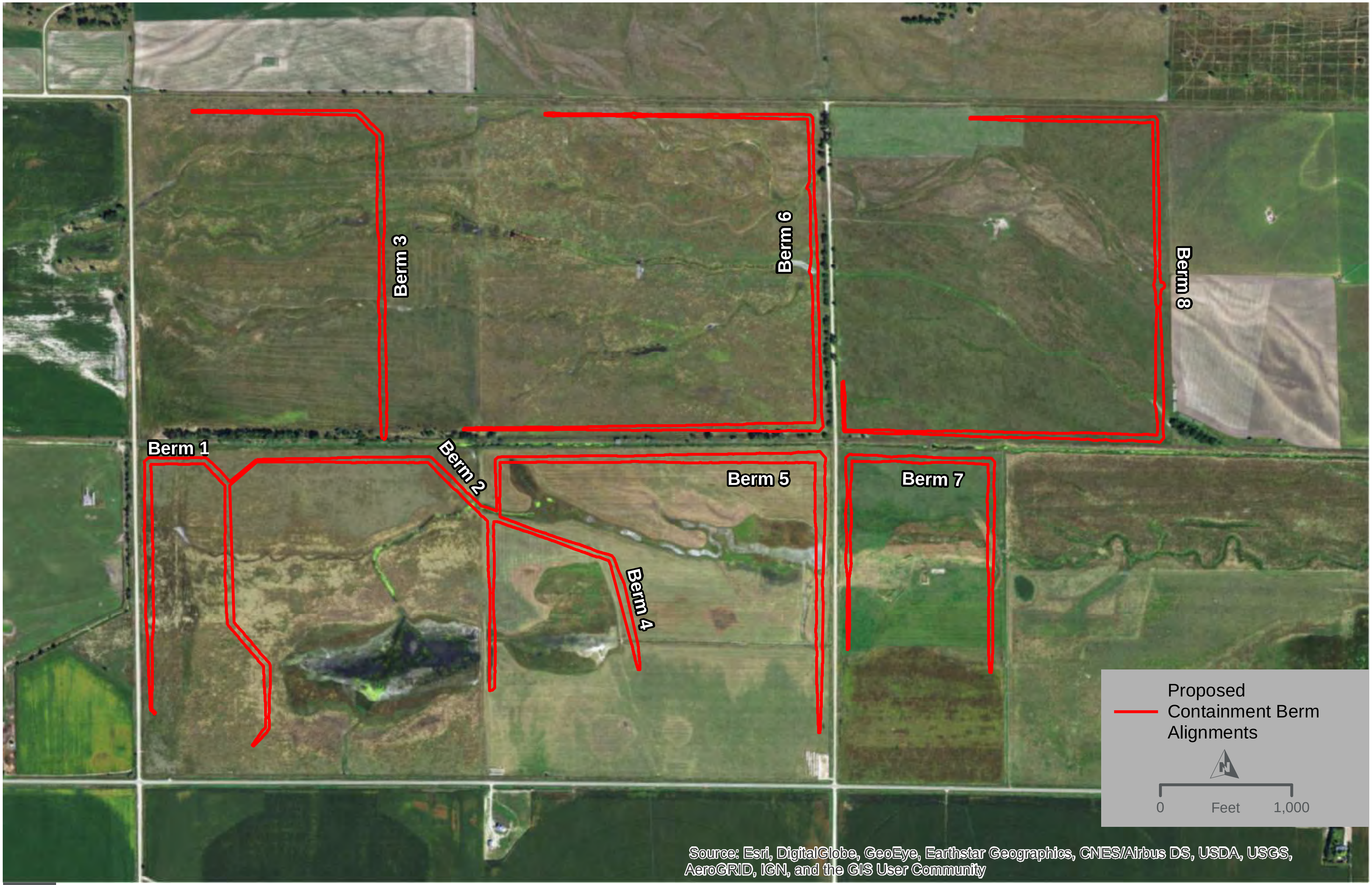

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

COTTONWOOD RANCH

PROPOSED CONTAINMENT BERM ALIGNMENTS

FIGURE 2

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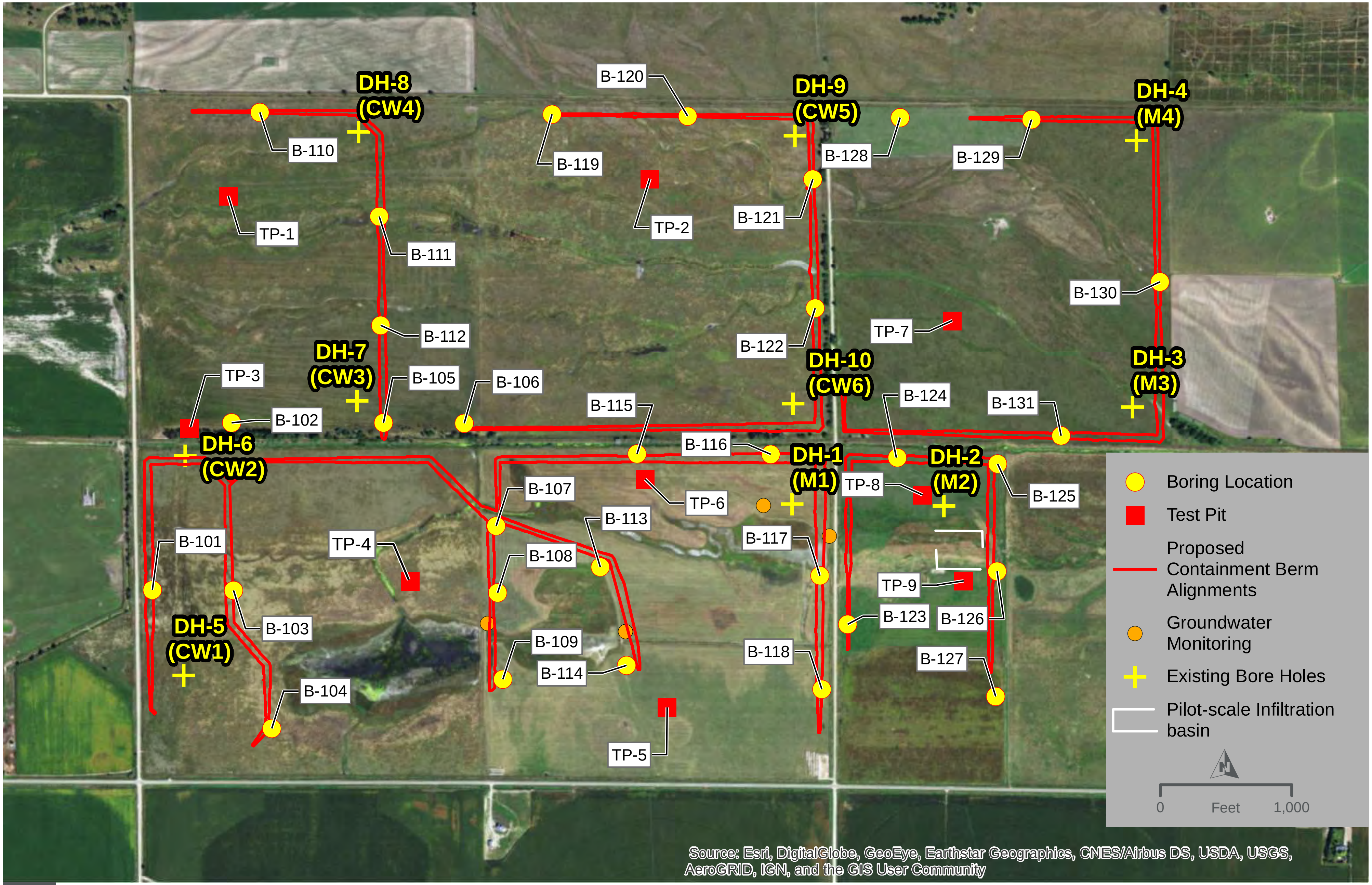

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HDR

COTTONWOOD RANCH

SITE AND GEOTECHNICAL BORING LOCATION MAP

FIGURE 3

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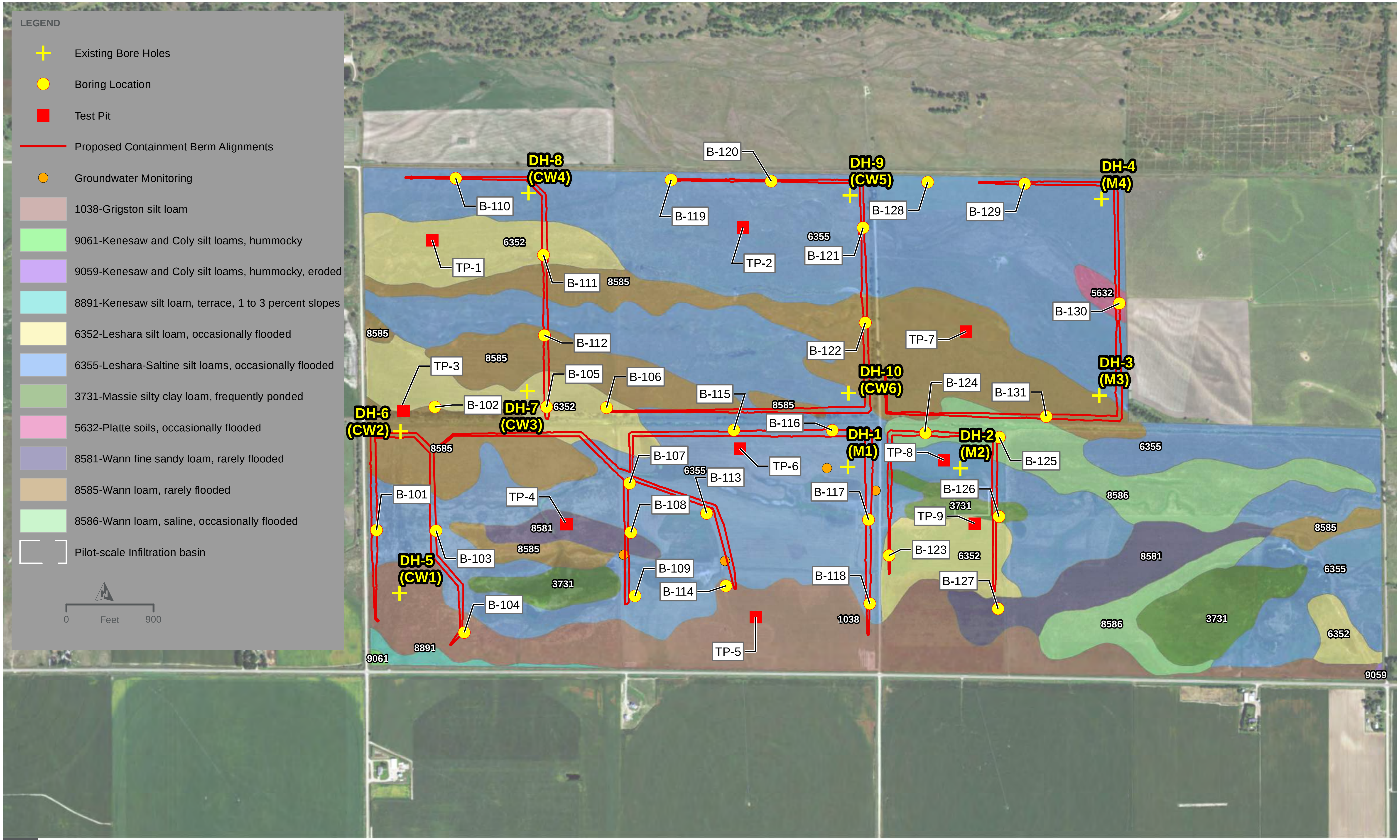

COTTONWOOD RANCH

SOIL TYPE AND GEOTECHNICAL BORING LOCATIONS

FIGURE 4

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COTTONWOOD RANCH BROAD SCALE RECHARGE PROJECT

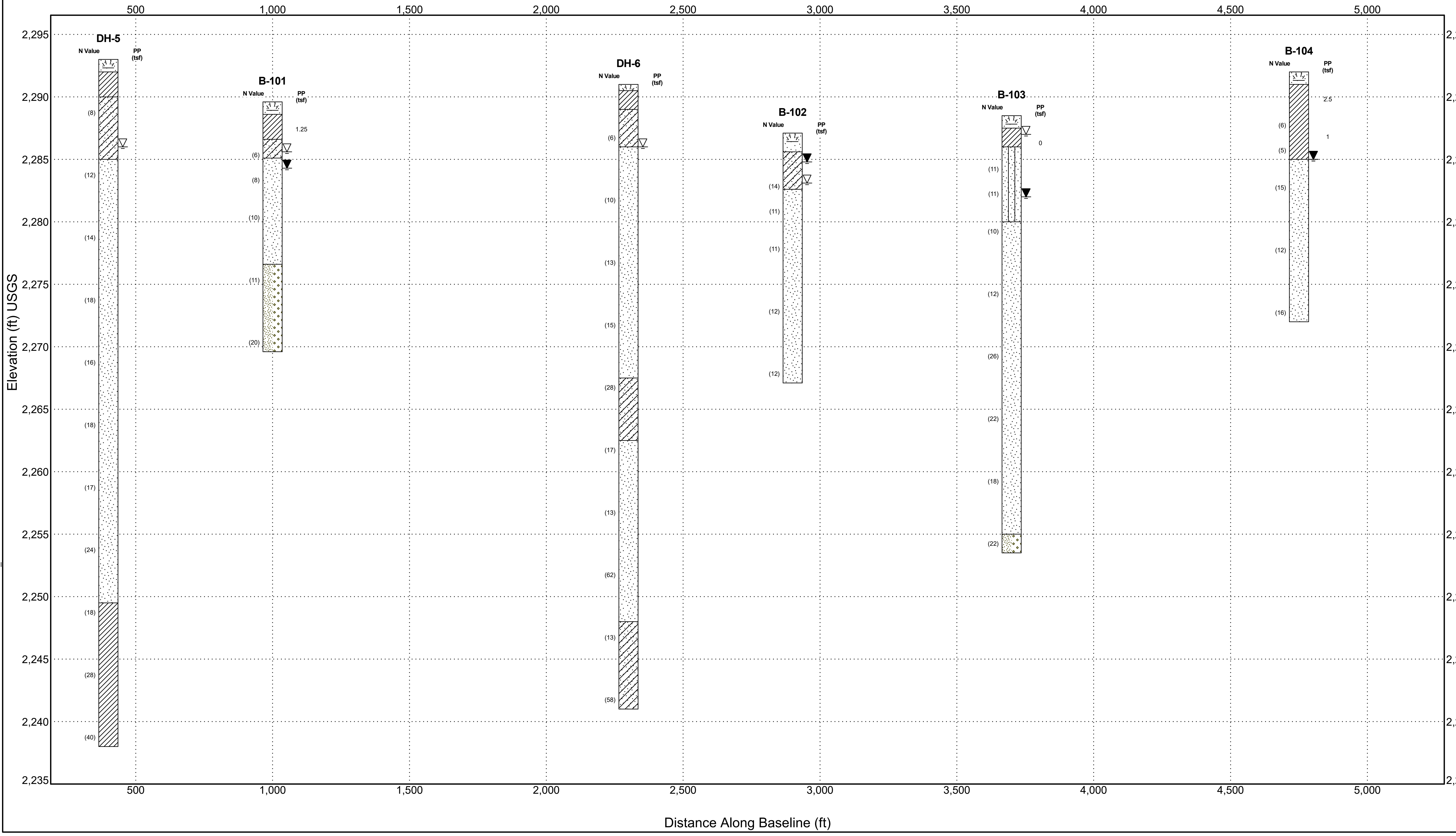
Appendix A

Logs of Test Borings and Test Pits

SUBSURFACE DIAGRAM
Berm No. 1

▨ Topsoil
▨ USCS Low Plasticity Clay
▨ USCS Clayey Sand
▨ USCS Poorly-graded Sand
▨
▨ USCS Silty Sand

CLIENT PRRIP
PROJECT NUMBER 10057849
PROJECT NAME Cottonwood Ranch BSR
PROJECT LOCATION Phelps County



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SUBSURFACE DIAGRAM
Berm No. 2

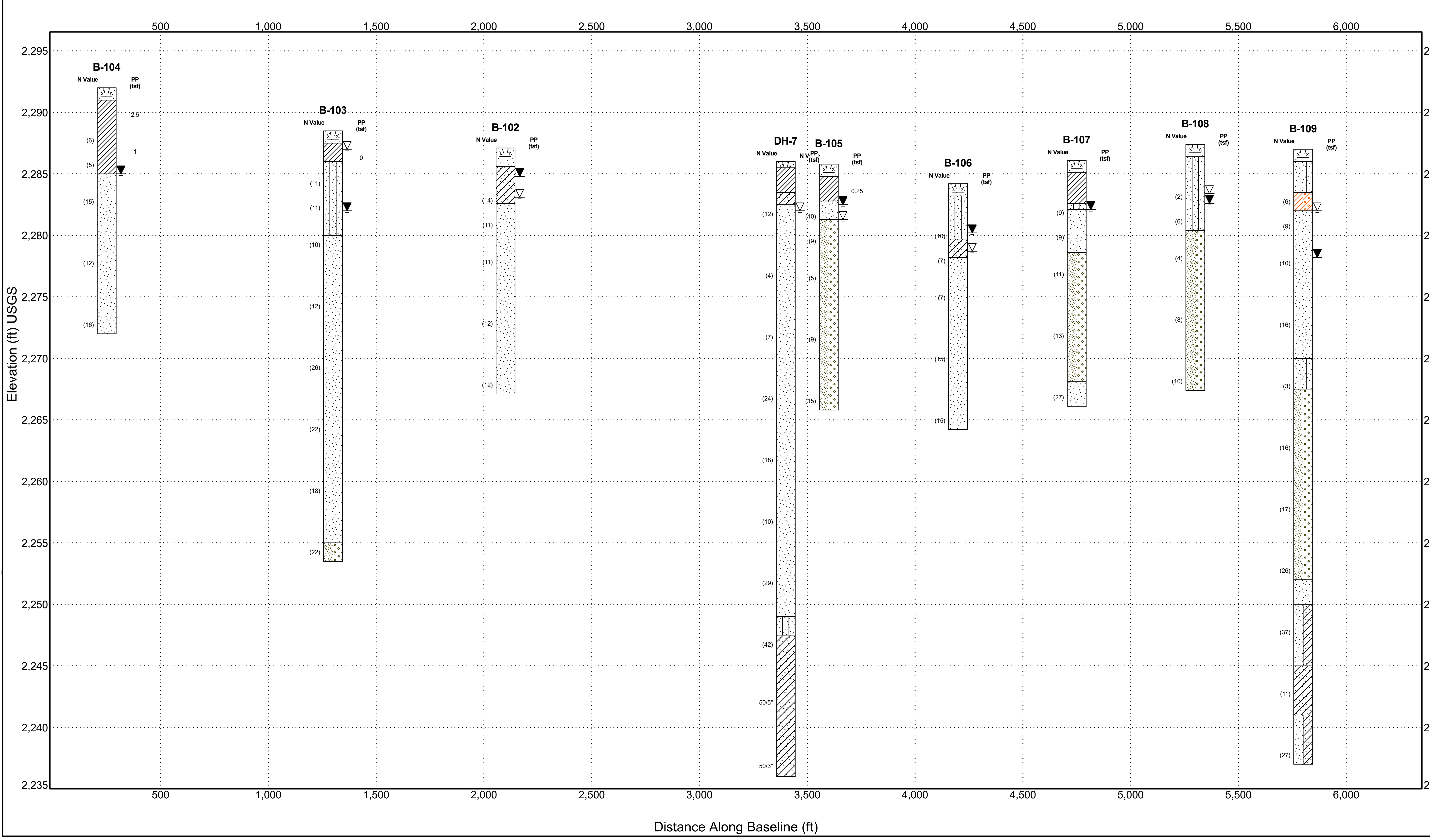
▨ Topsoil	▨ USCS Clayey Sand	▨ USCS Poorly-graded Sand
▨ USCS Low Plasticity Clay	▨ USCS Silty Sand	▨ USCS SP/SW
🟧 USCS CL/SC	▨ USCS Poorly-graded Sand with Clay	

CLIENT PRRIP

PROJECT NUMBER 10057849

PROJECT NAME Cottonwood Ranch BSR

PROJECT LOCATION Phelps County



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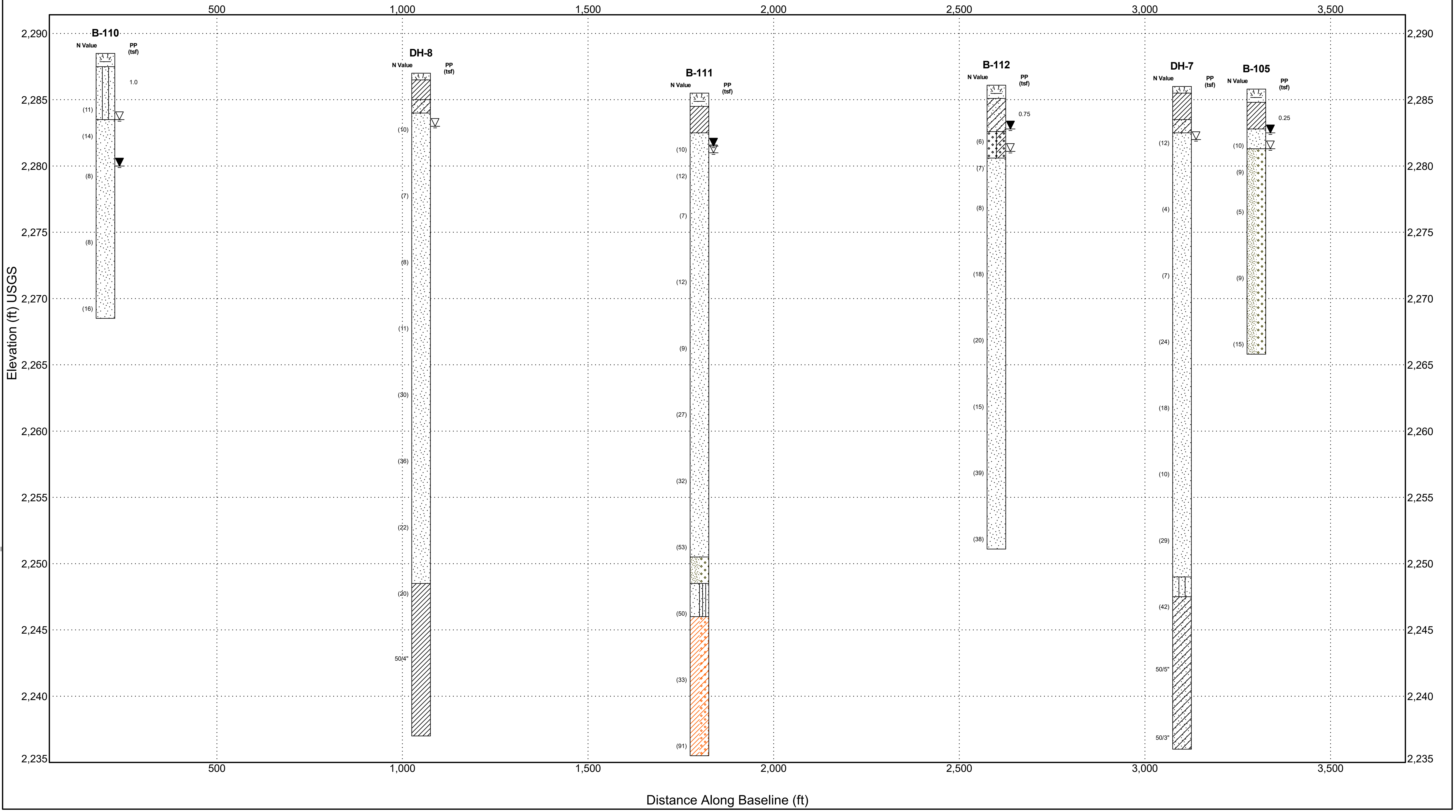
SUBSURFACE DIAGRAM
Berm No. 3

CLIENT PRRIP
PROJECT NUMBER 10057849

PROJECT NAME Cottonwood Ranch BSR
PROJECT LOCATION Phelps County

- ▨ Topsoil
- ▨ USCS SP/SW
- ▨ USCS CL/SC
- ▨ USCS Low Plasticity Clay
- ▨ USCS Silty Sand
- ▨ USCS Clayey Sand
- ▨ USCS Poorly-graded Sand
- ▨ USCS Poorly-graded Sand with Silt
- ▨ USCS Well-graded Sand with Clay



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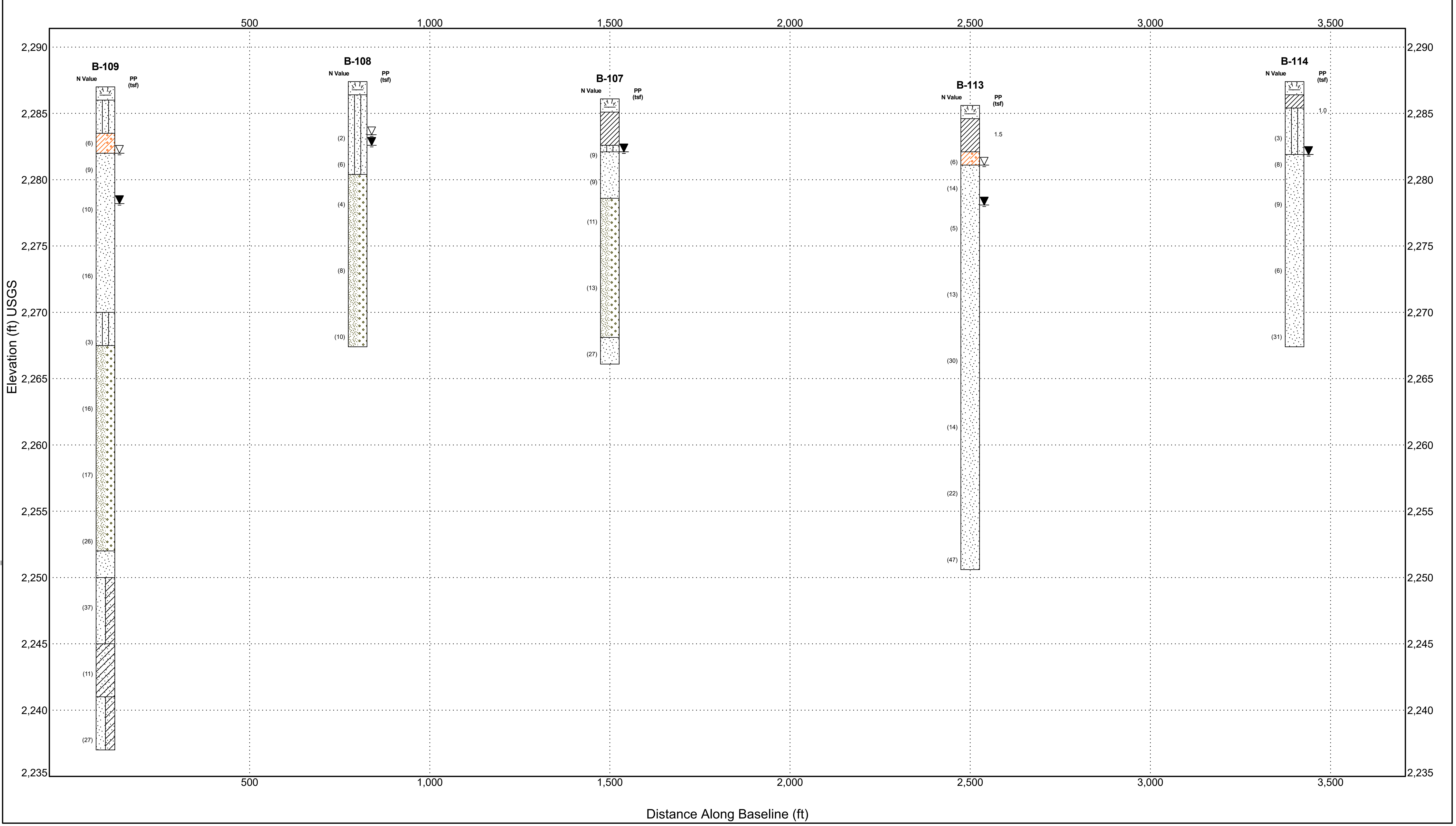
SUBSURFACE DIAGRAM
Berm No. 4

▨ Topsoil
▨ USCS Poorly-graded Sand
▨ USCS Poorly-graded Sand with Clay
▨ USCS Low Plasticity Clay
▨ USCS SP/SW
▨ USCS Clayey Sand
▨ USCS Silty Sand
🟧 USCS CL/SC

CLIENT PRRIP
PROJECT NUMBER 10057849
PROJECT NAME Cottonwood Ranch BSR
PROJECT LOCATION Phelps County



SUBSURFACE DIAGRAM
Berm No. 5

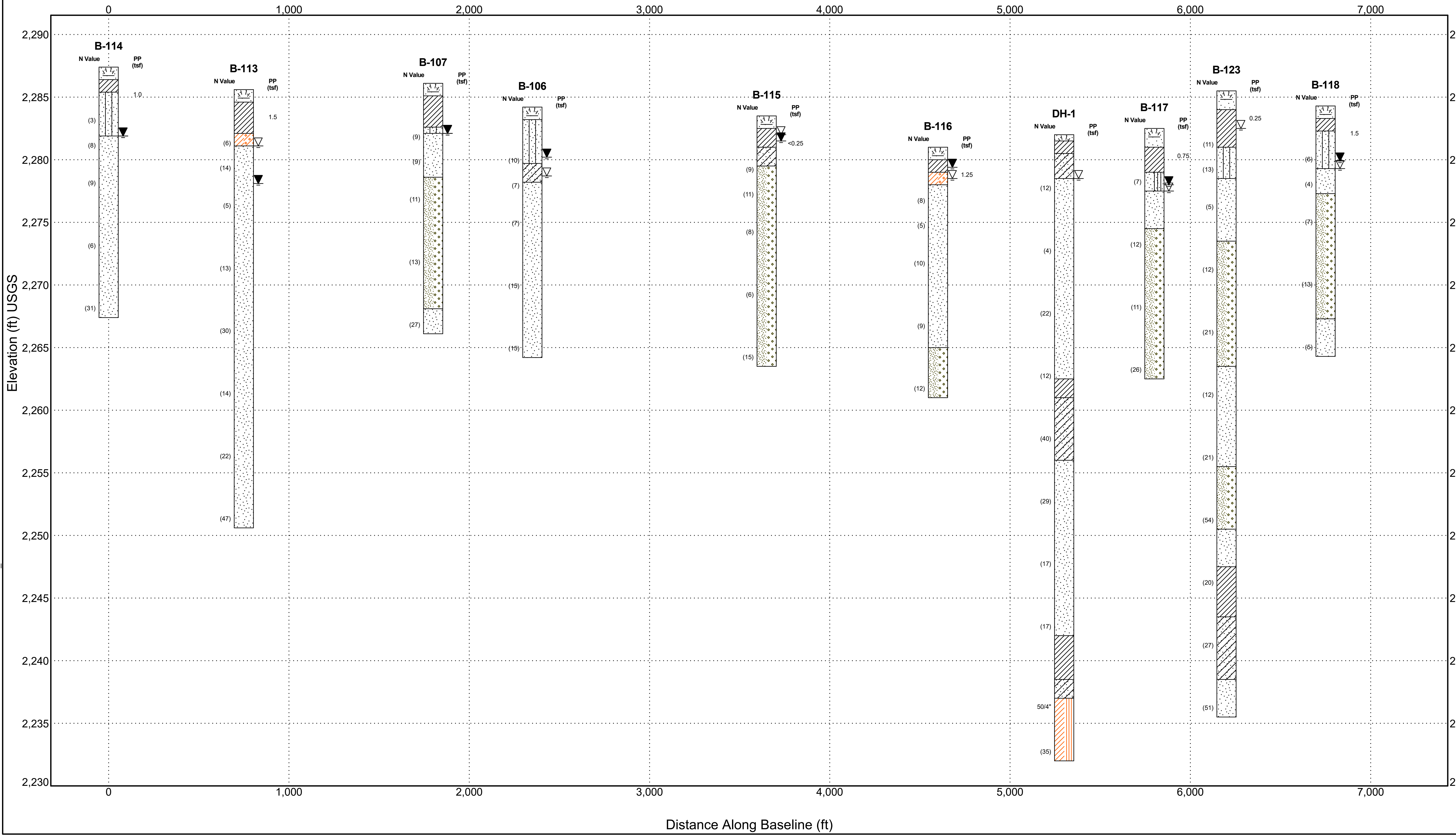
CLIENT PRRIP

PROJECT NUMBER 10057849

PROJECT NAME Cottonwood Ranch BSR

PROJECT LOCATION Phelps County

- ▨ Topsoil
- ▨ USCS Poorly-graded Sand
- ▨ USCS CL/SC
- ▨ USCS Silty Sand
- ▨ USCS Low Plasticity Clay
- ▨ USCS Poorly-graded Sand with Silt
- ▨ USCS Clayey Sand
- ▨ USCS SP/SW
- ▨ USCS CL/ML



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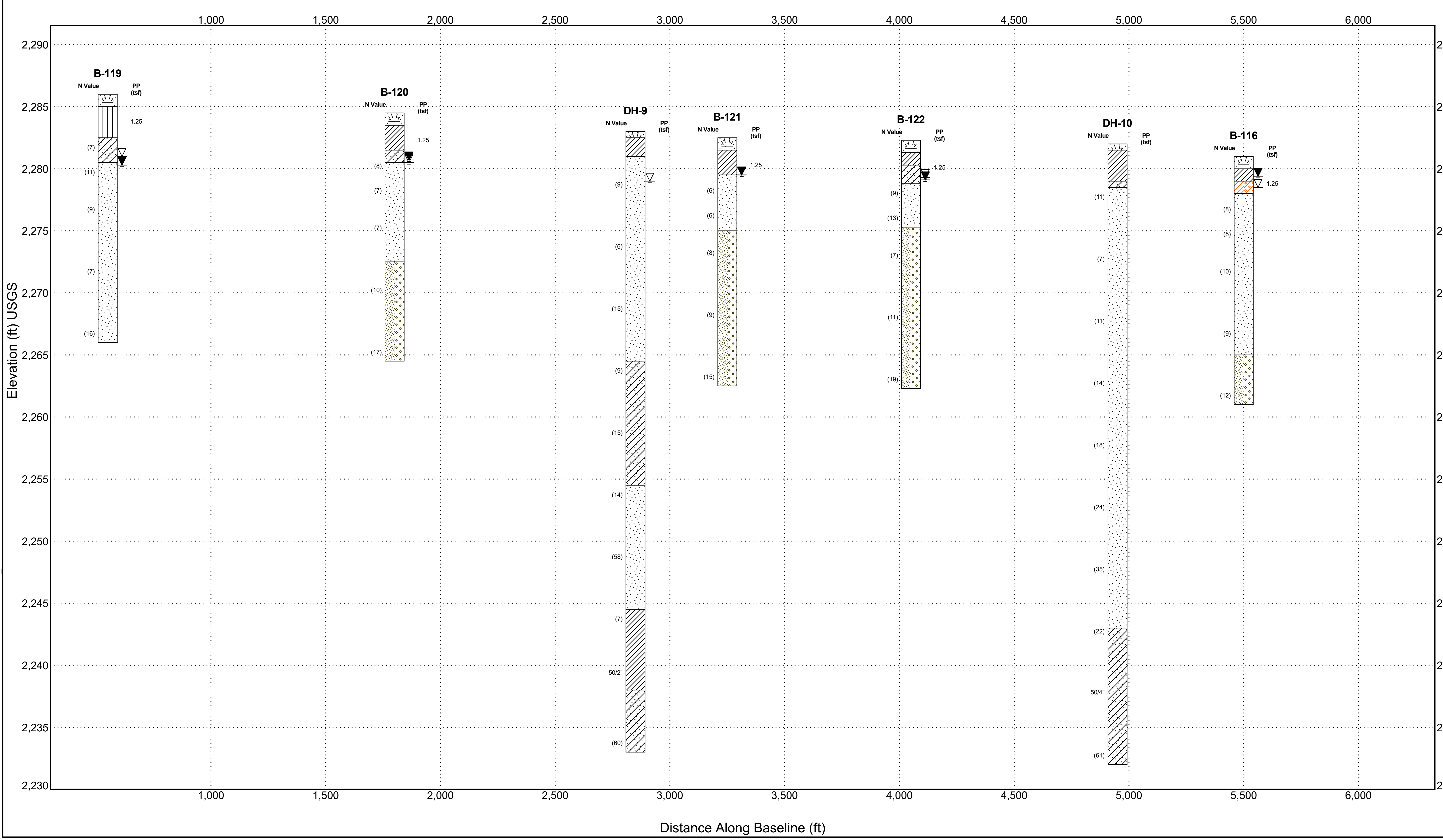
SUBSURFACE DIAGRAM
Berm No. 6

▨ Topsoil
▨ USCS Low Plasticity Clay
▨ USCS CL/SC
▨ USCS Poorly-graded Sand
▨ USCS SP/SW
▨ USCS Silt
▨ USCS Clayey Sand

CLIENT PRRIP
PROJECT NUMBER 10057849
PROJECT NAME Cottonwood Ranch BSR
PROJECT LOCATION Phelps County



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SUBSURFACE DIAGRAM
Berm No. 7

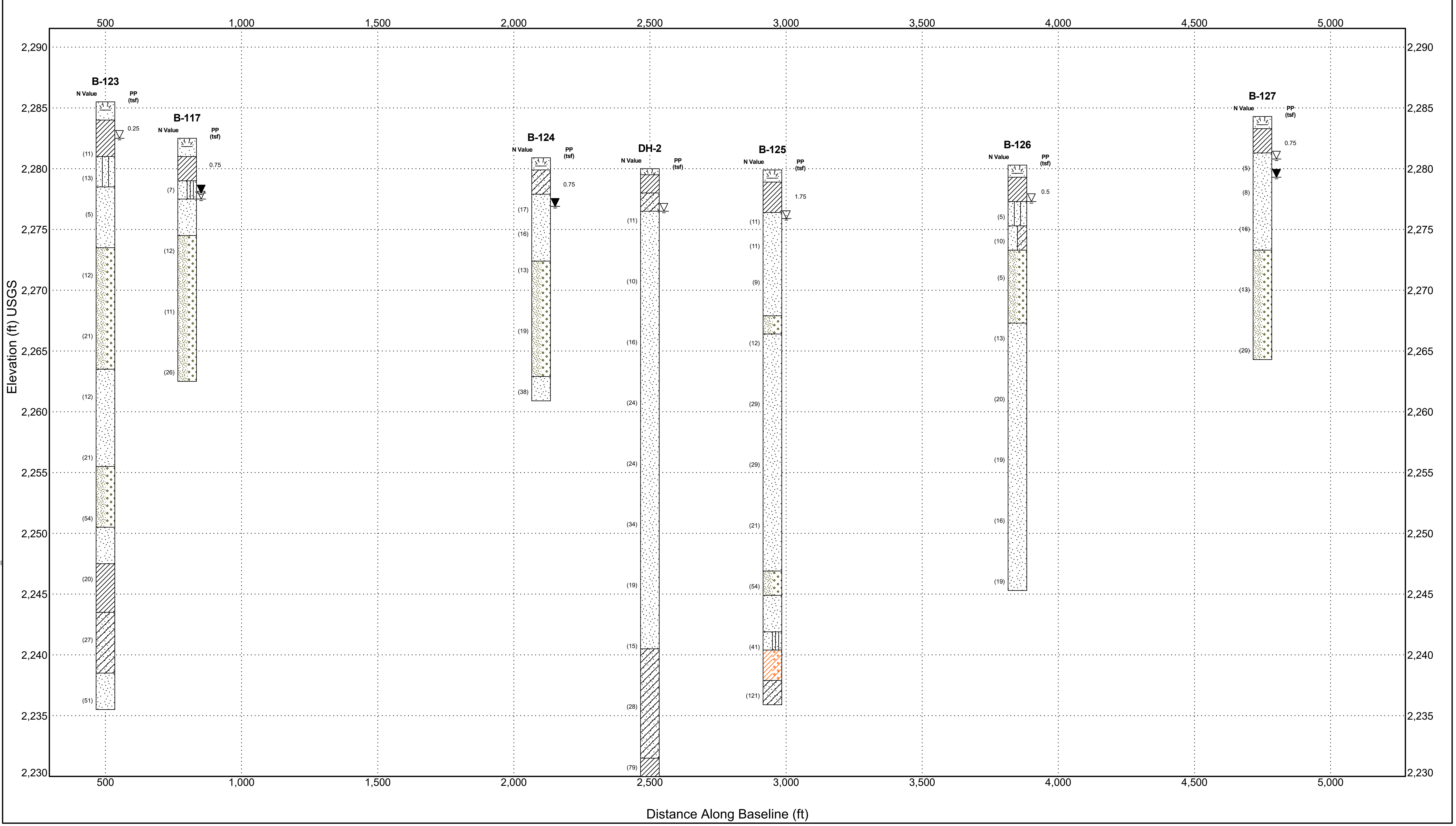
CLIENT PRRIP

PROJECT NUMBER 10057849

PROJECT NAME Cottonwood Ranch BSR

PROJECT LOCATION Phelps County

▨	Topsoil
▨	USCS Poorly-graded Sand
▨	USCS Clayey Sand
▨	USCS Low Plasticity Clay
▨	USCS SP/SW
🟧	USCS CL/SC
▨	USCS Poorly-graded Sand with Silt
▨	USCS Silty Sand
▨	USCS Poorly-graded Sand with Clay



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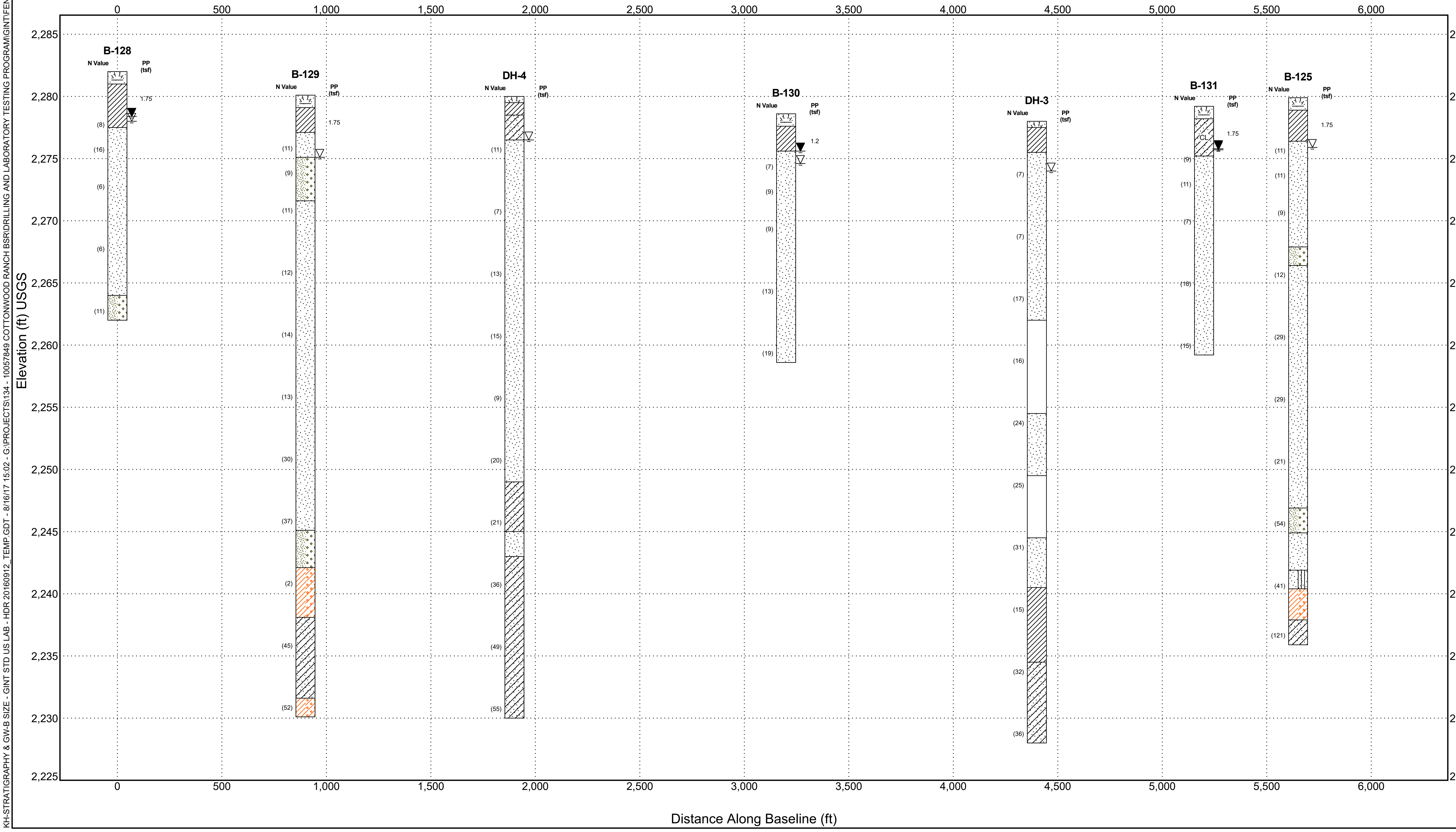
SUBSURFACE DIAGRAM
Berm No. 8

- Topsoil
- USCS SP/SW
- USCS Clayey Sand
- USCS Low Plasticity Clay
- USCS Poorly-graded Sand with Silt
- USCS Poorly-graded Sand
- USCS CL/SC

CLIENT PRRIP
PROJECT NUMBER 10057849
PROJECT NAME Cottonwood Ranch BSR
PROJECT LOCATION Phelps County



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MID-STATE ENGINEERING & TESTING, Inc.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-101	As Per Boring Location Plan	2289.6		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	Wet Cave 5.3'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N' BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey Brown	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey Brown	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy			1.25	
				Grey Brown								
	S-2	(6) 3/3/3	67	Grey Brown	Very Moist	Loose	SC	**ALLUVIAL DEPOSITS** Fine Grained w/Some Clay				
5					Saturated							5
				Light Grey Brown			SP	Fine Grained				
	S-3	(8) 5/4/4	67									
	S-4	(10) 6/5/5	67			Firm						
10												10
	S-5	(11) 7/6/5	17				SP/SW	Coarse Grained				
15												15
								Medium Grained w/Trace Gravel				
	S-6	(20) 11/9/11	67									
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-102	As Per Boring Location Plan	2287.1		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	Wet Cave 2.3'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS / FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Firm	SC	**DEVELOPED ZONE**	17.1	115.3	1.0	
				Dark Grey	Very Moist	Firm	SC	**ALLUVIAL TERRACE DEPOSITS** Clayey Sand w/Trace Gravel				
				Grey Brown								
	S-2	(14) 5/6/8	50		Saturated							
5												5
	S-3	(11) 7/5/6	60	Light Grey Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Medium to Coare Grained Medium Grained				
	S-4	(11) 3/4/7	83						9.7			
10												10
								Coarse Grained w/Trace Gravel				
	S-5	(12) 4/5/7	0	No Sample								
15												15
	S-6	(12) 9/9/3										
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, Inc.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-103	As Per Boring Location Plan	2288.5		35'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
1 1/2'	Wet Cave 6' 5"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Firm		**DEVELOPED ZONE**				
	U-1		100	Very Dark Grey	Very Moist Saturated	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy			0.0	
				Grey Brown	Saturated	Firm	SM	**ALLUVIAL DEPOSITS** Fine Grained w/Some Silt				
5	S-2	(11) 5/6/5	67						19.7			5
				Light Grey Brown								
	S-3	(11) 5/5/6	67					Medium Grained w/Some Gravel	14.7			
10	S-4	(10) 4/4/6	33				SP	Medium to Coarse Grained	11.8			10
15	S-5	(12) 7/7/5	33					Medium Grained				15
20	S-6	(26) 11/10/16	33					Fine Grained				20
25	S-7	(22) 11/10/12						Medium Grained				25
30	S-8	(18) 14/10/8						Fine Grained				30
								Fine to Medium Grained				
35	S-9	(22) 16/10/12					SP/SW	Medium Grained w/Some Gravel				35

Bottom of Hole 35'

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-104	As Per Boring Location Plan	2292.0		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
7'	Wet Cave 7'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N' BLOWS / FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE**				
				Dark Grey Brown	Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy	24.5		2.5	
				Grey Brown								
5	S-2	(6) 4/3/3	67		Very Moist	Soft					1.0	5
	S-3	(5) 4/2/3	67									
				Light Grey Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Fine to Medium Grained				
10	S-4	(15) 8/9/6	67									10
15	S-5	(12) 6/6/6	50					Rust				15
20	S-6	(16) 8/8/8	50									20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	**Cottonwood Ranch Project #10057849**
LOCATION:	**Phelps County, Nebraska**
JOB NO. 200-05-24	**DATE** 5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-105	As Per Boring Location Plan	2285.8		20'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE: Grass	DRILLER: Mid-State Engineering
			DRILLING METHOD	LOGGER
4 1/2'	Wet Cave 3.3		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT	SAMPLE NO. & TYPE	N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
	U-1		100	Very Dark Grey	Moist	Soft	CL	**DEVELOPED ZONE**			0.25	
				Dark Grey	Moist	Soft	CL	**ALLUVIAL TERRACE DEOPOSITS** Sandy				
					Very Moist	Very Soft						
	S-2	(10) 4/5/5	33	Light Grey Brown	Very Moist	Loose	SP	**ALLUVIAL DEPOSITS** Medium to Coarse Grained				
5					Saturated		SP/SW					5
	S-3	(90 4/4/5	33					w/Trace Gravel				
10	S-4	(5) 4/2/3	67					Coarse Grained w/Some Gravel				10
15	S-5	(9) 4/5/4	17									15
20	S-6	(15) 8/8/7	17									20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO. 200-05-24	DATE 5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-106	As Per Boring Location Plan	2284.2		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5 1/2'	Wet Cave 4'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Moist	Firm	ML/SM	**DEVELOPED ZONE**				
	U-1		100	Very Dark Grey	Moist	Firm	SM	**ALLUVIAL TERRACE DEOPOSITS** Silty Sand w/Trace Gravel	21.0	95.8	0.7	
				Dark Grey	Very Moist							
5	S-2	(10) 6/5/5	67									5
				Grey	Very Moist	Loose	SC	**ALLUVIAL DEPOSITS** Medium Grained w/Trace of Clay				
	S-3	(7) 4/3/4	50		Saturated				7.2			
							SP	Coarse Grained				
10	S-4	(70 6/4/3	50					Medium Grained				10
								Fine to Medium Grained				
15	S-5	(15) 10/8/7	17									15
								Coarse Grained				
20	S-6	(15) 6/6/9	67									20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	**Cottonwood Ranch Project #10057849**		
LOCATION:	**Phelps County, Nebraska**		
JOB NO.	**200-05-24**	**DATE**	**5/24/17**

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-107	As Per Boring Location Plan	2286.1		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	Wet Cave 4'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N' BLOWS / FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
				Very Dark Grey	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy	19.7	102.3	0.75	
				Grey								
	S-2	(9) 4/4/5	67	Light Grey Brown	Very Moist	Loose	SM	**ALLUVIAL DEPOSITS** Fine Grained				
5					Saturated		SP					5
	S-3	(9) 5/5/4	67									
								Medium Grained w/Some Gravel				
						Firm	SP/SW					
10	S-4	(11) 5/5/6	50									10
								Coarse Grained w/Some Gravel				
15	S-5	(13) 7/7/6	50									15
20	S-6	(27) 11/13/14	33				SP	Medium Grained				20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849		
LOCATION:	Phelps County, Nebraska		
JOB NO.	200-05-24	DATE	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-108	As Per Boring Location Plan	2287.4		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	Wet Cave 4.8'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Very Dark Grey	Very Moist	Soft	SM	**ALLUVIAL TERRACE DEPOSITS** Silty Sands	13.7			
				Grey Brown								
5	S-2	(2) 1/1/1	67		Saturated				17.8			5
	S-3	(6) 2/3/3	67	Light Brown	Saturated	Loose	SM	**ALLUVIAL DEPOSITS** Silty Fine Grained Sand	13.2			
						Very Loose	SP/SW	Medium Grained w/Some Gravel				
								Coarse Grained w/Some Gravel				
10	S-4	(4) 3/2/2	70									10
						Loose		Medium Grained				
15	S-5	(8) 6/5/3	50									15
20	S-6	(10) 7/5/5	67									20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, Inc.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-109	As Per Boring Location Plan	2287.0		50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'	Wet Cave 8' 9"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT	SAMPLE NO. & TYPE	"N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Firm	ML/SM	**DEVELOPED ZONE**	5.5	127.3	1.6	
				Very Dark Grey	Very Moist	Firm	SM	**ALLUVIAL TERRACE DEPOSITS** Silty Sands				
				Grey	Moist	Stiff						
5	S-2	(6) 2/2/4	67				CL/SC	Sandy Clay				5
	S-3	(9) 4/4/5	50	Light Grey Brown	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Fine Grained Medium Grained w/Some Gravel				
10	S-4	(10) 5/5/5	67			Firm						10
15	S-5	(16) 7/8/8	67					Medium Grained				15
						Very Loose	SM	Silty Sands				
20	S-6	(3) 3/1/2	67					Coarse Grained @ 19.5'	13.9			20
							SP/SW					
						Firm						
25	S-7	(16) 6/7/9	67					Gravel Seams				25
30	S-8	(17) 7/9/8	67					Medium to Coarse Grained				30
35	S-9	(26) 10/15/11	67					Coarse Gravel				35

MID-STATE ENGINEERING & TESTING, Inc.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO. 200-05-24	DATE 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-109	As Per Boring Location Plan	2287.0		50'

WATER LEVEL OBSERVATIONS WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'	Wet Cave 8' 9"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO & TYPE	N* BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Grey Brown	Saturated	Very Firm	SP	**ALLUVIAL DEPOSITS** Coarse Grained				
						Firm	SC/SP	Clayey Sands Fine to Medium Grained				
40	S-10	(37) 13/18/19	67									40
				Light Grey			SC	Fine Grained w/Calcium Streaks				
45	S-11	(11) 5/5/6	67									45
							SC/SP					
50	S-12	(27) 13/11/16	67			Very Firm						50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO. 200-05-24	DATE 5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-110	As Per Boring Location Plan	2288.5		20'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE: Grass DRILLING METHOD: 3 1/4" Hollow Stem Auger	DRILLER: Mid-State Engineering LOGGER: Mitchell Hoback
5'	Wet Cave 8.5'			

DEPTH FT.	SAMPLE NO. & TYPE	N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey Brown	Very Moist	Soft	SM	**ALLUVIAL TERRACE DEPOSITS** Silty Sands			1.0	
				Grey Brown								
	S-2	(11) 6/6/5	67	Grey	Very Moist	Firm	SM	**ALLUVIAL DEPOSITS** Silty Sands	21.1			
5												5
	S-3	(14) 6/6/8	67	Light Grey Brown	Saturated		SP	Fine Grained Medium Grained w/Rust				
	S-4	(8) 3/3/5	67			Loose						
10												10
	S-5	(8) 4/4/4	67									
15												15
	S-6	(16) 7/7/9				Firm						
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, Inc.	**BORING LOG**	PROJECT:	Cottonwood Ranch Project #10057849
		LOCATION:	Phelps County, Nebraska
		JOB NO. 200-05-24	DATE 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-111	As Per Boring Location Plan	2285.5		50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4 1/2'	Wet Cave 4'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		67						27.1	86.1		
				Dark Grey Brown	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy				
	S-2	(10) 5/5/5	67	Grey	Very Moist	Firm	SP	**ALLUVIAL DEPOSITS** Fine to Medium Grained				
5												5
				Light Grey Brown	Saturated							
	S-3	(12) 6/6/6	33									
								Rusty				
						Loose						
								Medium Grained				
	S-4	(7) 3/4/3	50						12.2			
10												10
						Firm						
	S-5	(12) 3/5/7	50									
15												15
						Loose		Fine to Medum Grained				
	S-6	(9) 2/5/4	17									
20												20
						Firm		Medium Grained w/Some Gravel				
	S-7	(27) 8/12/15	50						8.8			
25												25
						Dense		w/Larger Gravel				
	S-8	(32) 11/14/18	50									
30												30
								Medium Grained				
35	S-9	(33) 17/24/29	67									35

MID-STATE

ENGINEERING &

TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-111	As Per Boring Location Plan	2285.5		50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4 1/2'	Wet Cave 4'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Grey Brown	Saturated	Dense	SP/SW	**ALLUVIAL DEPOSITS** Medium Grained w/Gravel				
				Light Grey		Firm	SM/SP	Silty Sand				
40	S-10	(50) 5/8/42										40
				Brown & Grey Streaks	Saturated	Very Dense	CL/SC	**WEATHERED OGALLALA** Clayey Sand w/Calcium				
						Very Stiff						
45	S-11	(33) 9/17/16										45
				Pale Brown	Saturated	Hard	CL/SC	**OGALLALA GROUP**				
50	S-12	(91) 24/40/51										50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-112	As Per Boring Location Plan	2286.1		35'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'	Wet Cave 3' 4"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey	Very Moist	Soft	SC	**ALLUVIAL TERRACE DEPOSITS** w/Fine Sand	20.7	108.1	0.3	
				Grey				Calcium & Rust Stains				
5	S-2	(6) 4/4/2	33	Light Grey Brown	Very Moist	Loose	SC/SW	**ALLUVIAL DEPOSITS** Medium Grained w/Trace of Clay	14.9			5
	S-3	(7) 1/2/5	17		Saturated		SP	Fine to Medium Grained				
10	S-4	(8) 4/3/5	50					Medium Grained				10
						Firm		Fine to Medium Grained				
15	S-5	(18) 8/8/10	50									15
20	S-6	(20) 4/9/11	50					Fine Grained				20
25	S-7	(15) 6/7/8	33									25
						Dense		Medium Grained				
30	S-8	(39) 12/16/23	50					Fine Grained				30
35	S-9	(38) 14/17/21										35

Bottom of Hole 35'

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO. 200-05-24	DATE 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-113	As Per Boring Location Plan	2285.6		35'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE: Grass	DRILLER: Mid-State Engineering
4 1/2'	Wet Cave 7' 6"		DRILLING METHOD: 3 1/4" Hollow Stem Auger	LOGGER: Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Very Dark Grey Brown	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy			1.5	
	S-2	(6) 2/3/3	50	Grey			CL/SC					
5												5
	S-3	(14) 6/7/7	50	Light Grey Brown	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Fine Grained				
	S-4	(5) 2/2/3	50					Coarse Grained	11.2			
10												10
	S-5	(13) 6/7/6	50			Firm		Medium Grained w/Some Gravel				
15												15
	S-6	(20) 8/11/19	50									
20												20
	S-7	(14) 8/7/7	50					Coarse Grained				
25												25
	S-8	(22) 7/10/12	50					Medium Grained w/Some Gravel				
30												30
						Dense						
	S-9	(47) 13/24/23	67									
35												35

Bottom of Hole 35'

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/24/17

DRILL HOLE NO	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-114	As Per Boring Location Plan	2287.4		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5 1/2'	Wet Cave 5.5'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		67	Grey Brown	Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS**			1.0	
							SM					
	S-2	(3) 1/2/1	50	Light Brown	Very Moist				14.1			
5												5
	S-3	(8) 2/3/5	50	Light Grey Brown	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Fine Gravel				
	S-4	(9) 3/4/5	50					Fine to Medium Grained				
10												10
	S-5	(6) 3/3/3	0	No Sample								
15												15
						Very Firm						
	S-6	(31) 8/14/17	50									
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	**Cottonwood Ranch Project #10057849**
LOCATION:	**Phelps County, Nebraska**
JOB NO. 200-05-24	**DATE** 5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-115	As Per Boring Location Plan	2283.5		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
1 1/2'	Wet Cave 2'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Very Dark Grey	Very Moist	Very Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy			0.0	
				Dark Grey	Saturated							
				Light Grey Brown	Saturated	Loose	SC	**ALLUVIAL DEPOSITS** Fine Grained				
5	S-2	(9) 4/5/4	100				SP/SW	Medium Grained to Coarse				5
	S-3	(11) 4/5/6	100									
10	S-4	(8) 2/3/5	100									10
15	S-5	(6) 2/3/3										15
20	S-6	(15) 7/8/7										20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, Inc.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-116	As Per Boring Location Plan	2281.0		20'

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
2 1/2'	Wet Cave 1' 7"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS /FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Very Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Very Dark Grey	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS**			1.25	
				Dark Grey			CL/SC					
					Saturated			Sandy				
	S-2	(8) 5/5/3	100	Light Grey Brown	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Medium Grained				
5												5
	S-3	(5) 2/1/4	100									
						Firm						
	S-4	(10) 5/5/5	100									
10												10
						Loose						
	S-5	(9) 4/5/4	100									
15												15
						Firm	SP/SW					
	S-6	(12) 6/6/6	100									
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	**Cottonwood Ranch Project #10057849**
LOCATION:	**Phelps County, Nebraska**
JOB NO.	**200-05-24**
DATE	**5/24/17**

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-117	As Per Boring Location Plan	2282.5		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'	Wet Cave 4.5'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**	20.5	100.1	0.6	
				Dark Grey Brown	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy				
5	S-2	(7) 2/3/4	67	Grey	Saturated	Loose	SM/SP		13.9			5
	S-3			Grey Brown No Sample	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Medium Grained				
10	S-4	(12) 4/5/7	50			Firm	SP/SW	Coarse Grained				10
15	S-5	(11) 5/6/5	50					Gravel Seams				15
20	S-6	(26) 8/11/15	50					Medium Grained				20
								Bottom of Hole 20'				
25												25
30												30
35												35

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BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-118	As Per Boring Location Plan	2284.3		20'

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'	Wet Cave 4.4'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Firm	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey Brown	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy			1.5	
				Grey Brown	Very Moist	Loose	SM	**ALLUVIAL DEPOSITS** Silty Fine Grained Sands				
5	S-2	(6) 3/3/3	67						15.1			5
	S-3	(4) 3/2/2	67		Saturated	Very Loose	SP	Medium - Fined Grained @ 5 1/2'				
						Loose	SP/SW	Coarse Grained @ 7' Trace Gravel, Medium to Coarse Grained				
10	S-4	(7) 3/3/4	67									10
						Firm		Coarse Grained w/Some Large Gravel				
15	S-5	(13) 5/6/7	67									15
						Loose	SP					
20	S-6	(5) 2/2/3	20					Medium to Fine Grained				20
								Bottom of Hole 20'				
25												25
30												30
35												35

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BORING LOG

PROJECT:	**Cottonwood Ranch Project #10057849**
LOCATION:	**Phelps County, Nebraska**
JOB NO. 200-05-24	**DATE** 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-119	As Per Boring Location Plan	2286.0		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'	Wet Cave 5.7'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey Brown	Moist	Firm	ML	**ALLUVIAL TERRACE DEPOSITS**	15.3		1.25	
				Grey Brown				Sandy				
	S-2	(7) 1/2/5	33	Grey Brown	Moist	Loose	SC	**ALLUVIAL DEPOSITS** w/Trace of Clay				
5												5
					Saturated							
	S-3	(11) 6/5/6		Grey		Firm	SP	Fine Grained				
				Light Grey Brown		Loose						
	S-4	(9) 6/4/5	50					Medium Grained				
10												10
	S-5	(7) 5/4/3	50					w/Some Gravel				
15												15
	S-6	(16) 8/8/8	50			Firm		Fine Grained @ 19'				
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

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TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-120	As Per Boring Location Plan	2284.5		20'

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	**LOGGER**
4'	Wet Cave 3.8'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
				Dark Grey Brown	Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS**			1.25	
				Grey Brown	Very Moist	Soft						
					Firm	Loose	SC	Sandy				
	S-2	(8) 4/4/4	50									
5				Light Grey Brown	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Medium Grained				5
	S-3	(7) 5/4/3	50									
	S-4	(7) 2/3/4	50									
10												10
						Firm	SP/SW					
	S-5	(10) 4/5/5										
15												15
	S-6	(17) 10/9/8										
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

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BORING LOG

PROJECT: Cottonwood Ranch
Project #10057849

LOCATION: Phelps County, Nebraska

JOB NO. 200-05-24

DATE 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-121	As Per Boring Location Plan	2282.5		20'

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'	Wet Cave 3'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
								DEVELOPED ZONE				
	U-1		100	Dark Grey Brown	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy	26.0	88.0	0.7	
				Grey Brown								
	S-2	(6) 6/3/3	67	Light Grey Brown	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Medium Grained , Some Gravel				
5												5
	S-3	(6) 4/3/3	67									
							SP/SW	Medium to Coarse Grained w/Some Gravel				
	S-4	(8) 4/4/4	67									
10												10
	S-5	(9) 4/4/5	67									
15												15
						Firm						
	S-6	(15) 6/7/8	67									
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849		
LOCATION:	Phelps County, Nebraska		
JOB NO.	200-05-24	DATE	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-122	As Per Boring Location Plan	2282.3		20'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'	Wet Cave 3' 2"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**	27.9	85.7	0.25	
				Dary Grey Brown	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS**				
				Light Grey Brown	Very Moist	Loose	SC	**ALLUVIAL DEPOSITS** Fine Grained				
					Saturated							
5	S-2	(9) 3/4/5	100				SP	Fine to Medium Grained				5
	S-3	(13) 4/7/6	100			Firm		Medium Grained				
						Loose	SP/SW					
								medium to Coarse Grained @ 8'				
10	S-4	(7) 4/3/4	83					w/Some Gravel @ 9 1/2'				10
						Firm						
15	S-5	(11) 4/5/6	83					Medium Grained w/Trace Gravel				15
20	S-6	(19) 6/8/11						Fine to Medium Grained				20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
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BORING LOG

PROJECT:	**Cottonwood Ranch Project #10057849**
LOCATION:	**Phelps County, Nebraska**
JOB NO. 200-05-24	**DATE** 5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-123	As Per Boring Location Plan	2282.2		50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'			3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS / FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Very Soft	CL	**DEVELOPED ZONE**			0.25	
				Dark Grey Brown	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS**				
	S-2	(11) 5/6/5	67	Grey	Saturated							
5				Grey	Saturated	Firm	SM	**ALLUVIAL DEPOSITS** Medium Grained				5
				Light Grey Brown								
	S-3	(13) 5/5/8	67						7.8			
							SP	Fine Grained				
10	S-4	(5) 3/3/2	67			Loose		Medium to Fine Grained	14.0			10
						Firm	SP/SW	Medium Grained				
15	S-5	(12) 6/5/7	67									15
								Medium to Coarse Grained w/Some Gravel				
20	S-6	(21) 19/11/10	67									20
							SP	Very Fine Sands				
25	S-7	(12) 6/6/6	67									25
								Medium Grained				
30	S-8	(21) 11/12/9	67									30
							SP/SW	Medium to Coarse Grained w/Some Large Gravel				
35	S-9	(44) 11/17/37	67									35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-123	As Per Boring Location Plan	2282.2		50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'			3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N' BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Grey Brown	Saturated	Very Dense	SP	**ALLUVIAL DEPOSITS** Medium to Coarse Grained w/Some Large Gravel				
	S-10	(20) 5/8/12	67	Very Light Grey		Very Stiff	CL	Clay w/Fine Sand, Laminated				
40												40
						Firm	SC					
	S-11	(27) 15/13/14	67									
45												45
						Very Dense	SP	Fine to Medium Grained				
	S-12	(51) 15/22/29	67									
50												50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-124	As Per Boring Location Plan	2280.9		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	Wet Cave 4'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Grey Brown	Moist	Soft	SC	**ALLUVIAL TERRACE DEPOSITS** Clayey Sand	15.5		0.75	
					Very Moist							
	S-2	(17) 6/8/9	100	Light Grey Brown	Very Moist	Firm	SP	**ALLUVIAL DEPOSITS** Fine Grained				
					Saturated			Medium Grained				
5												5
	S-3	(16) 4/8/8	67					Fine to Medium Grained				
	S-4	(13) 9/5/8	67				SP/SW	Medium Grained				
10												10
	S-5	(19) 9/10/9										
15												15
	S-6	(38) 12/15/23					SP					
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, Inc.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-125	As Per Boring Location Plan	2279.9		44'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'			3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy			1.75	
	S-2	(11) 5/6/5	67	Light Grey Brown	Very Moist	Firm	SP	**ALLUVIAL DEPOSITS** Medium Grained				
5					Saturated							5
	S-3	(11) 5/5/6	67					Fine to Medium Grained				
10	S-4	(9) 5/5/4	67			Loose		Medium Grained				10
						Firm	SP/SW	Medium to Coarse Grained				
15	S-5	(12) 6/5/7	67				SP		11.6			15
20	S-6	(29) 10/14/15	67					Fine Grained				20
25	S-7	(29) 4/14/15	33									25
30	S-8	(21) 9/10/11	50					Medium Grained	13.3			30
35	S-9	(54) 18/25/29	50			Very Dense	SP/SW	Coarse Grained w/Gravel				35

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-125	As Per Boring Location Plan	2279.9		44'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
4'			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
			3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Grey Brown	Saturated	Very Dense	SP	**ALLUVIAL DEPOSITS** Coarse Grained w/Gravel				
40	S-10	(41) 3/7/34	67	Light Grey		Firm	SM/SP	Silty Fine Sand				40
				Light Grey	Saturated	Very Stiff	CL/SC	**WEATHERED OGALLALA** Clayey Sand w/Calcium				
	S-11	(121) 32/47/74	67	Pale Brown	Moist	Hard	SC	**OGALLALA GROUP**				
45								**Bottom of Hole 44'**				45
50												50
55												55
60												60
65												65
70												70

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849		
LOCATION:	Phelps County, Nebraska		
JOB NO.	200-05-24	DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-126	As Per Boring Location Plan	2280.3		35'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'			3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS /FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
				Dark Grey Brown	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy	18.6	106.0	0.7	
				Grey Brown								
5	S-2	(5) 3/2/3	67	Grey Brown	Saturated	Loose	SM	**ALLUVIAL DEPOSITS** Silty Sands	19.1			5
	S-3	(10) 3/5/5	67			Firm	SC/SP	Trace of Clay Medium Grained				
				Light Grey Brown		Loose	SP/SW					
10	S-4	(5) 4/3/2	50					Coarse Grained w/Some Gravel				10
15	S-5	(13) 6/7/6	50			Firm	SP	Fine Grained				15
20	S-6	(20) 5/9/11	67									20
25	S-7	(19) 8/9/10	50					Medium to Coarse Grained				25
30	S-8	(16) 8/8/8						Coarse Grained w/Some Gravel				30
35	S-9	(19) 6/7/12										35

Bottom of Hole 35'

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-127	As Per Boring Location Plan	2284.3		20'

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3 1/2'	Wet Cave 5'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**			0.75	
				Dark Grey Brown	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy				
				Grey Brown								
	S-2	(5) 3/3/2	67	Light Grey Brown	Very Moist	Loose	SP	**ALLUVIAL DEPOSITS** Fine / Medium Grained				
					Saturated							
5												5
	S-3	(8) 5/5/3										
	S-4	(16) 8/8/8				Firm						
10												10
							SP/SW	Medium to Coarse Grained				
	S-5	(13) 5/6/7										
15												15
								Medium Grained				
20	S-6	(20) 10/9/11										20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-128	As Per Boring Location Plan	2282.0		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	Wet Cave 3' 7"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Firm	CL	**DEVELOPED ZONE**				
	U-1		50	Dark Grey	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy			1.75	
5	S-2	(8) 3/3/5	100	Grey	Saturated							5
	S-3	(16) 4/8/8	100	Light Grey Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Fine to Medium Grained Heavy Rust Layer at 6 1/2' Slight Rust Below It				
								Coarse Sand w/Some Gravel @ 8'				
10	S-4	(6) 3/3/3	100			Loose		Fine Sand @ 9 1/2'				10
15	S-5	(6) 3/2/4	100									15
20	S-6	(11) 7/6/5				Firm	SP/SW	w/Some Large Gravel				20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849				
LOCATION:	Phelps County, Nebraska				
JOB NO.	200-05-24	DATE	5/25/17		
DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH	
B-129	As Per Boring Location Plan	2280.1		50'	

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'			3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N' BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey Brown	Very Moist	Soft	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy				
				Grey								
5	S-2	(11) 6/5/6	67	Light Grey Brown	Very Moist	Firm	SP	**ALLUVIAL DEPOSITS** Medium Grained Iron and Rust at 4 1/2'				5
	S-3	(9) 6/3/6	67		Saturated	Loose	SP/SW	Medium to Coarse Grained w/Some Gravel				
10	S-4	(11) 4/6/5	67			Firm	SP					10
15	S-5	(12) 5/4/8	67					w/Trace Large Gravel	11.9			15
20	S-6	(14) 6/7/7	67					Medium Grained				20
25	S-7	(13) 8/7/6	50					Fine Grained				25
30	S-8	(20) 8/14/16	33					Fine to Medium Grained	13.3			30
						Dense						
35	S-9	(37) 14/17/20										35

MID-STATE ENGINEERING & TESTING, INC.	BORING LOG	PROJECT:	Cottonwood Ranch Project #10057849
		LOCATION:	Phelps County, Nebraska
		JOB NO. 200-05-24	DATE 5/26/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-129	As Per Boring Location Plan	2280.1		50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'			3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Grey Brown	Saturated	Dense	SP/SW	**ALLUVIAL DEPOSITS** Medium Grained w/Gravel				
	S-10	(2) 1/1/1		Pale Brown		Very Loose	SC/CL	Sandy Clay w/Calcium				
40												40
				Light Brown	Saturated	Dense	SC	**WEATHERED OGALLALA** Sandy Clay w/Calcium				
	S-11	(45) 24/17/28										
45												45
	S-12	(52) 16/24/28		Pale Brown			SC/CL					
50												50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	**Cottonwood Ranch** **Project #10057849**
LOCATION:	**Phelps County, Nebraska**
JOB NO. 200-05-24	**DATE** 5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-130	As Per Boring Location Plan	2278.6		20'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	Wet Cave 3'		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Very Dark Grey	Very Moist	Soft	CL	**DEVELOPED ZONE**				
	U-1		100	Dark Grey Brown	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Sandy	23.3	84.1	0.5	
				Grey Brown								
	S-2	(7) 3/4/3	67	Light Grey Brown	Very Moist	Loose	SP	**ALLUVIAL DEPOSITS** Medium Grained				
					Saturated							
5												5
	S-3	(9) 6/5/4	67									
								Fine Grained				
	S-4	(9) 7/4/5	50					Medium Grained				
10												10
						Firm						
	S-5	(13) 4/6/7	50									
15												15
	S-6	(19) 18/9/10	37									
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/25/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
B-131	As Per Boring Location Plan	2279.2		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3 1/2'	Wet Cave 3' 5"		3 1/4" Hollow Stem Auger	Mitchell Hoback

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
	U-1		100	Very Dark Grey	Very Moist	Firm	CL	**DEVELOPED ZONE**	22.4	91.3	1.75	
				Dark Grey Brown	Very Moist	Firm	SC	**ALLUVIAL TERRACE DEPOSITS** Clayey Sands				
				Light Grey Brown	Saturated							
	S-2	(9) 5/4/5	100					**ALLUVIAL DEPOSITS**				
5				Light Grey Brown	Saturated	Loose	SP	Fine to Medium Grained				5
	S-3	(11) 4/5/6				Firm		Medium Grained				
						Loose						
10	S-4	(7) 3/3/4										10
15	S-5	(18) 5/7/11				Firm						15
20	S-6	(15) 4/8/7										20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
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BORING LOG

PROJECT: Cottonwood Ranch Project #10057849
LOCATION: Phelps County, Nebraska
JOB NO. 200-05-24
DATE 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-1	As Per Test Pit Location Plan	2287.353		3 1/2'

WATER LEVEL OBSERVATIONS

WHILE DRILLING	END OF DRILLING	HOURS
2 1/2'		

TYPE OF SURFACE: Grass / Weeds
DRILLER: Cook Construction
DRILLING METHOD: Track Excavator
LOGGER: Scott Barnett

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE 8"** Trace Fine Sand				
				Dark Grey	Very Moist	Firm	CL					
				Light Brown			CL/SC					
					Saturated		SP					
								Bottom of Hole 3 1/2'				
5												5
10												10
15												15

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT: Cottonwood Ranch Project #10057849

LOCATION: Phelps County, Nebraska

JOB NO.	DATE
200-05-24	5/24/17

DRILL HOLE NO	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-2	As Per Test Pit Location Plan	2283.657		3 1/2'

WATER LEVEL OBSERVATIONS				
WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Grass / Weeds	Cook Construction
			DRILLING METHOD	LOGGER
2'			Track Excavator	Scott Barnett

DEPTH FT.	SAMPLE NO & TYPE	N° BLOWS /FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
								DEVELOPED ZONE 6"				
				Dark Grey	Moist	Firm	CL	Trace Fine Sand				
				Light Brown	Very Moist			Lean Clays				
							SP	Clean Fine Sands No Gravel				
					Saturated							
								Bottom of Hole 3 1/2'				
5												5
10												10
15												15

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BORING LOG

PROJECT:	**Cottonwood Ranch Project #10057849**
LOCATION:	**Phelps County, Nebraska**
JOB NO. 200-05-24	**DATE** 5/24/17

DRILL HOLE NO	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-3	As Per Boring Location Plan	2293.06		3 1/2'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass / Weeds	Cook Construction
			DRILLING METHOD	LOGGER
3'			Track Excavator	Scott Barnett

DEPTH FT	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE 6"** Lean Clays w/Trace Gravel				
				Dark Grey	Moist	Firm	CL					
				Grey	Very Moist	Firm	SC					
					Saturated							
								Bottom of Hole 3 1/2'				
5												5
10												10
15												15

MID-STATE
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BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-4	As Per Test Pit Location Plan	2289.307		4'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass / Weeds	Cook Construction
			DRILLING METHOD	LOGGER
3'			Track Excavator	Scott Barnett

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT.	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
								DEVELOPED ZONE 6"				
				Dark Grey	Moist	Firm	CL	Heavy Roots, w/30% Sands				
				Brown				Increasing Sand w/Depth All Fine Sand Uniform				
				Light Brown			SC	Approximately 50 - 60% Fine Sand				
					Very Moist							
					Saturated							
								Bottom of Hole 4'				
5												5
10												10
15												15

MID-STATE ENGINEERING & TESTING, Inc.

BORING LOG

PROJECT: Cottonwood Ranch Project #10057849

LOCATION: Phelps County, Nebraska

JOB NO. 200-05-24

DATE 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-5	As Per Test Pit Location Plan	2288.74		6'

WATER LEVEL OBSERVATIONS			
WHILE DRILLING	END OF DRILLING	HOURS	
4 1/2'			

TYPE OF SURFACE: Grass / Weeds

DRILLER: Cook Construction

DRILLING METHOD: Track Excavator

LOGGER: Scott Barnett

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE 5"** Trace to 15% Sands				
				Brown	Very Moist		SC	Approximately 50% Fine Sands				
				Light Brown			SC/SM	Clayey Sands Increasing Sands w/Depth Approximately 30% Fines				
5					Saturated							5
								Bottom of Hole 6'				
10												10
15												15

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT: Cottonwood Ranch Project #10057840

LOCATION: Phelps County, Nebraska

JOB NO.	DATE
200-05-24	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-6	As Per Test Pid Location Plan	2283.403		3'

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	HOURS
1 1/2'		

TYPE OF SURFACE: Grass / Weeds

DRILLER: Cook Construction

DRILLING METHOD: Track Excavator

LOGGER: Scott Barnett

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Very Moist	Firm	SC	**DEVELOPED ZONE 6"** Approximately 50% Sand				
				Light Brown	Saturated			Approximately 70% Sand				
								Bottom of Hole 3'				
5												5
10												10
15												15

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849
LOCATION:	Phelps County, Nebraska
JOB NO. 200-05-24	DATE 5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-7	As Per Test Pit Location Plan	2280.045		4'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass / Weeds	Cook Construction
			DRILLING METHOD	LOGGER
1 1/2'			Track Excavator	Scott Barnett

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS / FT.	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE 6"** Approximately 25% Fines Increasing Sand w/Depth Approximately 30% Fines				
				Light Brown	Saturated		SC	Approximately 50% Fines				
							SP	Trace Fines and Gravel w/Rust				
								Bottom of Hole 4'				
5												5
10												10
15												15

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT:	Cottonwood Ranch Project #10057849		
LOCATION:	Phelps County, Nebraska		
JOB NO.	200-05-24	DATE	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-8	As Per Test Pit Location Plan	2280.734		3 1/2'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass / Weeds	Cook Construction
			DRILLING METHOD	LOGGER
1 1/2'			Track Excavator	Scott Barnett

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE 6"**				
					Saturated		SP	Approxiamtely 15% Fines				
							SW	Well Graded Sand w/Gravel				
								Bottom of Hole 3 1/2'				
5												5
10												10
15												15

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT: Cottonwood Ranch Project #10057849

LOCATION: Phelps County, Nebraska

JOB NO.	DATE
200-05-24	5/24/17

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
TP-9	As Per Test Pit Location Plan	2281.753		4 1/2'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass / Weeds	Cook Construction
			DRILLING METHOD	LOGGER
4'			Track Excavator	Scott Barnett

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE 6"**				
				Brown			CL					
				Light Brown			CL/SC	w/Trace Gravel/Coarse Sands				
							SC/SP	20% Fine Sand				
5								**Bottom of Hole 4 1/2'**				5
10												10
15												15

July 25, 2017

BOART LONGYEAR™

Kevin Christensen
Mid-State Engineering & Testing, INC.
11 East 11th Street
Kearney, NE 68847
308-237-0187
kearny@midstateengineering.com

Mr. Christensen,

Attached is the calibration results from the test conducted on August 25, 2016 in Katy Wroclawskie, Poland. This test shows the hammer efficiency in the lower left corner to be at 61%, along with the correlative data taken from the test.

Also attached are the documents from an original efficiency test from March 27, 2002 conducted in Dayton, Nevada.

Sincerely,

Jon Peterson
Customer Service Representative
2455 S 3600W
West Valley City, UT 84119
jon.peterson@boartlongyear.com

BOART LONGYEAR

SPT Hammer Energy Test Report

in accordance with BSEN ISO 22476-3:2005

Boart Longyear Poland
Popieluszki 30
55-080 Katy Wroclawskie

SPT Hammer Ref: LS250.2016.117
Test Date: 25/08/2016
Report Date: 26/08/2016
File Name: LS250.17.spt
Test Operator: BEATA

Instrumented Rod Data

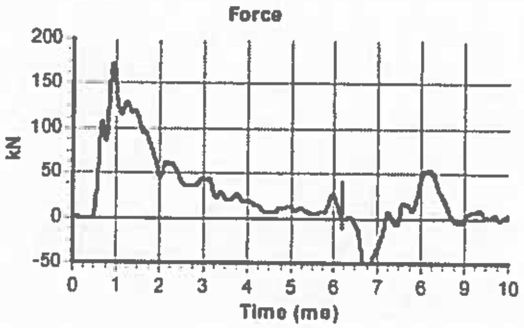
Diameter d_r (mm): 67
Wall Thickness t_r (mm): 7.6
Assumed Modulus E_a (GPa): 208
Accelerometer No.1: 10332
Accelerometer No.2: 10333

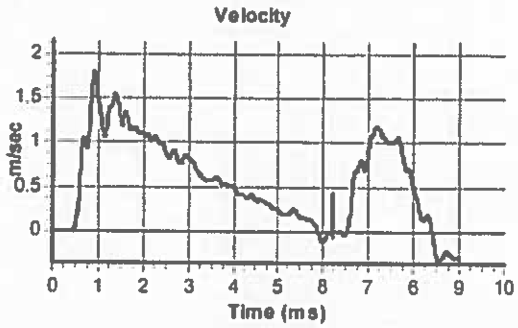
SPT Hammer Information

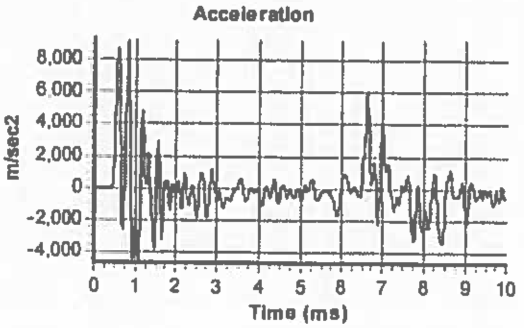
Hammer Mass m (kg): 63.5
Falling Height h (mm): 760
SPT String Length L (m): 14.5

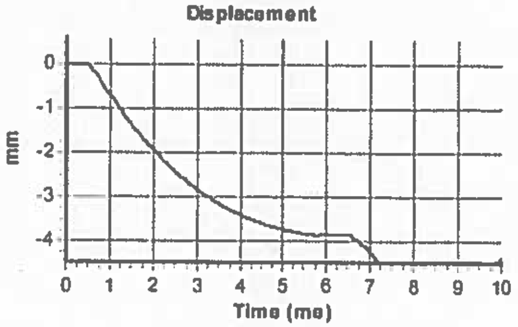
Comments / Location

Katy Wroclawskie, Poland









Calculations

Area of Rod A (mm2): 1418
Theoretical Energy E_{theor} (J): 473
Measured Energy E_{meas} (J): 287

Energy Ratio E_r (%): 61

Signed: Beata Surmiak
Title: Mechanical Engineer

January 14, 2005

Mr. Pat Muncy
Boart Longyear
2340 West 1700 South
Slat Lake City, Utah 84104

Re: Standard Penetration Test Energy Measurements
Boart Longyear Automatic SPT Hammer
Dayton, Nevada GRL Job No. 022013

Dear Mr. Muncy:

This report presents energy transfer measurements and calculations made on March 27, 2002 during Standard Penetration Tests (SPT) at a site near Dayton, Nevada. Dynamic tests were performed on an AWJ drill rod advanced by a Boat Longyear automatic SPT hammer. Goble Rausche Likins and Associates, Inc. (GRL) obtained the dynamic measurements with an instrumented AWJ subsection and a Model PAK Pile Driving Analyzer®.

Drilling and SPT Hammer Equipment

SPT energy measurements were made during nine sampling events in one soil borehole. The Boart Longyear automatic SPT hammer was mounted on a CME 75 drill rig.

Instrumentation

A model PAK Pile Driving Analyzer was used to collect and process the dynamic measurements of strain and acceleration. A two foot long section of AWJ rod (sub-section) was instrumented with two full bridge foil resistance strain gages and two accelerometers mounted approximately one ft from each end.

Analog signals from the strain gages and accelerometers were conditioned, digitized, stored and processed with a model PAK Pile Driving Analyzer® (PDA). Selected output from the PDA for each recorded impact included the maximum calculated rod top force, maximum rod top velocity, energy transfer by two methods and the hammer operating rate. Appendix A provides an introduction to dynamic pile testing methods.

Force and velocity records collected by the PDA were viewed on a graphic LCD screen during sampling to evaluate data quality.

Measurements and Calculations

The primary purpose of GRL's testing was the measurement of energy transfer from the Boart Longyear automatic SPT hammer to the AWJ drill rod. The PDA measurements of rod force and velocity were reviewed in the office after field testing, corrected or adjusted as necessary, and then replayed to calculate two transferred energy results: EMX and EF2

Energy transfer past the gage location, EMX, was computed by the PDA using force and velocity records as follows:

EMX ~= ~ INT FROM a TO b ~F~(t)~v~(t)~dt

The time "a" corresponds to the start of the record which is when the energy transfer begins and *"b"* is the time at which energy transferred to the rod reaches a maximum value.

In addition to the EMX energy calculation, we computed a value for energy transfer, EF2, using only force measurements as follows:

EF2 ~= ~c OVER EA ~ INT FROM a TO w ~[F~(t)] SUP 2 ~dt

where E, A and c are the Young's Modulus of Elasticity, cross-sectional area, and compression stress wave speed of the rod, respectively. Integration begins at time "a", which is equal to the time of impact, and ends at cut-off time, *"w"*, which is at the first occurrence of a zero force after impact. According to ASTM D 4633-86, the cut-off time must be compared with time 2L/c, where L is the distance between the measurement location and the end of the sampler. If "w" is less than 0.9*2L/c or greater than 1.2*2L/c, the EF2 result may not be used to evaluate energy. In practice, the time of zero force may fall outside these limits due to the effects of rod cross-sectional changes, connector conditions, end conditions, rod length, and other factors. No data was removed from the data sets because of the time of first zero force.

According to the expired ASTM D4633-86 standard, the Force-Squared energy computation (EF2) may be multiplied by three correction factors to obtain the desired energy result. The first two factors are a function of the rod length and the distance between the impact surface and the force measurement location, and are greater than or equal to unity. The third factor, K_c, is simply the ratio of the actual cutoff time, w, to the theoretical cut-off time, 2L/c. No correction factors were applied to the results.

Any cross-sectional area difference between the GRL sub-section and the AWJ drill rod, and any loose connections or changes in area at section joints, will result in stress wave reflections that can affect the calculation of energy transfer. The EF2 method, using only the force record, does not correctly calculate transferred energy in these situations. Fortunately the EMX transferred energy calculation method, utilizing both force and velocity records, is theoretically correct and the energy results are not adversely affected by cross-sectional area changes or loose connectors.

The transferred energy calculations by the EMX method hold theoretically in these cases when the EF2 method does not, and is therefore considered a more accurate and reliable representation of energy transfer from the SPT hammer. The EF2 results are not included in the Summary of Field Results (Table 1), but are included in the PDA output in Appendix B.

Results

Table 1 summarizes the average calculated transferred energies for the reliable and theoretically correct EMX method. The results presented are the average rod top values for the PDA data collected for each sampling event. The records averaged are all acceptable data for the sampling event with any poor quality data (very little) and the first few hammer blows removed. Transfer efficiency is defined as the calculated transferred energy divided by the theoretical hammer potential energy of 350 lb-ft, for the 140 lb SPT hammer falling 2.5 ft. The average auto hammer operating rate is reported in blows-per-minute (bpm). Also included are the average maximum rod top force and velocity.

Figure 1 is a graphical presentation of the calculated energy transfer efficiency as a function of hammer operating rate.

A general introduction to dynamic pile testing methods is included in this report as Appendix A. References for more detailed descriptions of our testing and analysis methods are available upon request.

Appendix B contains printed plots and tables of PDA results for all acceptable quality hammer blows. The plots and tables present selected measured and calculated results as a function of blow number. The results include EMX (transferred energy by the EMX method), ETR (energy transfer efficiency for the EMX method), EF2 (transferred energy by the EF2 method), FMX (maximum rod top force), VMX (maximum rod top velocity) and BPM (hammer operating rate). At the end of each table is a statistical evaluation of the results for each variable that includes the average, standard deviation and sample size. Sample PDA records of measured force and velocity versus time are presented in Appendix C.

Conclusions and Recommendations

1) One Boart Longyear automatic SPT hammer was monitored during nine sampling events (5 to 50 ft) in one boring location on March 27, 2002. The average EMX energy transfer efficiency for the nine testing events was 69%, with a range from 64% to 72%.

1) The subsurface conditions were described as sand and gravel. The penetration resistance was high with reported blow counts ranging from 61 blows for 18 inches to 58 blows for 6 inches.

1) The average hammer operating rate ranged from 30.1 bpm to 40.8 bpm, with an overall average rate of 38.1 bpm. The energy transfer efficiency appears to be directly related to the hammer operating rate; at 30.7 bpm the average transfer efficiency was 64% while at an operating rate of 40.8 bpm the average transfer efficiency was 70%. Figure 1 presents a plot of energy transfer efficiency as a function of hammer operating rate for the nine testing events monitored.

1) To adjust SPT N values for SPT hammer performance and variation, the Schmertman correction for N value adjustment to 60% transfer efficiency is:

$$N_{60} = (e_m/60)\, N_m$$

where: N_{60} = the corrected N value
e_m = the EFV energy transfer efficiency
N_m = the measured SPT N value

It was a pleasure to work with Pat Muncy on this interesting project. Please do not hesitate to contact us if you have any questions about this report.

Sincerely,

GOBLE RAUSCHE LIKINS
AND ASSOCIATES, INC.

Jay Berger

Appendix B

Laboratory Test Results

MID-STATE ENGINEERING & TESTING, INC.

SUMMARY OF SOILS TESTING

PROJECT Cottonwood Ranch Broad-Scale Project #10057849
LOCATION Phelps County, Nebraska
JOB NO. 200-05-24 **DATE** 6/27/2017

DRILL HOLE NO.	SAMPLE NO.	SAMPLE DEPTH (ft.)	WATER CONTENT %	DENSITY		VOID RATIO (e)	SAT (%)	UNCONFINED COMPRESSION		ATTERBERG LIMITS			%PASS #200 SIEVE	CLASS.	SPT BLOW COUNTS	REMARKS
				WET (pcf)	DRY (pcf)			QU (tsf)	Strain (%)	LL	PL	PI				
B-102	U-1	1/2 - 2'	17.1	135.0	115.3	0.462	100	1.0	3.5	29	17	12	42.2	SC		
	S-4	8 1/2 - 10'	9.7										3.8	SP		
B-103	S-2	3 1/2 - 5'	19.7							19	NP	NP	23.7	SM		
	S-3	5 1/2 - 7'	14.7										15.1	SM		
	S-4	8 1/2 - 10'	11.8										2.9	SP		
B-104	U-1	1/2 - 2'	24.5							26	15	11	64.6	CL		Dispersion Test - Grade ND1
B-106	U-1	1/2 - 2'	21.0	115.9	95.8	0.758	75	0.7	4.2	23	19	4	46.1	SM		
	S-3	5 1/2 - 7'	7.2										1.3	SP		
B-107	U-1	1/2 - 2'	19.7	122.4	102.3	0.647	82			38	19	22	66.6	CL		
B-108	U-1	1/2 - 2'	13.7							19	NP	NP	35.4	SM		
	S-2	3 1/2 - 5'	11.8							NP	NP	NP	29.5	SM		
	S-3	5 1/2 - 7'	13.2										22.7	SM		
B-109	U-1	1/2 - 2'	5.5	134.3	127.3	0.324	46	1.6	5.4	19	16	3	47.8	SM		
	S-6	18 1/2 - 20'	13.9										19.7	SM		
B-110	S-2	3 1/2 - 5'	21.1							NP	NP	NP	39.3	SM		
B-111	U-1	1/2 - 2'	21.1	109.4	86.1	0.957	75			45	22	23	70.4	CL		
	S-4	8 1/2 - 10'	12.2										0.7	SP		
	S-2	23 1/2 - 25'	8.8										4.5	SP		

MID-STATE ENGINEERING & TESTING, INC.

SUMMARY OF SOILS TESTING

PROJECT	Cottonwood Ranch Broad-Scale Project #10057849
LOCATION	Phelps County, Nebraska
JOB NO.	200-05-24
DATE	6/27/2017

DRILL HOLE NO.	SAMPLE NO.	SAMPLE DEPTH (ft.)	WATER CONTENT %	DENSITY		VOID RATIO (e)	SAT (%)	UNCONFINED COMPRESSION		ATTERBERG LIMITS			%PASS #200 SIEVE	CLASS.	SPT BLOW COUNTS	REMARKS
				WET (pcf)	DRY (pcf)			QU (tsf)	Strain (%)	LL	PL	PI				
B-112	U-1	1/2 - 2'	20.7	130.4	108.1	0.559	100	0.3	1.8	21	9	12	39.0	SC		
	S-2	3 1/2 - 5'	14.9										5.6	SC/SW		
B-113	S-4	8 1/2 - 10'	11.2										2.0	SP		
B-116	S-2	3 1/2 - 5'	14.1							17	NP	NP	40.7	SM		
B-117	U-1	1/2 - 2'	20.5	120.7	100.1	0.683	81	0.6	5.3	29	16	13	53.3	CL		
	S-2	3 1/2 - 5'	13.9							NP	NP	NP	8.4	SM/SP		
B-118	S-2	3 1/2 - 5'	15.1							NP	NP	NP	16.1	SM		
B-119	U-1	1/2 - 2'	15.3							NP	NP	NP	52.7	ML		
B-121	U-1	1/2 - 2'	26.0	110.9	88.0	0.914	77	0.7	4.5	27	12	15	51.3	CL		
B-122	U-1	1/2 - 2'	27.9	109.6	85.7	0.966	78			26	13	13	52.2	CL		
B-123	S-2	5 1/2 - 7'	7.8							NP	NP	NP	19.9	SM		
	S-4	8 1/2 - 10'	14.0										5.6	SP		
B-124	U-1	1/2 - 2'	15.5							24	14	16	38.5	SC		Dispersion Test - Grade ND1
B-125	U-1	1/2 - 2'								29	17	17		CL		Dispersion Test - Grade ND1
	S-5	13 1/2 - 15'	11.6										2.1	SP		
	S-2	28 1/2 - 30'	13.9										2.3	SP		

MID-STATE ENGINEERING & TESTING, INC.

SUMMARY OF SOILS TESTING

PROJECT Cottonwood Ranch Broad-Scale
Project #10057849
LOCATION Phelps County, Nebraska
JOB NO. 200-05-24
DATE 6/27/2017

DRILL HOLE NO.	SAMPLE NO.	SAMPLE DEPTH (ft.)	WATER CONTENT %	DENSITY		VOID RATIO (e)	SAT (%)	UNCONFINED COMPRESSION		ATTERBERG LIMITS			%PASS #200 SIEVE	CLASS.	SPT BLOW COUNTS	REMARKS
				WET (pcf)	DRY (pcf)			QU (tsf)	Strain (%)	LL	PL	PI				
B-126	U-1	1/2 - 2'	18.6	125.7	106.0	0.590	85	0.7	4.8	24	11	13	57.2	CL		
	S-2	3 1/2 - 5'	19.1							NP	NP	NP	29.8	SM		
B-128	U-1	1/2 - 2'								40	18	22		CL		Dispersion Test - Grade ND1
B-129	S-4	8 1/2 - 10'	11.9										1.0	SP		
	S-8	28 1/2 - 30'	13.3										2.0	SP		
B-130	U-1	1/2 - 2'	23.3	103.7	84.1	1.003	63	0.5	5.1	32	16	16	63	CL		
B-131	U-1	1/2 - 2'	22.4	111.7	91.3	0.845	71			24	14	10	34.3	SC		

MID-STATE

ENGINEERING & TESTING

11 East 11th St. Kearney, NE

Project:	Cottonwood Ranch Broad-Scale Project #10057849
Location:	Phelps County, Nebraska
Job No. 200-05-24	Date: 6/29/2017

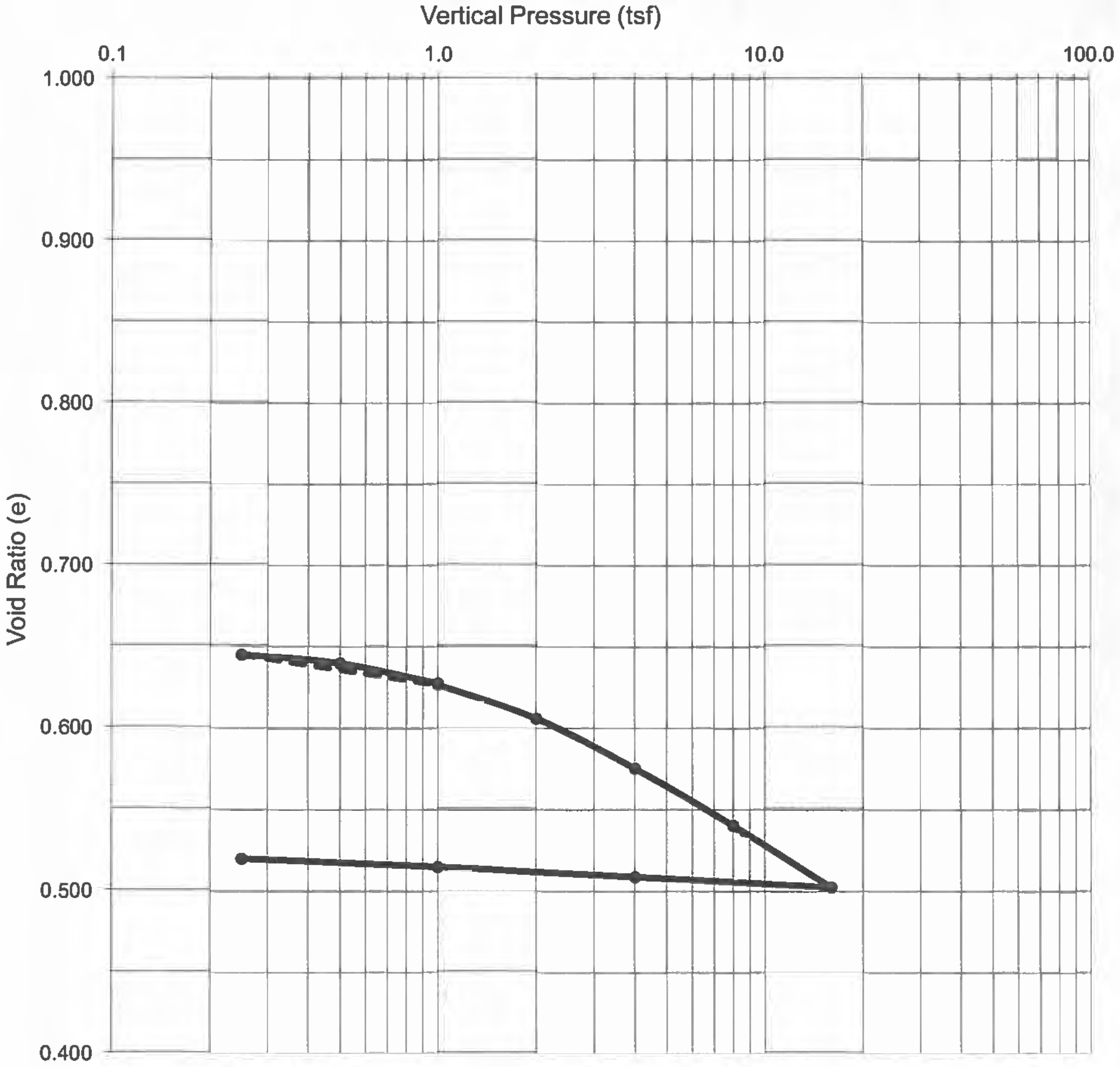
CONSOLIDATION TEST

Drill Hole # B-107 Sample # U-1 Sample Depth Interval 1/2 - 2'

Sample Description Very Dark Grey Sandy Lean Clay

Initial Water Content (%)	19.7	Dry Unit Weight (pcf)	102.3	Initial Saturation (%)	82.2
Final Water Content (%)	17.3	Specific Gravity (Assumed)	2.70		

Liquid Limit 38 Plastic Limit 16 Plasticity Index 22 Classification CL



MID-STATE

ENGINEERING & TESTING

11 EAST 11TH ST. KEARNEY, NE

Project:	Cottonwood Ranch Broad-Scale Project #10057849		
Location:	Phelps County, Nebraska		
Job No.	200-05-24	Date:	6/27/2017

CONSOLIDATION TEST

Drill Hole # B-111

Sample # U-1

Sample Depth Interval 1/2 - 2'

Sample Description Dark Grey Brown Sandy Lean Clay

Initial Water Content (%) 27.1

Dry Unit Weight (pcf) 86.1

Initial Saturation (%) 76.3

Final Water Content (%) 28.0

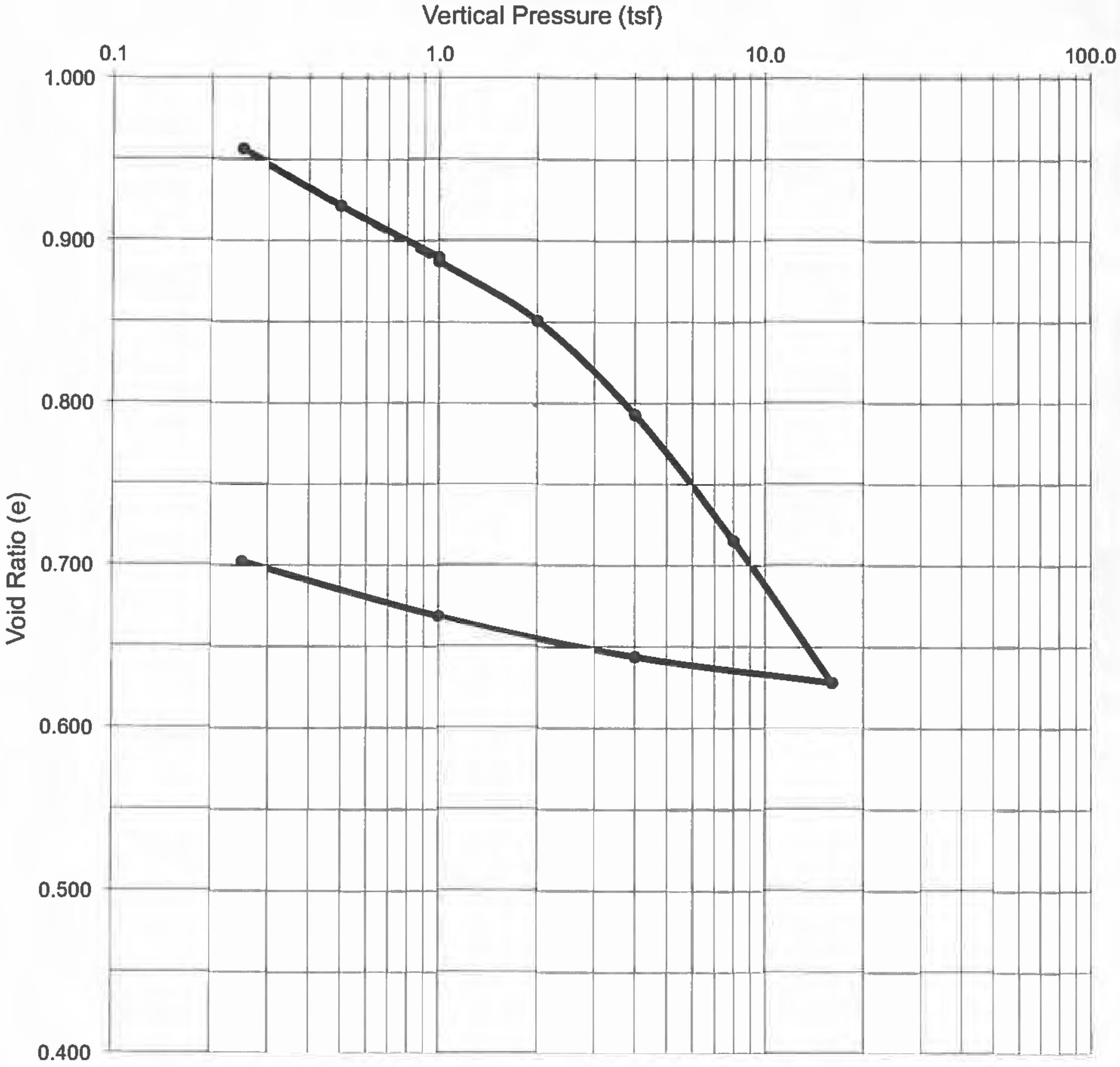
Specific Gravity (Assumed) 2.70

Liquid Limit 45

Plastic Limit 22

Plasticity Index 23

Classification CL

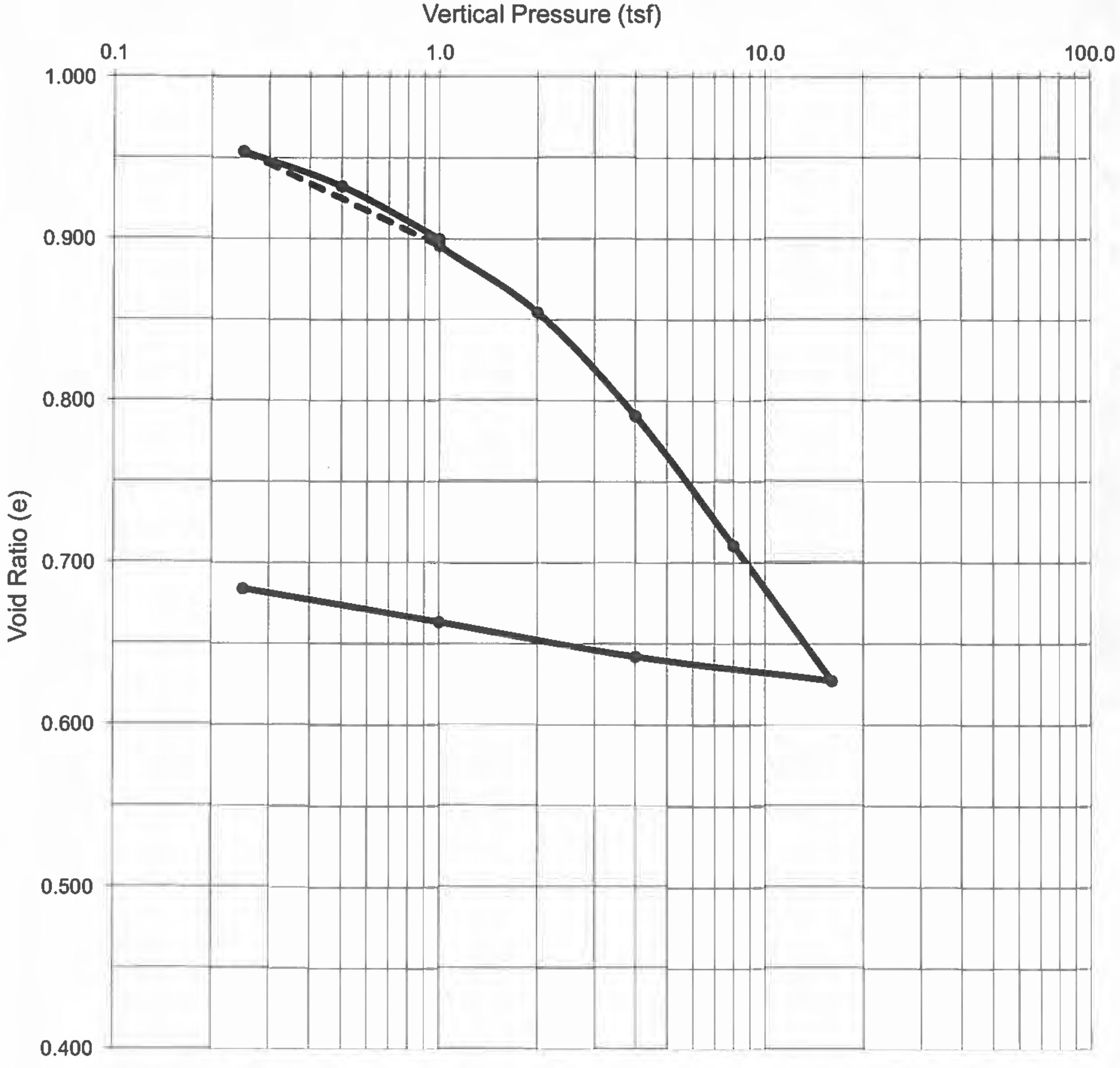


Mid-State
Engineering & Testing
11 East 11th St. Kearney, NE

Project: Cottonwood Ranch Broad-Scale Project #10057849
Location: Phelps County, Nebraska
Job No. 200-05-24 Date: 6/23/2017

CONSOLIDATION TEST

Drill Hole # B-122
Sample # U-1
Sample Depth Interval 1/2 - 2'
Sample Description Dark Grey Brown Sandy Lean Clay
Initial Water Content (%) 27.9
Dry Unit Weight (pcf) 85.7
Initial Saturation (%) 78.0
Final Water Content (%) 26.7
Specific Gravity (Assumed) 2.70
Liquid Limit 26
Plastic Limit 13
Plasticity Index 13
Classification CL



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ENGINEERING & TESTING

11 EAST 11TH ST. KEARNEY, NE

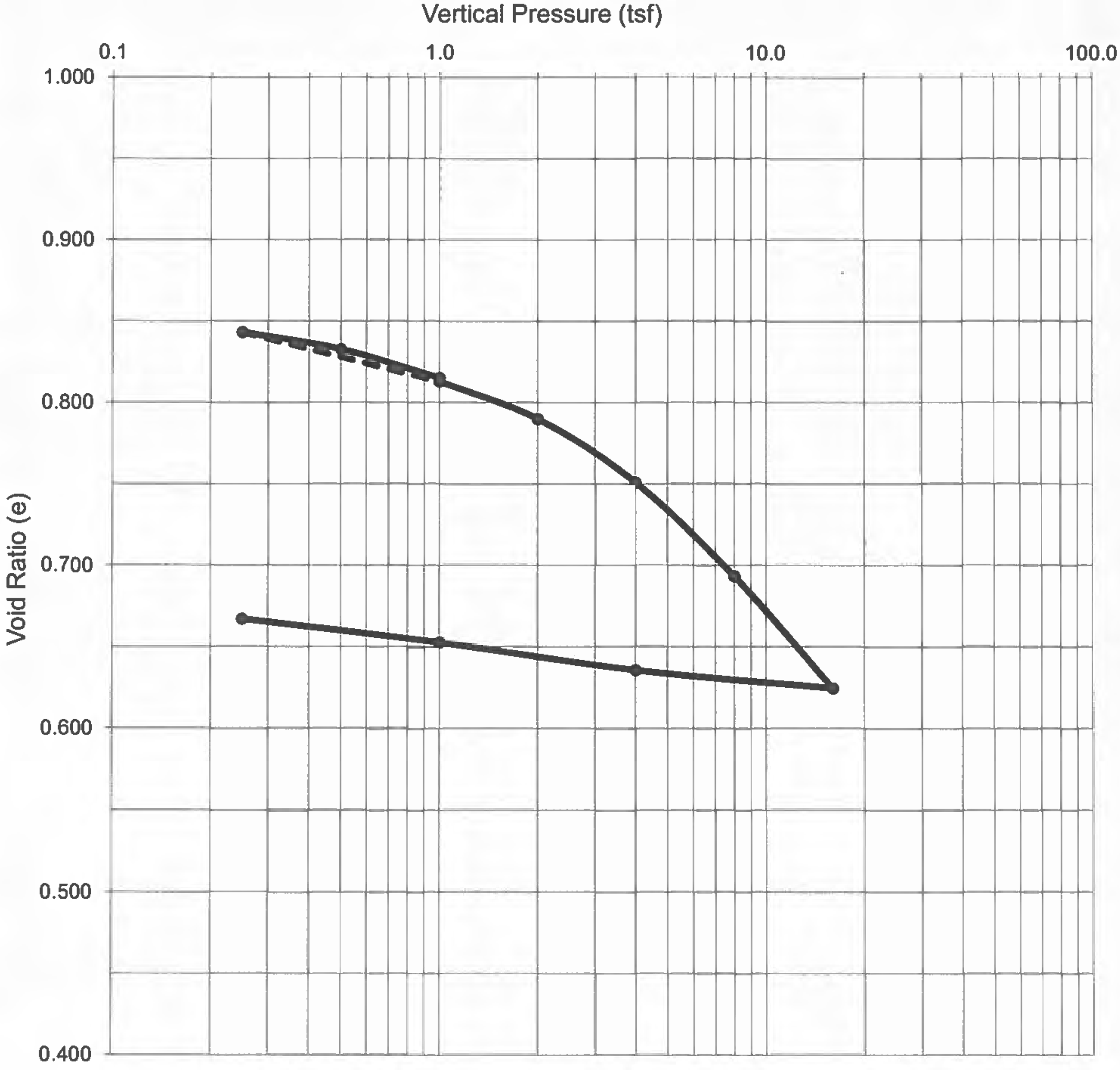
Project:	Cottonwood Ranch Broad-Scale Project #10057849
Location:	Phelps County, Nebraska
Job No. 200-05-24	Date: 7/3/2017

CONSOLIDATION TEST

Drill Hole # B-131 Sample # U-1 Sample Depth Interval 1/2 - 2'

Sample Description Dark Grey Brown Clayey Sand

Initial Water Content (%)	22.4	Dry Unit Weight (pcf)	91.3	Initial Saturation (%)	71.3
Final Water Content (%)	21.9	Specific Gravity (Assumed)	2.70		
Liquid Limit 24	Plastic Limit 14	Plasticity Index	10	Classification	SC



Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

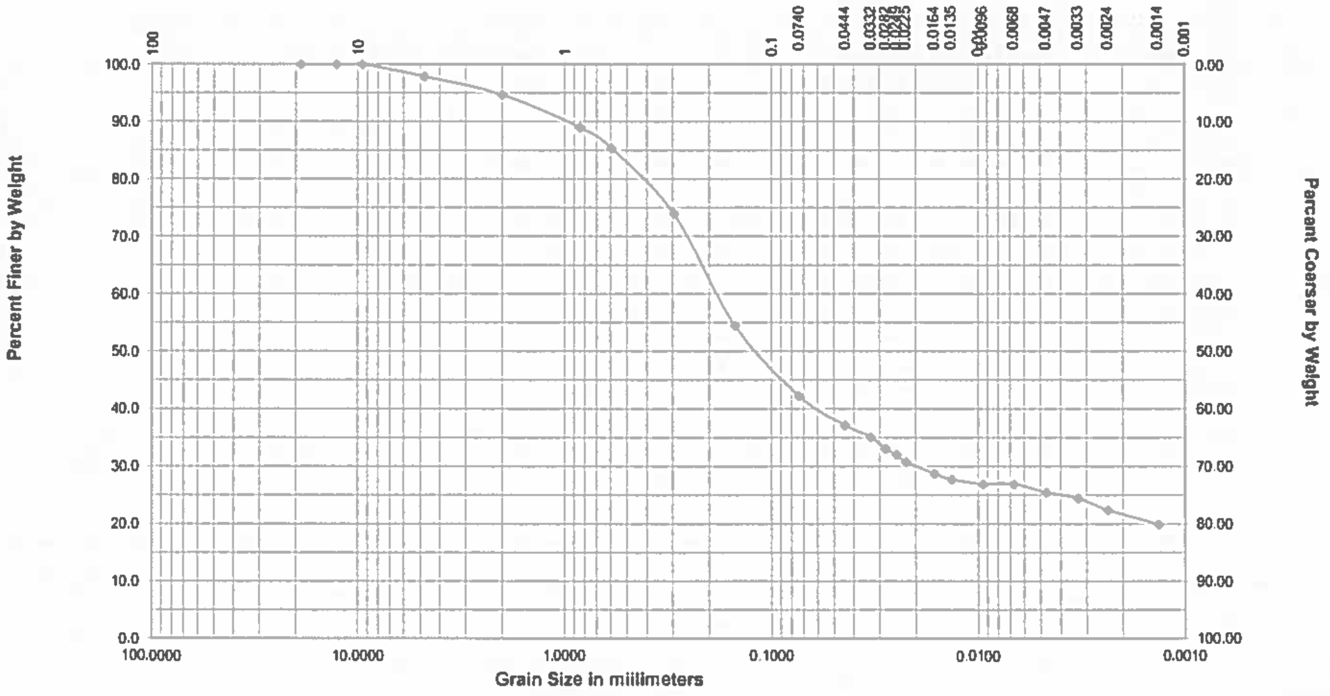
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraske		
M.S. Project #:	200-05-24	Tested By:	Don Bernett	Date:	6/20/2017
Sample id:	B-102, U-1 (1/2 - 2')	Sample Description:	Dark Grey Clayey Sand		

Wet Mess: (g)	181.80	Dispersing Agent	5g, HMP	S.G. Corr. Fector:	0.99	P-200 Dry Wt. (g)	84.1
Dry Mass, (g)	177.30	Soil Mass, (Air Dry), (g)	50.0	Moist. Corr. Fector:	0.9671	P-200 Tare Wt. (g)	58.2
Tare: (g)	45.10	Hydrometer Method	152H	Hygro. M.C.: (%)	3.4	Passing #200 (%)	42.30

t (min)	Temp. (F)	Temp. (C)	Hydrom.	Hydrom.	R*e	W	P	L	SQRT(L/t)	k	Grain Size
			C. Fect.	Reeding, R		(g)	(%)	(cm)			(mm)
Hydrometer Remerks:							100.0	Gradetion Remarks:			19.00
							100.0				12.70
							100.0				9.51
							97.9				4.78
							94.7				2.00
							89.0				0.8410
							85.4				0.5940
							74.0				0.2970
							54.5				0.1500
							42.30				0.0740
1	74.0	23.3	2.8	21.0	18.0	48.4	37.20	9.9	3.147	.01412	0.0444
2	74.0	23.3	2.8	20.0	17.0	48.4	35.15	11.1	2.353	.01412	0.0332
3	74.0	23.3	2.8	19.0	18.0	48.4	33.11	11.9	1.994	.01412	0.0282
4	74.0	23.3	2.8	18.5	15.5	48.4	32.08	12.5	1.766	.01412	0.0249
5	73.5	23.1	2.9	18.0	14.9	48.4	30.84	12.7	1.594	.01412	0.0225
10	73.5	23.1	2.9	17.0	13.9	48.4	28.80	13.5	1.182	.01412	0.0184
15	73.5	23.1	2.9	16.5	13.4	48.4	27.77	13.8	0.959	.01412	0.0135
30	74.0	23.3	2.8	16.0	13.0	48.4	26.96	14.0	0.682	.01402	0.0096
60	74.0	23.3	2.8	18.0	13.0	48.4	28.98	14.3	0.488	.01387	0.0068
120	73.0	22.8	3.0	15.5	12.3	48.4	25.51	14.4	0.347	.01363	0.0047
240	73.0	22.8	3.0	15.0	11.8	48.4	24.48	14.7	0.247	.01344	0.0033
480	73.0	22.8	3.0	14.0	10.8	48.4	22.44	14.8	0.176	.01353	0.0024
1440	72.0	22.2	3.3	13.0	9.6	48.4	19.96	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

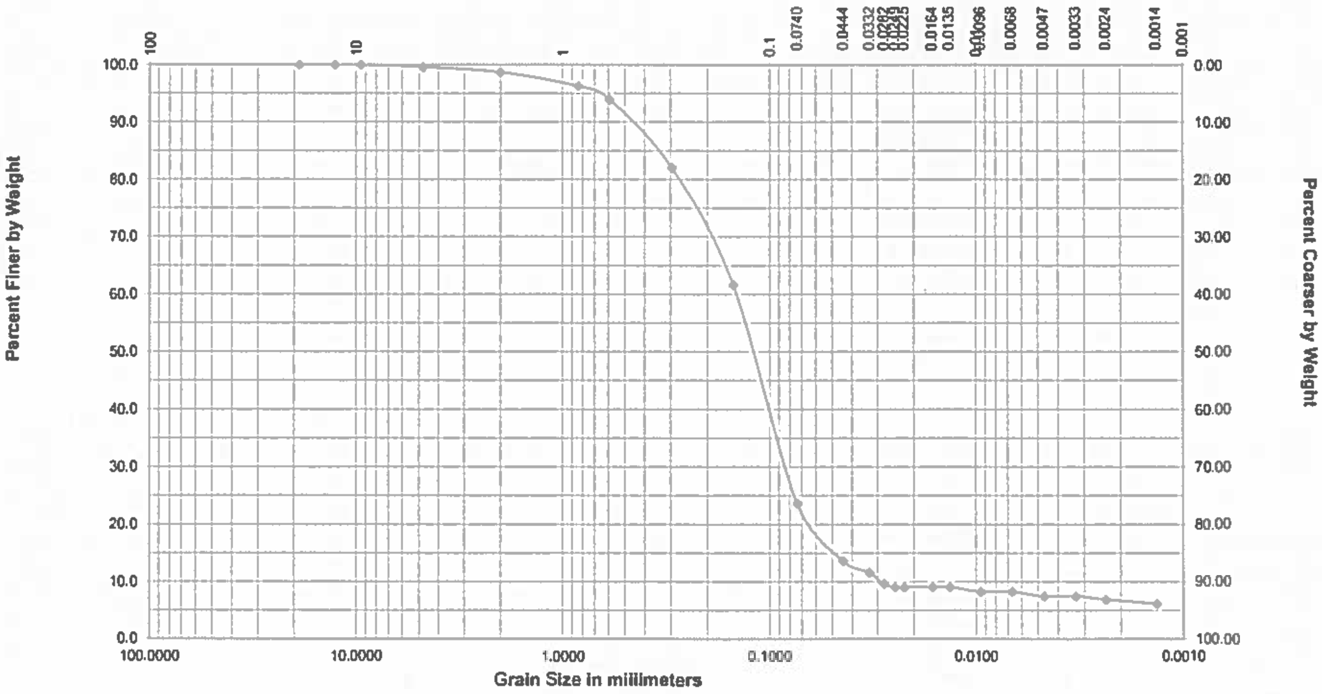
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska
M.S. Project #:	200-05-24	Tested By:	Don Barnett
		Date:	6/20/2017
Sample Id:	B-103, S-2 (3 1/2 - 5')	Sample Description:	Light Grey Brown Fine Grained Sand

Wet Mass: (g)	121.60	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	64.6
Dry Mass, (g)	120.70	Soil Mass, (Air Dry), (g)	50.0	Moist. Corr. Factor:	0.9882	P-200 Tare Wt. (g)	28.9
Tare: (g)	45.10	Hydrometer Method	152H	Hygro. M.C.: (%)	1.2	Passing #200 (%)	23.70

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fact.	Hydrom. Reading, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.6				4.76
							98.7				2.00
							96.3				0.8410
							94.0				0.5940
							82.1				0.2970
							81.7				0.1500
							23.70				0.0740
1	70.0	21.1	3.7	10.5	8.8	49.4	13.67	9.9	3.147	.01412	0.0444
2	70.0	21.1	3.7	9.5	5.8	49.4	11.67	11.1	2.353	.01412	0.0332
3	70.0	21.1	3.7	8.5	4.8	49.4	9.67	11.9	1.994	.01412	0.0282
4	71.0	21.7	3.5	8.0	4.5	49.4	9.09	12.5	1.766	.01412	0.0249
5	71.0	21.7	3.5	8.0	4.5	49.4	9.09	12.7	1.594	.01412	0.0225
10	71.0	21.7	3.5	8.0	4.5	49.4	9.09	13.5	1.162	.01412	0.0164
15	71.0	21.7	3.5	8.0	4.5	49.4	9.09	13.8	0.959	.01412	0.0135
30	71.5	21.9	3.4	7.5	4.1	49.4	8.30	14.0	0.882	.01402	0.0098
80	71.5	21.9	3.4	7.5	4.1	49.4	8.30	14.3	0.488	.01387	0.0068
120	72.0	22.2	3.3	7.0	3.7	49.4	7.51	14.4	0.347	.01383	0.0047
240	72.0	22.2	3.3	7.0	3.7	49.4	7.51	14.7	0.247	.01344	0.0033
480	73.0	22.8	3.0	6.5	3.4	49.4	6.93	14.8	0.176	.01353	0.0024
1440	76.0	24.4	2.4	5.5	3.1	49.4	6.20	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

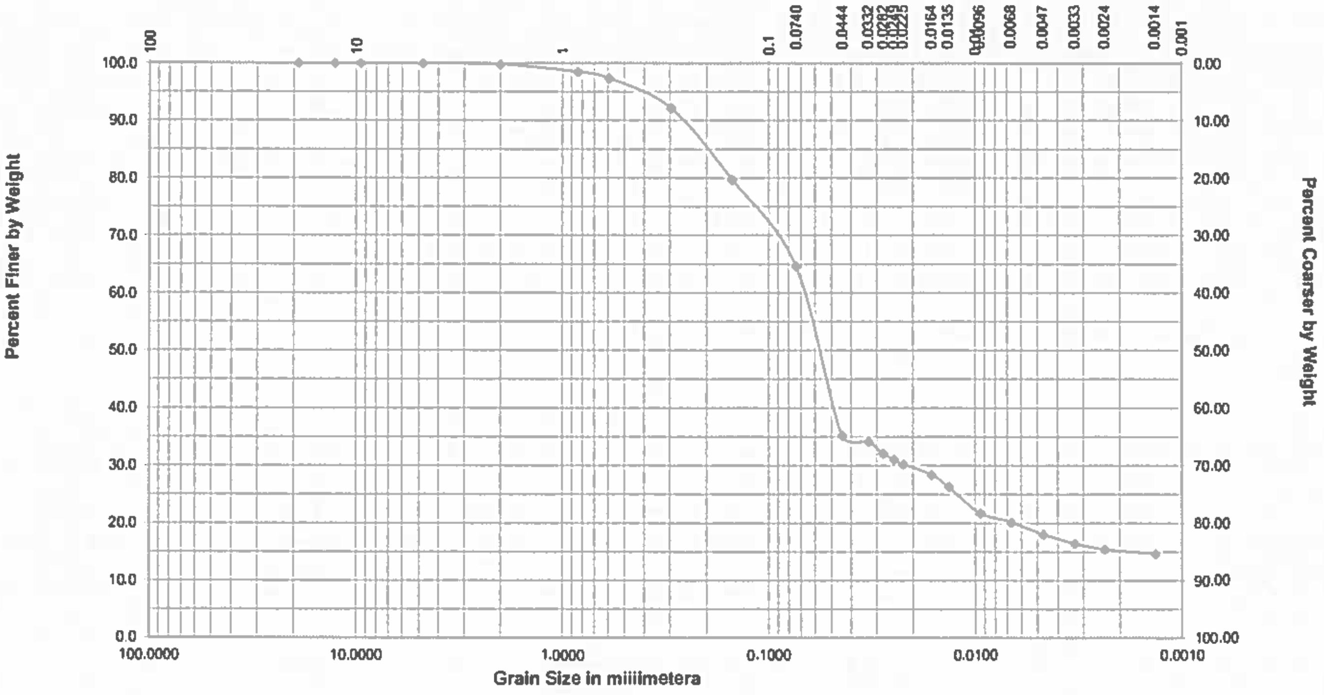
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska
M.S. Project #:	200-05-24	Tested By:	Don Bernett
		Date:	6/20/2017
Sample id:	B-104, U-1 (1/2 - 2')	Sample Description:	Dark Grey Brown Sandy Lean Clay

Wet Mass: (g)	185.50	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	43.6
Dry Mass, (g)	179.40	Soil Mass, (Air Dry), (g)	50.0	Moist. Corr. Factor:	0.9562	P-200 Tare Wt. (g)	26.7
Tara: (g)	46.20	Hydrometer Method	152H	Hygro. M.C.: (%)	4.8	Passing #200 (%)	64.65

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.78
							99.8				2.00
							98.5				0.8410
							97.4				0.5940
							92.2				0.2970
							79.7				0.1500
							64.65				0.0740
1	71.0	21.7	3.5	20.5	16.9	47.8	35.28	9.9	3.147	.01412	0.0444
2	71.0	21.7	3.5	20.0	16.4	47.8	34.24	11.1	2.353	.01412	0.0332
3	71.0	21.7	3.5	19.0	15.4	47.8	32.17	11.9	1.994	.01412	0.0282
4	71.0	21.7	3.5	18.5	14.9	47.8	31.13	12.5	1.766	.01412	0.0249
5	71.5	21.9	3.4	18.0	14.5	47.8	30.32	12.7	1.594	.01412	0.0225
10	72.0	22.2	3.3	17.0	13.6	47.8	28.47	13.5	1.182	.01412	0.0164
15	72.0	22.2	3.3	18.0	12.8	47.8	26.40	13.8	0.959	.01412	0.0135
30	71.0	21.7	3.5	14.0	10.4	47.8	21.82	14.0	0.682	.01402	0.0096
60	72.0	22.2	3.3	13.0	9.6	47.8	20.18	14.3	0.488	.01387	0.0068
120	72.0	22.2	3.3	12.0	8.7	47.8	18.11	14.4	0.347	.01363	0.0047
240	73.0	22.8	3.0	11.0	7.9	47.8	16.48	14.7	0.247	.01344	0.0033
480	73.0	22.8	3.0	10.5	7.4	47.8	15.44	14.8	0.178	.01353	0.0024
1440	78.0	24.4	2.4	9.5	7.0	47.8	14.69	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.
11 East 11th St.
Kearney, Nebraska 68847

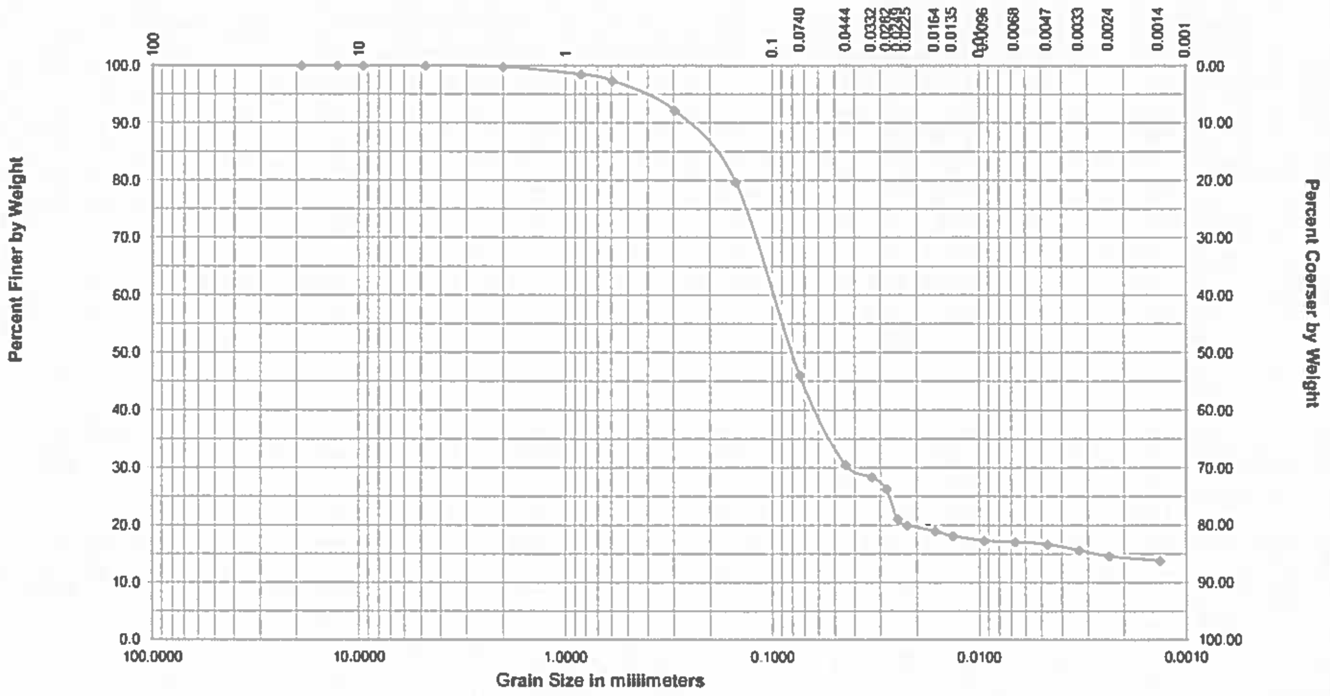
Hydrometer Analysis
ASTM D-422

Project:	Cottonwood Ranch Broed-Scale Project #10057849	Location:	Pheips County, Nebraske
M.S. Project #:	200-05-24	Tested By:	Don Bamett
		Date:	8/20/2017
Sample id:	B-108, U-1 (1/2 - 2')	Sample Description:	Dark Grey Clayey Sand

Wet Mess: (g)	169.50	Dispersing Agent	5g, HMP	S.G. Corr. Fector:	0.99	P-200 Dry Wt. (g)	52.2
Dry Mass, (g)	162.30	Soii Mass, (Alr Dry), (g)	50.0	Moist. Corr. Fector:	0.9430	P-200 Tere Wt. (g)	28.8
Tare: (g)	43.10	Hydrometer Method	152H	Hygro. M.C.: (%)	6.0	Pessing #200 (%)	46.13

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reeding, R	R"e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.76
							99.8				2.00
							98.5				0.8410
							97.4				0.5940
							92.2				0.2970
							79.7				0.1500
							46.13				0.0740
1	71.0	21.7	3.5	18.0	14.4	47.2	30.52	9.9	3.147	.01412	0.0444
2	71.0	21.7	3.5	17.0	13.4	47.2	28.42	11.1	2.353	.01412	0.0332
3	71.0	21.7	3.5	18.0	12.4	47.2	26.32	11.9	1.994	.01412	0.0282
4	71.0	21.7	3.5	13.5	9.9	47.2	21.07	12.5	1.766	.01412	0.0249
5	71.0	21.7	3.5	13.0	9.4	47.2	20.02	12.7	1.594	.01412	0.0225
10	71.0	21.7	3.5	12.5	8.9	47.2	18.97	13.5	1.162	.01412	0.0164
15	71.5	21.9	3.4	12.0	8.8	47.2	18.14	13.8	0.959	.01412	0.0135
30	72.0	22.2	3.3	11.5	8.2	47.2	17.32	14.0	0.882	.01402	0.0096
60	71.5	21.9	3.4	11.5	8.1	47.2	17.09	14.3	0.488	.01387	0.0068
120	73.0	22.8	3.0	11.0	7.9	47.2	18.71	14.4	0.347	.01383	0.0047
240	73.0	22.8	3.0	10.5	7.4	47.2	15.68	14.7	0.247	.01344	0.0033
480	73.0	22.8	3.0	10.0	6.9	47.2	14.61	14.8	0.176	.01353	0.0024
1440	76.0	24.4	2.4	9.0	6.5	47.2	13.84	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

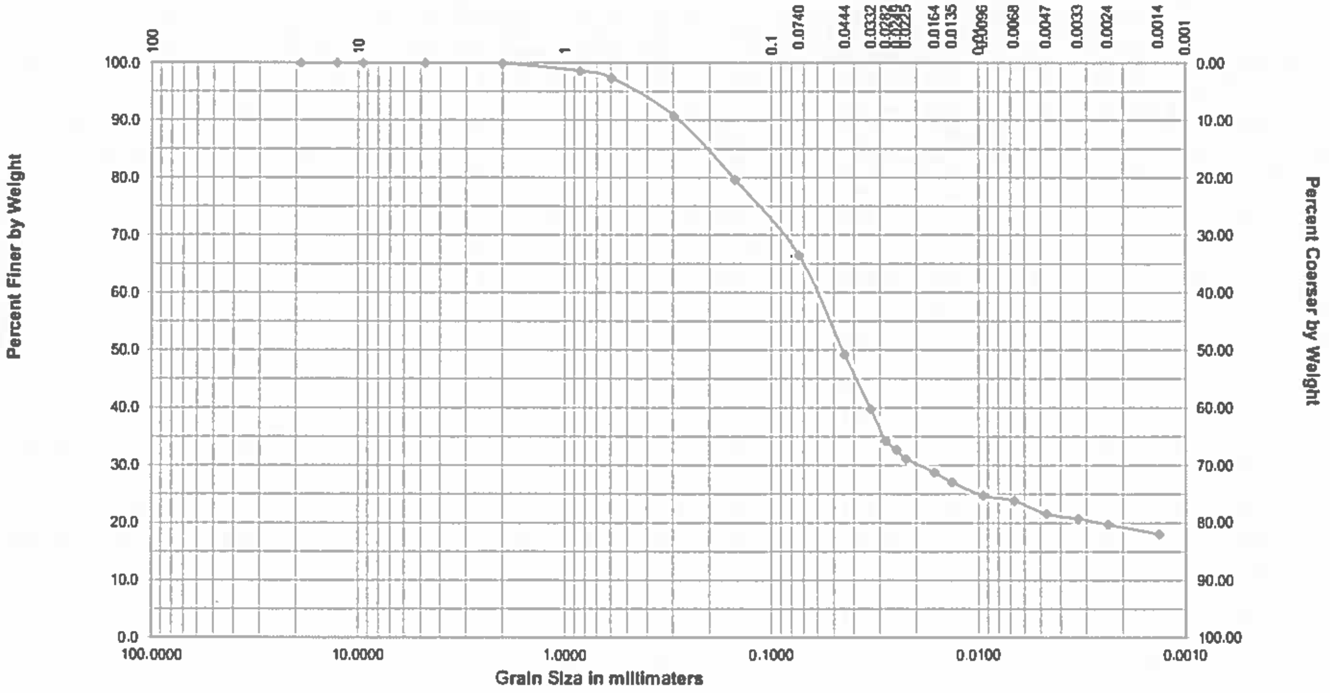
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback	Data:	6/29/2017
5ample Id:	B-107, U-1 (1/2 - 2')	Sample Description:	Very Dark Grey Sandy Lean Clay		

Wet Mass: (g)	31.23	Disparsing Agant	5g. HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	28.9
Dry Mass, (g)	30.61	Soil Mess, (Air Dry), (g)	85.0	Moist. Corr. Factor:	0.9672	P-200 Tare Wt. (g)	7.8
Tare: (g)	12.31	Hydrometar Method	152H	Hygro. M.C.: (%)	3.4	Passing #200 (%)	69.60

t (min)	Tamp. (F)	Temp. (C)	Hydrom. C. Fact.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometar Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.78
							99.9				2.00
							99.6				0.9410
							97.4				0.5940
							90.8				0.2970
							79.7				0.1500
							98.60				0.0740
1	77.0	25.0	4.2	35.5	31.0	62.9	49.32	9.9	3.147	.01412	0.0444
2	77.0	25.0	4.2	29.5	25.1	62.9	39.97	11.1	2.353	.01412	0.0332
3	77.0	25.0	4.2	26.0	21.6	92.9	34.36	11.9	1.994	.01412	0.0292
4	77.0	25.0	4.2	25.0	20.6	62.9	32.78	12.5	1.768	.01412	0.0249
5	77.0	25.0	4.2	24.0	19.8	62.9	31.21	12.7	1.594	.01412	0.0225
10	77.0	25.0	4.2	22.5	18.1	62.9	28.95	13.5	1.162	.01412	0.0164
15	76.5	24.7	4.2	21.5	17.1	62.9	27.18	13.9	0.959	.01412	0.0135
30	76.5	24.7	4.2	20.0	15.6	62.9	24.90	14.0	0.692	.01402	0.0098
60	76.0	24.4	4.3	19.5	15.0	62.9	23.91	14.3	0.498	.01387	0.0098
120	76.5	24.7	4.2	19.0	13.6	62.9	21.65	14.4	0.347	.01393	0.0047
240	78.0	24.4	4.3	17.5	13.1	62.9	20.76	14.7	0.247	.01344	0.0033
480	75.0	23.9	4.5	17.0	12.4	62.9	19.78	14.9	0.176	.01353	0.0024
1440	74.5	23.6	4.5	16.0	11.4	62.9	18.08	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



Mid-State Engineering & Testing, Inc.
11 East 11th St.
Kearney, Nebraska 68847

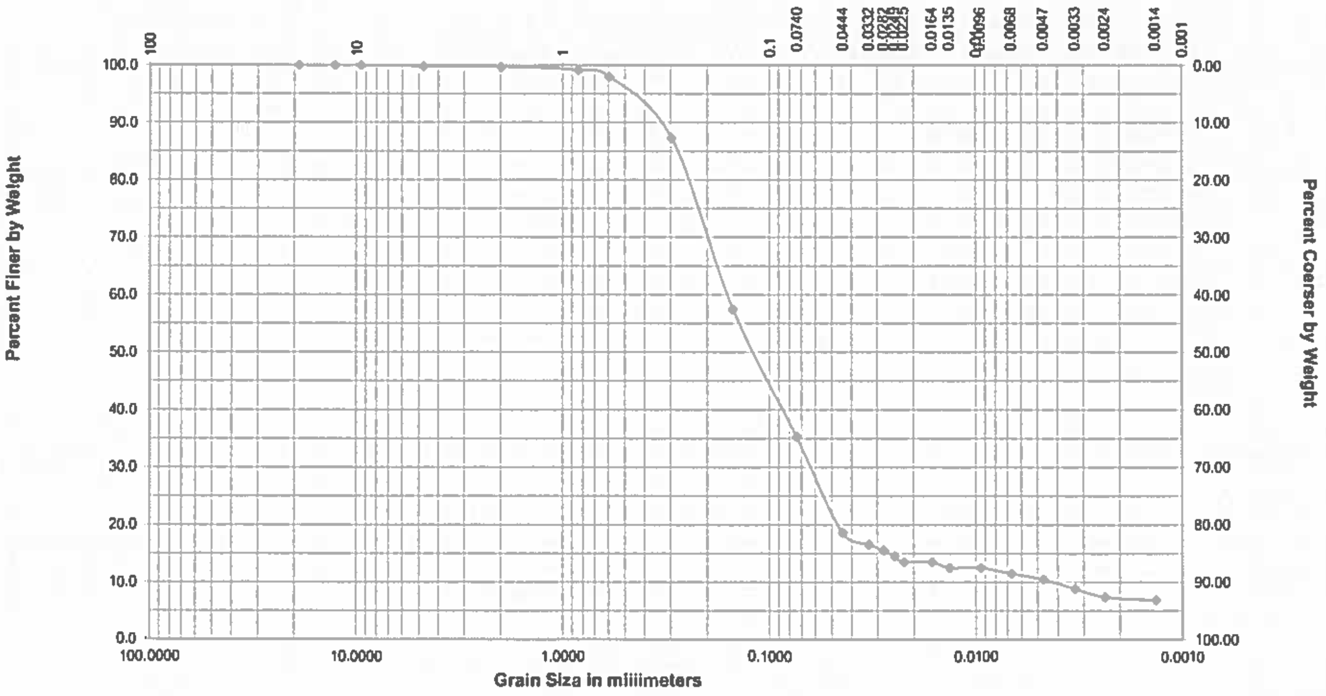
Hydrometer Analysis
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Don Barnett	Date:	8/21/2017
Sample id:	B-108, U-1 (1/2 - 2')	Sample Description:	Very Dark Grey Silty Sand		

Wet Mass: (g)	238.90	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	70.5
Dry Mass, (g)	233.90	Soil Mass, (Air Dry), (g)	50.0	Moist. Corr. Factor:	0.9745	P-200 Tare Wt. (g)	39.0
Tare: (g)	42.90	Hydrometer Method	152H	Hygro. M.C.: (%)	2.6	Passing #200 (%)	35.35

t (min)	Temp. (F)	Temp. (C)	Hydrom.	Hydrom.	R*a	W	P	L	SQRT(L/t)	k	Grain Size
			C. Fact.	Reading, R		(g)	(%)	(cm)			(mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.8				4.76
							99.7				2.00
							99.2				0.8410
							98.0				0.5940
							87.3				0.2970
							57.5				0.1500
							35.35				0.0740
1	74.0	23.3	2.8	12.0	9.1	48.7	18.83	9.9	3.147	.01412	0.0444
2	74.0	23.3	2.8	11.0	8.1	48.7	16.60	11.1	2.353	.01412	0.0332
3	74.0	23.3	2.8	10.5	7.8	48.7	15.58	11.9	1.994	.01412	0.0282
4	74.0	23.3	2.8	10.0	7.1	48.7	14.57	12.5	1.766	.01412	0.0249
5	74.0	23.3	2.8	9.5	6.6	48.7	13.55	12.7	1.594	.01412	0.0225
10	74.0	23.3	2.8	9.5	6.8	48.7	13.55	13.5	1.162	.01412	0.0164
15	74.0	23.3	2.8	9.0	6.1	48.7	12.54	13.8	0.959	.01412	0.0135
30	74.0	23.3	2.8	9.0	6.1	48.7	12.54	14.0	0.682	.01402	0.0096
60	74.0	23.3	2.8	8.5	5.8	48.7	11.52	14.3	0.488	.01387	0.0068
120	74.0	23.3	2.8	8.0	5.1	48.7	10.50	14.4	0.347	.01363	0.0047
240	75.0	23.9	2.8	7.0	4.3	48.7	8.90	14.7	0.247	.01344	0.0033
480	74.0	23.3	2.8	8.5	3.8	48.7	7.48	14.8	0.176	.01353	0.0024
1440	75.0	23.9	2.6	6.0	3.3	48.7	6.87	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

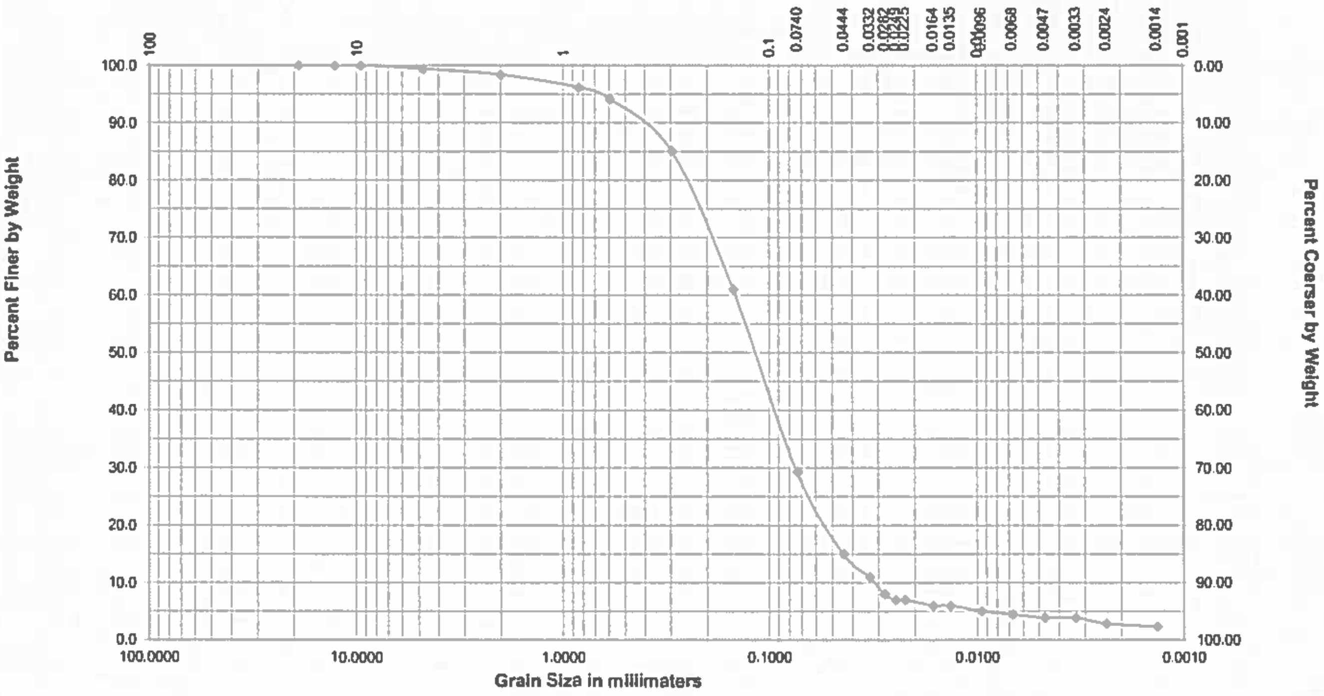
ASTM D-422

Project:	Cottonwood Rench Broad-Scale Project #10057849	Location:	Pheips County, Nebraska
M.S. Project #:	200-05-24	Tested By:	Don Bamett
		Data:	6/27/2017
Sample Id:	B-108, S-2 (3 1/2 - 5')	Sample Dascription:	Grey Brown Silty Sand

Wat Mass: (g)	139.00	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	61.8
Dry Mass, (g)	138.10	Soli Mess, (Air Dry), (g)	50.0	Moist. Corr. Factor:	0.9914	P-200 Tare Wt. (g)	26.8
Tare: (g)	33.90	Hydromatar Method	152H	Hygro. M.C.: (%)	0.9	Passing #200 (%)	29.40

t (min)	Tamp. (F)	Temp. (C)	Hydrom. C. Fact.	Hydrom. Raading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydromater Ramarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.4				4.76
							98.4				2.00
							96.2				0.8410
							94.2				0.5940
							85.1				0.2970
							61.1				0.1500
							29.40				0.0740
1	71.0	21.7	3.5	11.0	7.5	49.6	15.05	9.9	3.147	.01412	0.0444
2	71.0	21.7	3.5	9.0	5.5	49.6	11.06	11.1	2.353	.01412	0.0332
3	71.0	21.7	3.5	7.5	4.0	49.8	8.08	11.9	1.994	.01412	0.0282
4	71.0	21.7	3.5	7.0	3.5	49.8	7.06	12.5	1.768	.01412	0.0249
5	71.0	21.7	3.5	7.0	3.5	49.6	7.06	12.7	1.594	.01412	0.0225
10	71.0	21.7	3.5	6.5	3.0	49.8	6.06	13.5	1.182	.01412	0.0164
15	71.0	21.7	3.5	6.5	3.0	49.8	8.08	13.8	0.959	.01412	0.0135
30	71.0	21.7	3.5	6.0	2.5	49.6	5.06	14.0	0.682	.01402	0.0096
80	72.0	22.2	3.3	5.5	2.2	49.8	4.49	14.3	0.488	.01387	0.0068
120	73.0	22.8	3.0	5.0	1.9	49.8	3.91	14.4	0.347	.01363	0.0047
240	73.0	22.8	3.0	5.0	1.9	49.6	3.91	14.7	0.247	.01344	0.0033
480	73.0	22.8	3.0	4.5	1.4	49.6	2.91	14.8	0.176	.01353	0.0024
1440	74.0	23.3	2.8	4.0	1.2	49.6	2.34	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

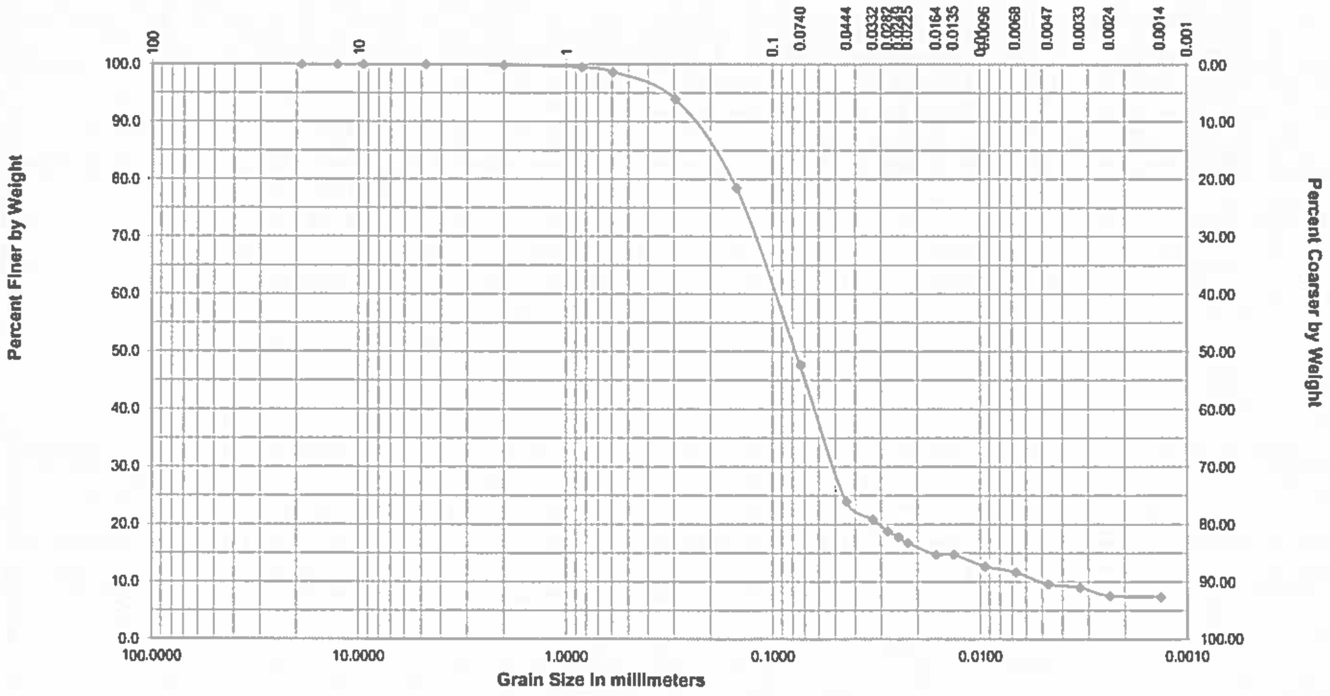
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Don Barnett	Date:	6/21/2017
Sample Id:	B-109, U-1 (1/2 - 2')	Sample Description:	Very Dark Grey		

Wet Mass: (g)	273.70	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	64.2
Dry Mass, (g)	264.80	Soil Mass, (Air Dry), (g)	50.0	Moist. Corr. Factor:	0.9609	P-200 Tare Wt. (g)	39.1
Tare: (g)	48.10	Hydrometer Method	152H	Hygro. M.C.: (%)	4.1	Passing #200 (%)	47.76

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.76
							99.9				2.00
							99.5				0.8410
							98.7				0.5940
							94.0				0.2970
							78.5				0.1500
							47.78				0.0740
1	74.0	23.3	2.8	14.5	11.6	48.0	24.05	9.9	3.147	.01412	0.0444
2	74.0	23.3	2.8	13.0	10.1	48.0	20.96	11.1	2.353	.01412	0.0332
3	74.0	23.3	2.8	12.0	9.1	48.0	18.90	11.9	1.994	.01412	0.0282
4	74.0	23.3	2.8	11.5	8.6	48.0	17.87	12.5	1.768	.01412	0.0249
5	74.0	23.3	2.8	11.0	8.1	48.0	16.84	12.7	1.594	.01412	0.0225
10	74.0	23.3	2.8	10.0	7.1	48.0	14.77	13.5	1.162	.01412	0.0164
15	74.0	23.3	2.8	10.0	7.1	48.0	14.77	13.8	0.959	.01412	0.0135
30	74.0	23.3	2.8	9.0	6.1	48.0	12.71	14.0	0.682	.01402	0.0098
60	74.0	23.3	2.8	8.5	5.6	48.0	11.88	14.3	0.488	.01387	0.0068
120	74.0	23.3	2.8	7.5	4.6	48.0	9.62	14.4	0.347	.01383	0.0047
240	75.0	23.9	2.8	7.0	4.3	48.0	9.03	14.7	0.247	.01344	0.0033
480	74.0	23.3	2.8	8.5	3.8	48.0	7.56	14.8	0.176	.01353	0.0024
1440	76.0	24.4	2.4	6.0	3.6	48.0	7.40	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

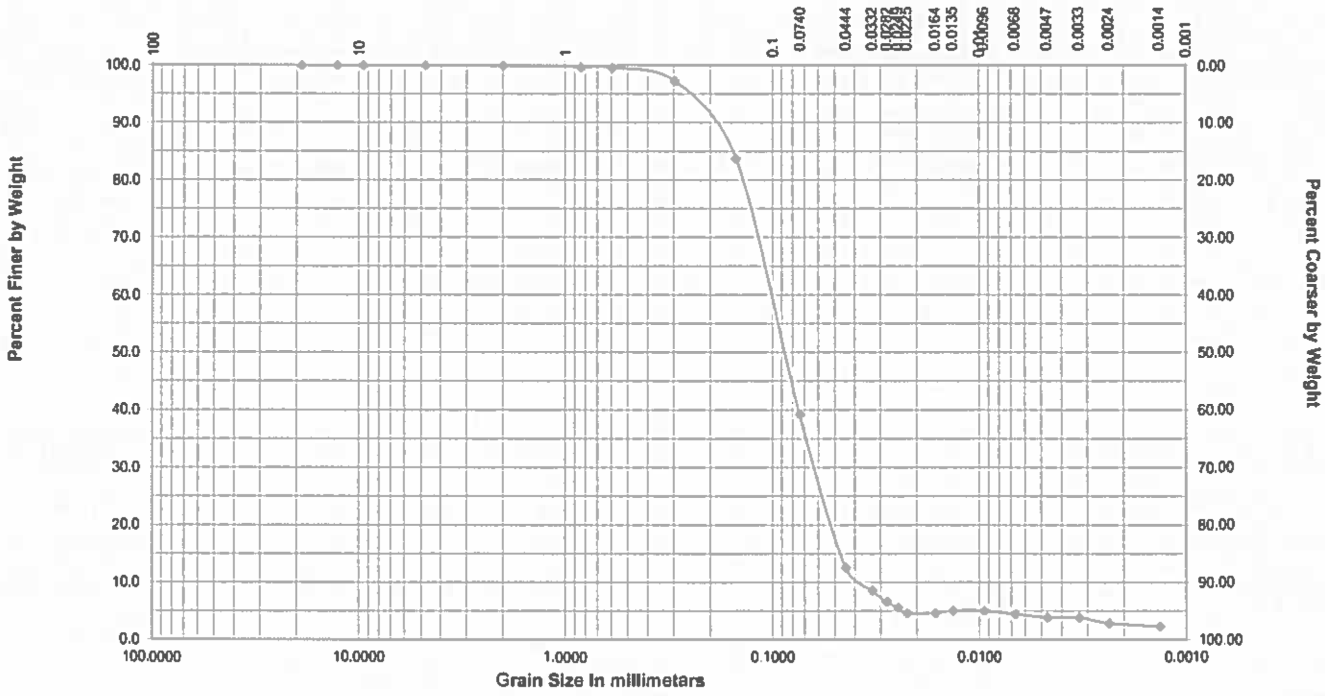
ASTM D-422

Project:	Cottonwood Rench Broad-Scale Project #10057849		Location:	Pheips County, Nebraska		
M.S. Project #:	200-05-24		Tested By:	Don Bamett	Date:	6/27/2017
Sample id:	B-110, S-2 (3 1/2 - 5')		Sample Description:	Grey Silty Sand		

Wet Mass: (g)	116.20	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	57.2
Dry Mass, (g)	115.60	Soil Mass, (Air Dry), (g)	50.0	Moist. Corr. Factor:	0.9916	P-200 Tare Wt. (g)	27.1
Tare: (g)	44.90	Hydrometar Mathod	152H	Hygro. M.C.: (%)	0.6	Pessing #200 (%)	39.29

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fact.	Hydrom. Raading, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Ramarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.76
							99.9				2.00
							99.7				0.6410
							99.8				0.5940
							97.3				0.2970
							83.8				0.1500
							39.29				0.0740
1	70.0	21.1	3.7	10.0	6.3	49.6	12.63	9.9	3.147	.01412	0.0444
2	70.0	21.1	3.7	8.0	4.3	49.6	8.83	11.1	2.353	.01412	0.0332
3	70.0	21.1	3.7	7.0	3.3	49.6	8.84	11.9	1.994	.01412	0.0262
4	70.0	21.1	3.7	8.5	2.6	49.6	5.64	12.5	1.766	.01412	0.0249
5	70.0	21.1	3.7	8.0	2.3	49.6	4.64	12.7	1.594	.01412	0.0225
10	70.0	21.1	3.7	8.0	2.3	49.6	4.64	13.5	1.162	.01412	0.0184
15	71.0	21.7	3.5	6.0	2.5	49.6	5.06	13.6	0.959	.01412	0.0135
30	71.0	21.7	3.5	6.0	2.5	49.6	5.06	14.0	0.662	.01402	0.0096
60	72.0	22.2	3.3	5.5	2.2	49.6	4.49	14.3	0.488	.01387	0.0086
120	73.0	22.8	3.0	5.0	1.9	49.6	3.91	14.4	0.347	.01363	0.0047
240	73.0	22.8	3.0	5.0	1.9	49.6	3.91	14.7	0.247	.01344	0.0033
460	73.0	22.8	3.0	4.5	1.4	49.6	2.91	14.6	0.178	.01353	0.0024
1440	74.0	23.3	2.6	4.0	1.2	49.6	2.34	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

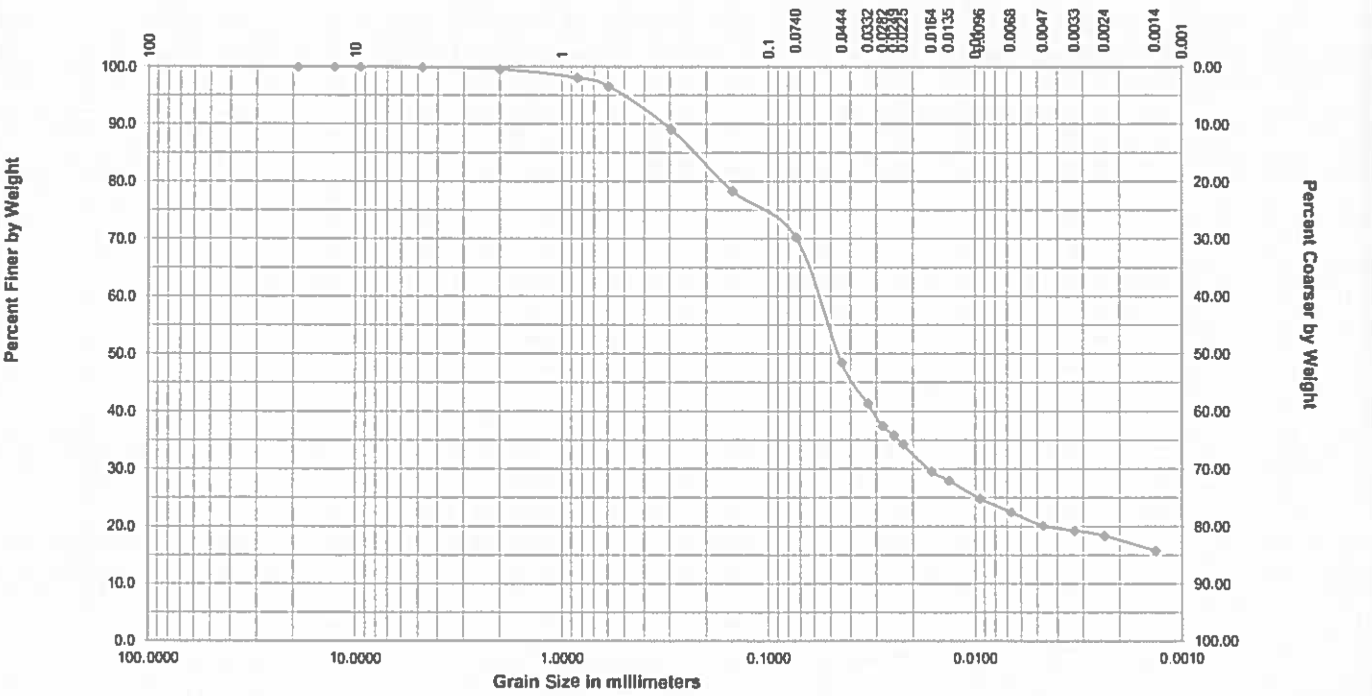
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback	Date:	8/29/2017
Sample Id:	B-111, U-1 (1/2 - 2')	Sample Description:	Dark Grey Brown Sandy Lean Clay		

Wet Mass: (g)	39.21	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	26.1
Dry Mass, (g)	38.47	Soil Mass, (Air Dry), (g)	65.0	Moist. Corr. Factor:	0.9687	P-200 Tare Wt. (g)	7.5
Tare: (g)	17.02	Hydrometer Method	152H	Hygro. M.C.: (%)	3.4	Passing #200 (%)	70.40

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R'a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.9				4.76
							99.6				2.00
							98.1				0.8410
							96.6				0.5940
							89.1				0.2970
							78.4				0.1500
							70.40				0.0740
1	77.0	25.0	4.2	35.0	30.5	62.8	48.58	9.9	3.147	.01412	0.0444
2	77.0	25.0	4.2	30.5	26.1	62.8	41.47	11.1	2.353	.01412	0.0332
3	77.0	25.0	4.2	28.0	23.8	62.8	37.53	11.9	1.994	.01412	0.0282
4	77.0	25.0	4.2	27.0	22.8	82.8	35.95	12.5	1.766	.01412	0.0249
5	77.0	25.0	4.2	26.0	21.6	62.8	34.38	12.7	1.594	.01412	0.0225
10	77.0	25.0	4.2	23.0	18.6	62.8	29.65	13.5	1.162	.01412	0.0164
15	77.0	25.0	4.2	22.0	17.8	62.8	28.07	13.8	0.959	.01412	0.0135
30	77.0	25.0	4.2	20.0	15.7	82.8	24.92	14.0	0.682	.01402	0.0096
60	77.0	25.0	4.2	18.5	14.2	62.8	22.56	14.3	0.488	.01387	0.0068
120	77.0	25.0	4.2	17.0	12.7	82.8	20.20	14.4	0.347	.01383	0.0047
240	76.5	24.7	4.2	16.5	12.1	82.8	19.30	14.7	0.247	.01344	0.0033
480	76.0	24.4	4.3	16.0	11.6	62.8	18.41	14.8	0.176	.01353	0.0024
1440	75.0	23.9	4.5	14.5	9.9	62.8	15.83	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.
11 East 11th St.
Kearney, Nebraska 68847

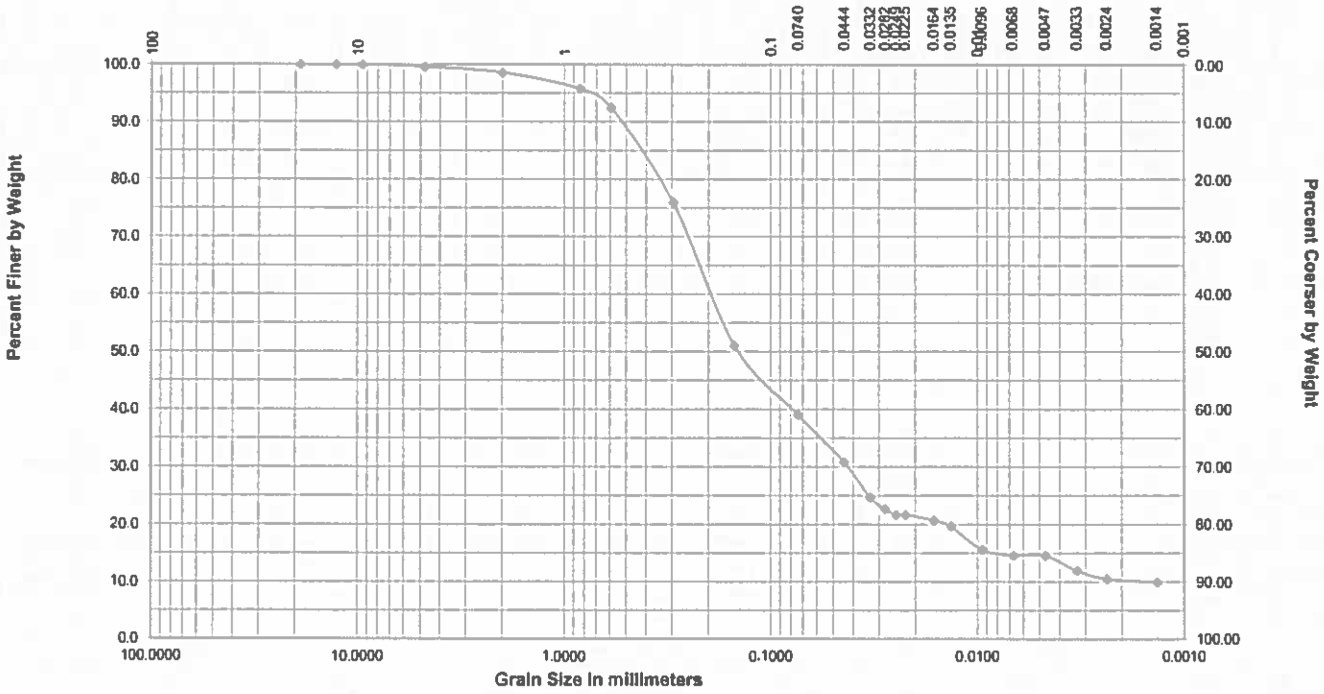
Hydrometer Analysis
ASTM D-422

Project:	Cottonwood Rench Broad-Scale Project #10057849	Location:	Phelps County, Nebraska
M.S. Project #:	200-05-24	Tested By:	Don Bamett
		Date:	6/21/2017
Sample Id:	B-112, U-1 (1/2 - 2')	Sample Description:	Qerk Gray Clayey Sand

Wet Mass: (g)	184.20	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	98.4
Dry Mess, (g)	160.60	Soil Mass, (Air Dry), (g)	50.0	Moist. Corr. Factor:	0.9721	P-200 Tere Wt. (g)	38.9
Tere: (g)	35.20	Hydrometer Method	152H	Hygro. M.C.: (%)	2.9	Passing #200 (%)	39.10

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fact.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.6				4.78
							99.6				2.00
							95.9				0.8410
							92.5				0.5940
							76.0				0.2970
							51.1				0.1500
							39.10				0.0740
1	74.0	23.3	2.9	19.0	15.0	48.9	30.90	9.9	3.147	.01412	0.0444
2	74.0	23.3	2.9	15.0	12.0	48.9	24.79	11.1	2.353	.01412	0.0332
3	74.0	23.3	2.9	14.0	11.1	49.6	22.75	11.9	1.994	.01412	0.0282
4	74.0	23.3	2.8	13.5	10.8	49.9	21.73	12.5	1.766	.01412	0.0249
5	74.0	23.3	2.8	13.5	10.6	49.9	21.73	12.7	1.594	.01412	0.0225
10	74.0	23.3	2.8	13.0	10.1	49.6	20.72	13.5	1.192	.01412	0.0164
15	74.0	23.3	2.8	12.5	9.9	49.6	19.70	13.9	0.959	.01412	0.0135
30	74.0	23.3	2.8	10.5	7.6	49.8	15.92	14.0	0.692	.01402	0.0096
60	74.0	23.3	2.9	10.0	7.1	49.6	14.60	14.3	0.498	.01387	0.0089
120	74.0	23.3	2.9	10.0	7.1	49.6	14.60	14.4	0.347	.01363	0.0047
240	75.0	23.9	2.9	9.5	5.9	49.6	11.98	14.7	0.247	.01344	0.0033
490	74.0	23.3	2.9	9.0	5.1	49.6	10.53	14.9	0.178	.01353	0.0024
1440	75.0	23.9	2.6	7.5	4.9	49.6	9.94	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

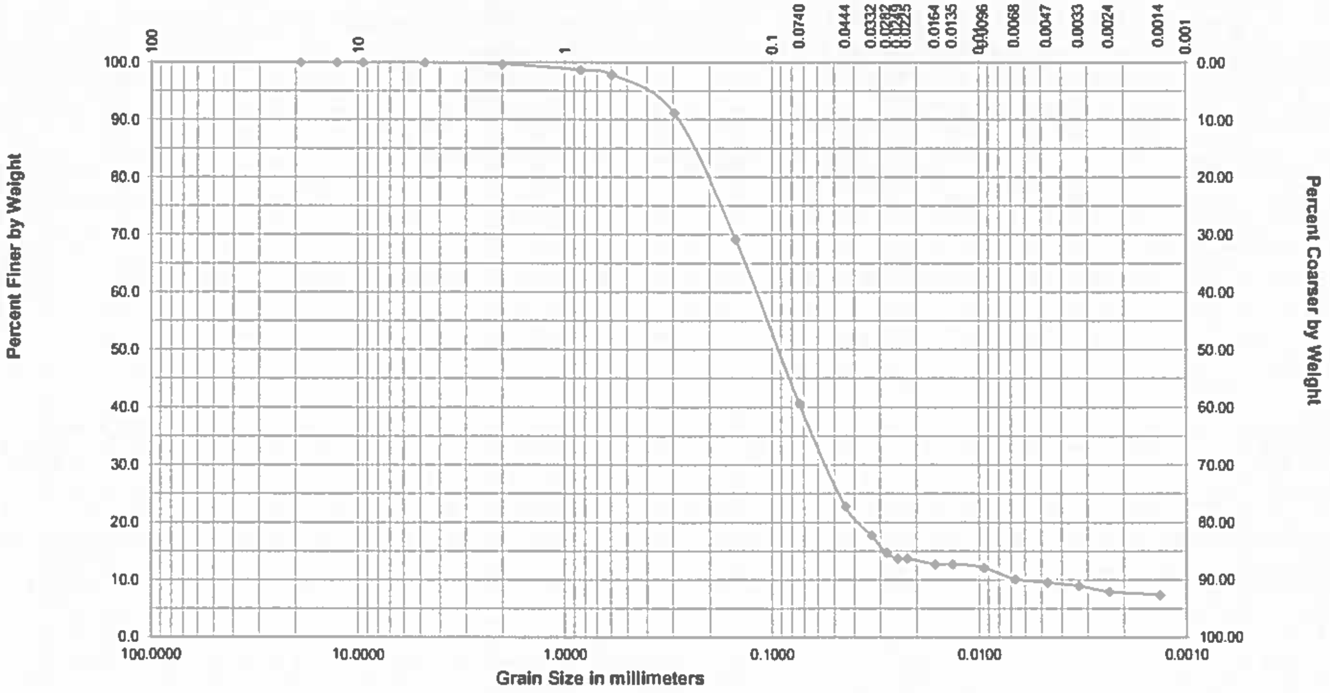
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057949	Location:	Phelps County, Nebraske		
M.S. Project #:	200-05-24	Tested By:	Don Bamett	Date:	6/27/2017
5ample Id:	B-114, S-2 (3 1/2 - 5')	Semple Description:	Light Brown Silty Sand		

Wet Mass: (g)	172.00	Dispersing Agent	5g, HMP	S.G. Corr. Fector:	0.99	P-200 Dry Wt. (g)	56.2
Dry Mass, (g)	169.70	Soli Mess, (Air Dry), (g)	50.0	Molst. Corr. Fector:	0.9922	P-200 Tere Wt. (g)	27.1
Tere: (g)	42.80	Hydrometer Method	152H	Hygro. M.C.: (%)	1.9	Pessing #200 (%)	40.75

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remerks:							100.0	Gradation Remerks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.78
							99.7				2.00
							99.7				0.8410
							97.9				0.5940
							91.2				0.2970
							99.2				0.1500
							40.75				0.0740
1	70.0	21.1	3.7	15.0	11.2	49.1	22.83	9.9	3.147	.01412	0.0444
2	70.0	21.1	3.7	12.5	9.7	49.1	17.79	11.1	2.353	.01412	0.0332
3	70.0	21.1	3.7	11.0	7.3	49.1	14.76	11.9	1.994	.01412	0.0292
4	70.0	21.1	3.7	10.5	9.9	49.1	13.79	12.5	1.768	.01412	0.0249
5	70.0	21.1	3.7	10.5	9.9	49.1	13.76	12.7	1.594	.01412	0.0225
10	70.0	21.1	3.7	10.0	6.3	49.1	12.75	13.5	1.162	.01412	0.0164
15	70.0	21.1	3.7	10.0	9.3	49.1	12.75	13.9	0.959	.01412	0.0135
30	71.0	21.7	3.5	9.5	9.0	49.1	12.17	14.0	0.992	.01402	0.0098
60	71.0	21.7	3.5	9.5	5.0	49.1	10.15	14.3	0.488	.01387	0.0068
120	72.0	22.2	3.3	9.0	4.7	49.1	9.57	14.4	0.347	.01393	0.0047
240	73.0	22.9	3.0	7.5	4.4	49.1	9.99	14.7	0.247	.01344	0.0033
490	73.0	22.9	3.0	7.0	3.9	49.1	7.98	14.9	0.176	.01353	0.0024
1440	74.0	23.3	2.9	6.5	3.6	49.1	7.40	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.
11 East 11th St.
Kearney, Nebraska 68847

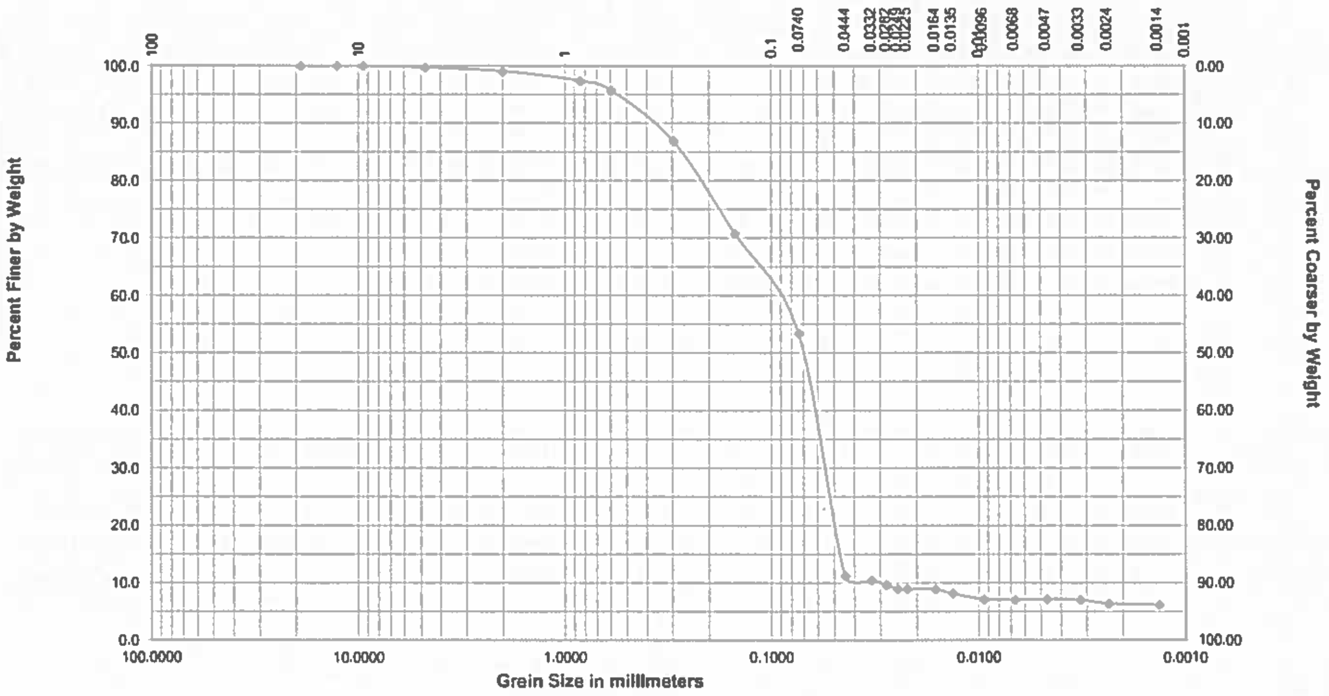
Hydrometer Analysis
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback	Date:	8/20/2017
Sample id:	B-117, U-1 (1/2 - 2')	Sample Description:	Dark Grey Sandy Lean Clay		

Wet Mass: (g)	31.04	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	37.3
Dry Mass, (g)	30.77	Soil Mass, (Air Dry), (g)	65.0	Moist. Corr. Factor:	0.9801	P-200 Tare Wt. (g)	7.8
Tare: (g)	17.48	Hydrometer Method	152H	Hygro. M.C.: (%)	2.0	Passing #200 (%)	53.38

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.7				4.78
							99.1				2.00
							97.4				0.8410
							95.7				0.5940
							88.9				0.2970
							70.8				0.1500
							53.38				0.0740
1	76.5	24.7	4.2	11.5	7.2	63.7	11.27	9.9	3.147	.01412	0.0444
2	76.5	24.7	4.2	11.0	8.7	83.7	10.49	11.1	2.353	.01412	0.0332
3	78.5	24.7	4.2	10.5	6.2	63.7	9.71	11.9	1.994	.01412	0.0282
4	76.5	24.7	4.2	10.0	5.7	63.7	8.94	12.5	1.788	.01412	0.0249
5	76.5	24.7	4.2	10.0	5.7	83.7	8.94	12.7	1.594	.01412	0.0225
10	78.5	24.7	4.2	10.0	5.7	63.7	8.94	13.5	1.162	.01412	0.0164
15	76.5	24.7	4.2	9.5	5.2	63.7	8.16	13.8	0.959	.01412	0.0135
30	75.5	24.2	4.4	9.0	4.8	63.7	7.17	14.0	0.882	.01402	0.0096
60	75.0	23.9	4.5	9.0	4.5	63.7	7.07	14.3	0.488	.01387	0.0068
120	75.5	24.2	4.4	9.0	4.6	63.7	7.17	14.4	0.347	.01383	0.0047
250	75.0	23.9	4.5	9.0	4.5	83.7	7.07	14.7	0.242	.01344	0.0033
480	75.5	24.2	4.4	8.5	4.1	83.7	6.40	14.8	0.176	.01353	0.0024
1440	74.5	23.6	4.5	8.5	3.9	63.7	6.19	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

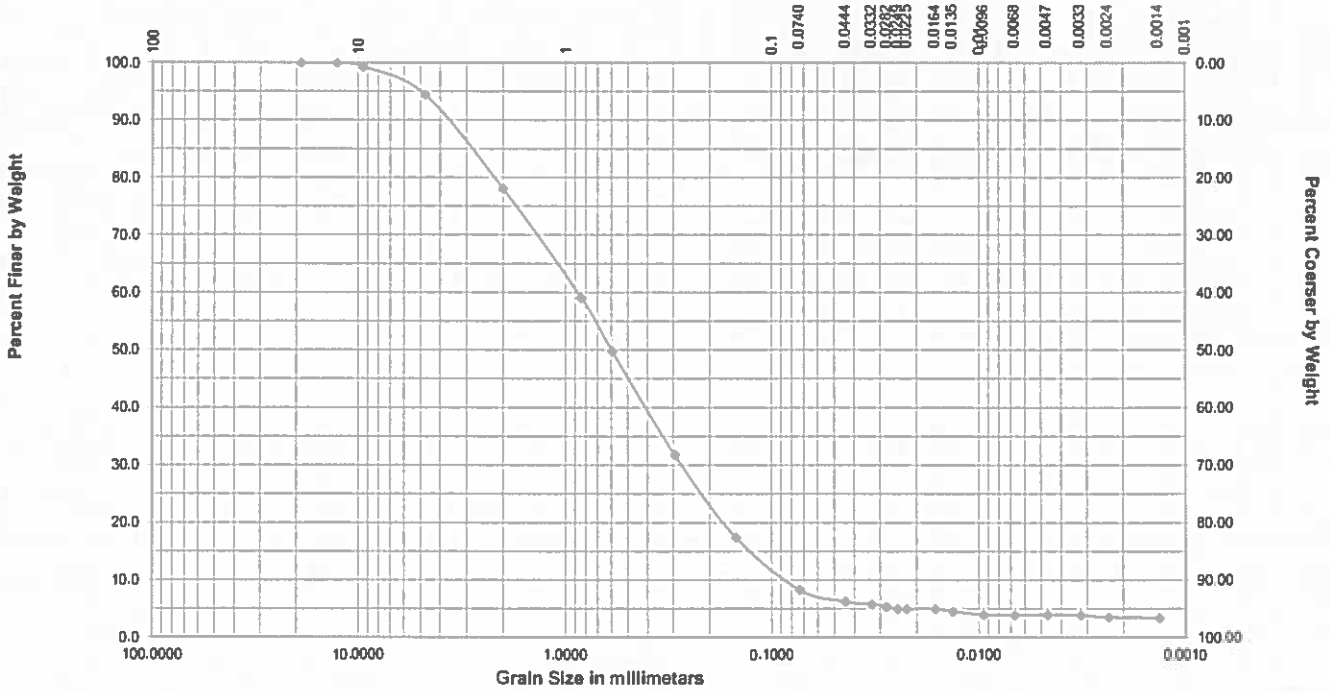
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback
		Date:	6/22/2017
Sample Id:	B-117, S-2 (3 1/2 - 5')	Sample Description:	Grey Brown Medium Grained Sand

Wet Mass: (g)	28.74	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	112.6
Dry Mass, (g)	28.72	Soil Mass, (Air Dry), (g)	115.0	Moist. Corr. Factor:	0.9982	P-200 Tare Wt. (g)	7.4
Tare: (g)	17.45	Hydrometer Method	152H	Hygro. M.C.: (%)	0.2	Passing #200 (%)	8.38

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							99.3				9.51
							94.5				4.76
							78.1				2.00
							59.1				0.8410
							49.8				0.5940
							31.9				0.2970
							17.5				0.1500
							8.38				0.0740
1	76.S	24.7	4.2	11.5	7.2	114.8	8.25	9.9	3.147	.01412	0.0444
2	76.S	24.7	4.2	11.0	6.7	114.8	5.82	11.1	2.353	.01412	0.0332
3	78.5	24.7	4.2	10.5	8.2	114.8	5.39	11.9	1.994	.01412	0.0282
4	76.5	24.7	4.2	10.0	5.7	114.8	4.98	12.5	1.768	.01412	0.0249
5	76.5	24.7	4.2	10.0	5.7	114.8	4.96	12.7	1.594	.01412	0.0225
10	78.5	24.7	4.2	10.0	5.7	114.8	4.96	13.5	1.162	.01412	0.0164
15	78.5	24.7	4.2	9.5	5.2	114.8	4.53	13.8	0.959	.01412	0.0135
30	75.5	24.2	4.4	9.0	4.6	114.8	3.98	14.0	0.682	.01402	0.0096
60	75.0	23.9	4.5	9.0	4.5	114.8	3.92	14.3	0.488	.01387	0.0068
120	75.5	24.2	4.4	9.0	4.6	114.8	3.98	14.4	0.347	.01383	0.0047
250	75.0	23.9	4.5	9.0	4.5	114.8	3.92	14.7	0.242	.01344	0.0033
480	75.5	24.2	4.4	8.5	4.1	114.8	3.55	14.8	0.176	.01353	0.0024
1440	74.5	23.6	4.5	8.5	3.9	114.8	3.43	15.0	0.102	.01328	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

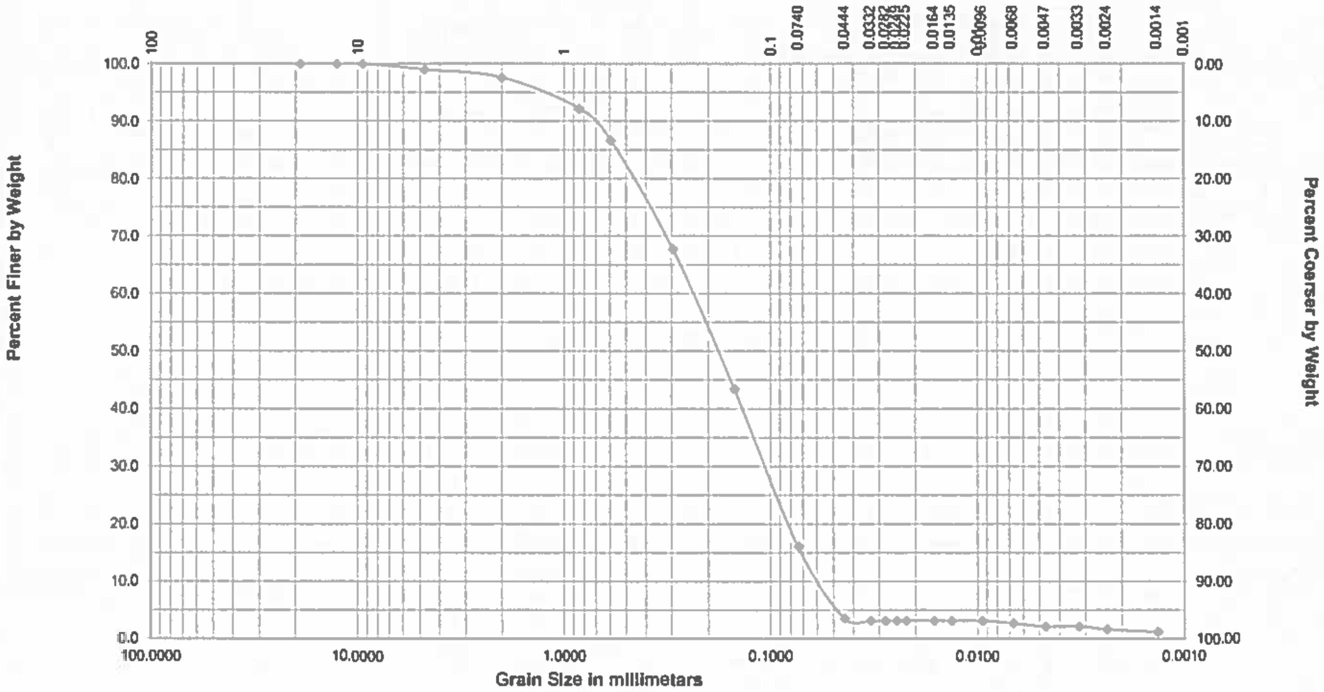
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback	Data:	6/22/2017
Sample Id:	B-116, S-2 (3 1/2 - 5')	Sample Dascription:	Gray Brown Fine Grained Sand		

Wet Mass: (g)	25.72	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	103.6
Dry Mass, (g)	25.70	Soil Mass, (Air Dry), (g)	115.0	Moist. Corr. Fector:	0.9966	P-200 Tere Wt. (g)	7.5
Tara: (g)	11.58	Hydromater Method	152H	Hygro. M.C.: (%)	0.1	Passing #200 (%)	16.14

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reeding, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydromater Ramarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.0				4.76
							97.6				2.00
							92.2				0.6410
							66.7				0.5940
							87.6				0.2970
							43.5				0.1500
							16.14				0.0740
1	78.0	24.4	4.3	6.5	4.1	114.6	3.81	9.9	3.147	.01412	0.0444
2	78.0	24.4	4.3	6.0	3.6	114.6	3.18	11.1	2.353	.01412	0.0332
3	76.0	24.4	4.3	6.0	3.6	114.6	3.18	11.9	1.694	.01412	0.0262
4	76.0	24.4	4.3	6.0	3.8	114.6	3.18	12.5	1.786	.01412	0.0249
5	76.0	24.4	4.3	6.0	3.6	114.6	3.18	12.7	1.594	.01412	0.0225
10	76.0	24.4	4.3	6.0	3.6	114.6	3.18	13.5	1.162	.01412	0.0164
15	76.0	24.4	4.3	6.0	3.6	114.6	3.18	13.6	0.959	.01412	0.0135
30	78.0	24.4	4.3	6.0	3.6	114.6	3.18	14.0	0.862	.01402	0.0096
60	76.0	24.4	4.3	7.5	3.2	114.6	2.74	14.3	0.468	.01387	0.0066
120	75.0	23.6	4.5	7.0	2.5	114.6	2.20	14.4	0.347	.01363	0.0047
250	75.0	23.6	4.5	7.0	2.5	114.6	2.20	14.7	0.242	.01344	0.0033
460	74.5	23.8	4.5	6.5	2.0	114.6	1.71	14.6	0.176	.01353	0.0024
1440	74.0	23.3	4.6	6.0	1.4	114.6	1.22	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

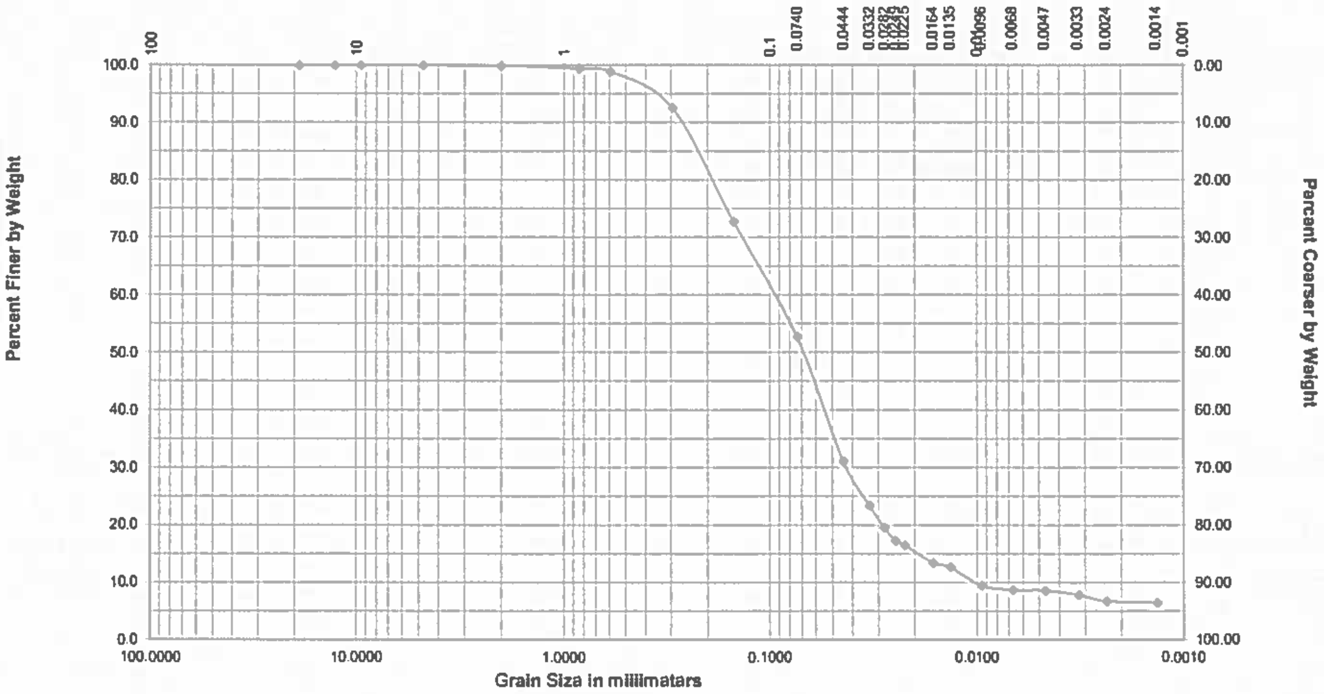
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057649	Location:	Pheips County, Nabraska
M.S. Project #:	200-05-24	Tested By:	Mitcheli Hoback
		Data:	6/22/2017
Sample id:	B-119, U-1 (1/2 - 2')	Sample Description:	Dark Grey Brown Sandy Lean Clay

Wet Mass: (g)	24.30	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	38.1
Dry Mass, (g)	24.16	Soil Mass, (Air Dry), (g)	65.0	Moist. Corr. Factor:	0.9900	P-200 Tare Wt. (g)	7.7
Tara: (g)	12.27	Hydrometar Mathod	152H	Hygro. M.C.: (%)	1.0	Passing #200 (%)	52.76

t (min)	Tamp. (F)	Tamp. (C)	Hydrom. C. Fact.	Hydrom. Raading, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydromater Remarks:							100.0	Gradation Ramarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.76
							99.9				2.00
							99.4				0.6410
							96.9				0.5940
							92.6				0.2970
							72.6				0.1500
							52.76				0.0740
1	76.5	24.7	4.2	24.5	20.0	64.4	31.15	9.9	3.147	.01412	0.0444
2	76.S	24.7	4.2	19.5	15.1	64.4	23.46	11.1	2.353	.01412	0.0332
3	76.S	24.7	4.2	17.0	12.6	64.4	19.62	11.9	1.994	.01412	0.0262
4	76.5	24.7	4.2	15.5	11.1	64.4	17.31	12.5	1.766	.01412	0.0249
5	76.5	24.7	4.2	15.0	10.6	64.4	16.54	12.7	1.594	.01412	0.0225
10	76.5	24.7	4.2	13.0	6.7	64.4	13.46	13.5	1.162	.01412	0.0164
15	76.5	24.7	4.2	12.5	6.2	64.4	12.69	13.6	0.959	.01412	0.0135
30	76.0	24.4	4.3	10.5	6.1	64.4	9.51	14.0	0.662	.01402	0.0096
60	76.0	24.4	4.3	10.0	5.6	64.4	6.74	14.3	0.486	.01387	0.0066
120	75.5	24.2	4.4	10.0	5.6	64.4	6.64	14.4	0.347	.01363	0.0047
250	75.5	24.2	4.4	9.5	5.1	64.4	7.67	14.7	0.242	.01344	0.0033
460	74.0	23.3	4.6	9.0	4.4	64.4	6.79	14.6	0.176	.01353	0.0024
1440	72.5	22.5	4.6	9.0	4.2	64.4	6.46	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057649	Location:	Phelps County, Nebraska
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback
Date:	6/20/2017		
Sample Id:	B-121, U-1 (1/2 - 2')	Sample Description:	Grey Brown Sandy Lean Clay

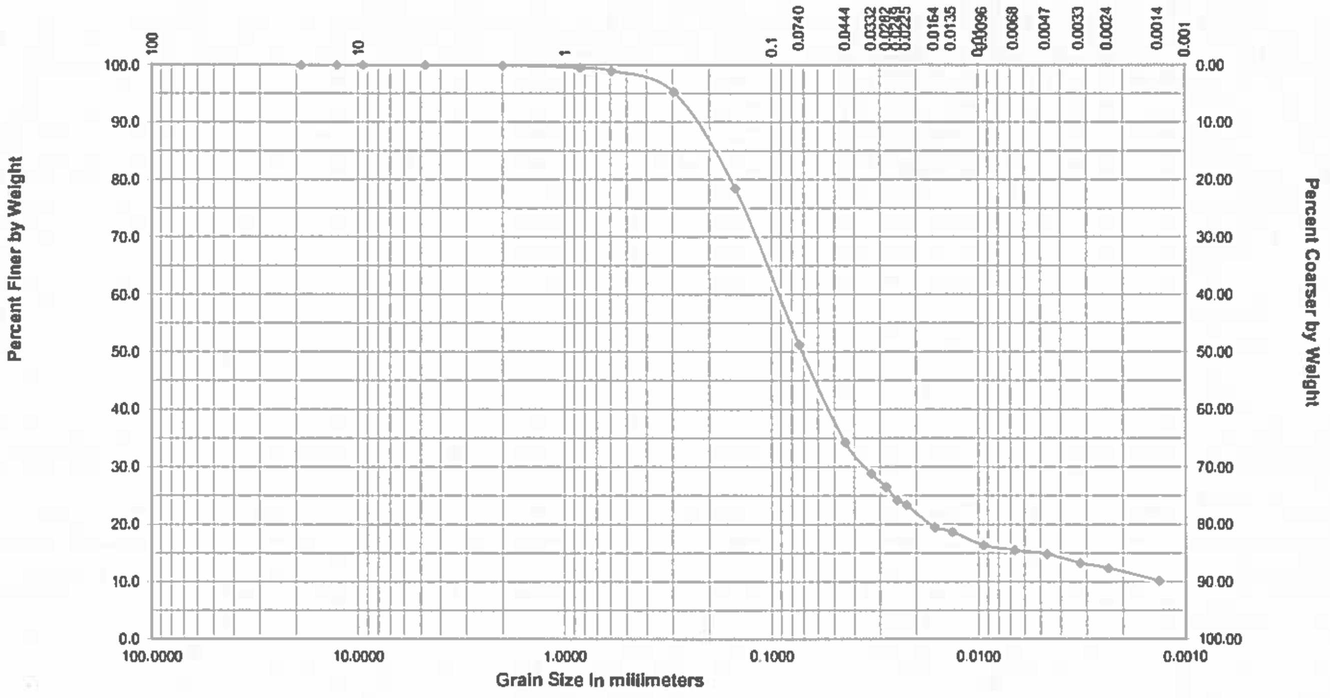
Wet Mass: (g)	26.37	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	38.3
Dry Mass, (g)	26.10	Soil Mass, (Air Dry), (g)	65.0	Moist. Corr. Factor:	0.9772	P-200 Tare Wt. (g)	7.4
Tare: (g)	14.54	Hydrometer Method	152H	Hygro. M.C.: (%)	2.3	Passing #200 (%)	51.35

Hydrometer Remarks:

Gradation Remarks:

t (min)	Temp. (F)	Temp. (C)	Hydrom.	Hydrom.	R*e	W	P	L	SQRT(L/t)	k	Grain Size
			C. Fact.	Reading, R		(g)	(%)	(cm)			(mm)
							100.0				19.00
							100.0				12.70
							100.0				9.51
							100.0				4.76
							99.9				2.00
							99.5				0.6410
							99.0				0.5940
							95.3				0.2970
							76.5				0.1500
							51.35				0.0740
1	75.0	23.9	4.5	26.5	21.6	63.5	34.37	9.9	3.147	.01412	0.0444
2	75.0	23.9	4.5	23.0	16.4	63.5	26.91	11.1	2.353	.01412	0.0332
3	75.0	23.9	4.5	21.5	16.9	63.5	26.57	11.9	1.994	.01412	0.0262
4	75.0	23.9	4.5	20.0	15.4	63.5	24.23	12.5	1.766	.01412	0.0249
5	75.0	23.9	4.5	19.5	14.9	63.5	23.46	12.7	1.594	.01412	0.0225
10	75.0	23.9	4.5	17.0	12.4	63.5	19.56	13.5	1.162	.01412	0.0164
15	75.0	23.9	4.5	16.5	11.9	63.5	16.76	13.6	0.959	.01412	0.0135
30	75.0	23.9	4.5	15.0	10.4	63.5	16.44	14.0	0.662	.01402	0.0096
60	74.5	23.6	4.5	14.5	9.9	63.5	15.56	14.3	0.486	.01387	0.0068
120	75.0	23.9	4.5	14.0	9.5	63.5	14.88	14.4	0.347	.01363	0.0047
250	75.0	23.9	4.5	13.0	6.5	63.5	13.32	14.7	0.242	.01344	0.0033
460	74.5	23.6	4.5	12.5	7.9	63.5	12.44	14.6	0.176	.01353	0.0024
1440	75.0	23.9	4.5	11.0	6.5	63.5	10.21	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

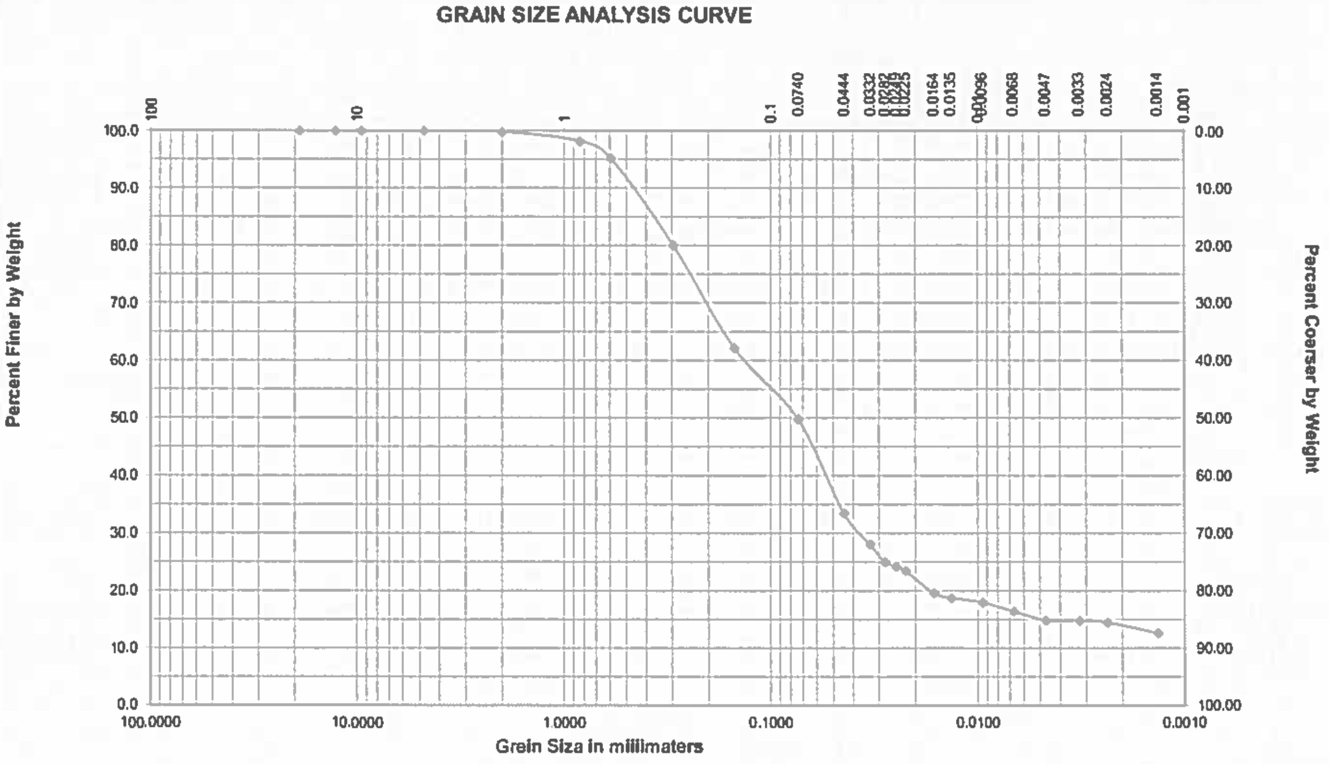
Hydrometer Analysis

ASTM D-422

Project:	Cottonwood Rench Broad-Scale Project #10057849	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback	Date:	6/22/2017
Sample id:	B-122, U-1 (1/2 - 2')	Sample Dascription:	Dark Grey Brown Sandy Lean Clay		

Wat Mass: (g)	31.79	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	39.7
Dry Mess. (g)	31.62	Soil Mess, (Air Dry), (g)	85.0	Moist. Corr. Fector:	0.9882	P-200 Tare Wt. (g)	7.5
Tare: (g)	17.44	Hydrometer Method	152H	Hygro. M.C.: (%)	1.2	Passing #200 (%)	49.87

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fact.	Hydrom. Raading, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.78
							99.8				2.00
							98.2				0.8410
							95.2				0.5940
							80.1				0.2970
							62.2				0.1500
							49.87				0.0740
1	76.5	24.7	4.2	28.0	21.5	64.2	33.53	9.9	3.147	.01412	0.0444
2	78.5	24.7	4.2	22.5	18.1	64.2	28.13	11.1	2.353	.01412	0.0332
3	76.5	24.7	4.2	20.5	16.1	64.2	25.05	11.9	1.994	.01412	0.0282
4	76.5	24.7	4.2	20.0	15.6	64.2	24.28	12.5	1.766	.01412	0.0249
5	78.5	24.7	4.2	19.5	15.1	64.2	23.51	12.7	1.594	.01412	0.0225
10	78.5	24.7	4.2	17.0	12.6	84.2	19.85	13.5	1.162	.01412	0.0164
15	76.0	24.4	4.3	16.5	12.1	64.2	18.78	13.8	0.959	.01412	0.0135
30	76.0	24.4	4.3	18.0	11.8	64.2	18.01	14.0	0.682	.01402	0.0096
60	76.0	24.4	4.3	15.0	10.6	64.2	16.47	14.3	0.488	.01387	0.0088
120	76.0	24.4	4.3	14.0	9.6	64.2	14.93	14.4	0.347	.01363	0.0047
250	75.5	24.2	4.4	14.0	9.5	64.2	14.82	14.7	0.242	.01344	0.0033
480	74.0	23.3	4.6	14.0	9.3	64.2	14.51	14.8	0.178	.01353	0.0024
1440	72.5	22.5	4.8	13.0	8.1	64.2	12.66	15.0	0.102	.01326	0.0014


GRAIN SIZE ANALYSIS CURVE

A-2532

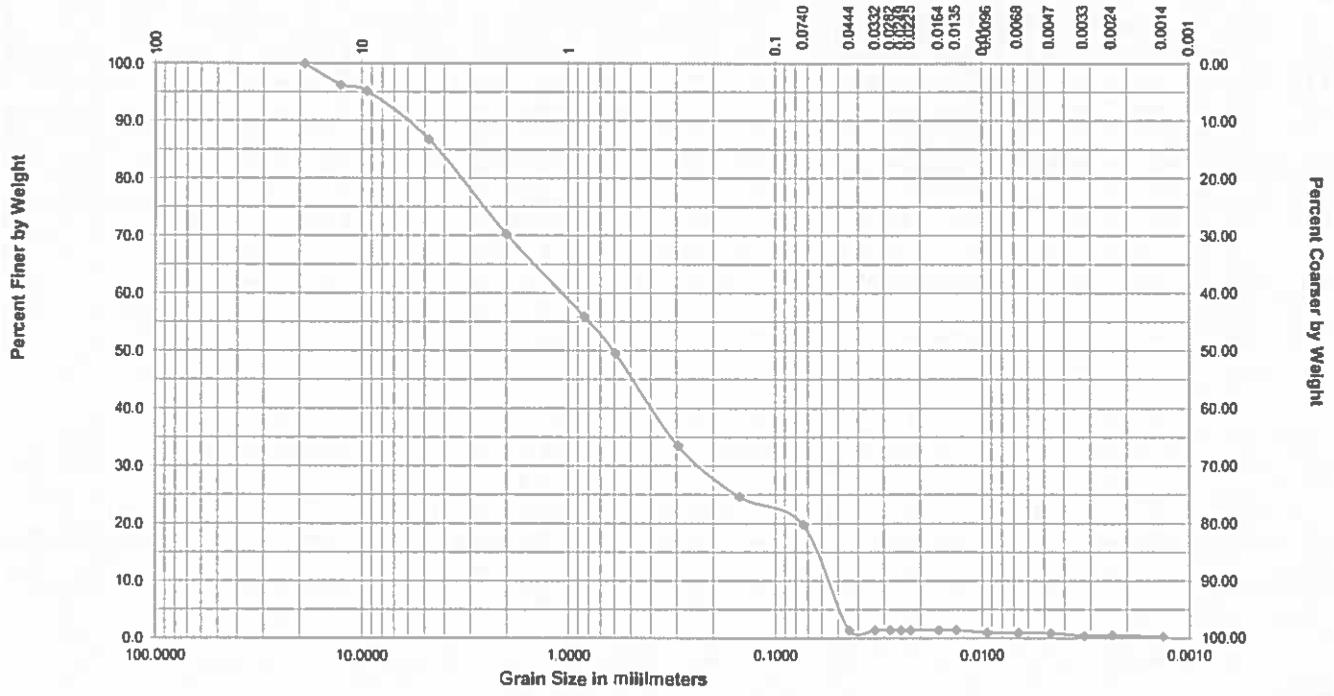
Mid-State Engineering & Testing, Inc.
11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849			Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24			Tested By:	Mitchell Hoback	Date:	6/22/2017
Sample Id:	B-123, S-3 (5 1/2 - 7')			Sample Description:	Light Grey Brown Medium Grained Sand		
Wet Mass: (g)	31.34	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	99.6
Dry Mass, (g)	31.31	Soil Mass, (Air Dry), (g)	115.0	Moist. Corr. Factor:	0.9980	P-200 Tare Wt. (g)	7.8
Tare: (g)	16.70	Hydrometer Method	152H	Hygro. M.C.: (%)	0.2	Passing #200 (%)	19.84

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fact.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							96.3				12.70
							95.2				9.51
							88.6				4.76
							70.3				2.00
							56.0				0.6410
							49.6				0.5940
							33.6				0.2970
							24.7				0.1500
							19.84				0.0740
1	76.0	24.4	4.3	6.0	1.7	114.8	1.45	9.9	3.147	.01412	0.0444
2	76.0	24.4	4.3	6.0	1.7	114.8	1.45	11.1	2.353	.01412	0.0332
3	76.0	24.4	4.3	6.0	1.7	114.8	1.45	11.9	1.994	.01412	0.0282
4	76.0	24.4	4.3	6.0	1.7	114.8	1.45	12.5	1.766	.01412	0.0249
5	76.0	24.4	4.3	6.0	1.7	114.8	1.45	12.7	1.594	.01412	0.0225
10	76.0	24.4	4.3	6.0	1.7	114.8	1.45	13.5	1.162	.01412	0.0164
15	76.0	24.4	4.3	6.0	1.7	114.8	1.45	13.8	0.959	.01412	0.0135
30	76.0	24.4	4.3	5.5	1.2	114.8	1.02	14.0	0.682	.01402	0.0096
60	75.5	24.2	4.4	5.5	1.1	114.8	0.96	14.3	0.488	.01387	0.0068
120	75.0	23.9	4.5	5.5	1.0	114.8	0.90	14.4	0.347	.01363	0.0047
250	75.0	23.9	4.5	5.0	0.5	114.8	0.47	14.7	0.242	.01344	0.0033
460	75.5	24.2	4.4	5.0	0.6	114.8	0.53	14.8	0.176	.01353	0.0024
1440	74.0	23.3	4.6	5.0	0.4	114.8	0.36	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

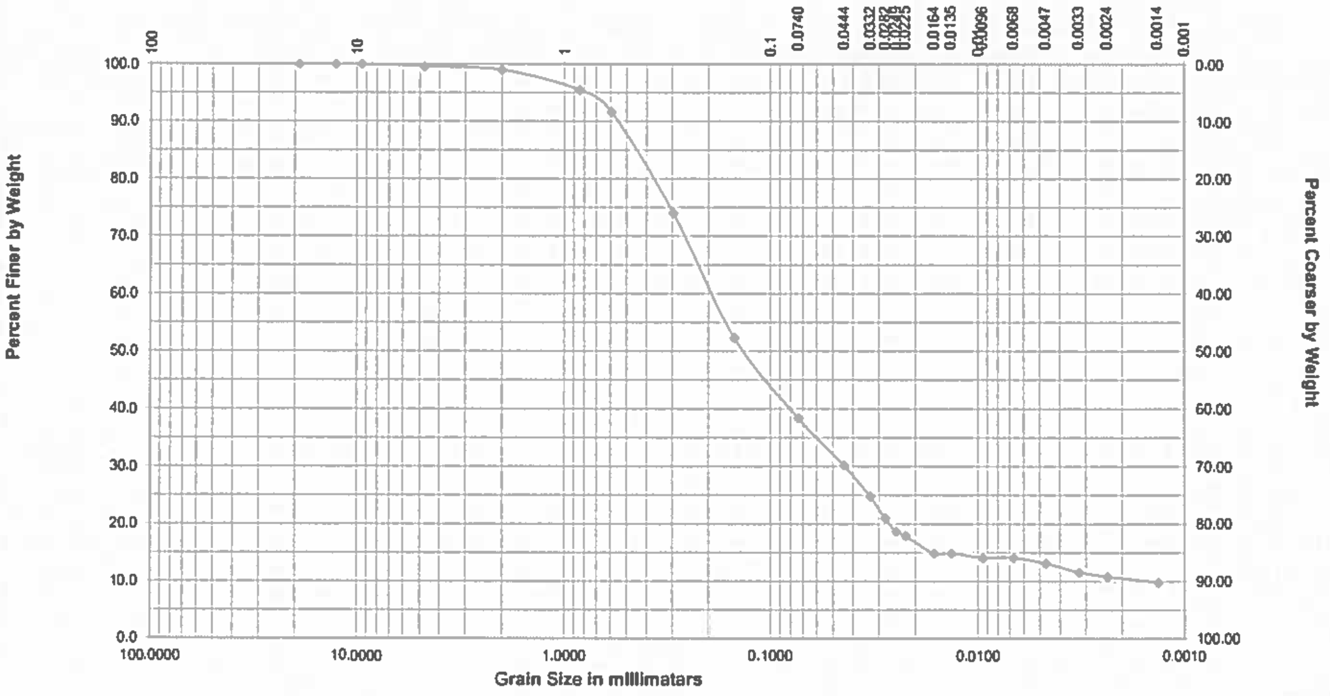
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057849	Location:	Pheips County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Mitcheli Hoback	Date:	6/22/2017
Sample id:	B-124, U-1 (1/2 - 2')	Sample Description:	Grey Brown Clayey Sand		
	\				

Wet Mass: (g)	28.71	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	47.2
Dry Mass, (g)	26.60	Soil Mass, (Air Dry), (g)	65.0	Moist. Corr. Factor:	0.9903	P-200 Tare Wt. (g)	7.6
Tare: (g)	17.34	Hydrometer Method	152H	Hygro. M.C.: (%)	1.0	Passing #200 (%)	38.48

t (min)	Temp. (F)	Temp. (C)	Hydrom.	Hydrom.	R*e	W	P	L	SQRT(L/t)	k	Grain Size
			C. Fact.	Reading, R		(g)	(%)	(cm)			(mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.6				4.76
							99.0				2.00
							95.5				0.6410
							91.7				0.5940
							74.1				0.2970
							52.4				0.1500
							38.48				0.0740
1	78.0	24.4	4.3	24.0	19.5	64.4	30.27	9.9	3.147	.01412	0.0444
2	76.0	24.4	4.3	20.5	16.0	64.4	24.69	11.1	2.353	.01412	0.0332
3	76.0	24.4	4.3	18.0	13.5	64.4	21.04	11.9	1.994	.01412	0.0282
4	76.0	24.4	4.3	18.5	12.1	64.4	18.74	12.5	1.768	.01412	0.0249
5	76.0	24.4	4.3	16.0	11.6	64.4	17.97	12.7	1.594	.01412	0.0225
10	76.0	24.4	4.3	14.0	9.8	84.4	14.69	13.5	1.162	.01412	0.0164
15	76.0	24.4	4.3	14.0	9.6	64.4	14.69	13.6	0.959	.01412	0.0135
30	78.0	24.4	4.3	13.5	9.1	64.4	14.12	14.0	0.682	.01402	0.0096
60	76.0	24.4	4.3	13.5	9.1	64.4	14.12	14.3	0.488	.01387	0.0068
120	75.0	23.9	4.5	13.0	8.5	64.4	13.15	14.4	0.347	.01383	0.0047
250	75.0	23.9	4.5	12.0	7.5	64.4	11.61	14.7	0.242	.01344	0.0033
480	75.0	23.9	4.5	11.5	7.0	64.4	10.84	14.6	0.176	.01353	0.0024
1440	74.0	23.3	4.6	11.0	6.3	64.4	9.86	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis

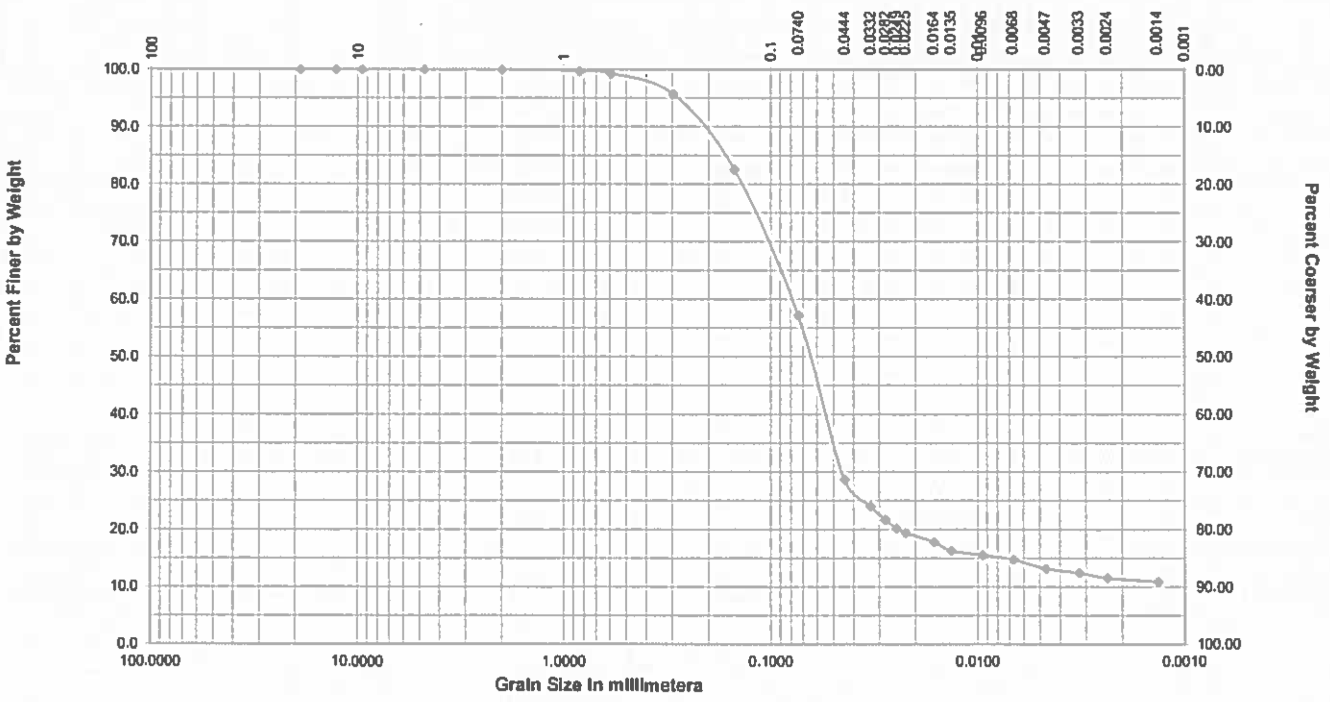
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057649	Location:	Phelps County, Nebraska		
M.S. Project #:	200-05-24	Tested By:	Mitchell Hoback	Date:	6/20/2017
Sample Id:	B-126, U-1 (1/2 - 2')	Sample Description:	Dark Grey Sandy Lean Clay		

Wet Mass: (g)	27.13	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	34.7
Dry Mass, (g)	26.88	Soil Mass, (Air Dry), (g)	65.0	Moist. Corr. Factor:	0.9832	P-200 Tare Wt. (g)	7.4
Tare: (g)	12.25	Hydrometer Method	152H	Hygro. M.C.: (%)	1.7	Passing #200 (%)	57.28

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R*e	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							100.0				4.76
							100.0				2.00
							99.7				0.8410
							99.3				0.5940
							95.7				0.2970
							82.6				0.1500
							57.28				0.0740
1	75.0	23.9	4.5	23.0	18.4	63.9	28.73	9.9	3.147	.01412	0.0444
2	75.0	23.9	4.5	20.0	15.4	63.9	24.09	11.1	2.353	.01412	0.0332
3	75.0	23.9	4.5	18.5	13.9	63.9	21.76	11.9	1.994	.01412	0.0282
4	75.0	23.9	4.5	17.5	12.9	63.9	20.21	12.5	1.766	.01412	0.0249
5	75.0	23.9	4.5	17.0	12.4	63.9	19.44	12.7	1.594	.01412	0.0225
10	75.0	23.9	4.5	16.0	11.4	63.9	17.69	13.5	1.162	.01412	0.0164
15	75.0	23.9	4.5	15.0	10.4	63.9	16.34	13.8	0.959	.01412	0.0135
30	75.0	23.9	4.5	14.5	9.9	63.9	15.57	14.0	0.682	.01402	0.0096
60	75.0	23.9	4.5	14.0	9.5	63.9	14.79	14.3	0.488	.01387	0.0086
120	75.0	23.9	4.5	13.0	8.5	63.9	13.24	14.4	0.347	.01363	0.0047
250	75.0	23.9	4.5	12.5	8.0	63.9	12.47	14.7	0.242	.01344	0.0033
480	74.5	23.6	4.5	12.0	7.4	63.9	11.59	14.8	0.176	.01353	0.0024
1440	75.0	23.9	4.5	11.5	7.0	63.9	10.92	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

Mid-State Engineering & Testing, Inc.
11 East 11th St.
Kearney, Nebraska 68847

Hydrometer Analysis
ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057649	Location:	Pheips County, Nabraska
M.S. Project #:	200-05-24	Tested By:	Mitcheli Hoback
		Date:	6/20/2017
5emple Id:	B-130, U-1 (1/2 - 2')	Sample Description:	Dark Grey Brown Sandy Lean Clay

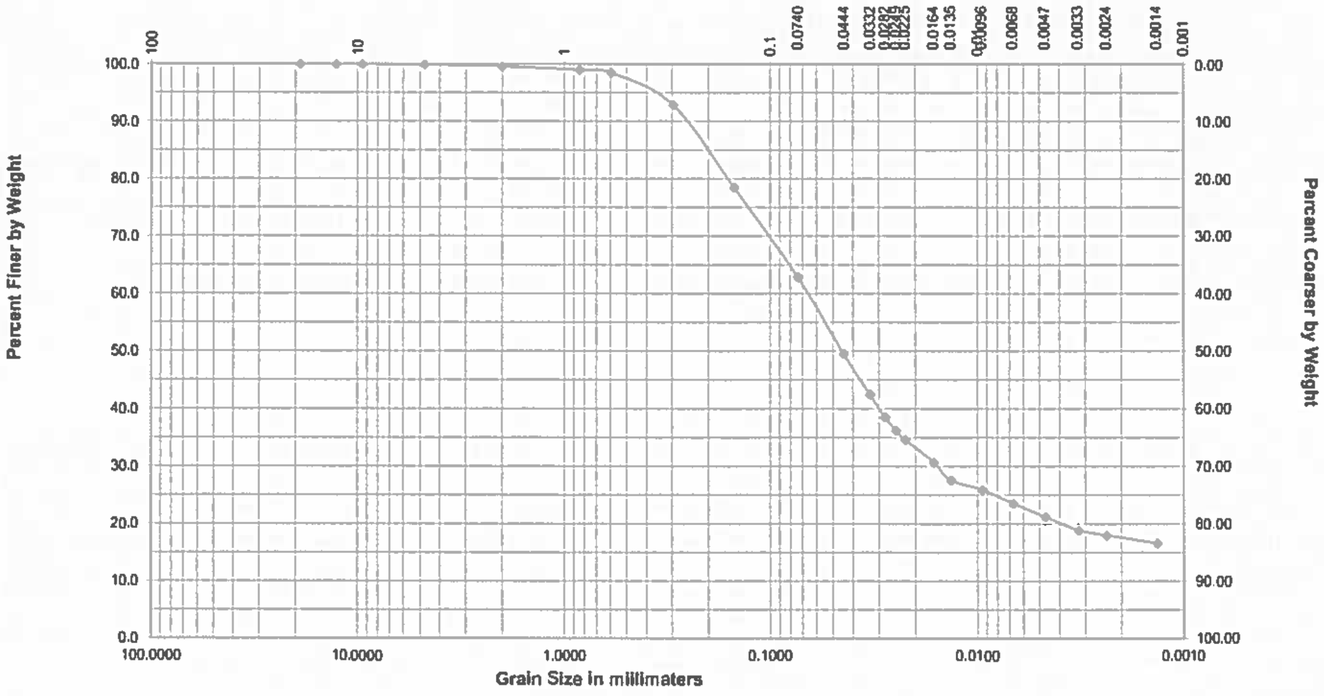
Wet Mass: (g)	37.71	Dispersing Agent	5g, HMP	S.G. Corr. Factor:	0.99	P-200 Dry Wt. (g)	30.7
Dry Mass, (g)	37.26	Soii Mass, (Alr Dry), (g)	65.0	Moist. Corr. Factor:	0.9713	P-200 Tere Wt. (g)	7.3
Tare: (g)	22.72	Hydrometar Method	152H	Hygro. M.C.: (%)	3.0	Passing #200 (%)	62.94

Hydrometar Remarks:

Gradation Ramarks:

t (min)	Temp. (F)	Tamp. (C)	Hydrom. C. Fact.	Hydrom. Raading, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Siza (mm)
							100.0				19.00
							100.0				12.70
							100.0				9.51
							99.9				4.76
							99.6				2.00
							99.0				0.6410
							96.5				0.5940
							92.9				0.2970
							76.5				0.1500
							82.94				0.0740
1	75.5	24.2	4.4	36.0	31.3	63.1	49.58	9.9	3.147	.01412	0.0444
2	75.5	24.2	4.4	31.5	28.6	63.1	42.52	11.1	2.353	.01412	0.0332
3	75.5	24.2	4.4	29.0	24.4	63.1	38.60	11.9	1.994	.01412	0.0262
4	75.5	24.2	4.4	27.5	22.9	63.1	36.25	12.5	1.766	.01412	0.0249
5	75.5	24.2	4.4	26.5	21.9	63.1	34.66	12.7	1.594	.01412	0.0225
10	75.5	24.2	4.4	24.0	19.4	63.1	30.76	13.5	1.162	.01412	0.0164
15	75.5	24.2	4.4	22.0	17.4	63.1	27.62	13.8	0.959	.01412	0.0135
30	75.0	23.9	4.5	21.0	16.4	63.1	25.95	14.0	0.662	.01402	0.0096
60	75.0	23.9	4.5	19.5	14.9	63.1	23.60	14.3	0.488	.01387	0.0068
120	75.0	23.9	4.5	18.0	13.4	63.1	21.24	14.4	0.347	.01363	0.0047
250	75.0	23.9	4.5	16.5	11.9	63.1	18.89	14.7	0.242	.01344	0.0033
460	74.5	23.8	4.5	16.0	11.4	83.1	16.00	14.8	0.176	.01353	0.0024
1440	75.5	24.2	4.4	15.0	10.5	63.1	16.65	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



Mid-State Engineering & Testing, Inc.

11 East 11th St.
Kearney, Nebraska 68847

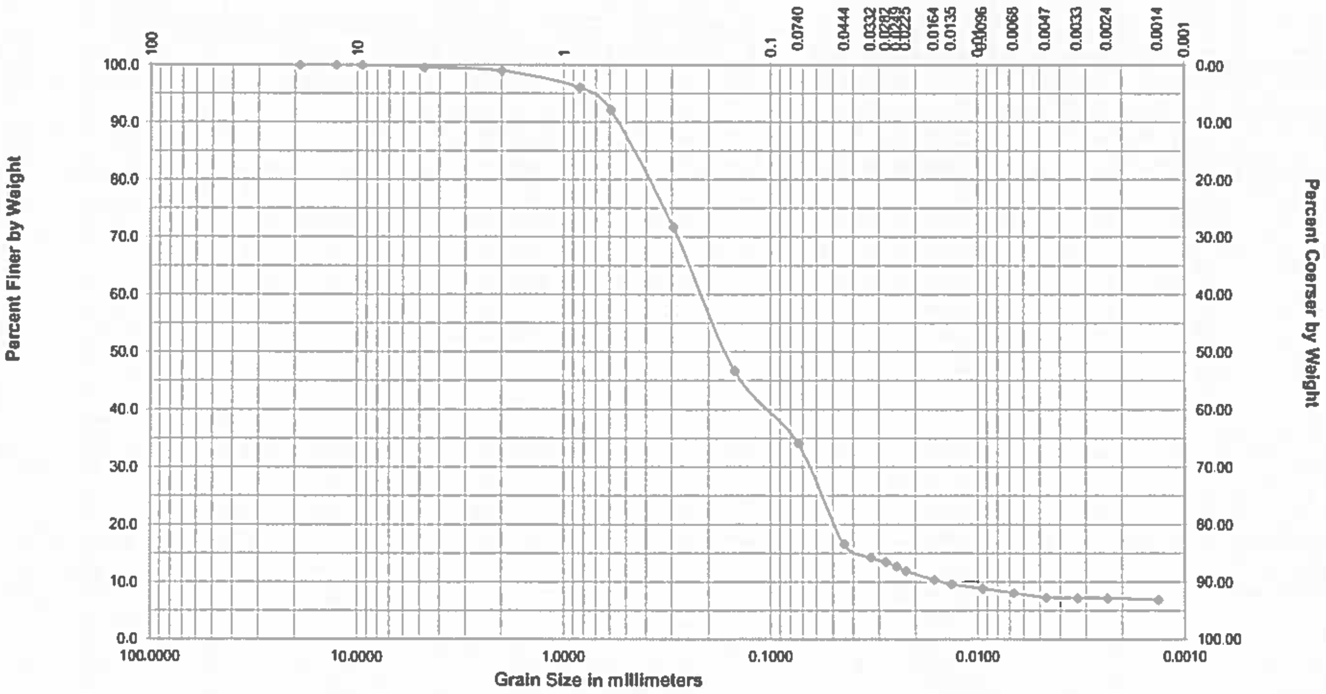
Hydrometer Analysis

ASTM D-422

Project:	Cottonwood Ranch Broad-Scale Project #10057649			Location:	Phelps County, Nebraska		
M.5. Project #:	200-05-24			Tested By:	Mitchell Hoback	Date:	6/29/2017
5emple Id:	B-131, U-1 (1/2 - 2')			Semple Description:	Derk Grey Brown Clayey Sand		
Wet Mess: (g)	36.43	Dispersing Agent	5g, HMP	S.G. Corr. Fector:	0.99	P-200 Dry Wt. (g)	49.6
Dry Mass, (g)	36.13	Soil Mess, (Air Dry), (g)	65.0	Moist. Corr. Fector:	0.9645	P-200 Tere Wt. (g)	7.5
Tere: (g)	17.05	Hydrometer Method	152H	Hygro. M.C.: (%)	1.6	Passing #200 (%)	34.21

t (min)	Temp. (F)	Temp. (C)	Hydrom. C. Fect.	Hydrom. Reading, R	R*a	W (g)	P (%)	L (cm)	SQRT(L/t)	k	Grain Size (mm)
Hydrometer Remarks:							100.0	Gradation Remarks:			19.00
							100.0				12.70
							100.0				9.51
							99.6				4.76
							99.0				2.00
							96.1				0.6410
							92.2				0.5940
							71.6				0.2970
							46.6				0.1500
							34.21				0.0740
1	76.5	24.7	4.2	15.0	10.6	64.0	16.63	9.9	3.147	.01412	0.0444
2	76.5	24.7	4.2	13.5	9.2	64.0	14.31	11.1	2.353	.01412	0.0332
3	76.5	24.7	4.2	13.0	6.7	64.0	13.54	11.9	1.994	.01412	0.0262
4	76.5	24.7	4.2	12.5	6.2	64.0	12.76	12.5	1.766	.01412	0.0249
5	76.5	24.7	4.2	12.0	7.7	64.0	11.99	12.7	1.594	.01412	0.0225
10	76.5	24.7	4.2	11.0	6.7	64.0	10.44	13.5	1.162	.01412	0.0164
15	76.5	24.7	4.2	10.5	6.2	64.0	9.67	13.6	0.959	.01412	0.0135
30	76.5	24.7	4.2	10.0	5.7	64.0	6.90	14.0	0.662	.01402	0.0096
60	76.5	24.7	4.2	9.5	5.2	64.0	6.12	14.3	0.466	.01387	0.0068
120	76.5	24.7	4.2	9.0	4.7	64.0	7.35	14.4	0.347	.01363	0.0047
240	76.0	24.4	4.3	9.0	4.6	64.0	7.25	14.7	0.247	.01344	0.0033
480	76.0	24.4	4.3	9.0	4.6	64.0	7.25	14.6	0.176	.01353	0.0024
1440	74.5	23.6	4.5	9.0	4.4	64.0	6.93	15.0	0.102	.01326	0.0014

GRAIN SIZE ANALYSIS CURVE



A-2532

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-102 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
3/8"	0.0	100.0	
#4	2.1	97.9	
#10	5.3	94.7	
#20	11.0	89.0	
#30	14.6	85.4	
#50	26.0	74.0	
#100	45.5	54.5	
#200	57.8	42.2	

I.D. NO. **A-2532**

MID-STATE
ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale
Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24

Date: 6/20/17

SAMPLE IDENTIFICATION B-102 S-4

SAMPLE LOCATION 8 1/2' - 10' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
1/2"	0.0	100.0	
3/8"	4.8	95.2	
#4	16.6	83.4	
#10	34.2	65.8	
#20	57.5	42.5	
#30	65.7	34.3	
#50	81.5	18.5	
#100	93.4	6.6	
#200	96.2	3.8	

I.D. NO. A-2532

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project:	Cottonwood Ranch Broad-Scale Project #10057849		
Location:	Phelps County, Nebraska		
Job No.:	200-05-24	**Date:**	6/20/17

SAMPLE IDENTIFICATION	B-103 S-2
SAMPLE LOCATION	3 1/2' - 5' Below Grade
SOURCE	
DATE RECEIVED	
REMARKS	

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
3/8"	0.0	100.0	
#4	0.4	99.6	
#10	1.3	98.7	
#20	3.7	96.3	
#30	6.0	94.0	
#50	17.9	82.1	
#100	38.3	61.7	
#200	76.3	23.7	

I.D. NO. A-2532

MID-STATE **ENGINEERING & TESTING**	**AGGREGATE TEST REPORT**	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.: 200-05-24	**Date:** 6/20/17

SAMPLE IDENTIFICATION B-103 S-3

SAMPLE LOCATION 5 1/2' - 7' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	2.8	97.2	
#10	10.2	89.8	
#20	24.0	76.0	
#30	33.3	66.7	
#50	49.3	50.7	
#100	59.4	40.6	
#200	84.9	15.1	

I.D. NO. A-2532

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-103 S-4

SAMPLE LOCATION 8 1/2' - 10' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	7.4	92.6	
3/8"	9.2	90.8	
#4	15.1	84.9	
#10	38.9	61.1	
#20	64.0	36.0	
#30	72.8	27.2	
#50	88.1	11.9	
#100	95.4	4.6	
#200	97.1	2.9	

I.D. NO. A-2532

MID-STATE **ENGINEERING & TESTING**	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849
		Location: Phelps County, Nebraska
		Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-104 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
3/8"	0.0	100.0	
#4	0.0	100.0	
#10	0.2	99.8	
#20	1.5	98.5	
#30	2.6	97.4	
#50	7.8	92.2	
#100	20.3	79.7	
#200	35.4	64.6	

I.D. NO. A-2532

MID-STATE
ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-106 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	0.2	99.8	
#10	0.6	99.4	
#20	3.0	97.0	
#30	6.6	93.4	
#50	37.9	62.1	
#100	49.9	50.1	
#200	53.9	46.1	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	AGGREGATE TEST REPORT	Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-106 S-3

SAMPLE LOCATION 5 1/2' - 7' Below Grade

SOURCE __________

DATE RECEIVED __________

REMARKS __________

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
1"	0.0	100.0	
3/4"	3.5	96.5	
1/2"	5.4	94.6	
3/8"	9.7	90.3	
#4	27.6	72.4	
#10	51.8	48.2	
#20	70.4	29.6	
#30	77.0	23.0	
#50	91.8	8.2	
#100	97.3	2.7	
#200	98.7	1.3	

I.D. NO. **A-2532**

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849
Location: Phelps County, Nebraska
Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-107 U-1
SAMPLE LOCATION 1/2' - 2' Below Grade
SOURCE
DATE RECEIVED
REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
#4	0.0	100.0	
#10	0.1	99.9	
#20	1.4	98.6	
#30	2.6	97.4	
#50	9.2	90.8	
#100	20.3	79.7	
#200	33.4	66.6	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849
		Location: Phelps County, Nebraska
		Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-108 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT
	RETAINED	PASSING	RETAINED / PASSING
3/8"	0.0	100.0	
#4	0.2	99.8	
#10	0.3	99.7	
#20	0.8	99.2	
#30	2.0	98.0	
#50	12.7	87.3	
#100	42.5	57.5	
#200	64.6	35.4	

I.D. NO. A-2532

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-108 S-2

SAMPLE LOCATION 3 1/2' - 5' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	0.6	99.4	
#10	1.6	98.4	
#20	3.8	96.2	
#30	5.8	94.2	
#50	14.9	85.1	
#100	38.9	61.1	
#200	70.5	29.5	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	AGGREGATE TEST REPORT		
		Project:	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.:	200-05-24
		Date:	6/20/17

SAMPLE IDENTIFICATION B-108 S-3

SAMPLE LOCATION 5 1/2' - 7' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
1/2"	0.0	100.0	
3/8"	0.8	99.2	
#4	3.7	96.3	
#10	7.7	92.3	
#20	15.1	84.9	
#30	19.5	80.5	
#50	33.8	66.2	
#100	59.9	40.1	
#200	77.3	22.7	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	AGGREGATE TEST REPORT	**Project:** Cottonwood Ranch Broad-Scale Project #10057849 **Location:** Phelps County, Nebraska	
		Job No.: 200-05-24	**Date:** 6/20/17

SAMPLE IDENTIFICATION B-109 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
#4	0.0	100.0	
#10	0.1	99.9	
#20	0.5	99.5	
#30	1.3	98.7	
#50	6.0	94.0	
#100	21.5	78.5	
#200	52.2	47.8	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	AGGREGATE TEST REPORT	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849		
		Location:	Phelps County, Nebraska		
		Job No.:	200-05-24	**Date:**	6/20/17

SAMPLE IDENTIFICATION B-109 S-6

SAMPLE LOCATION 18 1/2' - 20' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
1"	0.0	100.0	
3/4"	4.4	95.6	
1/2"	4.4	95.6	
3/8"	5.3	94.7	
#4	11.6	88.4	
#10	21.1	78.9	
#20	32.0	68.0	
#30	38.2	61.8	
#50	63.2	36.8	
#100	78.5	21.5	
#200	80.3	19.7	

I.D. NO. **A-2532**

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-110 S-2

SAMPLE LOCATION 3 1/2' - 5' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
#4	0.0	100.0	
#10	0.1	99.9	
#20	0.3	99.7	
#30	0.4	99.6	
#50	2.7	97.3	
#100	16.2	83.8	
#200	60.7	39.3	

I.D. NO. A-2532

MID-STATE **ENGINEERING & TESTING**	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849 **Location:** Phelps County, Nebraska **Job No.:** 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-111 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
3/8"	0.0	100.0	
#4	0.1	99.9	
#10	0.4	99.6	
#20	1.9	98.1	
#30	3.4	96.6	
#50	10.9	89.1	
#100	21.6	78.4	
#200	29.6	70.4	

I.D. NO. A-2532

MID-STATE
ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project:	Cottonwood Ranch Broad-Scale Project #10057849		
Location:	Phelps County, Nebraska		
Job No.:	200-05-24	**Date:**	6/20/17

SAMPLE IDENTIFICATION B-111 S-4

SAMPLE LOCATION 8 1/2' - 10' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
1/2"	0.0	100.0	
3/8"	0.9	99.1	
#4	7.1	92.9	
#10	20.7	79.3	
#20	46.1	53.9	
#30	57.7	42.3	
#50	84.3	15.7	
#100	97.8	2.2	
#200	99.3	0.7	

I.D. NO. A-2532

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-111 S-7

SAMPLE LOCATION 23 1/2' - 25' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
1"	0.0	100.0	
3/4"	5.5	94.5	
1/2"	7.1	92.9	
3/8"	7.7	92.3	
#4	12.4	87.6	
#10	26.9	73.1	
#20	53.0	47.0	
#30	63.7	36.3	
#50	81.9	18.1	
#100	91.6	8.4	
#200	95.5	4.5	

I.D. NO. A-2532

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-112 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	0.4	99.6	
#10	1.4	98.6	
#20	4.2	95.8	
#30	7.5	92.5	
#50	24.0	76.0	
#100	48.9	51.1	
#200	61.0	39.0	

I.D. NO. A-2532

MID-STATE **ENGINEERING & TESTING**	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849 **Location:** Phelps County, Nebraska **Job No.:** 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-112 S-2

SAMPLE LOCATION 3 1/2' - 5' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
3/8"	0.0	100.0	
#4	4.1	95.9	
#10	13.2	86.8	
#20	32.8	67.2	
#30	42.4	57.6	
#50	66.0	34.0	
#100	83.5	16.5	
#200	94.4	5.6	

I.D. NO. A-2532

MID-STATE **ENGINEERING &** **TESTING**	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849 **Location:** Phelps County, Nebraska **Job No.:** 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-113 S-4

SAMPLE LOCATION 8 1/2' - 10' Below Grade

SOURCE ____________________

DATE RECEIVED ____________________

REMARKS ____________________

____

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT
	RETAINED	PASSING	RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	1.5	98.5	
3/8"	3.2	96.8	
#4	9.5	90.5	
#10	40.5	59.5	
#20	76.0	24.0	
#30	85.1	14.9	
#50	95.0	5.0	
#100	95.6	4.4	
#200	98.0	2.0	

I.D. NO. **A-2532**

MID-STATE **ENGINEERING &** **TESTING**	**AGGREGATE TEST REPORT**	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.: 200-05-24	**Date:** 6/20/17

SAMPLE IDENTIFICATION B-114 S-2

SAMPLE LOCATION 3 1/2' - 5' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
#4	0.0	100.0	
#10	0.3	99.7	
#20	1.3	98.7	
#30	2.1	97.9	
#50	8.8	91.2	
#100	30.8	69.2	
#200	59.3	40.7	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	AGGREGATE TEST REPORT	**Project:** Cottonwood Ranch Broad-Scale Project #10057849 **Location:** Phelps County, Nebraska **Job No.:** 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-117 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	0.3	99.7	
#10	0.9	99.1	
#20	2.6	97.4	
#30	4.3	95.7	
#50	13.1	86.9	
#100	29.2	70.8	
#200	46.7	53.3	

I.D. NO. A-2532

MID-STATE
ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-117 S-2

SAMPLE LOCATION 3 1/2' - 5' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
1/2"	0.0	100.0	
3/8"	0.7	99.3	
#4	5.5	94.5	
#10	21.9	78.1	
#20	40.9	59.1	
#30	50.2	49.8	
#50	68.1	31.9	
#100	82.5	17.5	
#200	91.6	8.4	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849	
		Location: Phelps County, Nebraska	
		Job No.: 200-05-24	**Date:** 6/20/17

SAMPLE IDENTIFICATION B-118 S-2

SAMPLE LOCATION 3 1/2' - 5' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	1.0	99.0	
#10	2.4	97.6	
#20	7.8	92.2	
#30	13.3	86.7	
#50	32.2	67.8	
#100	56.5	43.5	
#200	83.9	16.1	

I.D. NO. A-2532

MID-STATE **ENGINEERING &** **TESTING**	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849 **Location:** Phelps County, Nebraska **Job No.:** 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-119 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
#4	0.0	100.0	
#10	0.1	99.9	
#20	0.6	99.4	
#30	1.1	98.9	
#50	7.4	92.6	
#100	27.2	72.8	
#200	47.3	52.7	

I.D. NO. A-2532

MID-STATE
ENGINEERING &
TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-121 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
#4	0.0	100.0	
#10	0.1	99.9	
#20	0.5	99.5	
#30	1.0	99.0	
#50	4.7	95.3	
#100	21.5	78.5	
#200	48.7	51.3	

I.D. NO. A-2532

MID-STATE **ENGINEERING & TESTING**	**AGGREGATE TEST REPORT**	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.: 200-05-24	**Date:** 6/20/17

SAMPLE IDENTIFICATION B-122 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT
	RETAINED	PASSING	RETAINED / PASSING
#4	0.0	100.0	
#10	0.2	99.8	
#20	1.8	98.2	
#30	4.8	95.2	
#50	19.9	80.1	
#100	37.8	62.2	
#200	47.8	52.2	

I.D. NO. A-2532

MID-STATE **ENGINEERING &** **TESTING**	# AGGREGATE TEST REPORT	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.:	200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-123 S-3

SAMPLE LOCATION 5 1/2' - 7' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	3.7	96.3	
3/8"	4.8	95.2	
#4	13.2	86.8	
#10	29.7	70.3	
#20	44.0	56.0	
#30	50.4	49.6	
#50	66.4	33.6	
#100	75.3	24.7	
#200	80.1	19.9	

I.D. NO. **A-2532**

MID-STATE
ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-123 S-4

SAMPLE LOCATION 8 1/2' - 10' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	17.4	82.6	
3/8"	17.4	82.6	
#4	19.7	80.3	
#10	25.4	74.6	
#20	34.1	65.9	
#30	40.0	60.0	
#50	72.2	27.8	
#100	88.8	11.2	
#200	95.0	5.0	

I.D. NO. A-2532

MID-STATE **ENGINEERING & TESTING**	**AGGREGATE TEST REPORT**	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.:	200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-124 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE ____________________

DATE RECEIVED ____________________

REMARKS ____________________

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
3/8"	0.0	100.0	
#4	0.4	99.6	
#10	1.0	99.0	
#20	4.5	95.5	
#30	8.3	91.7	
#50	25.9	74.1	
#100	47.6	52.4	
#200	61.5	38.5	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-125 S-5

SAMPLE LOCATION 13 1/2' - 15' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	1.1	98.9	
3/8"	3.5	96.5	
#4	10.2	89.8	
#10	21.5	78.5	
#20	40.4	59.6	
#30	53.0	47.0	
#50	82.6	17.4	
#100	94.6	5.4	
#200	97.9	2.1	

I.D. NO. A-2532

MID-STATE **ENGINEERING &** **TESTING**	**AGGREGATE TEST REPORT**	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.:	200-05-24
		Date:	6/20/17

SAMPLE IDENTIFICATION B-125 S-8

SAMPLE LOCATION 28 1/2' - 30' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	2.1	97.9	
3/8"	2.1	97.9	
#4	7.5	92.5	
#10	16.8	83.2	
#20	33.6	66.4	
#30	46.8	53.2	
#50	85.6	14.4	
#100	95.8	4.2	
#200	97.7	2.3	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849 **Location:** Phelps County, Nebraska **Job No.:** 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-126 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
#10	0.0	100.0	
#20	0.3	99.7	
#30	0.7	99.3	
#50	4.3	95.7	
#100	17.4	82.6	
#200	42.8	57.2	

I.D. NO. A-2532

MID-STATE
ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project: Cottonwood Ranch Broad-Scale Project #10057849

Location: Phelps County, Nebraska

Job No.: 200-05-24 **Date:** 6/20/17

SAMPLE IDENTIFICATION B-126 S-2

SAMPLE LOCATION 3 1/2' - 5' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT		SPECIFICATION PERCENT RETAINED / PASSING
	RETAINED	PASSING	
3/8"	0.0	100.0	
#4	0.3	99.7	
#10	1.1	98.9	
#20	2.6	97.4	
#30	4.5	95.5	
#50	15.9	84.1	
#100	38.5	61.5	
#200	70.2	29.8	

I.D. NO. A-2532

MID-STATE **ENGINEERING &** **TESTING**	**AGGREGATE TEST REPORT**	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.: 200-05-24	**Date:** 6/20/17

SAMPLE IDENTIFICATION B-129 S-4

SAMPLE LOCATION 8 1/2' - 10' Below Grade

SOURCE __________

DATE RECEIVED __________

REMARKS __________

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	10.3	89.7	
3/8"	11.7	88.3	
#4	20.0	80.0	
#10	33.5	66.5	
#20	49.7	50.3	
#30	58.5	41.5	
#50	85.0	15.0	
#100	96.0	4.0	
#200	99.0	1.0	

I.D. NO. A-2532

MID-STATE **ENGINEERING &** **TESTING**	**AGGREGATE TEST REPORT**	**Project:**	Cottonwood Ranch Broad-Scale Project #10057849
		Location:	Phelps County, Nebraska
		Job No.: 200-05-24	**Date:** 6/20/17

SAMPLE IDENTIFICATION B-129 S-8

SAMPLE LOCATION 28 1/2' - 30' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/4"	0.0	100.0	
1/2"	7.8	92.2	
3/8"	14.3	85.7	
#4	24.7	75.3	
#10	28.0	72.0	
#20	33.8	66.2	
#30	38.4	61.6	
#50	68.3	31.7	
#100	95.2	4.8	
#200	98.0	2.0	

I.D. NO. A-2532

MID-STATE
ENGINEERING & TESTING

AGGREGATE TEST REPORT

Project:	Cottonwood Ranch Broad-Scale Project #10057849
Location:	Phelps County, Nebraska
Job No.:	200-05-24
Date:	6/20/17

SAMPLE IDENTIFICATION B-130 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	0.1	99.9	
#10	0.4	99.6	
#20	1.0	99.0	
#30	1.5	98.5	
#50	7.1	92.9	
#100	21.5	78.5	
#200	37.0	63.0	

I.D. NO. A-2532

MID-STATE ENGINEERING & TESTING	**AGGREGATE TEST REPORT**	**Project:** Cottonwood Ranch Broad-Scale Project #10057849
		Location: Phelps County, Nebraska
		Job No.: 200-05-24 **Date:** 6/27/17

SAMPLE IDENTIFICATION B-131 U-1

SAMPLE LOCATION 1/2' - 2' Below Grade

SOURCE

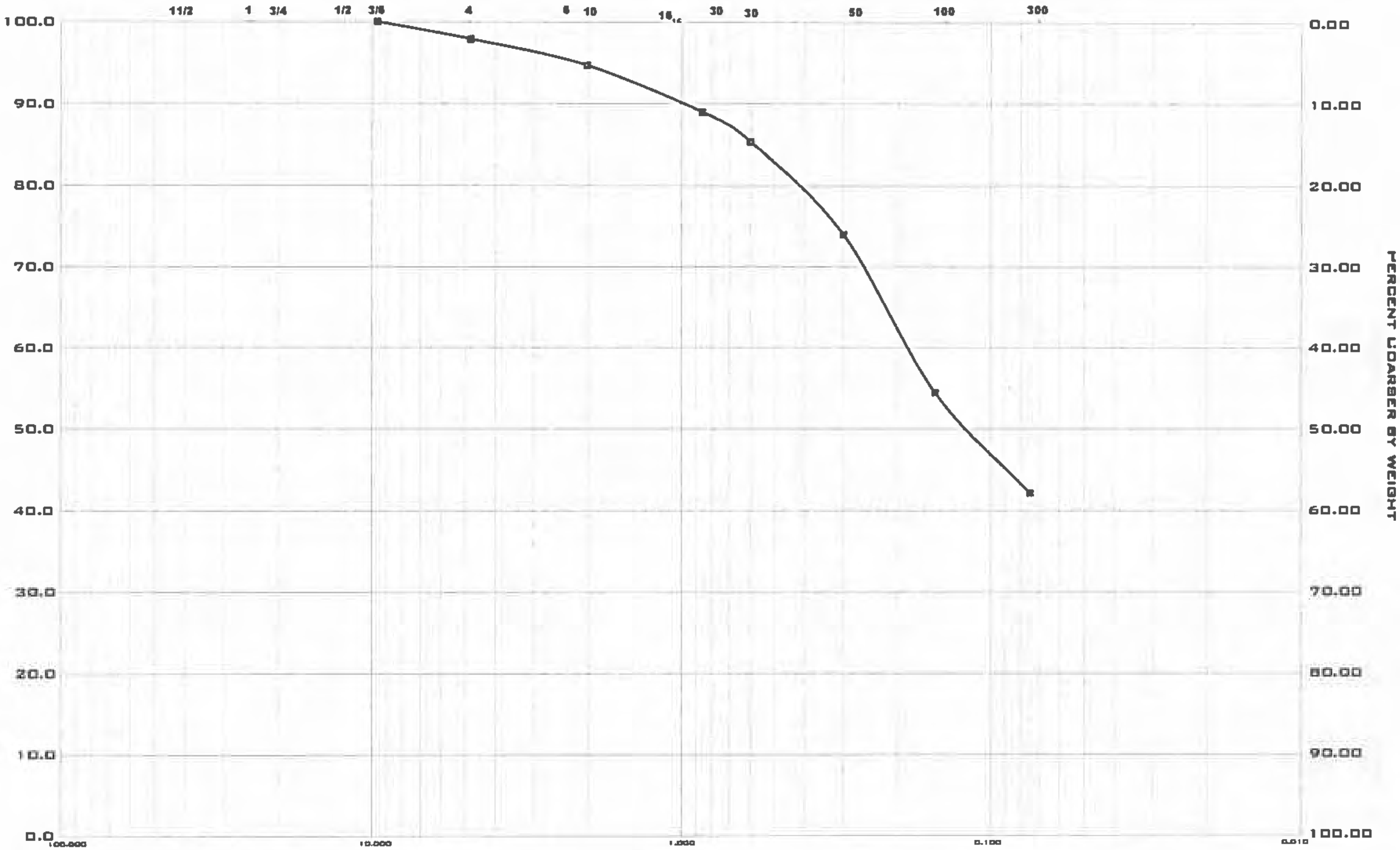
DATE RECEIVED

REMARKS

US STANDARD SIEVE NO.	CUMULATIVE PERCENT RETAINED	CUMULATIVE PERCENT PASSING	SPECIFICATION PERCENT RETAINED / PASSING
3/8"	0.0	100.0	
#4	0.4	99.6	
#10	1.0	99.0	
#20	3.9	96.1	
#30	7.8	92.2	
#50	28.2	71.8	
#100	53.2	46.8	
#200	65.7	34.3	

I.D. NO. A-2532

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-102	U-1	1/2 - 2'		SC

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

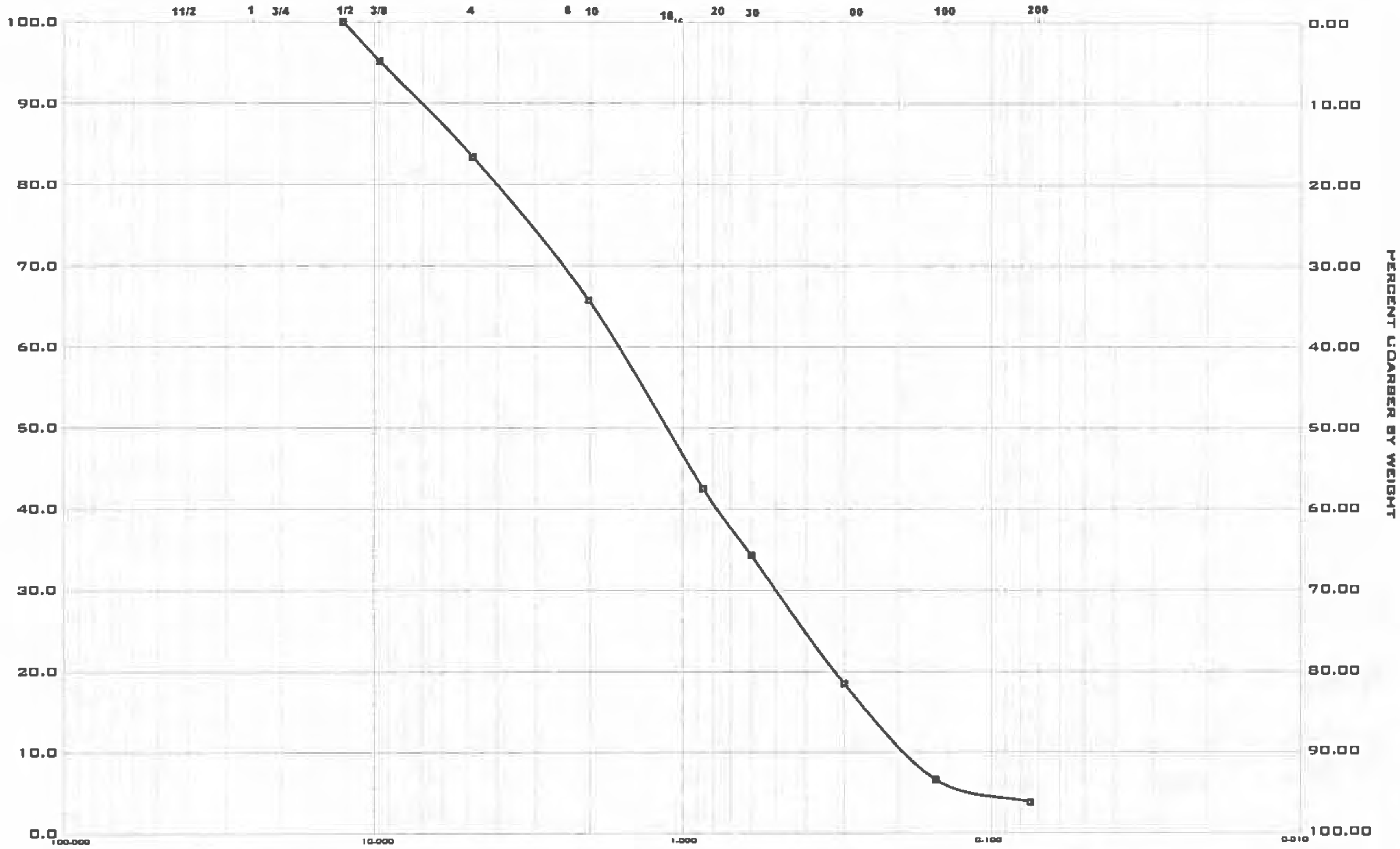
DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



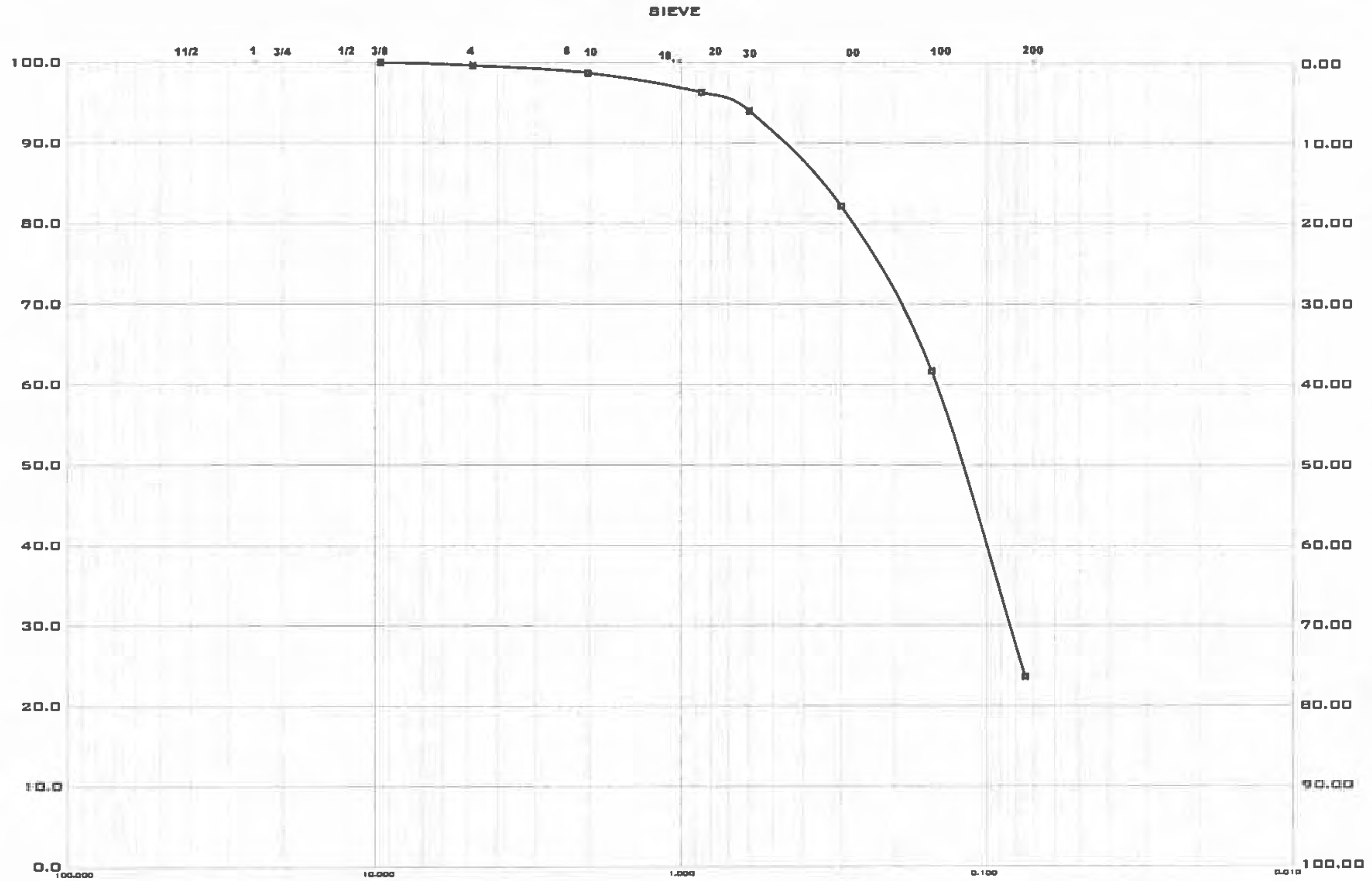
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-102	S-4	8 1/2 - 10'		SP

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-103	S-2	3 1/2 - 5'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

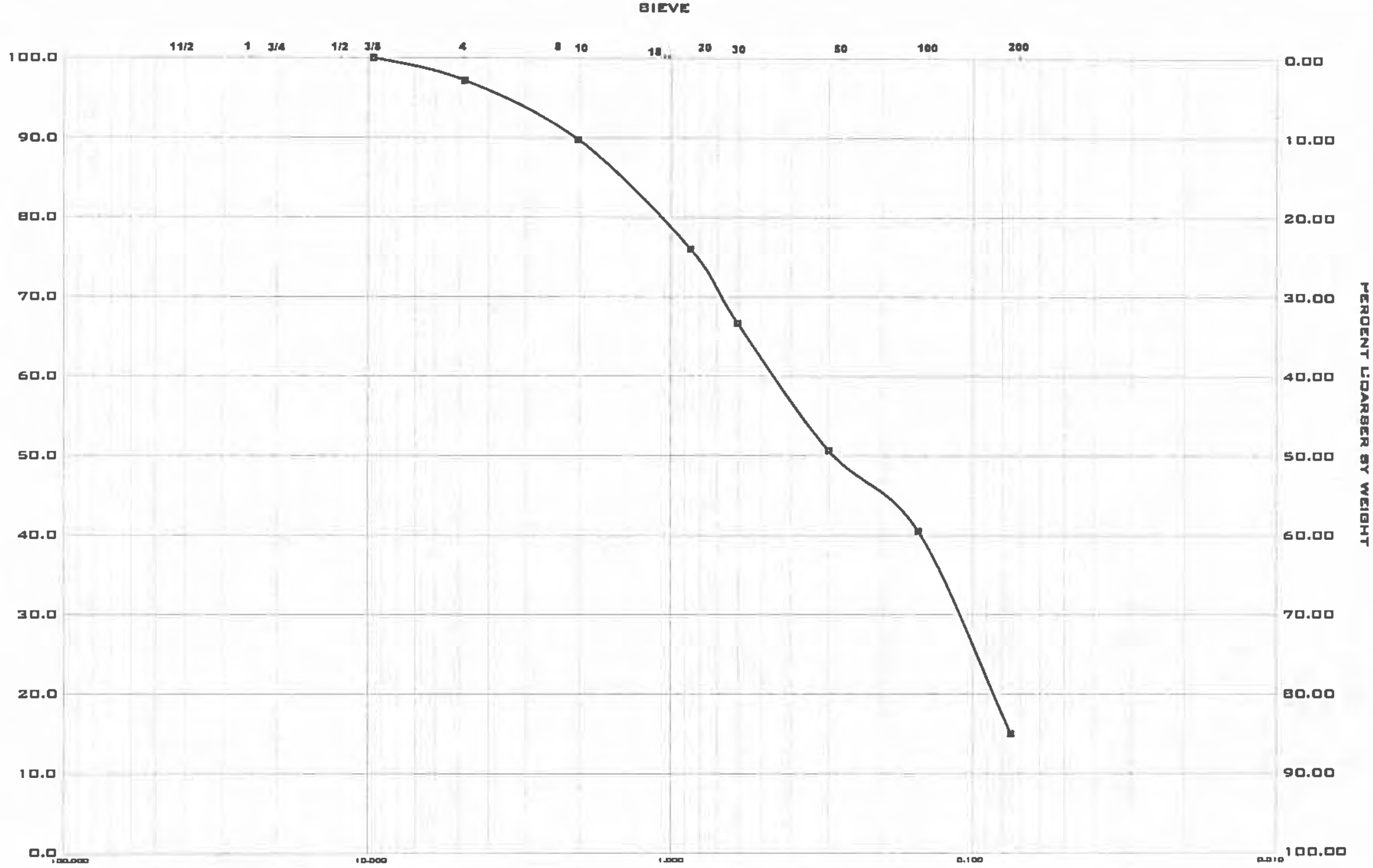
DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



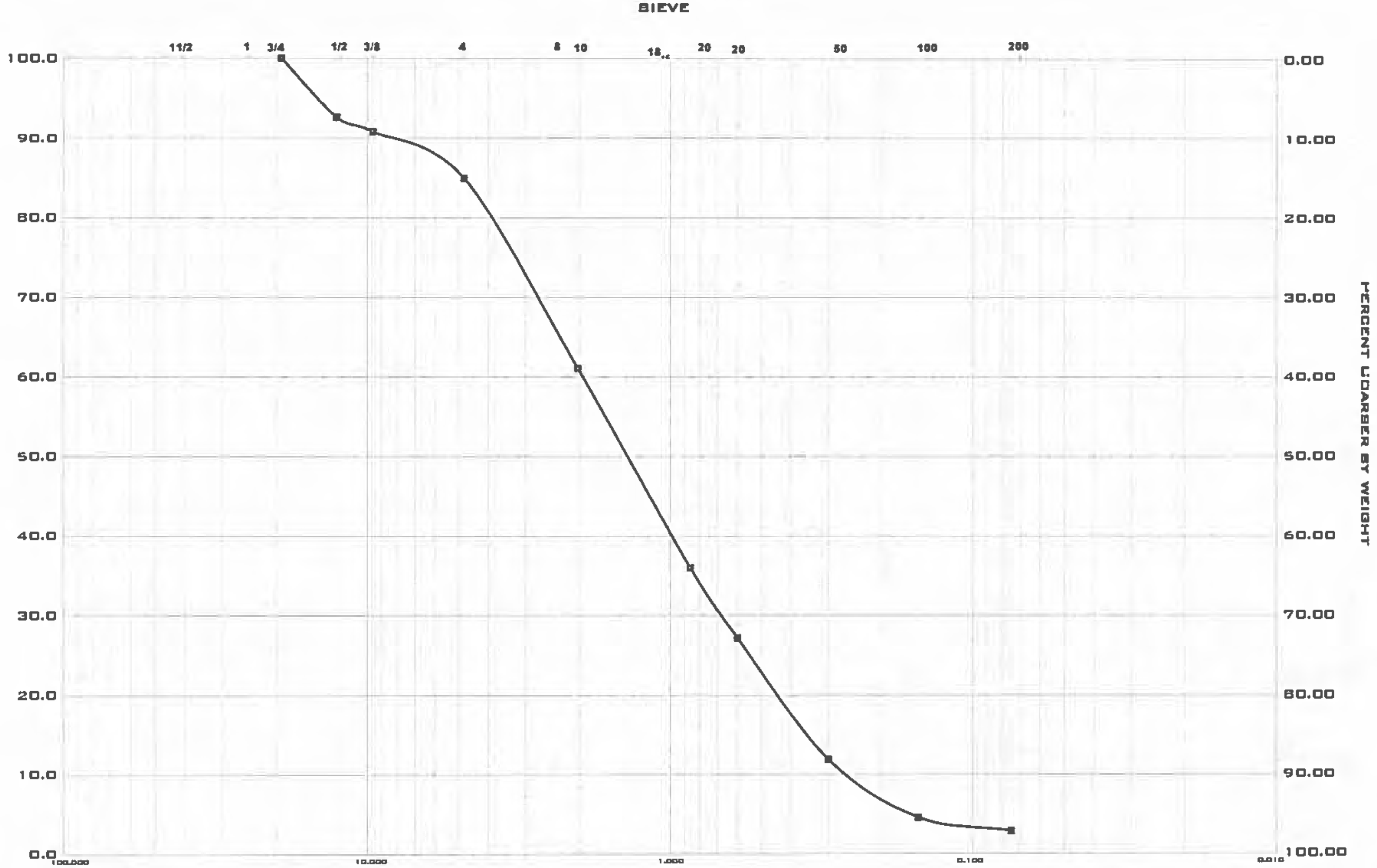
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-103	S-3	5 1/2 - 7'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-103	S-4	8 1/2 - 10'		SP

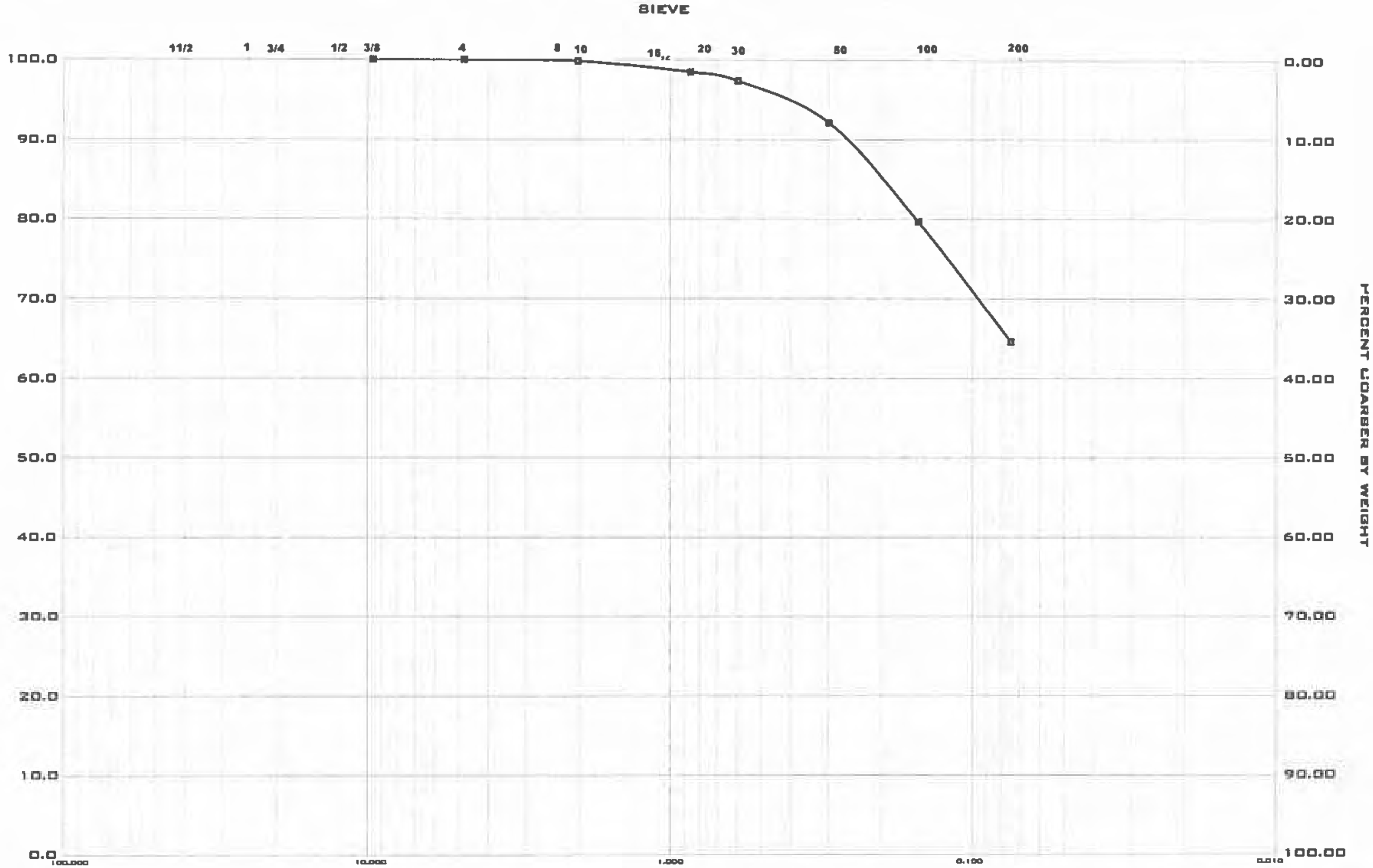
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-104	U-1	1/2 - 2'		CL

PROJECT. Cottonwood Ranch Broad-Scale Project #10057849

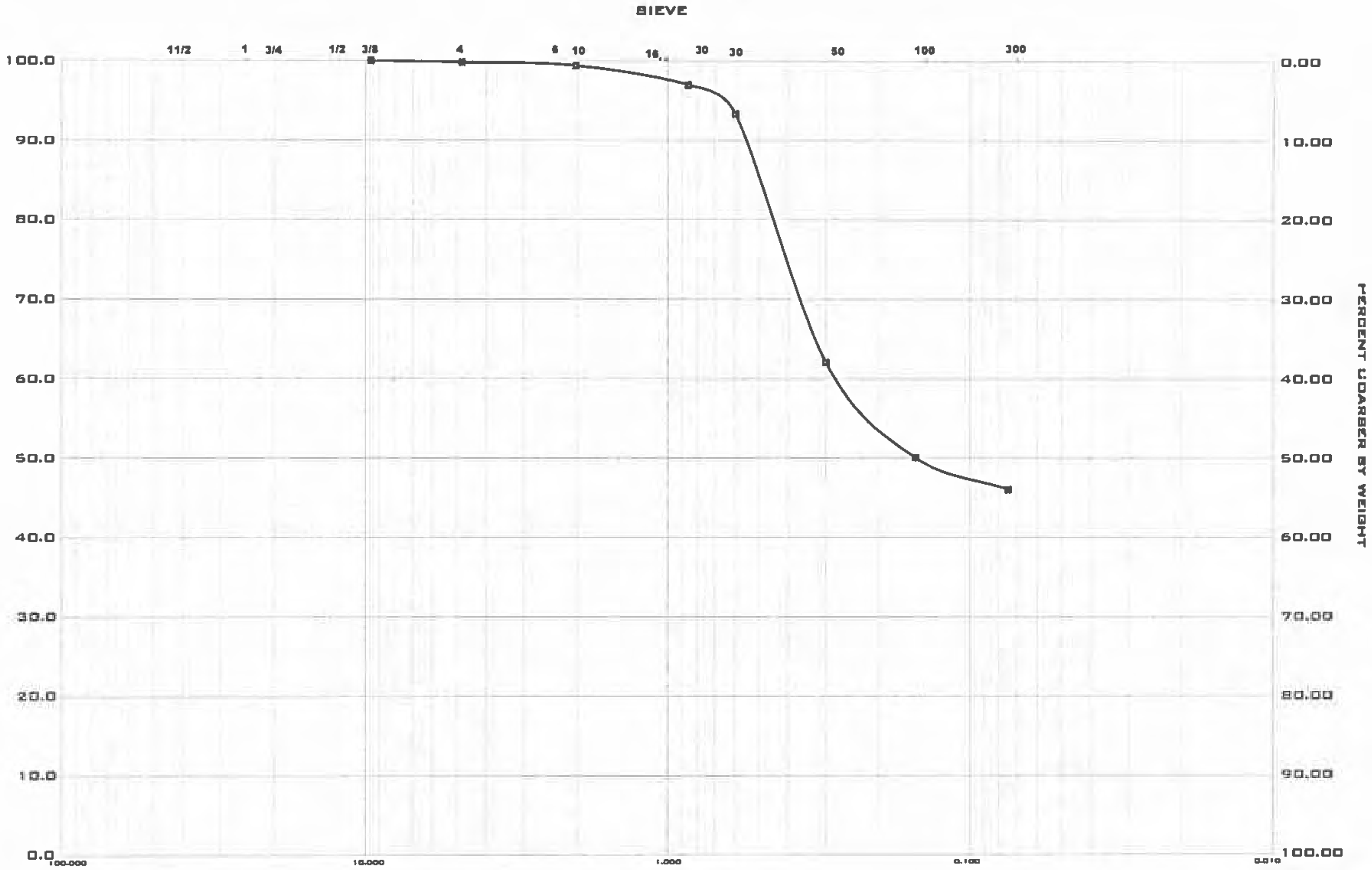
DATE. 6/20/2017

JOB NO 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-106	U-1	1/2 - 2'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

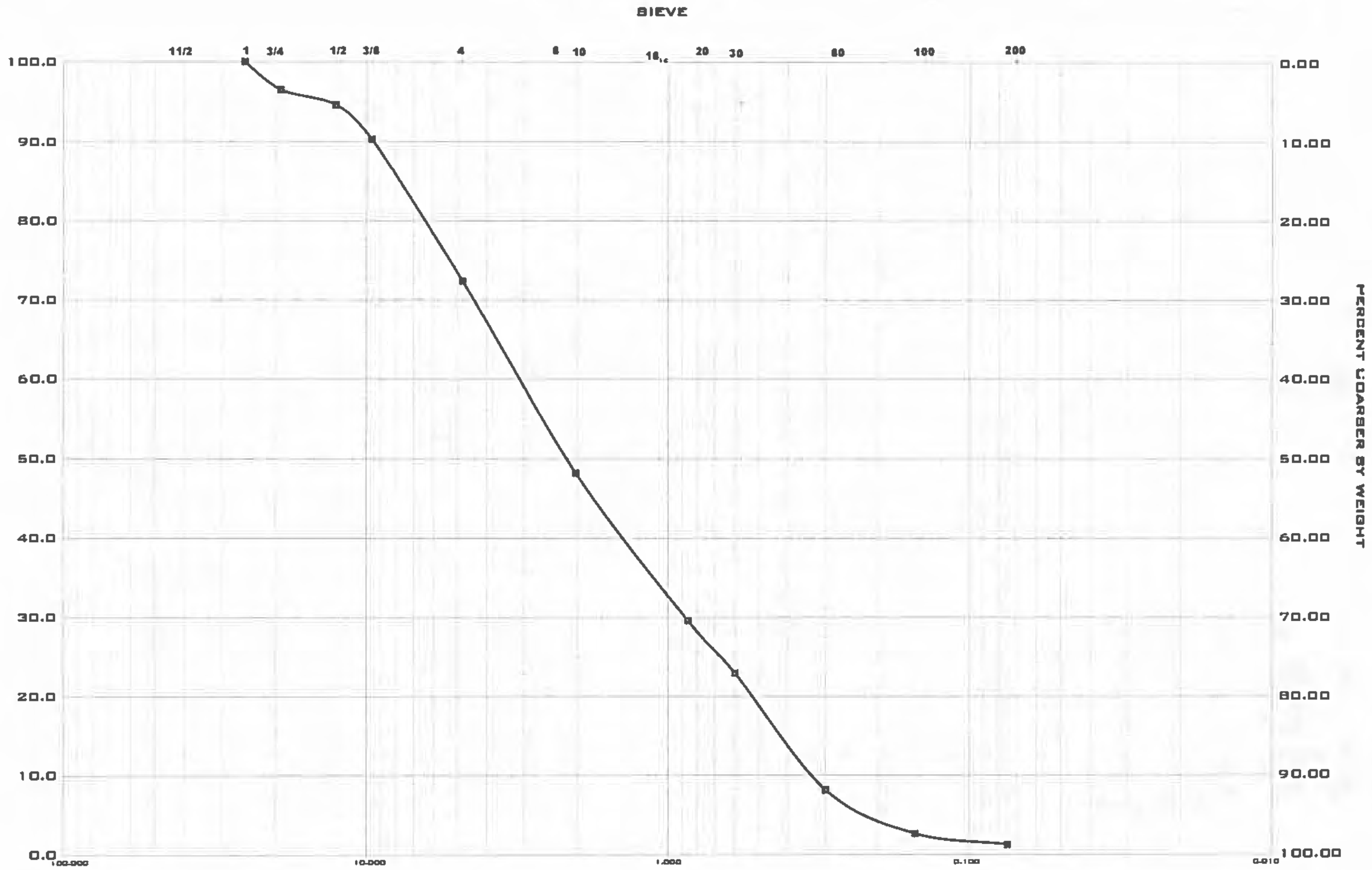
DATE: 6/20/2017

JOB NO 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-106	S-3	5 1/2 - 7'		SP

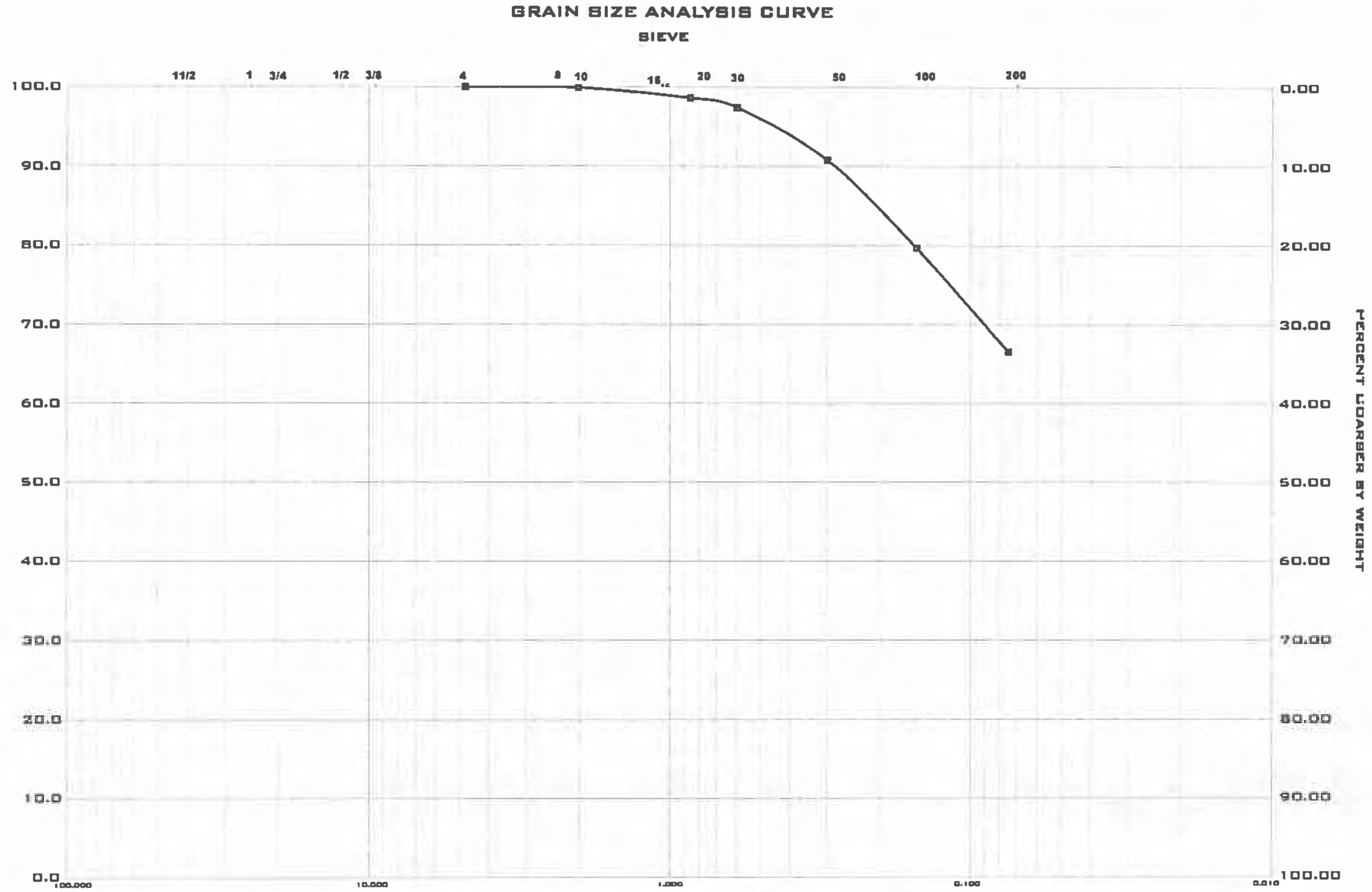
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

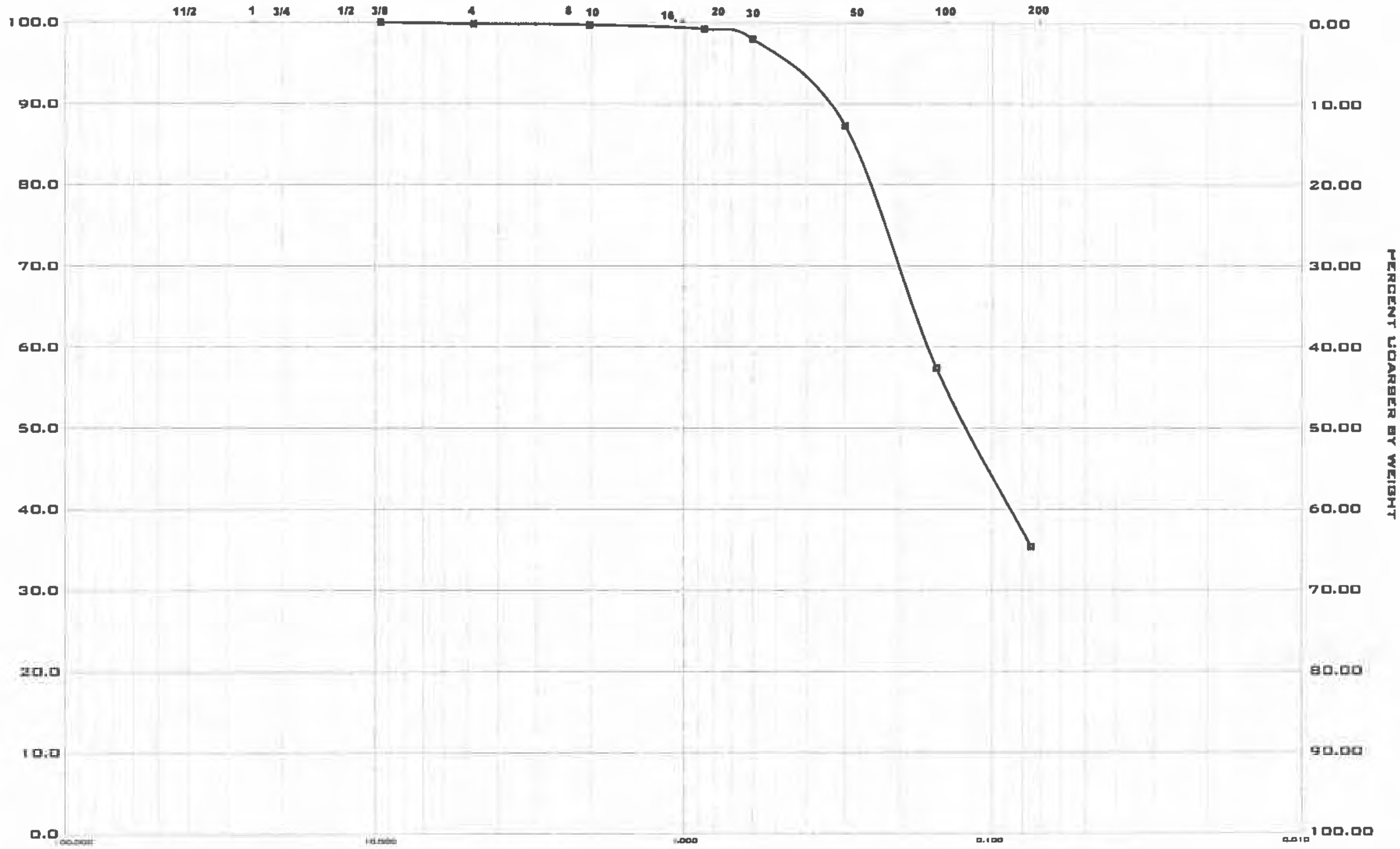


DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-107	U-1	1/2 - 2'		CL

PROJECT:	Cottonwood Ranch Broad-Scale Project #10057849		
DATE:	6/20/2017	JOB NO	200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



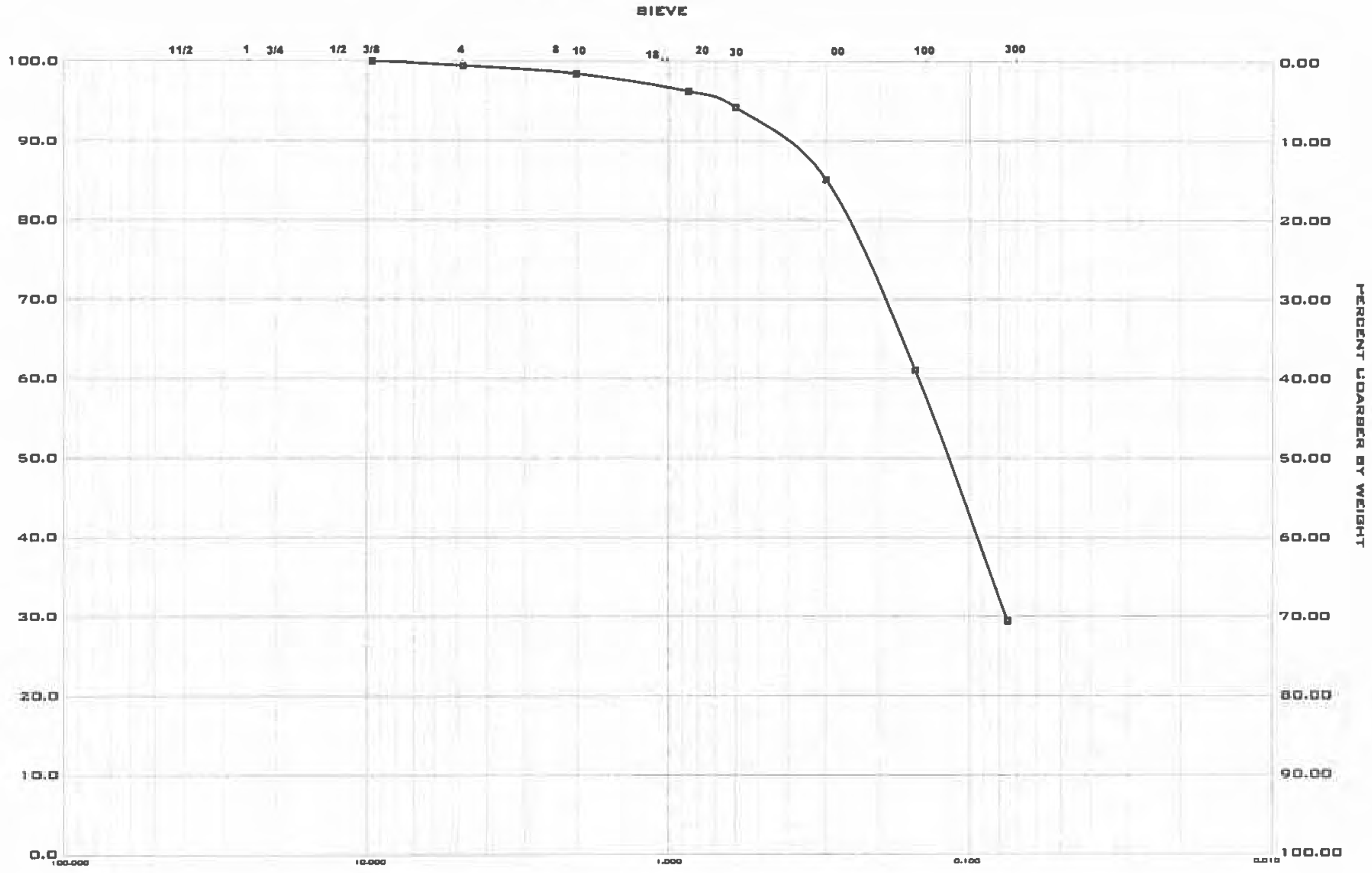
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-108	U-1	1/2 - 2'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE

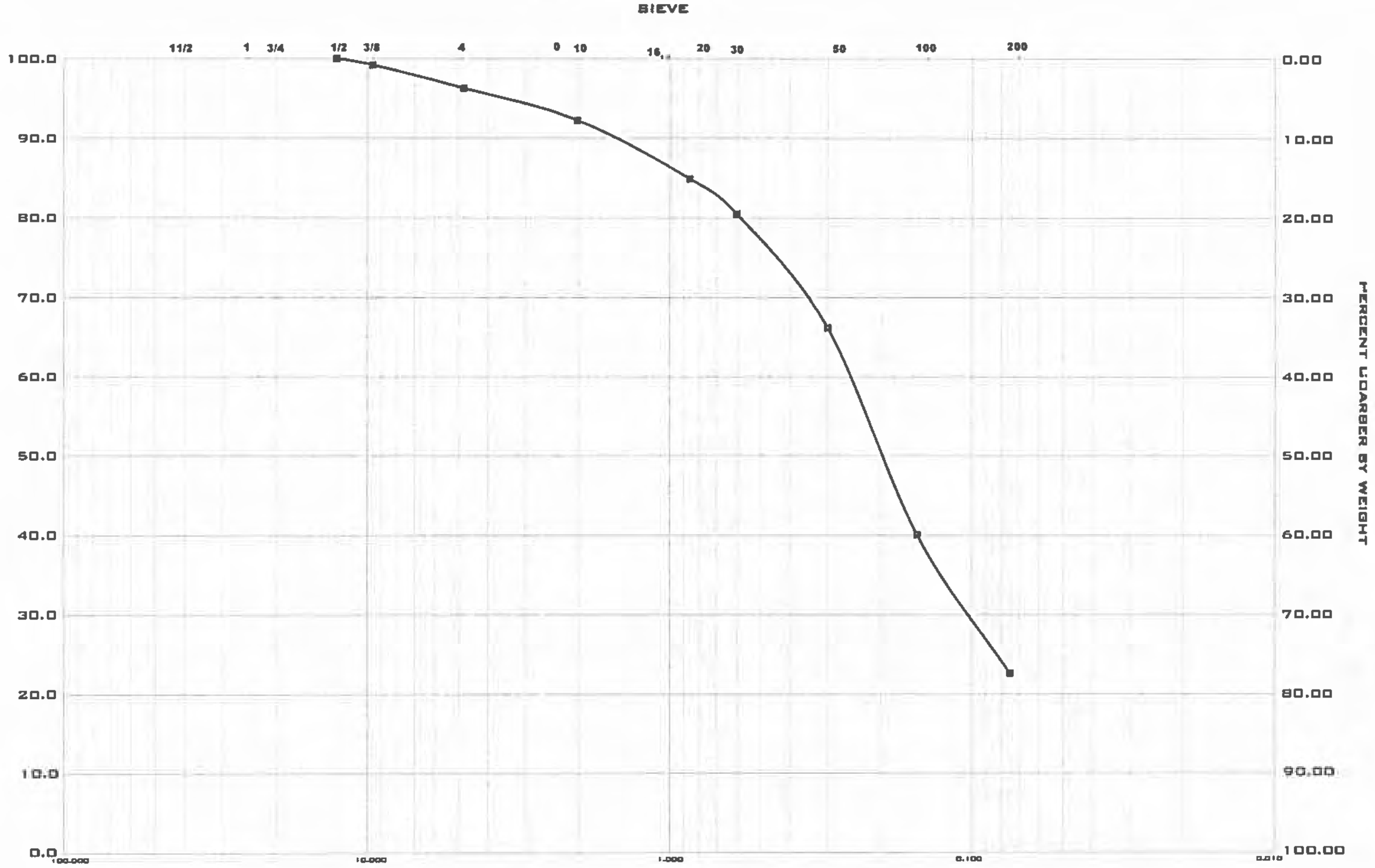


DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-108	S-2	3 1/2 - 5'		SM

PROJECT:	Cottonwood Ranch Broad-Scale Project #10057849		
DATE:	6/20/2017	JOB NO.	200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



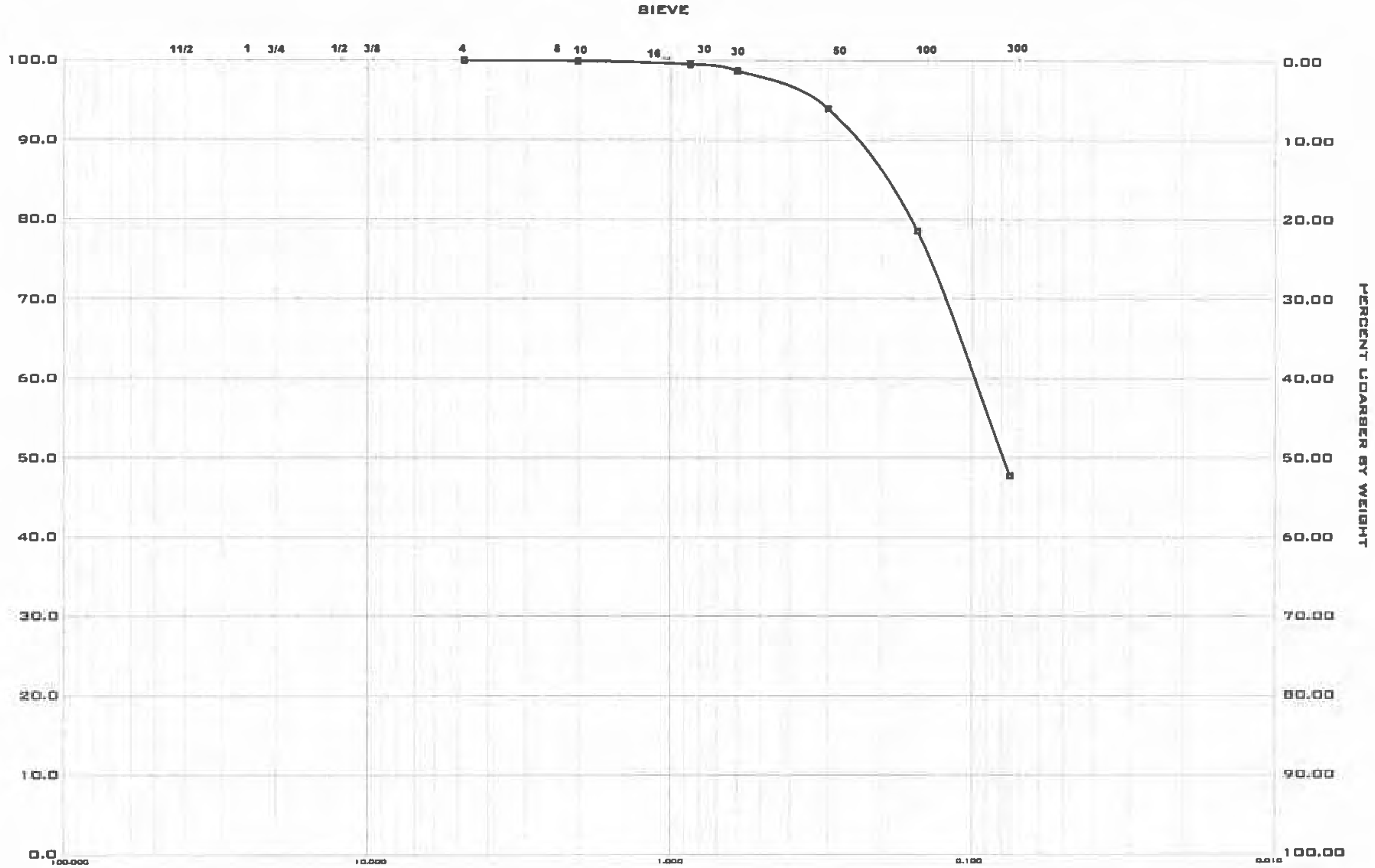
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-108	S-3	5 1/2 - 7'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-109	U-1	1/2 - 2'		SM

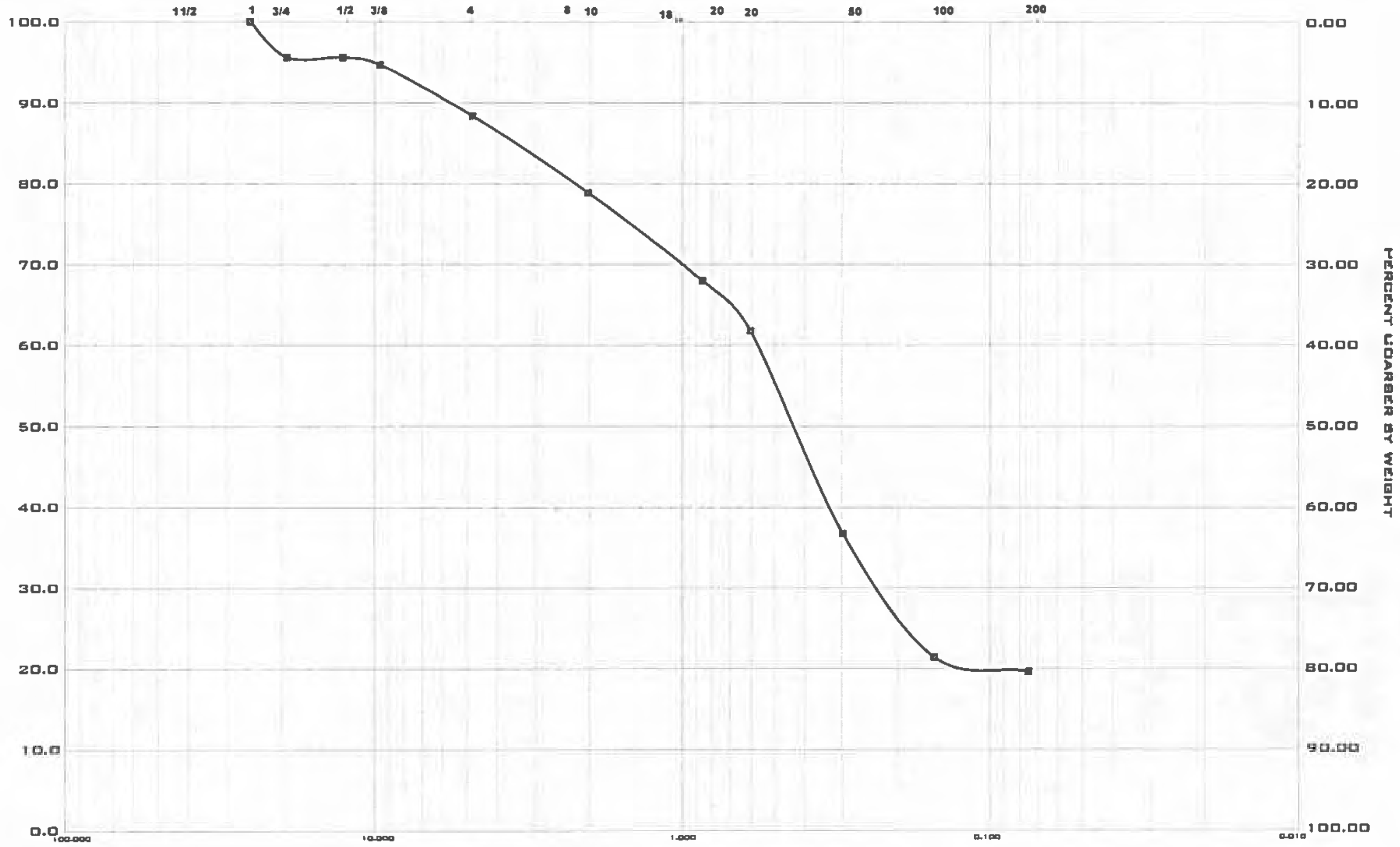
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-109	S-6	18 1/2 - 20'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

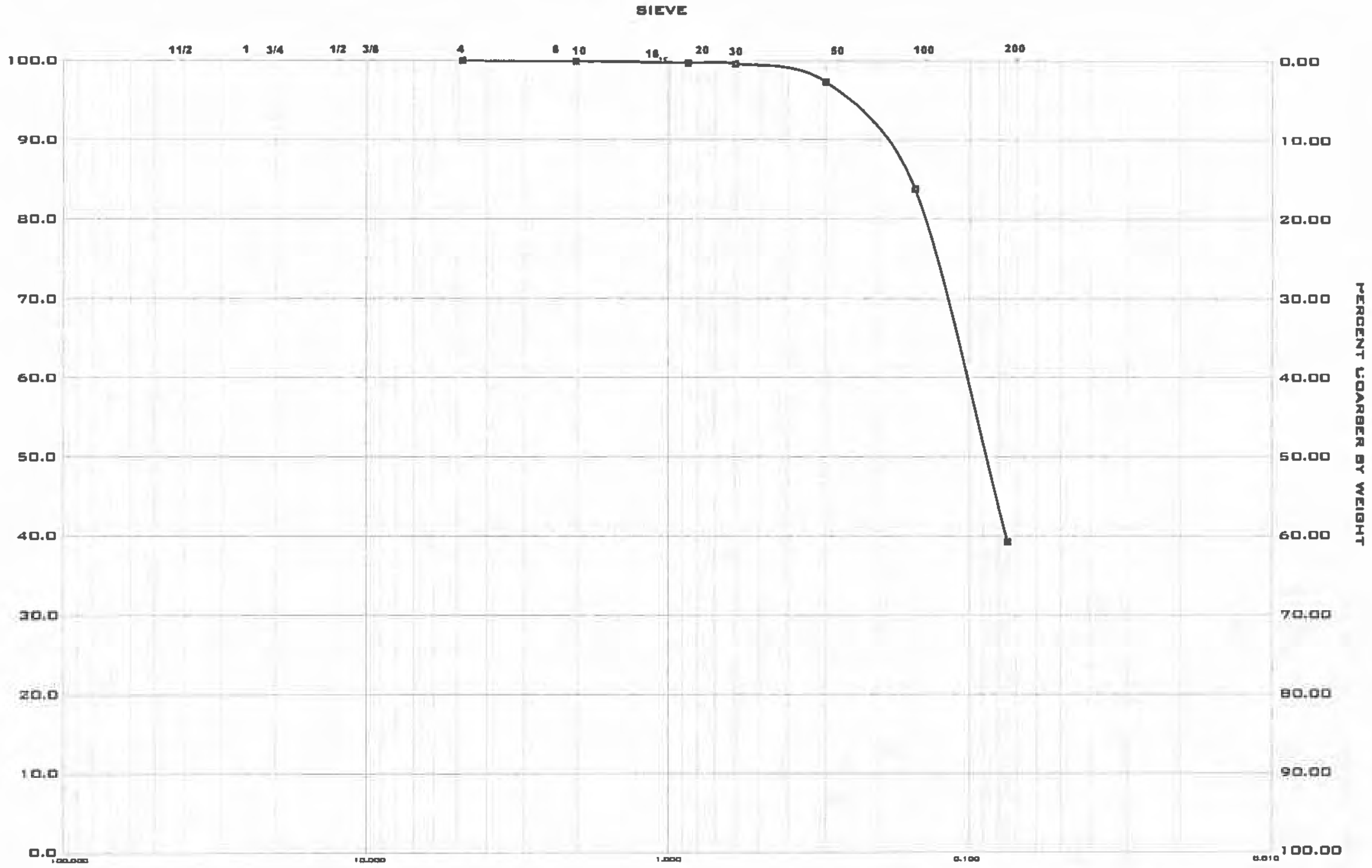
DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



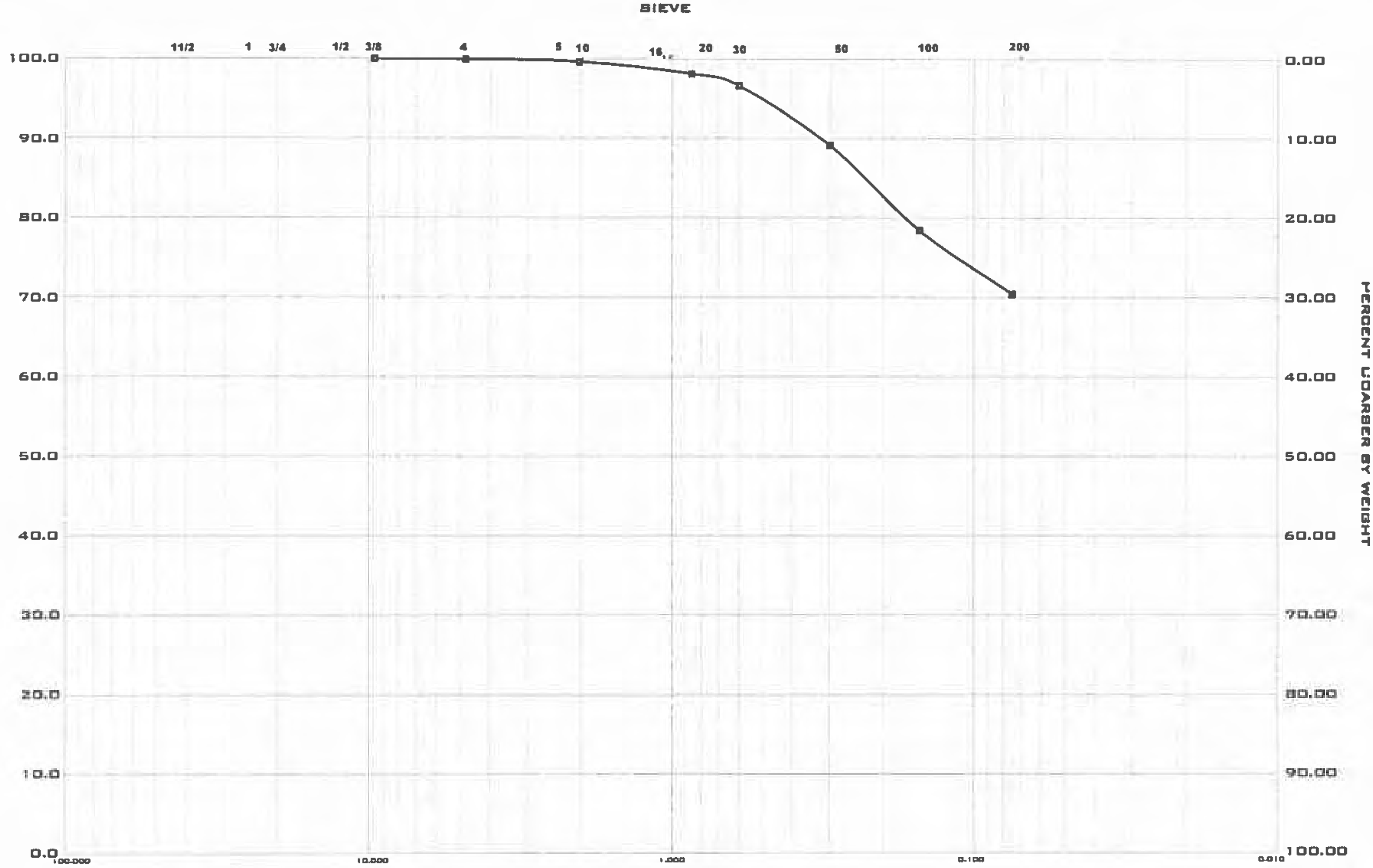
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-110	S-2	3 1/2 - 5'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-111	U-1	1/2 - 2'		CL

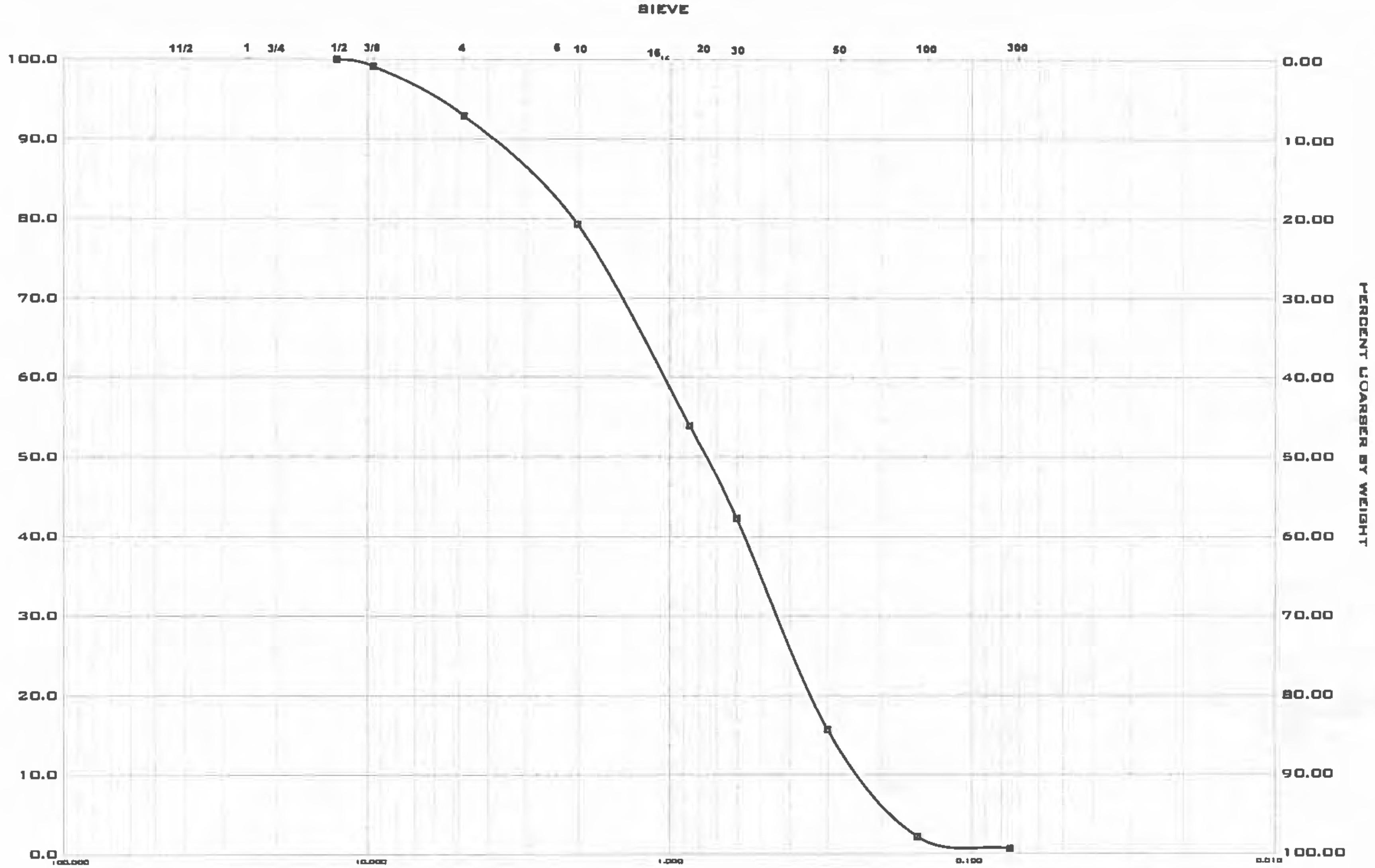
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



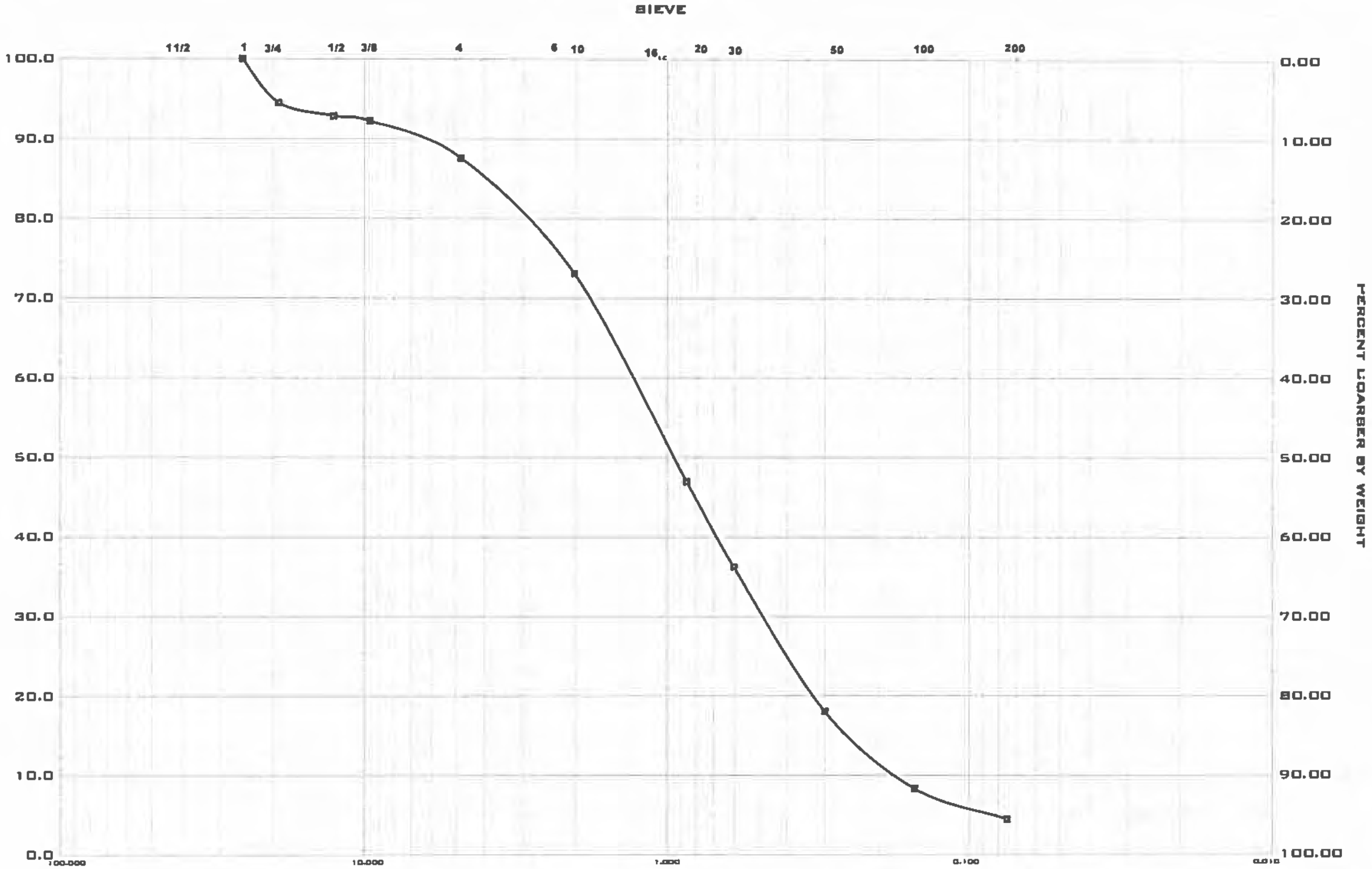
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-111	S-4	8 1/2 - 10'		SP

PROJECT: Coltonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



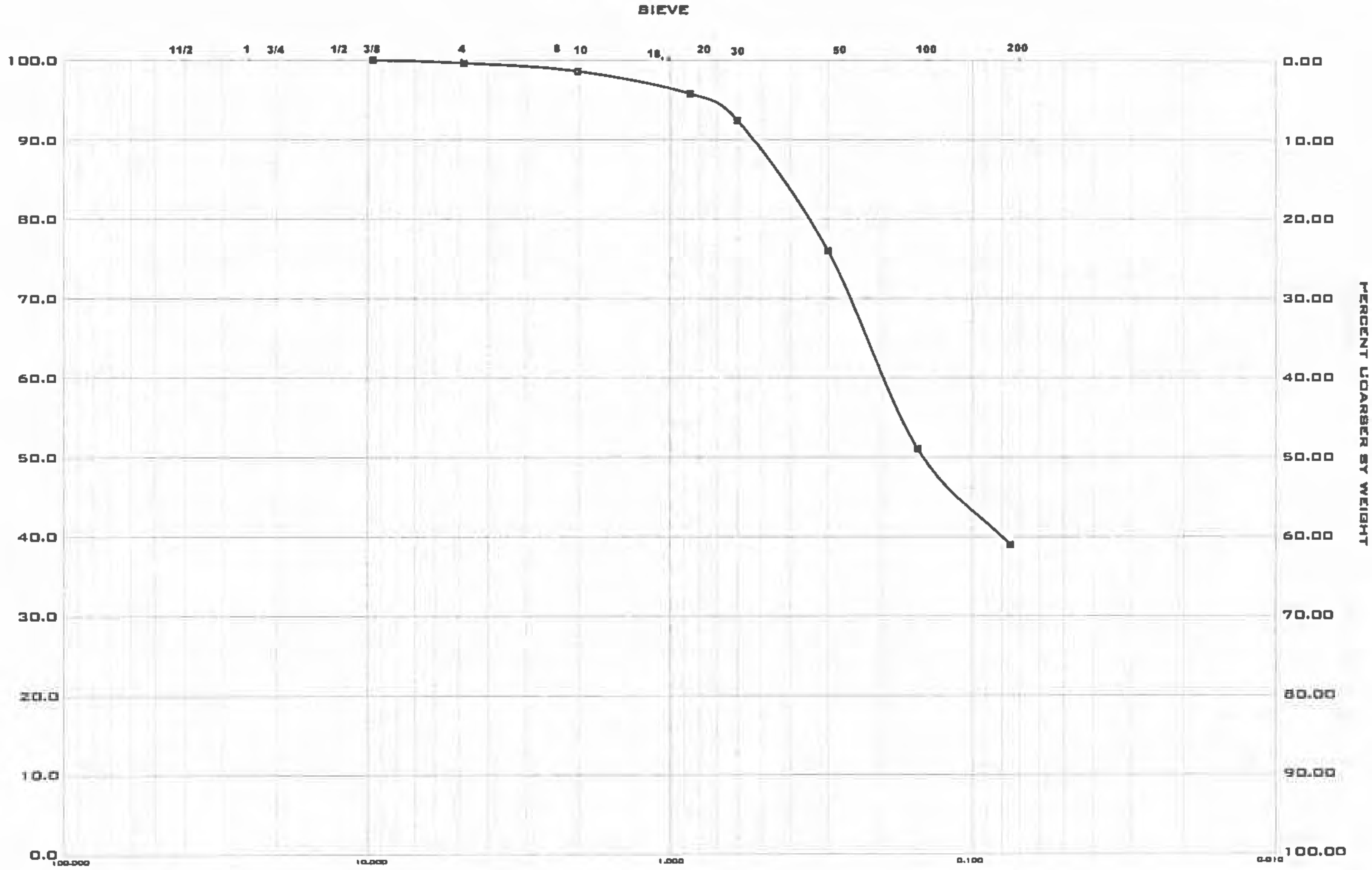
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-111	S-7	23 1/2 - 25'		SP

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE

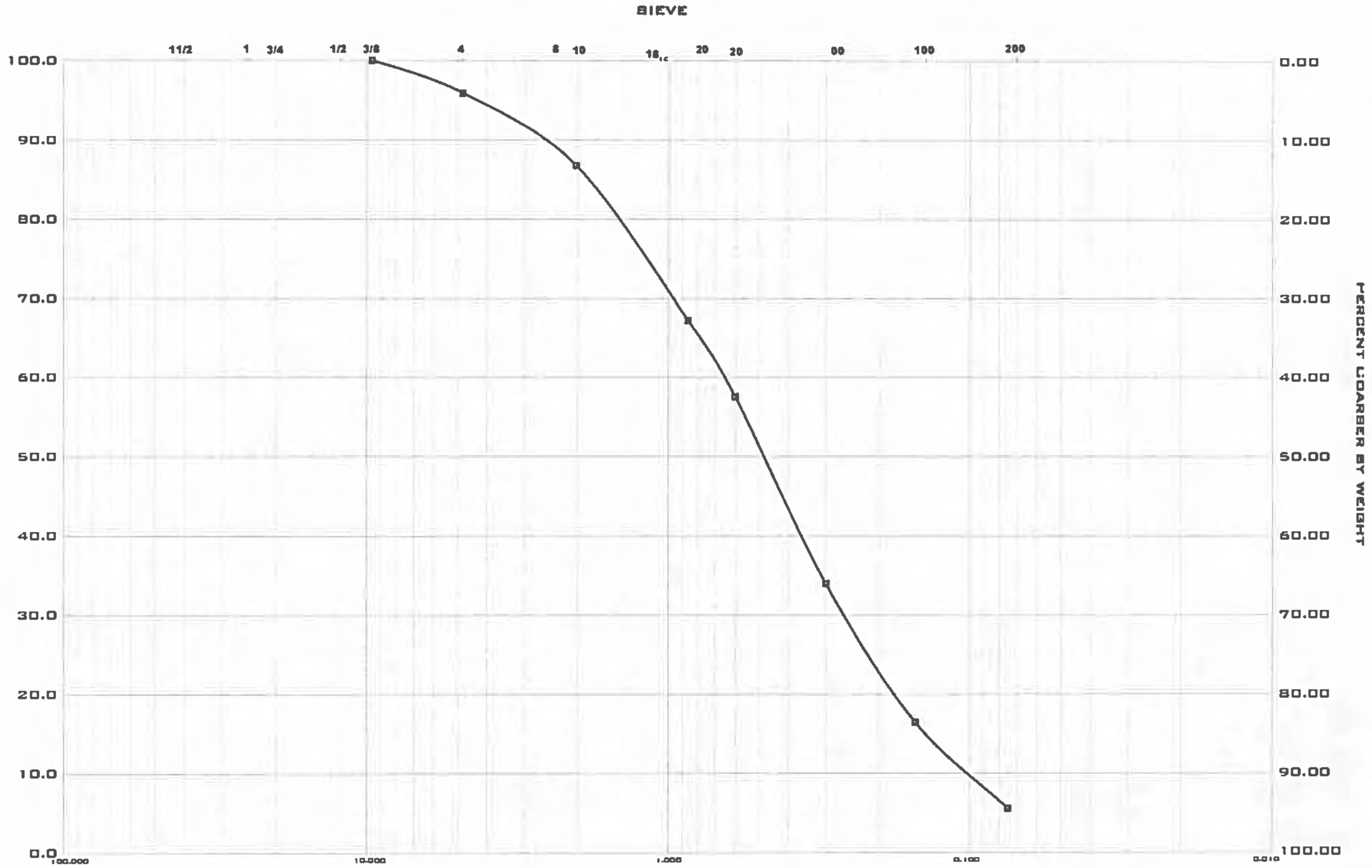


DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-112	U-1	1/2 - 2'		SC

PROJECT:	Cottonwood Ranch Broad-Scale Project #10057849		
DATE:	6/20/2017	JOB NO.	200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-112	S-2	3 1/2 - 5'		SC/SW

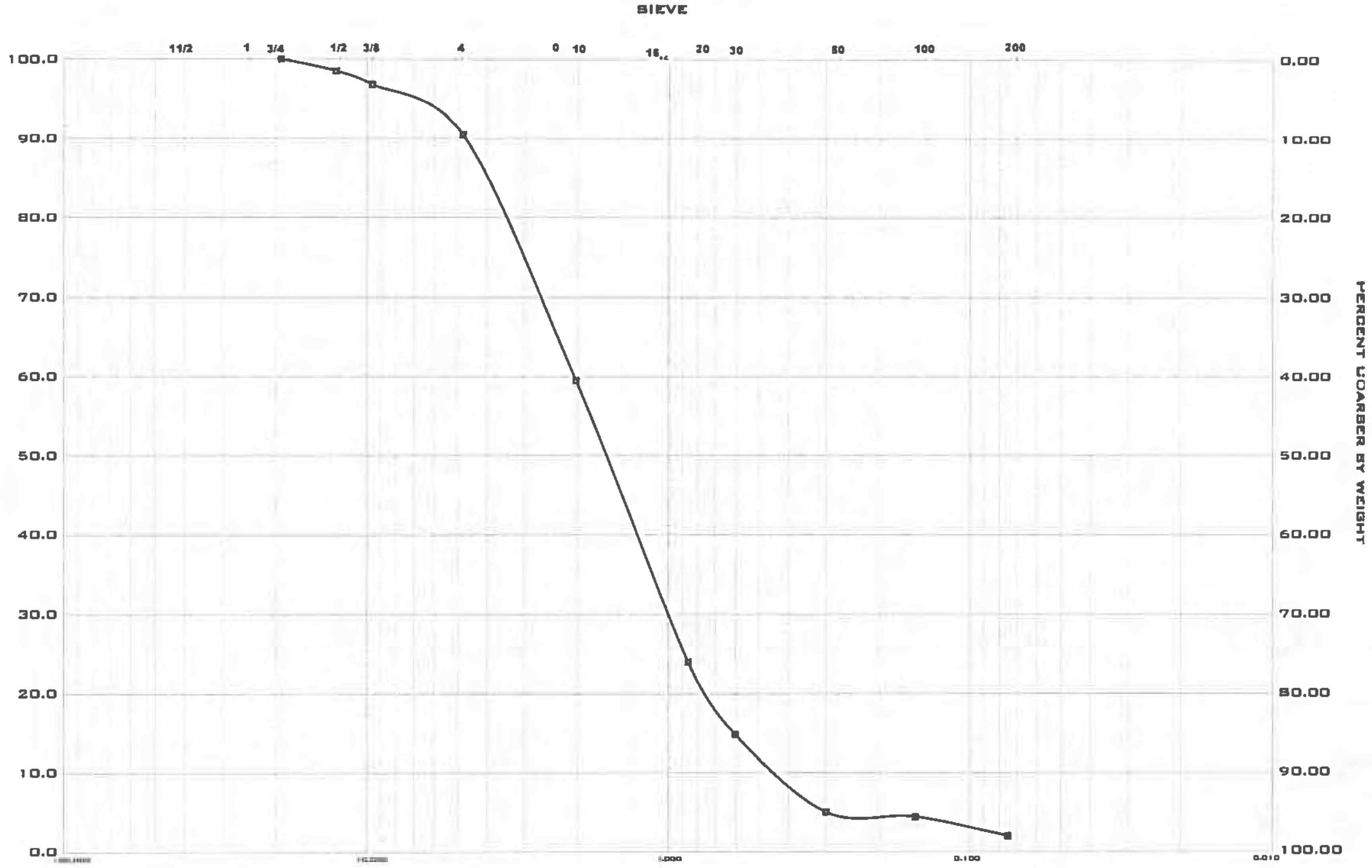
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



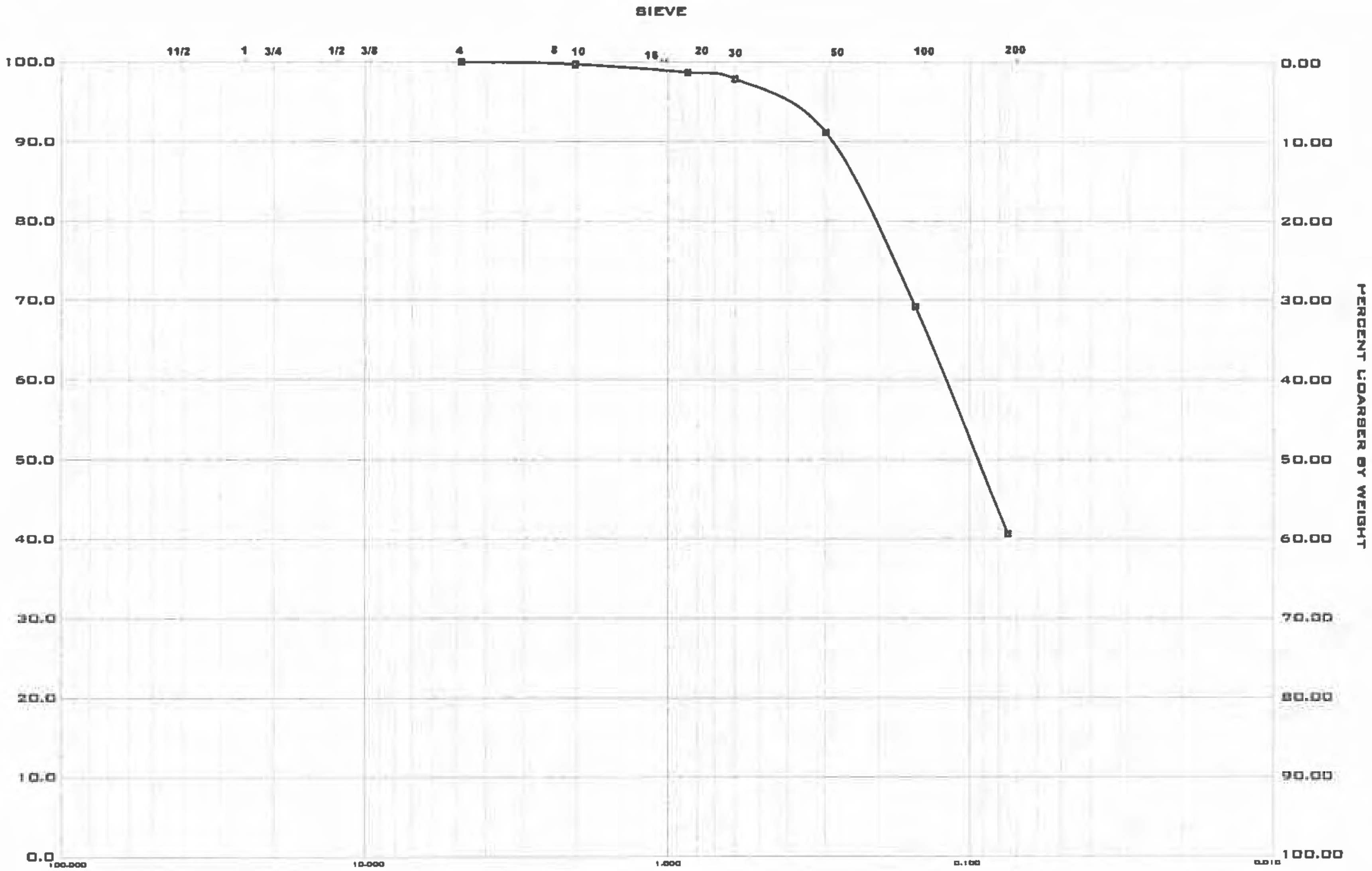
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-113	S-4	8 1/2 - 10'		SP

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-114	S-2	3 1/2 - 5'		SM

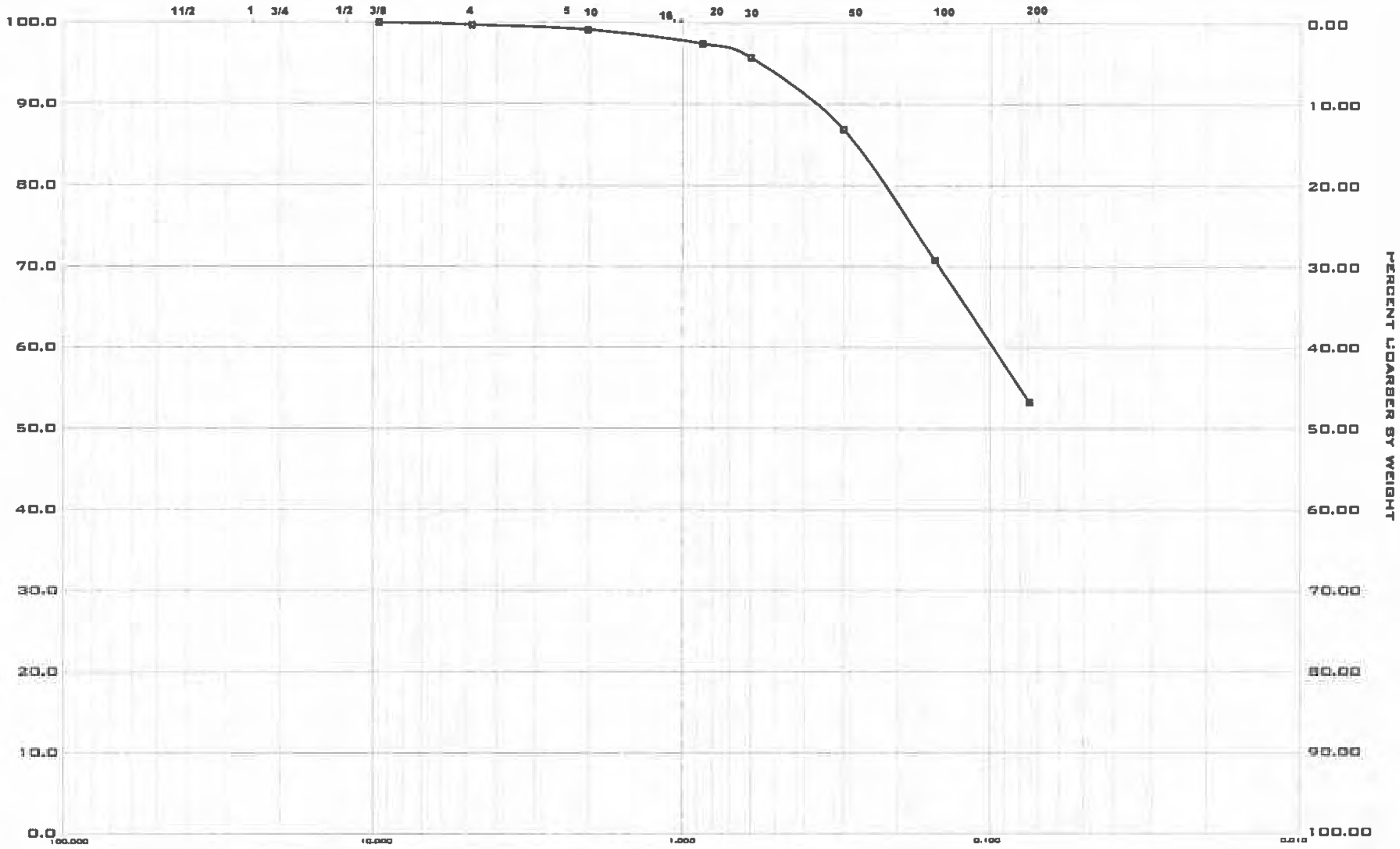
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE

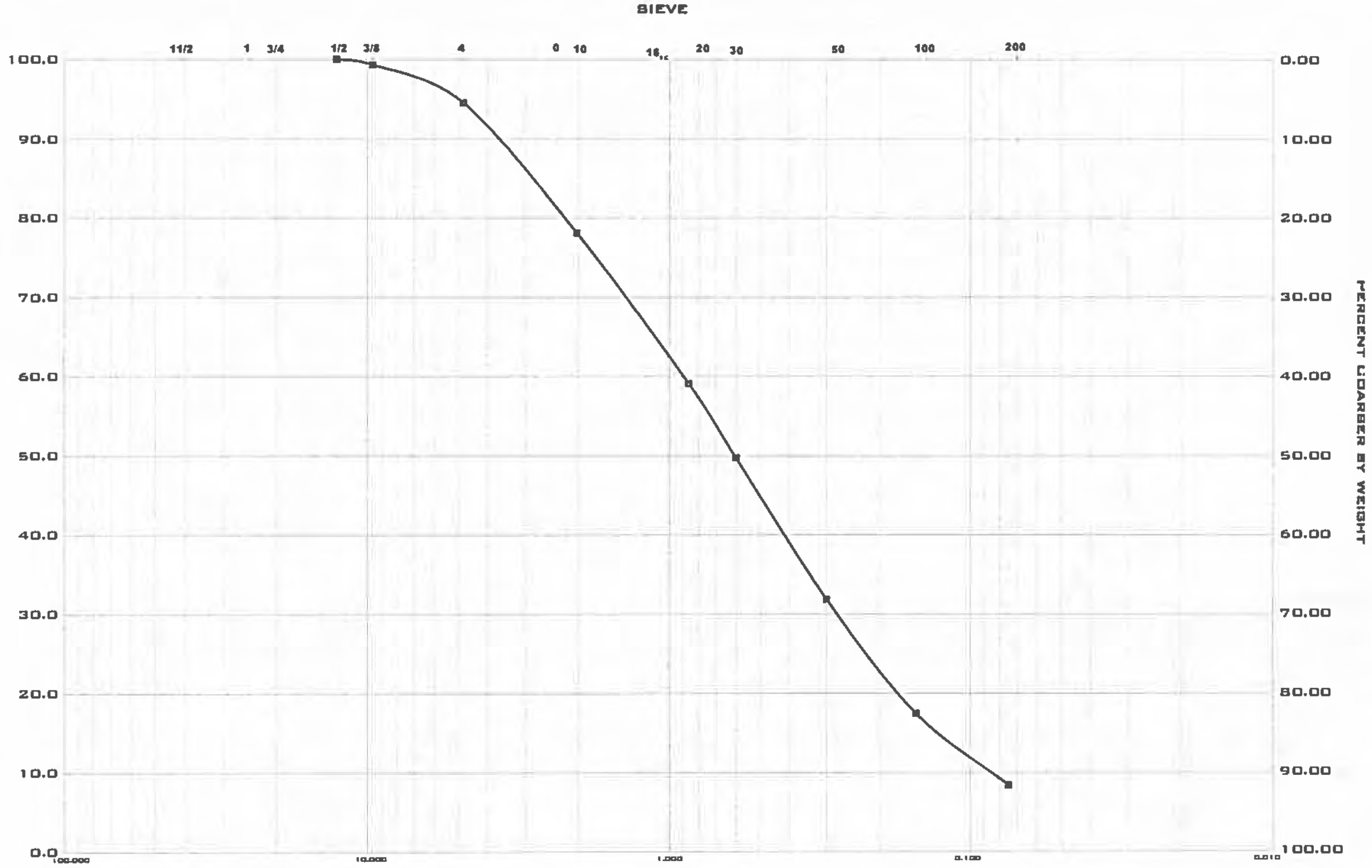


DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-117	U-1	1/2 - 2'		CL

PROJECT:	Cottonwood Ranch Broad-Scale Project #10057849		
DATE.	6/20/2017	JOB NO	200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-117	S-2	3 1/2 - 5'		SM/SP

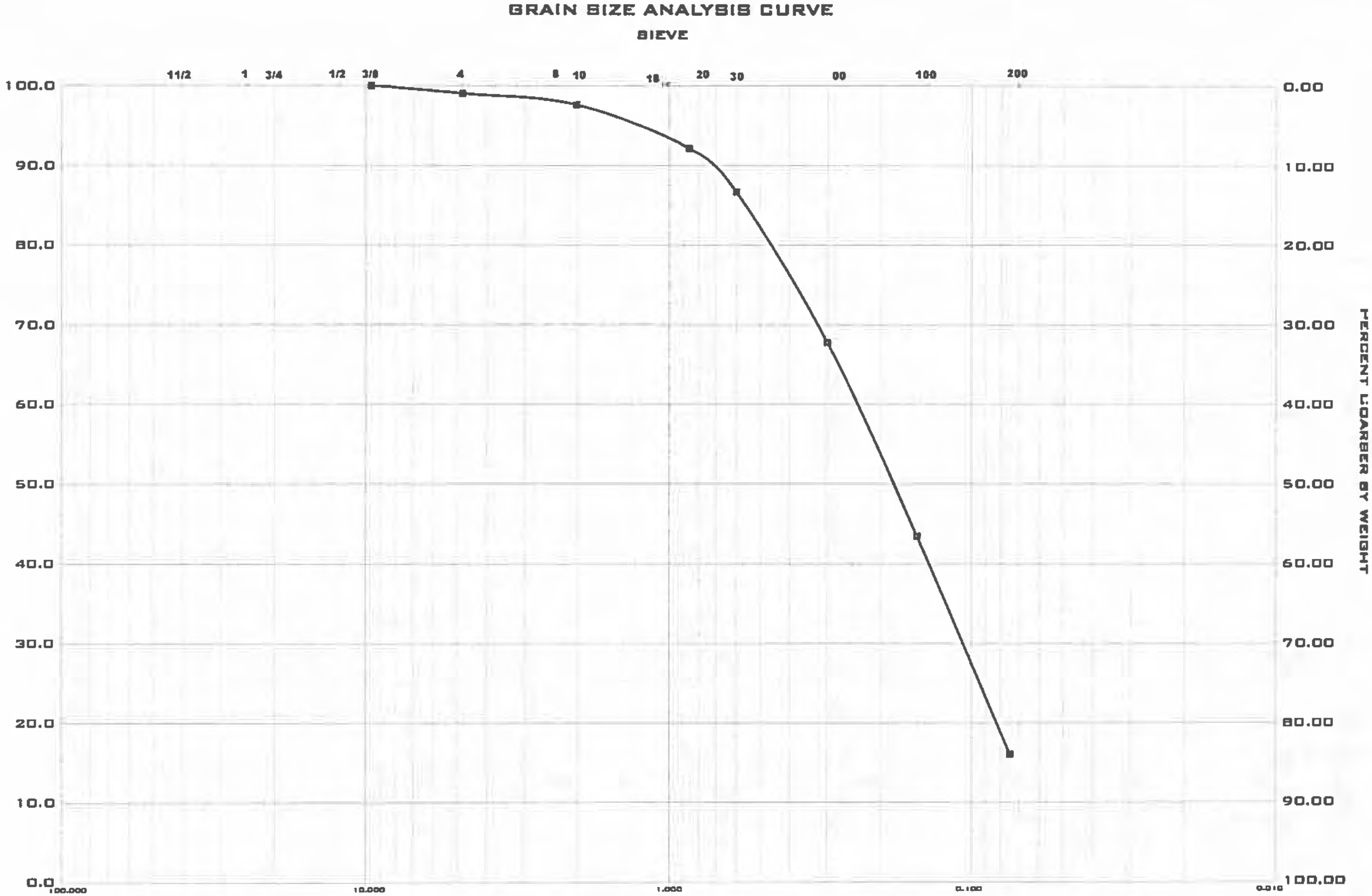
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-118	S-2	3 1/2 - 5'		SM

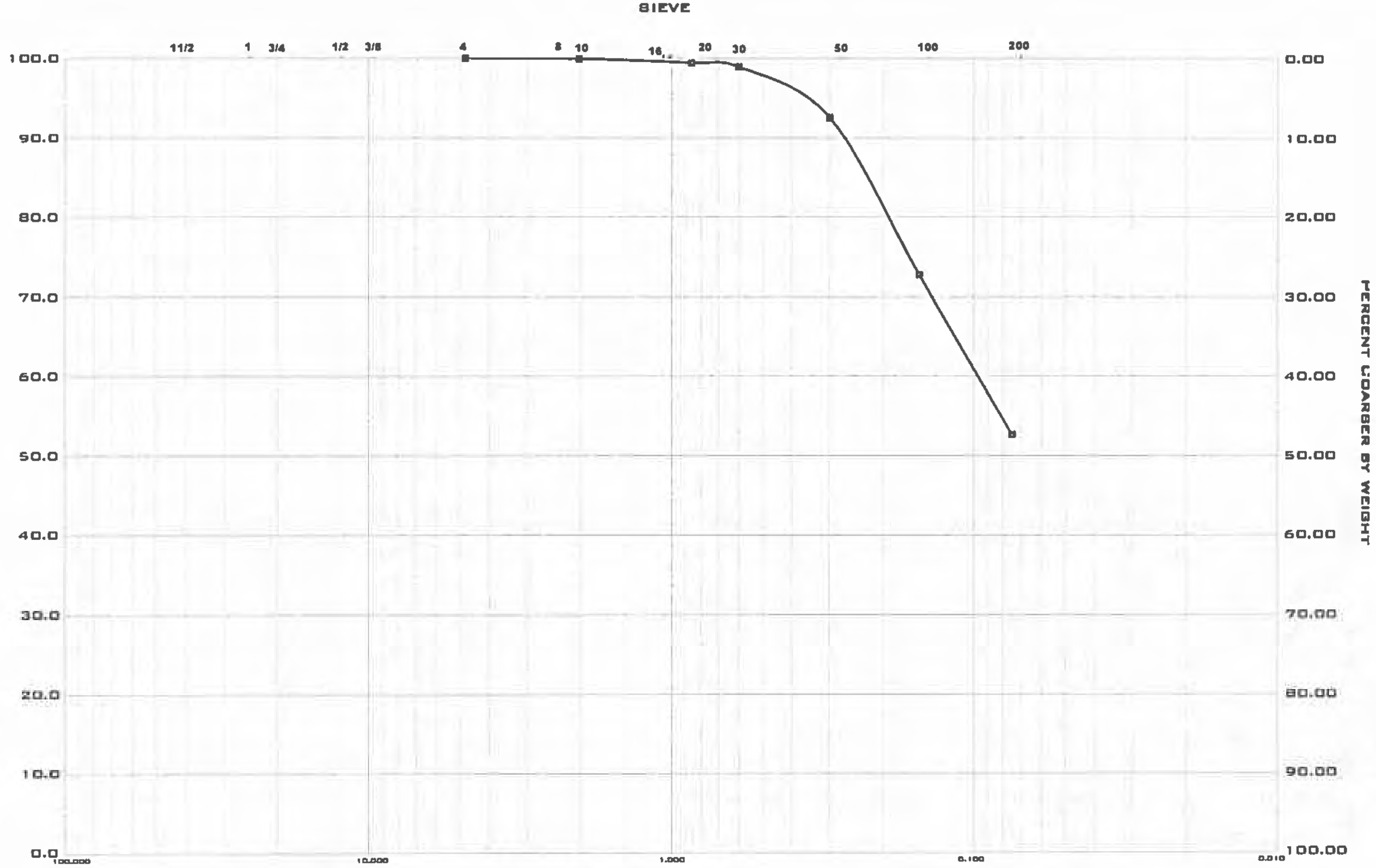
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-119	U-1	1/2 - 2'		ML

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

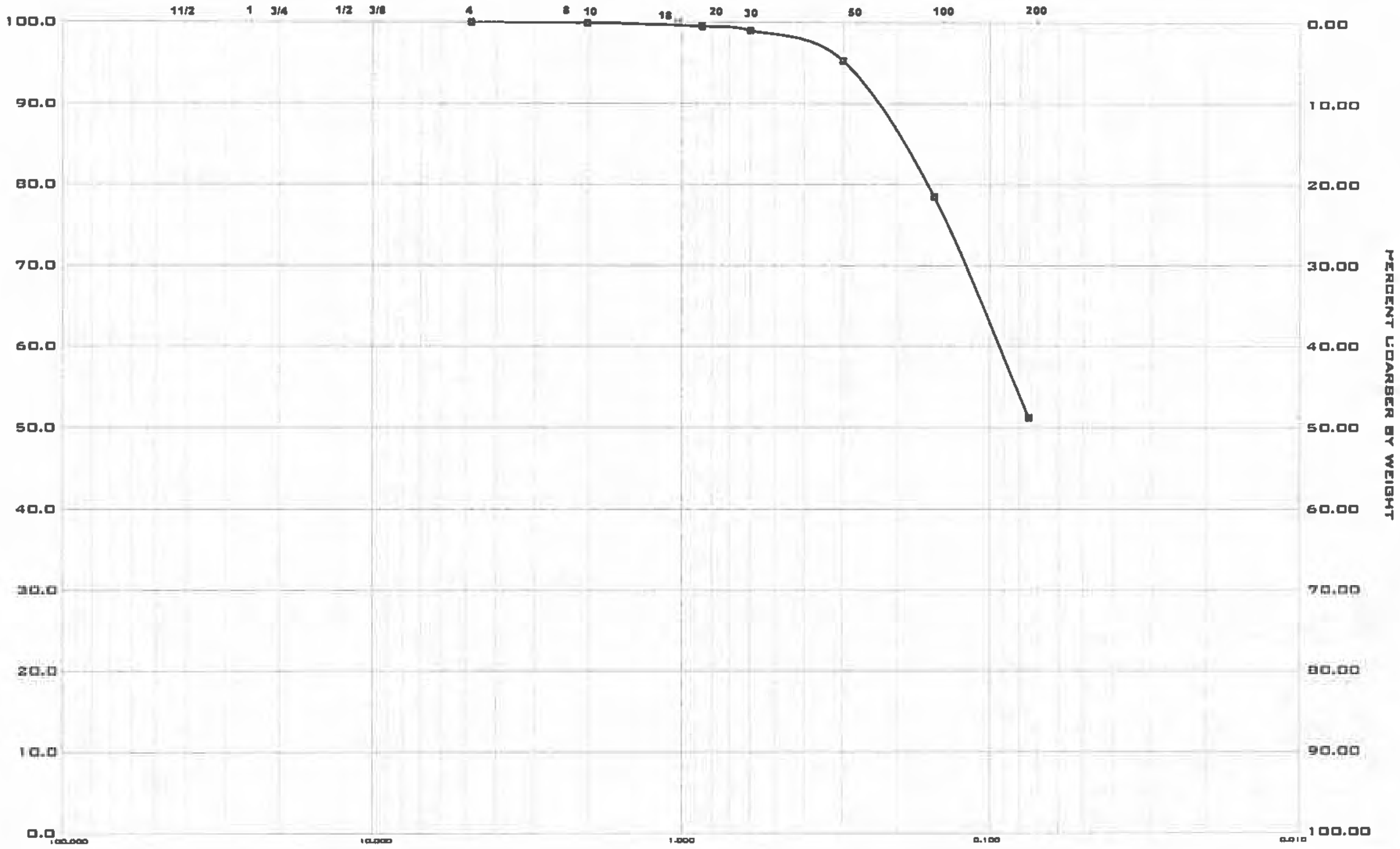
DATE: 6/20/2017

JOB NO 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-121	U-1	1/2 - 2'		CL

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

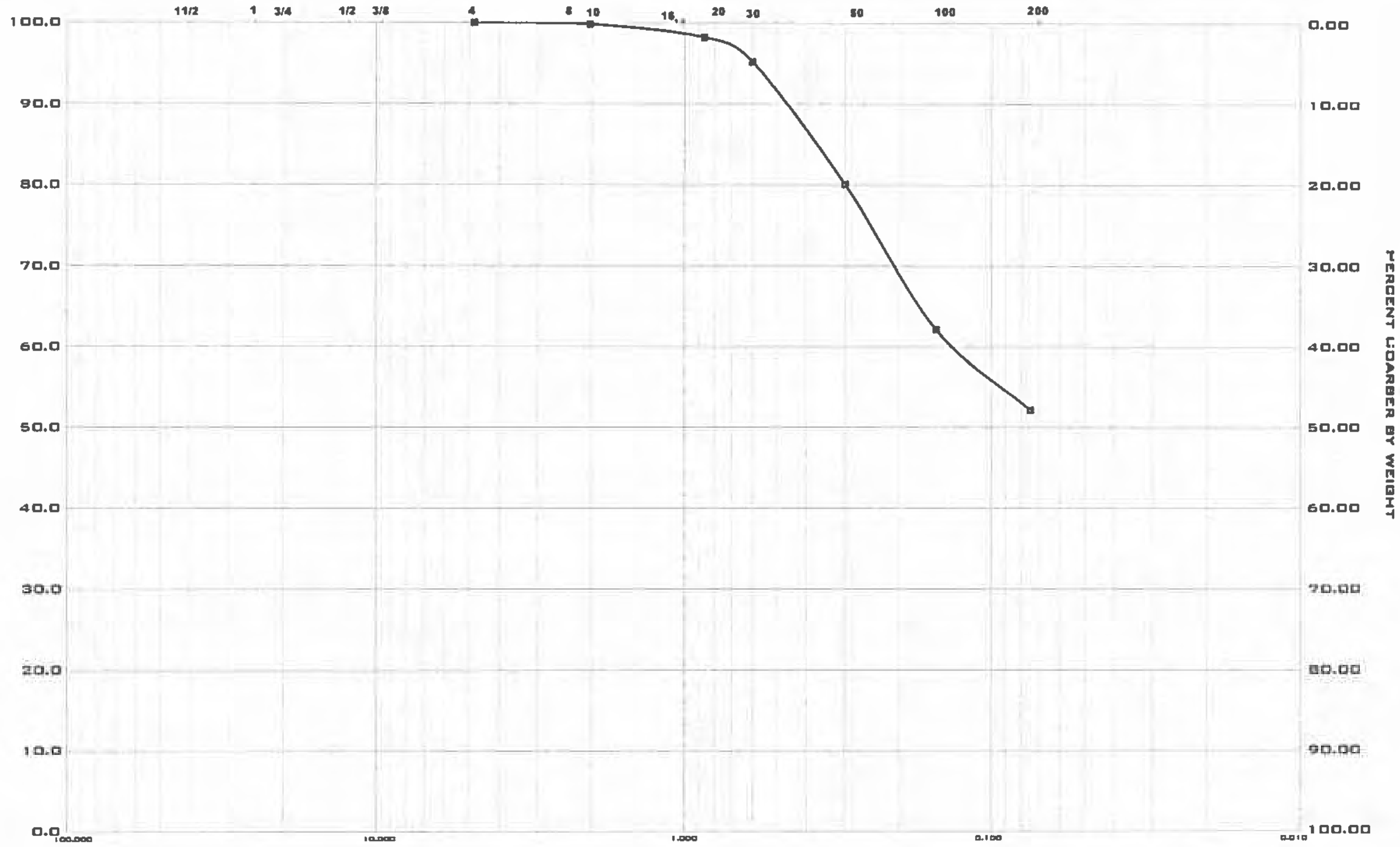
DATE: 6/20/2017

JOB NO 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE

SIEVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-122	U-1	1/2 - 2'		CL

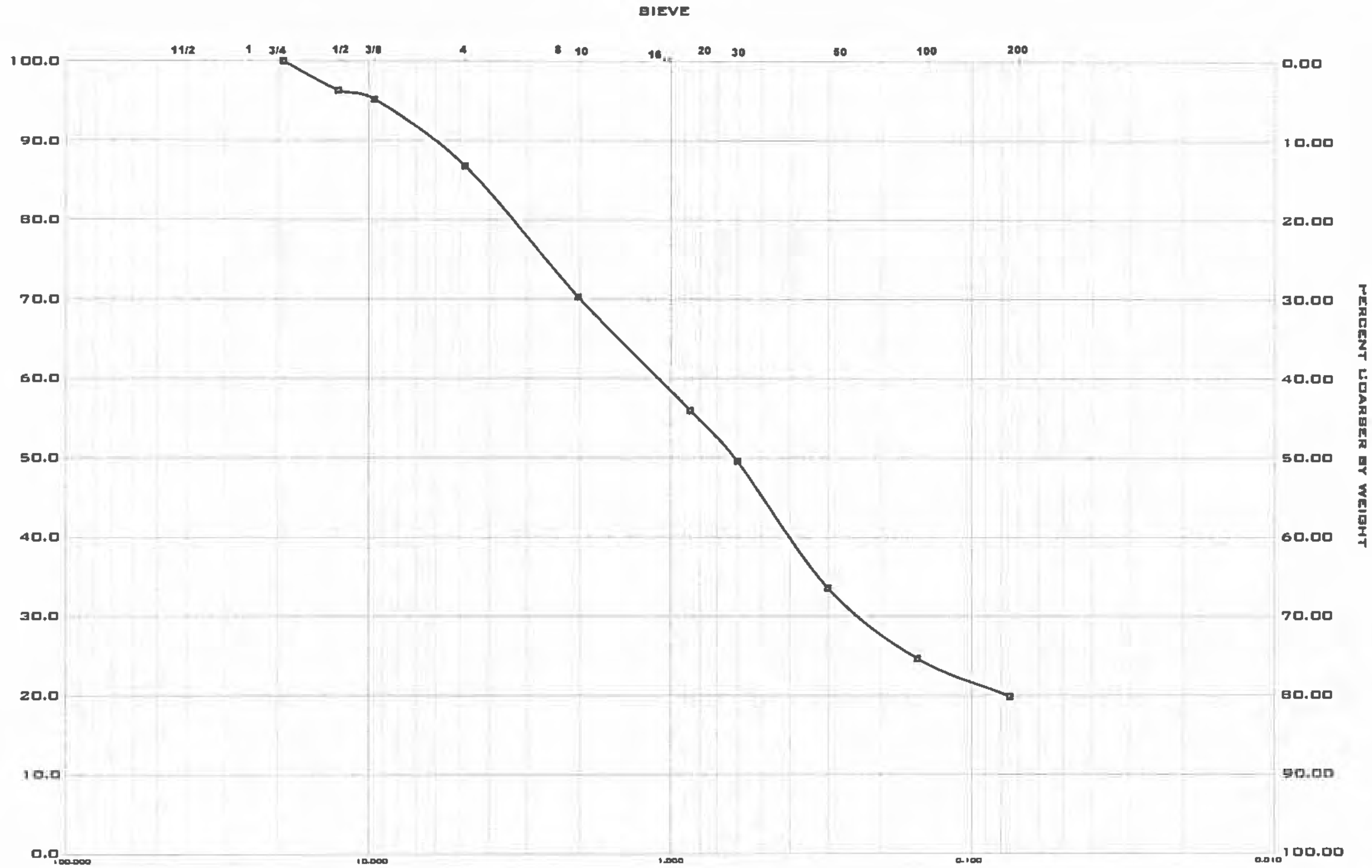
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE. 6/20/2017 JOB NO. 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



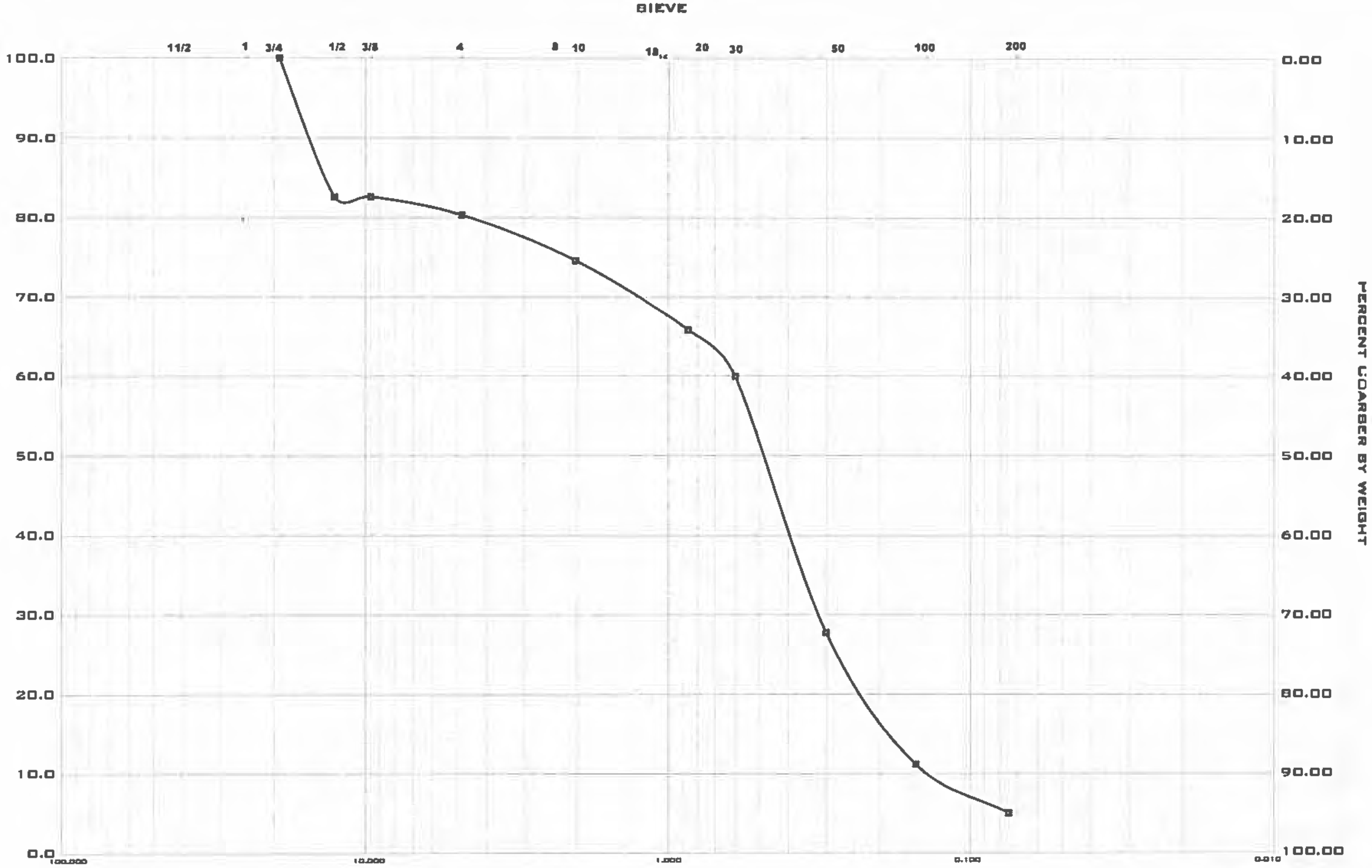
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-123	S-3	5 1/2 - 7'		SM

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE

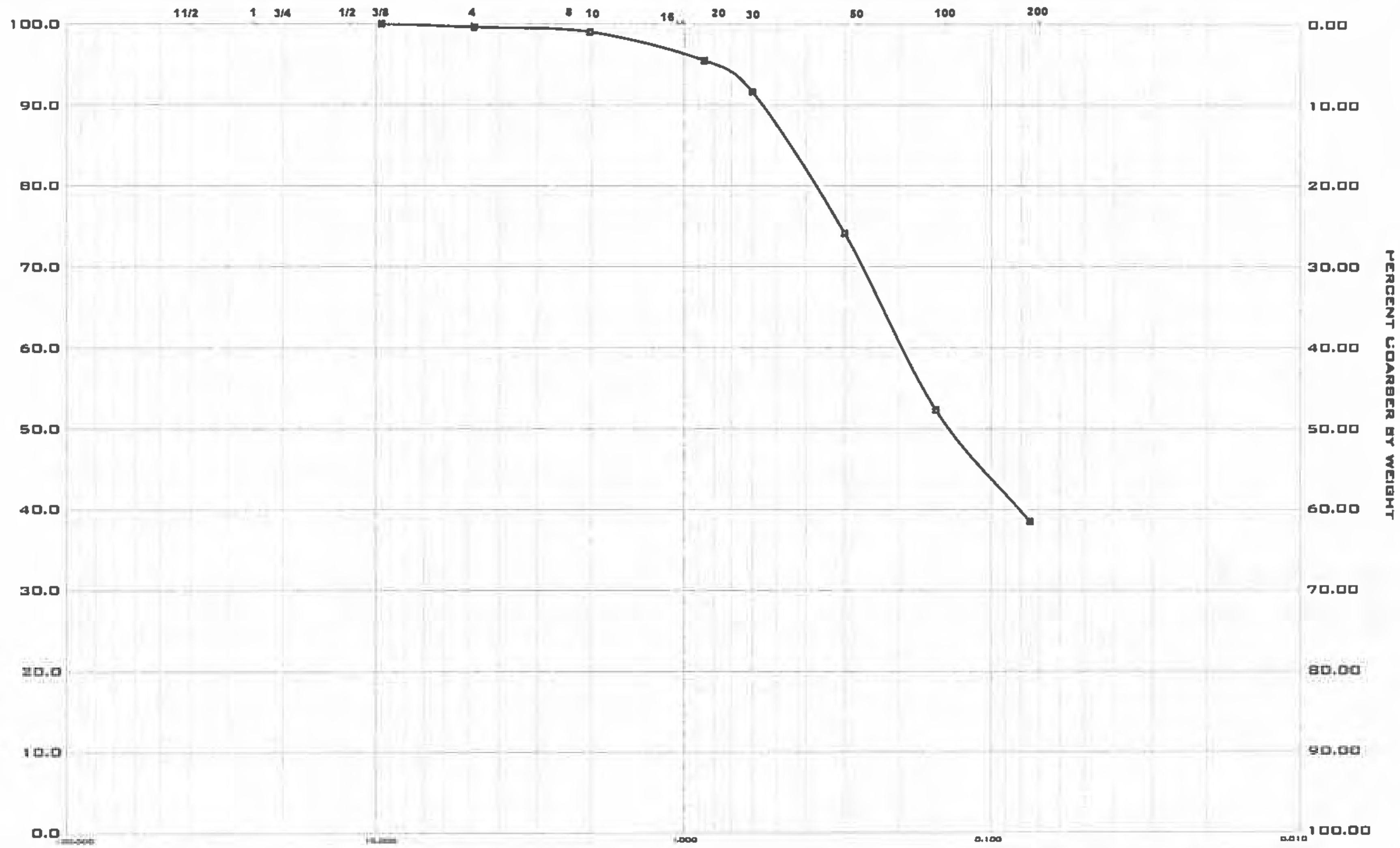


DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-123	S-4	8 1/2 - 10'		SP

PROJECT:	Cottonwood Ranch Broad-Scale Project #10057849		
DATE:	6/20/2017	JOB NO.	200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



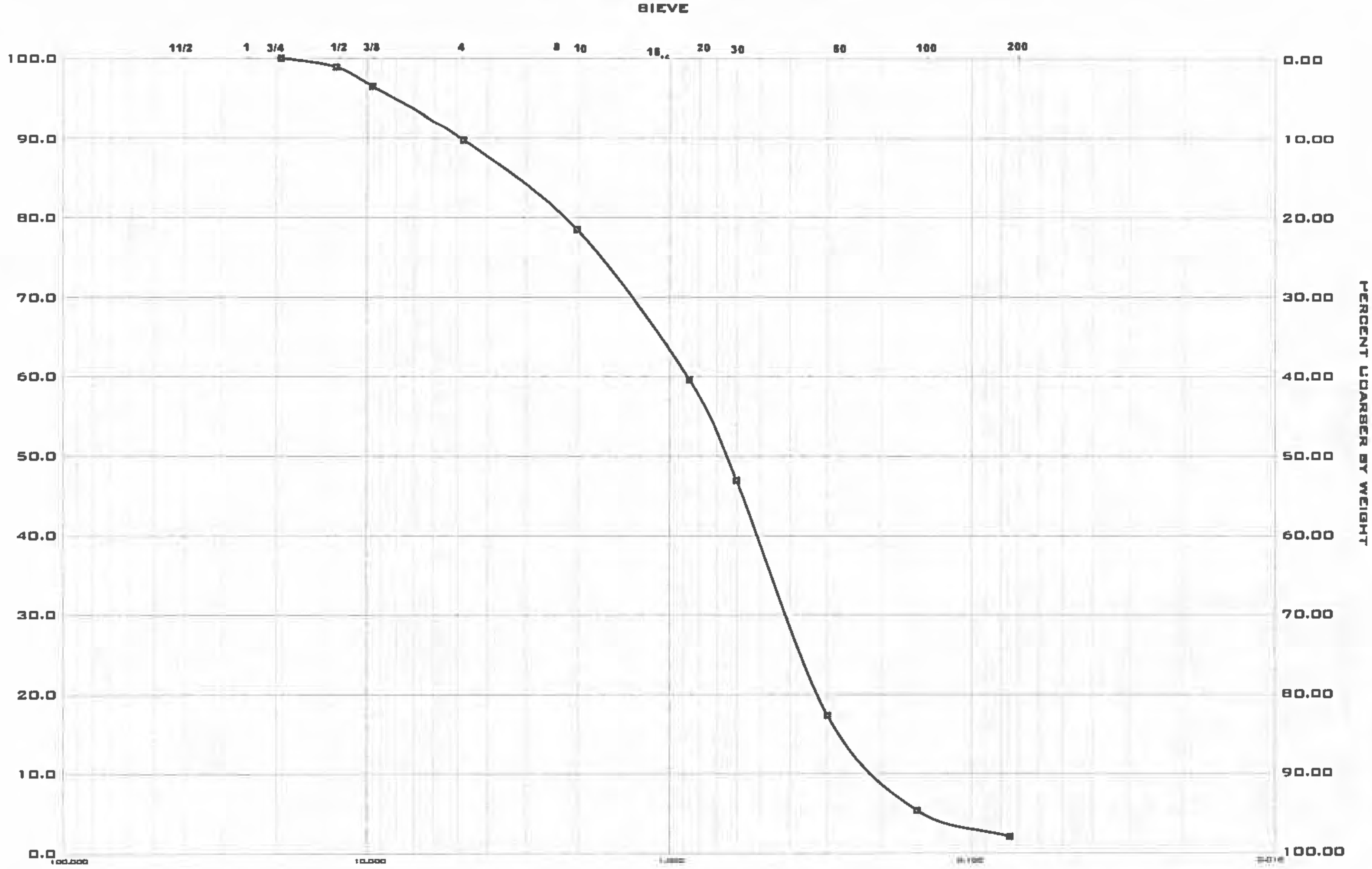
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-124	U-1	1/2 - 2'		SC

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE. 6/20/2017 JOB NO 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-125	S-5	13 1/2 - 15'		SP

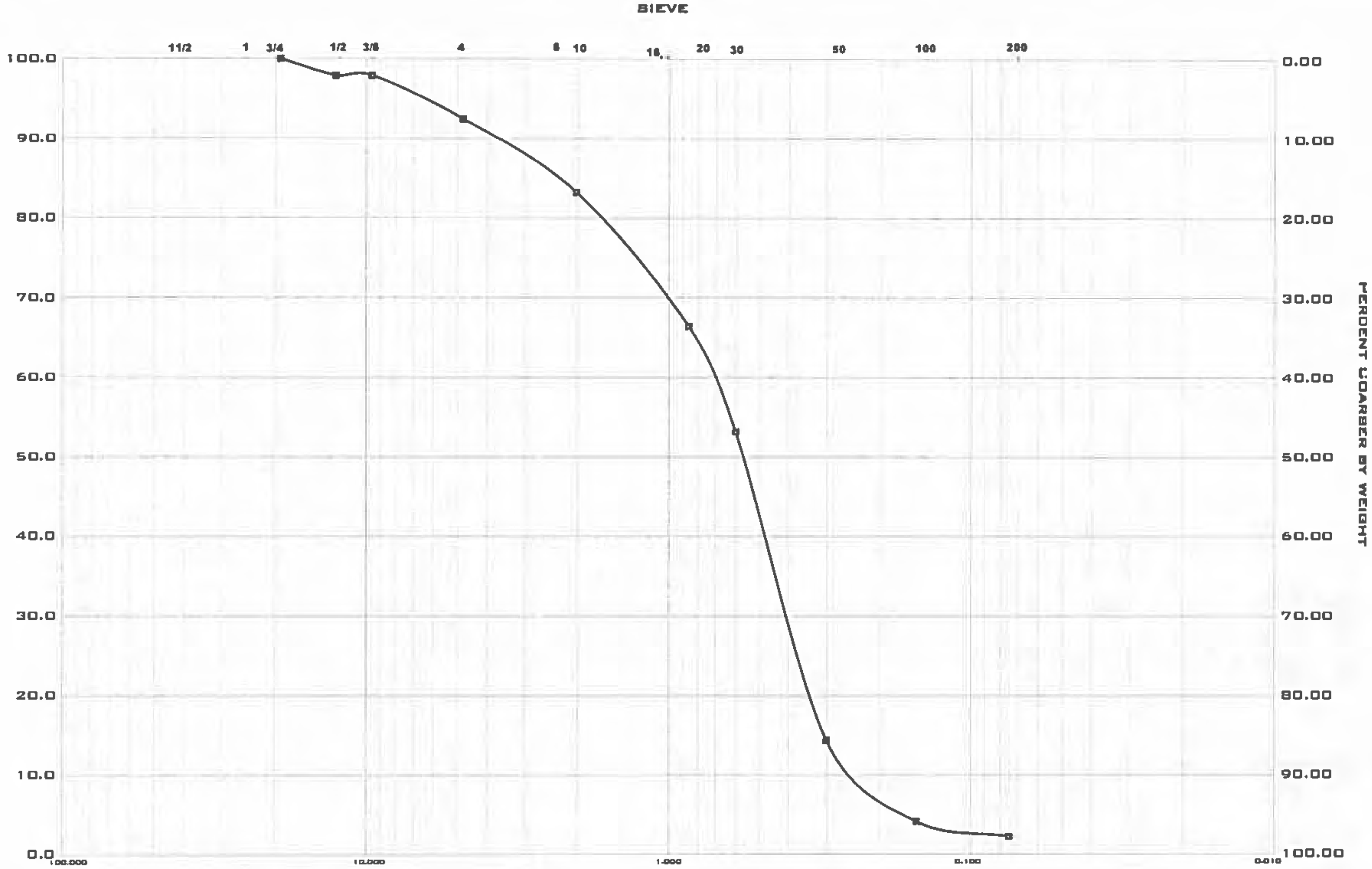
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



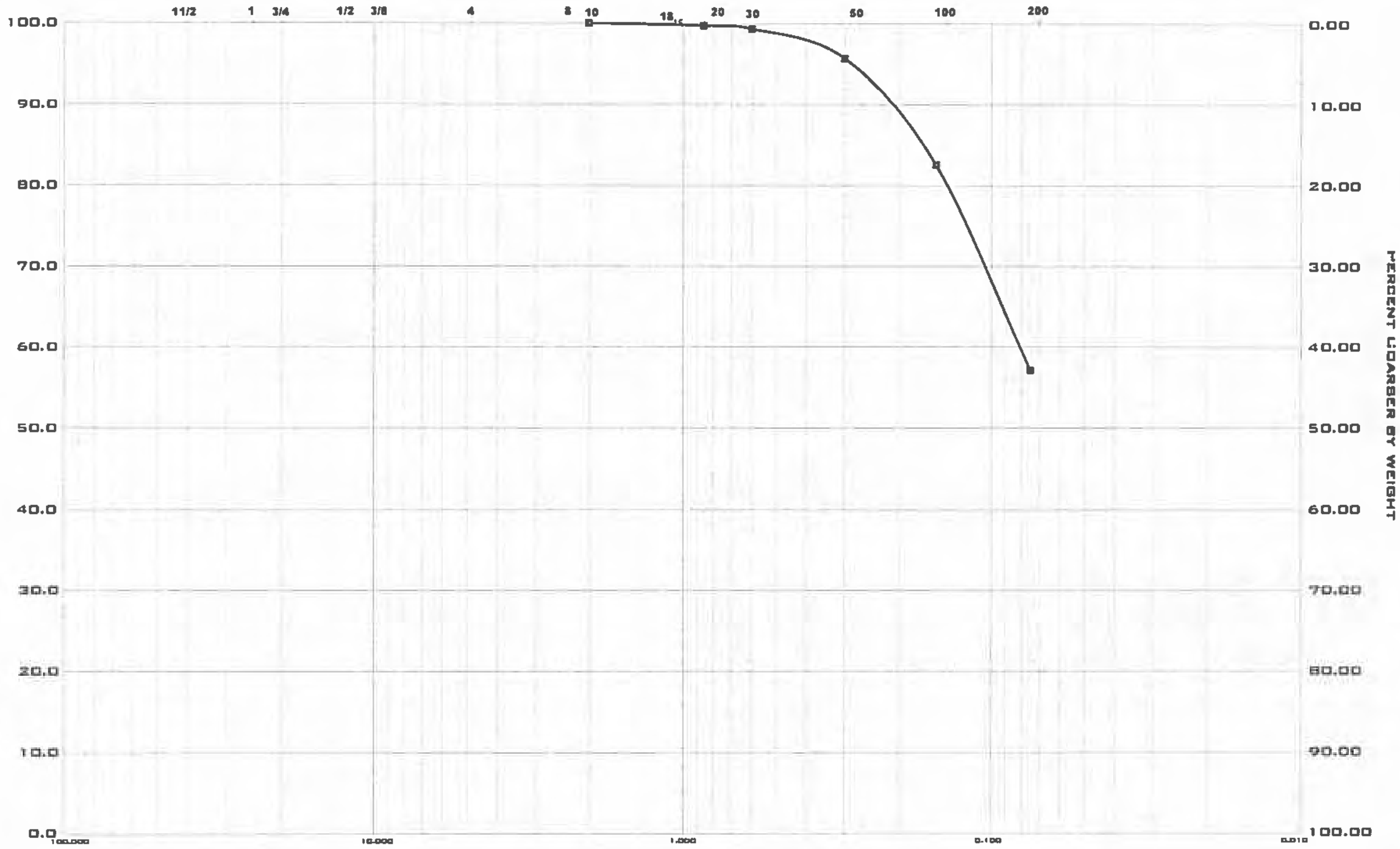
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-125	S-8	28 1/2 - 30'		SP

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-126	U-1	1/2 - 2'		CL

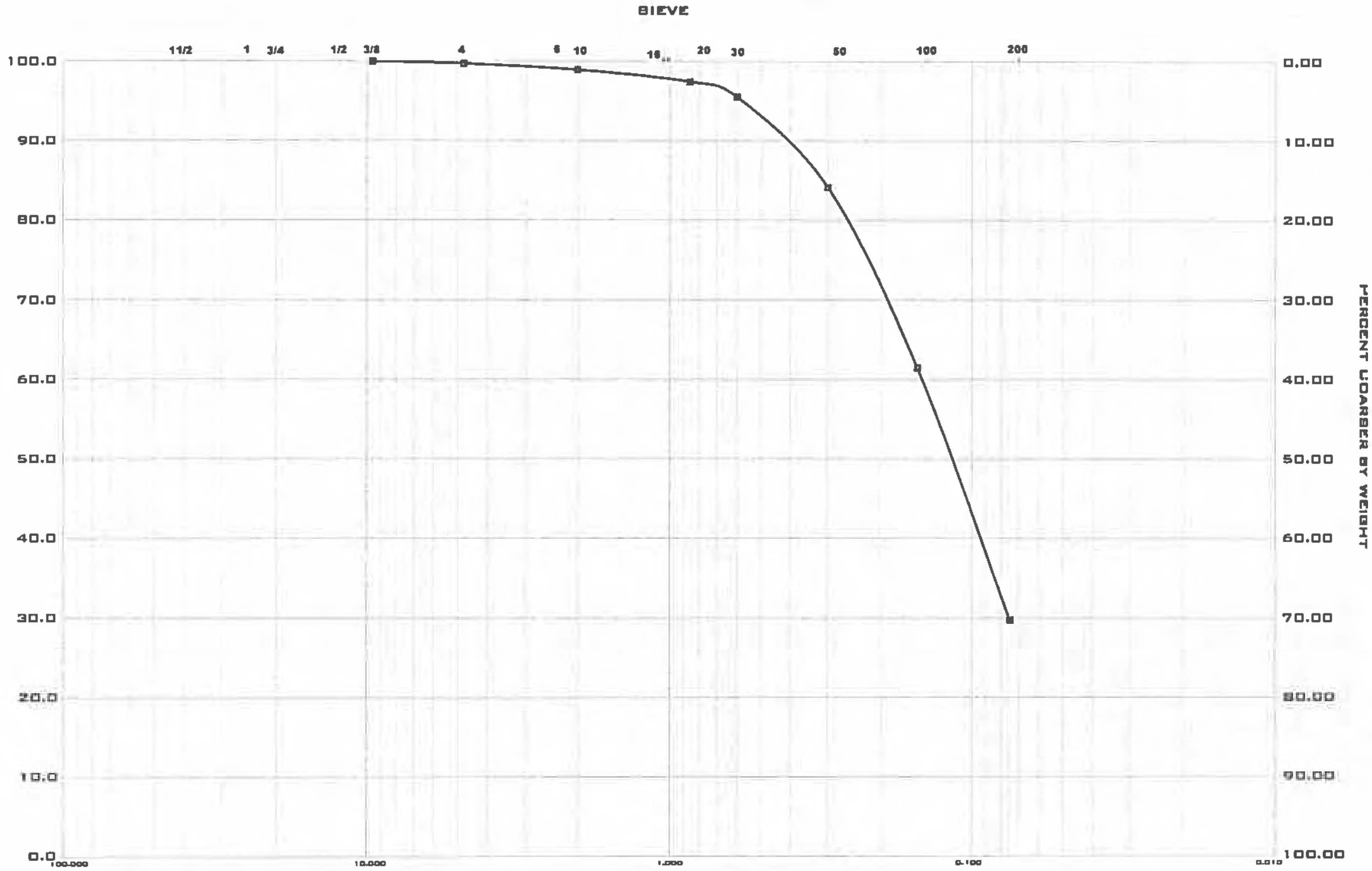
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-126	S-2	3 1/2 - 5'		SM

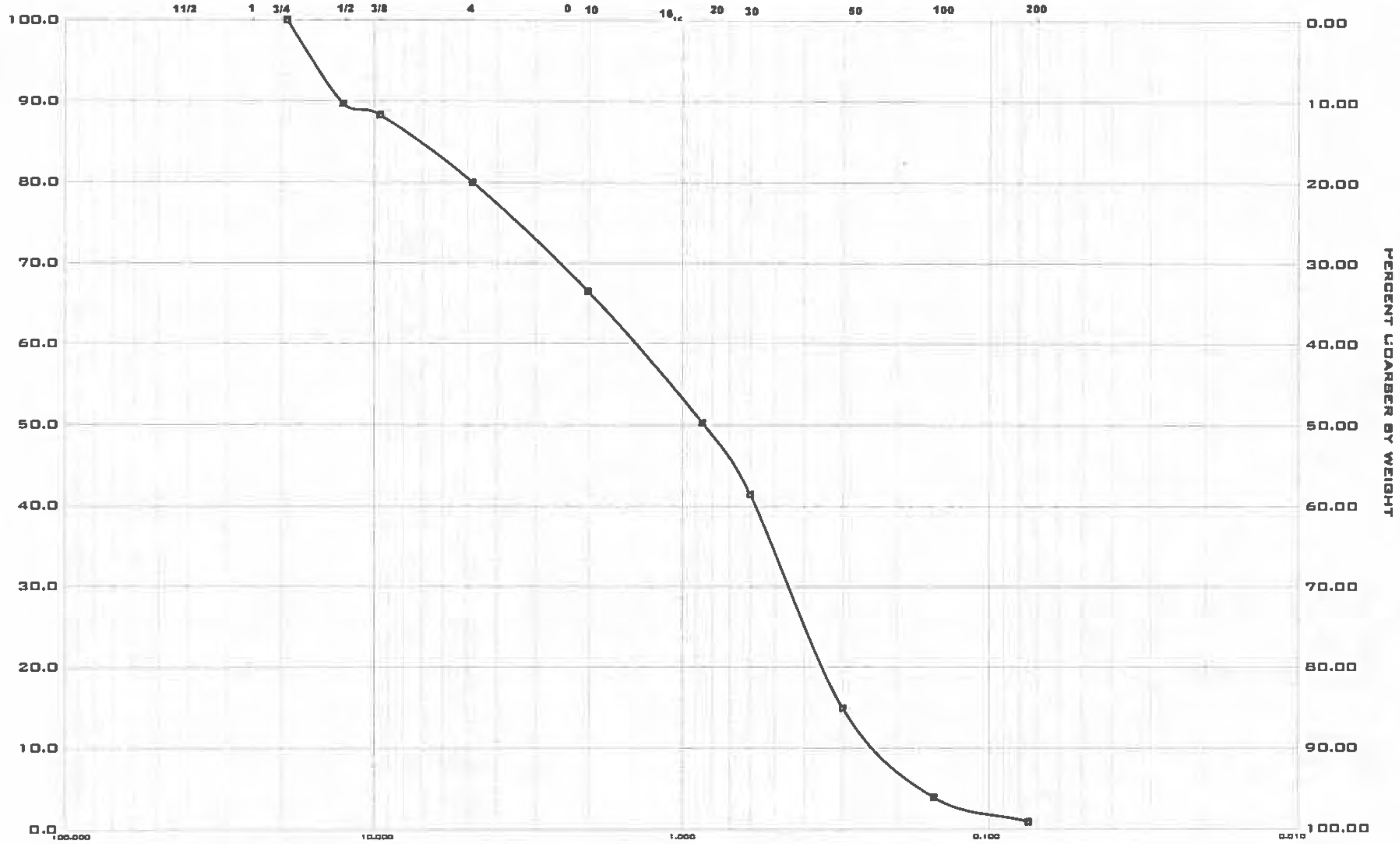
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE

SIEVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-129	S-4	8 1/2 - 10'		SP

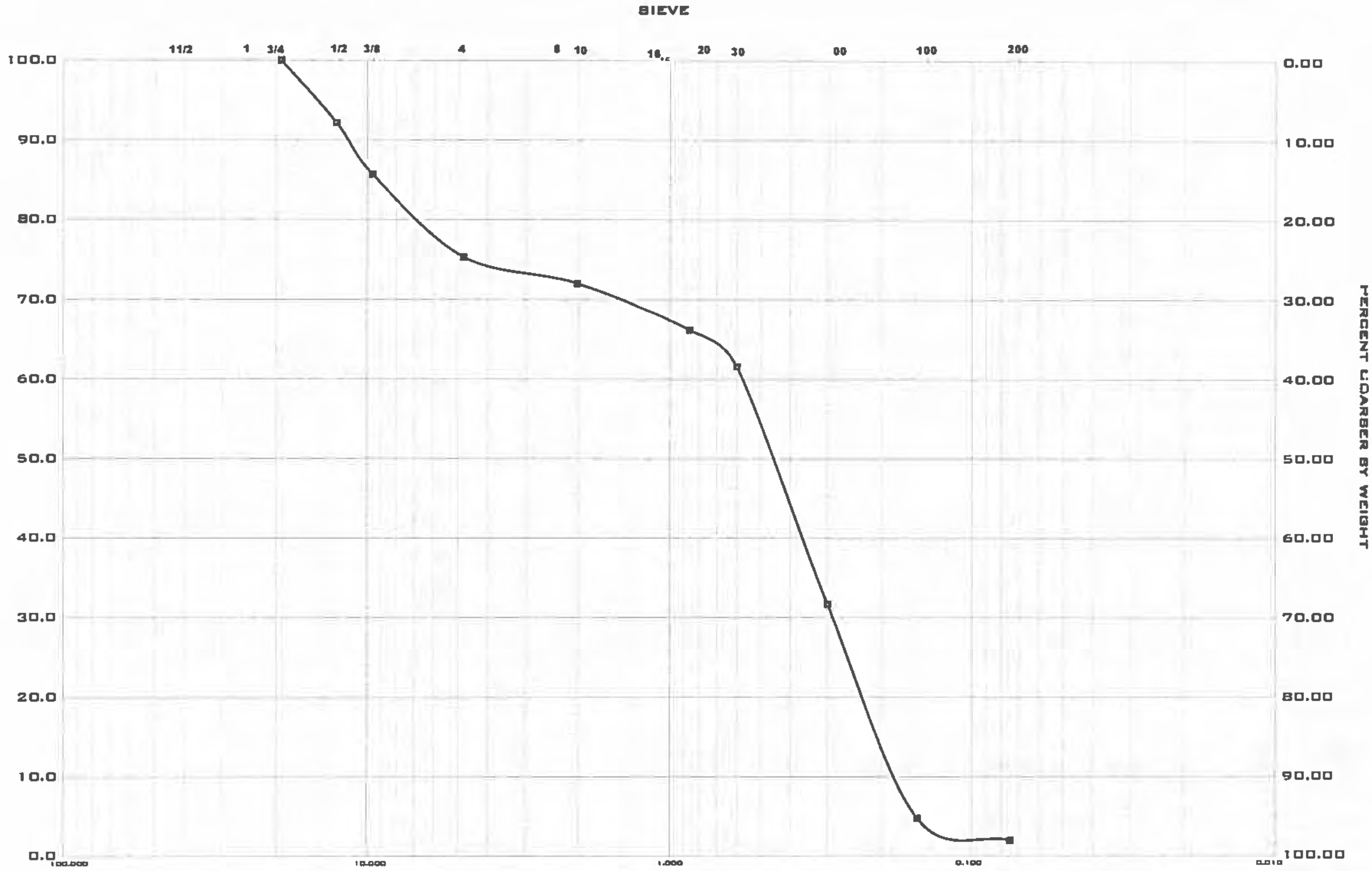
PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO 200-05-24

MID-STATE

ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



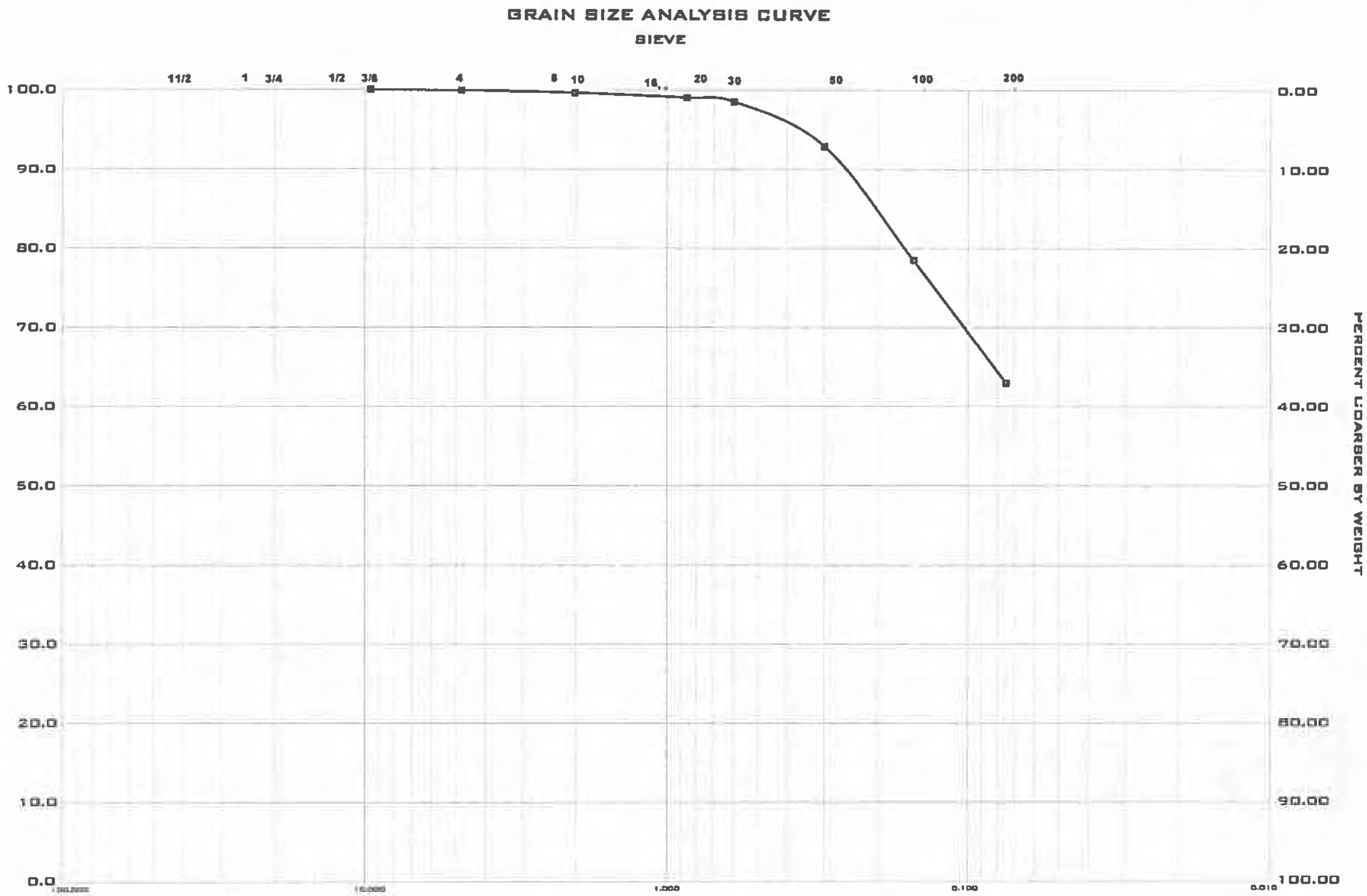
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-129	S-8	28 1/2 - 30'		SP

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017

JOB NO: 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.



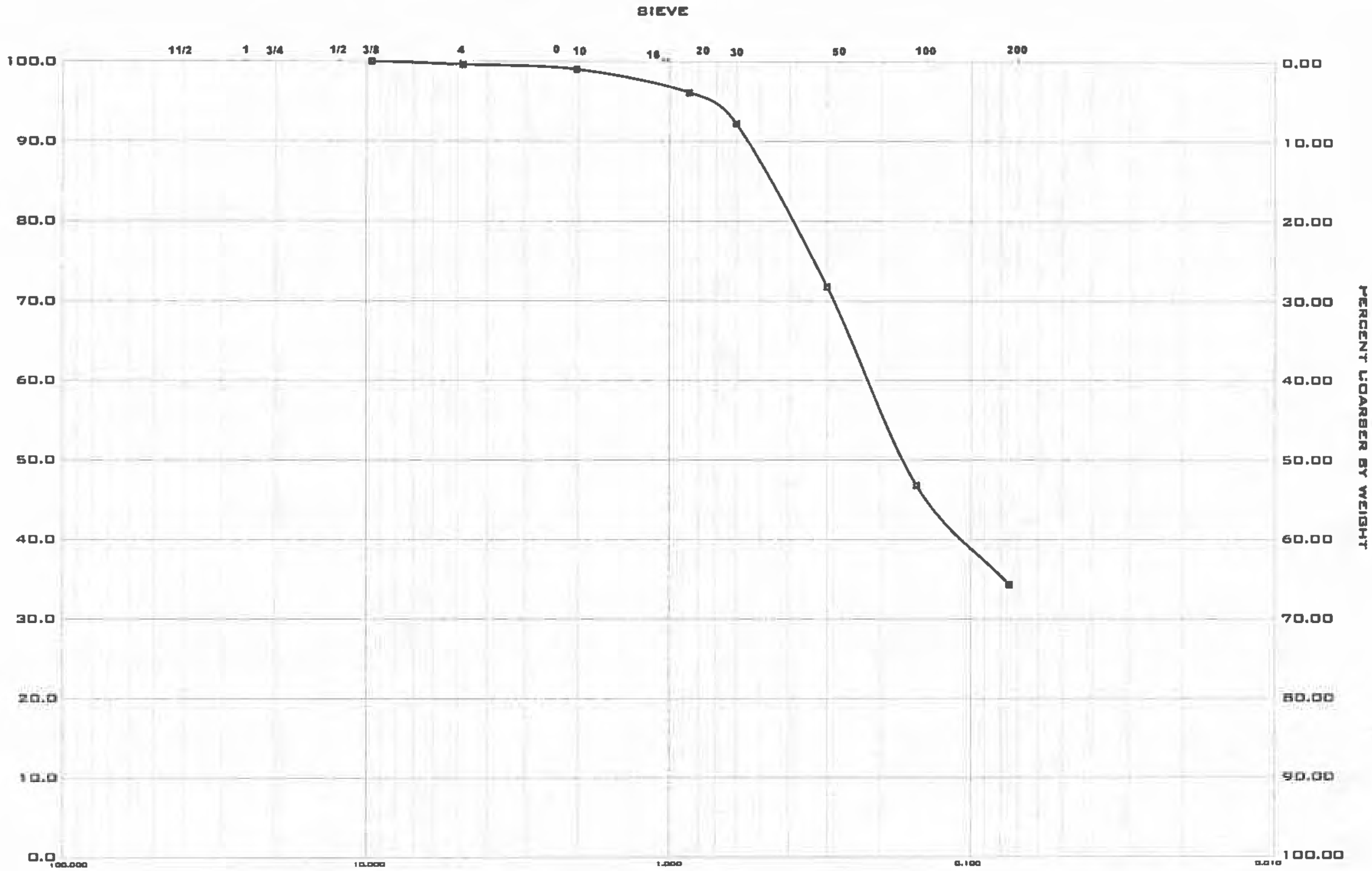
DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-130	U-1	1/2 - 2'		CL

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE: 6/20/2017 JOB NO 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

GRAIN SIZE ANALYSIS CURVE



DRILL HOLE	SAMPLE NUMBER	SAMPLE DEPTH	WATER CONTENT %	CLASSIFICATION
B-131	U-1	1/2 - 2'		SC

PROJECT: Cottonwood Ranch Broad-Scale Project #10057849

DATE. 6/20/2017

JOB NO. 200-05-24

MID-STATE
ENGINEERING AND TESTING, INC.

Appendix C
Percolation Test Reports

MID-STATE
Engineering
& Testing Inc.
279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch BSR
LOCATION	Elm Creek, NE
CLIENT	HDR
JOB NUMBER	200-05-24

Owner: HDR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25. Water was continouly placed in the hole throuhgout the day.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elasped (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-1	24"	24-May	3:30 PM	25-May	7:50 AM	25-May	8:00	6	0	0.00	
							8:01	5.875	1	0.13	8.0
							8:02	5.8125	2	0.19	10.7
							8:03	5.8125	3	0.19	16.0
							8:04	5.75	4	0.25	16.0
							8:05	5.6875	5	0.31	16.0
							8:10	5.3125	10	0.69	14.5
							8:15	5	15	1.00	15.0
							8:30	4.125	30	1.88	16.0
							9:00	2.25	60	3.75	16.0

P.E.
Person Conducting Test

A- 2532

MID-STATE
Engineering & Testing Inc.

279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT Cottonwood Ranch
LOCATION Elm Creek, NE
CLIENT HDR
JOB NUMBER 200-05-24

Owner: HDR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25. Water was continouly placed in the hole throuhgout the day. After initial testing, the hole was refilled and retested at 3:20 PM with the following results.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elasped (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-2	12"	24-May	10:30AM	25-May	7:45 AM	25-May	3:00 PM	6	0	0.00	
							3:01 PM	5.75	1	0.25	4.0
							3:02 PM	5.5625	2	0.44	4.6
							3:03 PM	5.3125	3	0.69	4.4
							3:04 PM	5.25	4	0.75	5.3
							3:05 PM	5	5	1.00	5.0
							3:10 PM	4.1875	6	1.81	3.3
							3:15 PM	3.25	7	2.75	2.5
						Mismeasured water - Ran dry					
TP-3	12"	24-May	10:30AM	25-May	7:45 AM	25-May	3:20 PM	6	0	0.00	
							3:21 PM	5.8125	1	0.19	5.3
							3:22 PM	5.75	2	0.25	8.0
							3:23 PM	5	3	1.00	3.0
							3:24 PM	5	4	1.00	4.0
							3:25 PM	5	5	1.00	5.0
							3:26 PM	5	6	1.00	6.0
							3:27 PM	4.8125	7	1.19	5.9
							3:28 PM	4.8125	8	1.19	6.7
							3:29 PM	4.6875	9	1.31	6.9
							3:30 PM	4.6875	10	1.31	7.6
							3:35 PM	4.5	15	1.50	10.0
							3:50 PM	4.125	30	1.88	16.0
							4:20 PM	3.625	60	2.38	25.3

P.E.
Person Conducting Test

A- 2532

MID-STATE
Engineering
& Testing Inc.
279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch
LOCATION	Elm Creek, NE
CLIENT	HDR
JOB NUMBER	200-05-24

Owner: HDR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25. At the end of initial testing at 8:15, this location was refilled retested at 8:30 AM with similar results.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elasped (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-3	24"	24-May	10:30AM	25-May	7:45 AM	25-May	7:45 AM	6	0	0.00	
							7:46 AM	5.875	1	0.13	8.0
							7:47 AM	5.75	2	0.25	8.0
							7:48 AM	5.625	3	0.38	8.0
							7:49 AM	5.5	4	0.50	8.0
							7:50 AM	5.375	5	0.63	8.0
							7:55 AM	4.8125	6	1.19	5.1
							8:00 AM	4.375	7	1.63	4.3
							8:15 AM	3.375	8	2.63	3.0
TP-3	24"	24-May	10:30AM	25-May	7:45 AM	25-May	8:30 AM	6	0	0.00	
							8:31 AM	5.875	1	0.13	8.0
							8:32 AM	5.75	2	0.25	8.0
							8:33 AM	5.6875	3	0.31	9.6
							8:34 AM	5.375	4	0.63	6.4
							8:35 AM	5.25	5	0.75	6.7
							8:40 AM	3.5	6	2.50	2.4
							8:45 AM	3	7	3.00	2.3
							9:00 AM	2.75	8	3.25	2.5

P.E.
Person Conducting Test

A- 2532

MID-STATE
Engineering
& Testing Inc.
279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch
LOCATION	Elm Creek, NE
CLIENT	HDR
JOB NUMBER	200-05-24

Owner: HDR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25. At the end of initial testing, this location was refilled and retested at 2:03 and 2:30 PM with similar results.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elasped (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-4	24"	24-May	10:30AM	25-May	12:45 PM	25-May	12:45 PM	6	0	0.00	
							12:46 PM	5	1	1.00	1.0
							12:47 PM	4.4375	2	1.56	1.3
							12:48 PM	3.875	3	2.13	1.4
							12:49 PM	3.375	4	2.63	1.5
							12:50 PM	2.875	5	3.13	1.6
							12:51 PM	2.375	6	3.63	1.7
							12:52 PM	1.9375	7	4.06	1.7
							12:53 PM	1.5	8	4.50	1.8
							12:54 PM	1.25	9	4.75	1.9
							12:55 PM	0.8125	10	5.1875	1.9
							12:58 PM	0	13	6.00	2.2
TP-4	24"	24-May	10:30AM	25-May	12:45 PM	25-May	2:30 PM	6	0	0.00	
							2:31 PM	5.25	1	0.75	1.3
							2:32 PM	4.5625	2	1.44	1.4
							2:33 PM	4.1875	3	1.81	1.7
							2:34 PM	3.5	4	2.50	1.6
							2:35 PM	3.25	5	2.75	1.8
							2:40 PM	1.5	10	4.50	2.2
							2:43 PM	0	13	6.00	2.2

P.E.
Person Conducting Test

A- 2532

MID-STATE
Engineering
& Testing Inc.
279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch
LOCATION	Elm Creek, NE
CLIENT	HOR
JOB NUMBER	200-05-24

Owner: HOR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		**Start**		**Reading (inch)**	**Time Elasped (min)**	**Water Drop (in)**	**Percolation Rate (min/in)**
		Day	**Time**	**Day**	**Time**	Day	Time				
TP-5	20"	24-May	10:30AM	25-May	1:00 PM	25-May	1:00 PM	6	0	0.00	
							1:01 PM	5.9375	1	0.06	16.0
							1:02 PM	5.875	2	0.13	16.0
							1:03 PM	5.8125	3	0.19	16.0
							1:04 PM	5.625	4	0.38	10.7
							1:05 PM	5.5625	5	0.44	11.4
							1:10 PM	5.4375	10	0.56	17.8
							1:15 PM	5.25	15	0.75	20.0
							1:30 PM	4.75	30	1.25	24.0
							2:00 PM	4.1667	60	1.83	32.7

, P.E.
Person Conducting Test

A- 2532

MID-STATE
Engineering
& Testing Inc.
279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch
LOCATION	Elm Creek, NE
CLIENT	HDR
JOB NUMBER	200-05-24

Owner: HDR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elapsed (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-6	12"	24-May	10:30AM	25-May	2:15 AM	25-May	2:15 PM	6	0	0.00	
							2:16 PM	5.8125	1	0.19	5.3
							2:17 PM	5.75	2	0.25	8.0
							2:18 PM	5.5625	3	0.44	6.9
							2:19 PM	5.5625	4	0.44	9.1
							2:20 PM	5.5	5	0.50	10.0
							2:25 PM	5.375	10	0.63	16.0
							2:30 PM	5.3125	15	0.69	21.8
							2:45 PM	5.1875	30	0.81	36.9
							3:15 PM	4.5	60	1.50	40.0

, P.E.
Person Conducting Test

A- 2532

MID-STATE

Engineering
& Testing Inc.
279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch
LOCATION	Elm Creek, NE
CLIENT	HDR
JOB NUMBER	200-05-24

Owner: HDR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elasped (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-7	12"	24-May	10:30AM	25-May	10:00 AM	25-May	10:15 AM	6	0	0.00	
							10:16 AM	5.8125	1	0.19	5.3
							10:17 AM	5.6875	2	0.31	6.4
							10:18 AM	5.5	3	0.50	6.0
							10:19 AM	5.5	4	0.50	8.0
							10:20 AM	5.3125	5	0.69	7.3
							10:25 AM	5.25	10	0.75	13.3
							10:30 AM	5	15	1.00	15.0
							10:45 AM	4.6875	30	1.31	22.9
							11:15 AM	4	60	2.00	30.0

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A- 2532

MID-STATE
Engineering
& Testing Inc.
279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch
LOCATION	Elm Creek, NE
CLIENT	HDR
JOB NUMBER	200-05-24

Owner: HDR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ____ Sandy Loam ____
silty loam ____ Clay Loam ____ Sandy Clay ____

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elasped (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-8	12"	24-May	1:50PM	25-May	11:10 AM	25-May	11:00	6	0	0.00	
							11:01	5.875	1	0.13	8.0
							11:02	5.75	2	0.25	8.0
							11:03	5.625	3	0.38	8.0
							11:04	5.5	4	0.50	8.0
							11:05	5.375	5	0.63	8.0
							11:06	5.25	6	0.75	8.0
							11:07	5.1875	7	0.81	8.6
							11:08	5.125	8	0.88	9.1
							11:09	5.0625	9	0.94	9.6
							11:10	5	10	1	10.0
							11:15	4.75	15	1.25	12.0
							11:20	4.4375	20	1.5625	12.8
							11:30	3.75	30	2.25	13.3
							11:45	2.9375	45	3.06	14.7
							12:00	2.125	60	3.875	15.5

P.E.
Person Conducting Test

A- 2532

MID-STATE
Engineering & Testing Inc.

279 Road D, Columbus, NE 68601
Office: (402) 562-7824 Fax: (402) 562-6894

PROJECT	Cottonwood Ranch 85R
LOCATION	Elm Creek, NE
CLIENT	HOR
JOB NUMBER	200-05-24

Owner: HOR
Address: 301 South 13th Street, Cornhusker Plaza Suite 601
Lincoln, NE 68508

Soil Type: Silty Clay x Silty Clay loam ___ Sandy Loam ___
silty loam ___ Clay Loam ___ Sandy Clay ___

Weather: Precip NA Temp 80

Notes: All Test Pit locations where filled throughout the day and evening 5-24 and then refilled a minimum of one hour prior to testing on 5-25.

Percolation Test Data

Hole No.	Hole Depth	Presaturation Period				Percolation Reading				Results	
		Start		End		Start		Reading (inch)	Time Elasped (min)	Water Drop (in)	Percolation Rate (min/in)
		Day	Time	Day	Time	Day	Time				
TP-9	24"	24-May	1:30PM	25-May	9:45 AM	25-May	10:00	6	0	0.00	
							10:01	4.5	1	1.50	0.7
							10:02	3.5	2	2.50	0.8
							10:03	3	3	3.00	1.0
							10:04	2.75	4	3.25	1.2
							10:05	2.375	5	3.63	1.4
							10:06	2	6	4.00	1.5
							10:07	1.625	7	4.38	1.6
							10:08	1.25	8	4.75	1.7
							10:09	1.1875	9	4.81	1.9
							10:10	1.1875	10	4.8125	2.1
							10:15	1	15	5.00	3.0
							10:20	0.75	20	5.25	3.8
TP-9	24"	24-May	1:30PM	25-May	9:45 AM	25-May	10:25	6	0	0.00	
							10:26	4.25	1	1.75	0.6
							10:27	3.5625	2	2.44	0.8
							10:28	2.8125	3	3.19	0.9
							10:29	2.375	4	3.63	1.1
							10:30	2	5	4.00	1.3
							10:31	1.75	6	4.25	1.4
							10:32	1.4375	7	4.56	1.5
							10:33	1.25	8	4.75	1.7
							10:34	0.875	9	5.13	1.8
							10:35	0.75	10	5.25	1.9
							10:40	0.25	15	5.75	2.6
							10:42	0	17	6	2.8

Scott Barnett, P.E.
Person Conducting Test

A- 2532

Appendix D

Previous Investigations

BROAD-SCALE RECHARGE FIELDWORK ACTIVITIES

3/15/2017

Investigation of Recharge Potential at the Cottonwood Ranch Complex: Infiltration Rates & Geotechnical Surveys

Prepared by Executive Director's Office of the
Platte River Recovery Implementation Program
4111 4th Avenue, Suite 6
Kearney, NE 68845

**Draft for Review by WAC:
Must be reproduced in color**

Contents

1 Introduction

1.1 Background

The Executive Director's Office (EDO) of the Platte River Recovery Implementation Program (Program) is investigating the feasibility of implementing broad-scale recharge as a Water Action Plan (WAP) project. If implemented, broad-scale recharge would act as a flow retiming mechanism in the Associated Habitat Reach (AHR) of the Platte River. Specifically, water would be diverted from the river when its flows are in excess of United States Fish and Wildlife Service (USFWS)-mandated target flows. The diverted water would be delivered to recharge basins throughout the Platte River valley, where the water would recharge into the alluvium, and the Program would receive credit for return flows to the AHR during times of shortage to target flows. Potential locations for broad-scale recharge operations are spread throughout the Platte River valley, but current EDO efforts are focused on the Cottonwood Ranch (CWR) complex (**Figure 1**). Efforts are being focused at the CWR complex due to (among other factors) its location under the Phelps County Canal, its proximity to the Platte River, and its various properties being owned or managed by the Program.

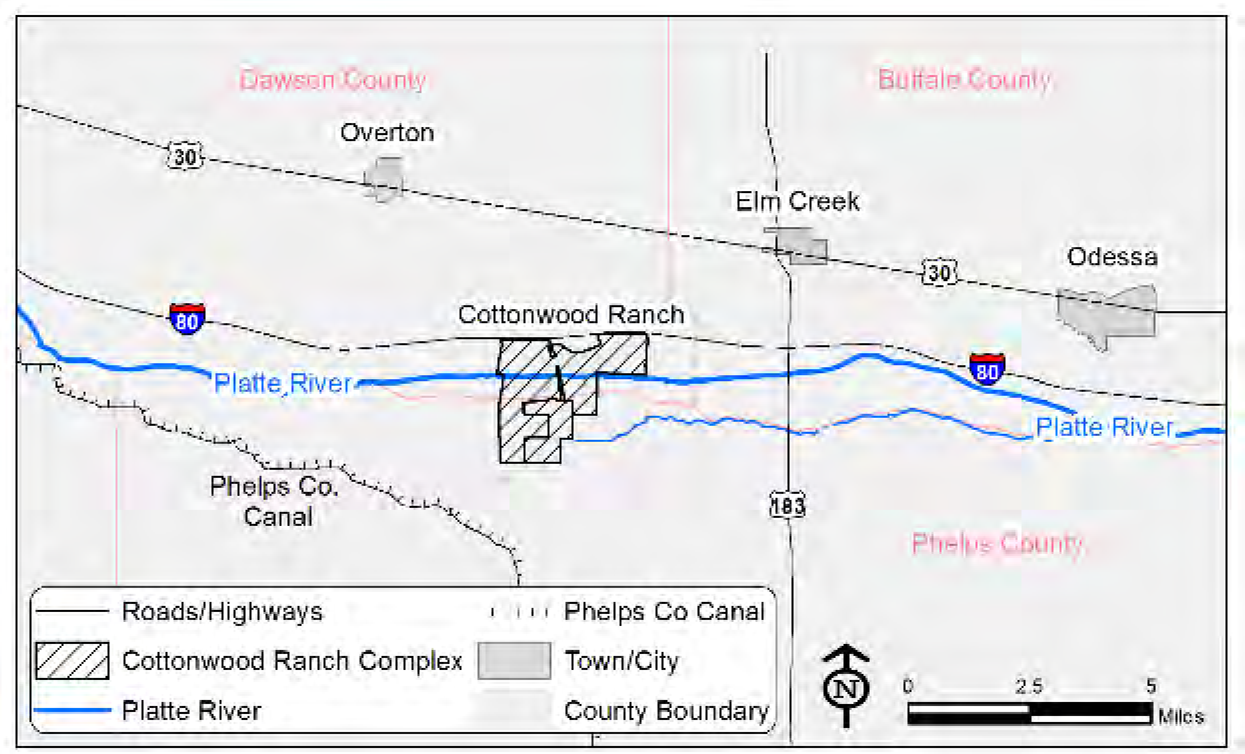


Figure 1: General location map showing the Cottonwood Ranch complex, as well as area towns, waterways and major roads.

One of the first steps in evaluating the feasibility of constructing a broad-scale recharge project at the CWR complex was to assess site characteristics as they relate to recharge potential. Specifically, the volume of water than can be recharged into the alluvial aquifer, and the resulting volume that returns to the river during times of shortage to target flows, are the most important factors when evaluating the broad-scale recharge project at the site. Consequently, accurately quantifying rates of infiltration and assessing subsurface conditions at the CWR complex were the main goals of the fieldwork that was completed by the EDO in

2016. This report presents the background information, methods, results, and conclusions of the fieldwork and subsequent analyses that made up the investigation.

1.2 Need for Fieldwork Activities

Data from the CWR complex that predates the 2016 fieldwork activities exists but is not sufficient to completely evaluate the potential effectiveness of a broad-scale recharge project. Most of the site specific hydrologic data from the complex was collected as part of the Program's wetland and wet meadow monitoring campaign that began in 2014. Groundwater levels were monitored at four locations on the property and surface water levels were monitored at four locations on the property (two of which were in the Peterson Ditch and two of which were in Program Cells 1 and 2) (**Figure 2**). These data have been used to estimate infiltration rates, but the setup of the monitoring network and operation of the wetland cells were such that rates could only be estimated in Program Cell #2 (**Figure 2**) during very specific times (i.e., when deliveries to the cell were cut off, which did not happen very often). These estimates ranged from about 0.2 ft/day when the wetland cells were first wetted to about 0.08 ft/day after the cells had been wetted for an extended period of time (e.g., on the order of two to three months). Although believed to be accurate, these estimates might not be reflective of infiltration rates under the anticipated operating conditions of the broad-scale recharge project.

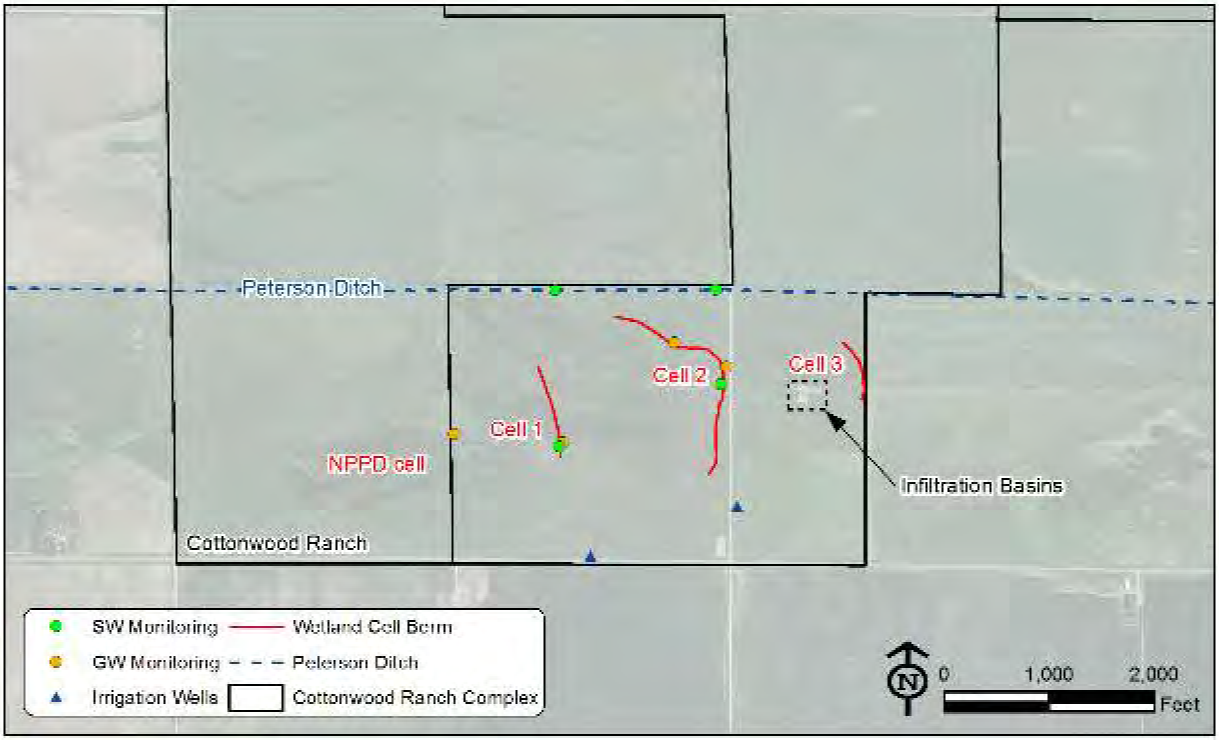


Figure 2: Site map of the southern portion of the Cottonwood Ranch complex, where recharge operations are likely to occur. Shown are wetland cells, surface water and groundwater monitoring equipment, irrigation wells and the location of the pilot-scale infiltration basins.

As it stands (in conceptual form), the broad-scale recharge project will include recharge basins where water is pooled above the ground surface behind earthen berms (bermed basins) and where water is pooled below the existing ground surface in excavated pits (pit basins) (**Attachment A**). The bermed basins will likely encompass the current wetland cells on the property as well as the pasture/wet meadow areas making up most of the complex's area. The infiltration rates estimated previously are likely representative of the wetland areas but might not be representative of the pasture/wet meadow areas or the to-be-constructed pit basin areas. Additionally, measures taken to limit infiltration and groundwater runoff during the wetland enhancement project (e.g., operation of check structures in the groundwater ditch, avoidance of topsoil disturbance, etc.) might not be implemented during times of recharge. As such, additional efforts were needed to quantify infiltration rate estimates under conditions consistent with the conceptual groundwater recharge project.

Beyond the hydrologic and hydraulic data, the existing data most relevant in the evaluation of the potential effectiveness of a broad-scale recharge project at the CWR complex are the subsurface logs developed during the installation of the four groundwater monitoring wells on the Morse property (**Figure 2**). The finished logs are presented in **Attachment B**. These logs were developed to a depth of 20 ft and show that the subsurface at the well locations are comprised of fine to medium grain sands and are covered by about 2 to 3 ft of topsoil. Depth to groundwater at these locations during well installation (September of 2015) was between 3 and 3.5 feet, which is consistent with other in-area groundwater level observations from the fall. Although the subsurface at the CWR complex is believed to be fairly homogeneous, additional data collected at other locations on the property were needed to ensure that conditions across the site were conducive to recharge operations.

1.3 Objectives

The objectives of the 2016 fieldwork campaign at the CWR complex were as follows:

1. Develop accurate infiltration rate estimates for the pasture/wet meadow areas represented by the bermed basin.
2. Develop accurate infiltration rate estimates for the excavated and low-lying areas represented by the pit basin.
3. Gather any additional subsurface information relevant to the broad-scale recharge concept feasibility assessment and/or design process.

2 Methods

2.1 Pilot-Scale Recharge Basins

Pilot-scale recharge basins with a surface area of about 0.1 acres (4,000 to 5,000 ft^2) were constructed and used to develop infiltration rate estimates for the pasture/wet meadow areas and the excavated/low-lying areas at the CWR complex. A bermed basin was constructed and designed to represent the recharge conditions of the pasture/wet meadow areas, and an excavated basin was constructed and designed to represent the recharge conditions of the excavated/low-lying areas. More specifically, the pit basin was constructed such that the topsoil was excavated and the sands/gravels of the alluvium were exposed and the bermed basin was constructed on top of the topsoil using the material excavated from the pit basin. These pilot-scale basins were used to develop infiltration rate estimates because they allowed for the estimation of infiltration rates in a setting that simulates the project-scale basins while maintaining a scale where key variables (e.g., depth of water, water surface area, inputs and outputs, etc.) were easily measured and/or monitored; and where unknowns were limited. The pilot-scale basins were sited directly south of Program Cell #3 (**Figure 2**).

2.1.1 Construction

The pilot-scale infiltration basins were constructed during the last week of February and first week of March in 2016 (**Figure 3**). The basins were constructed by a contractor who primarily used a bulldozer (dozer) to excavate the pit basin. The dozer was then used to push the excavated material to the location of the bermed basin, where the berms were shaped into piles and track-compacted into finished form. It is estimated that about 300 to 350 cubic yards (cy) of material was excavated and placed. The construction of the basins took about 1.5 days and was completed for a cost to the Program of $2,970.

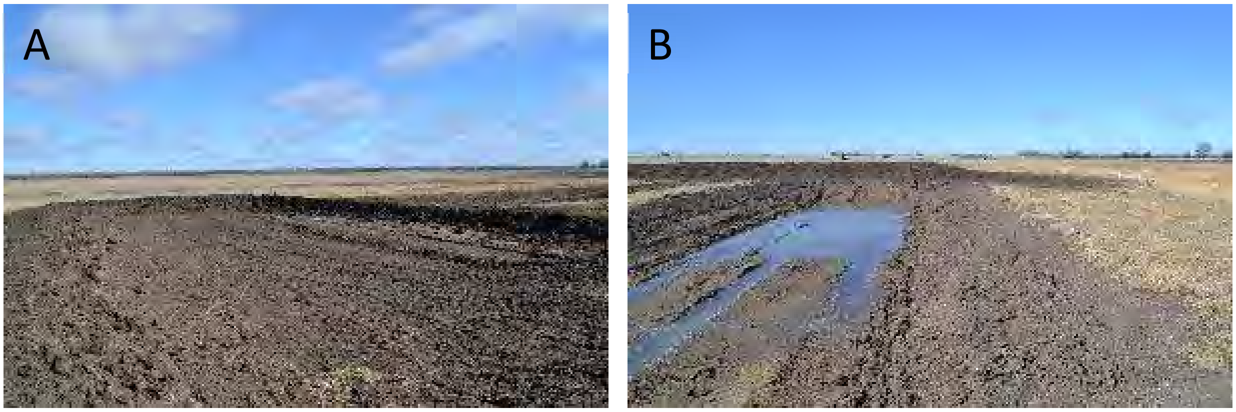


Figure 3: The newly constructed pilot-scale infiltration basins in March of 2016. In (A) the bermed basin is shown and in (B) the excavated basin is shown.

2.1.2 Operation and Monitoring

The pilot-scale basins were operated in a manner designed to mimic the intended operations of the broad-scale recharge project. To represent the pipeline deliveries to the project-scale basins, the pilot-scale basins were filled using water delivered through an 8-inch irrigation hose connected to the outlet of a permanent irrigation pipeline previously installed by the Program on the Morse property (**Figure 4**). The pipeline is connected to a vertical irrigation well equipped with a pump that extracts about 900 gallons per minute from the underlying aquifer. When desired, the pump was turned on, the irrigation hose was directed towards the pilot-scale basin of choice, the basin was filled to a desired level, and the pump was turned off. This process generally took 60 minutes or less. The water was then contained in the basin(s), which did not contain outlets, while it infiltrated into the ground. Once the basins were empty, they were refilled throughout the duration of the study period.

The water levels in the pilot-scale basins were monitored using pressure transducers (which were suspended in housings fabricated from PVC pipe) and staff gages (**Figure 4**). The pressure transducers measured and stored water pressure and temperature readings, which were converted to water depths, at 30 minute intervals. The readings were downloaded about once per month by field technicians. In addition, the staff gages were read and the readings were logged by field technicians (**Figure 4**). These readings were used as spot checks to ensure the quality of the data collected by the pressure transducers. In addition, precipitation was measured onsite using a tipping-scale precipitation gage and climatic variables (temperature, evapotranspiration, etc.) were downloaded from High Plains Regional Climate Center (HPRCC) weather stations in Kearney and Lexington, Nebraska, which are each about 15 to 20 miles east and west of the project site, respectively.

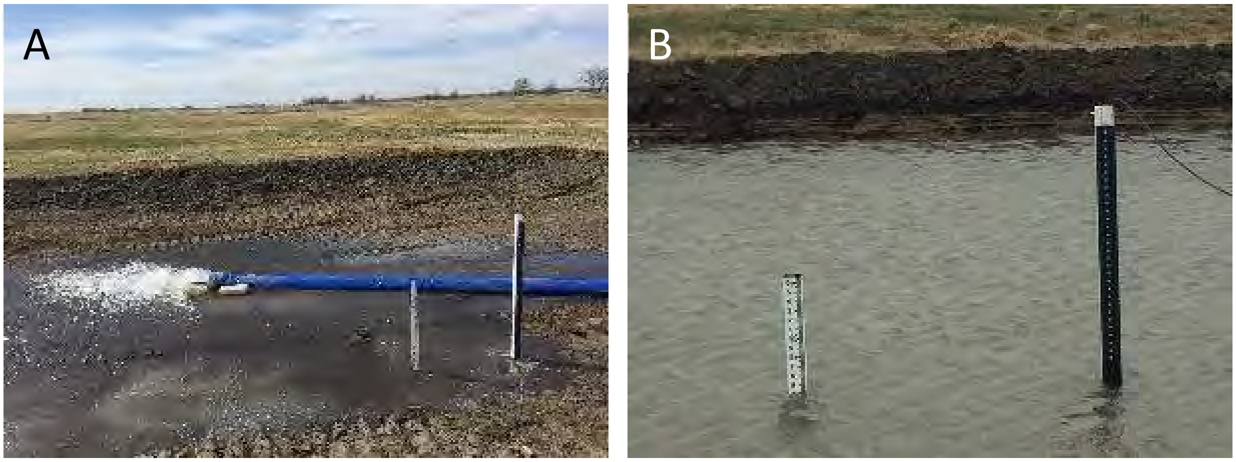


Figure 4: In (A) the 8-inch diameter irrigation hose is being used to fill the bermed basin, and in (B) the monitoring equipment (staff gage and data logger housing) is shown.

2.1.3 Calculations

The infiltration rates were calculated using a water budget approach by balancing the inputs and outputs of the pilot-scale basins during the recharge periods when the basins were filled and when water infiltrated into the ground. The only input during these times was precipitation, assuming no groundwater inflow (or equal inflow and outflow), and the outputs were evaporation and infiltration (**Figure 5**).

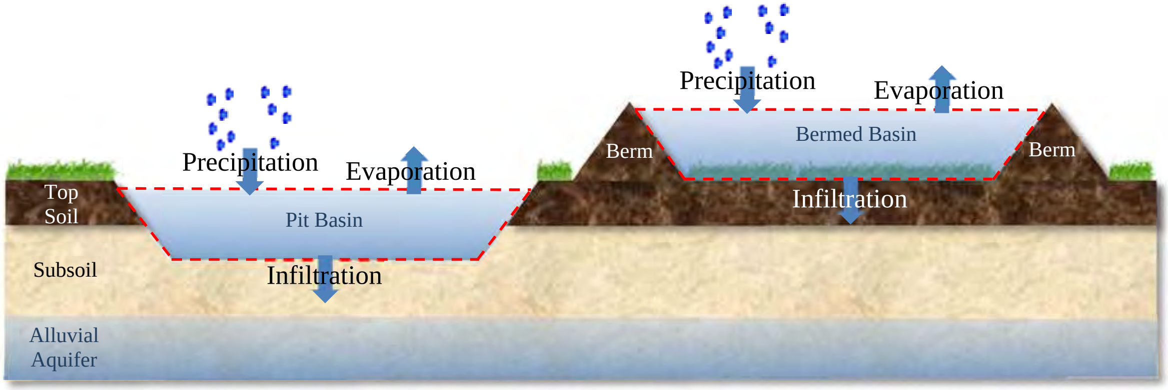


Figure 5: Water budget schematic for the pilot-scale recharge basins. The domain boundaries are defined by the red dashed line. The inputs and outputs across the domain boundaries are represented by the arrows crossing the boundary.

The water balance domain for each basin was defined as the basin’s bed and water surface. Consequently, the water budget for each basin can be written as:

$$P - E - I = \Delta S \qquad \textit{Equation 1}$$

where P = precipitation, E = evaporation, I = infiltration and ΔS = change in storage. As discussed above, precipitation and change in storage (i.e., water surface elevation) were measured on-site, and evaporation was measured at nearby weather stations. As such, Equation 1 can be rewritten as:

$$I = P - E - \Delta S \qquad \textit{Equation 2}$$

where each term is defined as a depth (in feet). Equation 2 was used to calculate an infiltration rate (in feet/day) for each day during the recharge periods. For each recharge period, the rate of change of the calculated daily rates was evaluated and an average daily infiltration rate for the entire period was calculated.

2.2 Geotechnical Investigations

The pilot-scale basins were valuable in that they allowed for the measurement of infiltration rates under conditions similar to the intended operating conditions of the full-scale project; however, their representativeness of the entire site is somewhat uncertain. Although surface and subsurface conditions across the site are known to be generally uniform, a subsurface investigation was designed to gather information related to the spatial variation of the conditions affecting recharge potential (primarily soil types). The investigation consisted of two major activities: (1) a borehole campaign designed by the EDO and carried out by a contractor in which boreholes were drilled and logs were developed at 10 locations across the site; and (2) fieldwork performed by the United States Geological Survey (USGS) in which continuous subsurface resistivity measurements were recorded across the site using a tool known as an Ohm-Mapper (**Figure 6**).

2.2.1 Boreholes

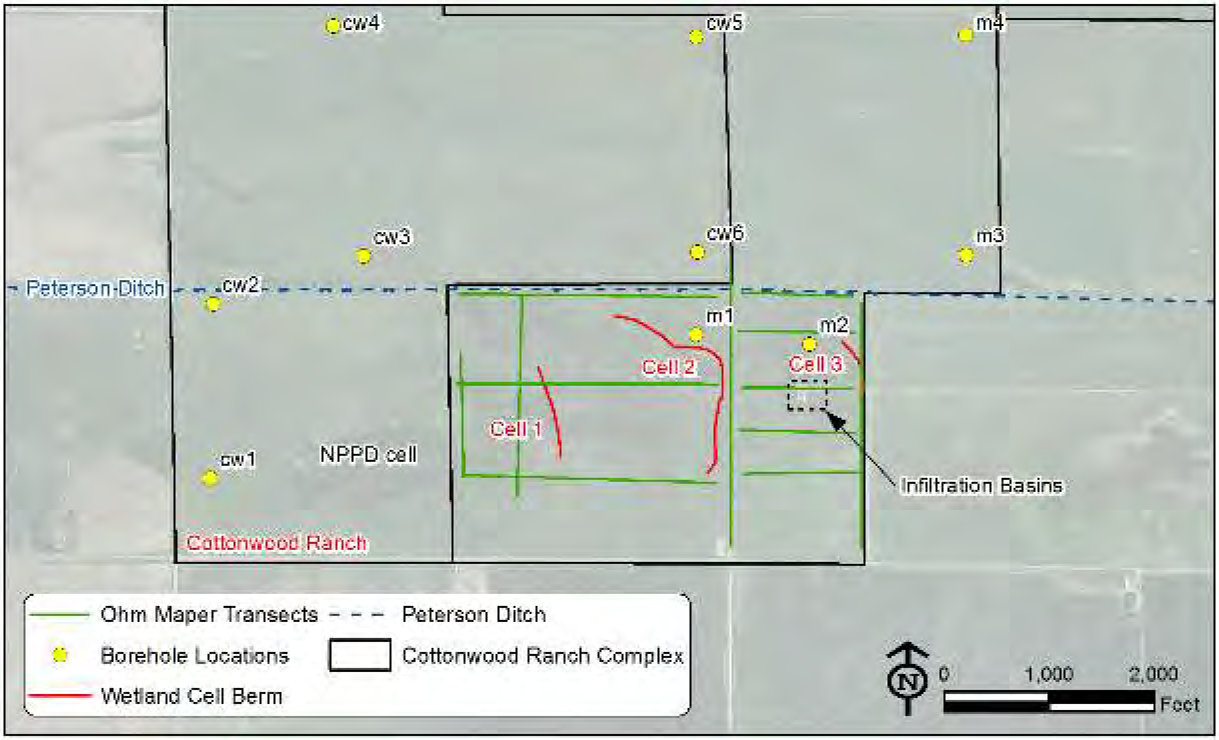


Figure 6: Site map of the southern portion of the Cottonwood Ranch complex. Borehole locations and USGS Ohm Mapper transects are shown.

The goal of the borehole campaign designed by the EDO was to characterize the subsurface conditions across the project site. This was a piece of a larger borehole campaign designed to assess the subsurface conditions south of the Platte River channel from roughly Lexington to Elm Creek, Nebraska; however only the boreholes from the Cottonwood Ranch complex are discussed here. Ten boreholes were drilled at locations spread throughout the site to capture potential varying subsurface conditions (**Figure 6**). A borehole log was developed for each of the locations and included, among other information, the following for each layers in the subsurface: number of blow counts per foot, consistency (i.e., firm, loose, etc.) and soil type (i.e., CL – clay w/ low plasticity, SC – clayey sand, etc.). The depth to groundwater at each location was also recorded. The drilling of the boreholes took about 3.5 days, while the lab work and write-ups (which included tests not addressed in this report) took about 3 additional weeks. This work was completed for a cost to the Program of $15,350 (or about $1,535 per hole, including drilling and lab work).

2.2.2 Ohm-Mapper Survey

The goal of the USGS geophysical investigation was to characterize the subsurface conditions across the project site using innovative, non-invasive technology. The Ohm Mapper, which is the tool used by the USGS, measures electrical resistivity at various depths below the ground surface. The tool is generally dragged behind a 4-wheeler such that resistivity measurements are continuously recorded along transects (**Figure 7**). Resistivity profiles can then be developed along the 4-wheeler's path. These profiles are informative because resistivity values are directly correlated to grain size such that profiles with larger resistivity values represent larger grain sizes and, consequently, have greater recharge potential (Burton et al., 2009; Hobza et al., 2014). In general, the Ohm Mapper has been used to evaluate canal seepage, either in the context of groundwater recharge or evaluating conveyance losses (Burton et al., 2009; Hobza et al., 2014). Applying the new technology at the project site allowed for the gathering of additional subsurface information while, at the same time, provided the EDO/Program the opportunity to evaluate the use of the technology during the feasibility assessment of future broad-scale recharge projects.

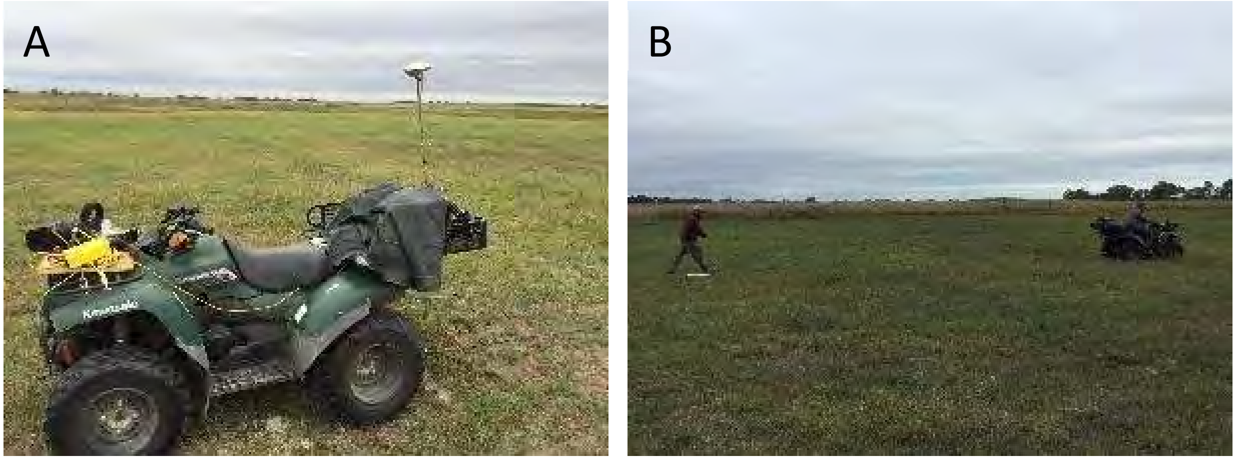


Figure 7: In (A) the 4-wheeler used to tow the Ohm Mapper equipment is shown, and in (B) the Ohm Mapper equipment is being towed by the 4-wheeler and a USGS employee is walking alongside to ensure proper function of the equipment.

The USGS was responsible for the Ohm Mapper fieldwork at the project site, as well as the data development, interpretation and presentation. The USGS performed the Ohm Mapper fieldwork during two days in September 2016 (**Figure 7**). Soil cores, separate from those collected during the borehole campaign, were subsequently collected by the USGS and used to validate the Ohm Mapper data. The data interpretation and initial presentation took about 1.5 months and it was presented to the EDO in November 2016. Final presentation of that data is be publically available (data available at: https://doi.org/10.5066/F70R9MKP). The total cost to the Program for this work was $30,000, which was 50% of the total cost of the project. The other $30,000 was contributed by the USGS.

3 Results & Discussion

The results of the infiltration testing activities and the geotechnical campaigns described above are presented in the three subsections below. In each case, the results are presented and followed by a brief discussion of implications as they relate to the broad-scale recharge project.

3.1 Infiltration Testing

The water levels (in feet) in each of the pilot-scale infiltration basins are shown in **Figure 8**, along with cumulative precipitation (in inches) over the study period. The sharp increases (i.e., near vertical lines) in water levels at the beginning of each event were due to the filling of the basins. The durations of the events (shaded in orange in **Figure 8**) continued until the water in the basin(s) had infiltrated into the ground (e.g., Event 1 in the bermed basin), or until the basins experienced significant precipitation/runoff inputs (e.g., Event 1 in the excavated basin). In total, there were 9 different events during the study period, which spanned from mid-March through mid-November: 4 fillings of the excavated basin and 6 fillings of the bermed basin. There were 10 total fillings because Event 1 included the filling of both the excavated and bermed basins. Subsequent fillings were performed separately to limit groundwater interference between the test basins.

Spot checks, where staff gage readings were compared to water levels collected by the data loggers, were performed throughout the study period to confirm the quality of the transducer-collected water level data (**Figure 8**). The overall quality of the data was good for most of the study period. The spot checks verified that the loggers were stationary and collecting accurate data, with the exception of the last two checks on the excavated basin (during Event 7 and Event 9). These last two checks resulted in staff gage readings that were higher than the water levels recorded by the data logger (i.e., actual water levels were higher than those recorded). This is likely due to the cable suspending the data logger being moved inadvertently during a data download or by wildlife. As such, the reported water levels were likely ‘accurate’ in that their values were correct after the logger had been moved but ‘inaccurate’ in that their base elevation was different than that during most of the study period. However, because the logger appears to have been moved instantaneously sometime between Event 5 and 7, the collected data was still be used to determine water level differences at a daily time step during Event 7. This is because the readings were not ‘bad’ (i.e., collecting erroneous readings), but simply off from previous events.

The only extended period with visually out of the ordinary water level data was from mid-April through the end of May when there were sharp increases and large fluctuations in the water levels in both basins (**Figure 8**). This behavior was a direct result of the 10-plus inches of rain received during that time. As a result, the excavated pit was nearly overtopped by groundwater inflows, surface runoff and direct precipitation, and the bermed basin experienced significant ponding from direct precipitation. The basins were not filled by the irrigation hose during this time period because they were nearly full from natural inputs, there were obvious violations of the water budget assumptions (namely, large groundwater inflow and surface water inflow volumes in the excavated basin), and the general inability to gather reliable data (sharp increases and decreases in water levels during large rainfall events).

The daily infiltration rates in each basin were calculated at a daily time step using the water balance presented in **Equation 2** and the water level data presented in **Figure 8**. The minimum, maximum and average daily infiltration rates during each event in each basin are shown in **Table 1**. In general, the infiltration rates in the bermed basin were two to three times greater than the rates in the excavated basin. In both cases, the maximum infiltration rates occurred during the early portion of each event when the hydraulic head was near its maximum (generally about 2.5 to 3 ft), and the minimum infiltration rates occurred during the later portion of each event when the hydraulic head in each basin was near 0 ft because the basins were nearly empty. Overall, the average infiltration rate across the entire study period was about

0.19 ft/d in the bermed basin and 0.08 ft/d in the excavated basin. The average maximum infiltration rate across the entire study period was about 0.30 ft/d in the bermed basin and 0.22 ft/d in the excavated basin, and the average minimums were 0.05 ft/d and 0.02 ft/d, respectively.

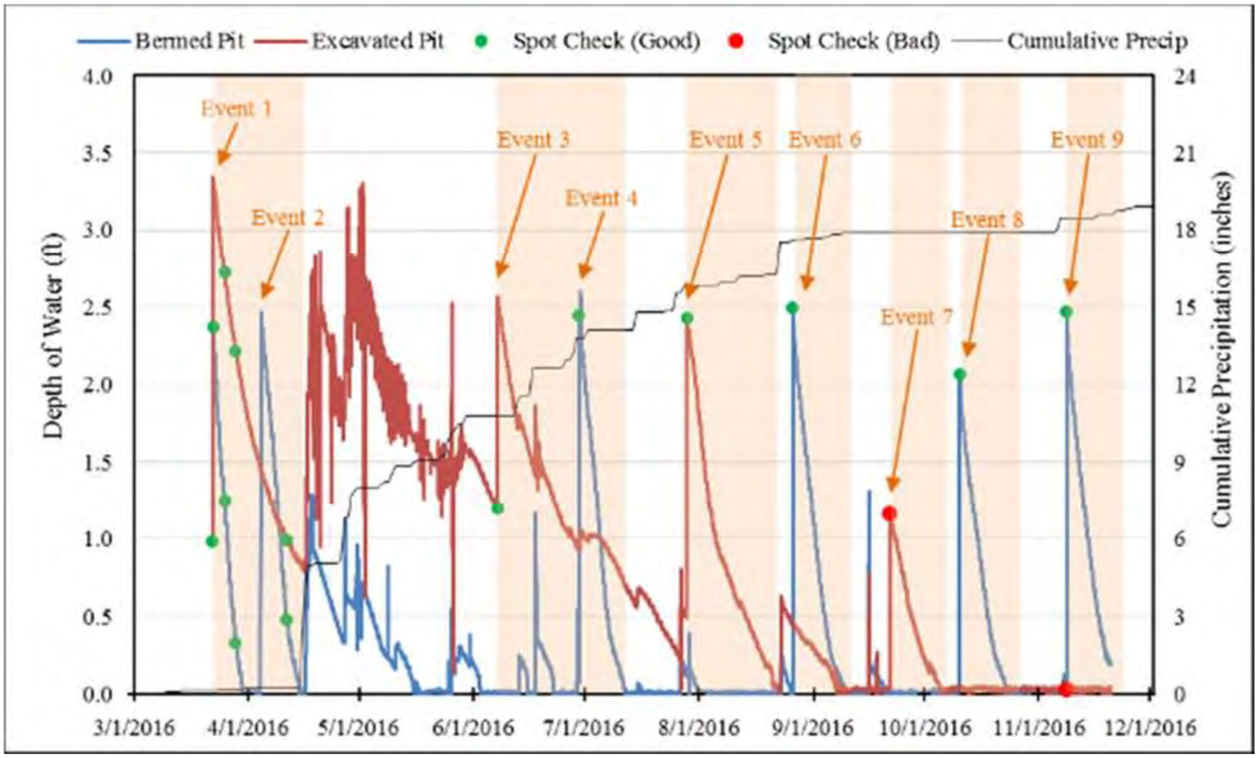


Figure 8: The water levels in the bermed (blue line) and excavated (red line) pilot basins are shown, along with cumulative precipitation measured from an on-site gage. Events (shaded in orange) and spot checks (green and red dots) are also shown.

In general, the event average daily infiltration rate in each basin decreased from the first event to the second event (**Table 1 and Figure 9**). This decrease persisted in the bermed basin until the infiltration rates appeared to level off near 0.15 ft/d. The increase in the event average rate in the bermed basin during Events 8 and 9 (from 0.14 to 0.18 ft/d) was likely due to the monitoring of the water levels during the last event being cut short due to the removal of data loggers in anticipation of cold weather (notice the bermed basin water level in **Figure 8** not reaching 0 ft during Event #9). If monitored, the typically very low infiltration rates during the last few days of an event would have lowered the event average closer to the rates observed (0.14 to 0.15 ft/d) in the bermed basin during Events 6 and 8. In the excavated basin, the average daily infiltration rate leveled off near 0.08 ft/d, and actually increased from Event 3 to Events 5 and 7.

Furthermore, area groundwater elevations did not seem to affect infiltration rates within a single basin (**Figure 9**). Infiltration rates dropped significantly from Event 1 to Events 2 and 3, when groundwater levels were relatively constant. Additionally, infiltration rates continued to decrease, or leveled off, during the study period when groundwater elevations were decreasing during the irrigation season. It appears that groundwater levels do not affect infiltration rates (within a basin) as long as they are a few feet below the ground surface. However, it is believed that one reason why infiltration rates in the bermed basin were much higher than those in the excavated basin was because the water in the bermed basin had a larger unsaturated zone in which to move water to than the excavated basin (i.e., the excavated basin was much closer to the water table and had less 'room' to move water to). It should be noted that infiltration tests were not performed during the April-May time period when groundwater elevations increased about 1.5 ft due to the large amount of precipitation. It is assumed that infiltration rates during this time period would have been much lower, if monitored.

Table 1: Minimum, maximum and average daily infiltration rates in the bermed and excavated basins.

	Event Dates		Bermed Basin Infiltration (ft/d)			Excavated Basin Infiltration (ft/d)		
Event	Start	Stop	Min	Avg	Max	Min	Avg	Max
1	3/23	3/30** 4/11	0.14	0.29	0.43	0.01	0.10	0.23
2	4/5	4/14	0.01	0.21	0.29	-	-	-
3	6/8	6/29	-	-	-	0.01	0.06	0.14
4	6/30	7/12	0.05	0.17	0.28	-	-	-
5	7/29	8/20	-	-	-	0.01	0.08	0.21
6	8/27	9/10	0.04	0.15	0.25	-	-	-
7	9/22	10/4	-	-	-	0.03	0.08	0.12
8	10/11	10/23	0.04	0.14	0.24	-	-	-
9	11/9	11/20	0.05	0.18	0.30	-	-	-
		Average	*0.05*	*0.19*	*0.30*	*0.02*	*0.08*	*0.22*

**The infiltration event in the bermed pit ended on 3/30, but the event in the excavated pit continued until 4/11.

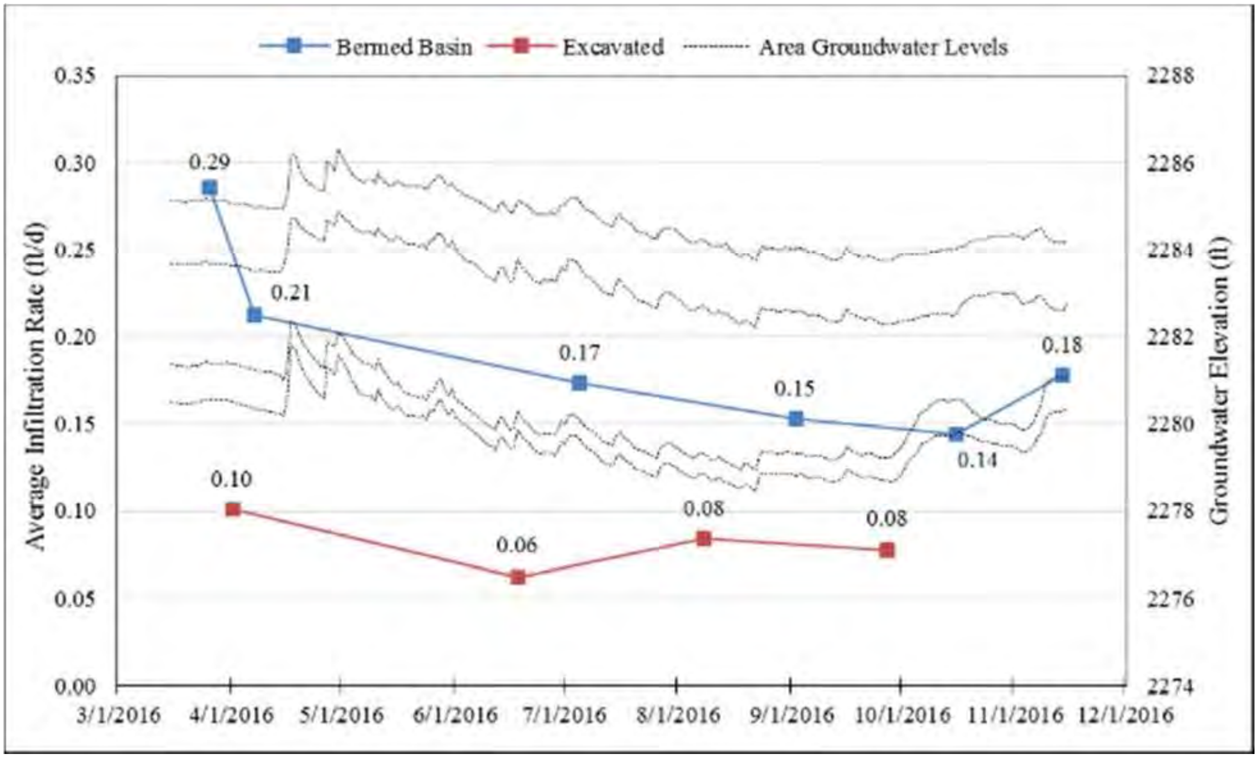


Figure 9: The average infiltration rate during each event for the duration of the study period. Also shown are area groundwater elevations.

Overall, the results of the infiltration tests suggest that infiltration rates will average about 0.20 ft/d in the bermed areas and about 0.08 ft/d in the low lying or excavated areas. The long-term infiltration rates in the bermed areas could trend to 0.15 ft/d. However, it should be noted that these average rates were developed in a falling-head scenario, and maximum rates near 0.30 to 0.25 ft/d in the bermed basin and 0.20 to 0.12 ft/d in the excavated basin could potentially persist if hydraulic heads are maintained (i.e., if water is consistently added to the basins to maximize water levels). Although these results seem counterintuitive because water in the bermed basin needs to infiltrate through topsoil before reaching the alluvial sands (as opposed to the water in the excavated pit being placed directly on the alluvial sands), they suggest that having a larger unsaturated area in which to infiltrate water is more important than dealing with limitations in infiltration due to the existing topsoil. However, the results also suggest that some factor(s) other than area-wide groundwater levels is causing the infiltration rates to decrease over the study period in the bermed basin. Potential factors are localized increases in groundwater (due to the filling of the basins) not captured by area wells and/or the bed of the basin 'silting in' as fines in the topsoil are suspended and deposited on the ground surface as the water infiltrates into the ground.

3.2 Geotechnical Investigations

3.2.1 Boreholes

The results of the borehole investigation suggest that the subsurface at the Cottonwood Ranch Complex is relatively uniform (borehole logs attached as **Appendix C**). The depth of the topsoil ranges from 2 to 8.5 ft and is about 3.5 ft at most locations. The topsoil generally consists of lean clays and fine sands. Beneath the topsoil, the alluvium (which was labeled as "Alluvial Terrace Deposits" in the logs) generally consists of about 40 ft of sands and fine gravels. Clay seams (typically about 0.5 to 1.0') and clayey sand layers were encountered in a few boreholes but these layers were generally deep beneath the surface (greater than 10 ft at almost every location). A low permeability layer, which is likely a cap on or the top of the Ogallala formation was encountered in every hole at a depth of 40 to 50 ft. This layer was generally greater than 10 ft thick, consisted of clays, sands and calcified material and had a very low permeability. The one sample collected that was adequate enough for permeability testing in the lab had a permeability on the order of 10^{-7} cm/s. In general, this suggests that the alluvium is likely separate from the underlying Ogallala aquifer/formation and water recharged in these materials would not seep into the Ogallala. These conditions, at least with respect to soil characteristics, are conducive to recharge. Furthermore, conditions near the pilot-scale recharge basins seemed to be reflective of conditions around the entire site, which suggests that the pilot basin results are representative of the entire property as site conditions are relatively uniform, as suggested by the similarities of the conditions encountered in each borehole.

3.2.2 Ohm-Mapper Survey

The complete preliminary results of the Ohm-Mapper survey (which consist of resistivity profiles to depths of about 26 ft) are shown in **Appendix D** and the average resistivity over the 24 ft-depth at each point along the transect are shown in **Figure 10** (data available at: https://doi.org/10.5066/F70R9MKP). The average resistivity across the site (averaged over the depth and then spatially) was about 40 ohm-meters, with a minimum of about 25 ohm-meters and maximum of about 70 ohm-meters at a given location (averaged over the depth) (**Figure 10**). In general, the average resistivity values across the site are relatively uniform with lower average values (around 30 to 35 ohm-meters) near historically wet areas and higher resistivity values (around 50 to 55 ohm-meters) in the pasture/wet meadow areas, although variations were present. The highest resistivity values were collected on the gravel road along the longest north-south transect. For reference, resistivity values averaged over depth in local canals were often below 20 or 30 ohm-meters, and below 10 ohm-meters in some locations (Hobza et al., 2014). In general, the resistivity values suggest that the site is fairly conducive to recharge and absent of any large ‘areas of concern’ (i.e., laterally extensive and/or thick deposits of fine materia) (Christopher Hobza, oral communication, 2016).

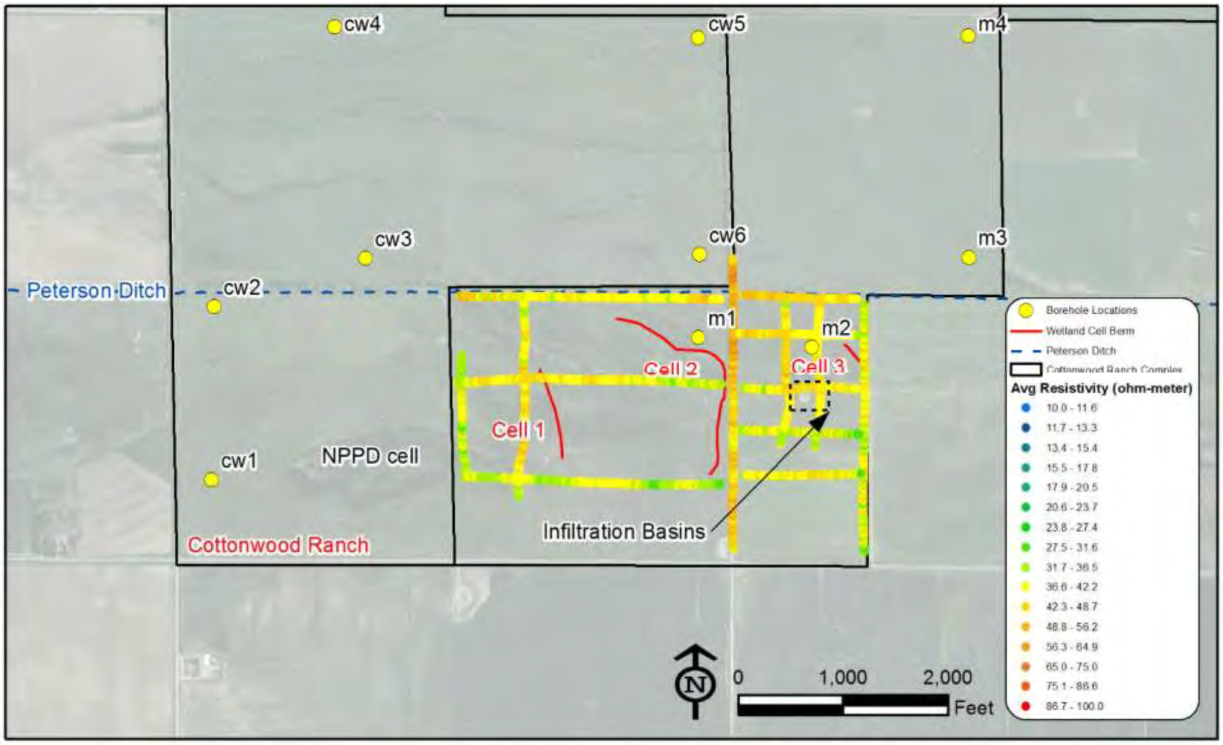


Figure 10: Figure showing average resistivity values over the depth of the profiles along each transect.

As mentioned in section 2.2.2, a major reason for performing the Ohm-Mapper survey was to evaluate it for future use. The attractiveness of the Ohm-Mapper is that it provides continuous subsurface data using non-invasive techniques. If accurate to the scale desired, this would allow for the evaluation of potential broad-scale recharge sites without needing to disrupt the ground surface by drilling and backfilling holes. The non-invasive approach at the project site was a positive; however, the pasture needed to be mowed and hayed for the technology to work, which somewhat offset the benefit of not disrupting the surface by drilling holes (i.e., efforts are needed to mow and hay as opposed to drill and backfill). Furthermore, for this application, clay seams of 0.5 to 1 ft thick were important to capture because they could significantly hinder recharge operations if persistent at shallow depths (which was not the case). However, it appeared that the vertical resolution of the Ohm-Mapper was too coarse to capture these layers as it did not detect the topsoil or the clay seams at depth (which were present in a few holes) (**Appendix D**). But it did represent the alluvial material (fine sands to fine gravels) well and showed that the resistivity of the alluvial material increases with depth because the material coarsens with depth (Christopher Hobza, oral communication, 2016). Overall, it appears that this technology is a generally useful technique but is not strong at identifying thin layers necessary for site-specific investigations and/or design. Instead, its usefulness to the Program is likely in a broader context when evaluating large areas or long continuous areas (i.e., canals) to identify areas that are and are not generally conducive to recharge, which can then be investigated further using boreholes.

4 Conclusions

The results of 2016 investigation of recharge potential at the Cottonwood Ranch Complex yielded the following conclusions:

1. Event average infiltration rates were about 0.20 ft/d in the bermed basin and 0.08 ft/d in the excavated basin. Over the long term, event average rates in the bermed basin appeared to level off near 0.15 ft/d. Consequently, it is assumed that upon completion of the broad-scale recharge project, areas represented by the bermed basin (i.e., pasture/wet meadow areas) will have an average infiltration rate near 0.20 ft/d to 0.15 ft/d, while areas represented by the excavated basin (i.e., excavated and low lying areas) will have an average near 0.08 ft/d.
2. In the bermed basin, infiltration rates decreased during the study period before leveling off near 0.15 ft/d. It is assumed that this decrease was due to two factors. The first was that the constant wetting of the basin increased the groundwater table (very locally) near the basin, resulting in less ‘room’ for the water to infiltrate (although this was not observed in the excavated basin). The more likely factor was that the bed of the basin started to ‘silt in’ due to the fines in the topsoil being suspended and uniformly replaced as the basin emptied, creating a ‘seal’. This could potentially be mitigated by tilling.
3. These infiltration rates were evaluated in a ‘falling head’ scenario (i.e., the basins were filled once and not ‘topped off’ during the events). The maximum infiltration rates, which were 0.30 ft/d and 0.22 ft/d in the bermed and excavated basins, respectively, occurred during the first portions of the events when hydraulic heads were at a maximum. As such, there is potential that the average infiltration rate could be increased if the water levels are ‘topped off’ during the events as to maintain the largest hydraulic head possible.
4. The results of the geotechnical campaign (both the boreholes and the Ohm-Mapper survey) suggest that the results from the infiltration basin are likely fairly representative of the entire site because the site conditions are relatively uniform, and because neither technique identified any ‘red flags’ with regards to recharge operations. In general, the site consists of 2 to 3 ft of topsoil, followed by 40 to 50 ft of alluvium with sands and gravels, and 10-plus ft of a low permeability hard layer. Clay seams are present in the alluvium at a few locations, but are relatively deep (10-plus ft). The Ohm-Mapper results suggest that that site is generally conducive to groundwater recharge.

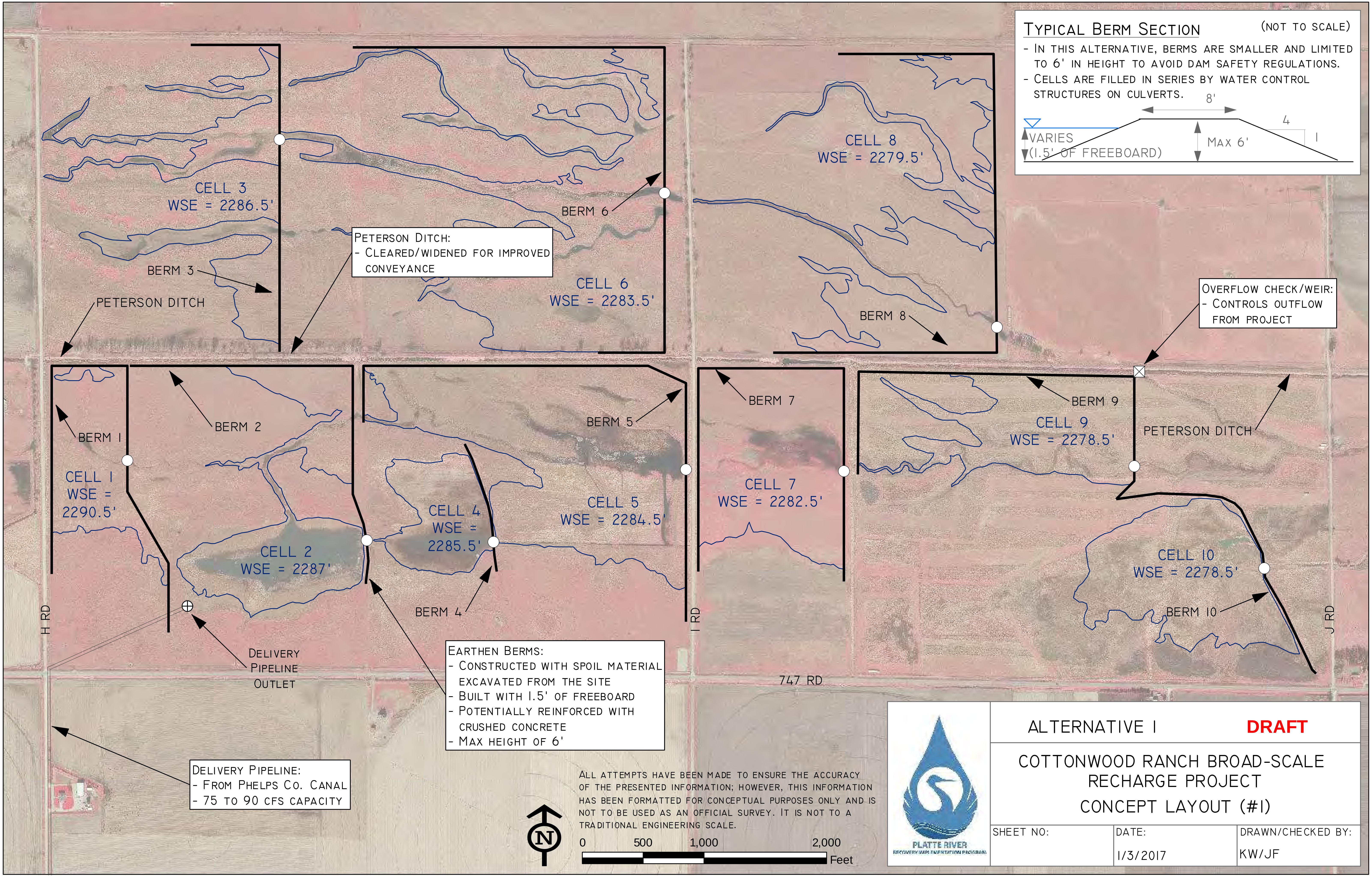
5 References

Burton, B.L., Johnson, M.R., Vrabel, Joseph, Imig, B.H., Payne, J.D., and Tompkins, R.E., 2009, Capacitively coupled resistivity survey of selected irrigation canals within the North Platte River valley, western Nebraska and eastern Wyoming, 2004 and 2007–2009: U.S. Geological Survey Scientific Investigations Report 2009–5194, 70 p., *https://pubs.usgs.gov/sir/2009/5194/pdf/SIR09-5194.pdf*

Hobza, C.M., Burton, B.L., Lucius, J.E., and Tompkins, R.E., 2014, Capacitively coupled and direct-current resistivity surveys of selected reaches of Cozad, Thirty-Mile, Orchard-Alfalfa, Kearney and Outlet Canals in Nebraska, 2012-13: U.S. Geologic Survey Open-File Report 2014-1007, 48 p., *https://pubs.usgs.gov/of/2014/1007/*

Attachment A:

Broad-scale recharge design concept schematics



TYPICAL BERM SECTION

(NOT TO SCALE)

- IN THIS ALTERNATIVE, BERMS ARE SMALLER AND LIMITED TO 6' IN HEIGHT TO AVOID DAM SAFETY REGULATIONS.
- CELLS ARE FILLED IN SERIES BY WATER CONTROL STRUCTURES ON CULVERTS.

PETERSON DITCH:
- CLEARED/WIDENED FOR IMPROVED CONVEYANCE

OVERFLOW CHECK/WEIR:
- CONTROLS OUTFLOW FROM PROJECT

DELIVERY PIPELINE OUTLET

EARTHEN BERMS:
- CONSTRUCTED WITH SPOIL MATERIAL EXCAVATED FROM THE SITE
- BUILT WITH 1.5' OF FREEBOARD
- POTENTIALLY REINFORCED WITH CRUSHED CONCRETE
- MAX HEIGHT OF 6'

DELIVERY PIPELINE:
- FROM PHELPS CO. CANAL
- 75 TO 90 CFS CAPACITY

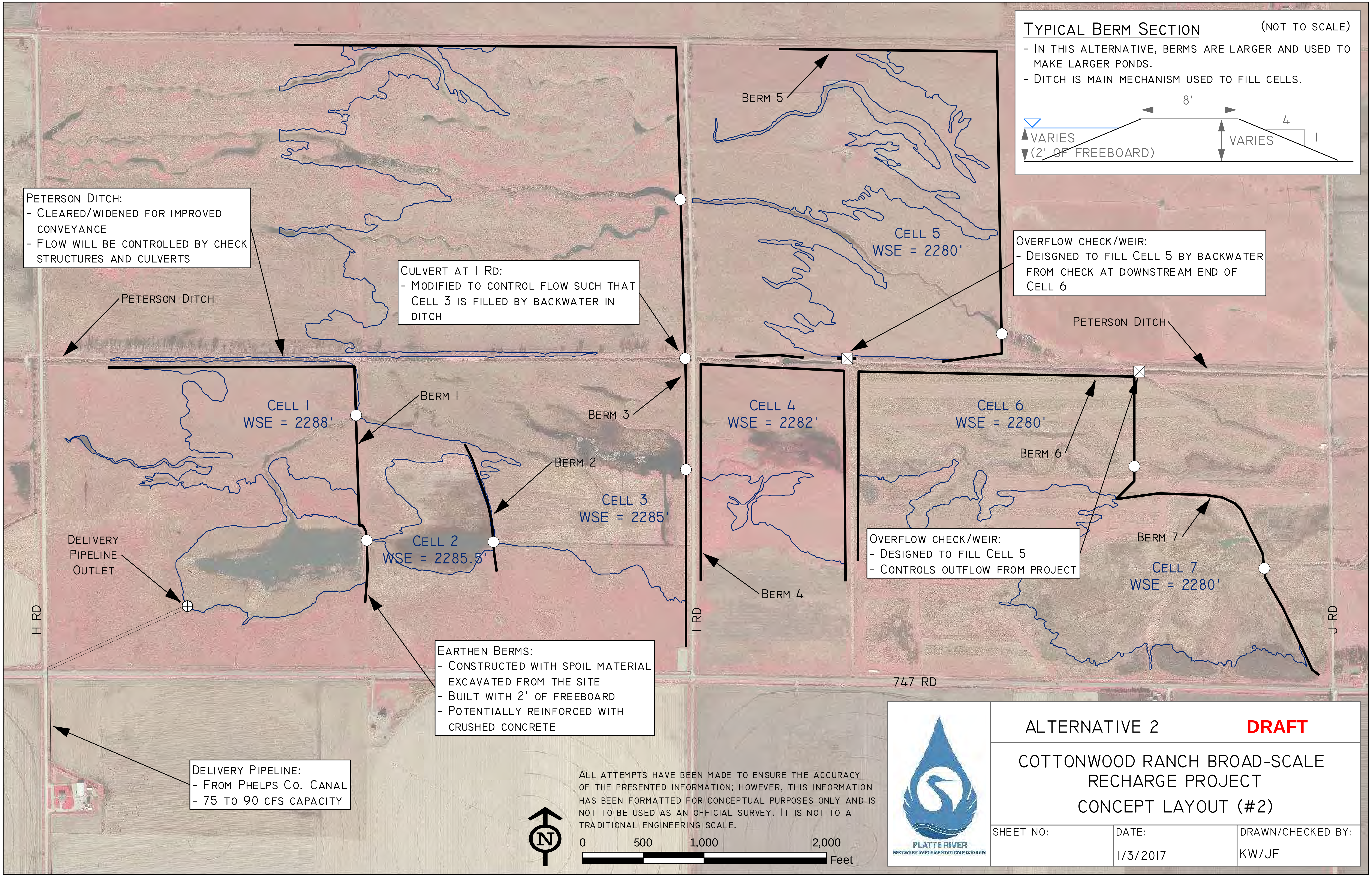
ALL ATTEMPTS HAVE BEEN MADE TO ENSURE THE ACCURACY OF THE PRESENTED INFORMATION; HOWEVER, THIS INFORMATION HAS BEEN FORMATTED FOR CONCEPTUAL PURPOSES ONLY AND IS NOT TO BE USED AS AN OFFICIAL SURVEY. IT IS NOT TO A TRADITIONAL ENGINEERING SCALE.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

ALTERNATIVE 1 **DRAFT**

COTTONWOOD RANCH BROAD-SCALE RECHARGE PROJECT
CONCEPT LAYOUT (#1)

SHEET NO:
DATE: 1/3/2017
DRAWN/CHECKED BY: KW/JF



TYPICAL BERM SECTION (NOT TO SCALE)
- IN THIS ALTERNATIVE, BERMS ARE LARGER AND USED TO MAKE LARGER PONDS.
- DITCH IS MAIN MECHANISM USED TO FILL CELLS.

PETERSON DITCH:
- CLEARED/WIDENED FOR IMPROVED CONVEYANCE
- FLOW WILL BE CONTROLLED BY CHECK STRUCTURES AND CULVERTS

CULVERT AT I RD:
- MODIFIED TO CONTROL FLOW SUCH THAT CELL 3 IS FILLED BY BACKWATER IN DITCH

OVERFLOW CHECK/WEIR:
- DEISGNED TO FILL CELL 5 BY BACKWATER FROM CHECK AT DOWNSTREAM END OF CELL 6

OVERFLOW CHECK/WEIR:
- DESIGNED TO FILL CELL 5
- CONTROLS OUTFLOW FROM PROJECT

EARTHEN BERMS:
- CONSTRUCTED WITH SPOIL MATERIAL EXCAVATED FROM THE SITE
- BUILT WITH 2' OF FREEBOARD
- POTENTIALLY REINFORCED WITH CRUSHED CONCRETE

DELIVERY PIPELINE:
- FROM PHELPS CO. CANAL
- 75 TO 90 CFS CAPACITY

ALL ATTEMPTS HAVE BEEN MADE TO ENSURE THE ACCURACY OF THE PRESENTED INFORMATION; HOWEVER, THIS INFORMATION HAS BEEN FORMATTED FOR CONCEPTUAL PURPOSES ONLY AND IS NOT TO BE USED AS AN OFFICIAL SURVEY. IT IS NOT TO A TRADITIONAL ENGINEERING SCALE.

PLATTE RIVER RECOVERY IMPLEMENTATION PROGRAM

ALTERNATIVE 2 **DRAFT**

COTTONWOOD RANCH BROAD-SCALE RECHARGE PROJECT
CONCEPT LAYOUT (#2)

SHEET NO:	DATE:	DRAWN/CHECKED BY:
	1/3/2017	KW/JF

Attachment B:

Monitoring well logs produced by Mid-State Engineering & Testing

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	Morse Property
LOCATION	Phelps County, Nebraska
JOB NO. 500-02-21	DATE 9/10/14

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
MW- 301	N 40 39' 35.60" W 99 29' 01.40"	2287.45		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING T.O.C.	24 HOURS T.O.C.	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3 1/2'	3 1/2'		4 1/4" Hollow Stem Auger	Kevin Christensen

DEPTH FT	SAMPLE NO. & TYPE	N° BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Greyish Brn	Moist	Firm	SC	**ALLUVIAL TERRACE DEPOSITS** Clayey Sand				
				Light Brown	Moist	Loose	SP	**ALLUVIAL DEPOSITS** Fine to Medium Grained Sand				
	S-1	(8) 3/4/4			Saturated							
5												5
10								Medium Grained Sand w/Trace of Gravel				10
15												15
	A-2											
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT	Morse Property
LOCATION	Phelps County, Nebraska
JOB NO.	500-02-21
DATE	9/10/14

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
MW- 302	N 40 39' 34.70" W 99 28' 47.90"	2285.26		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING T.O.C.	24 HOURS T.O.C.	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'	3'		4 1/4" Hollow Stem Auger	Kevin Christensen

DEPTH FT.	SAMPLE NO. & TYPE	N: BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Brown	Moist	Firm	SC	**ALLUVIAL TERRACE DEPOSITS** Clayey Sand				
				Light Brown	Moist	Firm	SP	**ALLUVIAL DEPOSITS** Medium Sand w/Occasional Gravel				
	S-1	(10) 3/4/6			Saturated							
5												5
10								More Gravel				10
15												15
20	**A-2**											20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	Morse Property
LOCATION	Phelps County, Nebraska
JOB NO.	500-02-21
DATE	9/10/14

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
MW- 303	N 40 39' 44.10" W 99 28' 34.10"	2282.67		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING T.O.C.	24 HOURS T.O.C.	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'	3'		4 1/4" Hollow Stem Auger	Kevin Christensen

DEPTH FT.	SAMPLE NO. & TYPE	N: BLOWS / FT.	REC %	COLOR	MOIST.	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Brown	Moist	Firm	SC	**ALLUVIAL TERRACE DEPOSITS** Clayey Sand				
				Light Brown	Moist	Firm	SP	**ALLUVIAL DEPOSITS** Fine to Medium Grained Sand w/Some Gravel				
	S-1	(11) 7/5/6			Saturated							
5												5
10												10
15												15
	A-2											
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

MID-STATE
ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	Morse Property
LOCATION	Phelps County, Nebraska
JOB NO.	500-02-21
DATE	9/10/14

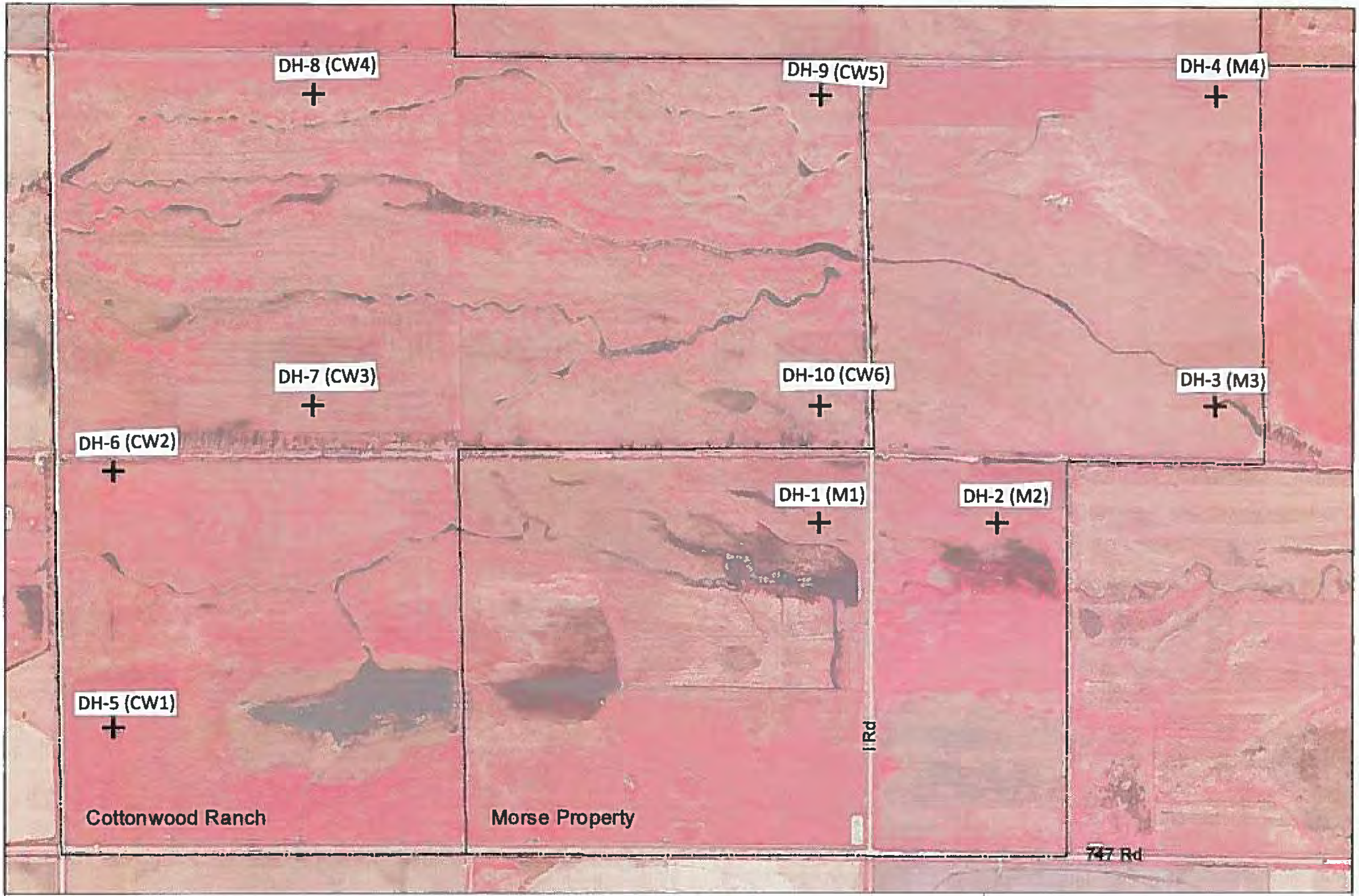
DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
MW- 304	N 40 39' 41.80" W 99 28' 27.60"	2282.5		20'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING T.O.C.	24 HOURS T.O.C.	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3'	3'		4 1/4" Hollow Stem Auger	Kevin Christensen

DEPTH FT.	SAMPLE NO. & TYPE	N" BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Brown	Moist	Firm	SC	**ALLUVIAL TERRACE DEPOSITS** Clayey Sand				
	S-1	(13) 5/6/7		Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Fine to Medium Grained Sand w/Gravel				
5												5
10								Medium Grained Sand w/Gravel				10
15												15
	A-2											
20												20
								Bottom of Hole 20'				
25												25
30												30
35												35

Attachment C:

Borehole logs produced by Mid-State Engineering & Testing



Cottonwood Ranch Geotechnical Investigation

Legend

+ Proposed Bore Holes

⬚ Property Boundaries

Attachment: **A**

Date: 8/11/2016

MID-STATE
ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County, Nebraska
JOB NO.	200-09-23
DATE	9/13/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-1 (M-1)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3 1/2'	3 1/2' Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Very Moist	Firm	CL	**DEVELOPED ZONE**				
				Dark Grey	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Fine Sand				
				Grey			SC	Clayey Sand				
5	S-1	(12) 5/6/6		Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Trace of Gravel	18.1			5
10	S-2	(4) 3/2/2				Very Loose						10
15	S-3	(22) 5/10/12				Very Firm			17.3			15
20	S-4	(12) 7/8/4				Firm						20
				Lt Grey Brn			CL	Lean Clay Layer w/Some Sand				
				Light Brown			SC					
25	S-5	(40) 14/17/23				Dense		Clayey Sand w/Some Gravel	12.2			25
							SP					
30	S-6	(29) 11/12/17				Very Firm		Poorly Graded Fine to Medium Sand w/Some Gravel	10.6			30
35	S-7	(17) 7/9/8				Firm			11.6			35

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT P16-020 Morse and Cottonwood Ranch

LOCATION Phelps County Nebraska

JOB NO. 200-09-23

DATE 9/13/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-1 (M-1)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N" BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Some Gravel				
40	S-8	(17) 12/9/8										40
				Lt Brn Grey	Saturated	Firm	CL	**OGALLALA FORMATION** Lean Clay w/Sand				
45	U-9						SC	Clayey Sand	26.2	96.1	PI=13	45
	S-10	(67) 12/17/50 3.5 inches				Very Dense	CL/ML	Silty Clay w/Fine Sand				
50	S-11	(35) 11/13/22				Dense		Cemented Calcium Concretions	27.6	94.5	PI=8	50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

MID-STATE
ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County, Nebraska
JOB NO.	200-09-23
DATE	9/12/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-2 (M-2)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
3 1/2'	6 1/2' Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS / FT	REC %	COLOR	MOIST.	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Very Moist	Firm	CL/SC	**DEVELOPED ZONE**				
	A-1			Dark Grey	Very Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Sand				
				Light Grey			SC	Clayey Sand				
5	S-2	(11) 5/6/5		Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Trace of Gravel				5
10	S-3	(10) 4/5/5				Loose		w/Some Gravel	12.2			10
15	S-4	(16) 5/6/10				Firm		Trace of Gravel				15
20	S-5	(23) 9/11/13				Very Firm		Very Fine Sand	11.0			20
								Poorly Graded Fine to Medium Sand w/Some Gravel				
25	S-6	(24) 7/11/13										25
30	S-7	(34) 11/17/17				Dense			11.7			30
35	S-8	(19) 12/10/9				Firm						35

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County Nebraska
JOB NO.	200-09-23
DATE	9/12/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-2 (M-2)	As Per Boring Location Plan			50'

DEPTH FT	SAMPLE NO. & TYPE	N° BLOWS / FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Trace of Gravel				
40	S-9	(15) 8/8/7							10.7			40
				Lt Grey Brn	Moist	Firm	CL	**OGALLALA FORMATION** Lean Clay w/Sand				
45	S-10	(28) 14/15/13		Lt Brn Grey		Very Firm	SP/SC	Clayey Sand w/Calcium Concretions	21.1	94.1	PI=NP	45
50	S-11	(79) 15/30/49				Very Dense	CL					50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

MID-STATE
ENGINEERING &
TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch		
LOCATION	Phelps County, Nebraska		
JOB NO.	200-09-23	DATE	9/14/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-3 (M-3)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	4 1/2' Wet Cave		4 1/4" Hollow Stem Auger	Shawn Cooney

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Grey Brown	Slightly Moist	Firm	CL	**DEVELOPED ZONE**				
				Grey Brown	Slightly Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Fine Sand				
				Grey Brown	Slightly Moist	Loose	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Some Gravel				
5	S-1	(7) 3/4/3			Saturated							5
10	S-2	(7) 3/3/4							11.3			10
								Clay Seam < 6" Thick				
15	S-3	(17) 8/8/9				Firm		Poorly Graded Coarse Sand w/Some Gravel	14.0			15
							SP/SC					
20	S-4	(16) 8/8/8						Clayey Sand w/Trace of Gravel	12.8			20
25	S-5	(24) 7/11/13				Very Firm	SP	Poorly Graded Medium Sand				25
30	S-6	(25) 7/10/15					SP/SC		16.3			30
35	S-7	(31) 10/14/17				Dense	SP	Clayey Sand w/Some Gravel	10.5			35

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County Nebraska
JOB NO.	200-09-23
DATE	9/14/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-3 (M-3)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS / FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Dense	SP	**ALLUVIAL DEPOSITS** Poorly Graded Coarse Sand w/Some Gravel				
	S-8	(15) 5/8/7		Lt Grey Brn	Moist	Firm	CL	**OGALLALA FORMATION** Lean Clay w/Fine to Medium Sand and Calcium				
40												40
					Saturated							
	S-9	(32) 16/14/16					SC	Clayey Sand	35.3	88.1	PI=19	
45												45
	S-10	(36) 12/15/21										
50												50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

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BORING LOG

PROJECT P16-020 Morse and Cottonwood Ranch

LOCATION Phelps County, Nebraska

JOB NO. 200-09-23

DATE 9/14/16

DRILL HOLE NO. DH-4 (M-4)

LOCATION OF DRILL HOLE As Per Boring Location Plan

ELEVATION

DATUM

TOTAL DEPTH 50'

WATER LEVEL OBSERVATIONS

WHILE DRILLING	END OF DRILLING	HOURS
3 1/2"	5' Wet Cave	

TYPE OF SURFACE Grass

DRILLER Mid-State Engineering

DRILLING METHOD 4 1/4" Hollow Stem Auger

LOGGER Shawn Cooney

DEPTH FT.	SAMPLE NO. & TYPE	N: BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Dk Grey Brn	Slightly Moist	Firm	CL	**DEVELOPED ZONE**				
				Dk Grey Brn	Slightly Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Fine Sand				
				Grey Brown	Moist		SC	Clayey Sand				
5	S-1	(11) 3/6/5		Grey Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Trace of Gravel	17.8			5
10	S-2	(7) 3/4/3				Loose		w/Some Gravel	12.4			10
15	S-3	(13) 6/6/7		Light Brown		Firm						15
20	S-4	(15) 7/7/8							10.9			20
25	S-5	(9) 5/4/5				Loose						25
30	S-8	(20) 7/9/11				Firm		Poorly Graded Medium Sand w/Trace of Gravel	12.6			30
							SP/SC					
35	S-7	(21) 10/11/10						Clayey Sand w/Gravel	11.8			35

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County Nebraska
JOB NO.	200-09-23
DATE	9/14/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-4 (M-4)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** w/Gravel				
				Grey Brown	Very Moist	Dense	SC	**OGALLALA FORMATION** Clayey Sand w/Some Gravel				
40	S-8	(36) 10/12/24										40
				Lt Brn Grey								
45	S-9	(49) 14/17/32										45
50	S-10	(55) 17/19/36				Very Dense		Cemented Calcium Concretions	27.7		PI=16	50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

MID-STATE ENGINEERING & TESTING, INC.	BORING LOG	PROJECT	P16-020 Morse and Cottonwood Ranch
		LOCATION	Phelps County, Nebraska
		JOB NO. 200-09-23	DATE 9/15/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-5 (CW-1)	As Per Boring Location Plan			55'

WATER LEVEL OBSERVATIONS: WHILE DRILLING	END OF DRILLING	HOURS	TYPE OF SURFACE	DRILLER
			Prairie Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
7'	7' Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT.	SAMPLE NO. & TYPE	N: BLOWS / FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Brown	Slightly Moist	Firm	CL	**DEVELOPED ZONE**				
				Dark Brown	Slightly Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Fine Sand				
	S-1	(6) 2/4/4		Light Brown	Moist	Loose	SC	Clayey Sand				
5					Very Moist							5
					Saturated							
	S-2	(12) 4/5/7		Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine Sand w/Trace of Gravel	17.9			
10												10
	S-3	(14) 5/7/7							16.1			
15												15
	S-4	(18) 5/7/11										
20												20
				Grey Brown								
	S-5	(16) 3/8/8						Fine to Medium Sand w/Trace of Gravel	10.1			
25												25
	S-6	(16) 6/8/10		Light Brown					10.5			
30												30
	S-7	(17) 7/7/10										
35												35

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County Nebraska
JOB NO.	200-09-23
DATE	9/15/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-5 (CW-1)	As Per Boring Location Plan			55'

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Trace of Gravel				
40	S-8	(24) 7/11/13				Very Firm			10.8			40
45	S-9	(18) 9/10/8		Lt Grey Brn	Moist	Firm	CL	**OGALLALA FORMATION** Lean Clay w/Some Calcium and Fine Sand				45
50	S-10	(28) 11/13/15		Lt Brn Grey	Very Moist	Very Firm			30.7	89.1	PI=23	50
55	S-11	(40) 13/16/24				Dense						55
								Bottom of Hole 55'				
60												60
65												65
70												70
75												75

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County, Nebraska
JOB NO.	200-09-23
DATE	9/15/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-6 (CW-2)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Prairie Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
5'	5' Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Grey Brown	Slightly Moist	Firm	CL	**DEVELOPED ZONE**				
				Grey Brown	Slightly Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Fine Sand				
					Moist	Loose	SC	Clayey Sand				
5	S-1	(6) 2/3/3							14.8			5
				Light Brown	Saturated	Loose	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine Sand w/Trace of Gravel				
10	S-2	(10) 2/5/5							10.9			10
15	S-3	(13) 5/6/7				Firm		Fine to Medium Grained Sand w/Trace of Gravel	10.6			15
20	S-4	(15) 10/9/6										20
25	S-5	(28) 15/12/16				Very Firm	SP/SC	Fine to Medium Grained Clayey Sand w/Some Gravel	10.7			25
30	S-6	(17) 7/7/10				Firm	SP	Fine to Medium Sand w/Some Gravel				30
35	S-7	(13) 7/7/6							13.0			35

MID-STATE
ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County Nebraska
JOB NO.	200-09-23
DATE	9/15/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-6 (CW-2)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS / FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Fine to Medium Sand Trace of Gravel				
40	S-8	(62) 16/30/32				Very Dense		Very Fine Sand, No Gravel	10.1			40
				Lt Grey Brn	Moist	Firm	SC	**OGALLALA FORMATION** Poorly Graded Clayey Sand				
45	S-9	(13) 2/5/8							20.3		Pi=8	45
50	S-10	(58) 10/17/41			Very Moist	Very Dense						50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County, Nebraska
JOB NO.	200-09-23
DATE	9/15/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-7 (CW-3)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Prairie Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	4' Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT.	SAMPLE NO. & TYPE	N: BLOWS /FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Dark Grey	Moist	Firm	CL	**DEVELOPED ZONE**				
	A-1			Dark Grey	Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Some Fine Sand				
				Grey Brown	Very Moist		SC	Clayey Sand				
5	S-2	(12) 4/6/6		Light Brown	Very Moist Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine to Medium Sand w/Trace of Gravel	13.6			5
10	S-3	(4) 2/2/2				Very Loose		Fine to Medium Grained Sand w/Trace of Gravel	11.4			10
15	S-4	(7) 3/3/4				Loose		Fine Grained Sand w/Trace of Gravel				15
20	S-5	(24) 10/11/13				Very Firm			11.2			20
25	S-6	(18) 7/9/9				Firm		Some Gravel	9.9			25
30	S-7	(10) 3/4/6				Loose		Fine to Medium Grained Sand w/Some Gravel				30
35	S-8	(29) 12/12/17				Very Firm			11.6			35

MID-STATE ENGINEERING & TESTING, INC.	BORING LOG		
		PROJECT	**P16-020 Morse and Cottonwood Ranch**
		LOCATION	**Phelps County Nebraska**
		JOB NO. 200-09-23	**DATE** 9/15/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-7 (CW-3)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N° BLOWS / FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Fine Grained Sand w/Some Gravel				
				Grey Brown			SM	Silty Fine Sand				
40	S-9	(42) 6/20/22		Grey Brown	Moist	Dense	SC	**OGALLALA FORMATION** Clayey Sand Alot of Calcium	19.1		PI=11	40
45	S-10	(50+) 30/50 5 Inches		Lt Brn Grey	Very Moist	Very Dense		Less Calcium				45
50	S-11	(72+) 4/22/50 3 Inches		Brownish Grey				Clayey Sand Cemented Calcium Layers				50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

MID-STATE **ENGINEERING & TESTING, INC.**	**BORING LOG**	PROJECT	P16-020 Morse and Cottonwood Ranch
		LOCATION	Phelps County, Nebraska
		JOB NO. 200-09-23	DATE 9/13/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-8 (CW-4)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Prairie Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	4' Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Dark Grey	Slightly Moist	Firm	CL	**DEVELOPED ZONE**				
				Dark Grey	Slightly Moist	Firm	CL	**ALLUVIAL TERRACE** Lean Clay w/Fine Sand				
				Grey			SC	Clayey Sand				
				Light Brown	Moist	Loose	SP	**ALLUVIAL DEPOSITS** Poorly Graded Sand w/Trace of Gravel, Rust Stains				
5	S-1	(10) 4/5/5			Saturated							5
10	S-2	(7) 3/3/4										10
15	S-3	(8) 6/3/5										15
20	S-4	(11) 4/5/6		Grey Brown		Firm						20
25	S-5	(30) 12/15/15		Light Brown		Very Firm						25
30	S-6	(36) 9/16/20		Lt Grey Brn		Dense						30
35	S-7	(22) 10/10/12				Very Firm						35

MID-STATE
ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County Nebraska
JOB NO.	200-09-23
DATE	9/13/16

DRILL HOLE NO	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-8 (CW-4)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS /FT	REC %	COLOR	MOIST	CONS	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Very Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Sand No Gravel				
40	S-8	(20) 9/10/10		Lt Grey Brn	Moist	Firm	CL	**OGALLALA FORMATION** Lean Clay w/Varying Amount of Fine Sand	21.2	92.0	PI=13	40
45	S-9	(75+) 12/25/50 4 inches		Lt Brn Grey		Very Dense		Cemented Calcium Concretions				45
50	S-10	(50+) 50 5.5 inches										50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch		
LOCATION	Phelps County, Nebraska		
JOB NO.	200-09-23	DATE	9/13/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-9 (CW-5)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Prairie Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	4' Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Grey Brown	Slightly Moist	Firm	CL	**DEVELOPED ZONE**				
				Grey Brown	Slightly Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Fine Sand				
				Lt Grey Brn	Slightly Moist	Loose	SP	**ALLUVIAL DEPOSITS** Poorly Graded Fine Sand w/Trace of Gravel				
					Moist							
	S-1	(9) 3/4/5										
5					Saturated							5
	S-2	(6) 3/3/3		Light Brown					13.9			
10												10
	S-3	(15) 6/7/8				Firm			12.8			
15												15
	S-4	(9) 4/4/5				Loose	SP/SC	Poorly Graded Fine to Medium Sand w/Some Clay	13.3			
20												20
	S-5	(15) 3/7/8				Firm						
25												25
	S-6	(14) 6/7/7					SP	Poorly Graded Fine to Medium Sand w/Trace of Gravel	14.7			
30												30
	S-7	(58) 15/25/33				Very Dense		w/Some Gravel	10.0			
35												35

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT P16-020 Morse and Cottonwood Ranch

LOCATION Phelps County Nebraska

JOB NO. 200-09-23

DATE 9/13/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-9 (CW-5)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N* BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Poorly Graded Sand w/Some Gravel				
40	S-8	(7) 10/4/3		Lt Grey Brn	Moist	Soft	CL	**OGALLALA FORMATION** Lean Clay w/Some Fine Sand				40
45	S-9	(50+) 50 2 Inches				Very Dense		Cemented Calcium Concretions				45
							SC					
50	S-10	(60) 15/25/35		Light Grey	Very Moist			Clayey Sand	29.8	81.8	PI=8	50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT	P16-020 Morse and Cottonwood Ranch
LOCATION	Phelps County, Nebraska
JOB NO.	200-09-23
DATE	9/14/16

DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-10 (CW-6)	As Per Boring Location Plan			50'

WATER LEVEL OBSERVATIONS			TYPE OF SURFACE	DRILLER
WHILE DRILLING	END OF DRILLING	HOURS	Prairie Grass	Mid-State Engineering
			DRILLING METHOD	LOGGER
4'	3' 8" Wet Cave		4 1/4" Hollow Stem Auger	Jerry Stithem

DEPTH FT.	SAMPLE NO. & TYPE	"N" BLOWS /FT.	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT
				Dk Grey Brn	Moist	Firm	CL	**DEVELOPED ZONE**				
				Dk Grey Brn	Moist	Firm	CL	**ALLUVIAL TERRACE DEPOSITS** Lean Clay w/Some Fine Sand				
				Grey Brown			SC	Clayey Sand				
5	S-1	(11) 9/4/7		Grey Brown	Saturated	Firm	SP	**ALLUVIAL DEPOSITS** Medium Grained Sand w/Some Gravel	14.1			5
10	S-2	(7) 3/3/4		Brown		Loose			13.9			10
15	S-3	(11) 4/5/6				Firm						15
20	S-4	(14) 8/7/7							14.4			20
25	S-5	(18) 8/9/9										25
30	S-6	(24) 5/12/12				Very Firm			13.7			30
35	S-7	(35) 9/17/18				Dense		w/Some Gravel	13.2			35

MID-STATE

ENGINEERING & TESTING, INC.

BORING LOG

PROJECT: P16-020 Morse and Cottonwood Ranch
LOCATION: Phelps County Nebraska
JOB NO.: 200-09-23
DATE: 9/14/16

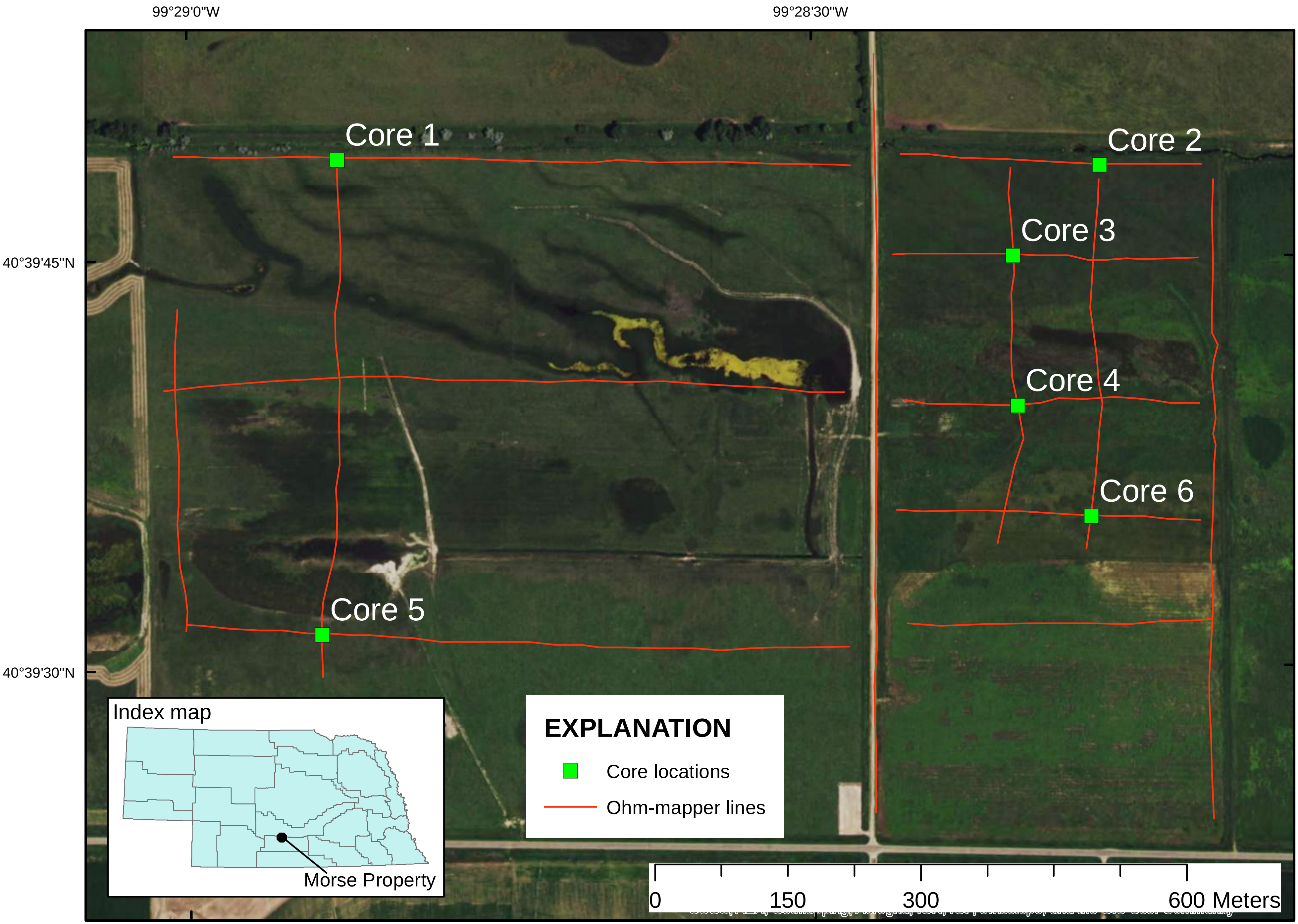
DRILL HOLE NO.	LOCATION OF DRILL HOLE	ELEVATION	DATUM	TOTAL DEPTH
DH-10 (CW-6)	As Per Boring Location Plan			50'

DEPTH FT.	SAMPLE NO. & TYPE	N BLOWS / FT	REC %	COLOR	MOIST	CONS.	SOIL TYPE (Class)	GEOLOGIC DESCRIPTION & OTHER REMARKS	MOIST %	DRY WEIGHT PCF	QU TSF	DEPTH FT.
				Light Brown	Saturated	Dense	SP	**ALLUVIAL DEPOSITS** Fine to Medium Sand w/Some Gravel				
	S-8	(22) 12/13/9										
40				Grey Brown	Moist	Very Firm	SC	**OGALLALA FORMATION** Clayey Sand	22.5	87.2	Pi=17	40
45	S-9	(81+) 10/31/50 4 inches				Very Dense		w/Calcium Deposits				45
50	S-10	(61) 11/18/43										50
								Bottom of Hole 50'				
55												55
60												60
65												65
70												70
75												75

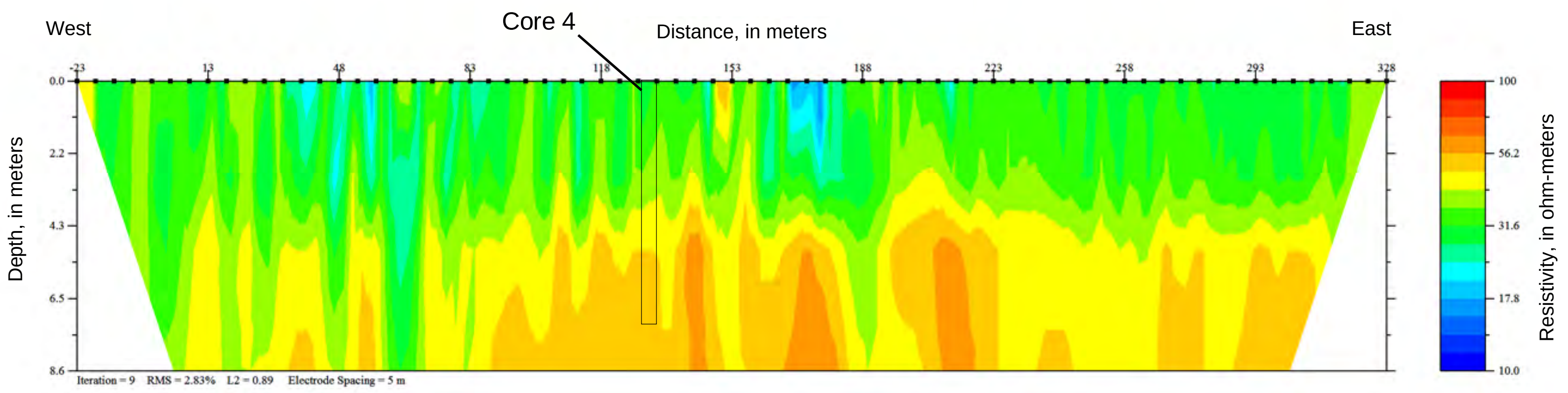
Attachment D:

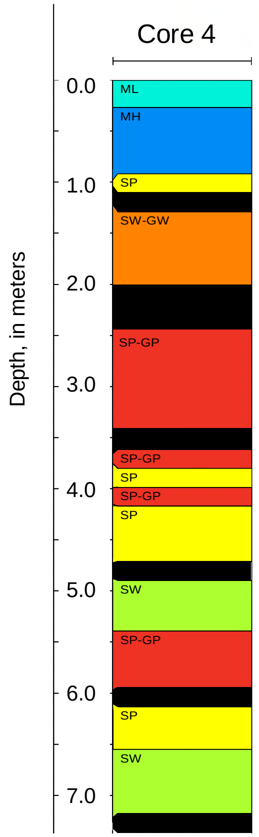
Deliverables from USGS Ohm-Mapper Survey

Data from USGS is very large (+100 MB) and is available upon request


99°29'0"W
99°28'30"W
40°39'45"N
40°39'30"N
Core 1
Core 2
Core 3
Core 4
Core 5
Core 6
Index map
Morse Property
EXPLANATION
Core locations
Ohm-mapper lines
0
150
300
600 Meters

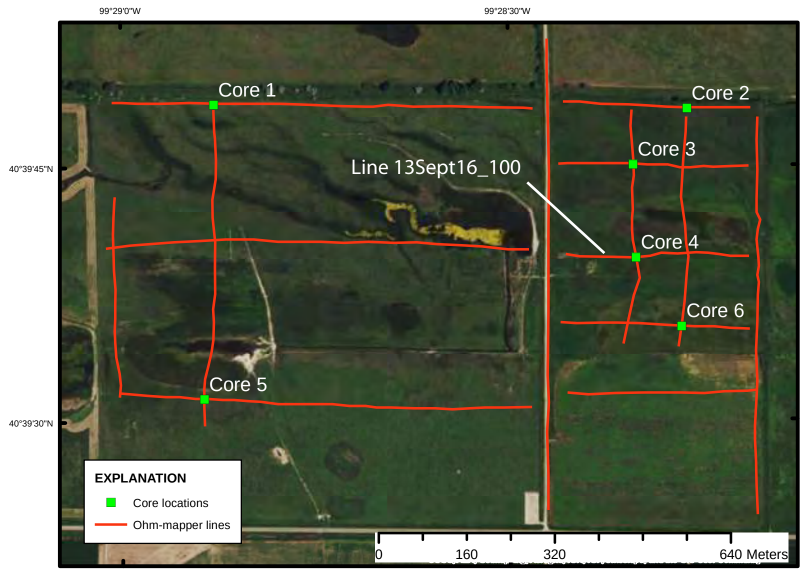
Inverted resistivity section: Line 13Sept16_100





Lithology

Label	Description
🟦 MH-CH	Clayey silt
🟦 MH	Silt, high-plasticity
🟦 ML	Silt, low-plasticity
🟩 ML-SP	Sandy silt
🟩 SP-ML	Silty sand
🟩 SW	Sand, poorly sorted
🟨 SP	Sand, well sorted
🟧 SW-GW	Poorly sorted sand and gravel
🟥 SP-GP	Well sorted sand and gravel
⬛ No recovery	



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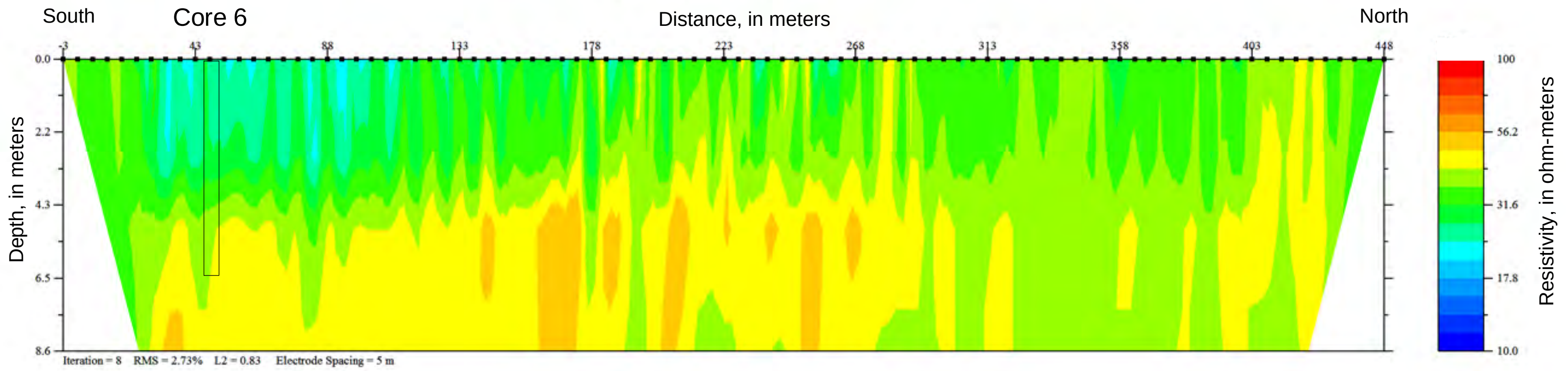

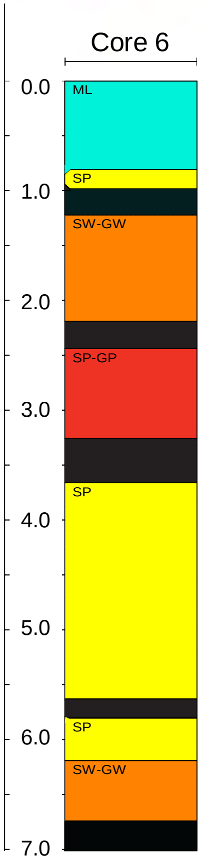

Lithology

Label	Description
🟦 MH-CH	Clayey silt
🟦 MH	Silt, high-plasticity
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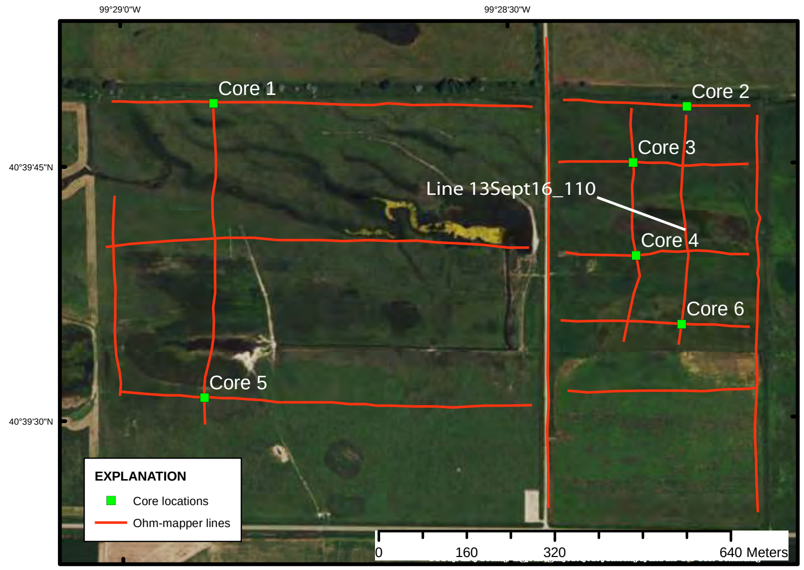
🟨 SP	Sand, well sorted
🟧 SW-GW	Poorly sorted sand and gravel
🟥 SP-GP	Well sorted sand and gravel
⬛ No recovery	



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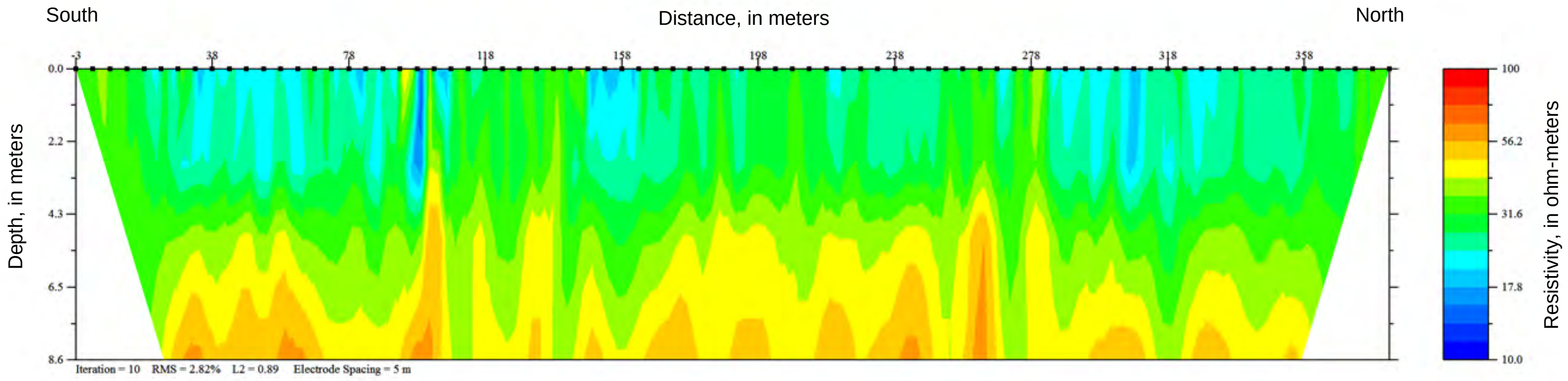

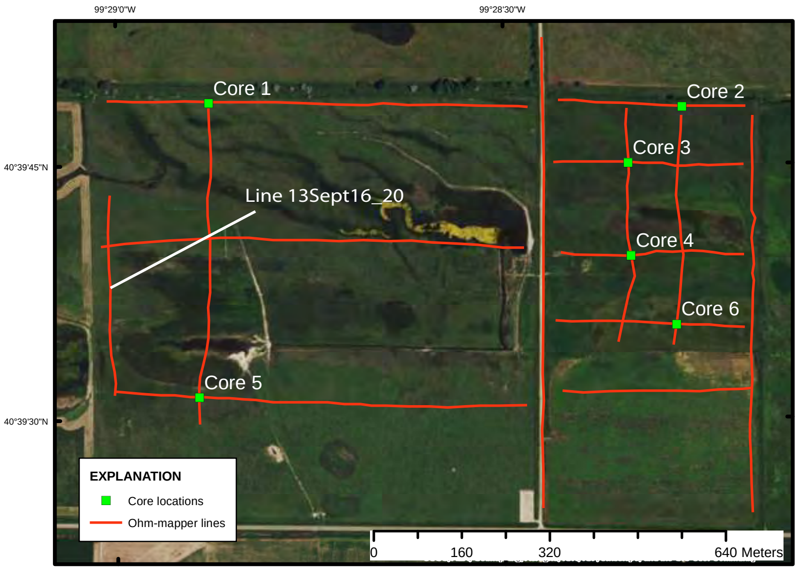

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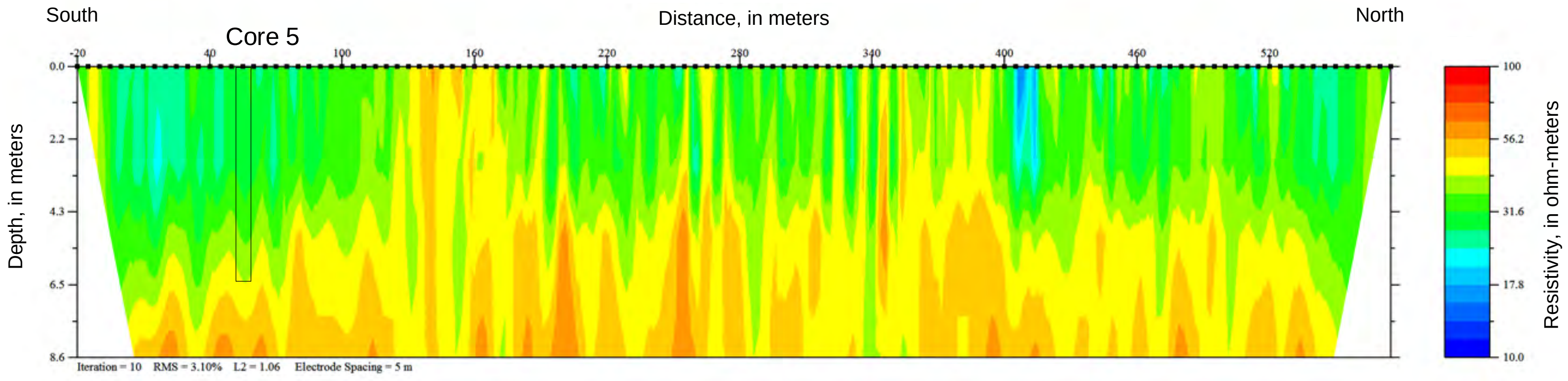
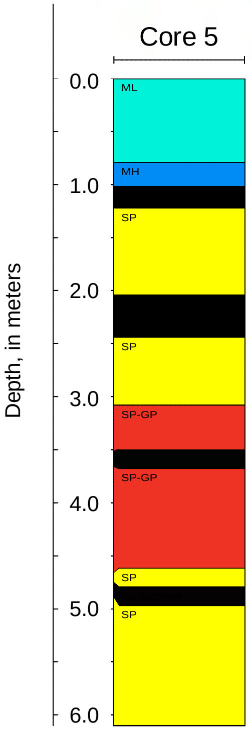
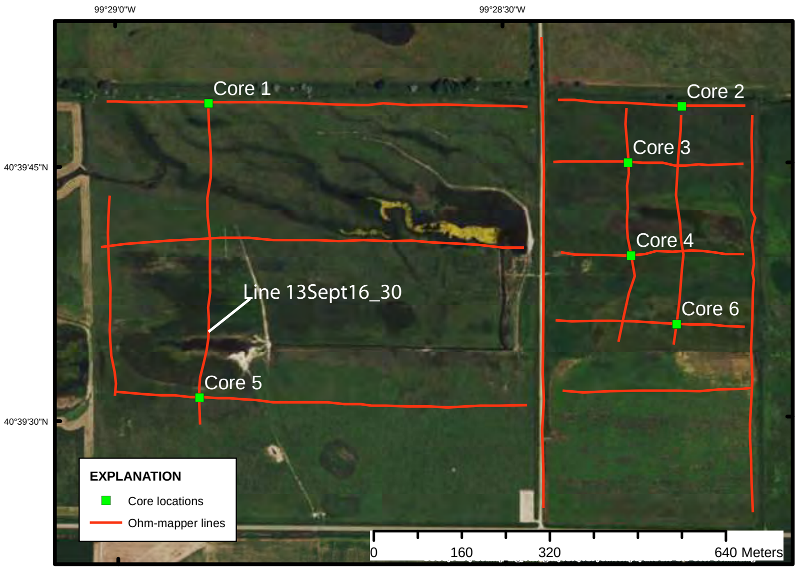




Lithology

	Label	Description
🟦	MH-CH	Clayey silt
🟦	MH	Silt, high-plasticity
🟦	ML	Silt, low-plasticity
🟩	ML-SP	Sandy silt
🟩	SP-ML	Silty sand
🟩	SW	Sand, poorly sorted
🟨	SP	Sand, well sorted
🟧	SW-GW	Poorly sorted sand and gravel
🟥	SP-GP	Well sorted sand and gravel
⬛	No recovery	



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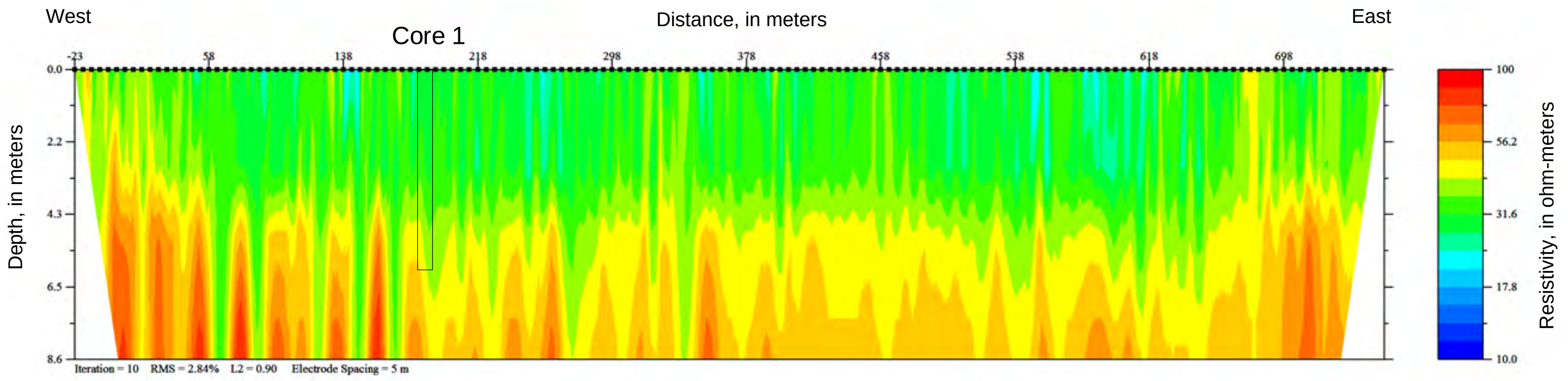

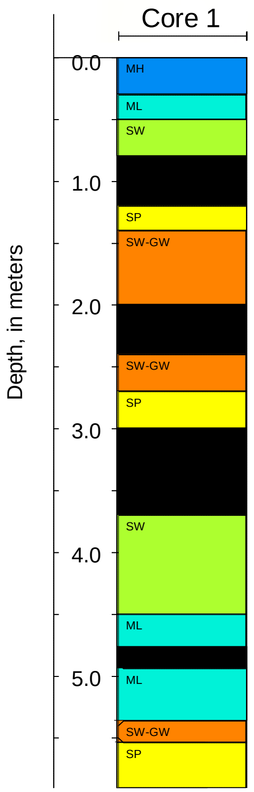

Lithology

Label	Description
🟦 MH-CH	Clayey silt
🟦 MH	Silt, high-plasticity
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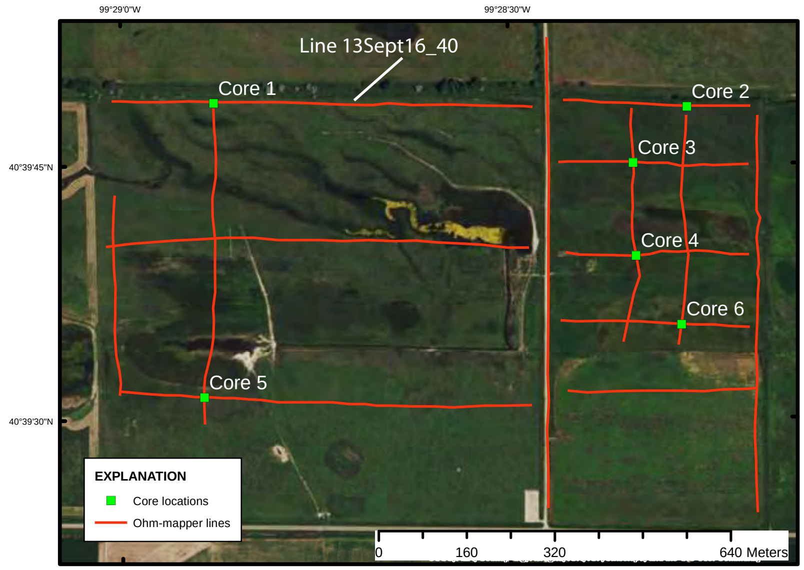
🟩 SW	Sand, poorly sorted
🟨 SP	Sand, well sorted
🟧 SW-GW	Poorly sorted sand and gravel
🟥 SP-GP	Well sorted sand and gravel
⬛ No recovery	



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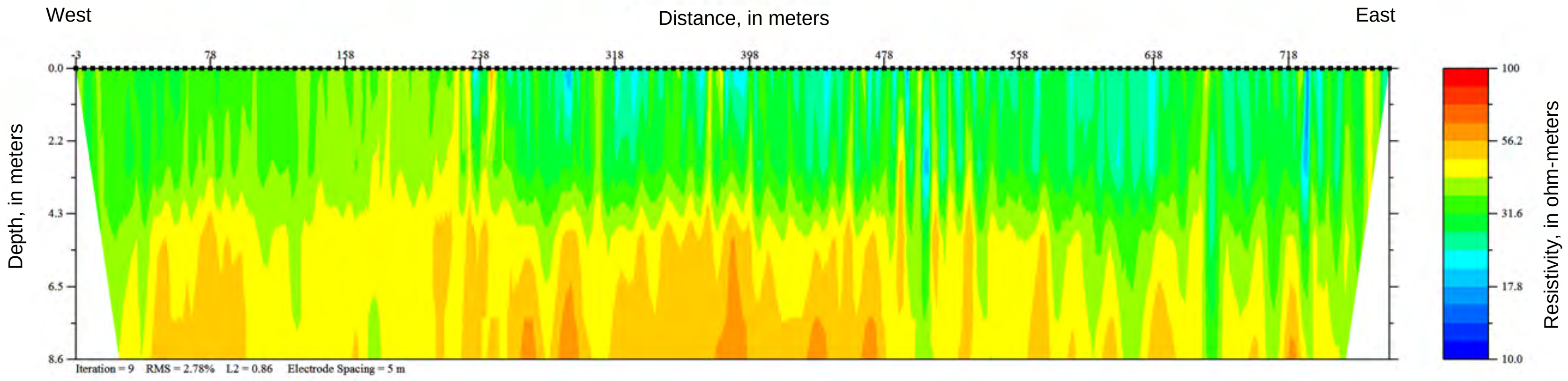

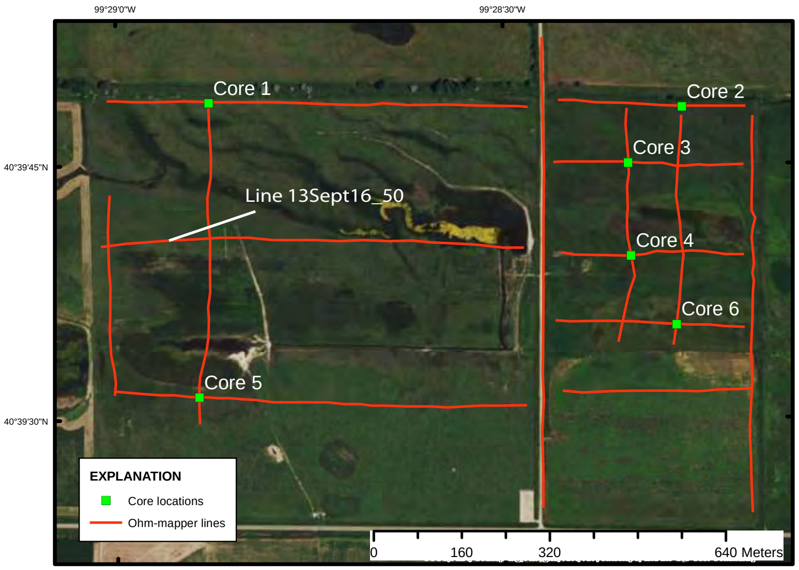

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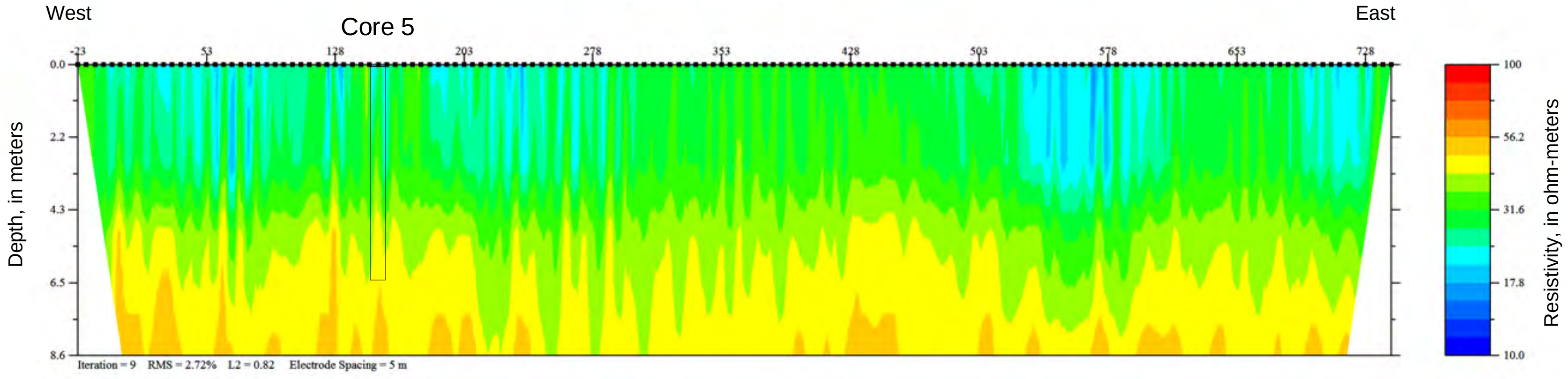
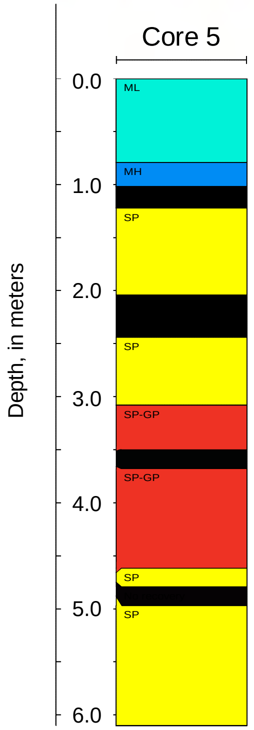
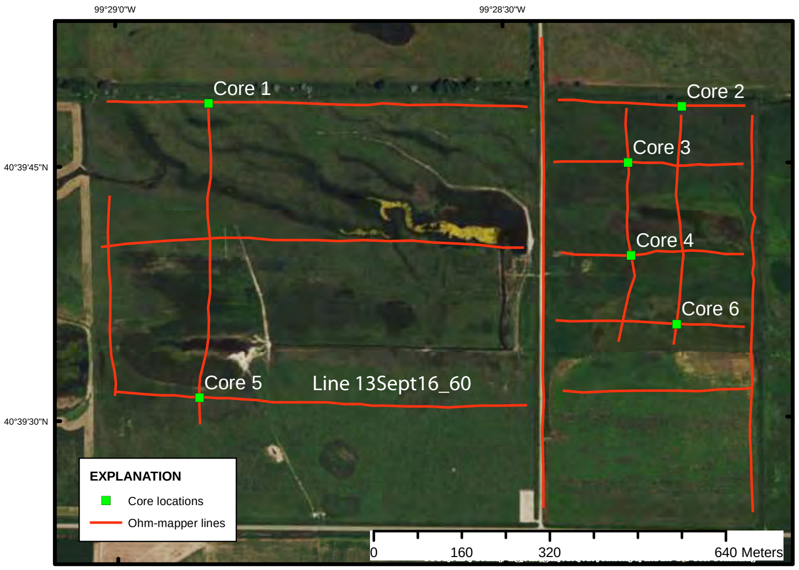




Lithology

	Label	Description
🟦	MH-CH	Clayey silt
🟦	MH	Silt, high-plasticity
🟦	ML	Silt, low-plasticity
🟩	ML-SP	Sandy silt
🟩	SP-ML	Silty sand
🟩	SW	Sand, poorly sorted
🟨	SP	Sand, well sorted
🟧	SW-GW	Poorly sorted sand and gravel
🟥	SP-GP	Well sorted sand and gravel
⬛	No recovery	



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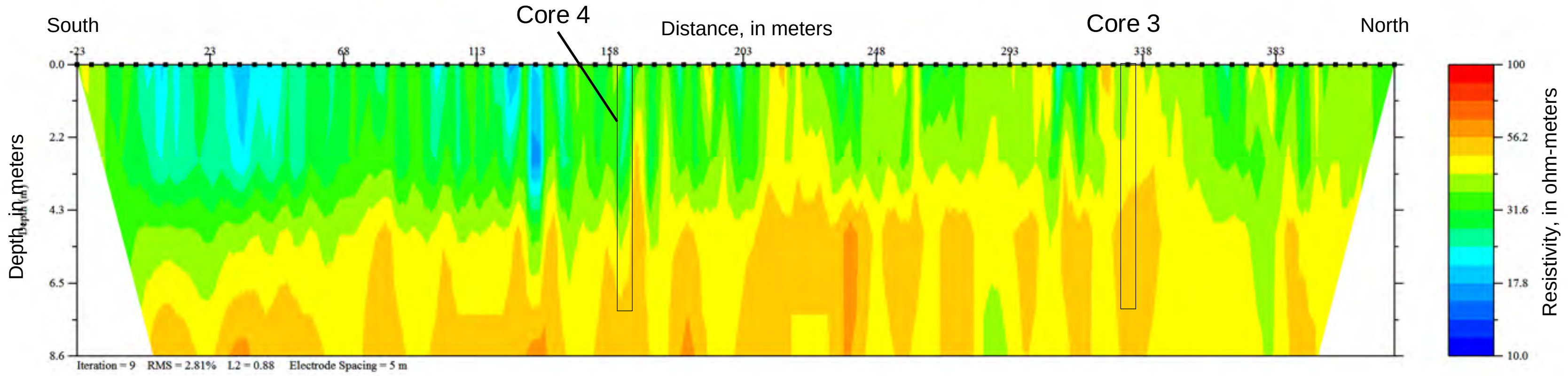
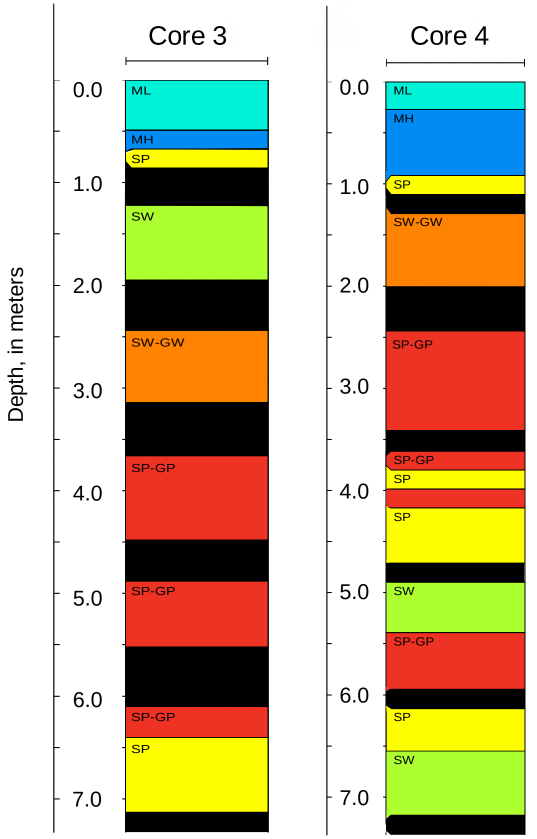
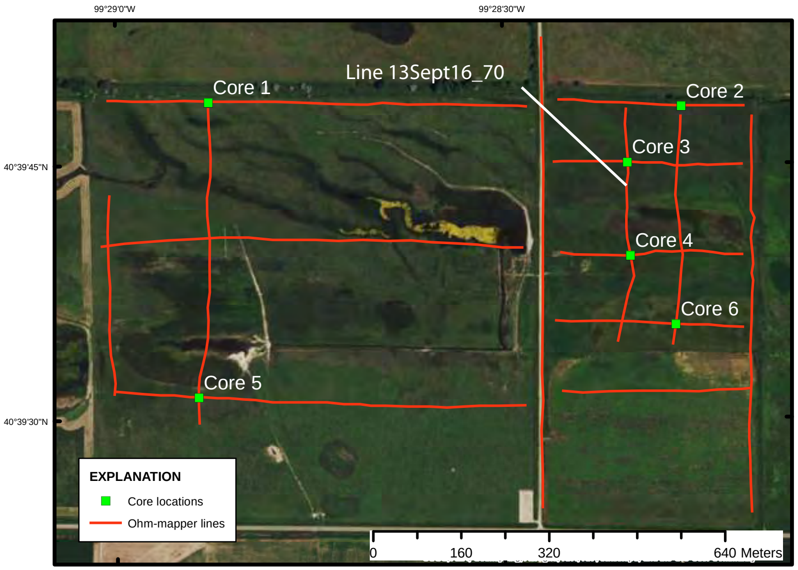


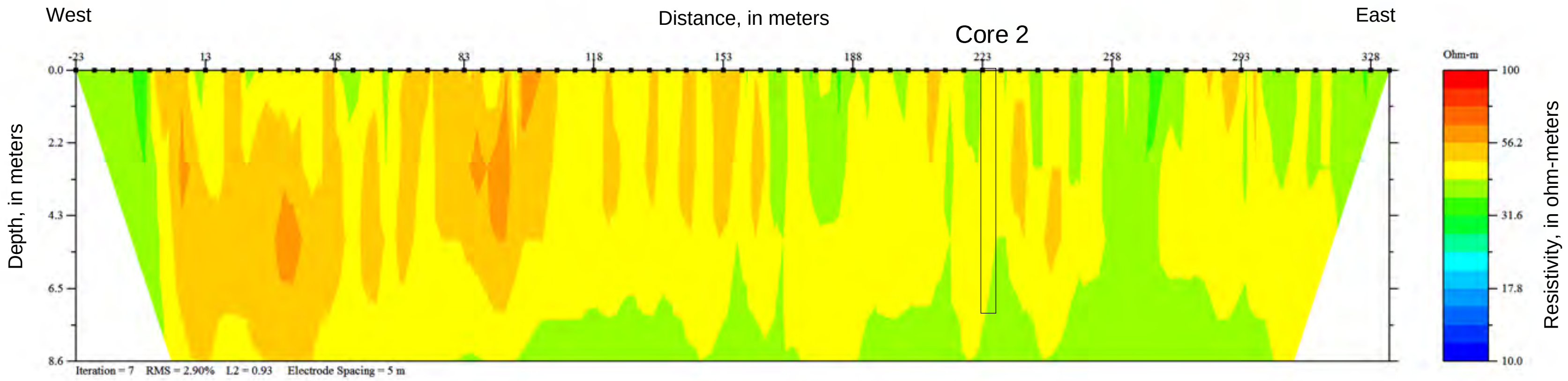


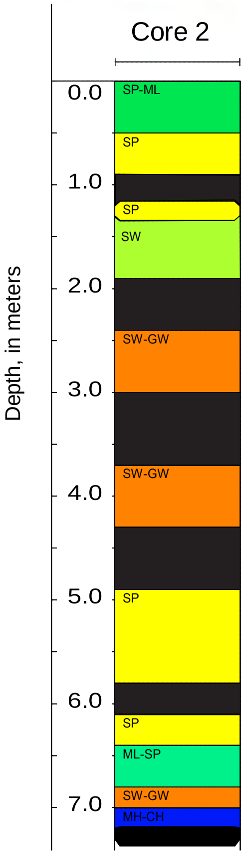
Lithology

	Label	Description
🟦	MH-CH	Clayey silt
🟦	MH	Silt, high-plasticity
🟦	ML	Silt, low-plasticity
🟩	ML-SP	Sandy silt
🟩	SP-ML	Silty sand
🟩	SW	Sand, poorly sorted
🟨	SP	Sand, well sorted
🟧	SW-GW	Poorly sorted sand and gravel
🟥	SP-GP	Well sorted sand and gravel
⬛	No recovery	



Inverted resistivitv section: Line 13Sept16_80





Lithology

Label	Description
🟦 MH-CH	Clayey silt
🟦 MH	Silt, high-plasticity
🟦 ML	Silt, low-plasticity
🟩 ML-SP	Sandy silt
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🟨 SP	Sand, well sorted
🟧 SW-GW	Poorly sorted sand and gravel
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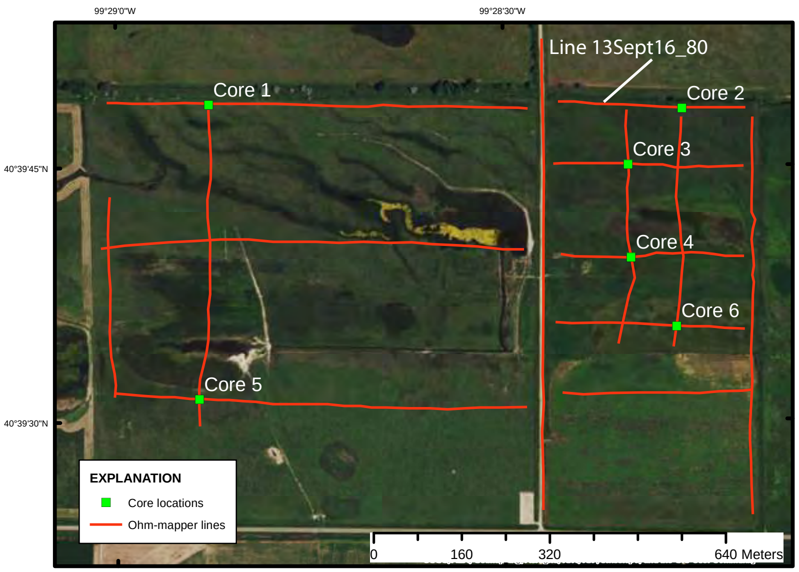

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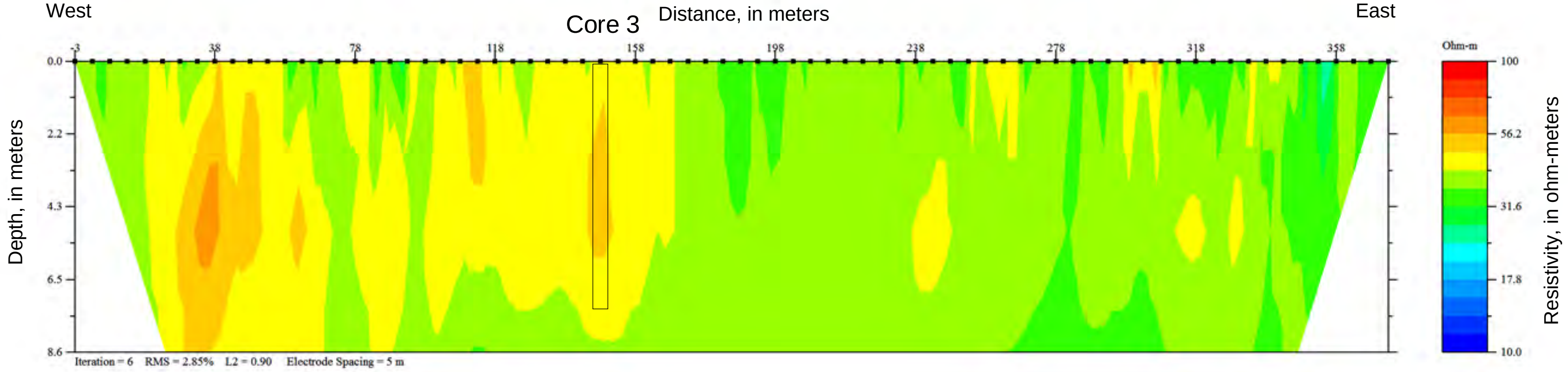

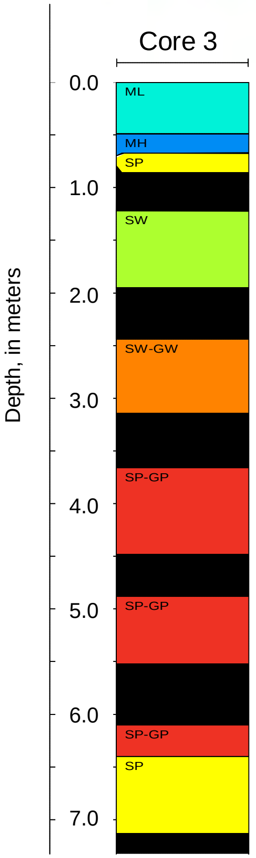

Lithology

	Label	Description
🟦	MH-CH	Clayey silt
🟦	MH	Silt, high-plasticity
🟦	ML	Silt, low-plasticity
🟩	ML-SP	Sandy silt
🟩	SP-ML	Silty sand
🟩	SW	Sand, poorly sorted
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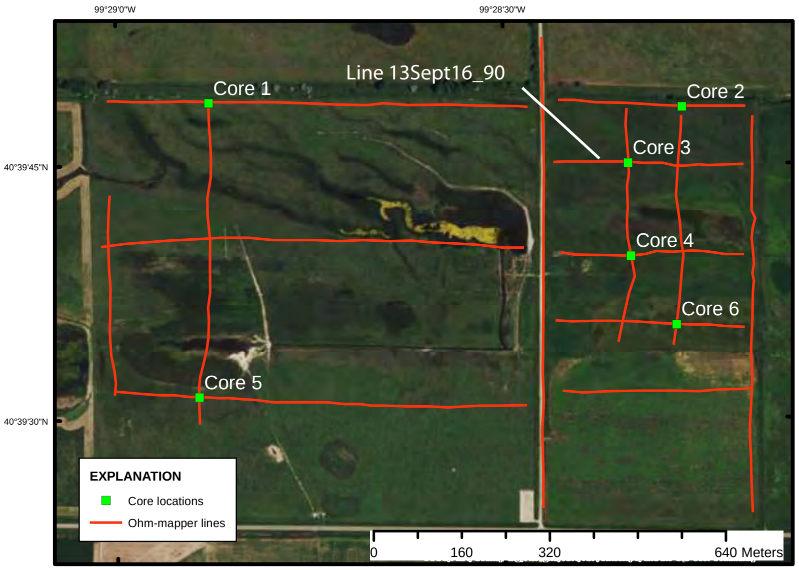
🟧	SW-GW	Poorly sorted sand and gravel
🟥	SP-GP	Well sorted sand and gravel
⬛	No recovery	



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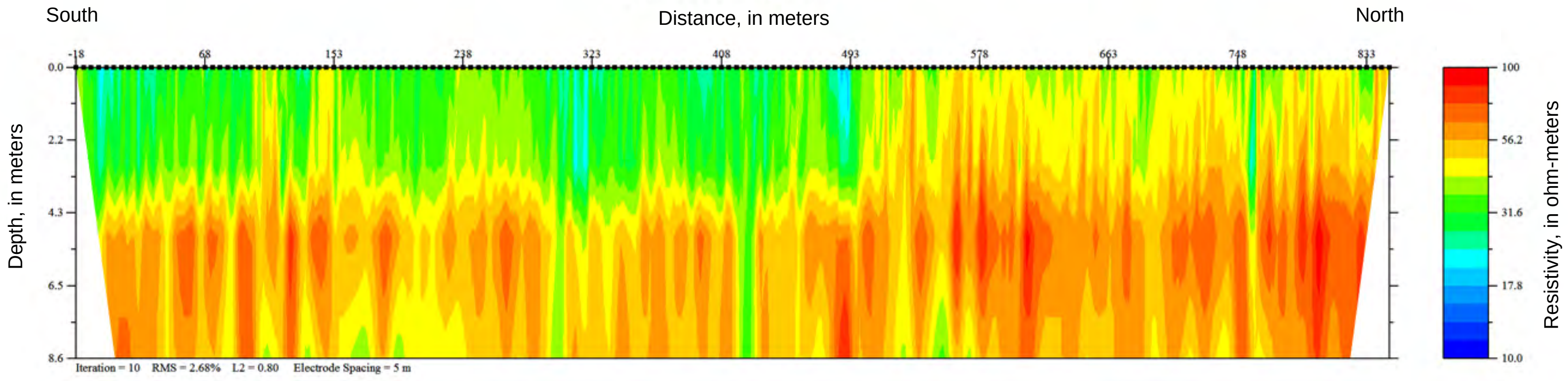

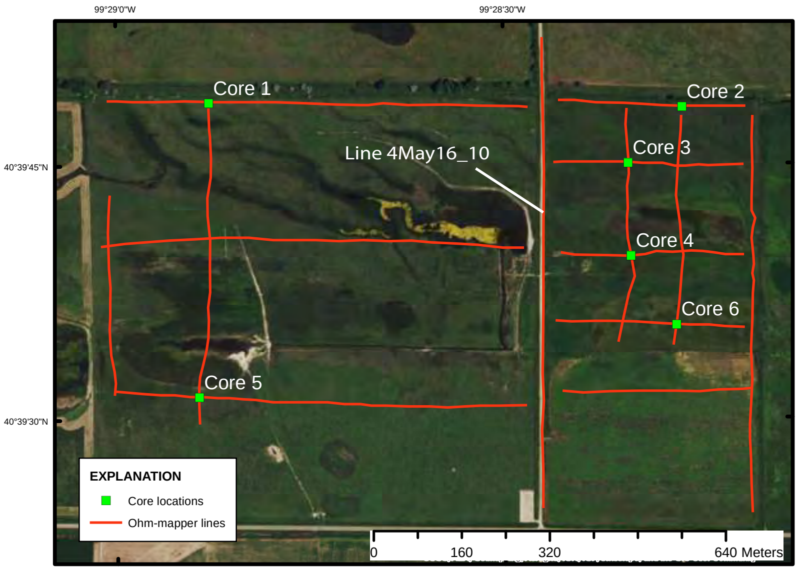

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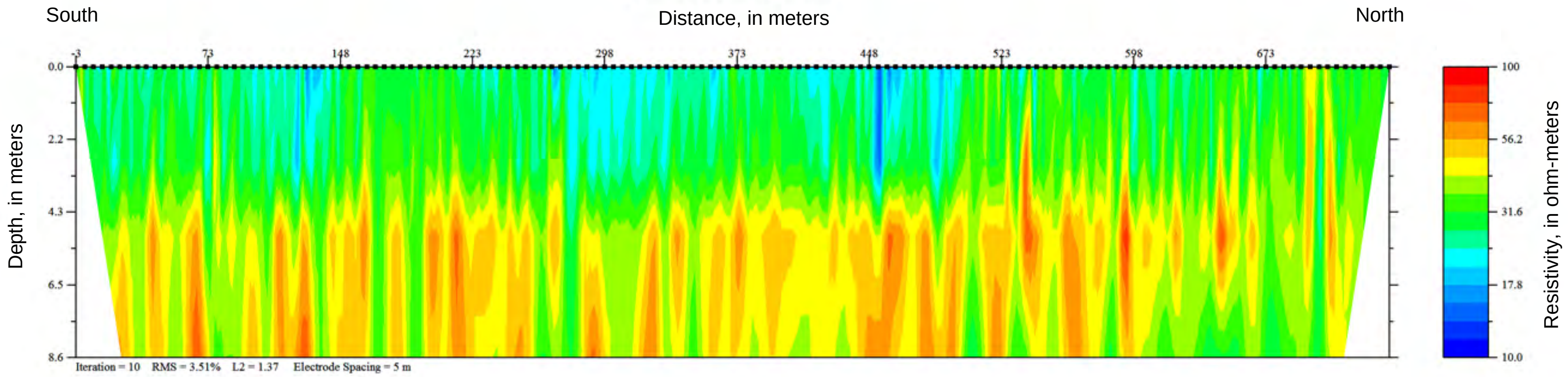

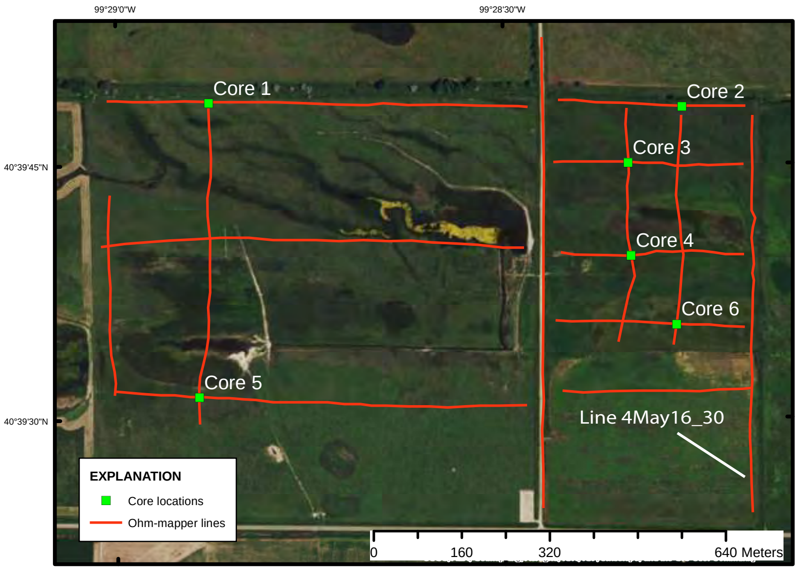

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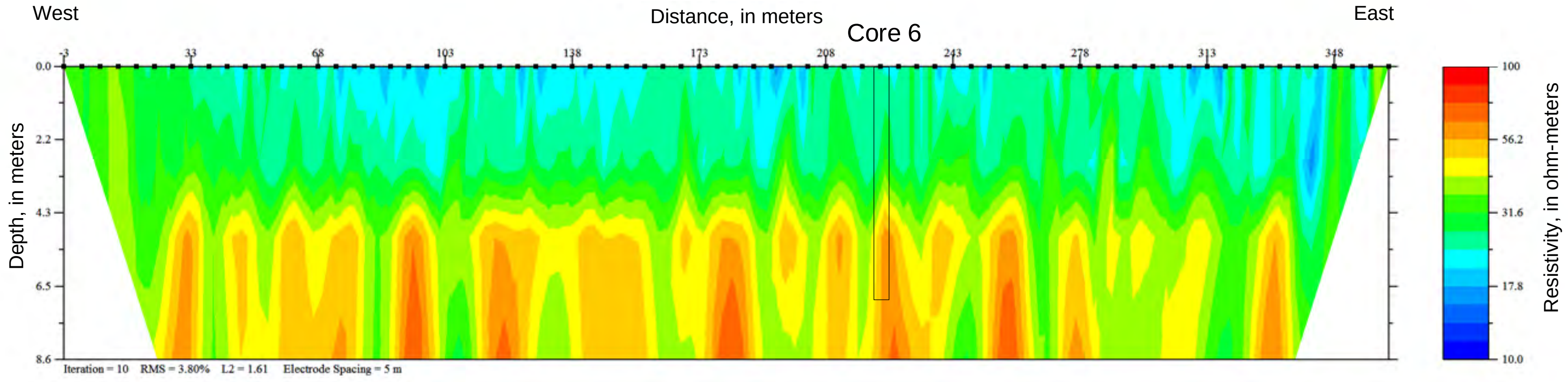

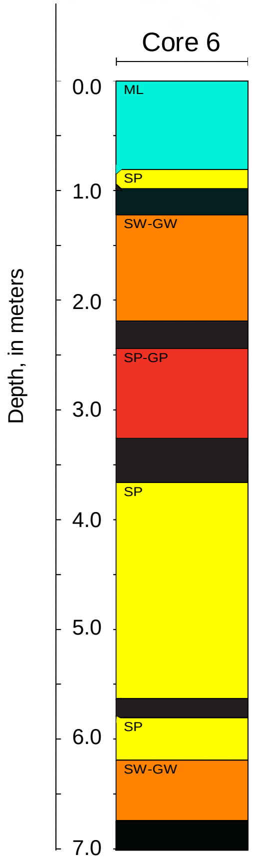

Lithology

Label	Description
🟦 MH-CH	Clayey silt
🟦 MH	Silt, high-plasticity
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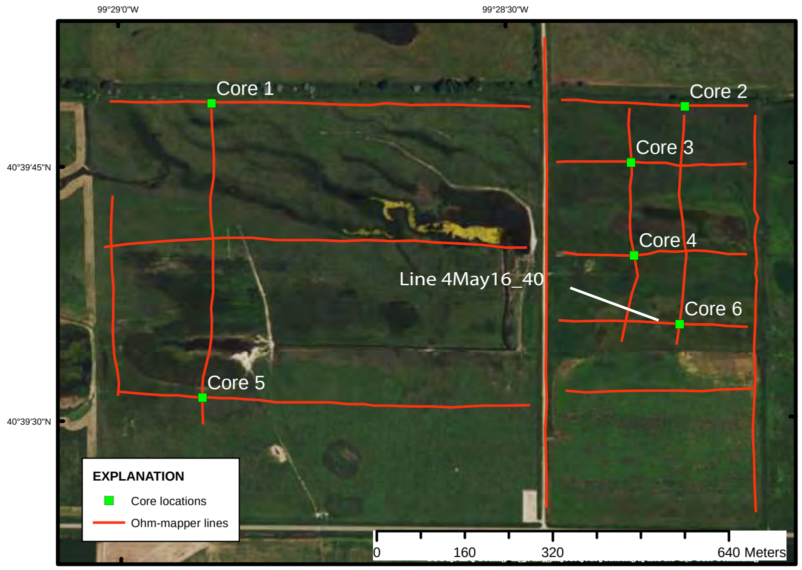

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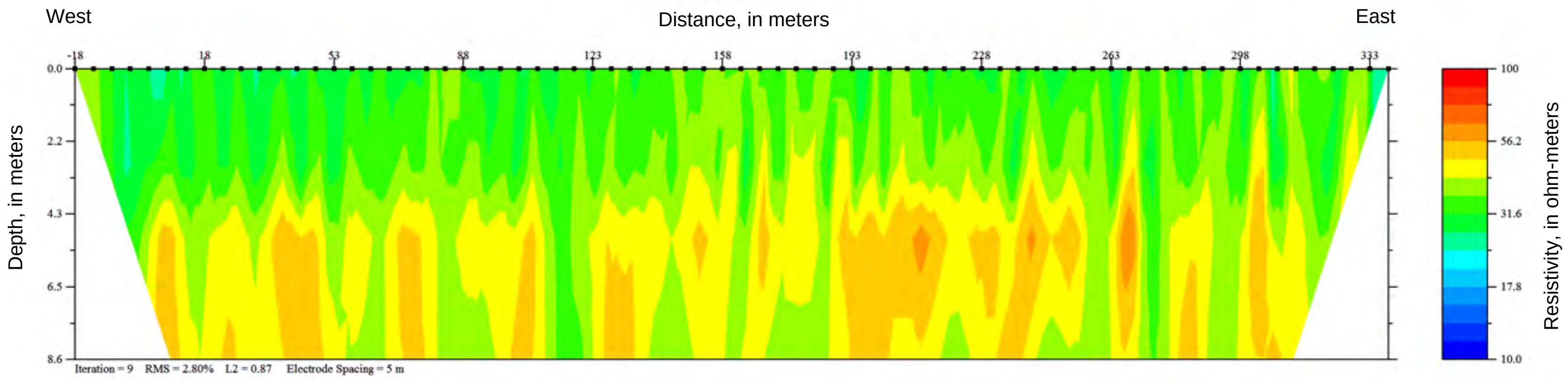
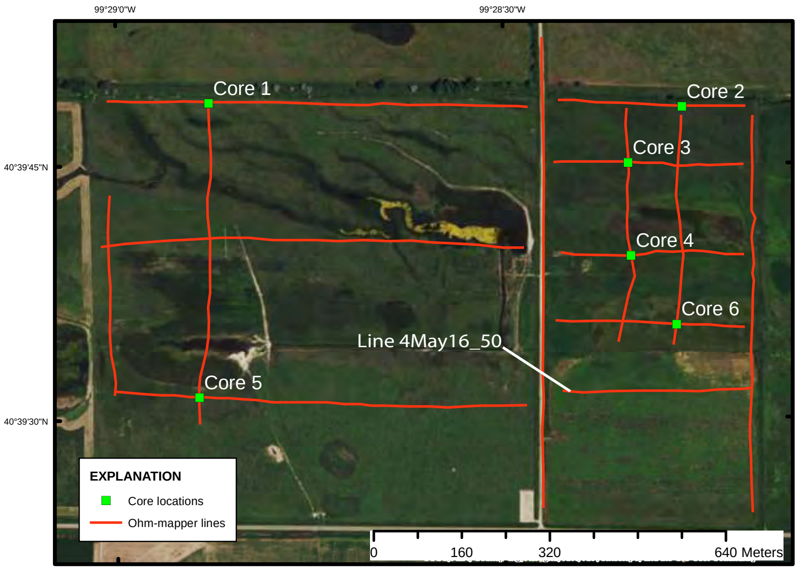




Appendix E

Development of Design Soil Parameters

Problem:
Derive hydraulic conductivity parameters to be used for seepage analysis.

References:
(1) USDA Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov)
(2) Investigation of Recharge Potential at the Cottonwood Ranch Complex: Infiltration Rates & Geotechnical Surveys, March 15, 2017, PRRIP.
(2) EM 1110-2-1901, Seepage Analysis and Control for Dams, Revised April 1993, USACE

Method:

HDR reviewed the Soil Survey for Phelps County (WSS, Reference No. 1) and identified the different soil regions mapped at the site. Permeability data was provided in the 1973 manuscript for each region based on depth and soil classification. Table 1 provides the permeability for each region and soil classification based the Soil Survey for Phelps County. The reported permeability values are believed to be intermediate between the vertical permeability, k_v, and the horizontal permeability, k_h and can be related to k_v or k_h, based on the following equation:

$$k_{ave} = \sqrt{k_v k_h}$$

Table 1: Permeability Based on Web Soil Survey (Reference No. 1)

Soil Layer	Soil Survey Region	USCS Class.	Depth (ft)	Permeability (ft/s)
Blanket	Leshara Silt Loam	CL	0 to 3	5E-05
Blanket	Leshara Silt Loam	ML/SM	3 to 4.5	1E-04
Sand	Leshara Silt Loam	SP	4.5 to 5	5E-04
Blanket	Platte Soils	CL	0 to 1	1E-05
Blanket	Platte Soils	ML/SM	1 to 1.5	1E-04
Sand	Platte Soils	SP	1.5 to 5	5E-04
Blanket	Kenesaw/Grigston Silt Loam	CL	0 to 5	5E-05
Blanket	Wann Sandy Loam	ML/SM	0 to 5	1E-04
Blanket	Wann Loam	CL	0 to 5	5E-05

The Platte River Recovery Implementation Program (PRRIP) completed two pilot scale infiltration tests at the site. The first test consisted of mounding soil on top of the grade to create a bermed basin. The second test consisted of excavating through the blanket soils to the underlying sand and mounding the excavated soils on the grade to create an excavated basin. The basins were filled with water and monitored in series over several months. Table 2 provides the resulting infiltration rate corrected for the water balance, as reported by the PRRIP. The reported infiltration rates are believed to be intermediate between the vertical hydraulic conductivity, k_v, and the horizontal hydraulic conductivity, k_h.

Table 2: Infiltration Rate Based on Pilot Scale

Soil Layer	Basin Type	Underlying Soil USCS Class.	Depth (ft)	Infiltration Rate (ft/s)
Blanket	Bermed	CL	0 to 2.5	2E-06
Sand	Excavated	SM	4.5+	1E-06

HDR completed a subsurface investigation to evaluate the subsurface stratigraphy, to collect samples for laboratory testing, and to develop soil parameters. Samples were collected from the blanket material and the sand layer beneath. The blanket layer is primarily classified as CL or SC, while the sand layer generally classifies as SP or SW.

Test pits were excavated in the different soil survey regions to classify the soil and determine depths to complete percolate tests. A percolation test was completed adjacent to each test pit location location by Mid-States Engineering, Inc. The test consisted of excavating a 4-inch diameter hole to the specified depth. Each hole was filled with water and allowed to saturate over night. The following day, each hole was filled with water to a depth of about 6 inches and measurements were taken on water depth versus time. Table 3 presents the infiltration rate reported by Mid-States Engineering, Inc. The reported infiltration rates are believed to be intermediate between the vertical hydraulic conductivity, k_v, and the horizontal hydraulic conductivity, k_h.

Table 3: Infiltration Rate Based on Test Pit Percolation Test

Soil Layer	Sample Location	Soil Survey Region	Test Depth (ft)	USCS Class.	Infiltration Rate (ft/s)
Blanket	TP-2	Leshara Silt Loam	0.5 to 1	CL	5E-05
Blanket	TP-6	Leshara Silt Loam	0.5 to 1	CL	3E-05
Blanket	TP-1	Leshara Silt Loam	1.5 to 2	CL	9E-05
Blanket	TP-8	Leshara Silt Loam	0.5 to 1	CL	9E-05
Blanket	TP-9	Leshara Silt Loam	1.5 to 2	CL	5E-04
Sand	TP-4	Leshara Silt Loam	1.5 to 2	SC	6E-04
Blanket	TP-7	Kenesaw/Grigston Silt Loam	0.5 to 1	CL	5E-05
Blanket	TP-5	Wann Sandy Loam	1.2 to 1.7	CL	4E-05
Sand	TP-3	Wann Sandy Loam	1.5 to 2	SC	6E-04

Grain-size distribution tests (ASTM D422) were completed by Mid-States Engineering, Inc. on 86 selected samples of the blanket and sand layers. Hazen's equation (Reference No. 3) was used to estimate the permeability based on the particle size.

$$k = AD_{10}^2$$

where:
k = permeability in cm/s
A = correlation coefficient
D_{10} = particle size in cm at which 10 percent of the material is finer by weight

Using the values presented in the tables and engineering judgement, the permeability values presented in Table 6 will be used for design. The fill soils, which will be derived from the blanket soils, were assumed to have a permeability an order of magnitude slower than the blanket soils.

Table 6: Design Permeability Values

Soil Layer	USCS Class.	k_v (ft/s)	k_v/k_h	k_h (ft/s)	k_{ave} (ft/s)
Fill	CL/SC	1.E-07	0.25	4E-07	2E-07
Blanket	CL/SC	1.E-06	0.25	4E-06	2E-06
Blanket	SM	1.E-05	0.25	4E-05	2E-05
Sand	SP/SW	3.E-04	0.25	1E-03	5E-04

Limitations

The geotechnical evaluations presented herein are based on geotechnical information provided to us, our field reconnaissance, the results of field exploration and laboratory testing completed for this study and those by others, correlations, and our engineering judgment and past experiences. Geotechnical engineering and the geologic sciences are characterized by uncertainty. Professional judgments presented herein are based partly on our understanding of the proposed construction, partly on our general experience and the state-of-the-practice at the time of this writing.

Table 4 presents the results of the grain-size data analysis. The permeability for cohesive soils classifiying as CL or SC are believed to represent the vertical permeabiilty, k_v, and the permeability for non-cohesive soils classifying as SM, SP, or SW are believed to represent the horizontal permeability, k_h.

Table 4: Permeability Based on Grain-Size

Soil Layer	USCS Class.	Average D_{10} (mm)	Permeability (ft/s)
Blanket	CL/SC	0.001	9E-08
Sand	SM	0.03	6E-05
Sand	SP/SW	0.2	2E-03

Permeability can be estimated using Figure 1 (Reference No. 3), based on classification. Table 5 presents the permeability based on classification. The permeability for cohesive soils classifiying as CL or SC are believed to represent the vertical permeability, k_v, and the permeability for non-cohesive soils classifying as SP or SW are believed to represent the horizontal permeability, k_h.

Table 5: Permeability Based on Soil Classification (Fig. 1)

Soil Layer	USCS Class.	Permeability (cm/s)	Permeability (ft/s)
Blanket	CL	1.00E-06	3E-08
Blanket	SC	1.00E-04	3E-06
Sand	SP	1.00E-02	3E-04
Sand	SW	1.00E-01	3E-03

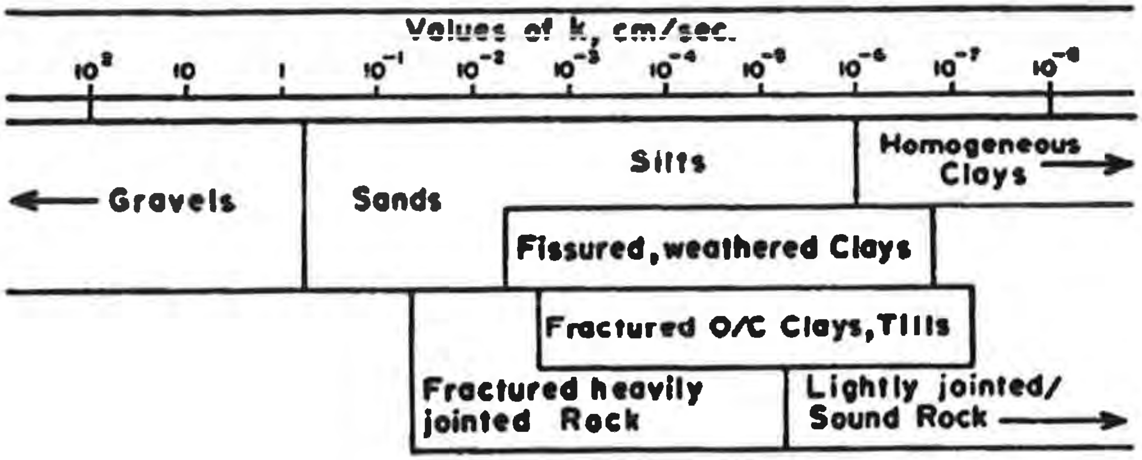


Figure 1: Approximate Range in Coefficient of Permeability of Soils and Rocks (Reference No. 3 Fig. 2-5

I. Problem:

Derive shear strength parameters for use in slope stability analyses.

II. References:

(1) NAVFAC DM 7.01, "Soil Mechanics", 1986
(2) FHWA GEC No. 10, "Drilled Shafts: Construction Procedures and LRFD Design Methods", 2010

III. Methodology:

A. Blanket Layer (CL/SC)

1. Undrained Strength (UU)

Based on 8 laboratory unconfined compressive strength tests ranged from 600 to 3,200 psf and averaged 1,500 psf. The average pocket penetrometer strength, which is considered equivalent to the laboratory unconfined compressive strength, was 2,000 psf and ranged from less than 500 psf to 5,000 psf. An unconfined compressive strength of 1200 psf captures 75 percent of the pocket penetrometer and laboratory tests.

Undrained shear strength, s_u, can be correlated to unconfined compressive strength, Q_c, using the following relationship:

$$s_u = \frac{Q_c}{2} = \frac{1200\,psf}{2} = 600\,psf$$

2. Total Stress (CU)

Total cohesion, c, and total friction angle, ϕ, can be estimated as 300 psf and 12°, respectively, based on experience.

3. Effective Stress (CD)

Laboratory testing on 14 selected samples resulted in plasticity indices ranging from 10 to 23 and

The effective friction angle for fine-grained soils can be correlated to the plasticity index, I_p using the chart provided in Figure 1.

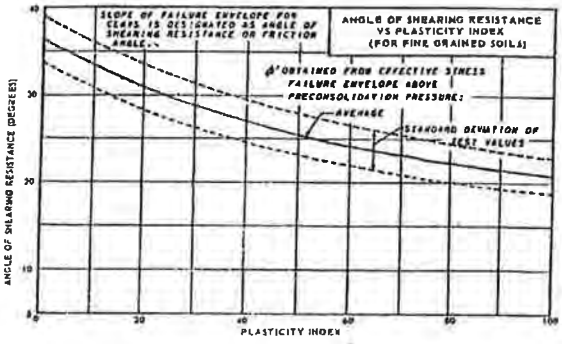


Fig.13. Correlation Between Effective Friction Angle and Plasticity Index for Fine-Grained Soils (After DM-7).

Figure 1: Correlation between Effective Friction Angle and Plasticity Index for Fine-Grained Soils from Reference No. 1.

Using the upper bound plasticity index of about 23, the effective friction angle is about 28°.

Since the soils are believed to be moderately overconsolidated, an effective cohesion of 50 psf will be used.

4. Unit Weight

Based on 10 laboratory unit weights on selected samples, the total unit weight ranged from about 104 to 135 pcf. The upper end values greater than 125 pcf are not believed to be representative of the blanket layer and were neglected. A total unit weight of 110 pcf captures 75 percent of the total unit weight tests.

B. Sand Layer (SW/SP)

1. Effective Stress (CD)

The SPT can be correlated to the effective friction angle using the following formula from Reference No. 1:

$$\phi' = \sqrt{15.4N_{60}} + 20°$$

The blow count ranged from 3 to 50 bpf, averaged about 16 bpf, and generally increased with depth. Based on information provided by Mid-States Engineering, Inc. the hammer efficiency is about 61%; therefore, no correction was used to determine N60.

Figure 2 provides the effective friction angle vs. elevation. This plot suggests that the effective friction increases with depth. An effective friction angle ranges from about 30° at the top to about 38° at the bottom of the layer captures about 75 percent of the effective friction angles.

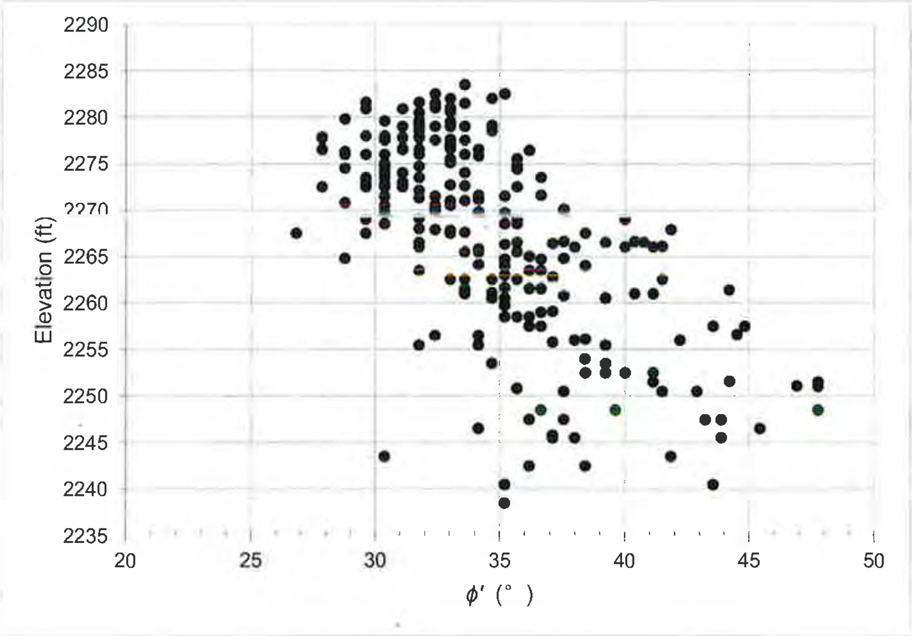


Figure 2. Elevation vs. friction angle for sand layer

2. Unit Weight

Total unit weight is assumed to be 115 pcf based on experience.

C. Fill

1. Undrained Shear Strength (UU)

Fill soils will be derived from the blanket layer. Undrained shear strength is assumed to be about 1,000 psf, based on experience for a moderately well compacted cohesive soil.

1. Total Stress (CU)

Total cohesion, c, and total friction angle, ϕ, are assumed to be 500 psf and 12°, respectively, based on experience.

2. Effective Stress (CD)

Effective friction angle, ϕ', and effective cohesion, c', are assumed to be 28° and 50 psf, respectively, based on experience.

3. Unit Weight

Total unit weight is assumed to be 125 pcf based on experience.

IV. Summary

Table 1 provides a summary of the recommended shear strength parameters.

Table 1: Shear Strength Design Parameters

		Unit Weight	(UU)		(CU)		(CD)	
	USCS	γ_{total}	c	ϕ	c	ϕ	c'	ϕ'
Material	**Class.**	pcf	psf	degr.	psf	degr.	psf	degr.
Fill	CL/SC	125	1000	0	500	12	50	28
Blanket Layer	CL/SC	110	600	0	300	12	50	28
Sand Layer	SW/SP	115	0	30-38*	0	30-38*	0	30-38*

*increasing from top to bottom

V. Limitations

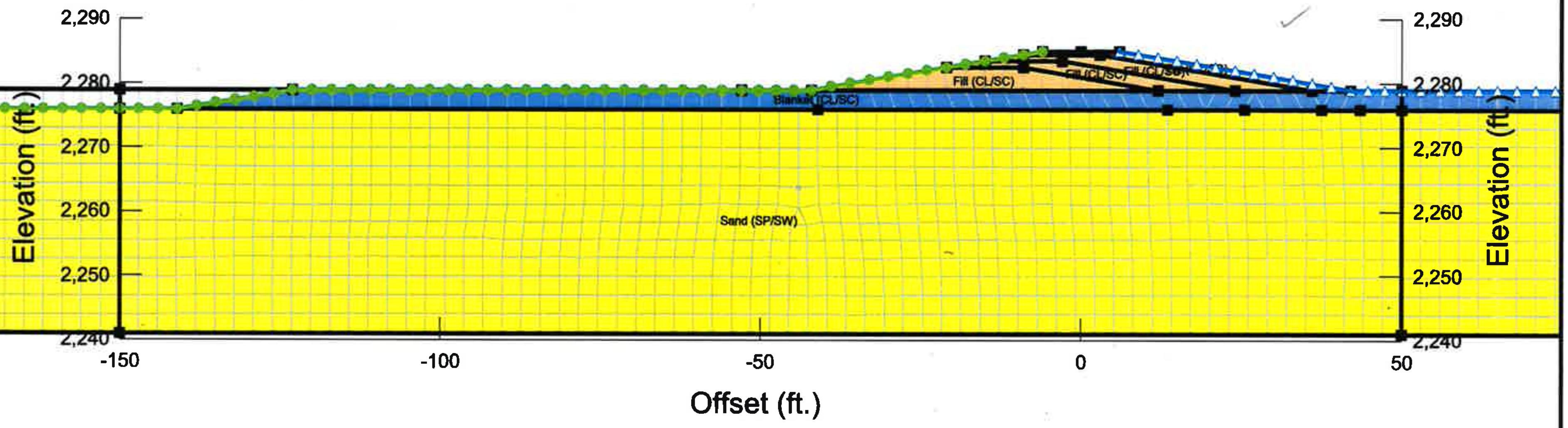
The geotechnical evaluations presented herein are based on geotechnical information provided to us, our field reconnaissance, the results of field exploration and laboratory testing completed for this study and those by others, correlations, and our engineering judgment and past experiences.

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

Appendix F
Seepage Analyses

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

✓



	Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/20/2017
	Berms 1 Through 8	Checked: PHP	Date: 11-30-17
	4.4 FT Pool - No Mitigation	SEEP/W 8.16	
	Berms Located Away from Conveyance Channel	Scale: 1:300	

PLATTE RIVER

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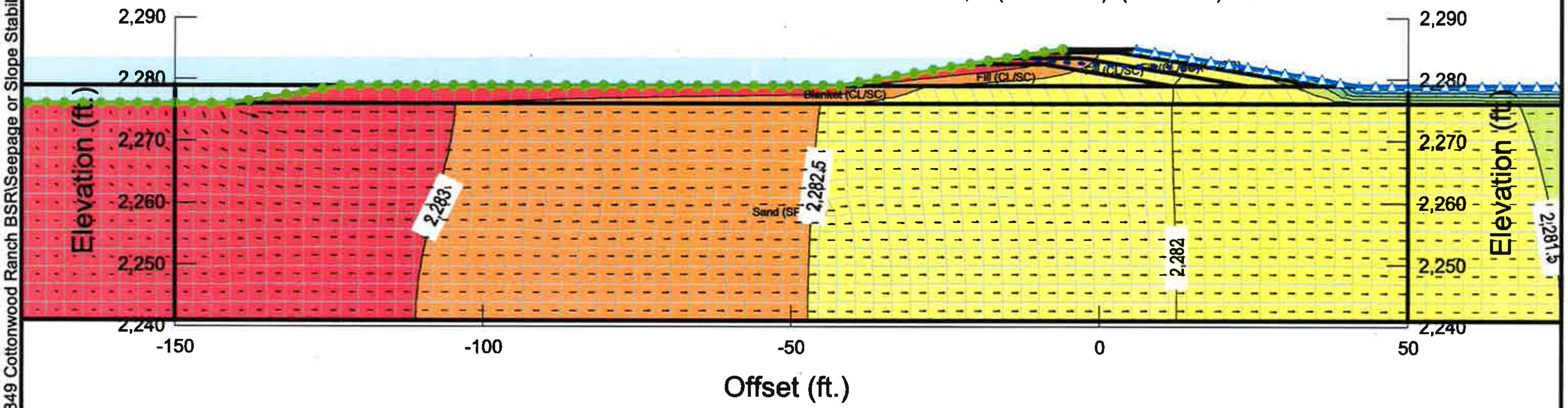
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Total Head	
🟦	2,279 - 2,279.5 ft
🟦	2,279.5 - 2,280 ft
🟩	2,280 - 2,280.5 ft
🟩	2,280.5 - 2,281 ft
🟩	2,281 - 2,281.5 ft
🟨	2,281.5 - 2,282 ft
🟨	2,282 - 2,282.5 ft
🟧	2,282.5 - 2,283 ft
🟥	2,283 - 2,283.5 ft

Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2281.7'-2279') / (2279' -2276') = 0.9



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 8
4.4 FT Pool - No Mitigation
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/20/2017
Checked: PBP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

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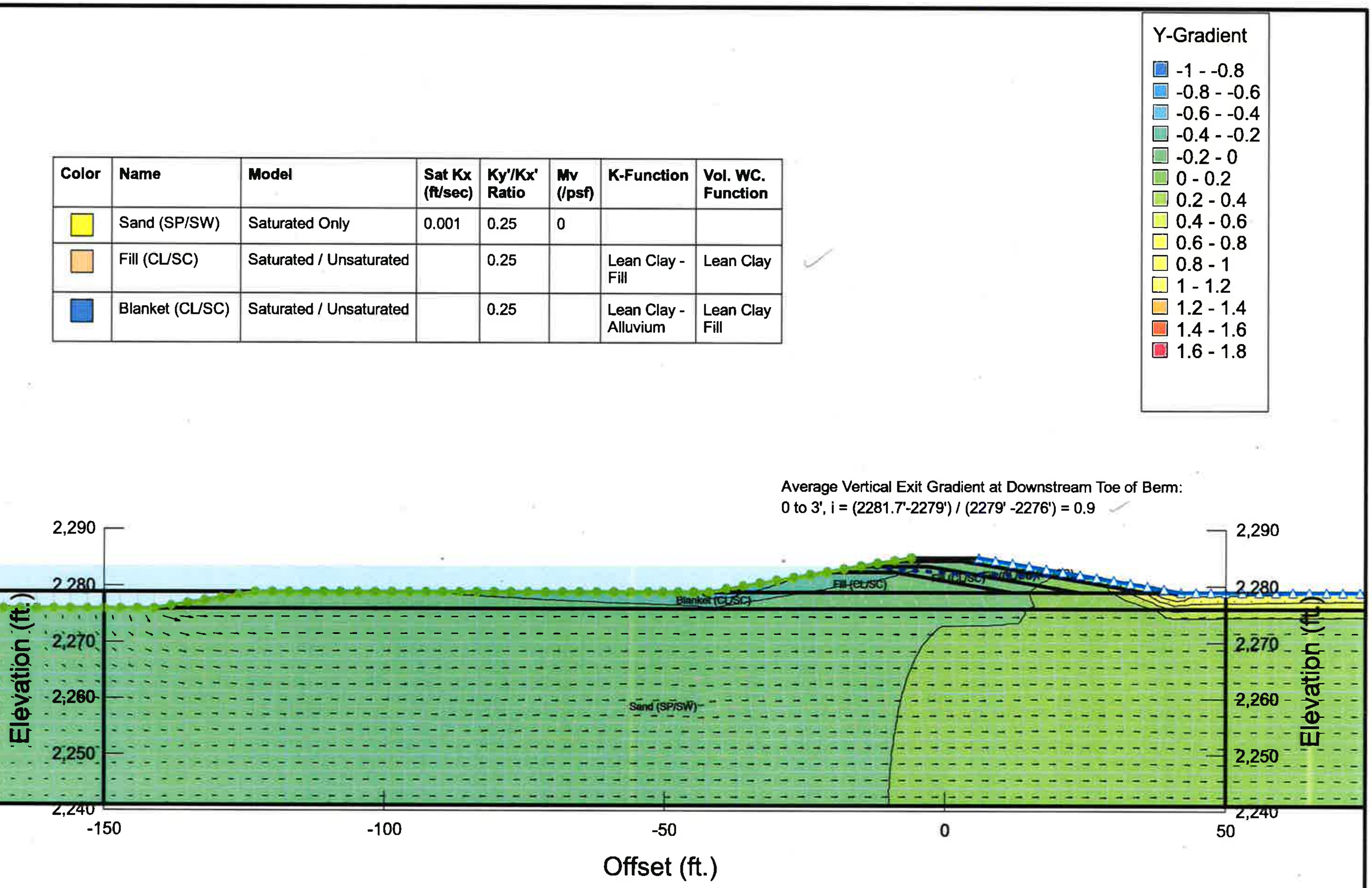
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

✓

Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2281.7'-2279') / (2279' -2276') = 0.9 ✓



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 8
4.4 FT Pool - No Mitigation
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/20/2017
Checked: PHP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

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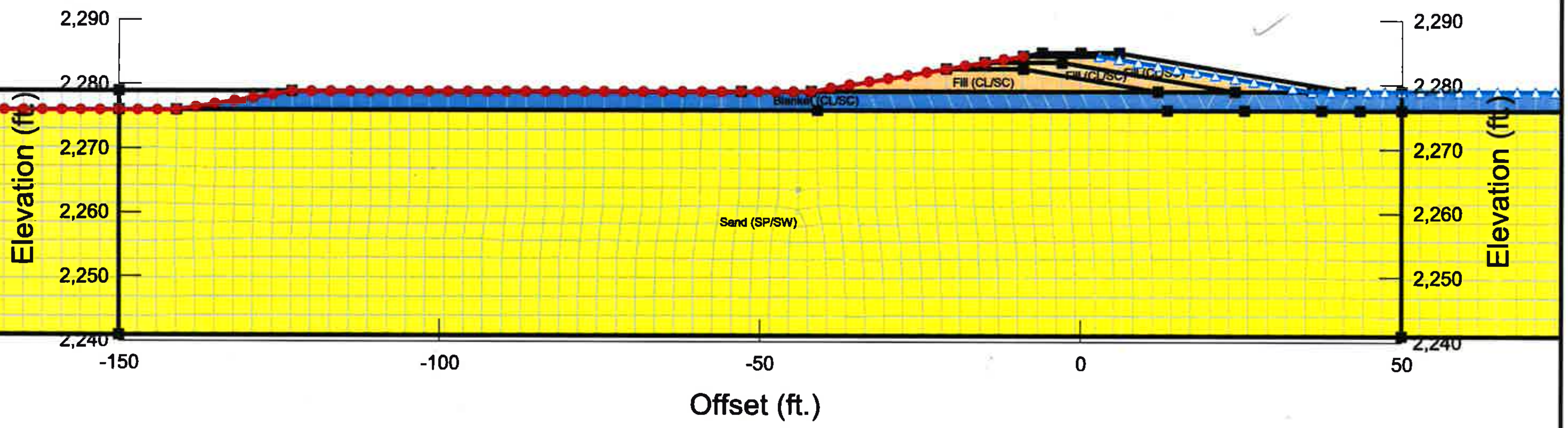
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 8
4.0 FT Pool - No Mitigation
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/20/2017
Checked: PHP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

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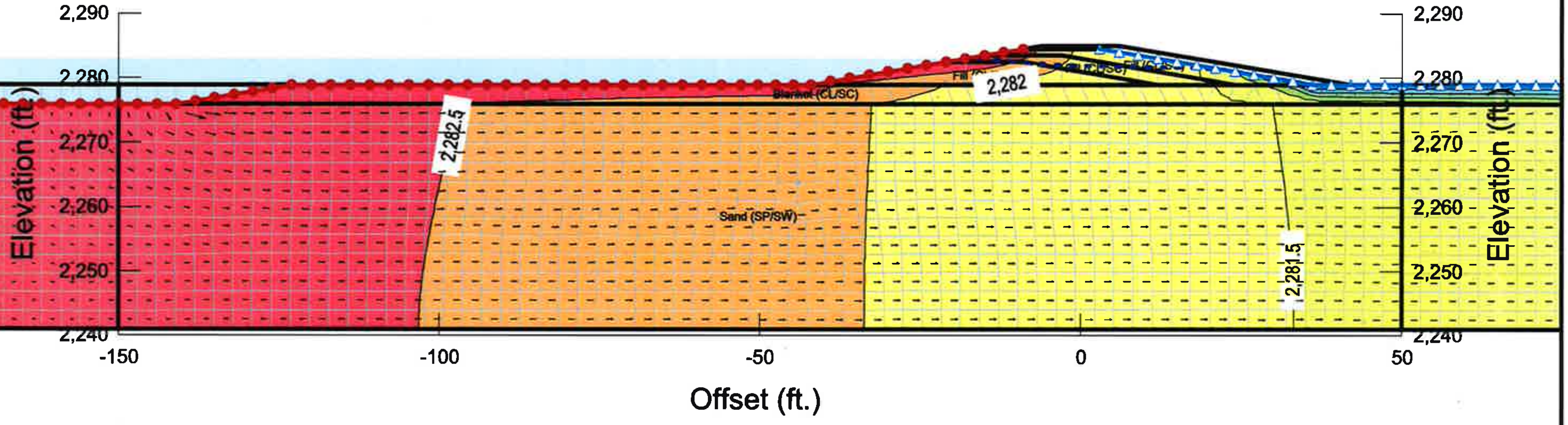
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Total Head

- 🟦 2,279 - 2,279.5 ft
- 🟦 2,279.5 - 2,280 ft
- 🟩 2,280 - 2,280.5 ft
- 🟩 2,280.5 - 2,281 ft
- 🟨 2,281 - 2,281.5 ft
- 🟨 2,281.5 - 2,282 ft
- 🟧 2,282 - 2,282.5 ft
- 🟥 2,282.5 - 2,283 ft

Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2281.4'-2279') / (2279' -2276') = 0.8



Cottonwood Ranch BSR, Phelps Co, NE		Computed: BPK	Date: 11/13/2017
Berms 1 Through 8		Checked: PHP	Date: 11-30-17
4.0 FT Pool - No Mitigation		SEEP/W 8.16	
Berms Located Away from Conveyance Channel		Scale: 1:300	

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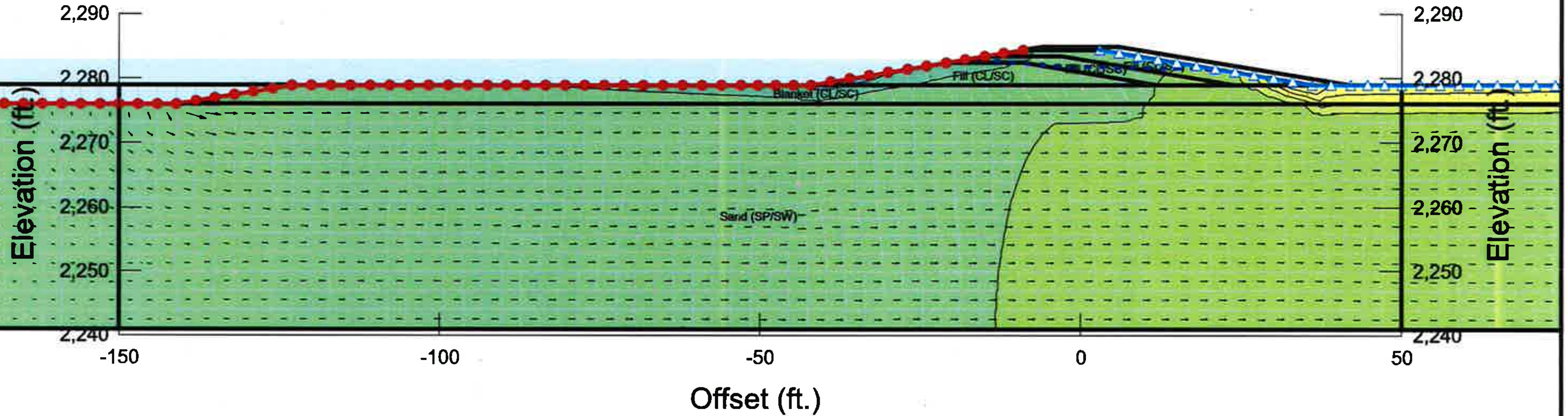
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2281.4'-2279') / (2279' -2276') = 0.8



Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/13/2017
Berms 1 Through 8	Checked: PKP	Date: 11-30-17
4.0 FT Pool - No Mitigation	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

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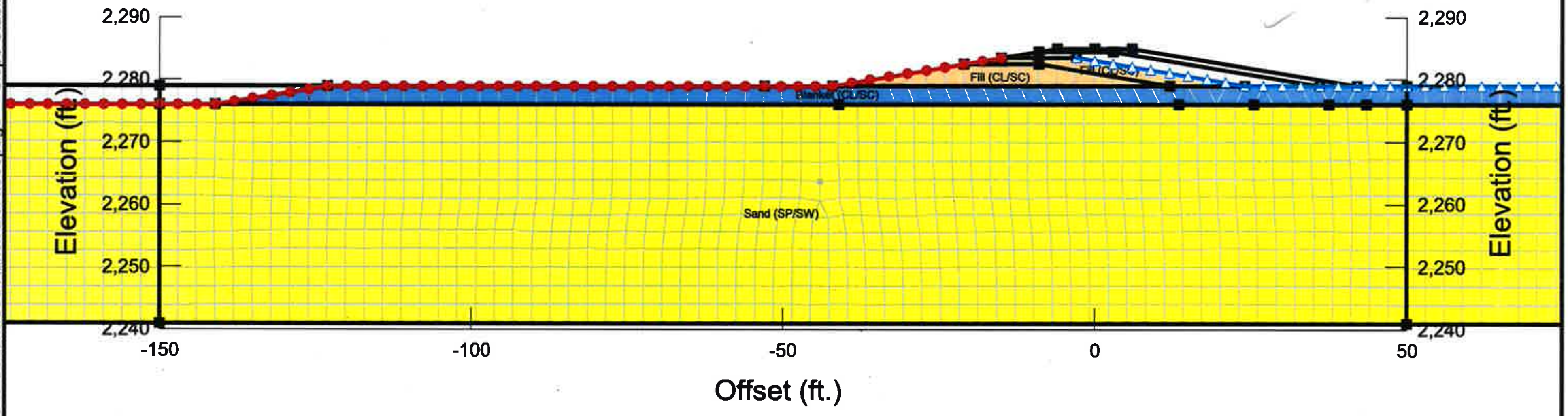
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 8
3.0 FT Pool - No Mitigation
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/20/2017
Checked: PHP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

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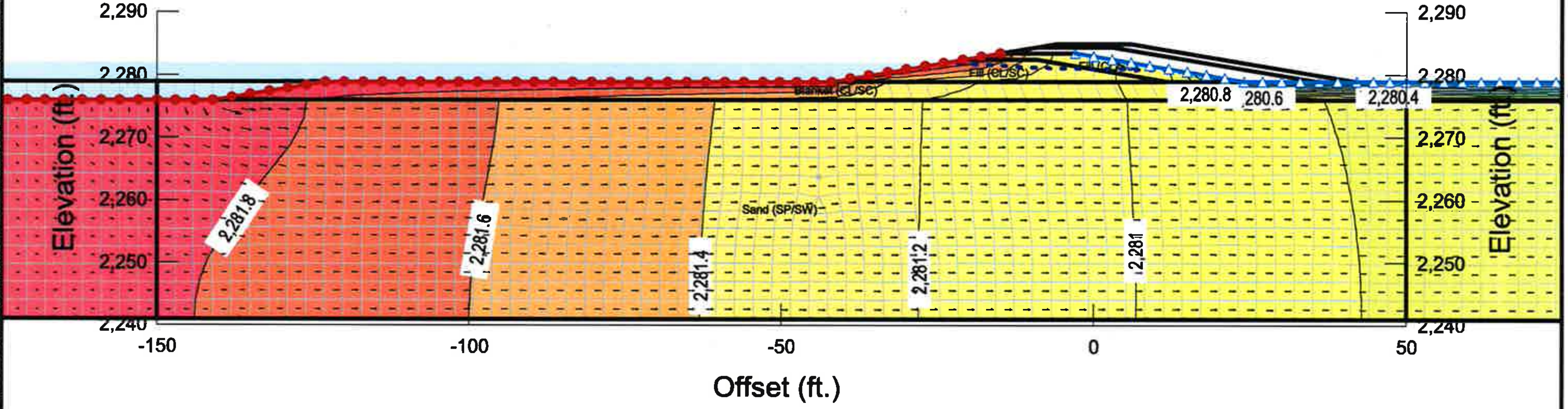
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Total Head

🟦	2,279 - 2,279.2 ft
🟦	2,279.2 - 2,279.4 ft
🟦	2,279.4 - 2,279.6 ft
🟩	2,279.6 - 2,279.8 ft
🟩	2,279.8 - 2,280 ft
🟩	2,280 - 2,280.2 ft
🟩	2,280.2 - 2,280.4 ft
🟩	2,280.4 - 2,280.6 ft
🟨	2,280.6 - 2,280.8 ft
🟨	2,280.8 - 2,281 ft
🟨	2,281 - 2,281.2 ft
🟨	2,281.2 - 2,281.4 ft
🟧	2,281.4 - 2,281.6 ft
🟥	2,281.6 - 2,281.8 ft
🟥	2,281.8 - 2,282 ft

Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2280.9'-2279') / (2279' -2276') = 0.63



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 8
3.0 FT Pool - No Mitigation
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/13/2017
Checked: PHP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

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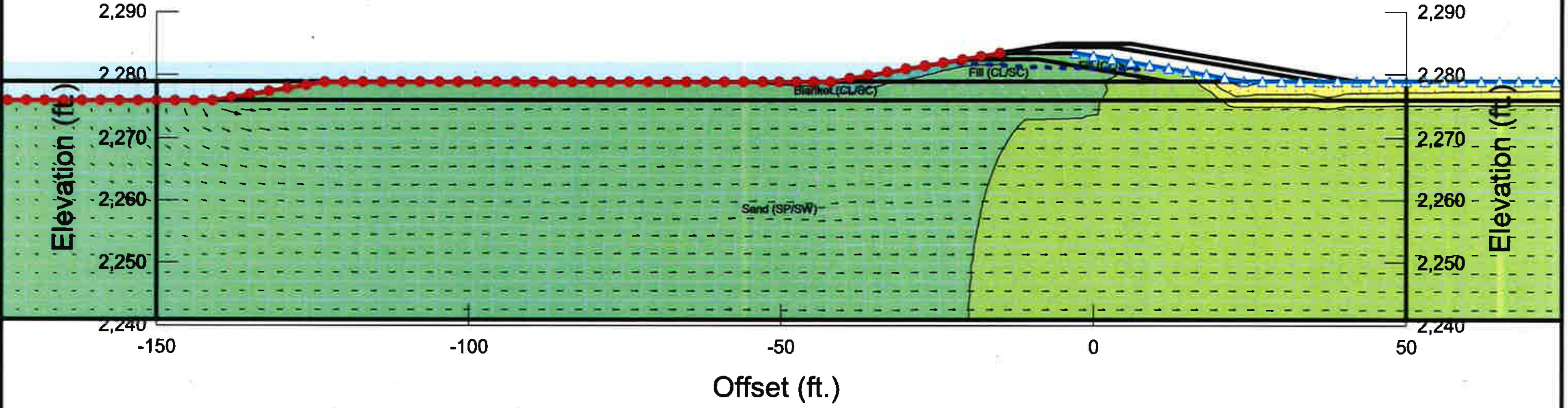
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Y-Gradient	
🟦	-0.8 - -0.6
🟦	-0.6 - -0.4
🟩	-0.4 - -0.2
🟩	-0.2 - 0
🟩	0 - 0.2
🟨	0.2 - 0.4
🟨	0.4 - 0.6
🟨	0.6 - 0.8
🟧	0.8 - 1
🟥	1 - 1.2

Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2280.9'-2279') / (2279' -2276') = 0.63



Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/13/2017
Berms 1 Through 8	Checked: PHP	Date: 11-30-17
3.0 FT Pool - No Mitigation	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

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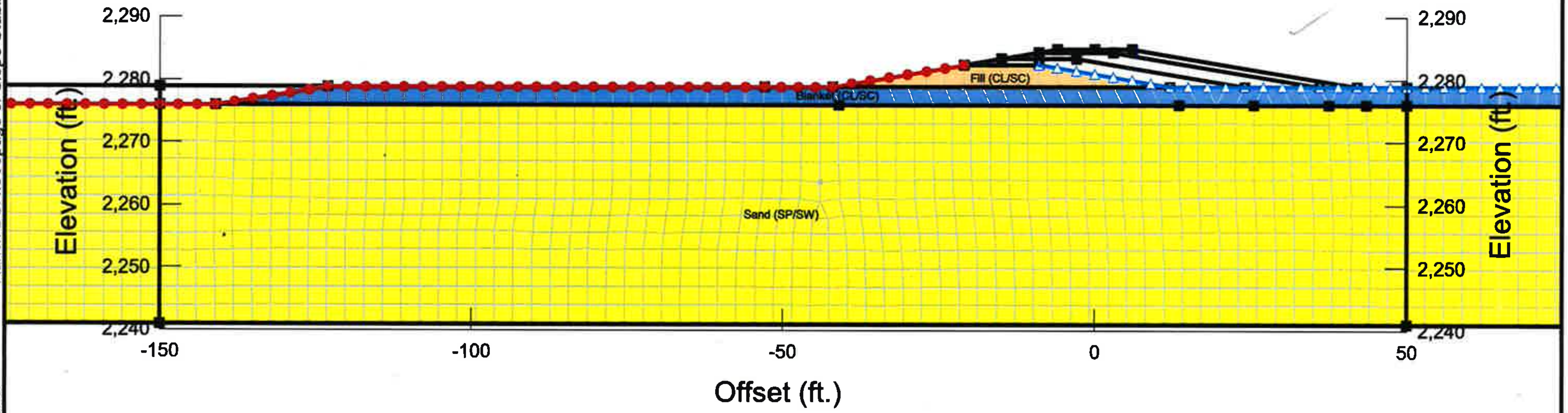
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 8
2.0 FT Pool - No Mitigation
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/20/2017
Checked: PHP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

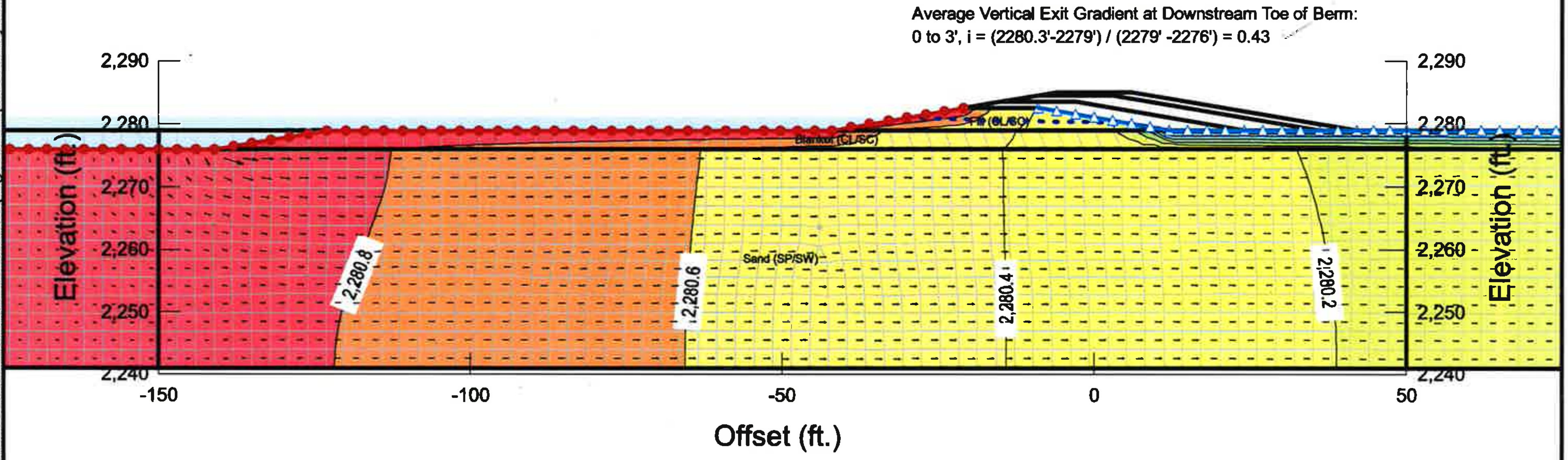
G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 8.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Total Head

- 🟦 2,279 - 2,279.2 ft
- 🟦 2,279.2 - 2,279.4 ft
- 🟩 2,279.4 - 2,279.6 ft
- 🟩 2,279.6 - 2,279.8 ft
- 🟩 2,279.8 - 2,280 ft
- 🟨 2,280 - 2,280.2 ft
- 🟨 2,280.2 - 2,280.4 ft
- 🟨 2,280.4 - 2,280.6 ft
- 🟧 2,280.6 - 2,280.8 ft
- 🟥 2,280.8 - 2,281 ft

Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2280.3'-2279') / (2279' -2276') = 0.43

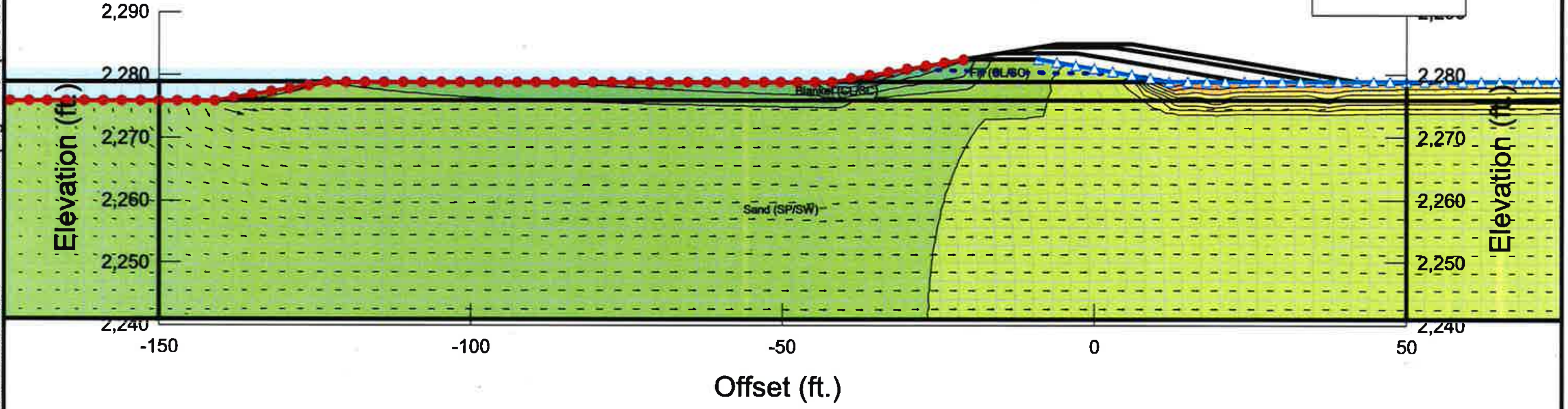


Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/13/2017
Berms 1 Through 8	Checked: PHP	Date: 11-30-17
2.0 FT Pool - No Mitigation	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 8.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

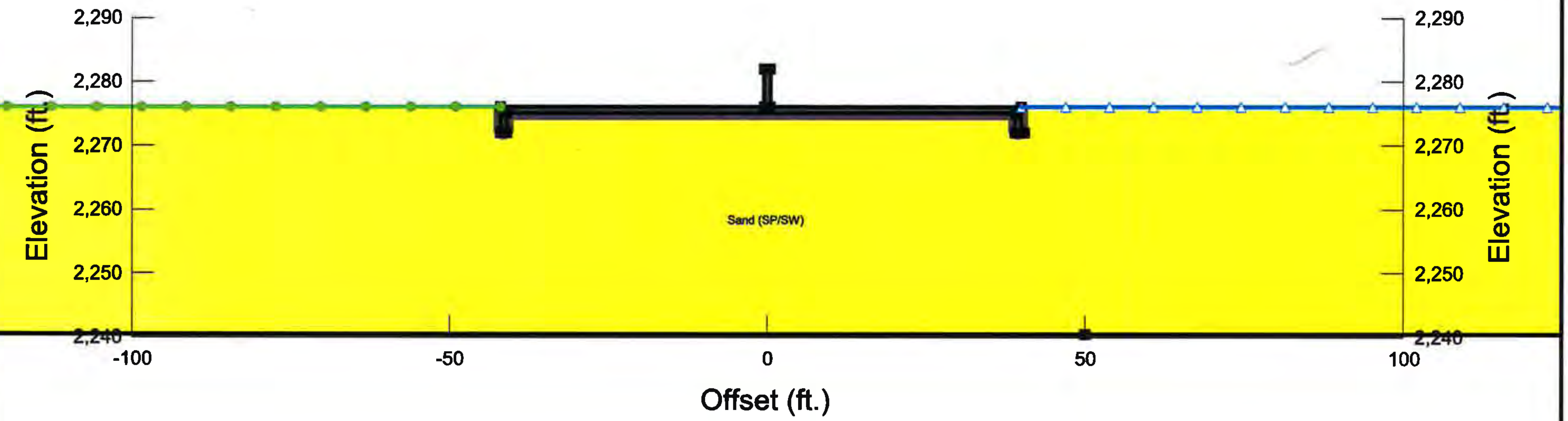
Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2280.3'-2279') / (2279' -2276') = 0.43



Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK
	Date: 11/13/2017
Berms 1 Through 8	Checked: PHP
	Date: 11-30-17
2.0 FT Pool - No Mitigation	SEEP/W 8.16
Berms Located Away from Conveyance Channel	Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 8.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Transpose (ft/sec)	K-Normal (ft/sec)
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
⬛	Concrete Flume	Interface				0	0



Cottonwood Ranch BSR, Phelps Co, NE
Control Structure at Berms 1 Through 8
4.5 FT Pool - No Mitigation
Concrete Flumes Located at Conveyance Channels

Computed: BPK
Date: 11/13/2017
Checked: FH
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

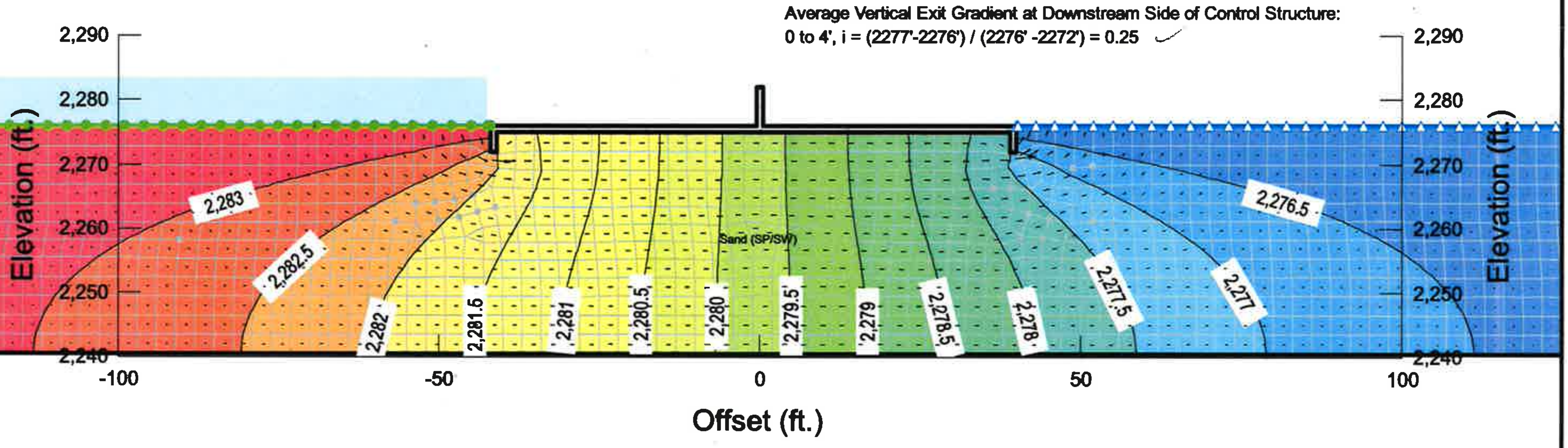
G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Concrete Flume Berms 1 through 8.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Transpose (ft/sec)	K-Normal (ft/sec)
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
⬛	Concrete Flume	Interface				0	0

Total Head

- 🟦 2,276 - 2,276.5 ft
- 🟦 2,276.5 - 2,277 ft
- 🟦 2,277 - 2,277.5 ft
- 🟩 2,277.5 - 2,278 ft
- 🟩 2,278 - 2,278.5 ft
- 🟩 2,278.5 - 2,279 ft
- 🟩 2,279 - 2,279.5 ft
- 🟩 2,279.5 - 2,280 ft
- 🟨 2,280 - 2,280.5 ft
- 🟨 2,280.5 - 2,281 ft
- 🟨 2,281 - 2,281.5 ft
- 🟨 2,281.5 - 2,282 ft
- 🟧 2,282 - 2,282.5 ft
- 🟥 2,282.5 - 2,283 ft
- 🟥 2,283 - 2,283.5 ft

Average Vertical Exit Gradient at Downstream Side of Control Structure:
0 to 4', i = (2277'-2276') / (2276' -2272') = 0.25 ✓



Cottonwood Ranch BSR, Phelps Co, NE
Control Structure at Berms 1 Through 8
4.5 FT Pool - No Mitigation
Concrete Flumes Located at Conveyance Channels

Computed: BPK	Date: 11/13/2017
Checked: PW	Date: 11-30-17
SEEP/W 8.16	
Scale: 1:300	

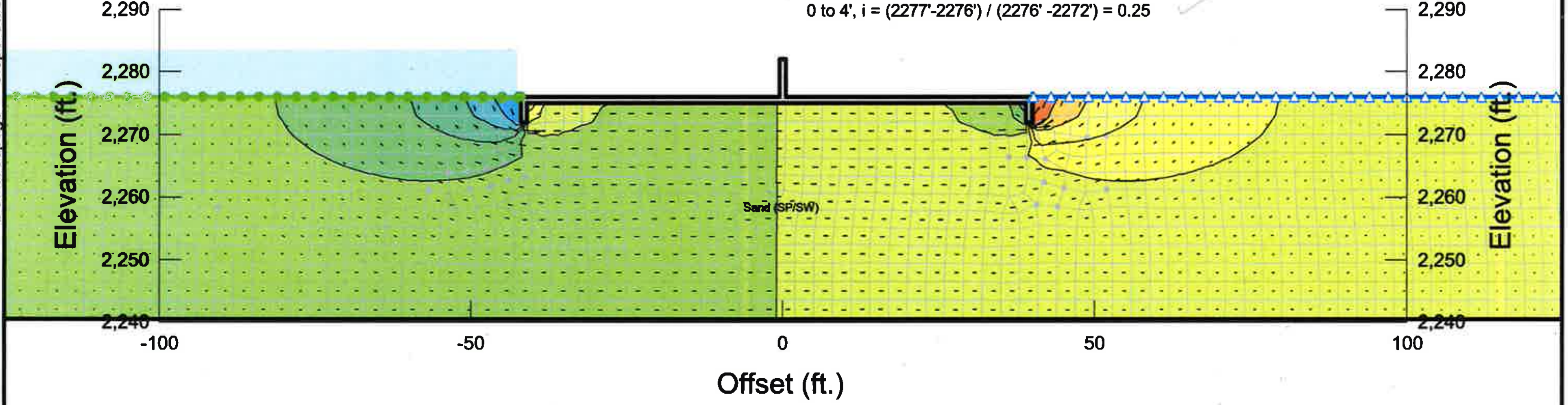
G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Concrete Flume Berms 1 through 8.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Transpose (ft/sec)	K-Normal (ft/sec)
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
■	Concrete Flume	Interface				0	0

Y-Gradient

🟦	-0.3 - -0.25
🟦	-0.25 - -0.2
🟦	-0.2 - -0.15
🟩	-0.15 - -0.1
🟩	-0.1 - -0.05
🟩	-0.05 - 0
🟨	0 - 0.05
🟨	0.05 - 0.1
🟨	0.1 - 0.15
🟨	0.15 - 0.2
🟧	0.2 - 0.25
🟥	0.25 - 0.3

Average Vertical Exit Gradient at Downstream Side of Control Structure:
0 to 4', i = (2277'-2276') / (2276' -2272') = 0.25

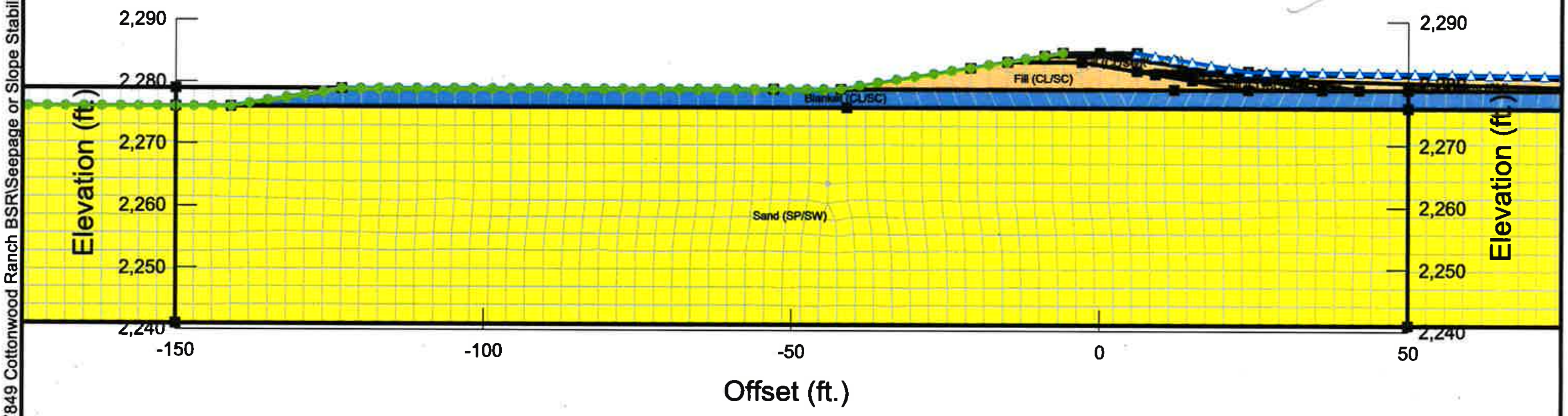


Cottonwood Ranch BSR, Phelps Co, NE		Computed: BPK	Date: 11/13/2017
Control Structure at Berms 1 Through 8		Checked: PKF	Date: 11-30-17
4.5 FT Pool - No Mitigation		SEEP/W 8.16	
Concrete Flumes Located at Conveyance Channels		Scale: 1:300	

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Concrete Flume Berms 1 through 8.gsz

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 4 with Seepage Berm
4.4 FT Pool - 250 FT Seepage Berm
Berms Located Away from Conveyance Channel

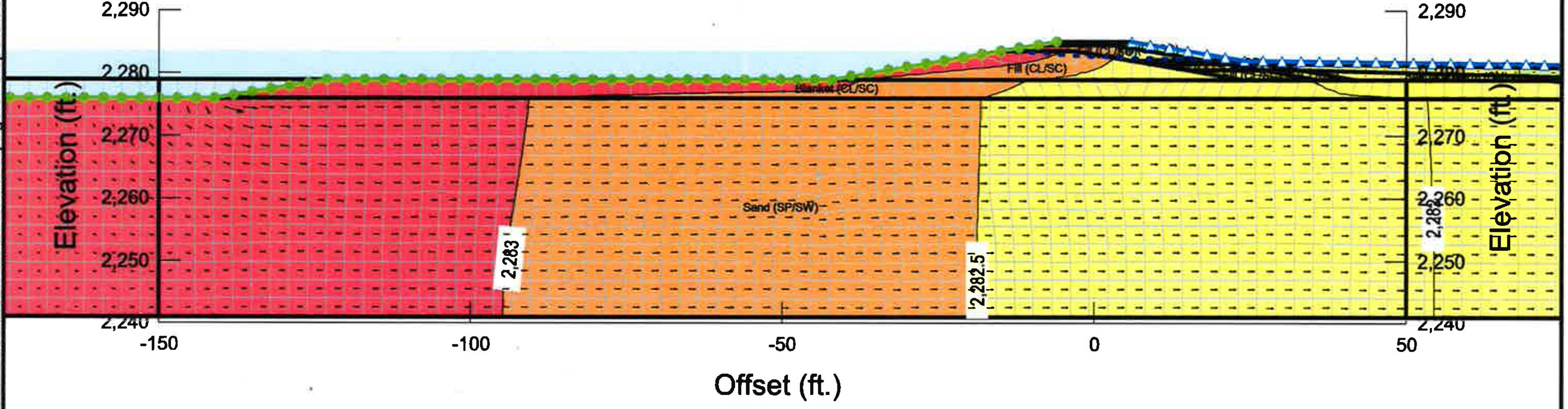
Computed: BPK
Date: 11/20/2017
Checked: PHY
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Total Head

- 🟦 2,279 - 2,279.5 ft
- 🟦 2,279.5 - 2,280 ft
- 🟩 2,280 - 2,280.5 ft
- 🟩 2,280.5 - 2,281 ft
- 🟩 2,281 - 2,281.5 ft
- 🟨 2,281.5 - 2,282 ft
- 🟨 2,282 - 2,282.5 ft
- 🟧 2,282.5 - 2,283 ft
- 🟥 2,283 - 2,283.5 ft

Average Vertical Exit Gradient at Downstream Toe of Seepage Berm:
0 to 3', i = (2280.5'-2279') / (2279' -2276') = 0.5



Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/20/2017
Berms 1 Through 4 with Seepage Berm	Checked: PHP	Date: 11-30-17
4.4 FT Pool - 250 FT Seepage Berm	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

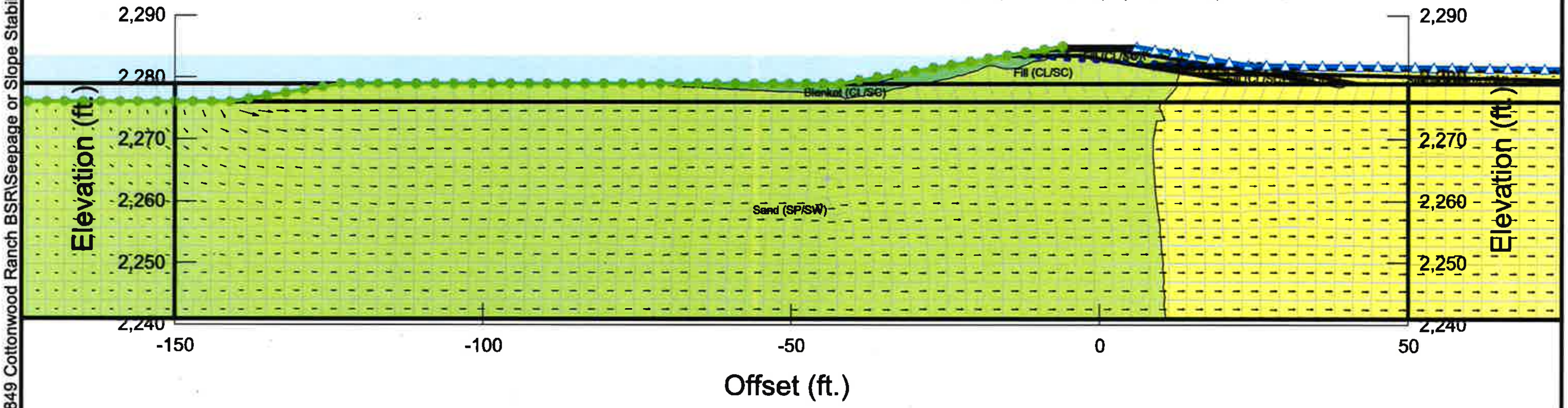
G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Y-Gradient

- 🟦 -0.8 - -0.6
- 🟦 -0.6 - -0.4
- 🟩 -0.4 - -0.2
- 🟩 -0.2 - 0
- 🟨 0 - 0.2
- 🟧 0.2 - 0.4
- 🟥 0.4 - 0.6

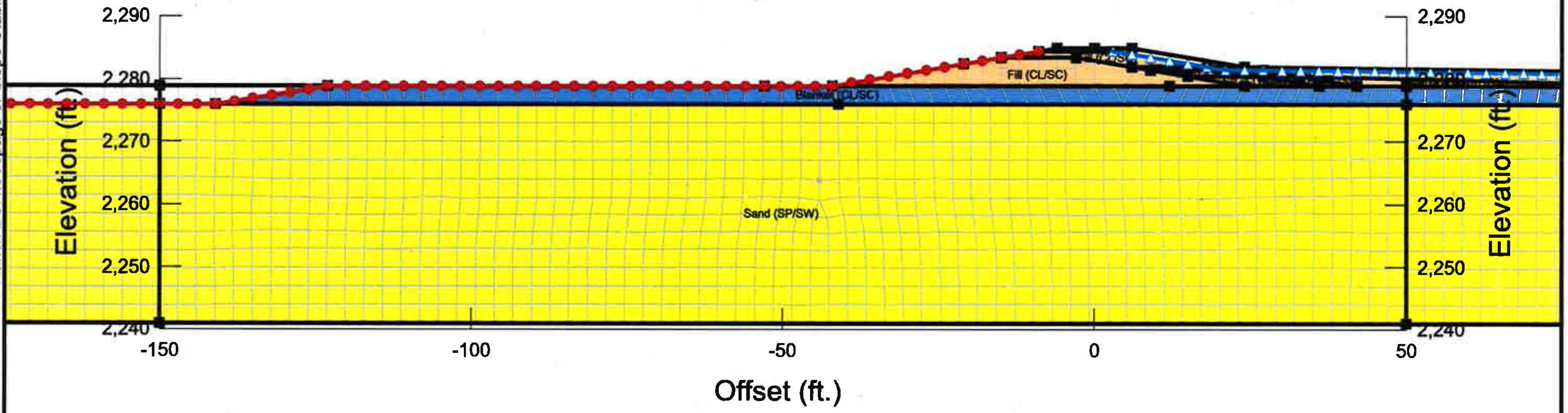
Average Vertical Exit Gradient at Downstream Toe of Seepage Berm:
0 to 3', i = (2280.5'-2279') / (2279' -2276') = 0.5 ✓



	Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/20/2017
	Berms 1 Through 4 with Seepage Berm	Checked: PHP	Date: 11-30-17
	4.4 FT Pool - 250 FT Seepage Berm	SEEP/W 8.16	
	Berms Located Away from Conveyance Channel	Scale: 1:300	

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

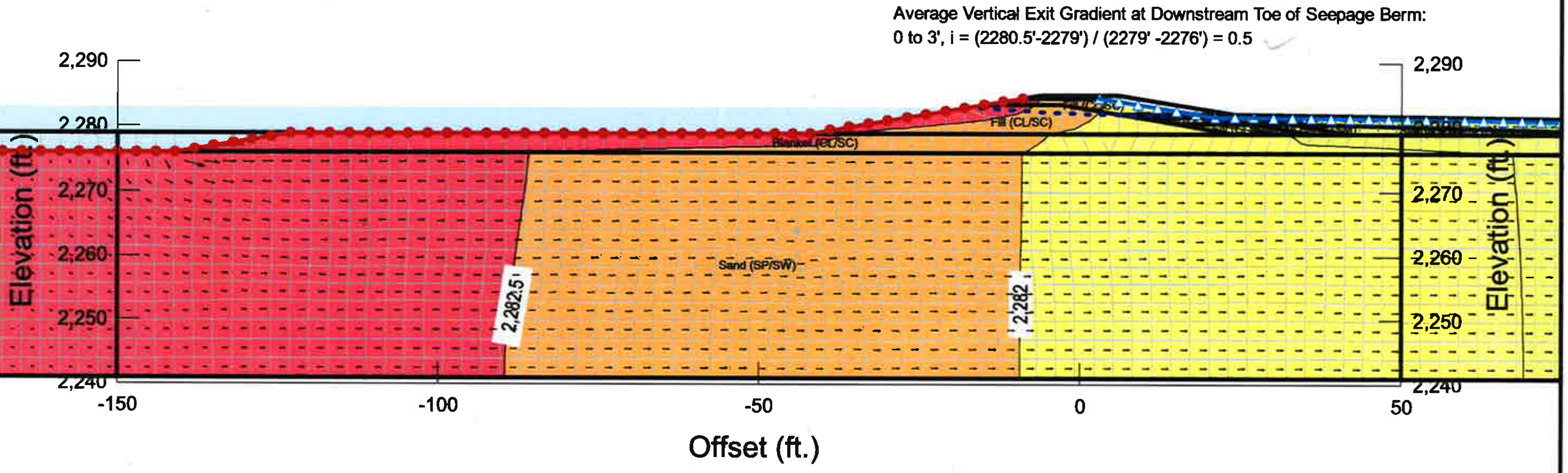


Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 4 with Seepage Berm
4.0 FT Pool - 200 FT Seepage Berm
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/20/2017
Checked: PHP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Average Vertical Exit Gradient at Downstream Toe of Seepage Berm:
0 to 3', i = (2280.5'-2279') / (2279' -2276') = 0.5

Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/13/2017
Berms 1 Through 4 with Seepage Berm	Checked: PHP	Date: 11-22-17
4.0 FT Pool - 200 FT Seepage Berm	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

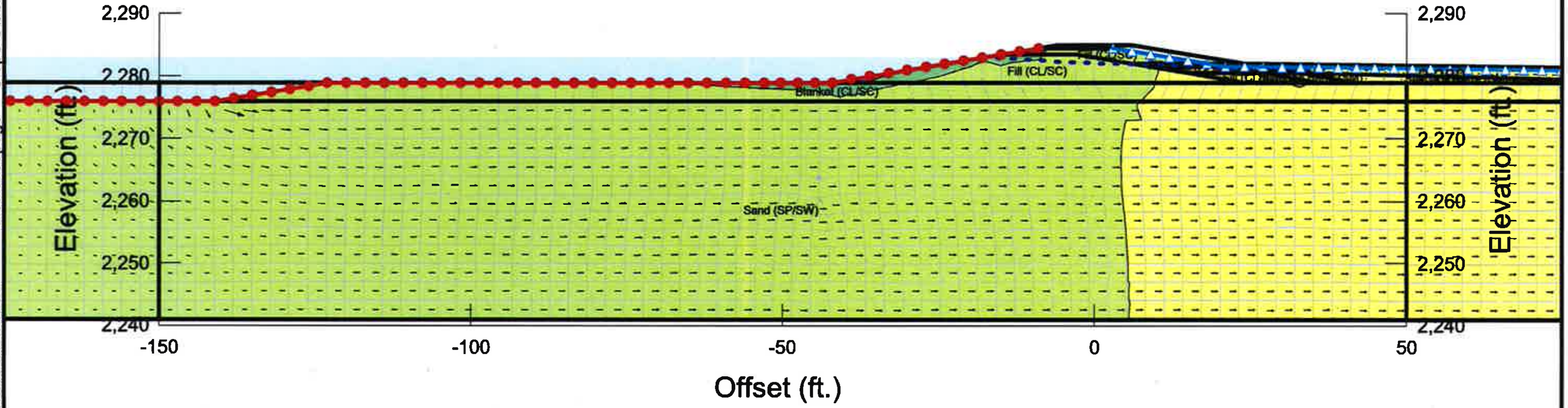
G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Y-Gradient

- 🟦 -0.8 - -0.6
- 🟦 -0.6 - -0.4
- 🟩 -0.4 - -0.2
- 🟩 -0.2 - 0
- 🟨 0 - 0.2
- 🟧 0.2 - 0.4
- 🟥 0.4 - 0.6

Average Vertical Exit Gradient at Downstream Toe of Seepage Berm:
0 to 3', i = (2280.5'-2279') / (2279' -2276') = 0.5

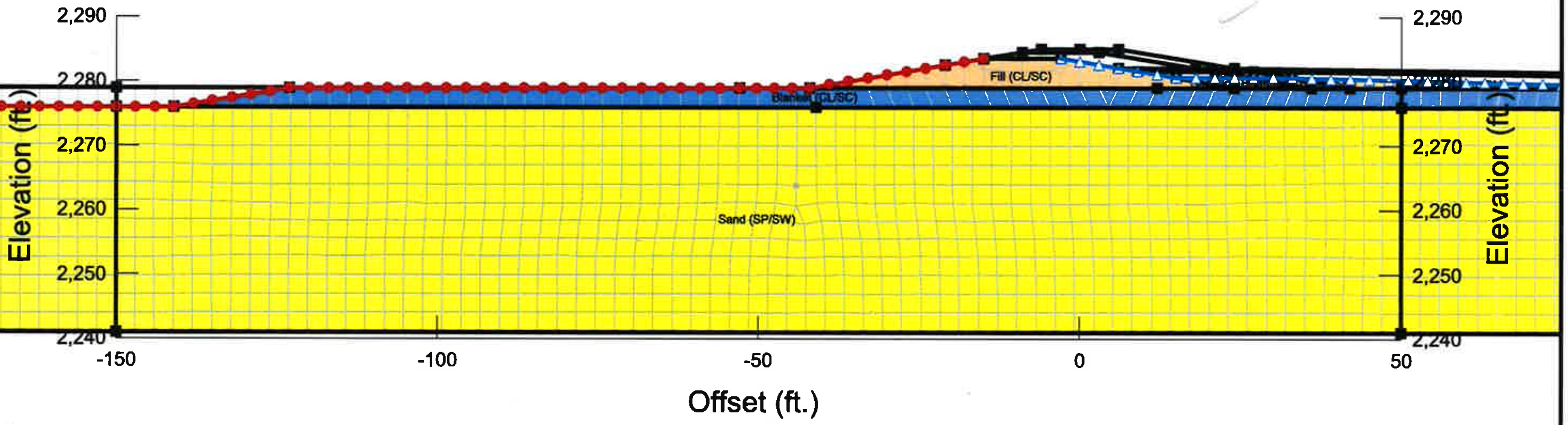


Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 4 with Seepage Berm
4.0 FT Pool - 200 FT Seepage Berm
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/13/2017
Checked: PKP
Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 4 with Seepage Berm
3.0 FT Pool - 75 FT Seepage Berm
Berms Located Away from Conveyance Channel

Computed: BPK
Date: 11/20/2017
Checked: PWP
Date: 11-21-17
SEEP/W 8.16
Scale: 1:300

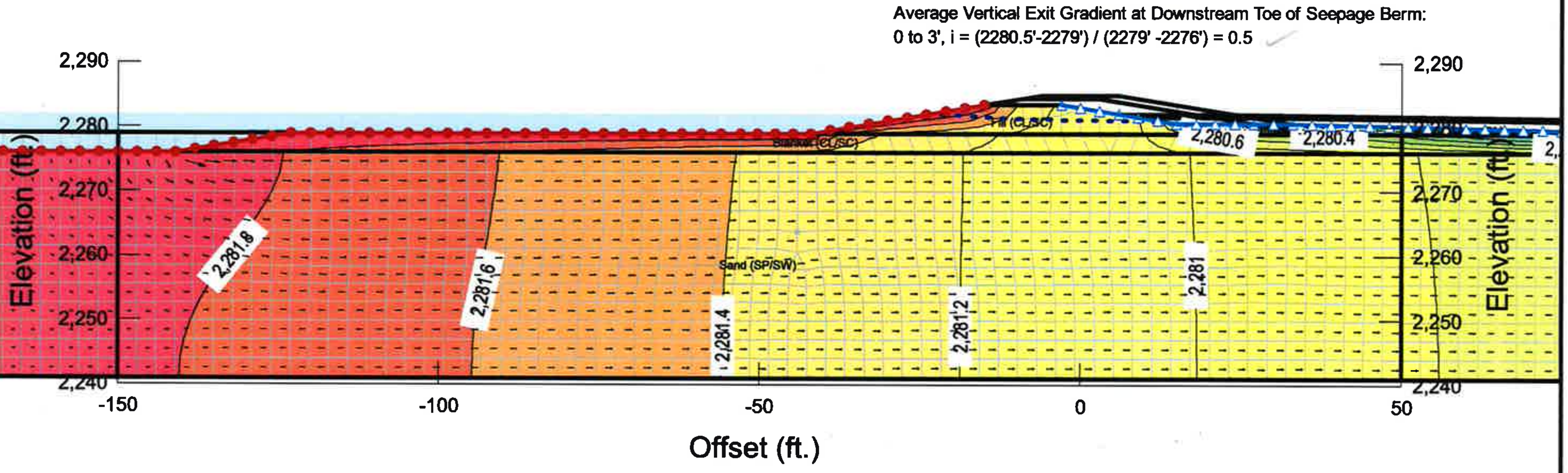
G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Total Head
- 🟦 2,279 - 2,279.2 ft
- 🟦 2,279.2 - 2,279.4 ft
- ▨ 2,279.4 - 2,279.6 ft
- 🟩 2,279.6 - 2,279.8 ft
- ■ 2,279.8 - 2,280 ft
- ■ 2,280 - 2,280.2 ft
- ▨ 2,280.2 - 2,280.4 ft
- 🟩 2,280.4 - 2,280.6 ft
- 🟨 2,280.6 - 2,280.8 ft
- 🟨 2,280.8 - 2,281 ft
- 🟨 2,281 - 2,281.2 ft
- 🟨 2,281.2 - 2,281.4 ft
- 🟧 2,281.4 - 2,281.6 ft
- 🟧 2,281.6 - 2,281.8 ft
- 🟥 2,281.8 - 2,282 ft

Average Vertical Exit Gradient at Downstream Toe of Seepage Berm:
0 to 3', i = (2280.5'-2279') / (2279' -2276') = 0.5



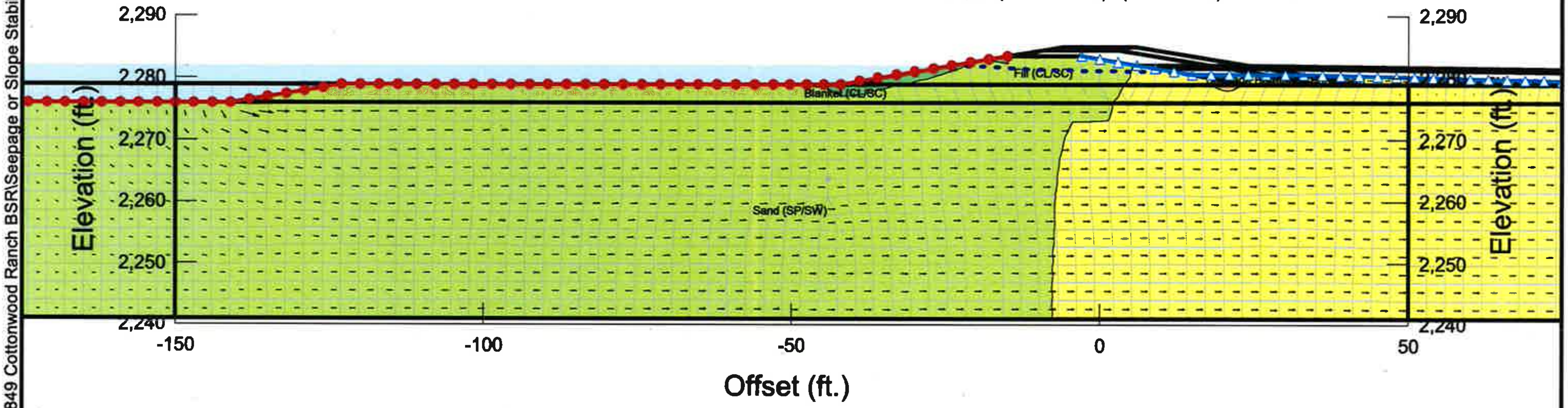
Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK — Date: 11/13/2017
Berms 1 Through 4 with Seepage Berm	Checked: PHP — Date: 11-30-17
3.0 FT Pool - 75 FT Seepage Berm	SEEP/W 8.16
Berms Located Away from Conveyance Channel	Scale: 1:300

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟧	Seepage Berm (SM)	Saturated Only	0.0002	0.25	0		
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

Y-Gradient

- 🟦 -0.8 - -0.6
- 🟦 -0.6 - -0.4
- 🟩 -0.4 - -0.2
- ▨ -0.2 - 0
- 🟨 0 - 0.2
- 🟧 0.2 - 0.4
- 🟥 0.4 - 0.6

Average Vertical Exit Gradient at Downstream Toe of Seepage Berm:
0 to 3', i = (2280.5'-2279') / (2279' -2276') = 0.5

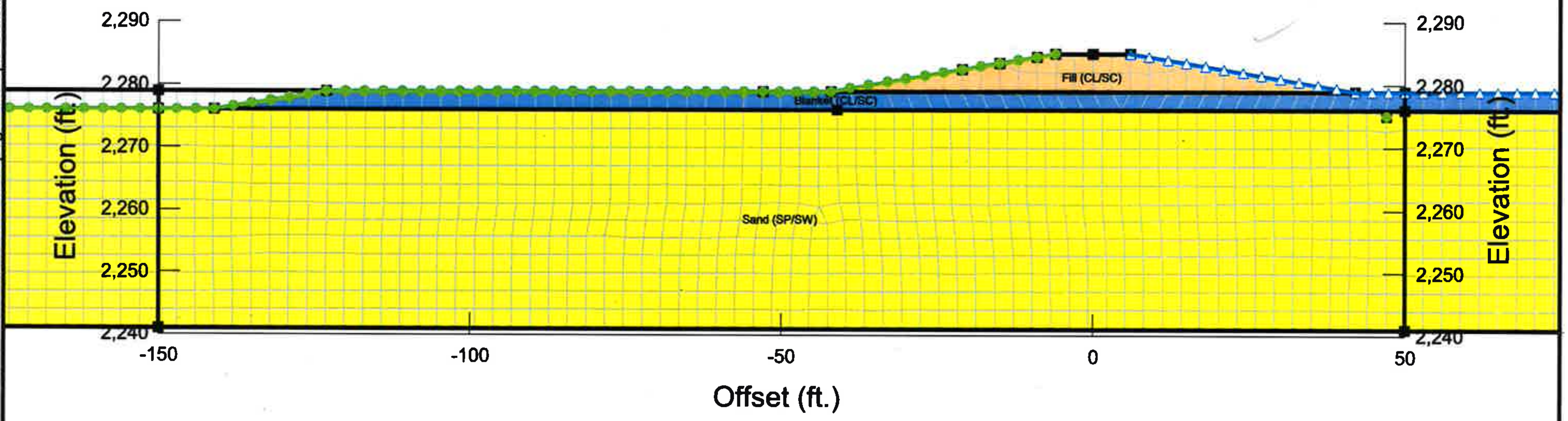


Cottonwood Ranch BSR, Phelps Co, NE
Berms 1 Through 4 with Seepage Berm
3.0 FT Pool - 75 FT Seepage Berm
Berms Located Away from Conveyance Channel

Computed: BPK Date: 11/13/2017
Checked: PH Date: 11-30-17
SEEP/W 8.16
Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 1 through 4 with Seepage Berm Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/16/2017
Berms 5 Through 8 with Toe Drain	Checked: PHP	Date: 11-30-17
4.4 FT Pool - Toe Drain	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 5 through 8 with Toe Drain Mitigation.gsz

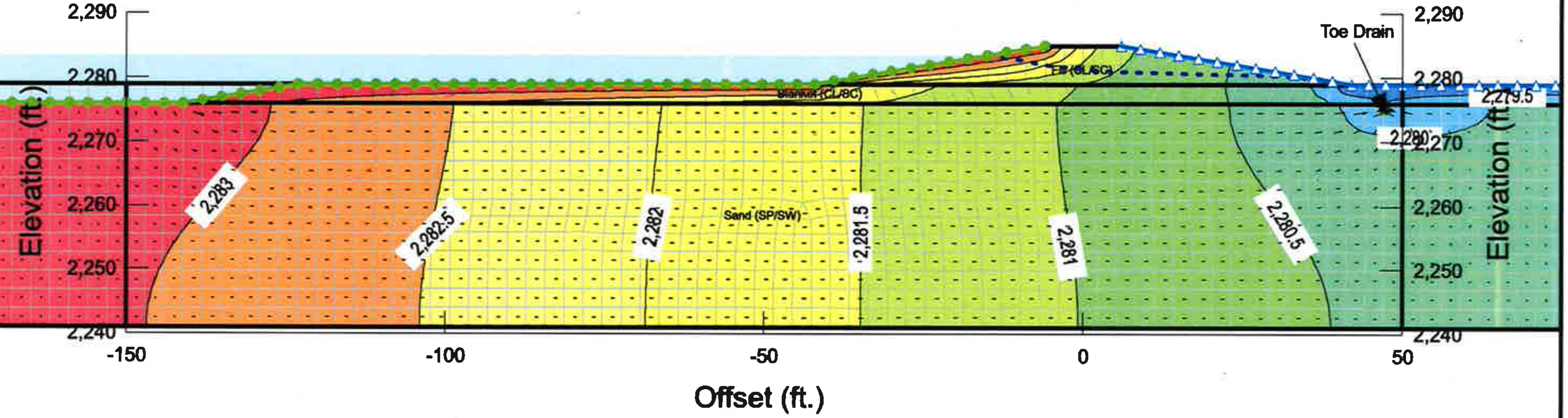
Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill

✓

Total Head

🟦	2,279 - 2,279.5 ft
🟦	2,279.5 - 2,280 ft
🟩	2,280 - 2,280.5 ft
🟩	2,280.5 - 2,281 ft
🟩	2,281 - 2,281.5 ft
🟨	2,281.5 - 2,282 ft
🟨	2,282 - 2,282.5 ft
🟧	2,282.5 - 2,283 ft
🟥	2,283 - 2,283.5 ft

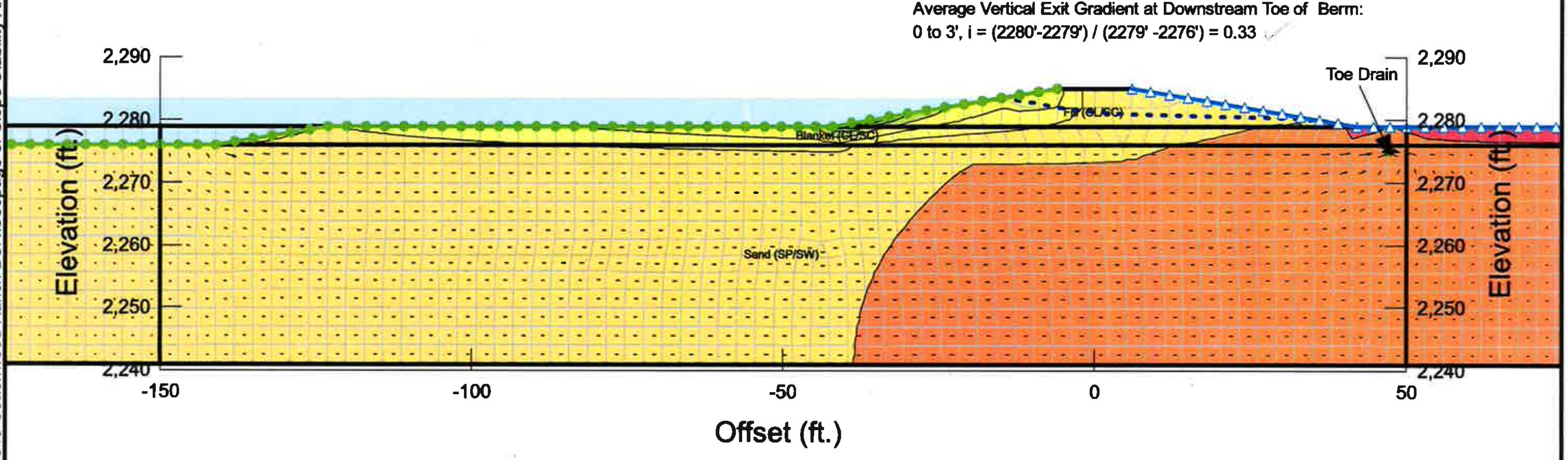
Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2280'-2279') / (2279' -2276') = 0.33 ✓



Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/20/2017
Berms 5 Through 8 with Toe Drain	Checked:	Date: 11-30-17
4.4 FT Pool - Toe Drain	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 5 through 8 with Toe Drain Mitigation.gsz

Color	Name	Model	Sat Kx (ft/sec)	Ky'/Kx' Ratio	Mv (/psf)	K-Function	Vol. WC. Function
🟨	Sand (SP/SW)	Saturated Only	0.001	0.25	0		
🟧	Fill (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Fill	Lean Clay
🟦	Blanket (CL/SC)	Saturated / Unsaturated		0.25		Lean Clay - Alluvium	Lean Clay Fill



Average Vertical Exit Gradient at Downstream Toe of Berm:
0 to 3', i = (2280'-2279') / (2279' -2276') = 0.33

Cottonwood Ranch BSR, Phelps Co, NE	Computed: BPK	Date: 11/20/2017
Berms 5 Through 8 with Toe Drain	Checked: PUP	Date: 11-30-17
4.4 FT Pool - Toe Drain	SEEP/W 8.16	
Berms Located Away from Conveyance Channel	Scale: 1:300	

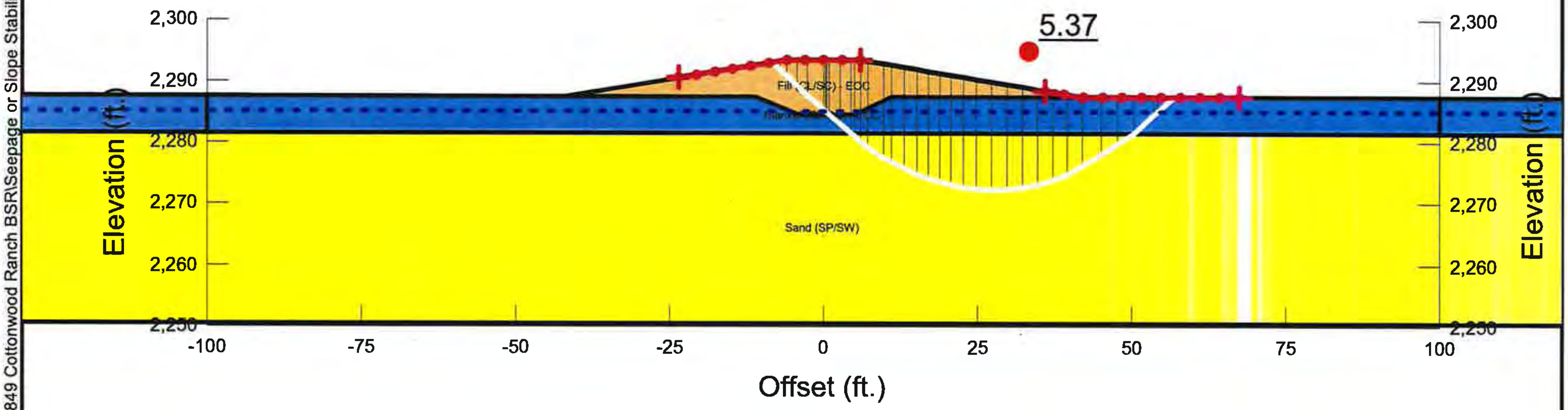
G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Final Design\Berms 5 through 8 with Toe Drain Mitigation.gsz

Appendix G

Slope Stability Analyses

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	Cohesion' (psf)	Phi' (°)
🟧	Fill (CL/SC) - EOC ✓	Undrained (Phi=0)	125 ✓	1,000		
🟦	Blanket (CL/SC) - EOC	Undrained (Phi=0)	110 ✓	600 ✓		
🟨	Sand (SP/SW)	Mohr-Coulomb ✓	115 ✓		0 ✓	30 ✓

√SPM 8-23-17



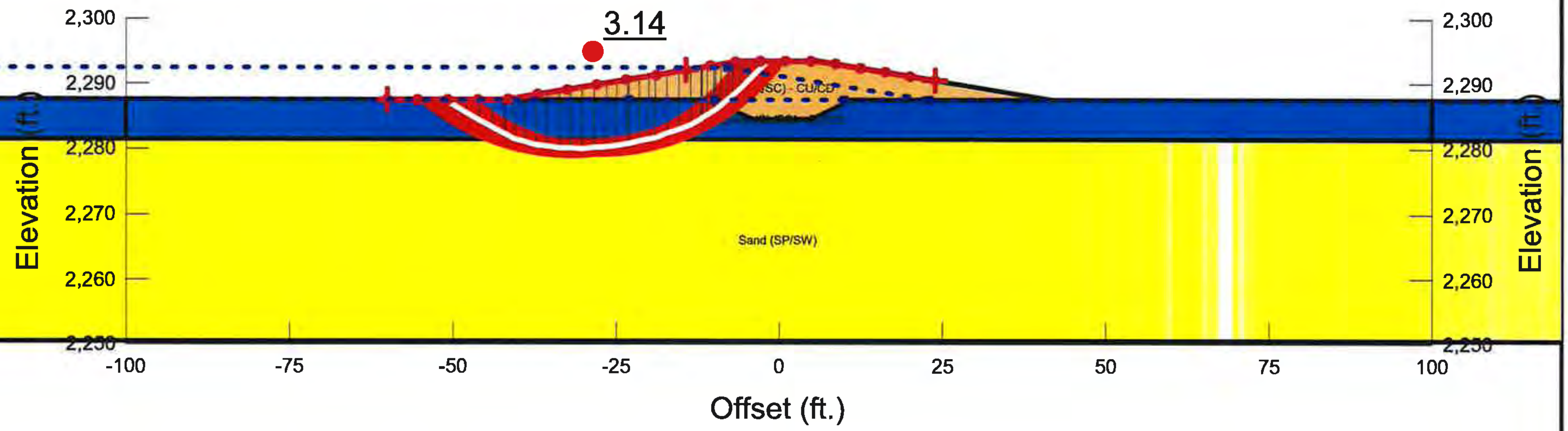
Cottonwood Ranch BSR, Phelps Co., NE
Critical Station
Berm Alternative with No Improvements
6:1 Slopes End of Construction

Date: 8/17/2017
Computed: BPK
Checked: SPM
Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Critical Section with 6 to 1 Slopes For Slope Stability.gsz

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion R (psf)	Phi R (°)
🟨	Sand (SP/SW)	Mohr-Coulomb	115 ✓	0 ✓	30 ✓	0	0
🟦	Blanket (CL/SC) - CU/CD	Mohr-Coulomb	110 ✓	50 ✓	28 ✓	300 ✓	12 ✓
🟧	Fill (CL/SC) - CU/CD	Mohr-Coulomb	125 ✓	50 ✓	28 ✓	500 ✓	12 ✓

✓SPM 8-23-17

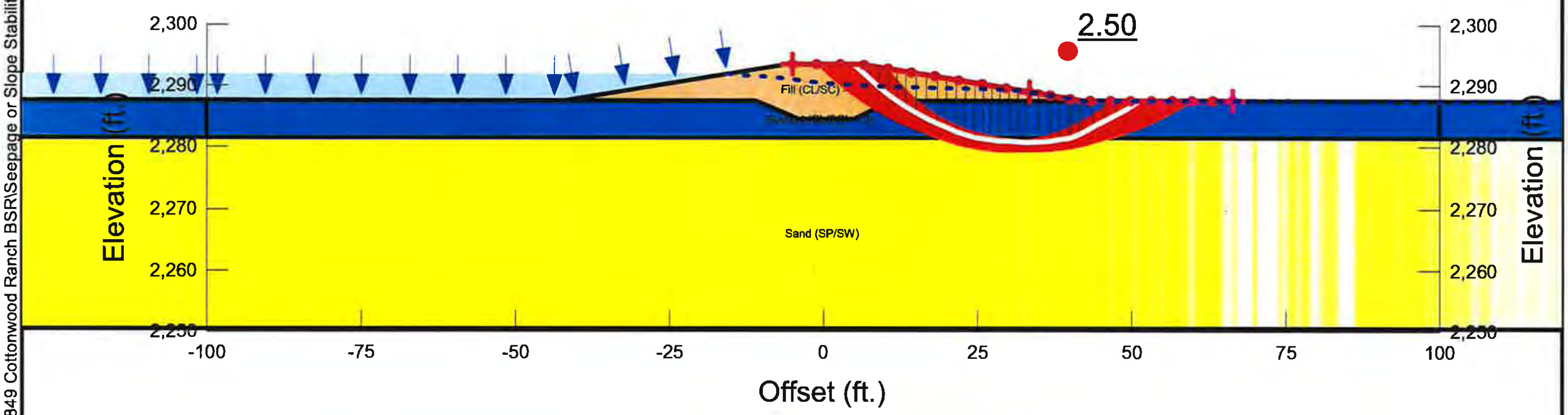


Cottonwood Ranch BSR, Phelps Co., NE	Date: 8/17/2017
Critical Station	Computed: BPK
Berm Alternative with No Improvements (2)	Checked: SPM
6:1 Slopes Rapid Drawdown	Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Critical Section with 6 to 1 Slopes For Slope Stability.gsz

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Sand (SP/SW)	Mohr-Coulomb	115	0	30
🟧	Fill (CL/SC) - CD	Mohr-Coulomb	125	50	28
🟦	Blanket (CL/SC) - CD	Mohr-Coulomb	110	50	28

√SPM 8-23-17

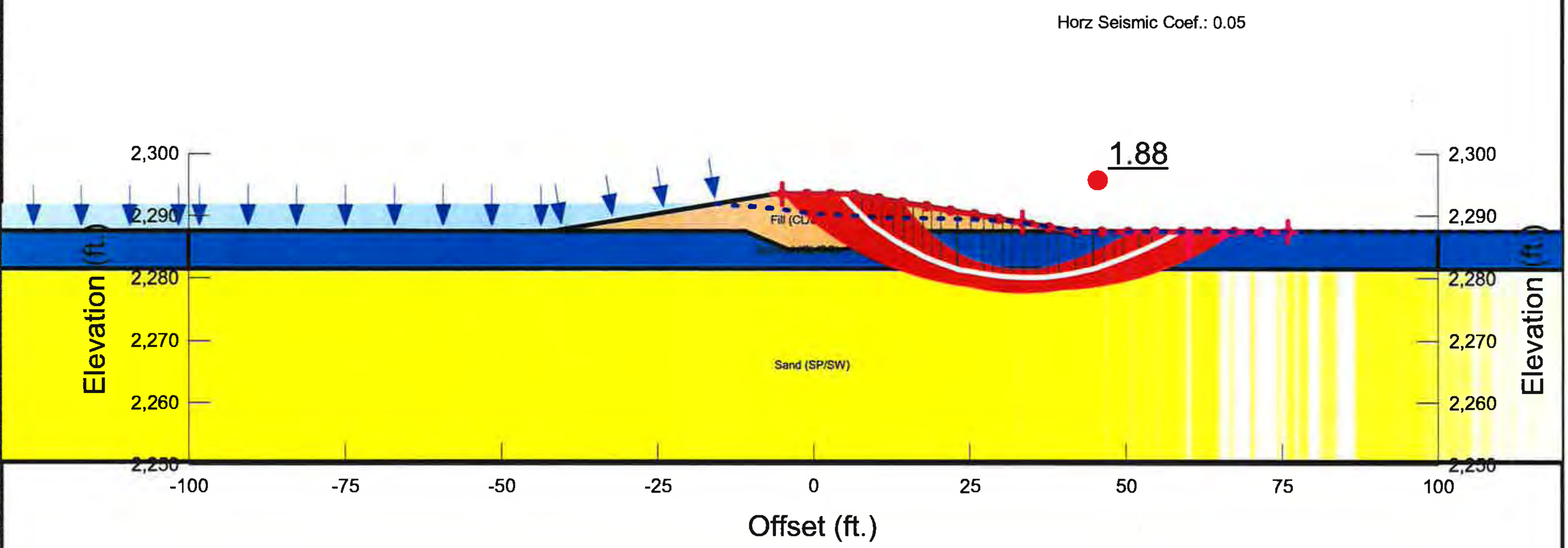


Cottonwood Ranch BSR, Phelps Co., NE	Date: 8/23/2017
Critical Station	Computed: BPK
Berm Alternative with No Improvements and 4.4-FT Pool	Checked: SPM
6:1 Slopes - Steady Seepage	Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Critical Section with 6 to 1 Slopes For Slope Stability.gsz

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟨	Sand (SP/SW)	Mohr-Coulomb	115	0	30
🟧	Fill (CL/SC) - CD	Mohr-Coulomb	125	50	28
🟦	Blanket (CL/SC) - CD	Mohr-Coulomb	110	50	28

√SPM 8-23-17



Cottonwood Ranch BSR, Phelps Co., NE	Date: 8/23/2017
Critical Station	Computed: BPK
Berm Alternative with No Improvements 4.4-FT Pool	Checked: SPM
6:1 Slopes Seismic	Scale: 1:300

G:\Projects\134 - 10057849 Cottonwood Ranch BSR\Seepage or Slope Stability Analyses\Critical Section with 6 to 1 Slopes For Slope Stability.gsz

Appendix H

Bearing Capacity Analyses

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Project:	CWR Broad Scale Recharge	Computed:	BPK	Date:	15-Nov-17
Subject:	Flume Wall	Checked:	[illegible]	Date:	11-30-17
Task:	Bearing Capacity (ASD)	Page:	1	of	1
Job #:		No:			

***Reference**: AASHTO Standard Specifications for Highway Bridges, 17th Edition, 2002.*

FOOTING GEOMETRY/ORIENTATION:

Eccentricity (e) =	0	
Footing Width (B) =	1	ft
Effective Footing Width (B' = B-2e) =	1	ft
Footing Length (L) =	L>5B	
Footing Embedment Depth (D_f) =	3.5	ft

SOIL PARAMETERS:

Soil Cohesion (c) =	0.00	psf
Angle of Internal Friction (Φ) =	30	degrees
Moist Unit Weight (γ) =	52.6	pcf

ULTIMATE BEARING CAPACITY:

$q_{ult} = cN_c + 0.5\gamma BN_\gamma + qN_q =$ 3,977 psf (EQ. 4.4.7.1-1)

c =	0.00	psf	
N_c =	30.14		*(Tbl. 4.4.7.1a)*
N_γ =	22.40		*(Tbl. 4.4.7.1a)*
B' =	1.00	ft	
q =	184.10	psf	
N_q =	18.40		*(Tbl. 4.4.7.1a)*

ALLOWABLE BEARING CAPACITY:

F.S. = 3.0

qallow = 1,326 psf = 9 psi

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Project:	CWR Broad Scale Recharge	Computed:	BPK	Date:	15-Nov-17
Subject:	Flume Wall	Checked:	[illegible]	Date:	[illegible]
Task:	Bearing Capacity (ASD)	Page:	1	of	1
Job #:		No:			

<u>Reference</u> : AASHTO Standard Specifications for Highway Bridges, 17th Edition, 2002.

FOOTING GEOMETRY/ORIENTATION:

Eccentricity (e) = 0

Footing Width (B) = 1 ft

Effective Footing Width (B' = B-2e) = 1 ft

Footing Length (L) = L>5B

Footing Embedment Depth (D_f) = 3.5 ft

SOIL PARAMETERS:

Soil Cohesion (c) = 600.00 psf

Angle of Internal Friction (Φ) = 0 degrees ✓

Moist Unit Weight (γ) = 52.6 pcf

ULTIMATE BEARING CAPACITY:

$q_{ult} = cN_c + 0.5\gamma BN_\gamma + qN_q =$ 3,268 psf (EQ. 4.4.7.1-1)

c = 600.00 psf

N_c = 5.14 *(Tbl. 4.4.7.1a)*

N_γ = 0.00 *(Tbl. 4.4.7.1a)*

B' = 1.00 ft

q = 184.10 psf

N_q = 1.00 *(Tbl. 4.4.7.1a)*

ALLOWABLE BEARING CAPACITY:

F.S. = 3.0

qallow = 1,089 psf = 8 psi

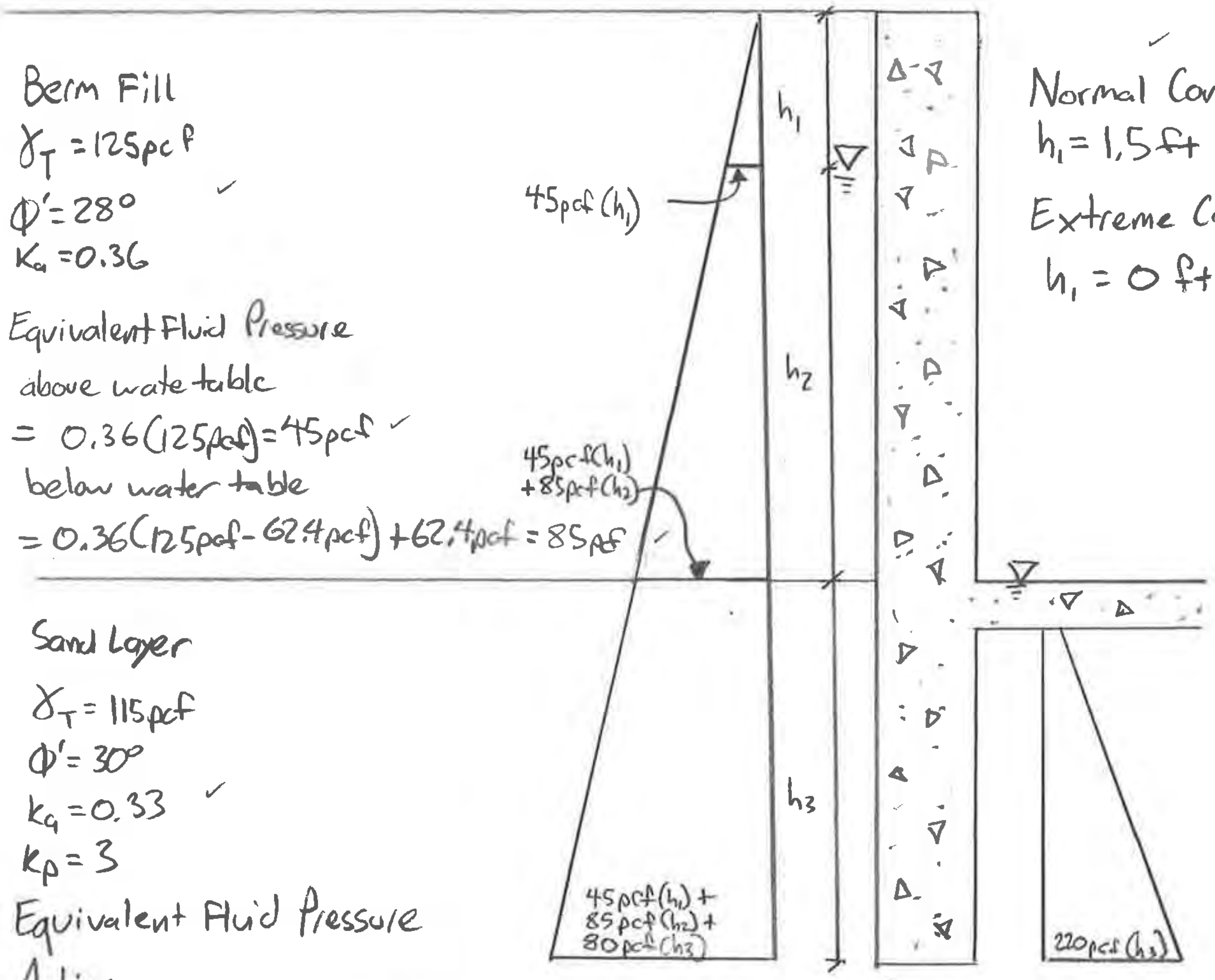
Appendix I

Lateral Earth Pressure Analyses

Project:	Cottonwood Ranch BSR	Computed:	BPK	Date:	12/1/17
Subject:	Flume Wall	Checked:	PWP	Date:	12-4-17
Task:	Lateral Earth Pressure	Page:	1	of:	1
Job #:		No:			

Lateral Earth Pressure Diagram

Flume Wall



Berm Fill

$\gamma_T = 125pcf$

$\phi' = 28°$ ✓

$K_a = 0.36$

Equivalent Fluid Pressure

above water table

$= 0.36(125pcf) = 45pcf$ ✓

below water table

$= 0.36(125pcf - 62.4pcf) + 62.4pcf = 85pcf$ ✓

Sand Layer

$\gamma_T = 115pcf$

$\phi' = 30°$

$k_a = 0.33$ ✓

$k_p = 3$

Equivalent Fluid Pressure

Active

$= 0.33(115pcf - 62.4pcf) + 62.4pcf = 80pcf$ ✓

Passive

$= 3(115pcf - 62.4pcf) + 62.4pcf = 220pcf$ ✓

✓

Normal Condition

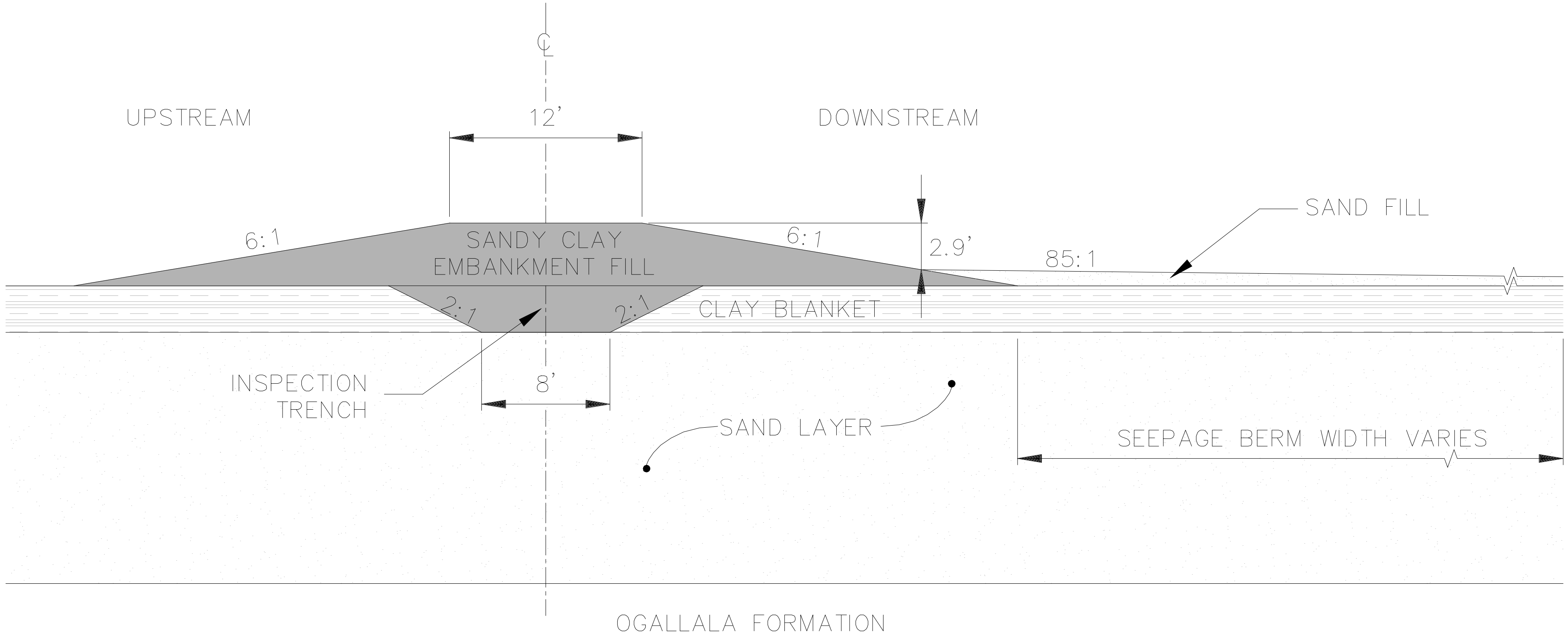
$h_1 = 1.5 ft$

Extreme Condition

$h_1 = 0 ft$

Appendix J

Mitigation Typical Sections



BERMS 1 THROUGH 4 WITH SEEPAGE BERM

PROJECT TITLE
PLATTE RIVER RECOVERY - COTTONWOOD RANCH

SHEET TITLE
FINAL ANALYSIS

PROJECT NUMBER
10057849

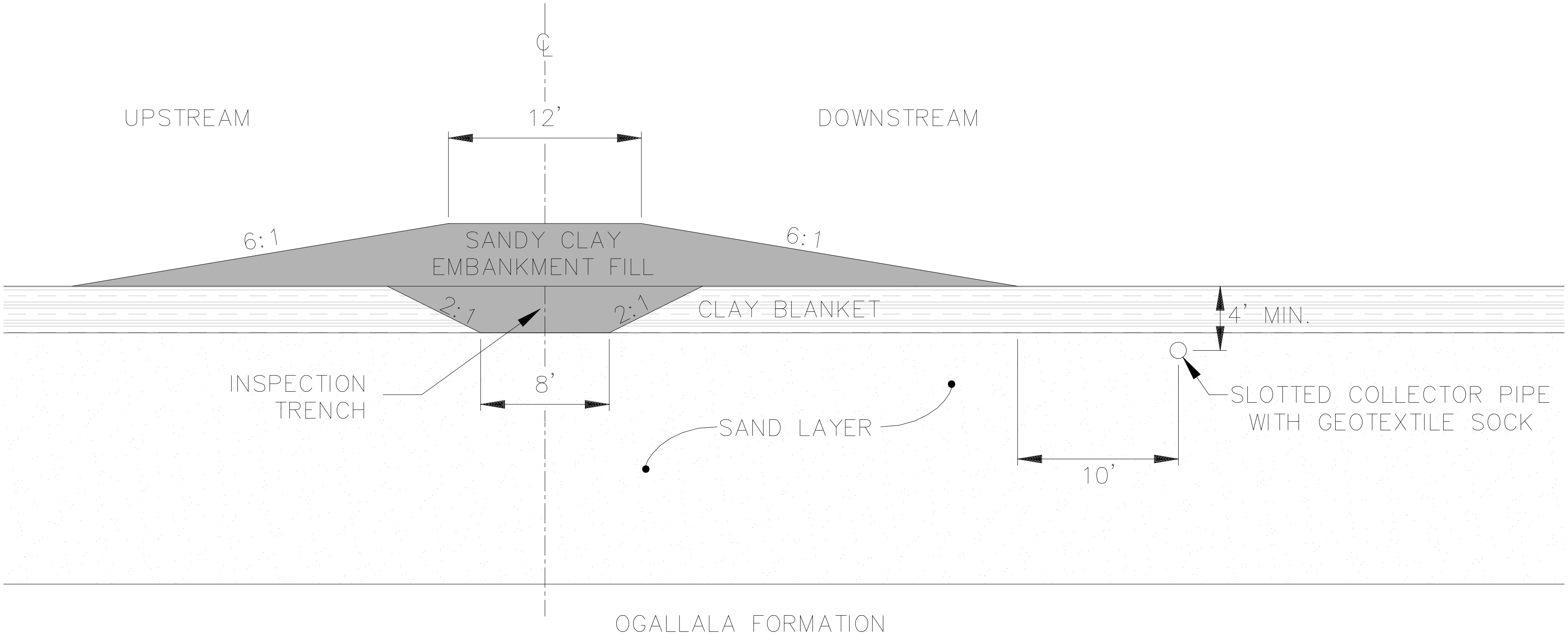
PROJECT MANAGER
P. Engelbert

DATE
11-20-2017

REFERENCE SHEET

REFERENCE DOCUMENT

EXHIBIT NUMBER
1



BERMS 5 THROUGH 8 WITH TOE DRAIN

PROJECT TITLE PLATTE RIVER RECOVERY - COTTONWOOD RANCH	PROJECT NUMBER 10057849	REFERENCE SHEET
SHEET TITLE FINAL ANALYSIS	PROJECT MANAGER P. Engelbert	REFERENCE DOCUMENT
	DATE 11-20-2017	EXHIBIT NUMBER 2

Appendix K

Filter Gradation Analyses

1.0 FILTER COMPATIBILITY ANALYSIS

1.1 References

- EM 1110-2-1901, Seepage Analysis and Control for Dams, USACE, Sep 1986.
- Design of Small Dams, USBR 1987
- David E. Kleiner, A Review of Filter Criteria for Embankment Dams, 25th Annual USSD Conference, Jun 2005.
- Gradation Design of Sand and Gravel Filters, Chapter 26, Part 633 National Engineering Handbook, United States Department of Agriculture (USDA)

1.2 Design Criteria Comparison

Design criteria for filter design, prevention of segregation, and pipe perforations obtained from USSD, USDA, USACE and USBR have been compared. The most conservative criteria were followed in the design.

1.2.1 Filter Design Criteria

USSD and USDA

Base Soil Category	**Base Soil Description, and Percent Finer than No. 200 (0.075 mm) Sieve** [1]	**Filter Criteria** [2]
1	Fine silts and clays; more than 85% finer	$D_{15} \le 9xd_{85}{}^{3}$
2	Sands, silts, clays and silty and clayey sands; 40 to 85% finer	$D_{15} \le 0.7mm$
3	Silty and clayey sands and gravels; 15 to 39% finer	$D_{15} \le \frac{40-A}{40-15}(4xd_{85} - 0.7mm) + 0.7mm^{4,5}$
4	Sands and gravels; less than 15% finer	$D_{15} \le 4xd_{85}{}^{6}$

Notes:

1. Category designation for soil containing particles larger than the #4 sieve (4.75 mm) is determined from a gradation curve of the base soil which has been adjusted to 100% passing the No. 4 (4.75 mm) sieve.

2. Filters are to have a maximum particle size of 75 mm (3 inches) and a maximum of 5% passing the No. 200 (0.075 mm) sieve with the plasticity index (PI) of the fines equal to zero. Note that the criteria relating the D90 to the D10 shown on Table "D10f and D90f Limits to Prevent Segregation" must be used to design the filter gradation ranges. These criteria force the designer to use uniform filter gradations that help to prevent segregation during placement. PI is determined on the material passing the No. 40 (0.425 mm) sieve in accordance with ASTM-D-4318. To ensure sufficient permeability, filters are to have a D15 size equal to or greater than 4xd15 but no smaller than 0.1 mm.

3. When 9xd85 is less than 0.2 mm, use 0.2 mm.

4. A = percent of base material passing the No. 200 (0.075 mm) sieve after any regrading.

5. When 4xd85 is less than 0.7 mm, use 0.7 mm.

6. In category 4, the d85 may be determined from the original gradation curve of the base soil without adjustments for particles larger than 4.75 mm.

USACE

Base Soil Category	Base Soil Description, and Percent Finer than No. 200 (0.075 mm) Sieve [1]	Filter Criteria [2]
1	Fine silts and clays; more than 85% finer	$D_{15} \le 9xd_{85}$ [3]
2	Sands, silts, clays and silty and clayey sands; 40 to 85% finer	$D_{15} \le 0.7mm$
3	Silty and clayey sands and gravels; 15 to 39% finer	$D_{15} \le \frac{40 - A}{40 - 15}(4xd_{85} - 0.7mm) + 0.7mm$ [4,5]
4	Sands and gravels; less than 15% finer	$D_{15} \le 4xd_{85}$ [6] to $D_{15} \le 5xd_{85}$ [6]

Note:

1. Category designation for soil containing particles larger than the #4 sieve (4.75 mm) is determined from a gradation curve of the base soil which has been adjusted to 100% passing the No. 4 (4.75 mm) sieve.

2. Filters are to have a maximum particle size of 75 mm (3 inches) and a maximum of 5% passing the No. 200 (0.075 mm) sieve with the plasticity index (PI) of the fines equal to zero. PI is determined on the material passing the No. 40 (0.425 mm) sieve in accordance with EM 1110-2-1906, "Laboratory Soils Testing." To ensure sufficient permeability, filters are to have a D15 size equal to or greater than 4xd15 but no smaller than 0.1 mm.

3. When 9xd85 is less than 0.2 mm, use 0.2 mm.

4. A = percent of base material passing the No. 200 (0.075 mm) sieve after any regrading.

5. When 4xd85 is less than 0.7 mm, use 0.7 mm.

6. In category 4, the criterion should be used in the case of filters beneath riprap subject to wave action and drains which may be subject to violent surging and/or vibration.

USBR

$$\frac{D_{15} \text{ of the filter}}{D_{15} \text{ of base material}} \geq 5$$

Notes: Provided that the filter does not contain more than 5 percent of material finer than 0.074 mm (No. 200 sieve) after compaction.

$$\frac{D_{15} \text{ of the filter}}{D_{85} \text{ of base material}} \leq 5$$

$$\frac{D_{85} \text{ of the filter}}{\text{Maximum opening of pipe drain}} \geq 2$$

Generally, the filter should be uniformly graded to provide adequate permeability and prevent segregation during processing, handling, and placing. From the above comparison, it shows USACE has the most conservative criterion. Therefore, it was followed in design.

1.2.2 Perforated Pipe Criteria

USDA

Criteria for filters used adjacent to perforated collector pipe	
Noncritical drains where surging or gradient reversal is not anticipated	The filter D_{85} must be greater than or equal to the perforation size
Critical drains where surging or gradient reversal is anticipated	The filter D_{15} must be greater than or equal to the perforation size

USBR

D85 size of the filter be equal to or greater than twice the size of the maximum opening in the pipe. (Page 219 of *Design of Small Dams*)

USACE

$$\frac{\text{Minimum 50 percent size of filter material}}{\text{hole diameter or slot width}} \geq 1.0$$

From the comparison, it can be seen USBR has the most conservative criterion.

1.2.3 Preventing Segregation Criteria

USSD - (USDA SCS, 1986; USBR, 1987; USACE 1993)
$D10_f$ and $D90_f$ Limits to Prevent Segregation

Minimum D_{10} mm	Maximum D_{90} mm
< 0.5	20
0.5 - 1.0	25
1.0 - 2.0	30
2.0 - 5.0	40
5.0 - 10	50
10 - 50	60

USDOA

Base Soil Category	If D_{10} is	Then Maximum D_{90} is
	(mm)	(mm)
All Categories	<0.5	20
	0.5 - 1.0	25
	1.0 - 2.0	30
	2.0 - 5.0	40
	5.0 - 10	50
	>10	60

The criteria for preventing segregation from USACE, USBR and USDA are the same.

1.3 Parameters Used in Analyses

The proposed NDOR 47B Fine Aggregate for Portland Cement Concrete was used as the USBR filter (D) and the sandy lean clay blanket layer was used as a base material (d) in the design. Both USACE (USSD) and USBR filter design criteria have been checked. The table below shows the NDOR 47B Fine Aggregate for Portland Cement Concrete.

Sieve Size	Percent Passing
1 Inch	100
No. 4	77-97
No. 8	50-70
No. 30	16-40
No. 200	0-3

1.4 Filter Criteria Check

The base soil category is 2. The minimum D_{15} is 0.2 mm and the maximum is 0.7 mm. The minimum d_{85} is 0.16 mm and the maximum is 0.2 mm. Where, D_{15} and d_{85} are the particle-size diameters corresponding to 15 and 85% of the filter and base respectively, passing on the cumulative particle-size distribution curve. The average percent of material passing the No. 200 sieve for the base material is 37 percent.

<u>Calculations:</u>

NDOR 47B Fine Aggregate for Portland Cement Concrete

D_{15} Filter Material (Minimum) = 0.2 mm
d_{85} Base Material (Minimum) = 0.2 mm
d_{15} Base Material (Minimum) = 0.001 mm

D_{15} Filter Material (Maximum) = 0.7 mm
d_{85} Base Material (Maximum) = 0.6 mm
d_{15} Base Material (Maximum) = 0.04 mm
prior to re-grading

Reference: Design of Small Dams

D_{15} of the filter $\leq$ 0.7mm

$$\frac{D_{15} \text{ of the filter}}{D_{15} \text{ of base material}} \geq 5$$

d_{15} =	0.001	D_{15} =	0.2	≥	$5xd_{15}$ =	0.005	OK
d_{15} =	0.001	D_{15} =	0.7	≥	$5xd_{15}$ =	0.005	OK
d_{15} =	0.04	D_{15} =	0.2	≥	$5xd_{15}$ =	0.2	OK
d_{15} =	0.04	D_{15} =	0.7	≥	$5xd_{15}$ =	0.2	OK

The analysis shows that the NDOR 47B Fine Aggregate for Portland Cement Concrete meets the filter and Permeability criteria.

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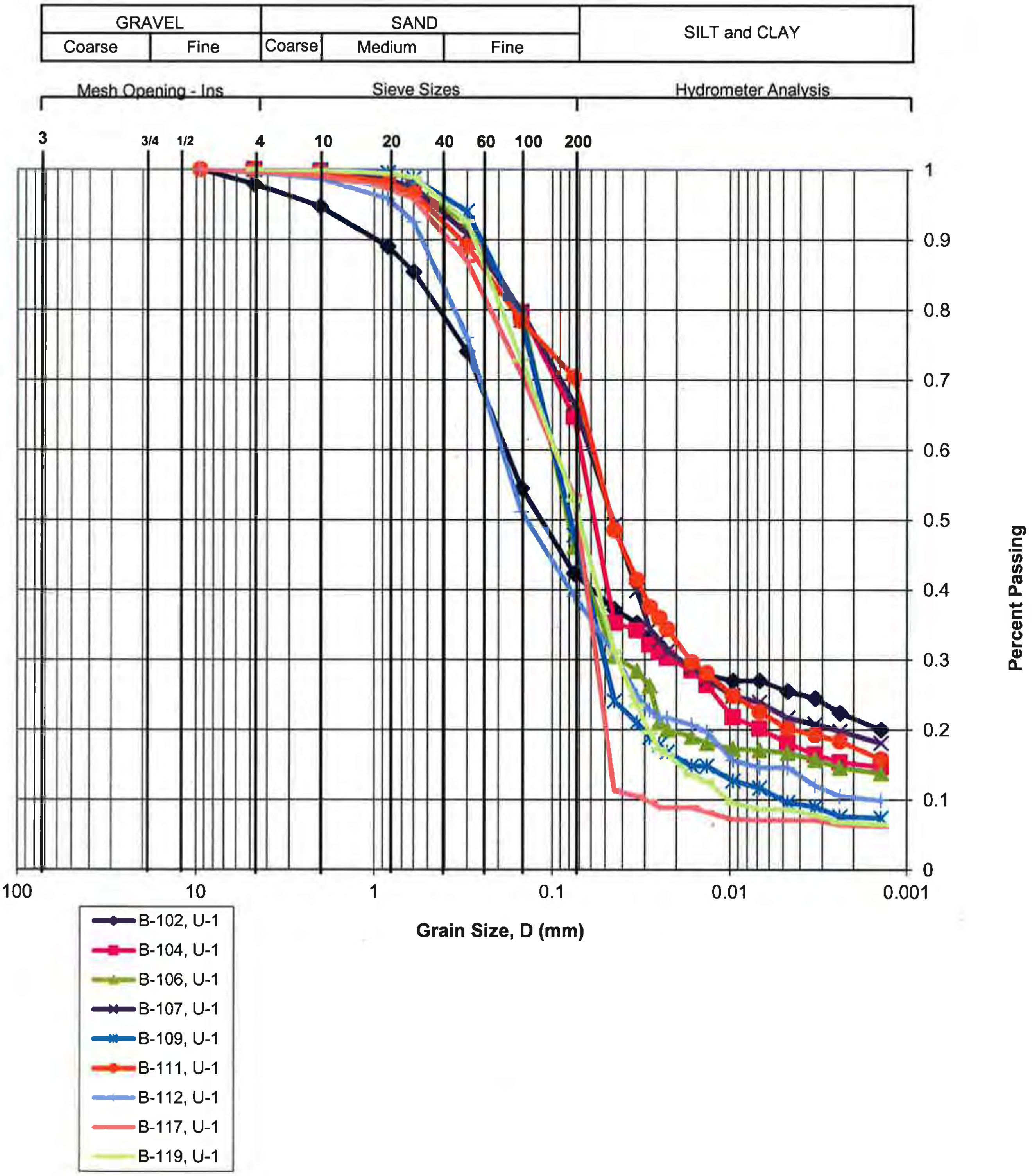
Project:	Cottonwood Ranch BSR	Computed:	BPK	Date:	20-Nov-17
Subject:	Toe Drain	Checked:	MKP	Date:	11-30-17
Task:	Filter Compatibility Analysis -Blanket Layer	Page:	1 of 1		
Job #:	10057849	No:	134		



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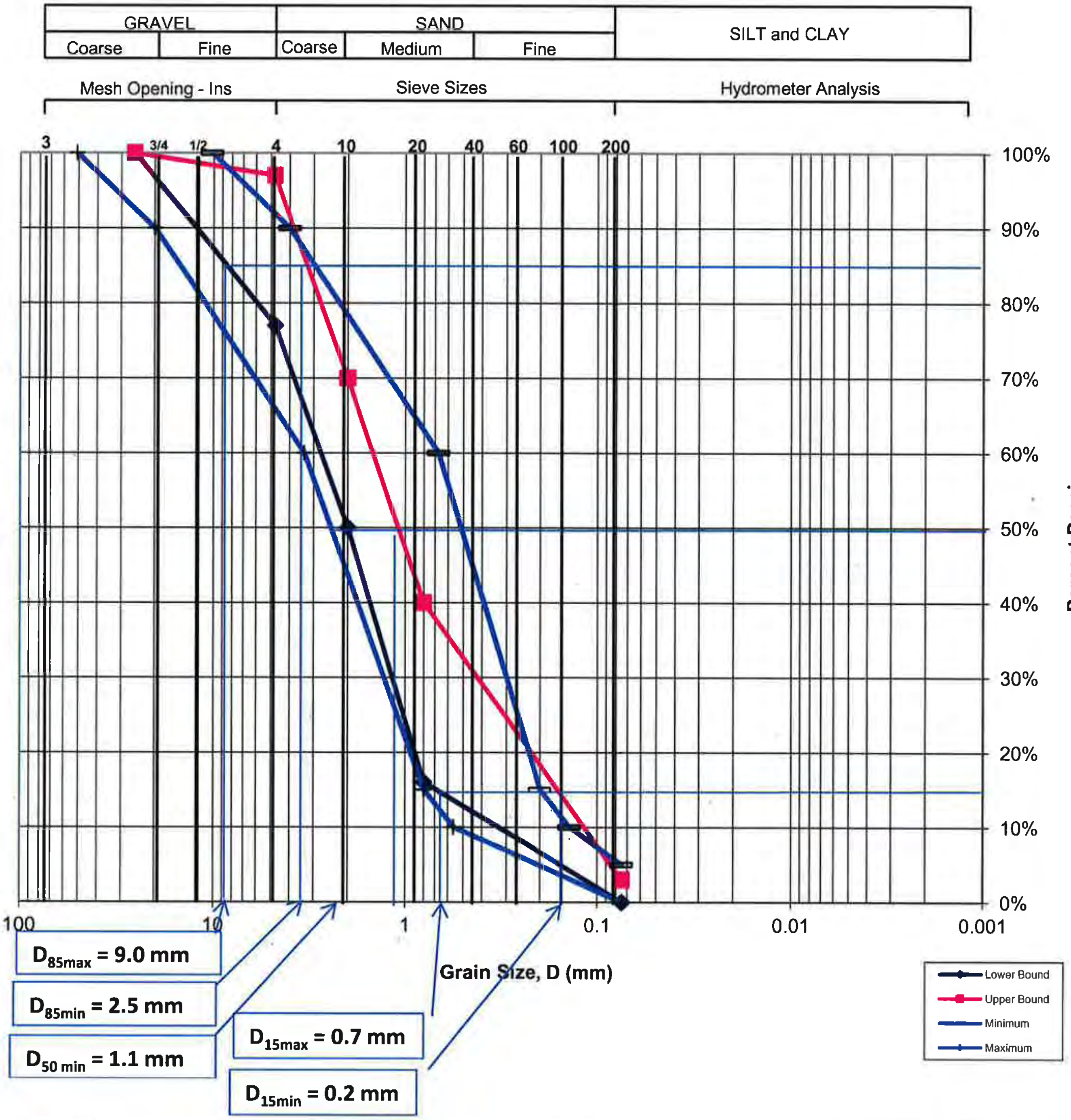
Project:	Cottonwood Ranch BSR	Computed:	BPK	Date:	20-Nov-17
Subject:	Toe Drain	Checked:	PHP	Date:	11 20-17
Task:	Filter Compatibility Analysis -Blanket Layer	Page:	1	of	1
Job #:	10057849	No:	134		



D_{85max} = 9.0 mm

D_{85min} = 2.5 mm

$D_{50\ min}$ = 1.1 mm

D_{15max} = 0.7 mm

D_{15min} = 0.2 mm

SAMPLE	CLASSIFICATION AND SYMBOL	Liquid Limit, %	Plastic Limit, %
	NDOR		
	47B Fine Aggregate for Concrete		

HDR | ONE COMPANY *Many Solutions*℠

Project:	Cottonwood Ranch BSR	Computed:	BPK	Date:	20-Nov-17
Subject:	Toe Drain	Checked:	PHP	Date:	11-30-17
Task:	Filter Compatibility Analysis - Sand Layer	Page:	1 of 5		
Job #:	10057849	No:	134		

1.0 FILTER COMPATIBILITY ANALYSIS

1.1 References

- EM 1110-2-1901, Seepage Analysis and Control for Dams, USACE, Sep 1986.
- Design of Small Dams, USBR 1987
- David E. Kleiner, A Review of Filter Criteria for Embankment Dams, 25th Annual USSD Conference, Jun 2005.
- Gradation Design of Sand and Gravel Filters, Chapter 26, Part 633 National Engineering Handbook, United States Department of Agriculture (USDA)

1.2 Design Criteria Comparison

Design criteria for filter design, prevention of segregation, and pipe perforations obtained from USSD, USDA, USACE and USBR have been compared. The most conservative criteria were followed in the design.

1.2.1 Filter Design Criteria

USSD and USDA

Base Soil Category	**Base Soil Description, and Percent Finer than No. 200 (0.075 mm) Sieve** [1]	**Filter Criteria** [2]
1	Fine silts and clays; more than 85% finer	$D_{15} \leq 9xd_{85}$ [3]
2	Sands, silts, clays and silty and clayey sands; 40 to 85% finer	$D_{15} \leq 0.7mm$
3	Silty and clayey sands and gravels; 15 to 39% finer	$D_{15} \leq \frac{40 - A}{40 - 15}(4xd_{85} - 0.7mm) + 0.7mm$ [4,5]
4	Sands and gravels; less than 15% finer	$D_{15} \leq 4xd_{85}$ [6]

Notes:

1. Category designation for soil containing particles larger than the #4 sieve (4.75 mm) is determined from a gradation curve of the base soil which has been adjusted to 100% passing the No. 4 (4.75 mm) sieve.

2. Filters are to have a maximum particle size of 75 mm (3 inches) and a maximum of 5% passing the No. 200 (0.075 mm) sieve with the plasticity index (PI) of the fines equal to zero. Note that the criteria relating the D90 to the D10 shown on Table "D10f and D90f Limits to Prevent Segregation" must be used to design the filter gradation ranges. These criteria force the designer to use uniform filter gradations that help to prevent segregation during placement. PI is determined on the material passing the No. 40 (0.425 mm) sieve in accordance with ASTM-D-4318. To ensure sufficient permeability, filters are to have a D15 size equal to or greater than 4xd15 but no smaller than 0.1 mm.

3. When 9xd85 is less than 0.2 mm, use 0.2 mm.

4. A = percent of base material passing the No. 200 (0.075 mm) sieve after any regrading.

5. When 4xd85 is less than 0.7 mm, use 0.7 mm.

6. In category 4, the d85 may be determined from the original gradation curve of the base soil without adjustments for particles larger than 4.75 mm.

USACE

Base Soil Category	Base Soil Description, and Percent Finer than No. 200 (0.075 mm) Sieve [1]	Filter Criteria [2]
1	Fine silts and clays; more than 85% finer	$D_{15} \le 9xd_{85}$ [3]
2	Sands, silts, clays and silty and clayey sands; 40 to 85% finer	$D_{15} \le 0.7mm$
3	Silty and clayey sands and gravels; 15 to 39% finer	$D_{15} \le \frac{40-A}{40-15}(4xd_{85} - 0.7mm) + 0.7mm$ [4,5]
4	Sands and gravels; less than 15% finer	$D_{15} \le 4xd_{85}$ [6] to $D_{15} \le 5xd_{85}$ [6]

Note:

1. Category designation for soil containing particles larger than the #4 sieve (4.75 mm) is determined from a gradation curve of the base soil which has been adjusted to 100% passing the No. 4 (4.75 mm) sieve.

2. Filters are to have a maximum particle size of 75 mm (3 inches) and a maximum of 5% passing the No. 200 (0.075 mm) sieve with the plasticity index (PI) of the fines equal to zero. PI is determined on the material passing the No. 40 (0.425 mm) sieve in accordance with EM 1110-2-1906, "Laboratory Soils Testing." To ensure sufficient permeability, filters are to have a D15 size equal to or greater than 4xd15 but no smaller than 0.1 mm.

3. When 9xd85 is less than 0.2 mm, use 0.2 mm.

4. A = percent of base material passing the No. 200 (0.075 mm) sieve after any regrading.

5. When 4xd85 is less than 0.7 mm, use 0.7 mm.

6. In category 4, the criterion should be used in the case of filters beneath riprap subject to wave action and drains which may be subject to violent surging and/or vibration.

USBR

$$\frac{D_{15} \text{ of the filter}}{D_{15} \text{ of base material}} \ge 5$$

Notes: Provided that the filter does not contain more than 5 percent of material finer than 0.074 mm (No. 200 sieve) after compaction.

$$\frac{D_{15} \text{ of the filter}}{D_{85} \text{ of base material}} \le 5$$

$$\frac{D_{85} \text{ of the filter}}{\text{Maximum opening of pipe drain}} \ge 2$$

Generally, the filter should be uniformly graded to provide adequate permeability and prevent segregation during processing, handling, and placing. From the above comparison, it shows USACE has the most conservative criterion. Therefore, it was followed in design.

1.2.2 Perforated Pipe Criteria

USDA

Criteria for filters used adjacent to perforated collector pipe	
Noncritical drains where surging or gradient reversal is not anticipated	The filter D_{85} must be greater than or equal to the perforation size
Critical drains where surging or gradient reversal is anticipated	The filter D_{15} must be greater than or equal to the perforation size

USBR

D85 size of the filter be equal to or greater than twice the size of the maximum opening in the pipe. (Page 219 of *Design of Small Dams*)

USACE

$$\frac{\text{Minimum 50 percent size of filter material}}{\text{hole diameter or slot width}} \geq 1.0$$

From the comparison, it can be seen USBR has the most conservative criterion.

1.2.3 Preventing Segregation Criteria

USSD - (USDA SCS, 1986; USBR, 1987; USACE 1993)
$D10_f$ and $D90_f$ Limits to Prevent Segregation

Minimum D_{10} mm	Maximum D_{90} mm
< 0.5	20
0.5 - 1.0	25
1.0 - 2.0	30
2.0 - 5.0	40
5.0 - 10	50
10 - 50	60

USDOA

Base Soil Category	If D_{10} is	Then Maximum D_{90} is
All Categories	(mm)	(mm)
	<0.5	20
	0.5 - 1.0	25
	1.0 - 2.0	30
	2.0 - 5.0	40
	5.0 - 10	50
	>10	60

The criteria for preventing segregation from USACE, USBR and USDA are the same.

1.3 Parameters Used in Analyses

The proposed custom gradation was used as the USBR filter (D) and the pervious sand foundation was used as a base material (d) in the design. Both USACE (USSD) and USBR filter design criteria have been checked. The table below shows the custom gradation.

Sieve Size	Percent Passing
2 Inch	100
1/2 Inch	35-100
No. 4	10-50
No. 10	8-10
No. 200	0-3

1.4 Filter Criteria Check

The base soil category is 4. The minimum D_{15} is 3 mm and the maximum is 8 mm. The minimum d_{85} is 2 mm and the maximum is 8 mm. Where, D_{15} and d_{85} are the particle-size diameters corresponding to 15 and 85% of the filter and base respectively, passing on the cumulative particle-size distribution curve. The average percent of material passing the No. 200 sieve for the base material is 5 percent.

Calculations:

Custom Gradation

D_{15} Filter Material (Minimum) = 3 mm

d_{85} Base Material (Minimum) = 1.8 mm

d_{15} Base Material (Minimum) = 0.1 mm

D_{15} Filter Material (Maximum) = 7 mm

d_{85} Base Material (Maximum) = 2.5 mm

d_{15} Base Material (Maximum) = 0.6 mm
prior to regrading

Reference: EM 1110-2-1901

$$\frac{D_{15} \text{ of the filter}}{d_{85} \text{ of base material}} \leq 4$$

d_{85} =	1.8	D_{15} =	3	≤	$4xd_{85}$ =	7.2	OK
d_{85} =	1.8	D_{15} =	7	≤	$4xd_{85}$ =	7.2	OK
d_{85} =	2.5	D_{15} =	3	≤	$4xd_{85}$ =	10	OK
d_{85} =	2.5	D_{15} =	7	≤	$4xd_{85}$ =	10	OK

Reference: Design of Small Dams

$$\frac{D_{15} \text{ of the filter}}{D_{15} \text{ of base material}} \geq 5$$

d_{15} =	0.1	D_{15} =	3	≥	$5xd_{15}$ =	0.5	OK
d_{15} =	0.1	D_{15} =	7	≥	$5xd_{15}$ =	0.5	OK
d_{15} =	0.6	D_{15} =	3	≥	$5xd_{15}$ =	3	OK
d_{15} =	0.6	D_{15} =	7	≥	$5xd_{15}$ =	3	OK

The analysis shows that the custom gradation meets the filter and Permeability criteria.

1.5 Pipe Perforations

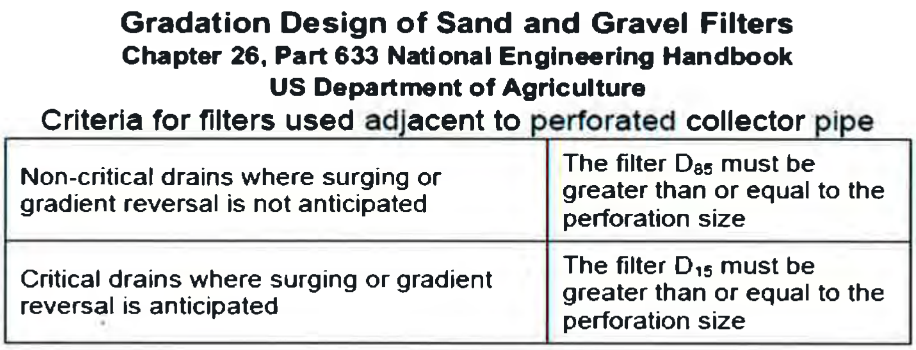
To prevent infiltration of the filter material into perforated pipe, the perforation size needs to be calculated. Pipe perforation size was calculated based on USACE, USDA and USBR criteria.

Criteria	Pipe Perforation Size (mm)
USDA	7.5
USACE	5
USBR	3.75

Calculations:

Custom Gradation

$D_{85\ \text{Min}}$ = 7.5
$D_{50\ \text{Min}}$ = 5
$D_{15\ \text{Min}}$ = 3



Gradation Design of Sand and Gravel Filters
Chapter 26, Part 633 National Engineering Handbook
US Department of Agriculture
Criteria for filters used adjacent to perforated collector pipe

Non-critical drains where surging or gradient reversal is not anticipated	The filter D_{85} must be greater than or equal to the perforation size
Critical drains where surging or gradient reversal is anticipated	The filter D_{15} must be greater than or equal to the perforation size

Perforated Pipe Size: 7.5 mm

USACE - EM 1110-2-1901, Seepage Analysis and Control for Dams

$$\frac{\text{Minimum 50 percent size of filter material}}{\text{hole diameter or slot width}} \geq 1.0$$

Perforated Pipe Size: 5 mm

USBR - Design of Small Dams

$$\frac{D_{85}\text{ of the filter}}{\text{Maximum opening of pipe drain}} \geq 2$$

Perforated Pipe Size: 3.75 mm

The analysis shows that pipe perforations up to 3 mm meets the criteria.

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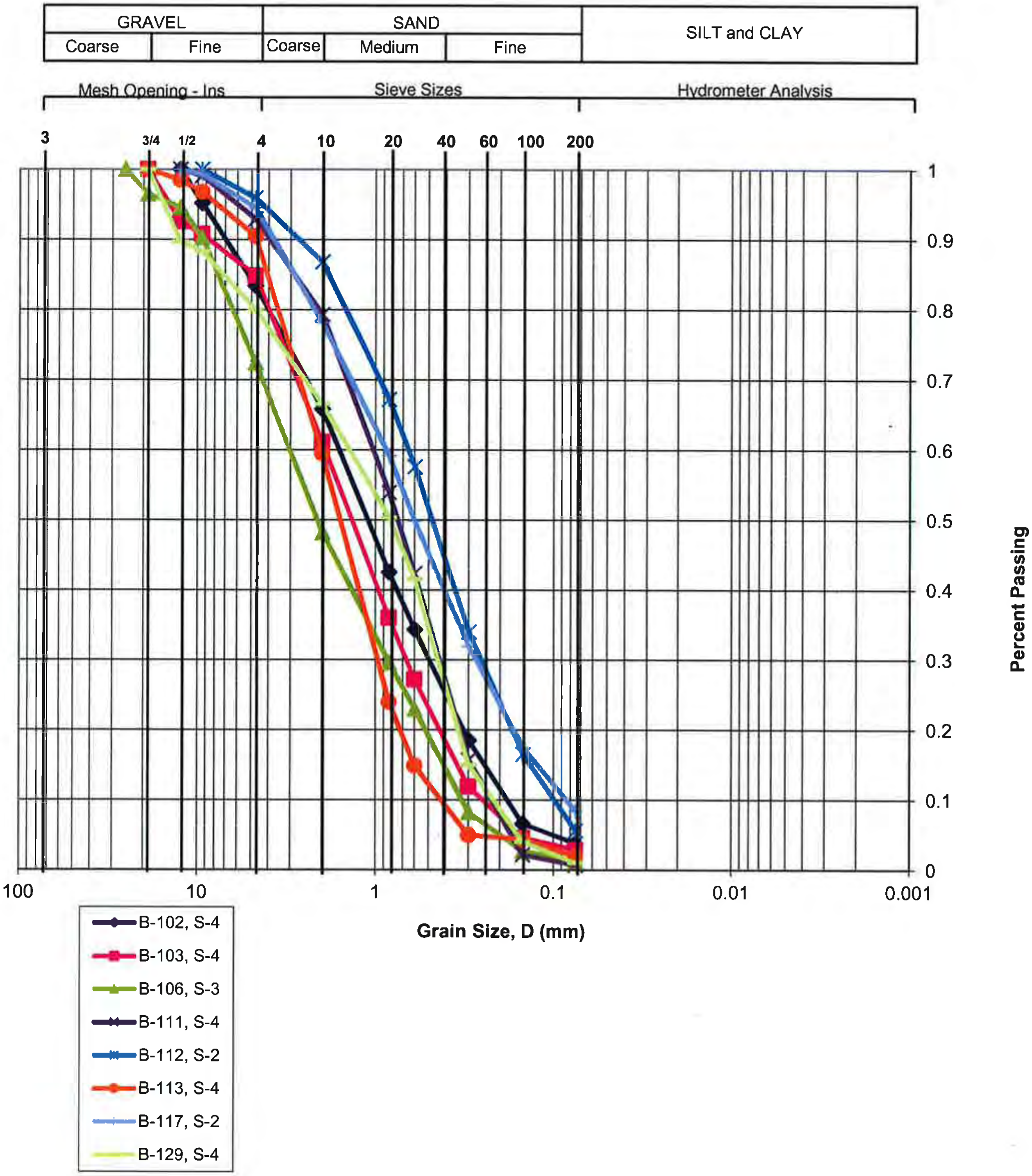
Project:	Cottonwood Ranch BSR	Computed:	BPK	Date:	20-Nov-17
Subject:	Toe Drain	Checked:	[illegible]	Date:	11-30-17
Task:	Filter Compatibility Analysis - Sand Layer	Page:	1	of	1
Job #:	10057849	No:	134		



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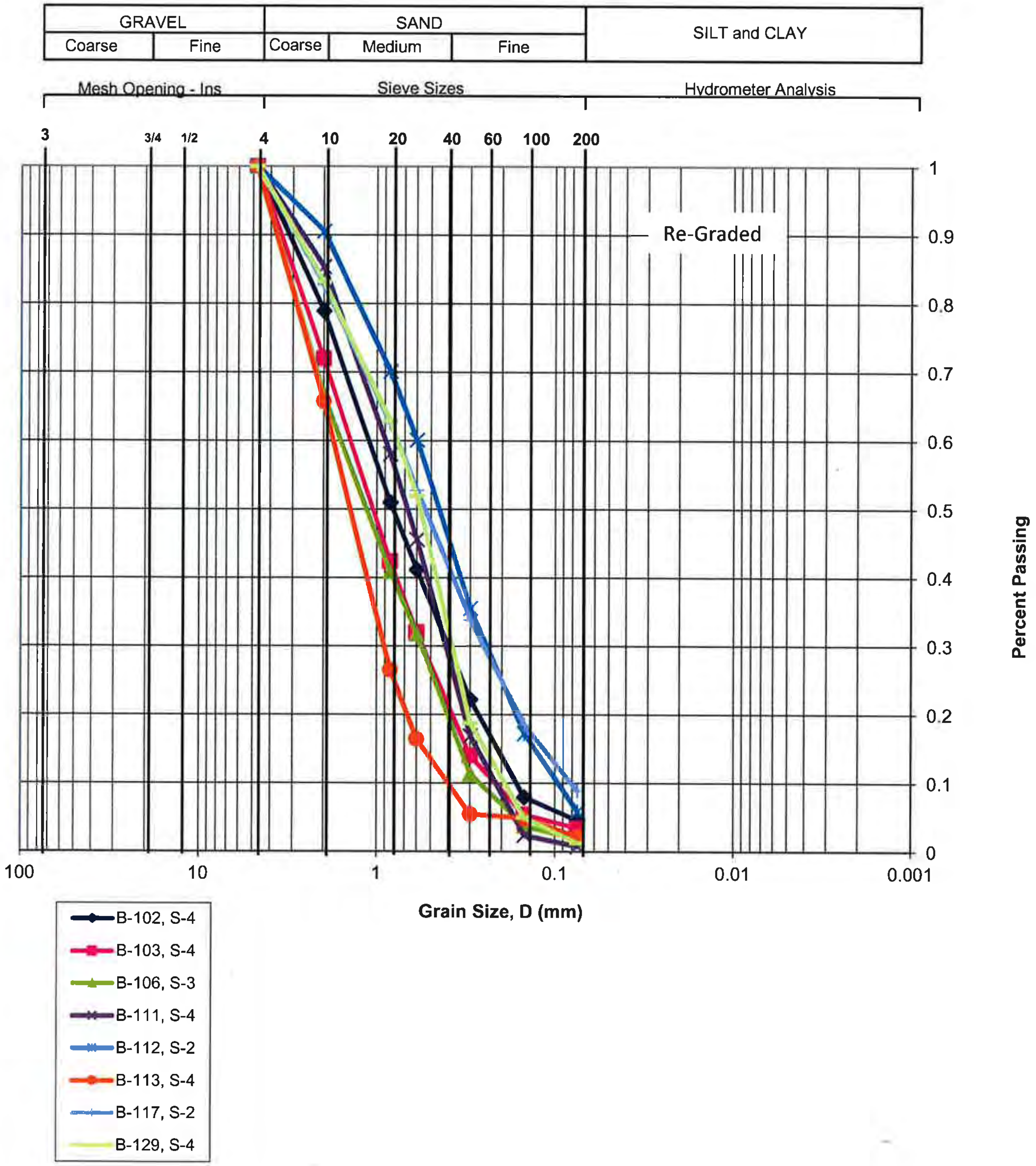
Project:	Cottonwood Ranch BSR	Computed:	BPK	Date:	20-Nov-17
Subject:	Toe Drain	Checked:	PHP	Date:	11-30-17
Task:	Filter Compatibility Analysis - Sand Layer	Page:	1	of	1
Job #:	10057849	No:	134		



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Project:	Cottonwood Ranch BSR	Computed:	BPK	Date:	20-Nov-17
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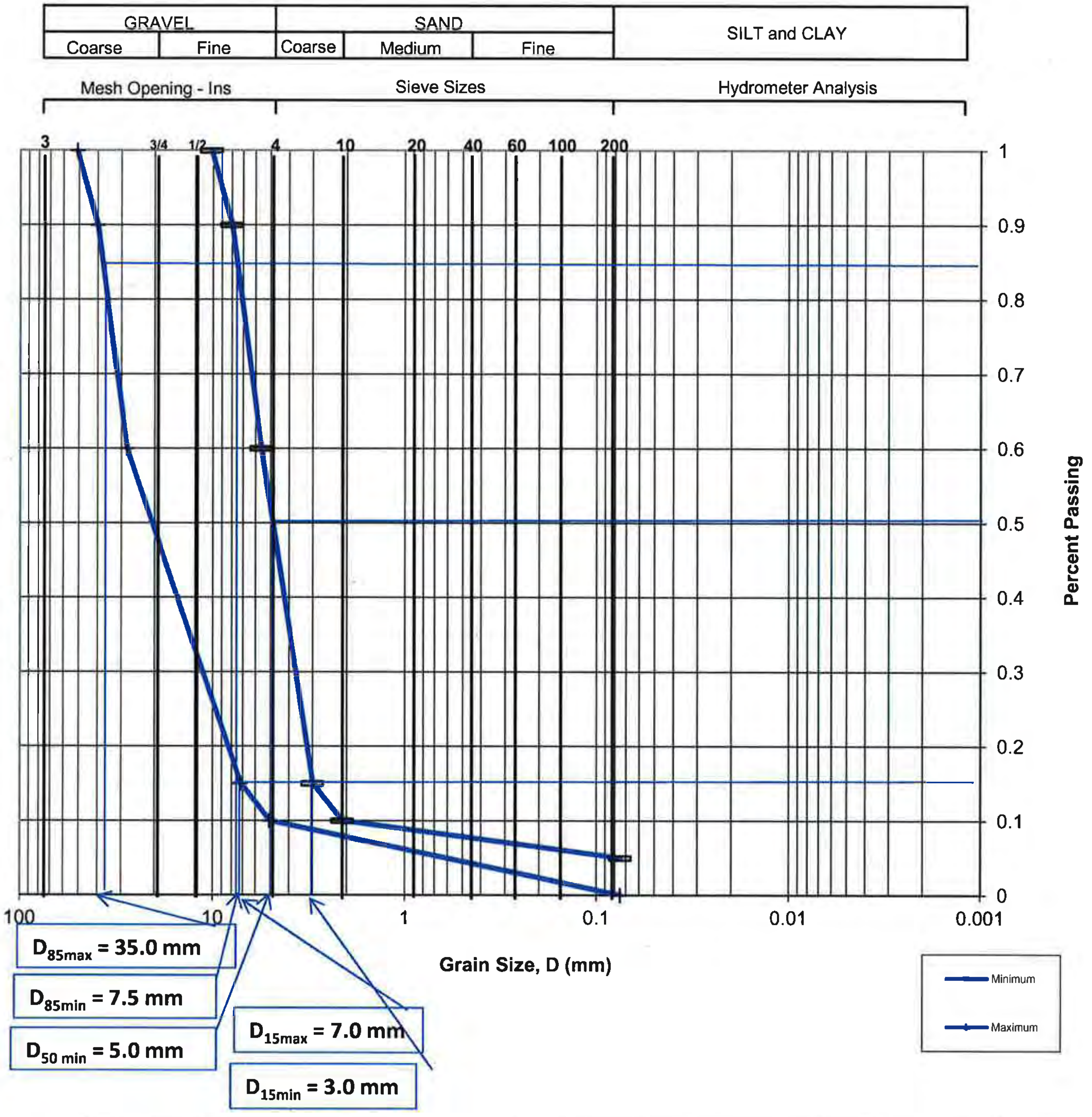

SAMPLE	CLASSIFICATION AND SYMBOL	Liquid Limit, %	Plastic Limit, %
	Custom Gradation		

BRYAN P.
KUMM
E-13166

December 6, 2017

I hereby certify that this engineering document was prepared by me or under my direct personal supervision and that I am a duly licensed Professional Engineer under the laws of the State of Nebraska.

December 6, 2017

Bryan P. Kumm **Date**

My license renewal date is December 31, 2017.

Pages covered by this seal: Pages 1 through 20, Figures 1 through 4, and Appendices A through K.