January 9,2026

Mr. Michael Smith, P.E.
Land Quality Bureau
Iowa Department of Natural Resources (IDNR)
6200 Park Avenue, Suite 200
Des Moines, IA 50321

RE: Submission of Emergency Action Plan
Metro Waste Authority – Metro Park West Landfill
Permit No. 08-SDP-03-84P

Dear Mr. Smith,

On behalf of Metro Waste Authority, HDR Engineering, Inc. (HDR) is submitting this emergency action plan (EAP) for the Metro Park West Landfill (MPW) located near Perry, Iowa. This plan provides guidance for the monitoring of the riverbank of the North Raccoon River adjacent to the closed municipal solid waste unit (Greene County Landfill) and includes recommendations on the installation and permitting requirements for potential protective measures.

The purpose of this emergency action plan is to address observed riverbank encroachment and its implications for critical infrastructure, including the toe drain and adjacent landfill slope. This submittal includes the following:

- Cover Letter
- Emergency Action Plan
- Appendixes for Emergency Action Plan

A brief summary of the EAP is illustrated as follows:

Purpose: The purpose of this EAP is to provide guidance on riverbank slope stability risk assessment and response for the Greene County municipal solid waste unit at Metro Waste Authority (MWA)'s Metro Park West (MPW), located northwest of Perry, Iowa. The channel of the Raccoon River to the south and west of MPW has migrated closer to the toe drain of the landfill. This EAP contains guidance on risk assessment from a channel migration and slope stability perspective to prevent collapse of the toe drain which could allow waste and leachate to enter the river.

Risk Assessment and Monitoring: Monitoring of the riverbank location and conditions is recommended at regular intervals with increased frequency during periods that indicate a slope stability emergency could occur. This monitoring consists of on-site observations of bank conditions and tracking of both predicted and observed rainfall and river flows from established gages.

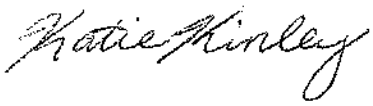
Mitigation and Preparedness Measures: Bank stabilization measures can be used to improve slope stability and slow erosion of the river bank. Riprap can be used to slow channel migration while sheet pile installation can provide adequate protection of the toe drain of the landfill. Both measures will require permitting and must be initiated when there is adequate distance from the MPW toe drain to the river bank.

EAP maintenance: The EAP will need to be updated to ensure that gages and measurement approaches are still applicable.

Please review the enclosed memorandum and supporting documentation. If you have any questions regarding this permit submittal, please do not hesitate to contact us at (402) 392-6980.

Sincerely,

HDR Engineering, Inc.



Katie Kinley, P.E.
Civil/Environmental Project Manager

Dan Bacehowski, CGP
Senior Client Manager

cc: Michael McCoy, Metro Waste Authority
Leslie Irlbeck, Metro Waste Authority
Andrew Phillips, Metro Waste Authority
Matt Morris, Metro Waste Authority

Attachments: Emergency Action Plan
Appendix A: Gage and Monitoring information
Appendix B: Permitting Matrix for stabilization methods
Appendix C: “Channel Meander Migration Analysis” HDR Report prepared for Metro Waste Authority (October 2025)
Appendix D: “Riverbank Slope Stability Analysis and Sheet Pile Design Evaluation” HDR Report prepared for Metro Waste Authority (November 2025)

Emergency Action Plan

Metro Waste Authority

Metro Park West Landfill

Perry, Iowa

January 2026

Metro Waste Authority

Table of Contents

Emergency Action Plan (EAP)

Metro Waste Authority – Metro Park West Landfill

Introduction

The purpose of this EAP is to provide guidance on riverbank slope stability risk assessment and response for the Greene County municipal solid waste unit at Metro Waste Authority (MWA)'s Metro Park West (MPW), located northwest of Perry, Iowa. The channel of the Raccoon River to the south and west of MPW has migrated closer to the toe drain of the landfill. This EAP contains guidance on risk assessment from a channel migration and slope stability perspective to prevent collapse of the toe drain which could allow waste and leachate to enter the river. Guidance is provided for monitoring precipitation and flow in the Raccoon River watershed using publicly available gages. Recommendations for measurement of riverbank migration and stabilization measures are also included. To prevent encroachment on the MPW location, mitigation measures and their corresponding permitting requirements are described.

Risk Assessment

An analysis of historical imagery and elevation data shows that the Raccoon River channel has migrated to the northeast and toward the MPW landfill, eroding the bank of the river approximately 8.7 feet per year (1930 – 2025) with increased rates of erosion associated with flooding events (Appendix C).

Migration of the Racoon River is significant enough to risk slope stability within the landfill and threatens the aforementioned toe drain. A collapse of the toe drain could lead to failure of the adjacent closed landfill waste slope located to the northeast of the riverbank, potentially allowing waste and leachate to enter the river.

Figure 1 shows the drainage area above the North Raccoon River gage and the weather and stream gages that are applicable for the MPW site. Figure 2 shows the location of MWA monitoring wells at the MPW site. Figure 3 shows historic Raccoon River channel alignments from 1930 to 2024, illustrating the migration of or the river channel toward MPW.

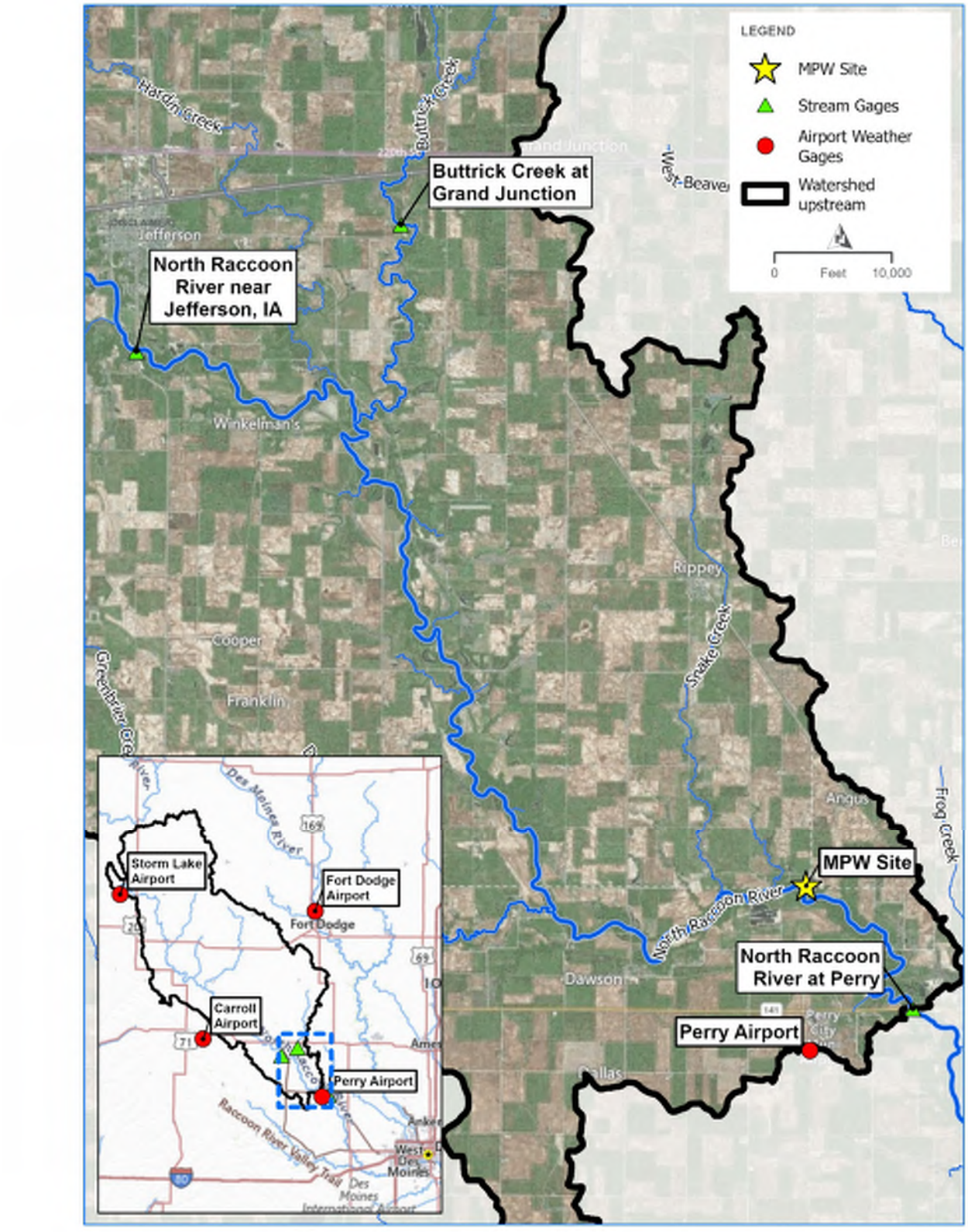


Figure 1. Site and gage locations

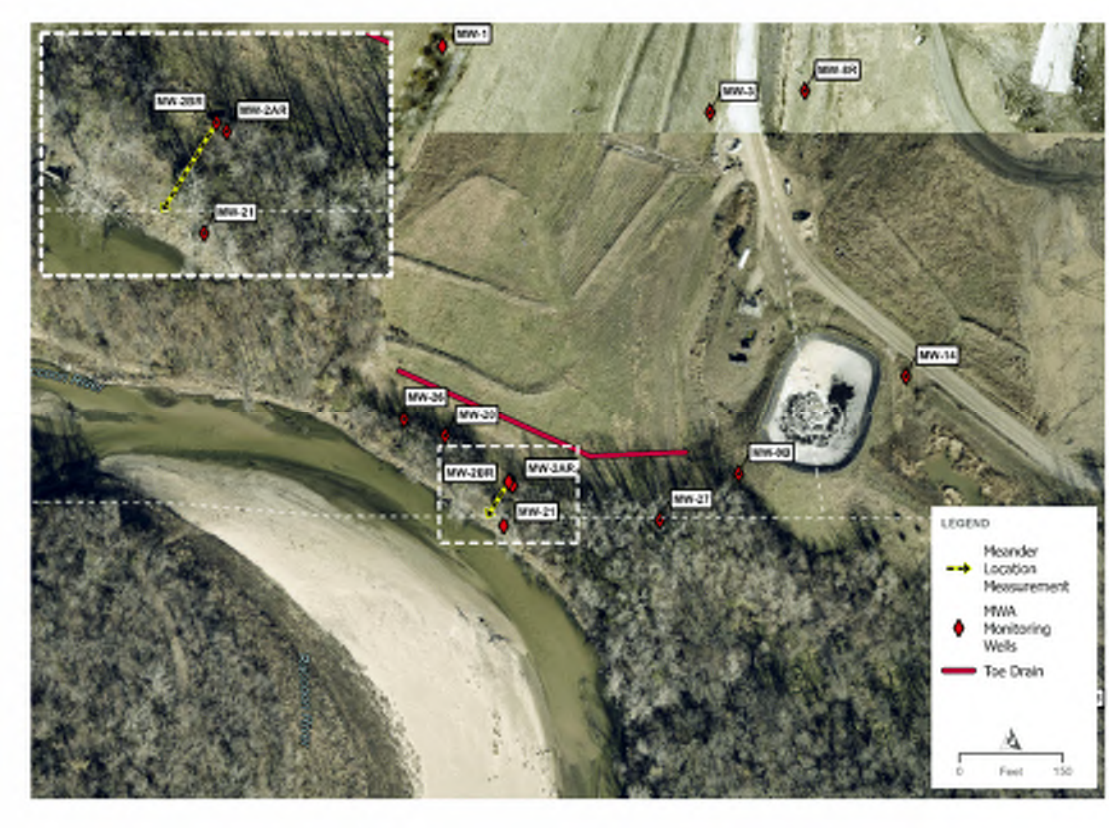


Figure 2. Location of MWA monitoring wells, MPW toe drain and suggested measurement alignment

Figure 3. Raccoon River migration from 1930-2024

Monitoring and Early Warning Systems

Erosion risk is most severe in periods where soil is saturated, and the river levels are low, leaving wet soil exposed to the air. Additional caution and monitoring should be taken in these periods.

If runoff or soil moisture conditions indicate that a flood or slope stability emergency could occur, MWA may assign staff to perform additional monitoring. Generally, personnel will be needed for monitoring based upon the forecasted degree of high water and the distance of the riverbank to the toe drain. Additional personnel may be needed if emergency repairs operations are warranted.

River Monitoring

High water levels in the Raccoon River are typically caused by severe thunderstorms that occur in the spring through fall, though they are possible throughout the year. Utilization of nearby stream gages, advanced weather radar, storm/flood warnings from the National Weather Service, can assist MPW staff in the preparation and monitoring of flood events with potential to impact the site.

U.S. Geological Survey (USGS) gages within the Raccoon River watershed should be used to monitor both predicted floods and flood peak recession near the MPW site. The Iowa Flood Information System (IFIS) provides basin wide monitoring and forecasting and is a useful tool to visualize flows and flood alert levels. Specific gages of interest include:

USACE GAGE "NORTH RACCOON RIVER NEAR PERRY IOWA"

- Immediately downstream of MPW site, corresponds closely with flows experienced at MPW.
- Water surface elevation data is collected at 15-minute intervals
- Drainage Area 2,169 square miles
- National Water Prediction Service provides forecasts at this gage during times of high water (https://water.noaa.gov/gauges/PROI4) which can be used in flood response planning.
- This gage is owned and operated by the U.S. Army Corps of Engineers

USGS "NORTH RACCOON RIVER NEAR JEFFERSON IOWA"

- Drainage area 1,619 square miles
- Gage number 05482500
- National Water Prediction Service provides forecasts at this gage during times of high water (https://water.noaa.gov/gauges/05482500)

USACE GAGE "BUTTRICK CREEK NEAR GRAND JUNCTION, IA"

- Drainage Area 214 square miles
- National Water Prediction Service provides forecasts at this gage during times of high water (https://water.noaa.gov/gauges/GJTI4)

IOWA FLOOD INFORMATION SYSTEM (IFIS)

The Iowa Flood Information System (IFIS) provides real time flood forecasting using rainfall data, soil moisture and river gage data. Personnel responsible for monitoring flood risk at MPW should utilize IFIS as a resource for basin-wide forecasting.

- (https://ifis.iowafloodcenter.org/ifis/automate.php)

Rainfall Monitoring

After rainfall or extended snow melt periods, soils can become saturated. Under saturated conditions the likelihood of bank failure increases. Monitoring rainfall accumulation and soil moisture should be used to trigger maintenance and measurement actions.

The Racoon River near the MPW site drains 2,169 square miles, making complete understanding of the spatiotemporal nature of rainfall within the watershed difficult using only a few rain gages. The Perry Iowa Airport gage (Station ID: PRO) is located near the MPW site, while the Storm Lake (Station ID: SLB), Fort Dodge (Station ID: FOD) and Carroll (Station ID: CIN) airport gages are outside the watershed but near the boundary to monitor precipitation upstream.

Perry Iowa Airport Rainfall Gage

NOAA Atlas 14 data for the Perry, Iowa airport in **Error! Reference source not found.** below. A 5-year recurrence interval rainfall is recommended to trigger daily monitoring actions. The 5-year 6-hour duration storm precipitation depth is 3.1 inches while the 5-year 24-hour storm duration precipitation depth is 3.8 inches.

It is recommended the MWA personnel with responsibility for emergency actions (i.e. the Compliance Coordinator) create an account with the interactive National Weather Service website (iNWS) and set river level alerts based on the Raccoon River near Perry Iowa gage and rainfall alerts based on the Perry Municipal Airport gage. Documentation on iNWS can be found in Appendix A.

Daily monitoring is recommended for as long as a gage remains at action level or and for 30-days after it falls below action level river stage.

(https://forecast.weather.gov/data/obhistory/KPRO.html)

Table 1. NOAA Atlas 14 data for Perry, Iowa Airport

Annual Exceedance Probability	Recurrence Interval (year)	Precipitation Depth (inches)	
		6-hour	24-hour
0.5	2	2.4	3.1
0.2	5	3.1	3.8
0.1	10	3.7	4.5
0.02	50	5.6	6.4
0.01	100	6.5	7.3
0.002	500	9.0	9.8

GAGE MONITORING ACTION

Monitor river and rainfall gages with alerts set to correspond to predicted high river stages. If any of the following conditions are met, monitoring should be increased to a daily frequency, and continue for 30-days after such event:

- **River level meets or is predicted to reach action stage at Perry, Iowa gage (14 ft)**
- **5-year or higher rainfall occurs in the area OR soil moisture is very high due to persistent rainfall or melting snow**

Local, Site Specific Monitoring

MWA currently conducts semi-annual groundwater monitoring at monitoring wells in Figure 3. Measurements of the riverbank shall be conducted in conjunction with those monitoring semi-annual monitoring events.

Regular monitoring shall be performed semiannually, with additional monitoring in high flow or high rainfall periods as described above. Results of monitoring will be recorded and reported to Iowa DNR annually with the groundwater monitoring results.

The individuals assigned to site monitoring will be responsible for traversing the site adjacent to the streambank, completing the site observation and monitoring forms (see Data Log Sheets), and identifying signs of bank erosion/ instability.

Riverbank Measurement

The Riverbank Channel Migration Memo (HDR 2025) tracks channel migration using measurements from monitoring well MW-2BR to the closest edge of the left bank near monitoring well MW-21.

In the event of a predicted flood (action level of 14 feet or higher) it is critical to monitor any additional channel migration. This should include measurement of the bank as soon as the NWS predicts the river will reach action level and for 30 days afterward. Additional erosion or

sloughing may have occurred due to high water, so additional caution is critical when taking these measurements.

Erosion and Instability
Indicators of bank erosion and instability include:

- Cracks in soil, seepage, or unusual wet areas
- Collapse of vegetation into the river or down the bank
- Slumping or sliding of bank areas
    - Early signs may be observed as cracks along the edge of the bank

Debris in River Channel
Local events such as the collapse of a tree can cause riverbank retreat. Changes in flow patterns due to debris in the channel can increase stream velocities against the bank causing increased erosion. Monitoring should include observation of changes to the channel so that debris can be removed as quickly as possible.

RIVERBANK MONITORING ACTION

If new bank collapse is observed or large debris is noticed in the Raccoon River channel that has the potential to change flow patterns, perform monitoring checklist below Monday through Friday for a 30 day period and notify MWA Compliance Coordinator.

Monitoring Responsibilities:

- **Patrol via foot or vehicle the stream bank**
- **Take photographs of all significant issues**
- **Record Stream gage readings on appropriate forms (see Data Log Sheets**)
- **Monitor and record distance from monitoring well to bank edge**
- **Look for signs of erosion and instability and document with photographs**
- **Monitor eroded/eroding areas along the streambank**
- **Notify supervisor of the status, any concerns, or maintenance needs**

Communication Protocols

In the event of an imminent bank collapse or rapid bank movement, do the following:

- Perform a head count of employees, contractors and guests
- Stay away from other nearby areas that may also be at risk
- Contact the MWA Compliance Coordinator
- Call 911 if there are any injuries or if someone may be buried under the failed slope

Emergency Response Procedures

Activation Criteria

Activation Criteria for bank stabilization measures is dependent on the distance from the bank to the MPW toe drain. Permitting timelines will affect the installation of bank stabilization measures

and should be considered part of the overall timeline. See Permit Considerations for more information.

Riprap
Riprap installation can be used to stabilize the riverbank to slow channel migration toward MPW. Permitting for the riprap installation is necessary because the required design will extend from the top of the riverbank to the toe of the riverbank (See Appendix D, section 6.2).

Sheet Pile
Sheet Pile installation requirements will depend on construction approach. The minimum distance necessary between the toe drain to the edge of the riverbank to install sheet pile will depend on the machinery and design requirements. Appendix D, section 6.2 and 7 include information on design requirements for sheet pile.

Roles and Responsibilities

The MWA Compliance Coordinator is responsible for documenting a distance that requires a bank stabilization measure. When the measurement from MW-2BR to the bank is:

40-ft from bank to MW-2BR– install sheet pile or approved equivalent.

Current measurement is 61.8-ft. At a roughly estimated migration of 10-ft per year, this may be triggered in about 2-years.

From date of trigger to sheet pile installation date, estimate 1-yr, or an additional 10-ft of migration (based on historic estimates, may vary). With this, sheet piles would be in place to the east of the tree line with about 30-ft of buffer. This is subject to change dramatically based on field conditions, therefore the 30-ft buffer is needed.

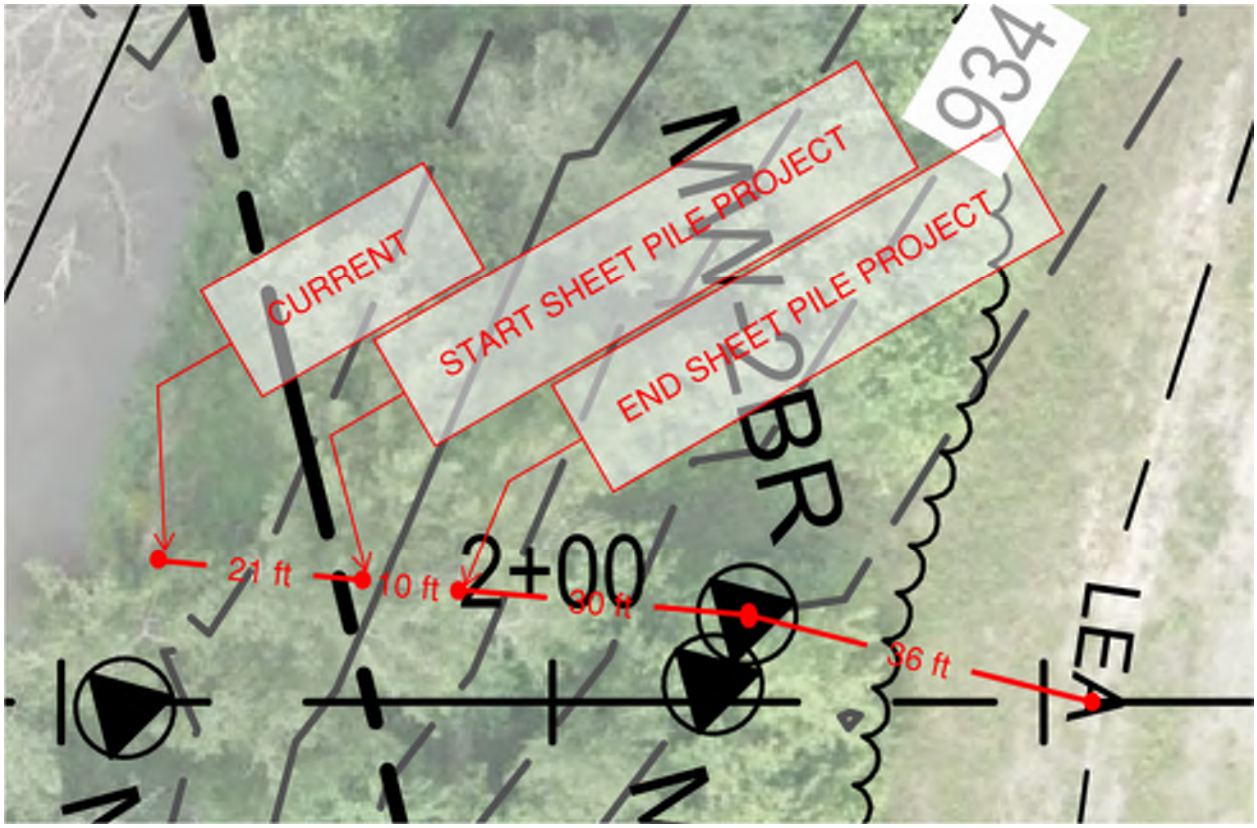


Figure 4. Sheet pile installation guidance

Sheet pile installation shall be installed between the tree line and toe drain for a minimum distance of 100-ft east of MW-2BR, and to 15-ft from the western property line.

Resource Mobilization

If channel migration reaches a point at which stabilization measures are needed, the MWA compliance coordinator will initiate sheet pile installation. This will entail an abbreviated design and bid process to install the sheet pile wall within 1-yr of triggering this action.

Mitigation and Preparedness Measures

Bank Stabilization

Sheet pile as a riverbank protection measure will meet the factor of safety criteria for slope failure while riprap can provide scour protection and additional slope stability. EPA guidance provides a recommended minimum value of Factor of Safety of 1.5 for slope stability measures in this location. Documentation of slope stability models using sheet pile and riprap can be found in Appendix D. Other stability approaches such as bendway weirs may also be considered to change behavior of flow in the river.

Sheet Pile Stabilization
Piles are a common stabilization method as they can withstand considerable shear forces. Slope stabilization using pile reinforcement can be used to reinforce the riverbank to increase the factor of safety under applied pore water pressure.

A slope stability engineering study (Appendix D) shows that a single layer sheet pile installed approximately 50 feet from the toe drain will provide adequate protection. The sheet pile specifications needed to satisfy the factor of safety criteria for both circular wedge and sliding block failure mechanisms are 30,000 lbf per unit length with installation at grade.

Rock Installation for bank protection and channel preservation

RIPRAP
Riprap installation can improve slope stability but does not reach an adequate factor of safety to prevent slope failure. Riprap should be considered in combination with other mitigation methods. Riprap sizing guidelines and requirements are listed below:

- Iowa Department of Transportation (IDOT) guidance specifies Class E riprap for this site (Appendix D)
- Placement of riprap will require regulatory approvals, including coordination with the U.S. Army Corps of Engineers (USACE).

Permit Considerations
The permitting matrix in Appendix B can be used to select the appropriate mitigation measure given the extent of channel migration, encroachment on the MPW and the predicted time to implement the measures.

Post Event Recovery and Rehabilitation

Damage Assessment

Damage Survey
Following a high flow event, or after an observation or measurement of channel migration toward the MW-2BR monitoring well, it is critical to document the distance from the well to the edge of the bank.

- MPW personnel should use monitoring stakes previously installed from the monitoring well to measure the distance from the well to the bank
- Drone imagery should be flown to assess the loss of bank or collapse of any structurally significant vegetation
- Inspection of the river channel should include documentation of any new debris in the river as well as changes to the path of the river

Damage Reporting
Damages will be reported to the chief executive officer.

Restoration

Repairs
Repairs will be determined by the degree of encroachment and the distance from the MPW toe drain and the riverbank. Refer to Mitigation and Preparedness Measures for repair criteria.

Financial Aid and Funding

Applications for funding of bank stabilization or other measures may affect project timelines. Funding of stabilization measures are outside the scope of this EAP but will need to be considered when anticipating timing of any design or construction measures.

EAP Maintenance and Review

Annual Review

River and Rain Gages:
Ensure that gages are still active and that website links are accurate.

On-Site Monitoring Plan:
Check that monitoring well (MW-2BR) is still the most appropriate starting point for migration measurement. If this is no longer appropriate, update the EAP with alternate wells or landmarks from which to measure. If the closest path to the riverbank has changed from the current alignment new measurement stakes or flags should be installed for future repeatable measurement.

Monitoring of Stabilization Measures
If bank stabilization measures are installed, MWA should perform semi-annual inspection of the bank near the installation. Report any changes to the bank or that indicate further erosion or movement to the MWA compliance officer.

Updates & Lessons Learned

After a slope failure event, notable movement in meander location, or any other slope related events at the MPW this EAP should be reviewed. If there are questions or issues that arise that this EAP does not address those sections should be noted and added. The MPW ERRAP should also be consulted as guidelines for emergency response.

Training

This EAP is structured as a reference and guide for monitoring and response of the Raccoon River riverbank. Employees of the MWA or MWP who have responsibilities related to monitoring and emergency response at the MWP should all be familiar with the contents of this EAP. The existence and contents of this document should be part of both onboarding and ongoing training for MPW staff.

Appendices

Appendix A: Gage and Monitoring information

Appendix B: Permitting Matrix for stabilization methods

Appendix C: “Channel Meander Migration Analysis” HDR Report prepared for Metro Waste Authority (October 2025)

Appendix D: “Riverbank Slope Stability Analysis and Sheet Pile Design Evaluation” HDR Report prepared for Metro Waste Authority (November 2025)

Data Log Sheets

Riverbank distance and condition form

Date	Time	Distance from groundwater well 2BR to bank (ft)	Description of bank

Stream gage and Precipitation Report Form

Date	Time	Gage Name (river or airport)	River Gage Reading (ft)	Precipitation Reading (in)

Groundwater Monitoring Well Report From

Date	Time	Well Location	Well Reading	Comments

Appendix A

Gage and Monitoring Information

Metro Waste Authority

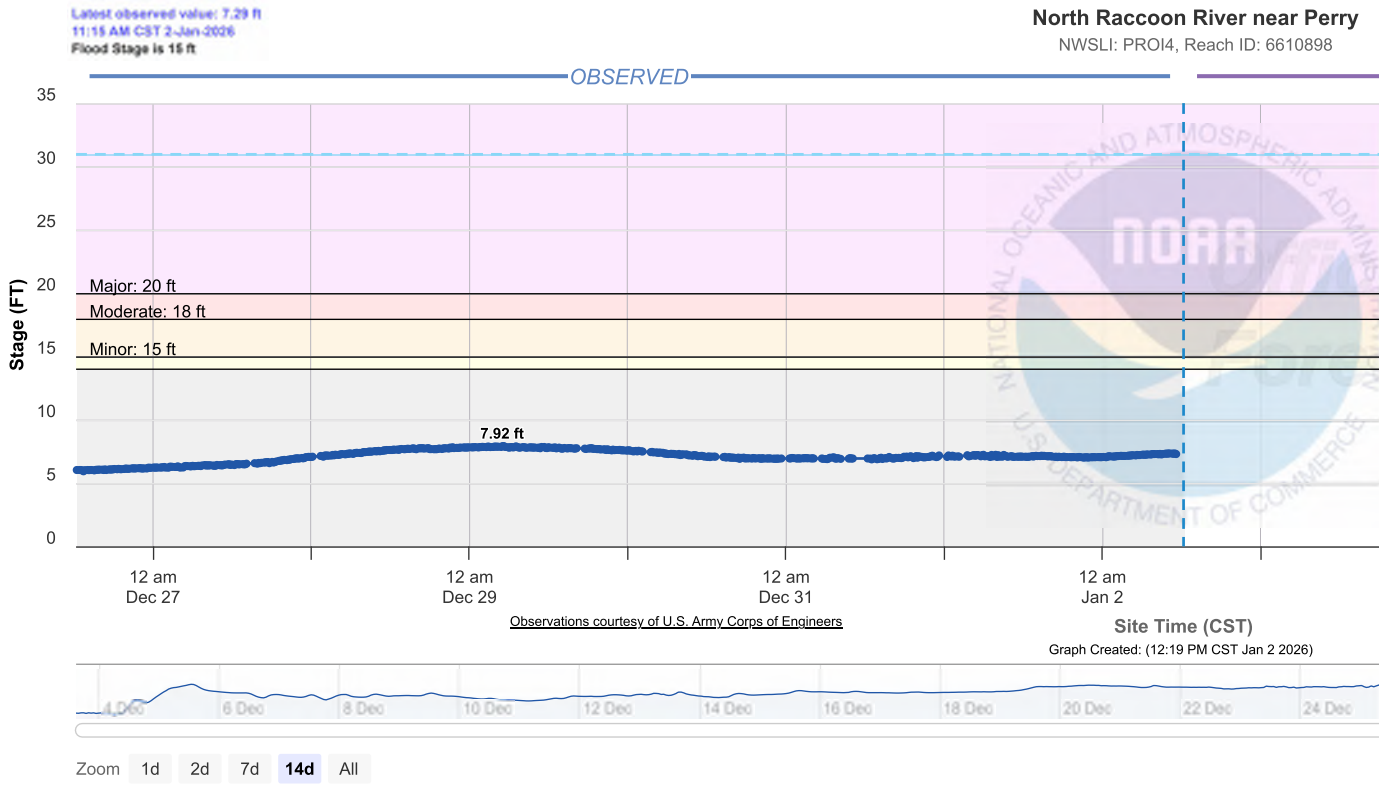
North Raccoon River near Perry

Last updated: Jan 2, 2026, 12:19 PM CST

No watches, warnings or advisories are in effect for this area.

Official Forecast | National Water Model Guidance

← UPSTREAM GAUGE (DAWI4) | DOWNSTREAM GAUGE (MBNI4) →



Scale to Flood Categories

Auto Refresh

Traces and Thresholds Click to turn on/off display

Observed (OBS) 01/02/2026 11:15 AM CST

Record: 31 ft

CATEGORY	STAGE
Major Flooding	**20 ft**
Extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations.	
Moderate Flooding	**18 ft**
Some inundation of structures and roads near stream.	
Minor Flooding	**15 ft**
Minimal or no property damage, but possibly some public threat.	
Action	**14 ft**
The level which, when reached by a rising stream, represents the level where the NWS or a customer/partner needs to take some type of mitigation action in preparation for possible significant hydrologic activity.	

Reliability of the Forecast:

NOTE: Forecasts are issued as needed during times of high water, but are not routinely available.

Flood Impacts

21.6 - Water affects a two-block area of Grove St in Adel east of US 169. Water is 2 to 3 feet deep over the south entrance to the Dallas county fairgrounds off of US 169. Water affects businesses north of Adel on west side of US 169 as well as the entrance to Island Park campground and soccer complex in Adel.

20 - Limited evacuations may begin in residential areas of Adel...along with extensive sandbagging.

19 - Approaches to the US 169 bridge over the river north of Adel are impassable.

18 - Water affects many rural roads.

17.1 - Water begins impacting US 169 just north of Adel near the fairgrounds.

17 - Water approaches the bottom of the US 169 bridge on the north side of Adel and affects agricultural land northeast of Adel.

16.5 - Water affects 125th Trl north of Dawson and west of Hwy P46. Water may also affect portions of US 169 north of Adel near the fairgrounds.

16 - Water affects 180th Lane west of Minburn.

15 - Water affects the wastewater treatment facility as well as agricultural land in the Perry area. Near Adel...water affects the fairgrounds and golf course. Northwest of Adel...water affects Sportsman Club Rd and Midland Trl.

13 - Water affects agricultural land.

Gauge Info

Coordinates	41.8354, -94.1320
RFC	NCRFC (/rfc/NCRFC)
State	IA (/state/IA)
WFO	DMX (/wfo/dmx)
County	Dallas
Data Provider(s)	
USACE	U.S. Army Corps of Engineers

Gauge Location

☐ Display PROI4 marker
☐ Display FEMA's National Flood Hazard Layers

Recent Crests

1. 12.58 ft on 12-28-2022 **(P)**
2. 31.04 ft on 01-29-2022
3. 29.52 ft on 02-11-2021 **(P)**
4. 12.99 ft on 03-22-2020 **(P)**
5. 18.09 ft on 03-20-2019 **(P)**
6. 30.05 ft on 01-18-2018 **(P)**
7. 15.48 ft on 05-24-2017 **(P)**
8. 20.78 ft on 12-17-2015
9. 19.40 ft on 06-26-2015
10. 15.28 ft on 07-03-2014 **(P)**

SHOW ALL

Historic Crests

1. 31.04 ft on 01-29-2022
2. 30.05 ft on 01-18-2018 **(P)**
3. 29.52 ft on 02-11-2021 **(P)**
4. 23.00 ft on 07-10-1993
5. 22.70 ft on 03-20-1979
6. 21.67 ft on 06-10-2008
7. 20.82 ft on 08-13-2010 **(P)**
8. 20.78 ft on 12-17-2015
9. 20.29 ft on 04-27-2007
10. 20.00 ft on 06-19-1990

SHOW ALL

Low Water Records

1. 2.37 ft on 03-14-1998
2. 2.38 ft on 09-09-2023
3. 2.45 ft on 09-03-2017
4. 2.45 ft on 10-01-2017
5. 2.54 ft on 02-19-2022
6. 2.56 ft on 12-14-2020
7. 2.69 ft on 09-29-2020
8. 2.71 ft on 02-11-2012
9. 2.95 ft on 04-10-2014
10. 2.96 ft on 02-05-2000

SHOW ALL

Vertical Datum Table

TYPE	NGVD29
Major Flooding	929.41 ft
Moderate Flooding	927.41 ft
Minor Flooding	924.41 ft
Action	923.41 ft
Latest Value	916.70 ft
Gauge Zero	909.41 ft

Gauge Photos

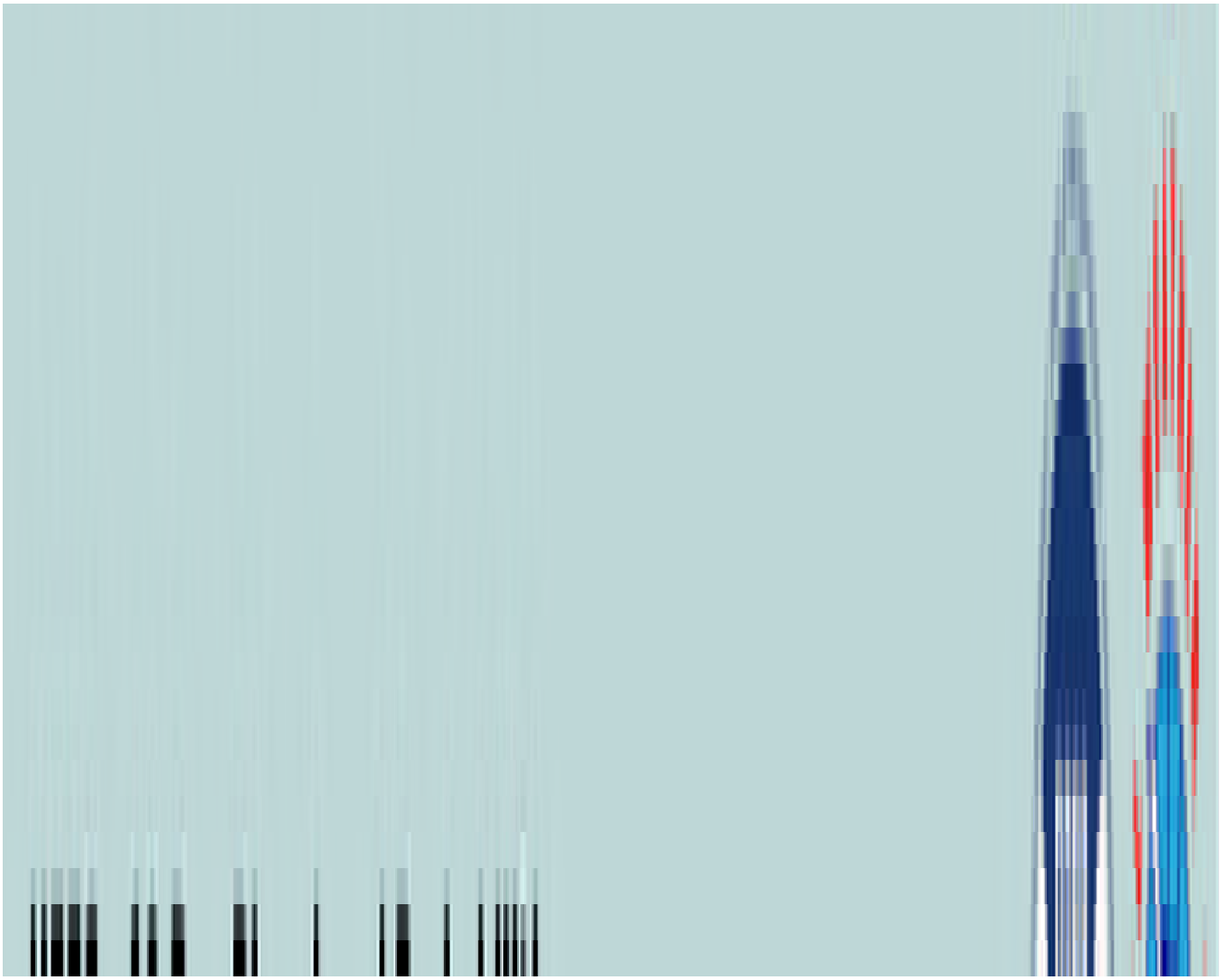
No Images Found

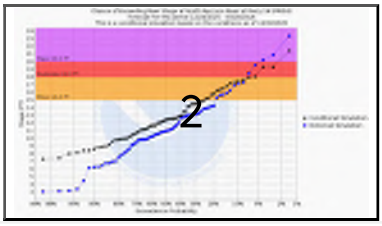
Probability Information

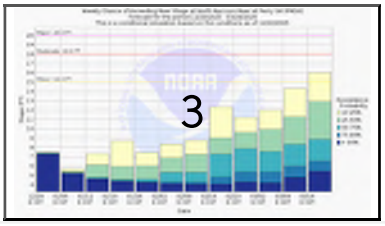
Photo 1 of 3

Short Range Forecast Uncertainty

About this graph (/about/chance-of-exceeding-river-stage) | Product Description Document (/about/short-term-probabilistic-guidance-product)







Unique Local Info

- How low could the river get? (http://water.weather.gov/resources/rsync/exceedance/PROI4.nonexc.90day.gif)

Collaborative Agencies

The National Weather Service prepares its forecasts and other services in collaboration with agencies like the US Geological Survey, US Bureau of Reclamation, US Army Corps of Engineers, Natural Resource Conservation Service, National Park Service, ALERT Users Group, Bureau of Indian Affairs, and many state and local emergency managers across the country. For details, please click here (/about/meet-our-partners).

Resources

Hydrologic Resource Links

- River Forecast Centers (/about/rfc)
- NWS Des Moines Hydro Decision Support Page (https://www.weather.gov/dmx/dsshydro)
- NWS Inundation Mapping Locations (/about/fim-locations)

Additional Resource Links

- NWS Precipitation and River Forecasting (https://www.noaa.gov/jetstream/rfcs)
- U.S. Geological Survey (map of sites) (https://waterwatch.usgs.gov/new/index.php?r=ia&id=ww_current)

- NWS Flood Inundation Mapping Information (https://www.weather.gov/news/232609-experimental-flood-inundation-maps)
- Area Hydrographs (/area/DMX)
- Hourly River Stages (https://forecast.weather.gov/product.php?site=DMX&issuedby=DMX&product=RVA&version=1&glossary=1)
- NWPS Resources & Frequently Asked Questions (FAQs) (https://www.weather.gov/media/dmx/Hydro/DMX_NWPS_WebPageResourcesFAQs.pdf)
- U.S. Geological Survey (table of sites) (https://waterdata.usgs.gov/ia/nwis/current/?type=flow&group_key=basin_cd)
- U.S. Army Corps of Engineers
- Iowa Flood Center (stream sensors)
- Snow Information (https://www.nohrsc.noaa.gov/)

WFO Information

Weather Forecast Office
Des Moines
9607 NW Beaver Dr.
Des Moines, IA 50131
(515) 270-2614 (tel:(515) 270-2614)
Ask Questions/Webmaster (mailto:w-dmx.webmaster@noaa.gov,cr.dmx-hydro@noaa.gov?)
Official Homepage (https://www.weather.gov/DMX)

IFIS

North Raccoon River at Perry

Stream Sensor (USGS)

Gauge Height: 7 ft 4 in

Last Reported: Jan 2, 2026 1:15 pm [Get SMS]

NO FLOOD ALERT

MORE INFO

STATE OF IOWA

Population 3,190,369

Land Area 55,672 sq mi

Flood Alerts (observations)

USGS USGS STREAM GAUGE

City: Perry

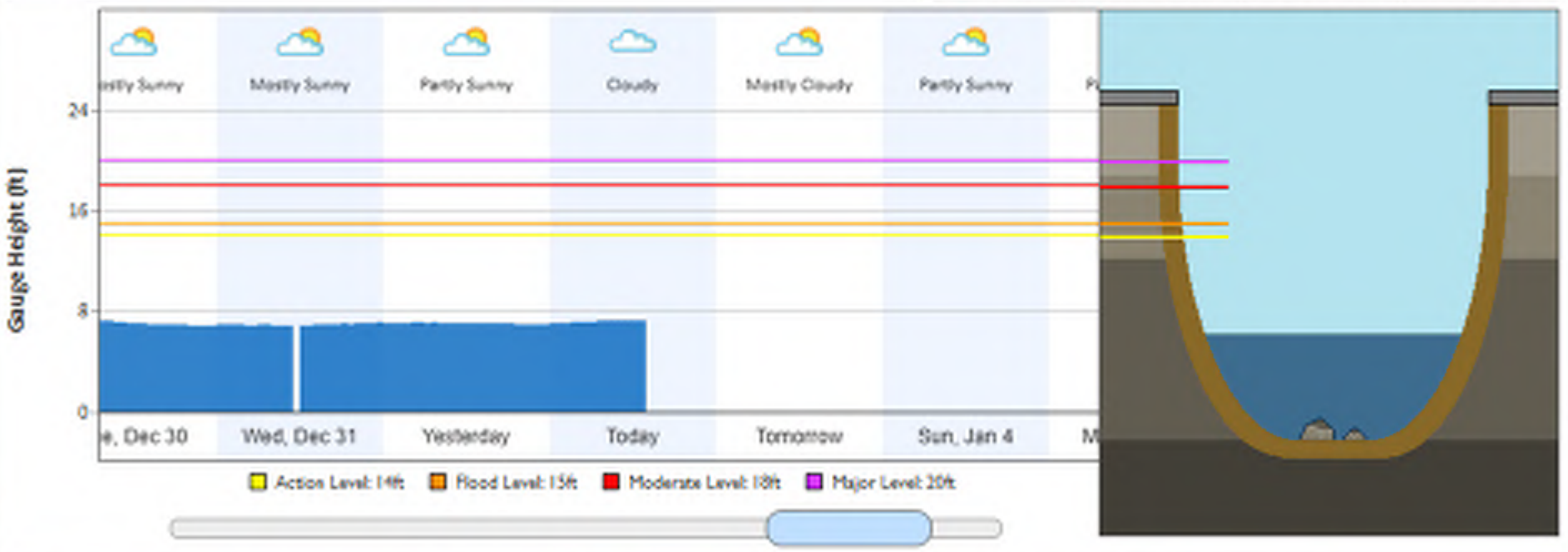
River: North Raccoon River

Station ID: PROI4 (NWS)

Forecast: NWS Forecast (PROI4)

Last Reported: Fri, January 2, 2026 1:15 pm

Last Reading: 7 ft 4 in Switch Data View: [stage - elevation]



LEGEND

Snow Drizzle Light Moderate Heavy Downpour

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NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: IA

Data description

Data type: Precipitation depth | Units: English | Time series type: Partial duration

Select location

1) Manually:

a) By location (decimal degrees, use "-" for S and W): Latitude: Longitude: Submit

b) By station (list of IA stations): PERRY (13-6566)

c) By address: Search

2) Use map:

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 8, Version 2

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.388 (0.310-0.500)	0.455 (0.363-0.586)	0.570 (0.453-0.736)	0.672 (0.532-0.869)	0.821 (0.637-1.08)	0.944 (0.715-1.25)	1.07 (0.790-1.43)	1.21 (0.861-1.63)	1.40 (0.965-1.90)	1.55 (1.04-2.11)
10-min	0.568 (0.453-0.732)	0.666 (0.531-0.859)	0.835 (0.664-1.08)	0.984 (0.779-1.27)	1.20 (0.932-1.58)	1.38 (1.05-1.83)	1.57 (1.16-2.10)	1.77 (1.26-2.38)	2.05 (1.41-2.78)	2.27 (1.53-3.09)
15-min	0.693 (0.553-0.893)	0.812 (0.647-1.05)	1.02 (0.810-1.31)	1.20 (0.950-1.55)	1.47 (1.14-1.94)	1.68 (1.28-2.23)	1.91 (1.41-2.56)	2.16 (1.54-2.91)	2.50 (1.72-3.40)	2.77 (1.85-3.77)
30-min	0.988 (0.787-1.27)	1.16 (0.926-1.50)	1.46 (1.16-1.88)	1.72 (1.36-2.23)	2.11 (1.64-2.79)	2.42 (1.84-3.21)	2.75 (2.03-3.68)	3.10 (2.21-4.18)	3.59 (2.48-4.88)	3.98 (2.68-5.42)
60-min	1.27 (1.02-1.64)	1.51 (1.20-1.94)	1.92 (1.53-2.48)	2.29 (1.81-2.96)	2.85 (2.21-3.78)	3.31 (2.51-4.39)	3.80 (2.80-5.09)	4.33 (3.09-5.84)	5.07 (3.60-7.02)	5.67 (3.91-7.72)
2-hr	1.56 (1.26-1.99)	1.85 (1.50-2.38)	2.38 (1.92-3.03)	2.88 (2.29-3.64)	3.68 (2.82-4.70)	4.19 (3.23-5.50)	4.84 (3.62-6.42)	5.55 (4.00-7.42)	6.55 (4.67-8.88)	7.36 (5.09-9.93)
3-hr	1.72 (1.40-2.17)	2.05 (1.67-2.58)	2.65 (2.15-3.34)	3.20 (2.59-4.04)	4.05 (3.22-5.20)	4.75 (3.70-6.22)	5.56 (4.17-7.30)	6.39 (4.64-8.50)	7.60 (5.34-10.2)	8.58 (5.87-11.5)
6-hr	2.02 (1.67-2.50)	2.39 (1.97-2.98)	3.07 (2.52-3.81)	3.71 (3.03-4.61)	4.73 (3.79-6.00)	5.55 (4.36-7.15)	6.47 (4.94-8.44)	7.49 (5.51-9.87)	8.96 (6.38-11.9)	10.2 (7.01-13.5)
12-hr	2.31 (1.93-2.81)	2.72 (2.27-3.32)	3.46 (2.88-4.22)	4.14 (3.42-5.07)	5.16 (4.19-6.52)	6.01 (4.77-7.62)	6.93 (5.33-8.80)	7.92 (5.88-10.3)	9.33 (6.69-12.3)	10.5 (7.30-13.8)
24-hr	2.69 (2.27-3.23)	3.08 (2.60-3.70)	3.79 (3.19-4.56)	4.46 (3.74-5.37)	5.48 (4.52-6.84)	6.35 (5.10-7.94)	7.29 (5.69-9.24)	8.33 (6.26-10.7)	9.81 (7.11-12.8)	11.0 (7.78-14.4)
2-day	3.07 (2.63-3.62)	3.50 (3.00-4.13)	4.27 (3.65-5.05)	4.98 (4.23-5.90)	6.05 (5.03-7.41)	6.94 (5.64-8.54)	7.90 (6.23-9.86)	8.94 (6.79-11.3)	10.4 (7.63-13.4)	11.6 (8.27-15.0)
3-day	3.33 (2.87-3.89)	3.81 (3.29-4.48)	4.66 (4.00-5.48)	5.42 (4.64-6.38)	6.55 (5.48-7.93)	7.49 (6.12-9.12)	8.48 (6.72-10.6)	9.56 (7.29-12.5)	11.1 (8.15-14.1)	12.3 (8.69-16.7)
4-day	3.56 (3.09-4.14)	4.08 (3.54-4.74)	4.98 (4.31-5.80)	5.79 (4.99-6.75)	6.98 (5.86-8.39)	7.96 (6.53-9.62)	8.99 (7.16-11.0)	10.1 (7.74-12.6)	11.6 (8.61-14.8)	12.9 (9.27-16.4)
7-day	4.22 (3.70-4.83)	4.80 (4.21-5.50)	5.81 (5.08-6.67)	6.70 (5.83-7.72)	8.01 (6.80-9.60)	9.08 (7.53-10.8)	10.2 (8.20-12.4)	11.4 (8.81-14.1)	13.1 (9.74-16.4)	14.4 (10.4-18.2)
10-day	4.83 (4.27-5.48)	5.46 (4.82-6.21)	6.56 (5.78-7.47)	7.52 (6.59-8.58)	8.92 (7.61-10.5)	10.1 (8.39-11.9)	11.2 (9.09-13.5)	12.5 (9.72-15.3)	14.2 (10.7-17.8)	15.6 (11.4-19.7)
20-day	6.60 (5.91-7.36)	7.41 (6.64-8.28)	8.77 (7.83-9.82)	9.93 (8.82-11.1)	11.6 (9.97-13.3)	12.9 (10.8-14.9)	14.2 (11.6-16.8)	15.6 (12.2-18.8)	17.4 (13.2-21.5)	18.9 (13.9-23.5)
30-day	8.00 (7.30-8.92)	9.06 (8.18-10.2)	10.7 (9.60-11.9)	12.0 (10.7-13.3)	13.9 (12.0-15.7)	15.3 (13.0-17.5)	16.7 (13.7-19.5)	18.1 (14.3-21.7)	20.0 (15.2-24.5)	21.5 (15.9-26.5)
45-day	9.95 (9.07-10.9)	11.2 (10.2-12.2)	13.1 (11.9-14.4)	14.7 (13.3-16.2)	16.8 (14.8-18.9)	18.4 (15.7-20.9)	19.9 (16.6-23.1)	21.5 (17.0-25.4)	23.4 (17.9-28.4)	24.9 (18.6-30.8)
60-day	11.5 (10.6-12.5)	13.0 (11.9-14.1)	15.2 (13.9-16.5)	17.0 (15.5-18.5)	19.4 (17.0-21.5)	21.1 (18.1-23.8)	22.8 (18.9-26.2)	24.6 (19.4-28.6)	26.4 (20.2-31.7)	27.8 (20.9-34.1)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in CSV format: Precipitation frequency estimates | Submit

Note: Temporary disruptions may occur Wednesdays from 4-7 pm ET during routine maintenance.

iNWS - FAQ

General

Supported Web Browsers

Chrome
Firefox 3.6+
Internet Explorer 8+
Opera 15+
Safari 6+

Using iNWS on a mobile device

iNWS was designed to be used in a desktop web browser.
One of our top priorities is to create a mobile-friendly version of iNWS in the future.

Alerts

How do I receive text message (SMS) alerts on my phone?

You can enable text message alerts on the Account Settings page.

Which cell phone carriers does iNWS support?

We currenly support the following carriers: AT&T/Cingular, Sprint/Nextel/Boost, T-Mobile, Verizon, Alltel, U.S. Cellular, Cellular One/Dobson, Virgin Mobile US, Cincinnati Bell, Midrivers, and Nemont/Sagebrush.

How long should it take to receive an iNWS alert once the NWS issues a product?

We send our alerts only a few moments afte the NWS product is issued by the Weather Forecast Office. However, the time it takes for you to receive the alert depends on your cell phone carrier or email provider.

When creating an iNWS alert area, what types of NWS products fall into each product category?

Severe
- Severe Thunderstorm Watches, Warnings, and Statements
- Tornado Watches and Warnings

Winter Weather
- Avalanche Watches, Warnings, and Special Bulletins
- Snow Squall Warnings
- Blizzard Watches and Warnings
- Lake Effect Snow Watches, Warnings, and Advisories
- Wind Chill Watches, Warnings, and Advisories
- Winter Storm Watches and Warnings
- Winter Weather Advisories
- Freezing Rain Advisories
- Ice Storm Warnings

Hydrology
- Flood Statements and Warnings
- Flash Flood Watches, Statements, and Warnings

Marine Weather
- Open Lake Forecasts (GLF)
- Special Marine Warnings and Marine Weather Statements
- Small Craft Advisories
- Gale Watches and Warnings
- Storm Watches and Warnings
- Hurricane Force Wind Watches and Warnings
- Heavy Freezing Spray Watches and Warnings
- Hazardous Seas Watches and Warnings
- Ashfall Warnings
- Nearshore Marine Forecasts (NSH)
- Offshore Water Forecasts (OFF)

Coastal Hazards
- Coastal Flood Watches, Warnings, Advisories, and Statements
- Lakeshore Flood Watches, Warnings, and Advisories
- High Surf Advisories and Warnings
- Rip Current Statements
- Beach Hazard Statements
- Public Tsunami Messages (TSU)
- LSH Products
- TIB Products

Tropical
- Hurricane/Typhoon Local Statements (HLS)
- Tropical Cyclone Forecasts and Advisories (TCM)
- Tropical Cyclone Public Advisories (TCP)
- Hurricane Watches and Warnings
- Tropical Storm Watches and Warnings
- Typhoon Watches and Warnings

Aviation
- Airport Weather Warnings

Non-Precipitation

- Excessive Heat Watches and Warnings
- Freeze Watches and Warnings
- High Wind Watches and Warnings
- Extreme Cold Watches and Warnings
- Dust Storm Warnings
- Hard Freeze Warnings
- Air Stagnation Advisories
- Ashfall Advisories
- Blowing Dust Advisories
- Dense Fog Advisories
- Dense Smoke Advisories
- Freezing Fog Advisories
- Frost Advisories
- Heat Advisories
- Lake Wind Advisories

Civil Emergencies
- Child Abduction Emergencies
- Civil Danger Warnings
- Civil Emergency Messages
- Earthquake Warnings
- Evacuation Immediate
- Fire Warnings

Appendix B

Permitting Matrix for stabilization methods

Metro Waste Authority

Permit / Approval	Agency	Applicability	Agency Review	Notes
Clean Water Act Section 404: Nationwide Permit No. 13 "Bank Stabilization" OR Regional Permit No. 40 "Bank Stabilization in Iowa"	USACE Rock Island Regulatory	TBD Dependent Upon Selected Alternative	30-90 days	404 authorization would be required of the riprap alternative, but is likely not required of the sheet pile alternative. Both the Nationwide and Regional permits authorize riprap bank stabilization, but the Regional Permit includes higher impact allowances than the Nationwide Permit: 2,000 linear feet vs 500 linear feet of impacted channel bank, and 2.0 CY vs 1.0 CY of riprap volume per running foot of bank below the OHWM. The Iowa DNR has provided Section 401 Water Quality Certification for both the Nationwide and Regional permits. Individual WQC is not required. If required, CWA Section 404 authorization is a federal nexus that necessitates USACE-demonstrated compliance with the National Historic Preservation Act and the Endangered Species Act, as noted in the following.
Endangered Species Act Section 7	USFWS	TBD Dependent Upon Selected Alternative and Federal Nexus	30-120 days	A USFWS Information for Planning and Consultation (IPaC) resource list was generated for the project area. The following ESA-listed species may occur in the project area: Indiana bat (endangered), Tricolored bat (proposed endangered), Topeka shiner (endangered), and Monarch butterfly (proposed threatened). Notably, the project reach of the Racoon River is designated critical habitat for Topeka shiner. As associated, the riprap alternative (only) would likely require some level of consultation with USFWS. Less notably, tree removal activities could impact listed bat species and may be subject to seasonal timing restrictions.
National Historic Preservation Act Section 106	Iowa SHPO	TBD Dependent Upon Selected Alternative and Federal Nexus	1-30 days	ISites public viewer shows no historic standing structures in proximity to the project and no archaeological resources in the section in which the project is located. No effects to historic properties are anticipated.
National Environmental Policy Act (NEPA)	TBD Dependent Upon Federal Funding			This entry is specific to possible federal funding sources, which would prompt NEPA compliance by the funding agency, and possible information provisions from MWA. This entry goes beyond the NEPA approval that is inherent to CWA Section 404 permit authorization, as listed above.
Floodplain Development	Iowa DNR	Yes	30-120 days	Zone A. Panel 19073C0500C Iowa DNR PERMT system indicates coordination is required.
NPDES General Permit No. 2: Construction Stormwater	Iowa DNR	Likely	1-10 days	Assumes greater than 1 acre of ground disturbance. Requires a public notice and Stormwater Pollution Prevention Plan development.

Sovereign Lands	Iowa DNR	No	N/A	Iowa DNR PERMT system indicates Sovereign Lands permitting is not required.
Floodplain Development	Greene County	TBD	TBD	Zone A. Panel 19073C0500C Greene County website does not specify whether or not the county requires floodplain permitting beyond that of Iowa DNR. Specific coordination is required.
Other Local Permits	Greene County	TBD	TBD	Greene County website does not specify whether or not the county requires any permitting for the proposed activities. Specific coordination is required.

Appendix C

Metro Waste Authority

Channel Meander Migration Analysis

Metro Waste Authority

Metro Park West Landfill

Perry, Iowa

October 2025

Metro Waste Authority

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Table of Contents

Figures

Attachments

References

1. United States Department of Transportation, Federal Highway Administration. (2023). *Highways in the river environment: Roads, rivers, and floodplains (Hydraulic Engineering*

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1 Purpose

The purpose of this report is to present the results of the channel meander analysis for the riverbank that is actively retreating toward the closed Greene County municipal solid waste unit (MSW) at Metro Waste Authority's Metro Park West, located northwest of Perry, Iowa. The objective of this task is to estimate the rate of approximate meander migration to characterize the risk to the existing landfill infrastructure. This memo details the process used to evaluate the rate of meander migration using available aerial imagery, LiDAR, and data collected during the site visit.

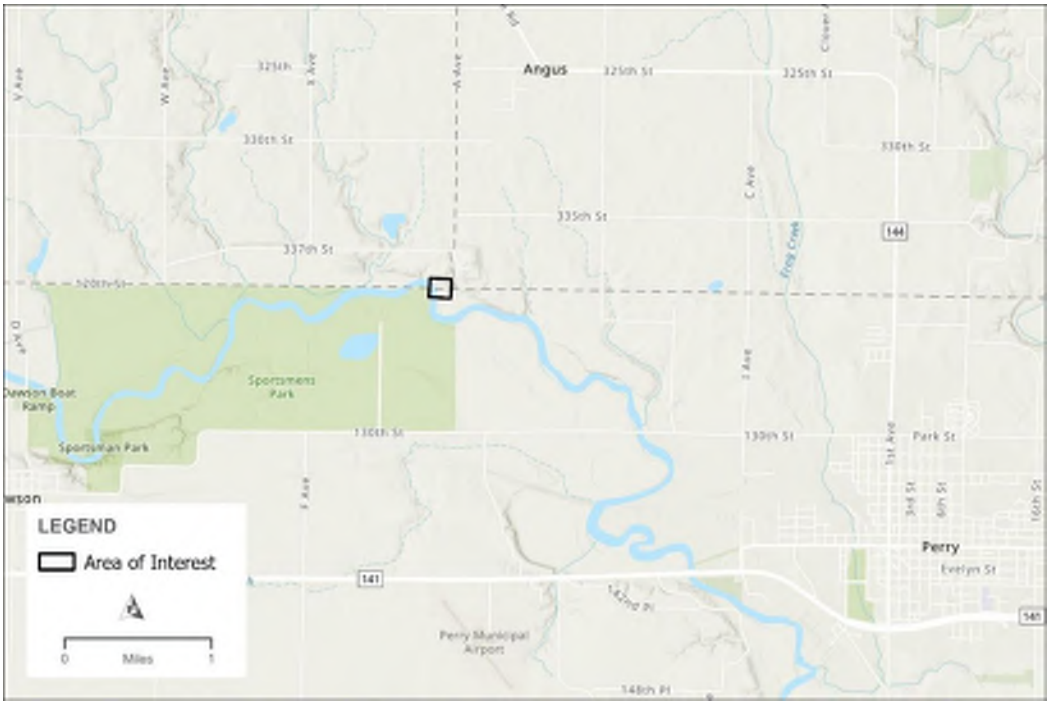

Figure 1: Vicinity map showing study area

The site lays on the intersection of three counties, Greene, Dallas, and Boone. United States Geological Survey (USGS) gages are located along this stretch of river, one on the upstream side near Jefferson and one on the downstream near Van Meter below the confluence of the South Raccoon and North Raccoon Rivers. The dominant land use for the region draining to the area of interest is row crops of soybean and corn. Channel migration was assessed using methods found in Federal Highway Administration's (FHWA) manuals, HEC-16 (**Reference 1**) and HEC-20 (**Reference 2**), and in the National Cooperative Highway Research Program (NCGRP) report 533 (**Reference 3**).

2 Data Collection and Review

2.1 Topographic and Bathymetric Data

Light detection and ranging (LiDAR) derived topographic data were downloaded from USGS (**Reference 4**) to gain an understanding of current and historic elevations. For the current observation, LiDAR flown in 2020 was used (**Reference 5**). The LiDAR has 1-meter raster cell sizes. For the historic observation LiDAR, flown between 1999 and 2013 was used (**Reference 6**). This dataset does not have an exact year for when it was flown above the study area but based on aerial imagery it was prior to 2010. This LiDAR has approximately 30-meter by 30-meter (98.4252-foot by 98.4252-foot) raster cell sizes. Both datasets have a horizontal datum of North American of Datum of 1983 (NAD 83) and a vertical datum of North American Vertical Datum of 1988 (NAVD 88). A bathymetric surface was not used in this analysis because it is not publicly available for this area.

2.2 Aerial and Historic Imagery

Historic aerial imagery was pulled down from the Iowa Geographic Map Server (**Reference 7**) for the years 1930, 1960, 1990, 2010, 2019, 2023, and 2024. The data pre-2000 does not contain the years the imagery was collected. It was assumed that the starting year of those decades be used for the calculations in the analysis.

2.3 Infrastructure Inventory

Existing topographic survey provided infrastructure inventory and locations for monitoring wells, landfill toe drain, pump for toe drain, and seepage pond.

3 Site Visit

On October 16, 2025, the HDR team visited Metro Waste Authority's west campus to conduct a site visit for the study bank. The team took collected measurements and pictures to characterize existing conditions of the site and bank location. Locations of photos are shown below in Figure 2.

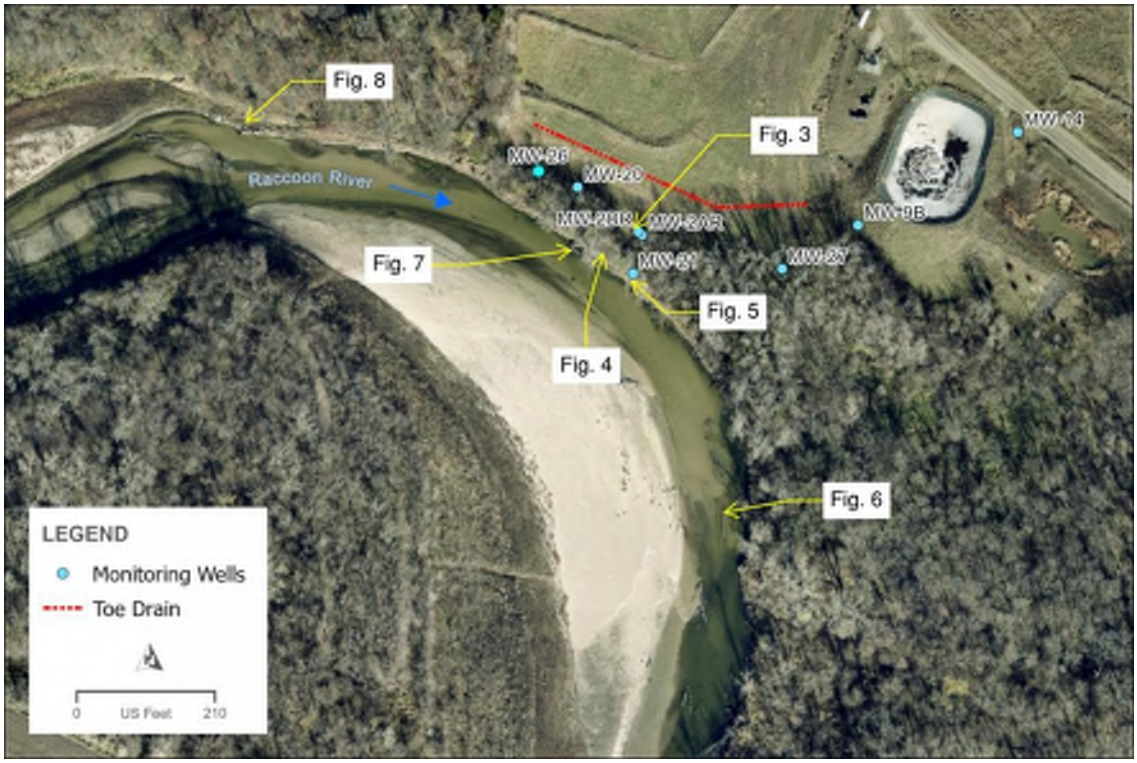

Figure 2: Planview of site visit image locations

To understand the current state of the site, the team measured the distance from well MW-2BR (center of well) to the edge of the left bank near well MW-21. This measurement alignment was chosen because it is where the bank is closest to the toe drain and is a known location where repeated measurements can be easily performed in the future. The measurement was 61.8 feet which is shown in Figure 3 and is used in one of the analyses for the migration of the bank for the 2025 data point.

Figure 3: Image of tape measurement from MW-2BR well to top of bank (looking towards river)

From where the edge of bank was measured above, the top of bank to the edge of water was measured to be approximately 14 feet. Depth of water on the day of site visit was visually estimated to be approximately 5 to 10 feet.

Figure 4: View of tape measure from top of bank to edge of water

Well MW-21 was 2 feet from the top of bank when measuring parallel to the river and was 4 feet from the top of bank when measuring perpendicular to the water. The bank is eroding from the west of the well at a greater extent than from the from the south. The bank on the south side of the well seems to be staying in place due to the roots from a large bush. Well MW-21 is at an immediate risk of being undermined by the channel.

Figure 5: View of MW-21 looking east

Large woody debris was observed in many places along the banks and in the channel which can be seen in Figure 6. Figure 7 shows an accumulation of large woody debris pile just upstream of MW-21. This illustrates that the channel is actively eroding the left bank causing large woody material to fall into the channel and against the banks. .

Figure 6: Large woody debris in channel looking upstream

Figure 7: Large woody debris directly upstream of well MW-21

In Figure 8, upstream of the site on private land, large slabs of concrete were seen along the left bank.

Figure 8: Looking upstream to the west at the concrete slabs on the left bank

4 Channel Meander Migration Analysis

4.1 Meander Belt Width

The NCHRP (**Reference 3**) manual defines “meander belt” as “the distance between lines drawn tangent to the extreme limits of successive, fully developed meanders”. The meander-belt width outlines the area where the river has previously been and can be used to extrapolate where the river may migrate to in the future (**Reference 1**). The elevations shown in LiDAR can be used to estimate the area the river meanders within by noting abrupt changes in ground surface elevation. These features are created by the river as the meanders propagate through the area. For this analysis a relative elevation model (REM) was created from LiDAR flown in 2020. The REM symbolizes the surrounding land based on its elevation relative to the channel centerline. Since a bathymetric surface was not available, the stream centerline elevation is based on water surface elevation from when the LiDAR was flown in 2020. In Figure 9, areas that are bright white show where the channel currently is and areas of more grey-white show where it has been in the past. The dotted yellow line in this figure was drawn where abrupt changes in elevation occur. This is the estimated meander belt.

The FHWA (**Reference 2**) manual states: “The meander belt formed is often fifteen to twenty times the channel width.” The meander belt in Figure 9 is approximately 4 times the channel width. Meander belt width extents on the right bank (south) have been potentially obscured by agricultural practices and the ratio of meander belt to channel width could be larger than estimated.

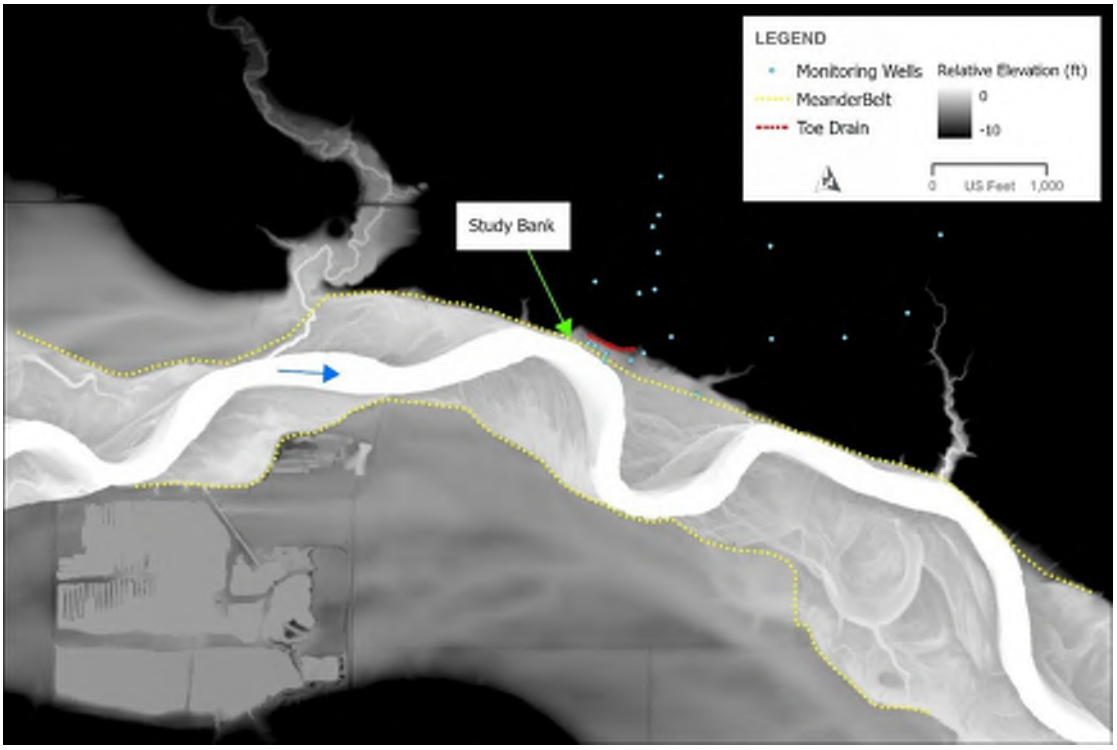

Figure 9 Meander belt (shown in yellow dots) overlayed on the relative elevation surface

4.2 Comparison of Aerial Imagery

For each year of aerial imagery, the channel outline was digitized starting from 5,000 feet upstream and ending 3,000 feet downstream of the study bank. Figure 10 shows the bank outlines overlayed on top of each other. Maps for each year can be found in Appendix A.

Figure 10: Digitized channel outlines 1930-2024

4.3 Migration Rate

The magnitude of meander migration was estimated by drawing circles to best fit the outer bank of the study meander. This method is outlined in the NCHRP manual and FHWA manuals. Two circles were drawn each year because the meander is not one simple arc but instead is comprised of two. The rate of migration was determined by measuring from the centroid of a circle from one year to the next. An example of this can be seen in Figure 11. Using all the analyzed years, the average migration change was 7.3 feet per year for the western bend and 8.2 feet per year for the eastern bend. The greatest per year change for the western bend was between 2010 and 2019 when the channel shifted approximately 9.4 feet per year. For the eastern bend, the greatest change was from 1960 to 1990 when the channel moved at a magnitude of 11.7 feet per year. Additionally, the time period of 1990 to 2010 was on the larger scale with 10.3 feet of change per year. These results can help to predict future bank retreat however they cannot account for localized scour and erosion.

	Western Bend		Eastern Bend	
Years[a]	**Total Migration (feet)**	**Average Annual migration (feet per year)**	**Total Migration (feet)**	**Average Annual migration (feet per year)**
1930 to 1960	236.2	7.9	224.8	7.5
1960 to 1990	245.7	8.2	350.8	11.7
1990 to 2010	99.8	5.0	94.6	4.7
2010 to 2019	84.3	9.4	93.0	10.3
2019 to 2023	20.9	5.2	6.9	1.7
2023 to 2024	3.5	3.5	2.9	2.9
Interval Average[b]	N/A	6.5	N/A	6.5
Period of Record Average[c]	N/A	7.3	N/A	8.2

[a] Prior to 2010, the aerial imagery did not contain the exact year the photos were collected, for this analysis it was assumed that the data were collected at the beginning of the decade

[b] Calculated using the interval specific rates of migration

[c] Calculated using the total distance migrated over the total period of record

Table 1: Migration distances and rates from 1930-2024

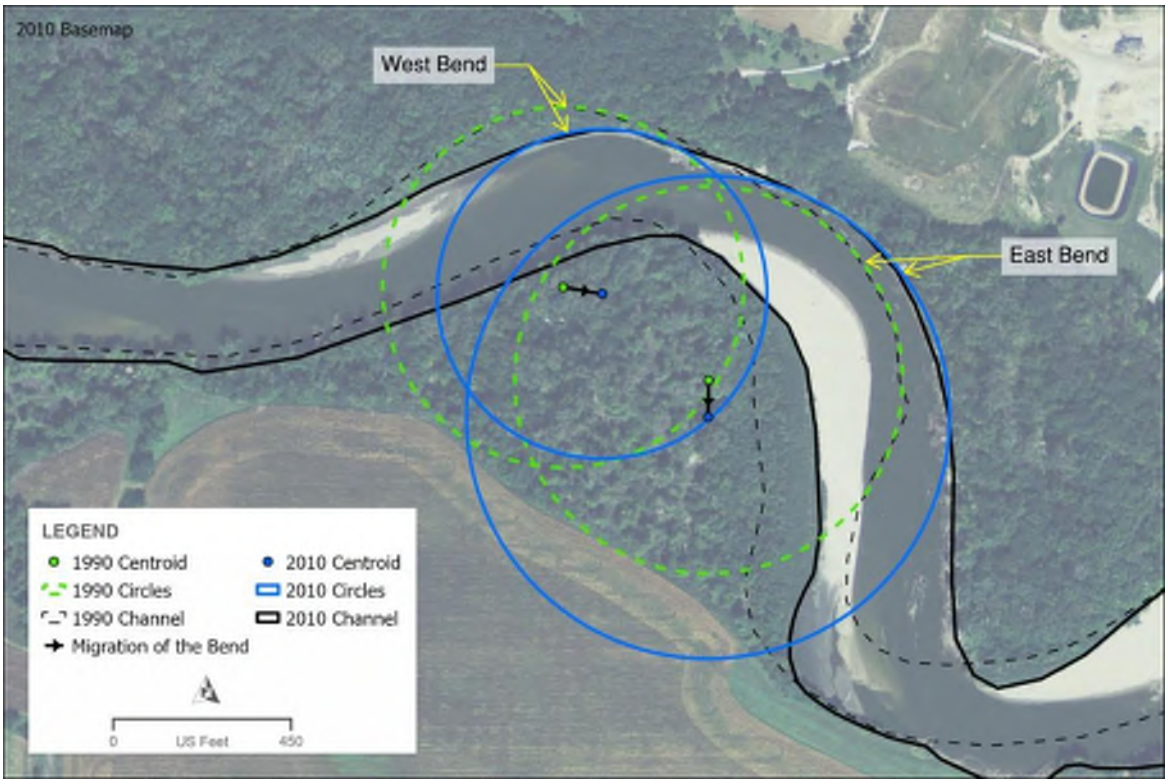

Figure 11: Showing outline of river for 1990 and 2010 with best fit circles to match the outer bends. The arrows demonstrate the migration of the bends

4.4 Bank Migration in Relation to Well MW-2BR

As the meander bend propagates downstream, the perpendicular distance between the left bank of the river to well MW-2BR decreases. During the site visit, the distance from MW-2BR to the top of the left bank was measured approximately perpendicular to the channel because it represents the shortest distance between the bank and the toe drain of the closed landfill and because the measurement can be repeatable for future analyses. Based on this measurement a cross section was developed (Figure 12) to understand the change in distance from the well to the top of bank over the years of record. This cross section was plotted, and each bank line was drawn based on relative station to the well. The 1930 aerial shows the creek was nearly 900 feet away, while the 2024 aerial shows the creek approximately 62-feet away. In the last forty years the bank has migrated approximately 140 feet closer to MW-2BR. These distances can be seen in Table 2. The greatest yearly bank retreat was seen from 1960 to 1990 when the rate of change was 21 feet per year. In the last six years the rate of bank retreat has been approximately a foot per year; however still in relatively recent years from 2010 to 2019 the bank moved roughly 7 feet per year. On average, over the period studied, the yearly bank retreat was 8.7 ft.

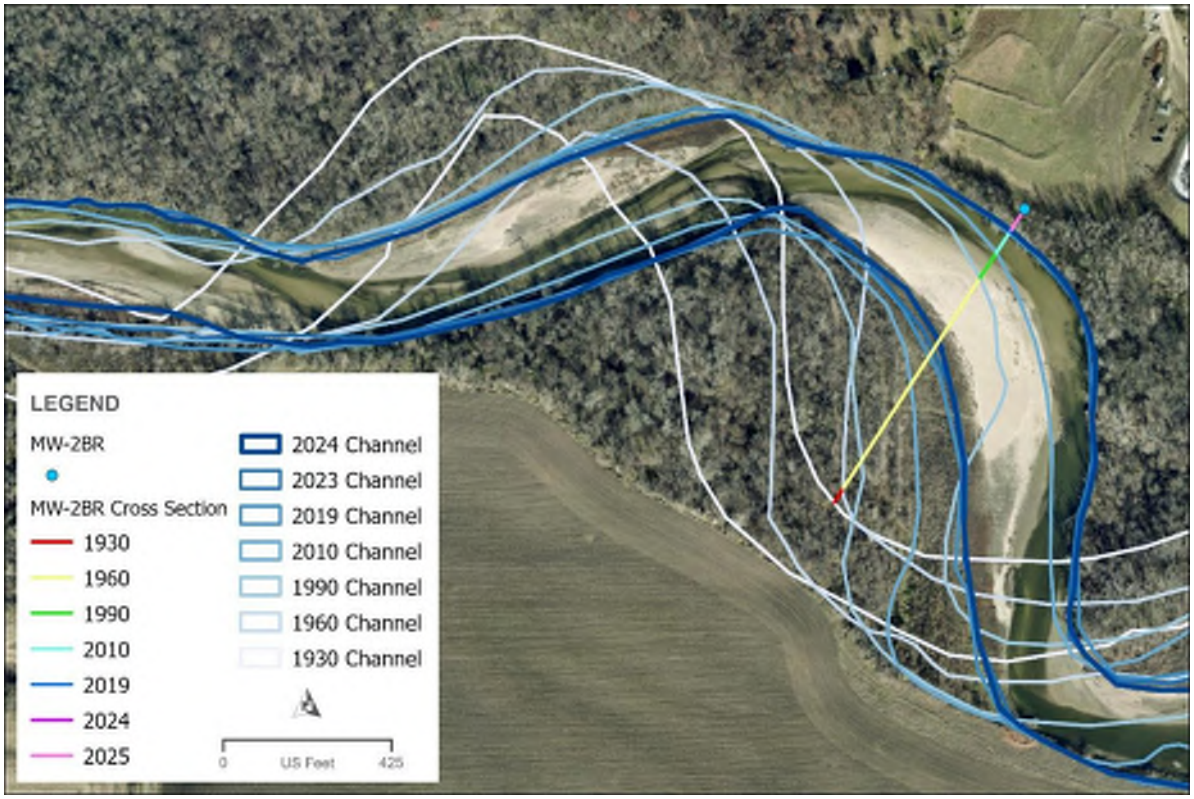

Figure 12: Planview of cross section

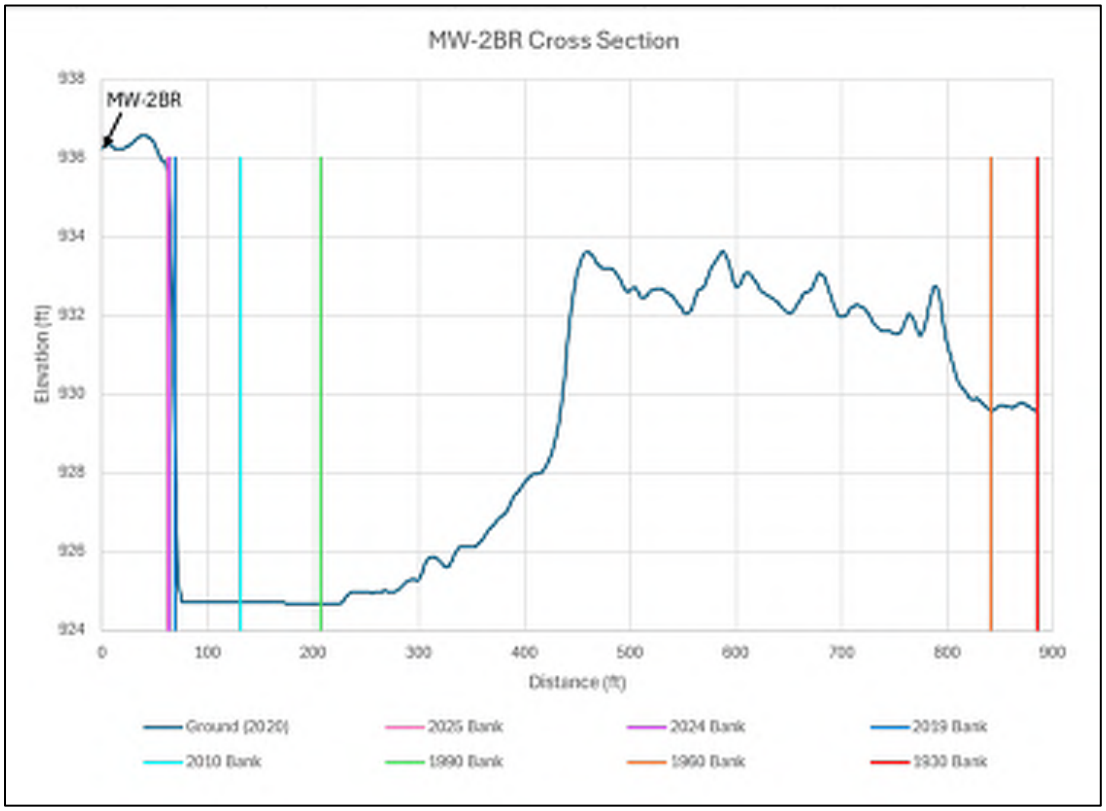

Figure 13: Plot of cross section (looking downstream)

Year	Distance to MW-2BR (ft)	Average Annual migration (feet per year)
1930	884.7	
1960	840.8	1.5
1990	207.0	21.1
2010	131.5	3.8
2019	68.9	7.0
2024	62.9	1.2
2025	61.8[a]	1.1
Period of Record Average		8.7

[a] Measurement taken in the field

Table 2: Measurements of distance from MW-2BR to the top of left bank

5 Conclusions

The channel migration analysis shows that over 90 years, the meander bend that is threatening to erode into well MW-21 has moved east and slightly north approximately 790 feet. The relative distance from MW-2BR to the top of the bank of has decreased from 884.4 feet (1930) to 61.8 feet (2025). The period of record average for the bank retreat heading toward MW-2BR was estimated 8.7 feet per year. From 1930 to 2024, the average meander migration rate of was 7.3 feet per year for the western bend and 8.2 feet per year for the eastern bend, with a maximum yearly rate of 9.4 feet per year for the western bend and 11.7 feet per year for the eastern bend. The landfill infrastructure is at risk as the Raccoon River continues to migrate and as the left bank continues to retreat. A monitoring plan is recommended to observe the bank location over time and to develop mitigation strategies.

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Attachment A

Historic Channels

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Appendix D

Metro Waste Authority

Riverbank Slope Stability Analysis and Sheet Pile Design Evaluation

Metro Waste Authority

Metro Park West Landfill

Perry, Iowa

November 2025

Metro Waste Authority

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Table of Contents

Figures

Attachments

References

1. Slope/W by GeoStudio 2025.1.1, Version 25.1.1.182, GEOSLOPE International Ltd.
2. Unified hazard tool. U.S. Geological Survey. (n.d.). Retrieved February 9, 2023, from https://earthquake.usgs.gov/hazards/interactive/
3. Raccoon River Riverbank Analysis and Riverbank Cross Sections (Figures 1 and 2)
4. 2019 Phytoremediation Analysis Borings
5. 2022 ACM Borings and lab reports
6. GeoStudio Example File Reinforcement with Piles. Document accessed October 21, 2025, from https://files.seequent.com/GeoStudio/SlopeW/Reinforcement%20with%20Piles.pdf

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1 Purpose

The purpose of this report is to present the results of a slope stability evaluation completed for the closed Greene County municipal solid waste unit (MSW) at Metro Waste Authority's Metro Park West, located northwest of Perry, Iowa. The analyses were done for the southwest-facing landfill slope; the riverbank of the North Raccoon River (River) adjacent to the MSW; and the larger area combining both the riverbank and the landfill slopes.

The slope stability evaluations presented in this report are intended to assess the current conditions of the North Raccoon Riverbank, specifically its behavior in the event of riverbank landward shift and encroachment upon the previously installed toe drain. The objective is to identify suitable locations for implementing protective measures to prevent potential collapse of the toe drain and failure of the adjacent closed landfill waste slope located to the northeast (landward – toward the right on the model cross sections in **Attachment** A) of the toe drain.

2 Approach

To address potential slope instability along the southwest side of the existing closed MSW landfill, a sheet pile wall is considered near the toe drain to intercept lateral movement of the North Raccoon River. This measure would protect critical infrastructure, including the toe drain and adjacent landfill slope, from failure due to riverbank encroachment. As part of this evaluation, slope stability analyses using GeoStudio models will simulate scenarios where the riverbank advances toward the toe drain and waste slope. These simulations will help assess reductions in the factor of safety and evaluate a potential mitigation method consisting of a sheet pile wall to reduce the potential for slope instability. Two-dimensional limit equilibrium methods were used to evaluate slope stability for static conditions. Per the United States Geological Survey (**Reference 2**), the site was determined not to be in a seismic impact zone. See Section 4 of this report for additional discussion regarding seismic analysis. The base computer program, GeoStudio Slope/W (**Reference 1**), was used to run Morgenstern-Price analysis type circular arc and sliding block slip surfaces. Search techniques within Slope/W were used to find the critical slip surface producing the minimum factor of safety for each method. The location of the critical slip surface is a function of the site geometry (slope angle and height); material stratigraphy; physical properties of the soil and waste; external loads; weight of soil and/or waste; and groundwater conditions.

The factor of safety for the circular arc failure assumed slip surfaces passing through the riverbank, waste fill, and the underlying foundation soils. A sliding block stability was checked by projecting a failure surface through the anticipated failure plane.

Soil properties used to evaluate stability of existing conditions, as well as the impact of installing a sheet pile near the toe drain, were modeled utilizing long-term soil characteristics. These characteristics were chosen because the riverbank, waste, and underlying soils have been in place for extended periods of time and have become consolidated over time. The long-term parameters are more representative of the existing conditions than short term parameters.

2.1 Model Development Showing Riverbank Failure Progression

Each scenario of potential failure surface, riverbank, and waste slope through riverbank was analyzed under the following cases. For all the model runs, a high groundwater level at about 10 feet above historic observations recorded in nearby groundwater monitoring wells and low Raccoon River level, at an elevation of 920 ft above mean sea level [AMSL] are conservatively estimated.

- Case 1 - Base Model
  Riverbank is assumed to remain in the same location as it was during the installation of the toe drain, approximately 140 ft southeast (SE) of the toe drain. This base model serves as a reference condition for evaluating slope stability and understanding how encroachment scenarios may impact the factor of safety.

- Case 2 – Riverbank shifted 20 ft. NE
  Riverbank is assumed to have shifted 20 ft. northeast (NE), moving closer to the toe drain, located approximately 120 ft to the SE of the toe drain.

- Case 3 - Riverbank shifted 40 ft. NE
  Riverbank is assumed to have shifted 40 ft. NE, moving closer to the toe drain, located approximately 100 ft to the SE of the riverbank toe.

- Case 4 - Toe Drain Collapse – Riverbank Shifted 120 ft. NE
  Riverbank is assumed to have shifted 120 feet NE, resulting in a slip surface that initiates at the top of the toe drain and terminates at the riverbank toe. Because the toe drain was installed in close proximity to the riverbank, the groundwater did not have sufficient time to lower through dewatering. This configuration represents a critical encroachment condition used to evaluate slope stability.

- Case 5 - Toe Drain Collapse – Clay Softened - Riverbank Shifted 120 ft. NE
  Similar to the condition described in Case 4, with an additional assumption that the underlying silty clay soil layer of the riverbank is saturated due to the advancing riverbank resulting in a fully softened condition. Saturation leads to a loss of cohesive strength in the clay, reducing its cohesion. The loss of cohesion will result in the clay behaving more like a granular material with a friction angle of approximately 28°. This softened soil condition significantly impacts the slope's stability by diminishing the soil's ability to resist shear forces. The fully softened case is thought to be the critical case and highlights the vulnerability of the slope to failure during extreme hydraulic changes.

- Case 6 - Toe Drain Collapse – Clay Softened - Riverbank Shifted 120 ft. NE – New Riverbank Surface
  This scenario builds directly upon the conditions modeled in Case 5. The slip plane of the riverbank which corresponds to a factor of safety of close to 1 in Case 5, is now assumed to represent the new geometry of the riverbank following slope failure. This updated surface reflects the progressive nature of riverbank failure, where the weakened soil mass collapses and the bank advances inland toward the adjacent waste slope.

  By incorporating the failed geometry into the model, Case 6 simulates the post-failure condition and evaluates the implications of continued encroachment. It highlights how slope instability can evolve over time, especially when cohesive strength is lost in saturated clay layers and underscores the importance of proactive stabilization measures to prevent further advancement toward waste mass.

The trial slip surfaces are defined using both a. Entry and Exit (Circular Wedge) and b. Block Specified method (Sliding Block) in all cases. All slip surfaces originate from the top of the bank and exit at the bottom, under the river. The Morgenstern-Price limit equilibrium method is used to determine the factor of safety of the trial slip surfaces. A piezometric line establishes the pore water pressure conditions throughout the domain.

2.2 Model Development for Riverbank Stabilization

As a riverbank protection measure, a single layer of sheet pile was modeled approximately 50 ft northwest of the installed toe drain. Based on the model run for progressive riverbank failure, it is assumed that the riverbank has advanced 70 ft towards the toe drain from its existing location (Base Model – Case 1). In the GeoStudio 2D model, the sheet piles are represented as a single layer of pile reinforcement with a shear reduction factor of 1.5 and an out-of-plane spacing of 1 ft. The model assumes that the resisting shear force acts parallel to the slip surface, as specified in the pile reinforcement settings.

The resisting shear force provided by the sheet pile is determined through a trial-and-error approach, evaluating two types of trial slip surfaces:

a. Entry and Exit (Circular Wedge)

b. Block Specified (Sliding Block)

For each case, the factor of safety is checked to ensure it is greater than 1.5, confirming the effectiveness of the sheet pile in stabilizing the failure surface.

3 Material Properties and Sections

Soil material characteristics of each soil were determined based on a combination of historic boring logs from the 2019 phytoremediation project, 2022 Assessment of Corrective Management (ACM) boring logs and lab soil tests, historic groundwater well boring logs, and review of known correlations between index properties and estimated strength properties. The material characteristics are listed in the following table.

Material Characteristics – Long Term

Material/Description	Moist Unit Weight (PCF)	Cohesion (PSF)	Friction Angle (DEG)
Silty Clay	110	250	21
Silty Clay (Softened)	110	0	28
Silty Sand	115	0	31
Toe Drain Aggregate	125	0	33
Waste	70	300	33

Notes (Basis):

1. Drained cohesion (long term) for the clay materials was estimated to be 250 PSF. Typical values range from 0 to 500 PSF assumed for over-consolidated clays.
2. Effective cohesion (long term) for the sands was assumed to be zero.
3. Friction angle for the sands and silt was estimated using the average dry unit weight and using Figure 7, Correlations of Strength Characteristics for Granular Soils from NAVFAC Soil Mechanics Design Manual 7.1.
4. Effective friction angle (long term) for the clays was estimated based on the plasticity index values.
5. In both Case 5 and Case 6, regions adjacent to the riverbank surface are assumed to lose cohesive strength due to saturation caused by progressive riverbank advancement toward the toe drain. This saturation effect is modeled by modifying the soil properties of the silty clay layer in affected zones, designating them as silty clay (softened).

4 Seismicity

The site location was not within a seismic impact zone, which is defined in EPA guidance documents. According to seismic-hazard maps, such zones are characterized by a peak bedrock horizontal acceleration exceeding 0.1g, with a 2% probability of exceedance in 50 years (or 10% in 250 years). As shown in Attachment C, the specific location of Metro Park West exhibits a peak bedrock acceleration of only 0.0281g, which is well below the threshold. Therefore, seismic loading was not considered in any of the slope stability model runs.

5 Stability Analysis Results and Conclusions

5.1 Model Results: Riverbank Failure Progression

The table below summarizes results from the stability analyses for the different scenarios of riverbank slope failure:

Run	GW Height	River Height	Slip Surface	Factor of Safety	Slip Surface Location
Base Model – Case 1					
1	High	Low	Circular (Critical)	0.996	Riverbank
7	High	Low	Sliding Block (Critical)	0.634	Riverbank
Riverbank shifted 20 ft – Case 2					
2	High	Low	Circular (Critical)	1.022	Riverbank
8	High	Low	Sliding Block (Critical)	0.650	Riverbank
Riverbank shifted 40 ft – Case 3					
3	High	Low	Circular (Critical)	1.059	Riverbank
9	High	Low	Sliding Block (Critical)	0.663	Riverbank
Toe Drain Collapse - Riverbank shifted 120 ft – Case 4					
4	High	Low	Circular (Critical)	0.903	Toe Drain and Riverbank
10	High	Low	Sliding Block (Critical)	0.609	Toe Drain and Riverbank
Toe Drain Collapse – Clay Softened - Riverbank Shifted 120 ft. NE – Case 5					
5A	High	Low	Circular (Critical)	0.587	Toe Drain, and Riverbank
5B[1]	High	Low	Circular (Not critical)	0.997	Toe Drain, and Riverbank
5C	High	Low	Circular (Not Critical)	1.500	Waste toe, Toe Drain, and Riverbank
5C	High	Low	Circular (Not Critical)	1.532	Waste toe, Toe Drain, and Riverbank
11A	High	Low	Sliding Block (Critical)	0.229	Riverbank
11B[1]	High	Low	Sliding Block (Not critical)	0.999	Waste toe, Toe Drain, and Riverbank
11C	High	Low	Sliding Block (Not Critical)	1.498	Overall slope
Toe Drain Collapse – Clay Softened - Riverbank Shifted 120 ft. NE – New Riverbank Surface – Case 6					
6A	High	Low	Circular (Not Critical)	0.992	Waste toe, Toe Drain, and Riverbank
6B	High	Low	Circular (Not Critical)	1.492	Overall slope
12A	High	Low	Sliding Block (Not Critical)	0.991	Waste toe, Toe Drain, and Riverbank
12B	High	Low	Sliding Block (Not Critical)	1.496	Overall slope

[1] The slip plane of the riverbank which corresponds to a factor of safety of close to 1 in model run 5B and 11B, is assumed to represent the new geometry of the riverbank following slope failure for Case 6 models.

5.2 Model Results: Riverbank Protective Measures

The table below summarizes the results of the stability analyses used to determine the required resisting shear force for sheet pile design. This was achieved through a trial-and-error approach, ensuring the factor of safety is higher than 1.5 for each evaluated slip surface, and includes evaluation with rip rap installation.

Run	GW Height	River Height	Slip Surface	Factor of Safety	Decision
Resisting shear force per unit length along the riverbank = 15,000 lbf					
13A	High	Low	Circular (Critical)	1.629	Qualifies
13B	High	Low	Sliding Block (Critical)	0.803	Fails
Resisting shear force per unit length along the riverbank = 30,000 lbf					
14A	High	Low	Circular (Critical)	1.629	Qualifies
14B	High	Low	Sliding Block (Critical)	4.665	Qualifies
Resisting shear force with rip rap installation					
15A	High	Low	Circular (Critical)	0.973	Fails
15B	High	Low	Sliding Block (Critical)	0.668	Fails

6 Results

EPA Guidance (Solid Waste Disposal Facility Criteria, EPA530-R-93-017) provides recommended minimum values of Factor of Safety (FS) for slope stability based on consequences and uncertainty of strength measurements. For these analyses, FS of 1.5 was used because seismic loading was not considered in any of the slope stability model runs.

6.1 Riverbank Failure

The localized slope stability for the riverbank should be addressed immediately with corrective actions that will reinforce the slope and further prevent additional sloughing and slope failure, which could lead to uncertainty of the slope that is acting as a buttress to the south side of the closed MSWLF Unit.

Initial model runs for both circular wedge and sliding block failure modes revealed a factor of safety (FS) close to or less than 1, indicating that the driving forces acting on the riverbank slope exceed the resisting forces. This imbalance suggests an imminent failure condition, with the slip surface likely to migrate toward the toe drain.

In Case 5, the assumption that the silty clay layer becomes saturated and loses cohesive strength results in a significant reduction in FS. This condition demonstrates how saturation and softening of soil can critically compromise slope integrity, leading to toe drain failure. A comparison between Case 4 and Case 5 highlights the impact of soil softening on slope stability under encroachment conditions.

Case 6 builds upon this progression by adopting the failure surface from Case 5 (FS ≈ 1) as the new riverbank geometry, simulating post-failure conditions. Analysis of failure surfaces with FS < 1 and FS < 1.5 in both Case 5 and Case 6 for circular wedge and sliding block modes indicates a clear trend: that riverbank failure may continue to advance toward the closed landfill waste slope unless effective stabilization measures are implemented.

The calculated factors of safety for the analyses indicate the riverbank slope is unstable. This is also evident and consistent with current conditions. Several of the monitoring wells show subsidence (settlement) between the concrete pad and the existing surrounding grades.

6.2 Riverbank Protective Measures

Using sheet piles as a riverbank protection measure demonstrated an increase in the factor of safety, effectively stabilizing the slope and preventing further failure. Based on the analysis results, a single-layer sheet pile with a shear strength of 15,000 lbf per unit length along the riverbank provides sufficient resistance against circular wedge failure but is inadequate for sliding block failure. To meet the factor of safety criteria for both failure mechanisms, a design incorporating sheet piles with a shear strength of 30,000 lbf per unit length is required, ensuring comprehensive slope stability.

Rip rap was also evaluated for its effectiveness in providing scour protection and overall stability. The analysis was based on a modeled section with an 18-inch thickness and a solid rock density unit weight of 165 pounds per cubic foot (PCF). For modeling, the bulk unit weight was reduced to 135 PCF to account for voids between stones and porosity. Standard rip rap specified by the Iowa Department of Transportation (IDOT) is Class E, characterized by a top size of 250 pounds, with 50% of the material exceeding 90 pounds and 90% exceeding 5 pounds. While the factor of safety showed improvement with this configuration, it was not enough to reach the minimum 1.5. It might provide some protection against scouring, but it would likely not prevent slope failure. Also, it is important to note that placing materials within the waterway would require regulatory approvals, including coordination with the U.S. Army Corps of Engineers (USACE). This process could be time-consuming and may present challenges that outweigh the potential benefits of implementation. Rip rap should be considered in combination with other mitigation concepts.

The outputs from the computer results of stability analyses are attached to this report in **Attachment B**.

7 Conclusions and Recommendations

The stability analyses indicate a clear potential for slope instability along the riverbank in the absence of adequate protective measures. Without intervention, there is a risk of further encroachment toward critical infrastructure, including the toe drain and the adjacent closed landfill waste slope.

The implementation of sheet piles as a riverbank protection measure may be an effective mitigation approach. Specifically, a single-layer sheet pile with a shear strength of 30,000 lbf per unit length appears to satisfy the factor of safety criteria for both circular wedge and sliding block failure mechanisms. This design provides sufficient resistance to reduce the likelihood of further slope movement and protect surrounding infrastructure. This preliminary evaluation does not constitute a final design; additional analyses and design development will be required.

7.1 Recommendations

It is recommended to continue development of the Emergency Action Plan (EAP) for this area and increase monitoring along the riverbank. This may involve a combination of geotechnical, hydrological, and visual observation techniques. Some strategies to be considered include:

1. Surveying and Topographic Monitoring
2. Inclinometers and Extensometers
3. Settlement Monitoring
4. Piezometers and Groundwater Monitoring
5. Visual Inspections and Photographic Documentation
6. River Stage and Flow Monitoring
    a. River gauges to track water level fluctuations that may influence bank saturation and erosion.
    b. Hydrological modeling to predict encroachment scenarios based on flow rates and sediment transport.

In addition to increasing monitoring, immediately proceeding with the design of mitigation measures along the riverbank is recommended. Start with a comprehensive evaluation of all feasible mitigation strategies, including sheet pile installation, hydraulic improvements, and slope stabilization, such as rip rap, to address the observed instability and prevent further encroachment toward critical infrastructure.

Figures

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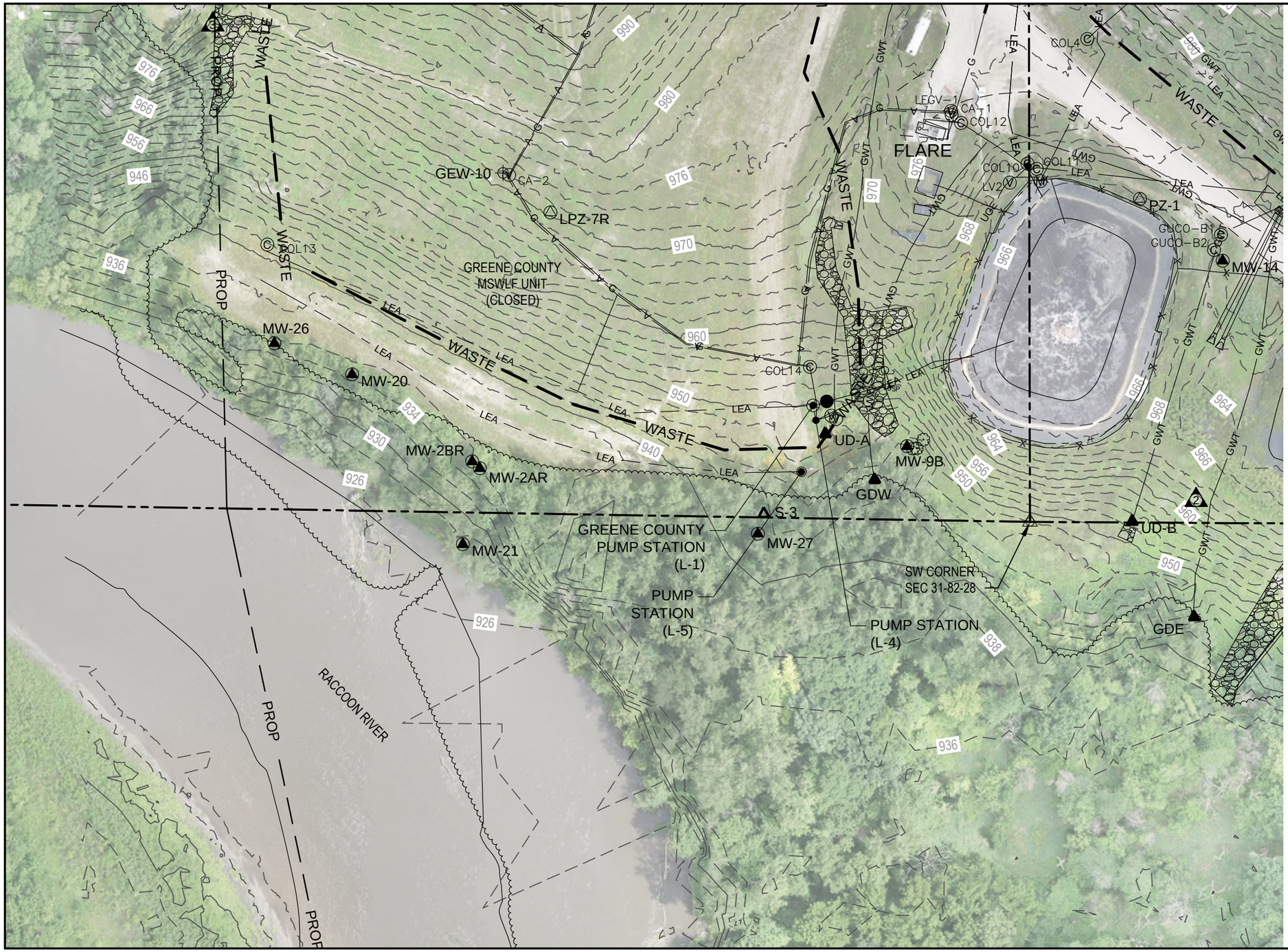

NOTES

1. EXISTING TOPO PREPARED BY HDR INC. DATED JULY 2, 2025.

80 0 80 160

SCALE IN FEET

RIVER BANK ANALYSIS

METRO PARK WEST

DATE
SEPTEMBER 2025

FIGURE
1

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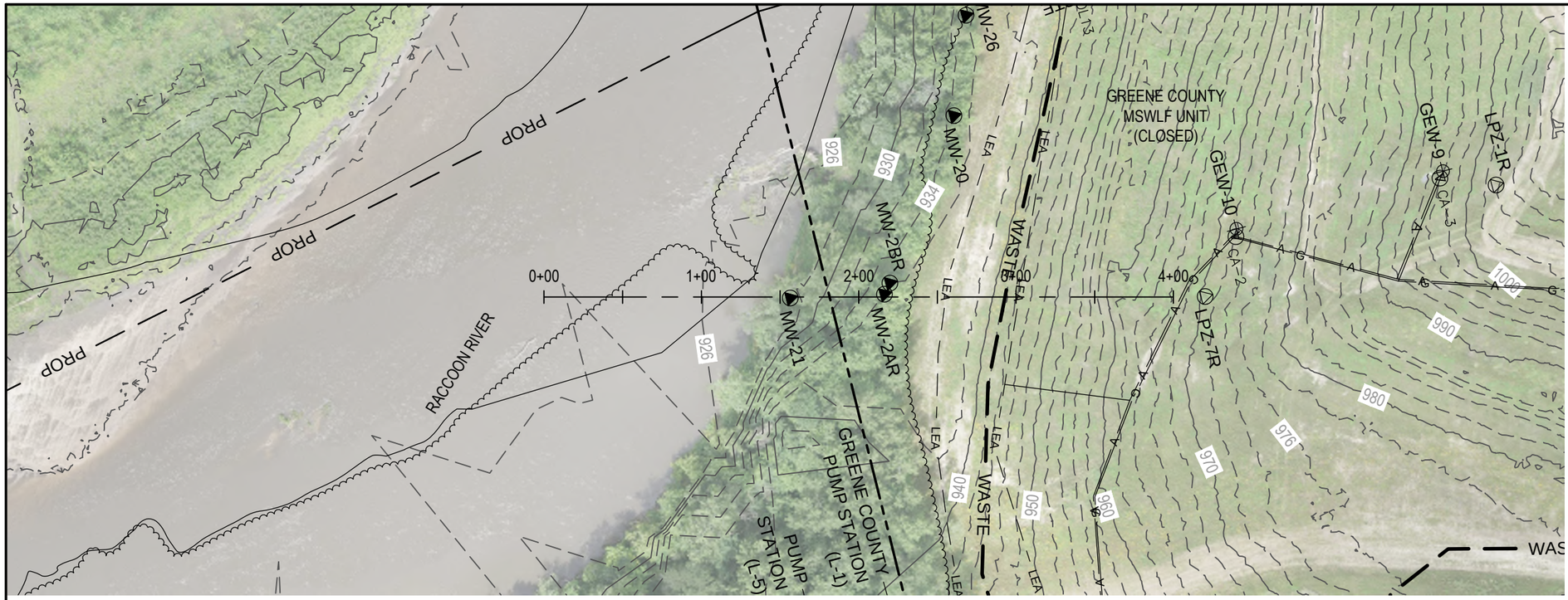

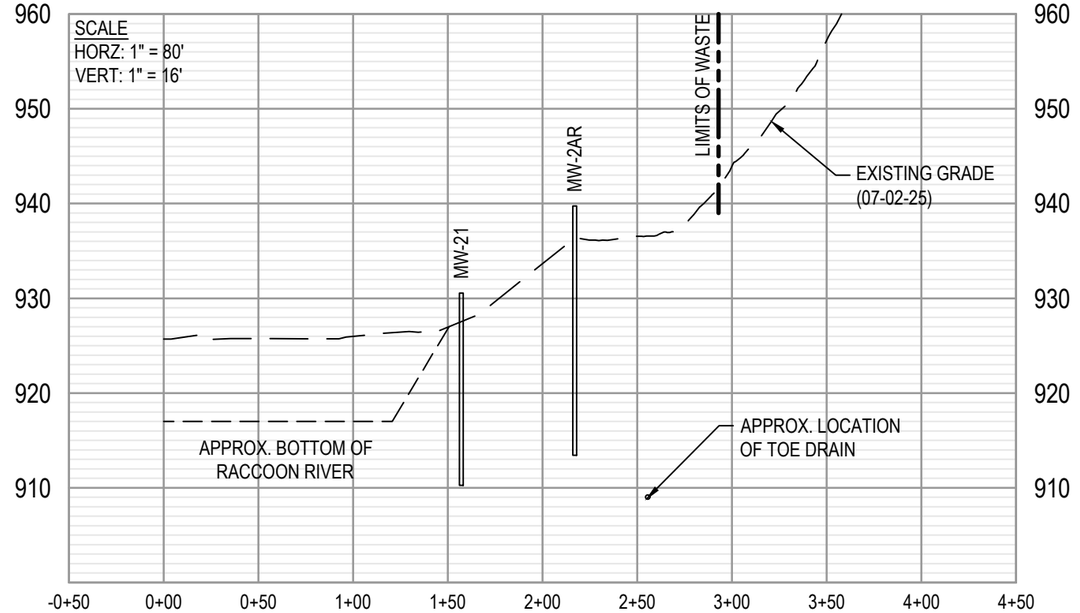

NOTES

1. EXISTING TOPO PREPARED BY HDR INC. DATED JULY 2, 2025.

80 0 80 160

SCALE IN FEET

RIVER BANK CROSS SECTION

METRO PARK WEST

DATE
OCTOBER 2025

FIGURE
2

Attachment A

Plans, Cross Sections and Soil Profiles

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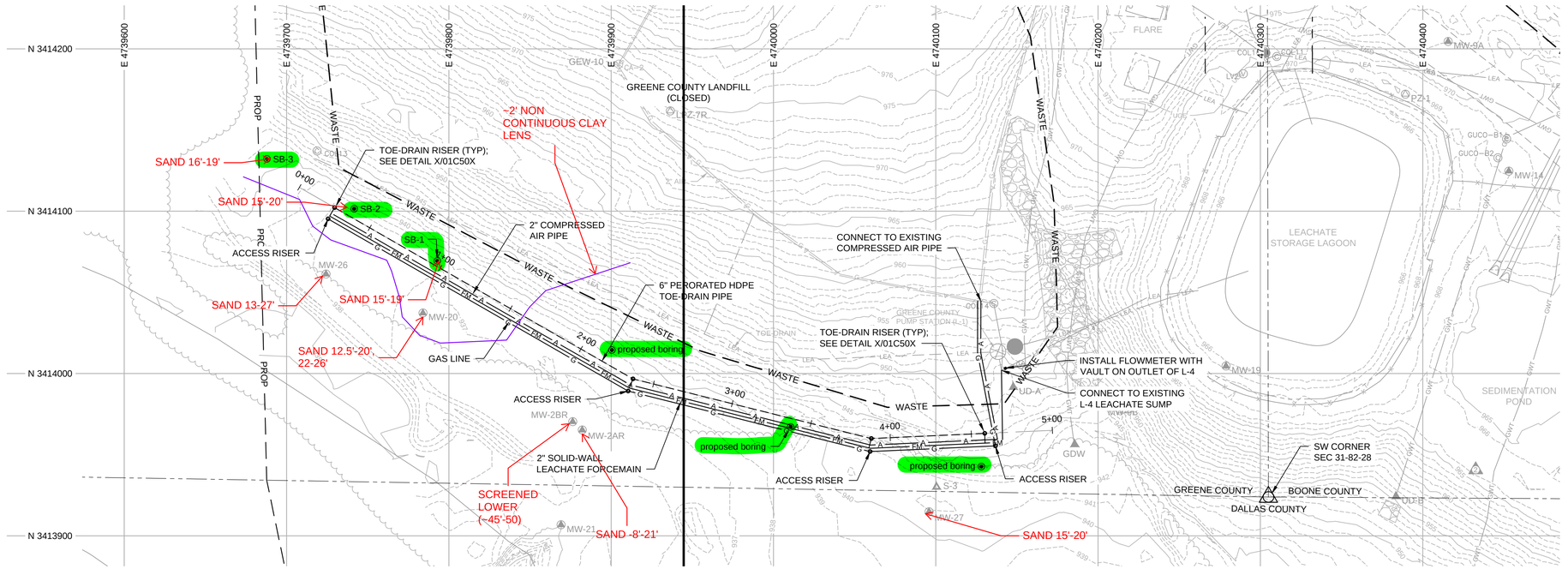

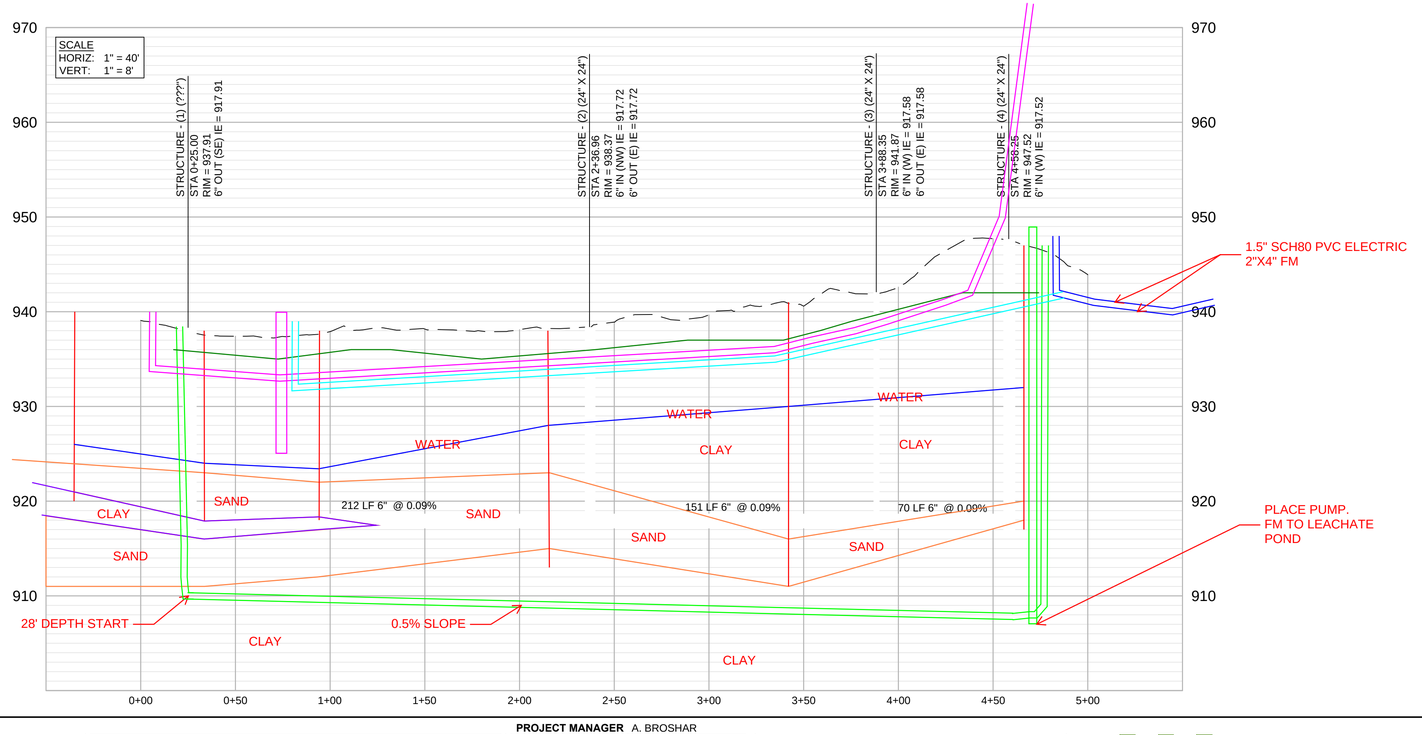

ESTIMATE QUANTITY OF GROUNDWATER PUMPED

ASSUME 1e-4 CM/S HORIZONTAL CONDUCTIVITY

CROSS SECTIONAL AREA OF TOE DRAIN =

LENGTH ~500'
SAND THICKNESS ~8'

=4000-SF = 3,716,122 CM^2

*1E-4 CM/S = 371.61 CM^3/S

=5.89 GPM

ISSUE	DATE	DESCRIPTION
1	01/19/2023	ISSUED FOR 90% REVIEW
0	12/23/2022	ISSUED FOR 60% REVIEW

PROJECT MANAGER	A. BROSHAR
CIVIL	A. BROSHAR
CIVIL	K. KINLEY
DRAWN BY	M. BICKFORD
PROJECT NUMBER	10359069

DRAFT

Metro Waste Authority

METRO PARK WEST
MWA PROJECT P-64
CELL D LINER CONSTRUCTION AND
GREENE CO. LANDFILL IMPROVEMENTS

TOE-DRAIN IMPROVEMENTS

0 1" 2"

FILENAME 02C101.dwg
SCALE 1" = 40'

SHEET 02C101

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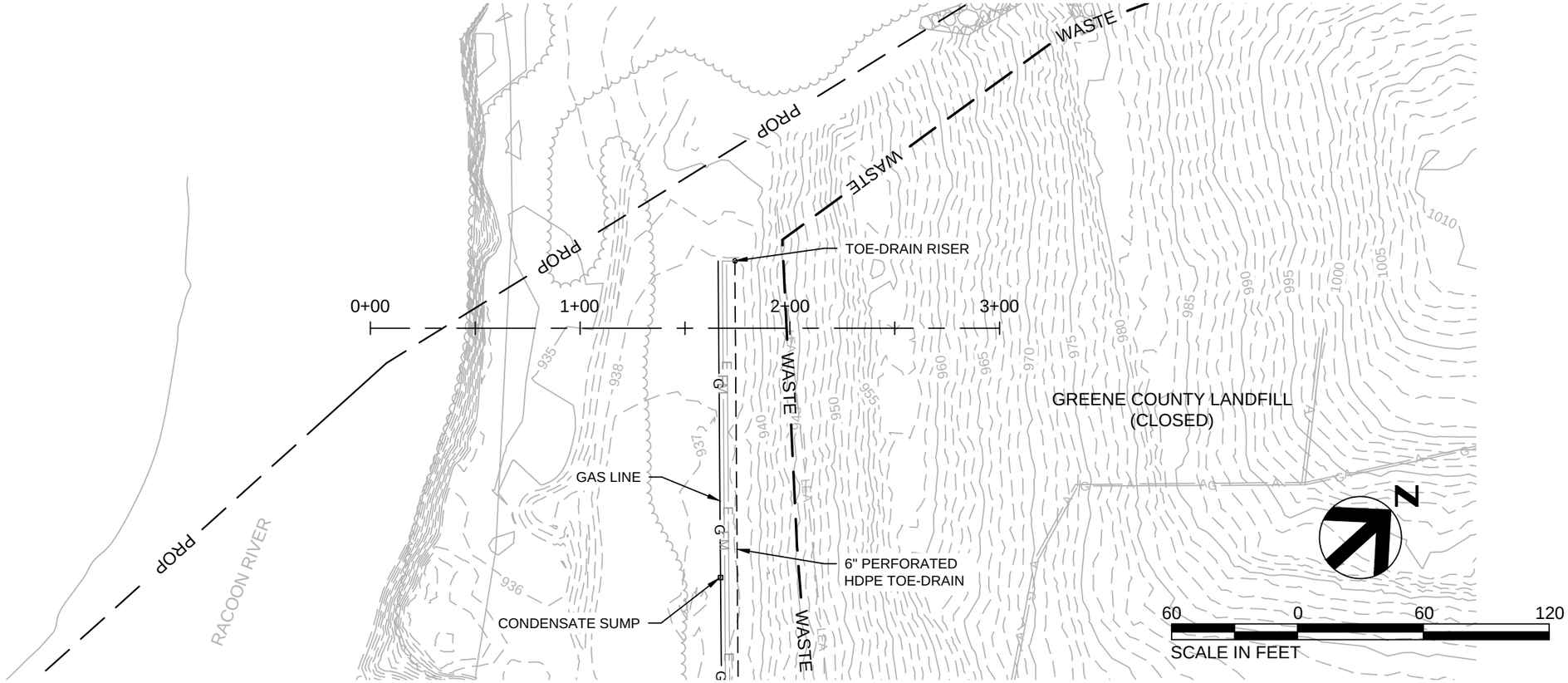

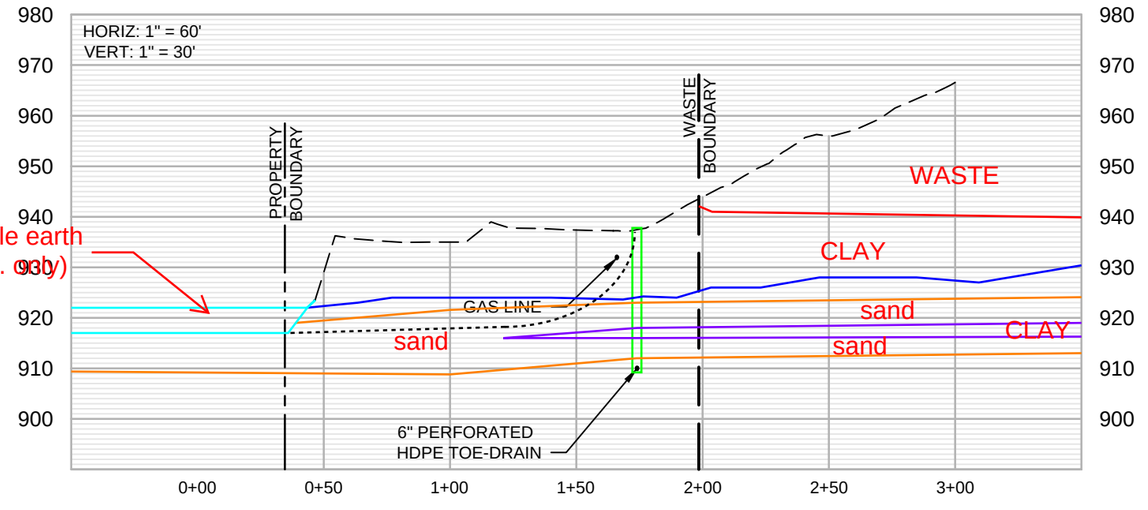

est. from google earth profile (approx. only)

SECTION CUT AT STATION 00+57 ON TOE DRAIN PROFILE

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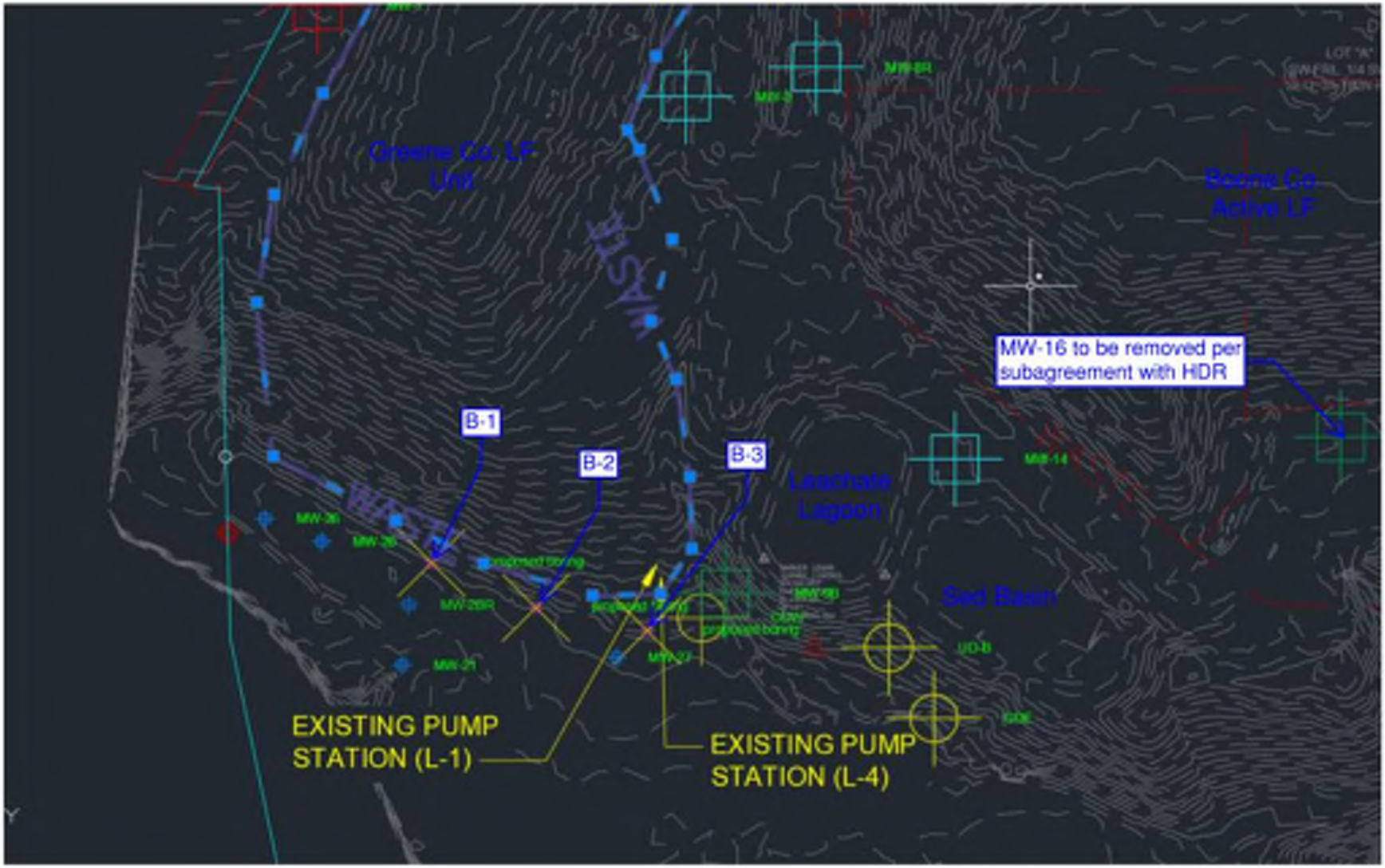
METRO WASTE AUTHORITY
METRO PARK WEST
MWA PROJECT P-64

GREENE COUNTY LANDFILL TOE-DRAIN CROSS SECTION

DATE
JANUARY 2023

FIGURE
1

Metro Park West



Soil Boring Log And Monitoring Well Construction Diagram for: B-1

Facility Name: Metro Park West Landfill - Perry, Iowa	Northing: 676951.01000	Easting: 1459071.99
Well Contractor Name: N/A	Drilling Method**: Direct Push	
Well Contractor Registration No: N/A	Boring Depth (ft) x Diameter (in): 25'	
Logged by: Cameron Lahn	Ground Surface Elevation (ASL): 947.25'	
Start Date: 12/20/2022 Finish Date: 12/20/2022	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0	Backfilled with bentonite upon completion →				100.0	CL	(0'-4') Brown Silty Sandy Clay (Trace Sand)
1					100.0		
2					100.0		
3					100.0		
4					100.0	CL	(4'-16') Dark Gray Silty Clay
5					100.0		
6					100.0		
7					100.0		
8					100.0		
9					100.0		
10					100.0		
11					100.0		
12					100.0		
13					100.0		
14					100.0		
15					100.0		
16					100.0	SC	(16'-20') Dark Gray Sandy Silt
17					100.0		
18					100.0		
19					100.0		
20		B-1	CC		100.0	CL	(20'-25') Dark Gray Silty Clay
21		B-1	CC		100.0		
22		B-1	CC		100.0		
23		B-1	CC		100.0		
24		B-1	CC		100.0		
25		B-1	CC		100.0		
26	**End of boring**						
27							
28							
29							
30							
31							

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	N/A	**Borehole Diameter:**	3.25"	**Location:**	MPW Landfill
Time:	N/A	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	N/A	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: B-2

Facility Name: Metro Park West Landfill - Perry, Iowa	Northing: 679603.62960	Easting: 1459182.155
Well Contractor Name: N/A	Drilling Method**: Direct Push	
Well Contractor Registration No: N/A	Boring Depth (ft) x Diameter (in): 29'	
Logged by: Cameron Lahn	Ground Surface Elevation (ASL): 945.61'	
Start Date: 12/20/2022 Finish Date: 12/20/2022	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0	Backfilled with bentonite upon completion →				100.0	ML	(0'-2') Dark Brown Silty Sandy Clay
1					100.0		
2					100.0		(2'-3') Wood Interference
3					100.0	CL	(3'-7') Gray Silty Clay
4					100.0		
5					100.0		
6					100.0		
7					100.0	CL	(7'-18') Dark Gray Silty Clay
8					100.0		Wet at 8'
9					100.0		
10					100.0		
11					100.0		
12					100.0		
13					100.0		
14					100.0		
15					100.0		
16					100.0		
17					100.0		
18					100.0	SM	(18'-22') Dark Gray Silty Sandy Clay
19					100.0		
20					100.0		
21					100.0		
22					100.0	SW	(22'-23') Sand
23					100.0	CL	(23'-26') Dark Gray Silty Clay
24					100.0		
25					100.0		
26		B-2	CC		100.0	CL	(26'-29') ~~Dark Gray Sandy Silty Clay~~ Gray fine-med sand (per lab results)
27		B-2	CC		100.0		
28		B-2	CC		100.0		
29		B-2	CC		100.0		
30	**End of boring**						
31							

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

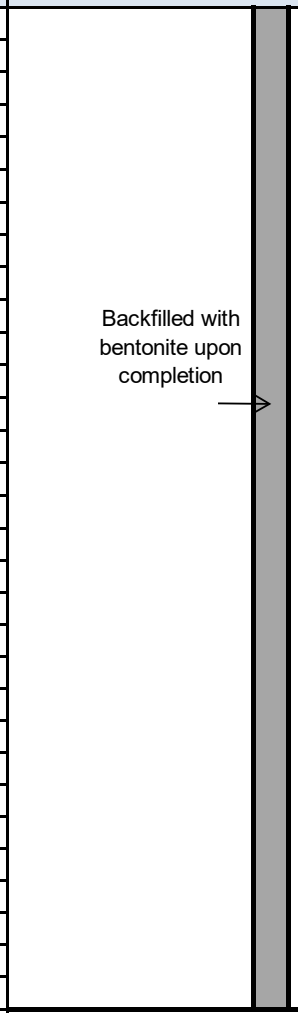
**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	N/A	**Borehole Diameter:**	3.25"	**Location:**	MPW Landfill
Time:	N/A	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	N/A	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: B-3

Facility Name: Metro Park West Landfill - Perry, Iowa	Northing: 679579.26600	Easting: 1459299.656
Well Contractor Name: N/A	Drilling Method**: Direct Push	
Well Contractor Registration No: N/A	Boring Depth (ft) x Diameter (in): 30'	
Logged by: Cameron Lahn	Ground Surface Elevation (ASL): 939.72'	
Start Date: 12/20/2022 Finish Date: 12/20/2022	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0					100.0	ML	(0'-4') Brown with Rust Silty Sandy Clay
1					100.0		
2					100.0		
3					100.0		
4					100.0	CL	(4'-5') Gray Brown Silty Clay
5					5.0		(5'-10') NR
6					100.0		
7					100.0		Wet at 7'
8					100.0		
9					100.0		
10					100.0	CL	(10'-22') Dark Gray Silty Clay
11					100.0		
12					100.0		
13					100.0		
14					100.0		
15					100.0		
16					100.0		
17					100.0		
18					100.0		
19					100.0		
20					100.0		
21					100.0		
22					100.0	SW	(22'-22.5') Sand
23					100.0	CL	(22.5'-25') Dark Gray Silty Clay
24					100.0		27'
25		B-3	CC		100.0	SC	(25'-~~30'~~) Gray Sandy Silty Clay
26		B-3	CC		100.0		
27		B-3	CC		100.0		(27'-29')Dark Gray Sand
28		B-3	CC		100.0		
29		B-3	CC		100.0		
30		B-3	CC		100.0		
31	**End of boring**						

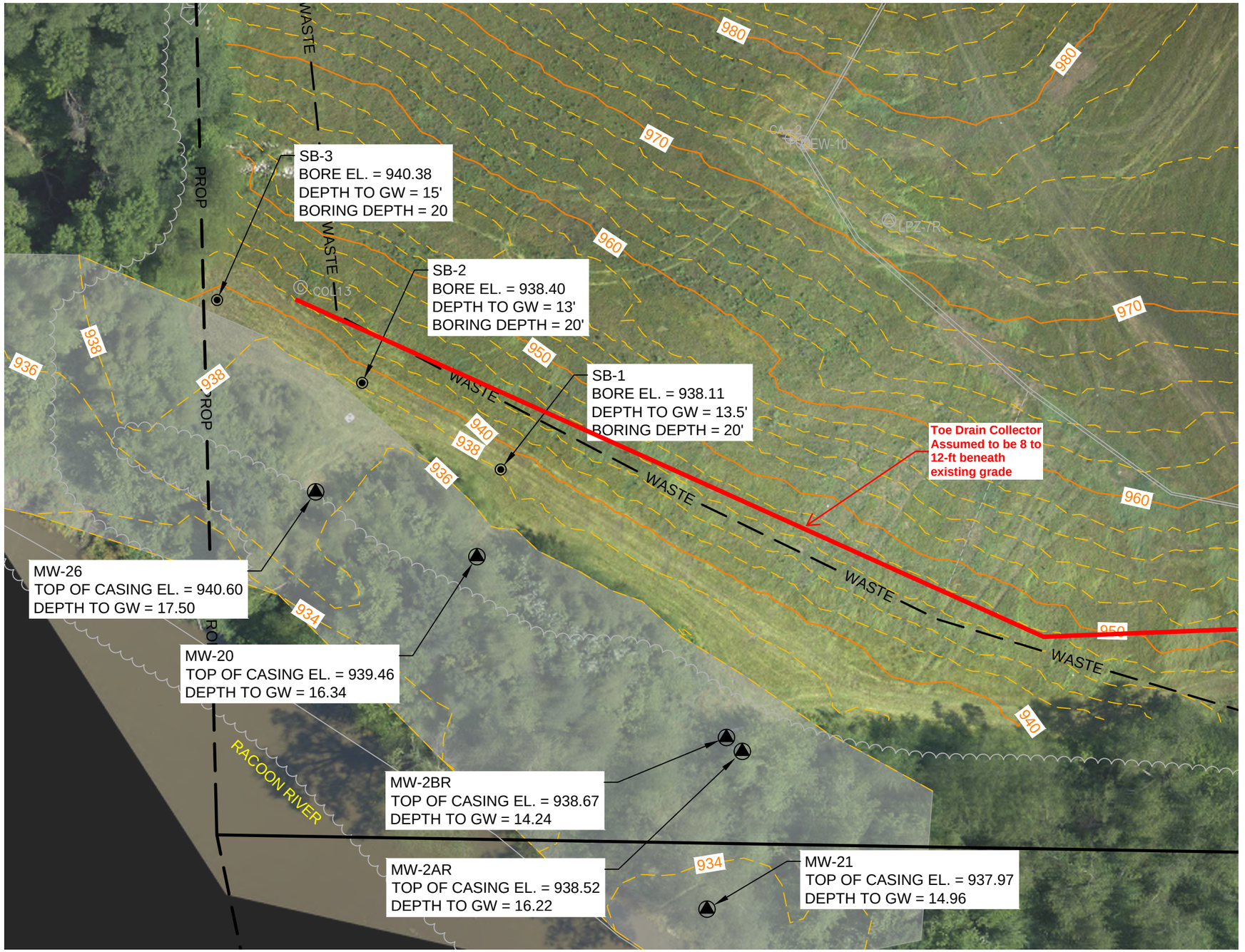
Backfilled with bentonite upon completion

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	N/A	**Borehole Diameter:**	3.25"	**Location:**	MPW Landfill
Time:	N/A	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	N/A	**Well Screen Size:**	-	**Project No.:**	10310518



LEGEND

AREA OF ASSUMED GRADE OUTSIDE OF JUNE 2021 SURVEY.

LEGEND

1. EXITING CONTOURS ARE A COMBINATION OF AERIAL SURVEY PROVIDED BY AEROVIEW SERVICES, DATED JUNE 30, 2021 AND ASSUMED GRADE CONTINUATION TOWARDS RACOON RIVER BANK.

N

40 0 40 80

SCALE IN FEET

Metro Waste Authority

METRO WASTE AUTHORITY
METRO PARK WEST

PHYTOREMEDIATION ANALYSIS

DATE
JULY 2022

FIGURE
1

C:\pwworking\central01\d3083959\Fig 1 - Phytoremediation Analysis.dwg, Layout1, 7/12/2022 10:54:15 AM, MBICKFORD

Soil Boring Log And Monitoring Well Construction Diagram for: SB-1 (East)

Facility Name: Metro Park West Landfill		X Coordinates: 41.863643	Y Coordinates: -94.166123
Well Contractor Name: Jordan Lowry		Drilling Method**: Direct Push	
Well Contractor Registration No: 12145		Boring Depth (ft) x Diameter (in): 20' x 2.0'	
Logged by: Kris Sommer		Ground Surface Elevation (ASL): -	
Start Date: 6/8/2021	Finish Date: 6/8/2021	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type*	PID/FID (PPM)	USCS	Sample Descriptions: soil, color, classification, observation
0		1	CC			(0"-3") Grass and Root Zone
1				0.0	MH CL SP	(3"-1') Dark Brown Silty Clay with Trace Sand
2				0.0	SP	(1'-2') Brown Sand
3				0.0	MH CL	(2'-3') Dark Brown, Dark Gray Silty Clay
4				0.0	MH CL	(4'-7') Gray Silty Clay
5		2	CC	0.0		
6	←			0.0		
7	Backfilled with bentonite upon completion			0.0	SP MH CL	(7'-12') Dark Brown Sandy Silty Clay
8				0.0		
9				0.0		
10		3	CC	0.0		
11				0.0		
12				0.0	SW CL	(12'-15') Dark Brown Fine Sandy Clay
13				0.0		(v 13.5) Groundwater Encountered During Sampling Activities
14				0.0		
15		4	CC	0.0	SP	(15-16') Brown Sand
16				0.0	SW	(16'-17) Gray Fine Sand
17				0.0		
18				0.0		
19				0.0	CH SP	(19'-20') Gray Clay with Trace Sand
20	**End of boring**	5	CC	0.0		
21						
22						
23						
24						
25						

* Sample Types:	** Drilling Method Options:	Symbols to Use:
Split Spoon (SS) Continuous Core (CC)	Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)	v – Static Water Level s – sample collected

Observation Date:	-								
Time:	-								
Static Water Level (ASL):	-								

Soil Boring Log And Monitoring Well Construction Diagram for: SB-2 (Central)

Facility Name: Metro Park West Landfill	X Coordinates: 41.863730	Y Coordinates: -94.166312
Well Contractor Name: Jordan Lowry	Drilling Method**: Direct Push	
Well Contractor Registration No: 12145	Boring Depth (ft) x Diameter (in): 20' x 2.0'	
Logged by: Kris Sommer	Ground Surface Elevation (ASL): -	
Start Date: 6/8/2021 Finish Date: 6/8/2021	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type*	PID/FID (PPM)	USCS	Sample Descriptions: soil, color, classification, observation
0		1	CC			(0"-3") Grass and Root Zone
1				0.0	SP MH CL	(3"-4') Brown Sandy Silty Clay
2				0.0		
3				0.0		
4				0.0	SP CH	(4'-5') Gray Brown Sandy Clay
5		2	CC	0.0	SP CH	(5'-7') Dark Brown Sandy Clay
6	← Backfilled with bentonite upon completion			0.0		
7				0.0	CL CH	(7'-19') Dark Brown Clay
8				0.0		
9				0.0		
10		3	CC	0.0		
11				0.0		
12				0.0	SW CL	(12'-15') Dark Brown Fine Sandy Clay
13				0.0		(v 13.0) Groundwater Encountered During Sampling Activities
14				0.0		
15		4	CC	0.0	SP	(15-16') Brown Sand
16				0.0	SW	(16'-17) Gray Fine Sand
17				0.0		
18				0.0		
19				0.0	SP	(19'-20') Brown Sand
20	**End of boring**	5	CC	0.0		
21						
22						
23						
24						
25						

* Sample Types:	** Drilling Method Options:	Symbols to Use:
Split Spoon (SS) Continuous Core (CC)	Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)	v – Static Water Level s – sample collected

Observation Date:	-									
Time:	-									
Static Water Level (ASL):	-									

Soil Boring Log And Monitoring Well Construction Diagram for: SB-3 (West)

Facility Name: Metro Park West Landfill	X Coordinates: 41.863813	Y Coordinates: -94.166510
Well Contractor Name: Jordan Lowry	Drilling Method**: Direct Push	
Well Contractor Registration No: 12145	Boring Depth (ft) x Diameter (in): 20' x 2.0'	
Logged by: Kris Sommer	Ground Surface Elevation (ASL): -	
Start Date: 6/8/2021 Finish Date: 6/8/2021	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type*	PID/FID (PPM)	USCS	Sample Descriptions: soil, color, classification, observation
0		1	CC			(0"-3") Grass and Root Zone
1				0.0	MH CL	(3"-1') Brown Silty Clay
2				0.0	SW	(1'-2') Light Brown Sand
3				0.0	MH CL SP	(2'-3') Brown Silty Clay Trace Sand
4				0.0	SP CH	(3'-8') Gray Brown Sandy Clay
5		2	CC	0.0		
6	← Backfilled with bentonite upon completion			0.0		
7				0.0		
8				0.0	MH CL	(8'-16') Brown Rust Silty Clay
9				0.0		
10		3	CC	0.0		
11				0.0		
12				0.0		
13				0.0		
14				0.0		
15		4	CC	0.0	SW	(16'-19') Gray Sand
16				0.0		(v 15') Groundwater Encountered During Sampling Activities
17				0.0		
18				0.0		
19				0.0	CH SP	(19'-20') Gray Clay with Trace Sand
20	**End of boring**	5	CC	0.0		
21						
22						
23						
24						
25						

* Sample Types:	** Drilling Method Options:	Symbols to Use:
Split Spoon (SS) Continuous Core (CC)	Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)	v – Static Water Level s – sample collected

Observation Date:	-								
Time:	-								
Static Water Level (ASL):	-								

January 12, 2023

Project No: 221571MWA

EcoSource, LLC
6424 University Ave
Windsor Heights, Iowa 50324

Re: **Geotechnical Laboratory Testing**
Metro Park West
Des Moines, Iowa

Dear Mr. Jordan Lowry:

As per your request, CMT has completed the laboratory testing for the above stated project. Enclosed you will find the results of the requested tests, as listed below.

Sample ID	Hydrometer Analysis, ASTM D422	Atterberg Limits, ASTM D4318	Permeability, ASTM D5084	Porosity, ή
B-1 20-25 ft	X	X	X	0.423
B-2 25-30 ft	X	X	X	0.358
B-3 10-15 ft	X	X	X	0.493

Tests were conducted in general accordance with ASTM test methods and procedures noted. Please feel free to call should you have questions or if I may be of further assistance.

Sincerely,

Sybil K. Ferrier
Digitally signed by Sybil K. Ferrier
Date: 2023.01.12 09:48:14 -06'00'

Sybil K. Ferrier, P.E.
Principal Engineer

JH/SF

1610 East Madison Ave. • Des Moines, Iowa 50313
(515) 263-0794 • Fax (515) 263-0851
www.cmt-iowa.com

APPENDIX

1610 East Madison Ave • Des Moines, Iowa 50313
(515) 263-0794 • Fax (515) 263-0851
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GENERAL NOTES - BORING LOG DESCRIPTIONS

Soil descriptions stated on the Boring Logs are based on the Unified Soil Classification System as stated in ASTM Designations D-2487 and D-2488. The Unified Soil Classification group symbol listed in the table below correlate to the group symbols listed on the Boring Logs. The classification is mainly based on visual observations to define the soil characteristics. If a more detailed soil description is required, additional soil testing will be conducted to better define the soil characteristics.

Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name	Group Symbol	Group Name
SW	Well-graded Sand	GW	Well-graded Gravel	CL	Lean Clay	CH	Fat Clay
SP	Poorly-graded Sand	GP	Poorly-graded Gravel	ML	Silt	MH	Elastic Silt
SM	Silty Sand	GM	Silty Gravel	OL or OH	Organic Silt Organic Clay	Pt	Peat
SC	Clayey Sand	GC	Clayey Gravel				

RELATIVE DENSITY OF COARSE-GRANED SOILS		**CONSISTENCY OF FINE-GRAINED SOILS**		
SPT, bpf	*Relative Density*	*Unconfined Compressive Strength, Q_u, psf*	*Consistency*	*SPT, bpf*
0-3	Very Loose	< 500	Very Soft	0 – 2
4-9	Loose	500 - 1,000	Soft	2 – 4
10-29	Medium Dense	1,001 - 2,000	Medium Stiff	4 – 8
30-49	Dense	2,001 – 4,000	Stiff	8 – 15
50-80	Very Dense	4,001 – 8,000	Very Stiff	15 – 30
80+	Extremely Dense	8,001 – 16,000	Hard	30 – 100
		>16,000	Very Hard	>100

GRAIN SIZE TERMINOLOGY		**RELATIVE PROPORTIONS**		
Major Component of Sample	*Size Range*	*Descriptive Terms(s) (of components also present in sample)*	*Fines Percent of Dry Weight*	*Sand and Gravel Percent of Dry Weight*
Cobbles	12 in. to 3 in. (300 mm to 75 mm)	Trace	< 5	< 15
Gravel	3 in. to #4 sieve (75 mm to 4.75 mm)	With	5 – 12	15 – 29
Sand	#4 to #200 sieve (4.75 mm to 0.074 mm)	Modifier	> 12	> 30
Silt or Clay	Passing #200 sieve (> 0.074 mm)			

DRILLING AND SAMPLING ABBREVIATIONS

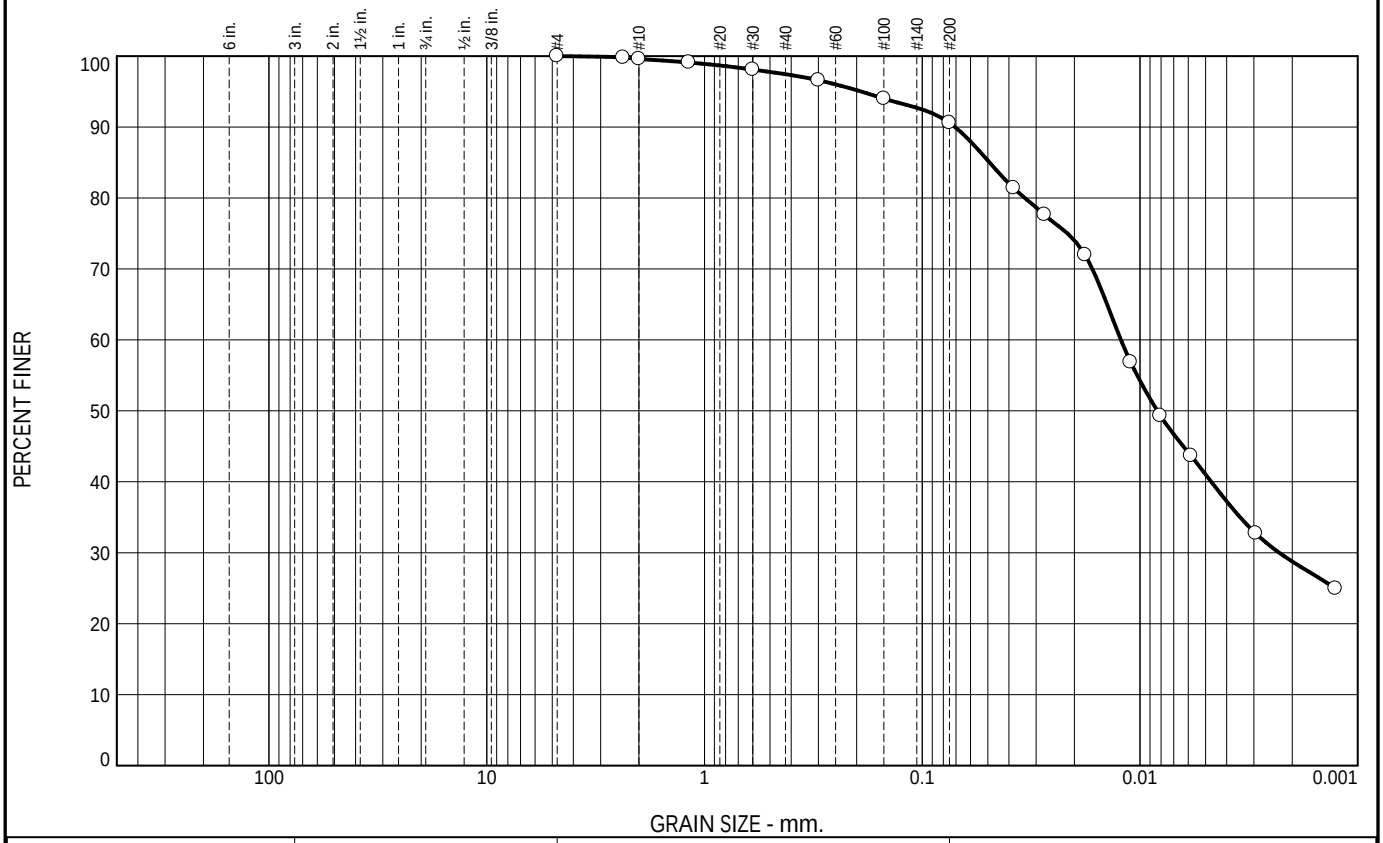
Drilling Methods

CFA – Continuous Flight Auger; typically, 4, 6, or 8 inches in diameter (ASTM D 1452)
HSA – Hollow Stem Auger; 6 or 8 inches in diameter, continuous flight auger remains in bore hole with undisturbed soil samples obtained from center of auger.
HA – Hand Auger; typically with a 4 inch or less diameter auger

Sample Types

SS - Split Spoon; samples obtained with a 140 lb manual hammer in accordance with ASTM D1586.
SSA – Split Spoon; samples obtained with a 140 lb automatic hammer in accordance with ASTM D 1586.
ST – Shelby Tube; thin walled tube samples, typically for cohesive soils, in accordance with ASTM D1587.
SPT- Standard Penetration Test: The number of blows required to drive a sampler, either split spoon or drive cone, into the soil with a 140 lb mass dropped a distance of 30 inches, in accordance with ASTM D 1586, and the number of blows are recorded in each 6 inch interval over a distance of 18 inches. Blow counts are reported for each 6 inch interval or the sum of the last two intervals is reported. The sum of the last two intervals is referred to as N, in blows per foot.
BS – Bulk Disturbed Sample
CPT – Cone Penetration Test; A device in which a 60° cone is pushed continuously into the soil and the cone end resistance is measured for skin friction and end bearing (ASTM D3441).

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.4	2.1	6.9	61.8	28.8

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	99.8		
#10	99.6		
#16	99.1		
#30	98.1		
#50	96.6		
#100	94.0		
#200	90.6		
0.0381 mm.	81.4		
0.0275 mm.	77.6		
0.0179 mm.	72.0		
0.0111 mm.	56.9		
0.0081 mm.	49.3		
0.0058 mm.	43.7		
0.0029 mm.	32.7		
0.0013 mm.	25.0		

* (no specification provided)

Soil Description

Dark grayish brown silty clay trace sand

Atterberg Limits

PL= 22 LL= 46 PI= 24

Coefficients

D_{90}= 0.0707 D_{85}= 0.0491 D_{60}= 0.0122
D_{50}= 0.0083 D_{30}= 0.0023 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-7-6(24)

Remarks

Sampled by others.

Location: B-3
Sample Number: 1 Depth: 10 - 15 FT Date: 12/27/22

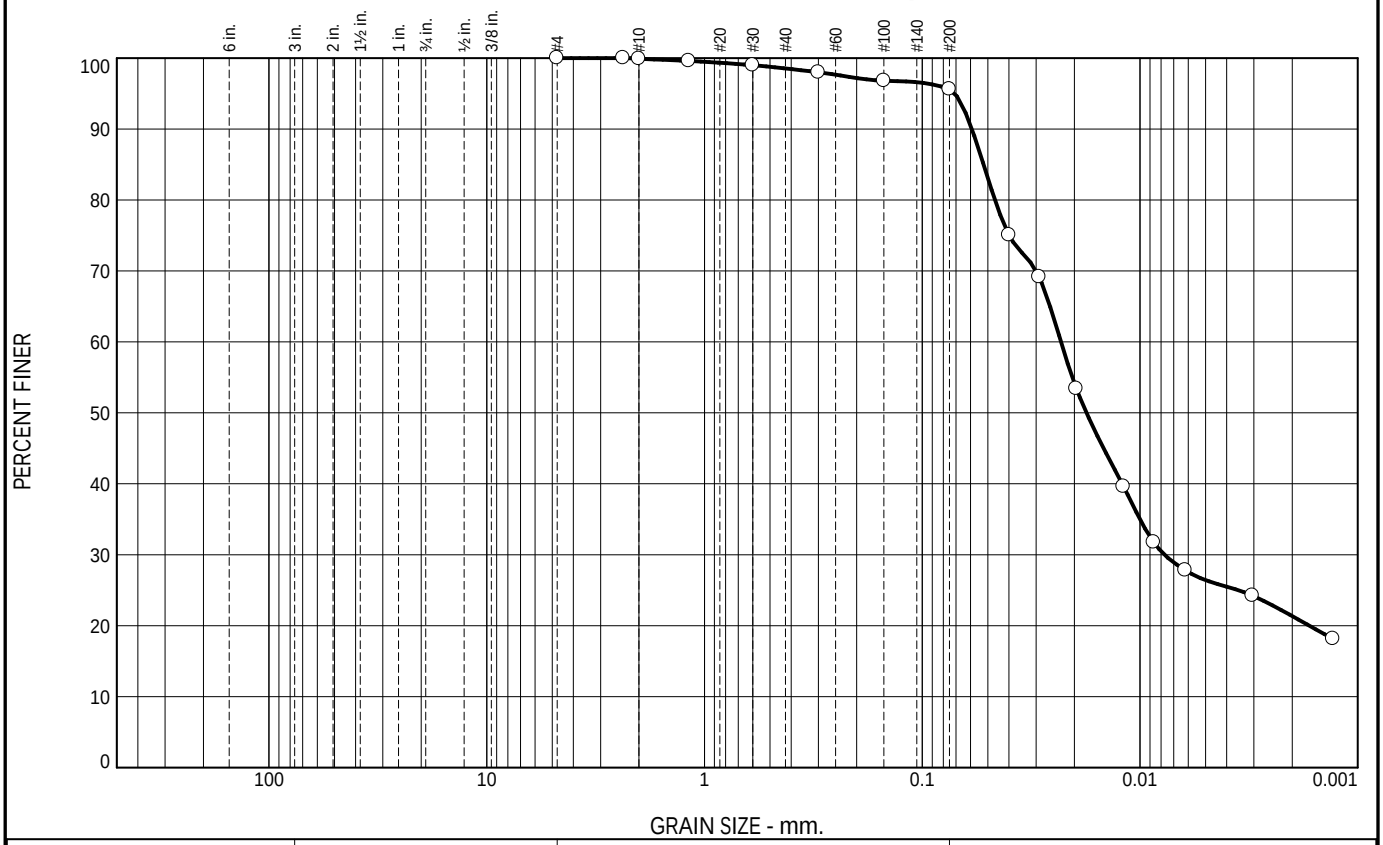
Construction Materials Testing

Client: EcoSource, LLC.
Project: Metro Waste Authority

Project No: 221571MWA Figure

Tested By: J.Hopkins Checked By: S.Ferrier

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.1	1.4	2.9	74.3	21.3

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#8	100.0		
#10	99.9		
#16	99.6		
#30	99.0		
#50	98.0		
#100	96.8		
#200	95.6		
0.0400 mm.	75.1		
0.0290 mm.	69.1		
0.0196 mm.	53.4		
0.0119 mm.	39.6		
0.0087 mm.	31.8		
0.0062 mm.	27.8		
0.0030 mm.	24.2		
0.0013 mm.	18.1		

* (no specification provided)

Soil Description

Gray very silty clay trace sand

Atterberg Limits

PL= 22 LL= 36 PI= 14

Coefficients

D_{90}= 0.0592 D_{85}= 0.0523 D_{60}= 0.0231
D_{50}= 0.0176 D_{30}= 0.0077 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= CL AASHTO= A-6(14)

Remarks

Sampled by others.

Location: B-1
Sample Number: 2 Depth: 20 - 25 FT Date: 12/27/22

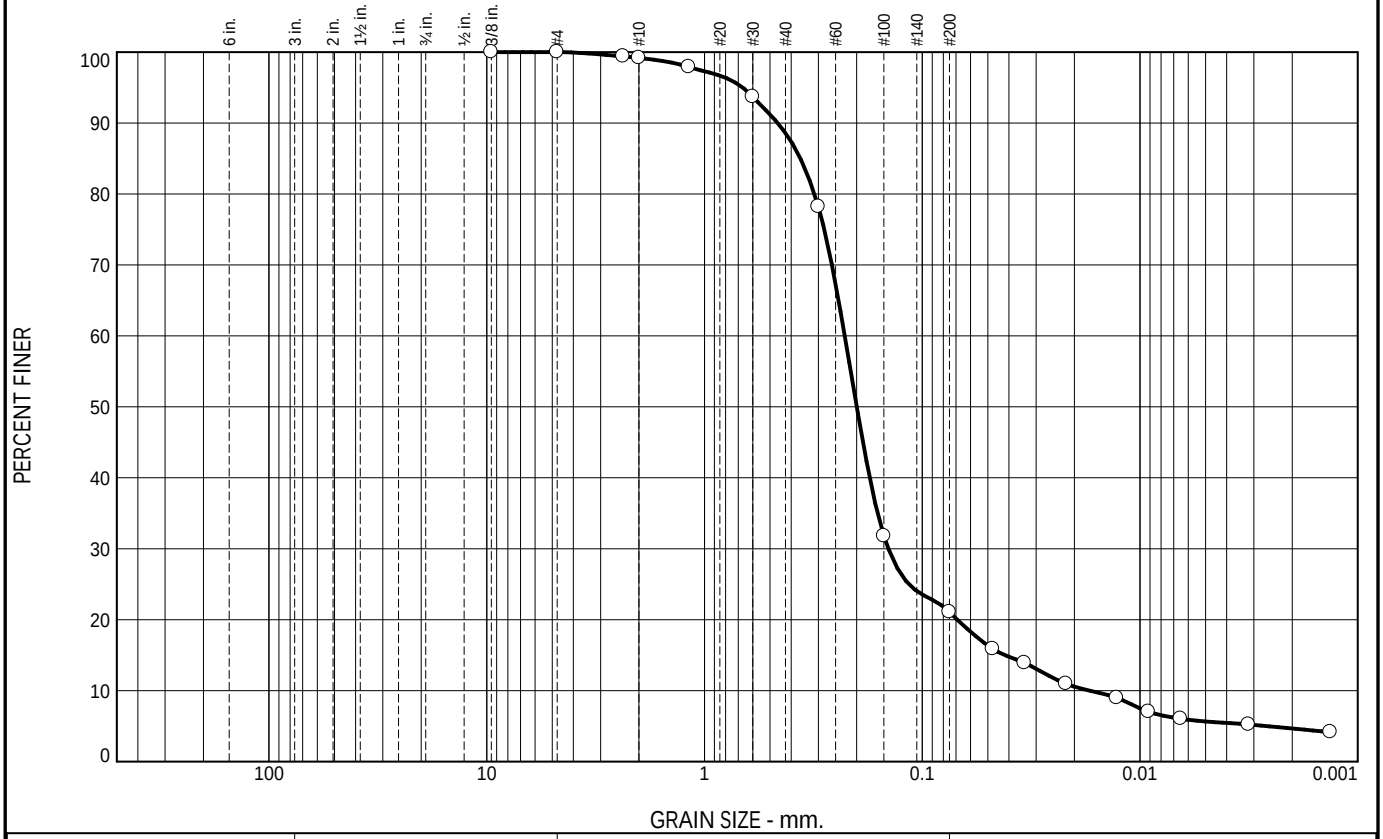
Construction Materials Testing

Client: EcoSource, LLC.
Project: Metro Waste Authority

Project No: 221571MWA Figure

Tested By: J.Hopkins Checked By: S.Ferrier

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.8	10.6	67.5	16.4	4.7

SIEVE SIZE OR DIAMETER	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
3/8"	100.0		
#4	100.0		
#8	99.4		
#10	99.2		
#16	97.9		
#30	93.7		
#50	78.2		
#100	31.8		
#200	21.1		
0.0474 mm.	15.9		
0.0339 mm.	13.9		
0.0219 mm.	11.0		
0.0128 mm.	9.0		
0.0091 mm.	7.0		
0.0065 mm.	6.0		
0.0032 mm.	5.2		
0.0013 mm.	4.2		

* (no specification provided)

Soil Description

Gray fine to medium sand trace silt

Atterberg Limits

PL= NP LL= NV PI= NP

Coefficients

D_{90}= 0.4607 D_{85}= 0.3630 D_{60}= 0.2269
D_{50}= 0.1998 D_{30}= 0.1430 D_{15}= 0.0417
D_{10}= 0.0170 C_u= 13.32 C_c= 5.29

Classification

USCS= SM AASHTO= A-2-4(0)

Remarks

Sampled by others.

Location: B-2
Sample Number: 2 Depth: 25 - 30 FT Date: 12/27/22

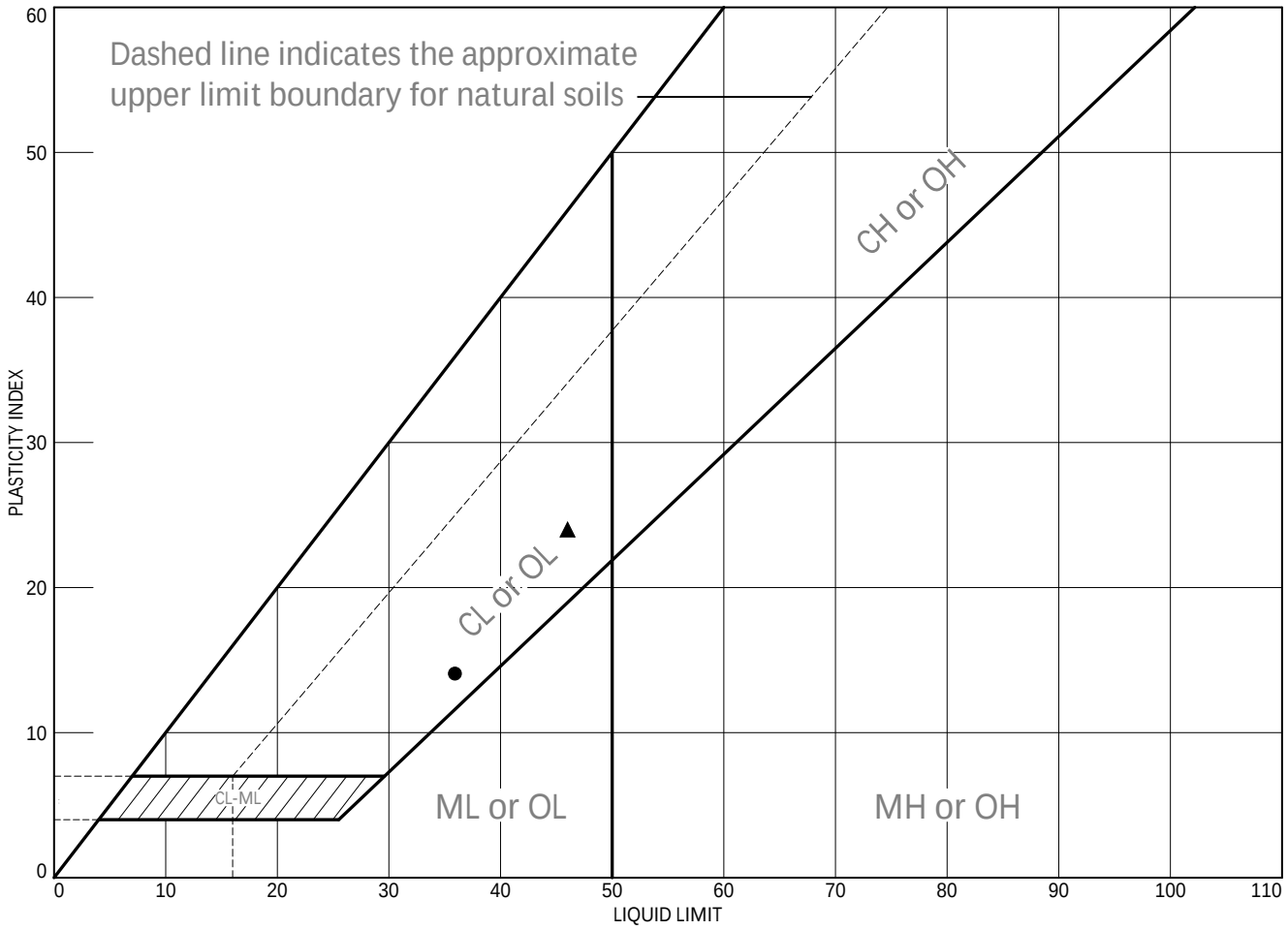
Construction Materials Testing

Client: EcoSource, LLC.
Project: Metro Waste Authority

Project No: 221571MWA Figure

Tested By: J.Hopkins Checked By: S.Ferrier

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Gray very silty clay trace sand	36	22	14	98.5	95.6	CL
■	Gray fine to medium sand trace silt	NV	NP	NP	88.6	21.1	SM
▲	Dark grayish brown silty clay trace sand	46	22	24	97.5	90.6	CL

Project No. 221571MWA Client: EcoSource, LLC.

Project: Metro Waste Authority

●Location: B-1 Depth: 20 - 25 FT Sample Number: 2

■Location: B-2 Depth: 25 - 30 FT Sample Number: 2

▲Location: B-3 Depth: 10 - 15 FT Sample Number: 1

Remarks:

●As received moisture content - 22.5%

■As received moisture content - 20.2%

▲As received moisture content - 33.8%

Figure

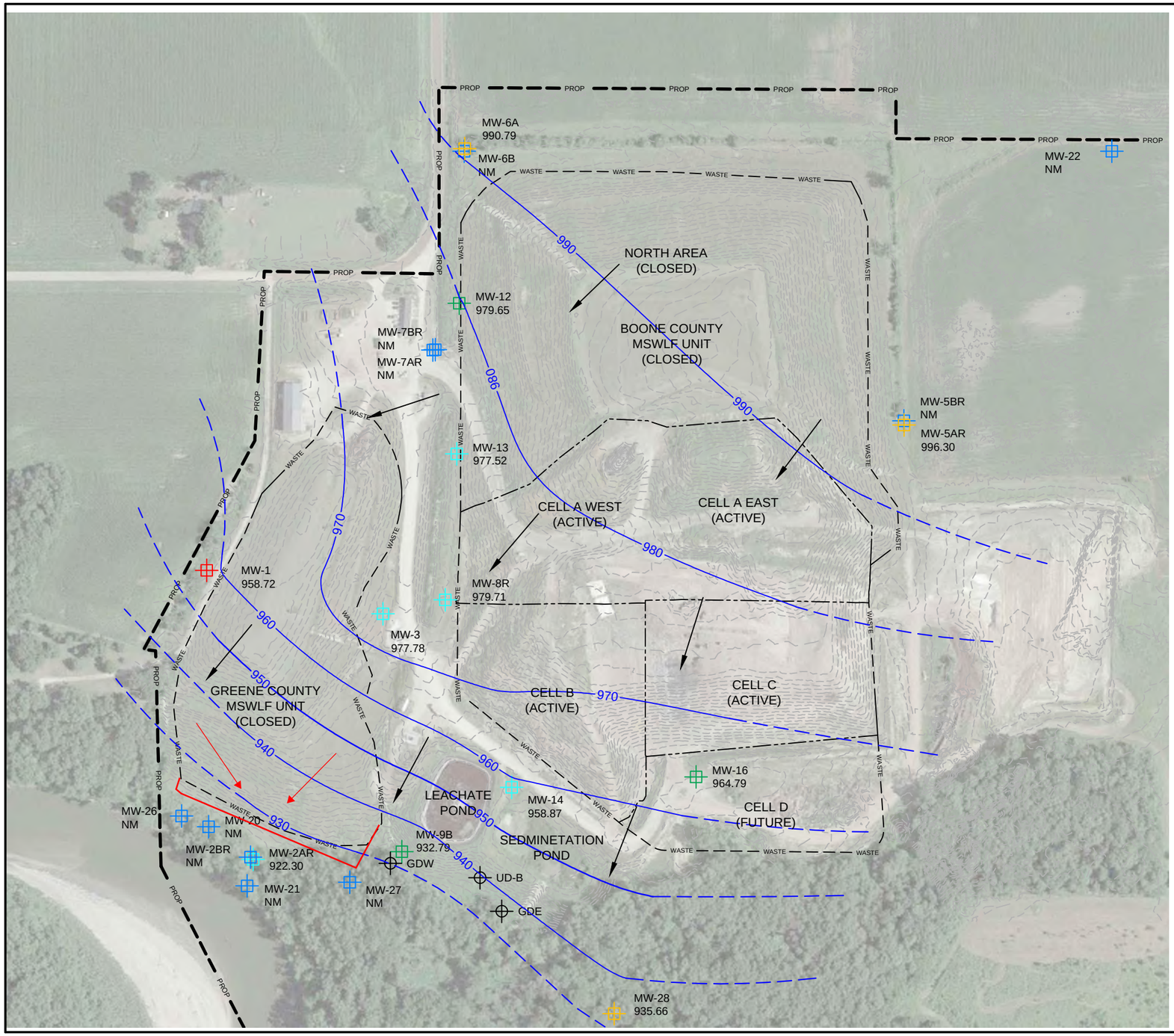
Tested By: D.Tarnow Checked By: S.Ferrier

Hydraulic Conductivity Test Data ASTM D5084

Project: Metro Waste Date: 1/9/2023

Client: Construction Materials Testing Job No.: 14205

Boring No.:	B-1	B-2	B-3				
Sample No.:							
Depth (ft):	20-25	20-25	10-15				
Location:							
Sample Type:	Core	Core	Core				
Soil Classification:	Lean Clay w/lenses and laminations of silt (CL)	Fine to Medium Sand (SM)	Lean Clay slightly organic (CL)				
Atterberg Limits Liquid Limit:							
Atterberg Limits Plastic Limit:							
Atterberg Limits Plasticity Index:							
Permeability Test	Intact Flex Wall	Intact Flex Wall	Intact Flex Wall				
Before Test Conditions Saturation %:							
Before Test Conditions Porosity:							
Before Test Conditions Height (in):	2.39	1.96	1.92				
Before Test Conditions Diameter (in):	1.65	1.44	1.37				
Before Test Conditions Dry Density (pcf):	96.6	110.6	84.8				
Before Test Conditions Water Content:	25.2%	20.2%	20.2%				
Test Conditions Test Type:	Falling	Falling	Falling				
Test Conditions Max Head (ft):	5.0	5.0	5.0				
Test Conditions Confining press. (Effective-psi):	2.0	2.0	2.0				
Test Conditions Trial Numbers:	7-11	7-11	7-11				
Test Conditions Water Temp °C:	22.0	22.0	22.0				
Test Conditions Compaction:							
Test Conditions Saturation %:	96.2%	96.1%	96.1%				
Coefficient of Permeability							
K @ 20 °C (cm/sec)	**3.2×10^{-8}**	**3.5×10^{-4}**	**3.1×10^{-7}**				
K @ 20 °C (ft/min)	**6.2×10^{-8}**	**6.9×10^{-4}**	**6.1×10^{-7}**				
Notes:							



N

250 0 250 500

SCALE IN FEET

GREENE COUNTY MSWLF UNIT WELL NETWORK	
WELL ID	CURRENT MONITORING PROGRAM
MW-1	ASSESSMENT
MW-2AR	PRE-CORECTIVE ACTION
MW-3	PRE-CORECTIVE ACTION
MW-6A	BACKGROUND / UPGRADIENT
MW-28	BACKGROUND / UPGRADIENT

BOONE COUNTY MSWLF UNIT WELL NETWORK	
WELL ID	CURRENT MONITORING PROGRAM
MW-5AR	BACKGROUND / UPGRADIENT
MW-8R	PRE-CORECTIVE ACTION
MW-9B	DETECTION
MW-12	DETECTION
MW-13	PRE-CORECTIVE ACTION
MW-14	PRE-CORECTIVE ACTION
MW-16	DETECTION
GDE	DETECTION
GDW	DETECTION
UD-B	TREATED AS LEACHATE

LEGEND

- PERMITTED EDGE OF WASTE
- CELL BOUNDARY
- PROPERTY LINE
- 990 GROUNDWATER CONTOUR
- INFERRED GROUNDWATER CONTOUR
- GROUNDWATER FLOW DIRECTION
- ASSESSMENT MONITORING WELL
- BACKGROUND MONITORING WELL
- DETECTION MONITORING WELL
- PRE CORRECTIVE ACTION WELL
- WELL - WATER LEVEL ONLY
- GROUNDWATER UNDERDRAIN

NOTES:

1. THE COORDINATE SYSTEM USED FOR THIS MAP IS THE NAD IOWA STATE PLANE SOUTH ZONE (1042).
2. GROUND SURFACE TOPOGRAPHY PROVIDED ON JUNE 30, 2021.
3. NM - STATIC WATER LEVEL MEASUREMENT WAS NOT OBTAINED.

Metro Waste Authority

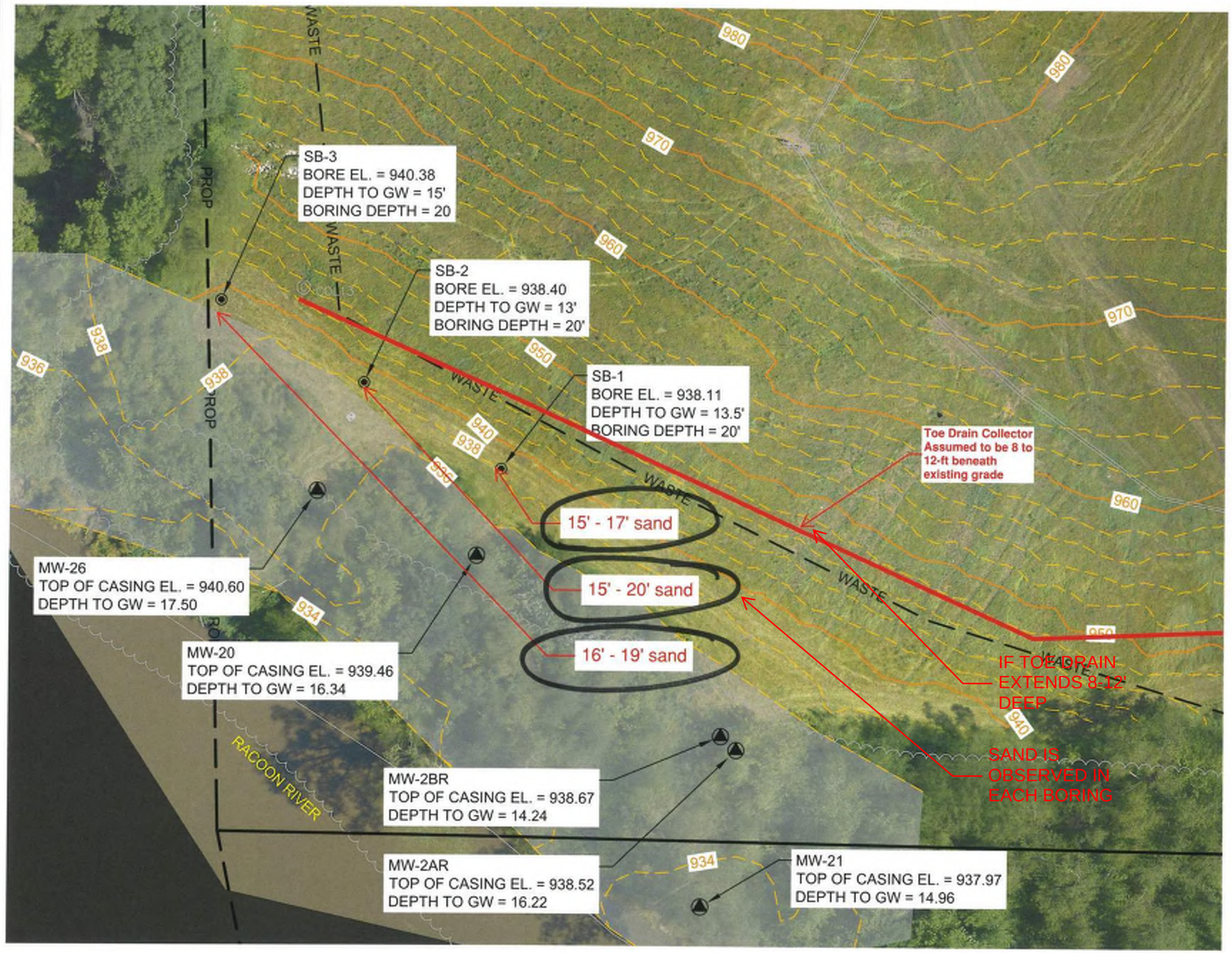
HDR

METRO WASTE AUTHORITY
METRO PARK WEST
GREENE & BOONE COUNTY MSWLF UNITS

GROUNDWATER CONTOUR MAP - MARCH 2022

DATE
JULY 2022

FIGURE
2



LEGEND

AREA OF ASSUMED GRADE OUTSIDE OF JUNE 2021 SURVEY.

LEGEND

1. EXITING CONTOURS ARE A COMBINATION OF AERIAL SURVEY PROVIDED BY AEROVIEW SERVICES, DATED JUNE 30, 2021 AND ASSUMED GRADE CONTINUATION TOWARDS RACOON RIVER BANK.

N

40 0 40 80
SCALE IN FEET

Metro Waste Authority

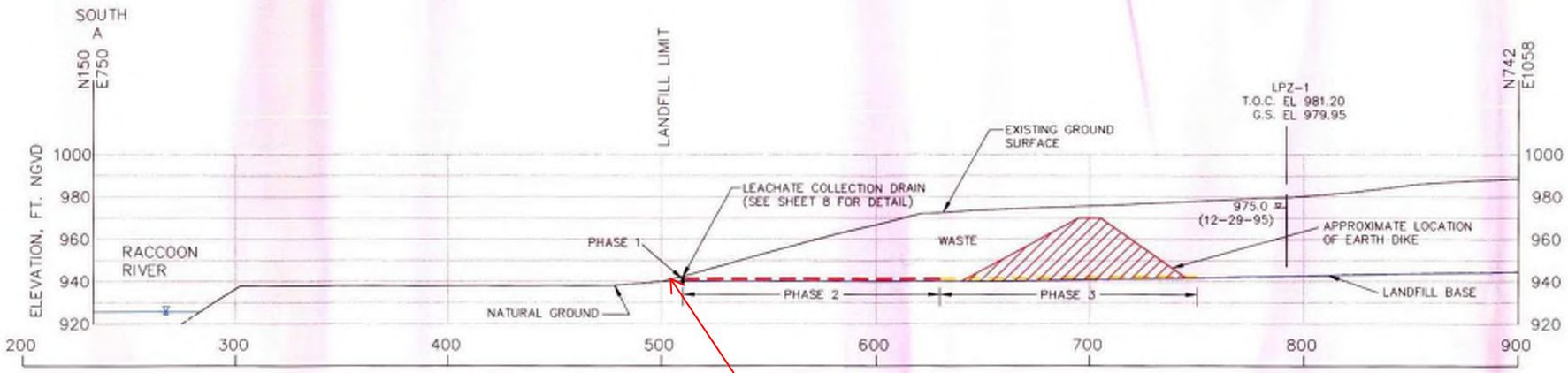
HDR

METRO WASTE AUTHORITY
METRO PARK WEST

PHYTOREMEDIATION ANALYSIS

DATE
JULY 2022

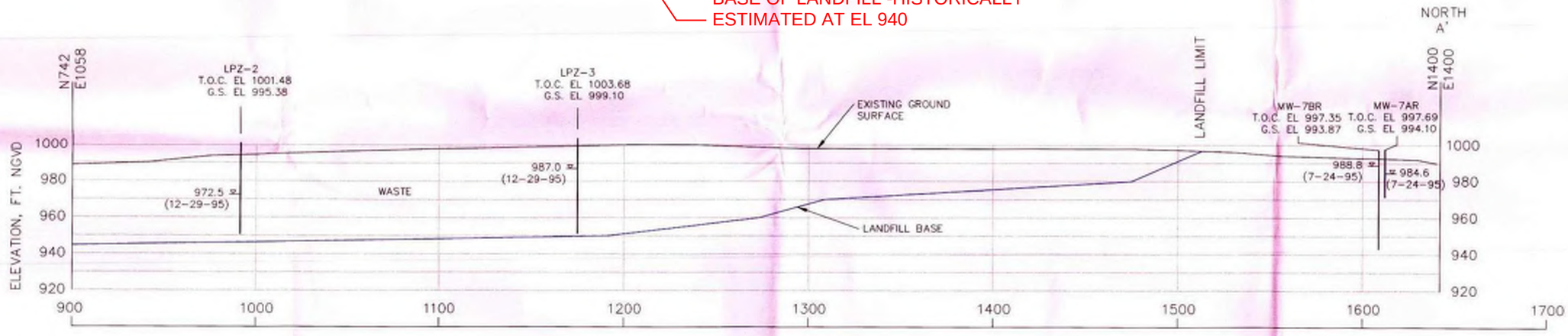
FIGURE
1



BASE OF LANDFILL -HISTORICALLY
ESTIMATED AT EL 940

WELL LEGEND

± FLUID ELEVATION
(7-24-95) – DATE OF FLUID MEASUREMENT
T.O.C. – TOP OF CASING ELEVATION, (FT.)
G.S. – GROUND SURFACE ELEVATION, (FT.)



1/4 SECTION A–A'
HORIZONTAL SCALE: 1"=30'
VERTICAL SCALE: 1"=30'

NOTE: LANDFILL BASE ELEVATIONS ARE APPROXIMATE. ACTUAL IN-SITU CONDITIONS MAY VARY.
THE ABOVE REPRESENTS A CONTINUOUS SECTION BROKEN AT STATION N742,E1058

REFERENCE: McCLURE ENGINEERING CO. LANDFILL DESIGN PLANS, DECEMBER 17, 1980, SHEET UNTITLED.

Filename: SHEET4.DWG
Project No.: E96010
Drawn By: JLH
Reviewed By:

Barker Environmental Service
A TEAM Services Organization
1300 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: (515) 256-8814 Fax: (515) 256-0152

North Dallas Sanitary Landfill
Leachate Control Plan

Section A - A'

Con 12-1-1
Doc # 41653

SHEET NO.
4

HDR

Boring Log

Project Name	Project Number	Drilling Company
MPW Toe Borings		Array Env. / EcoSource

Boring No.	Location	Casing El.	Drilling Rig Type and Drilling Method
B 1-2022.ACM	MPW		Geoprobe 7822 DT

Sample No.	HNU Reading (ppm)	Depth (feet)	Completion	Description	Elevation (feet)	Remarks
				Brown sandy lean clay (SCL)	3'	
	0	5		Gray sandy lean clay trace gravel (SCL) Glacial Till	5	
				▽ WL @ 8'		
	0	10		- dark gray after 10'	10	
	0	15			15	
					16'	
				Gray medium-coarse SAND trace gravel		
	0	20			20	
					22.5'	
				sandy lean clay		
	0	25		Dark gray SCL (GT)	25	
				Bottom of Boring @ 25'		
	0	30			30	
	0	35			35	
	0	40			40	

Water Level			Logged By	Sampled By
While Drilling:	After Drilling:	# Days After Drilling:		
8'	NA		Date Started:	Date Completed

HDR

Boring Log

Project Name	Project Number	Drilling Company
MPW Toe Borings		Array Env / EcoSource

Boring No.	Location	Casing El.	Drilling Rig Type and Drilling Method
B2.2022.Acq	MPW		Geoprobe 7822 DT

Sample No.	HNU Reading (ppm)	Depth (feet)	Completion	Description	Elevation (feet)	Remarks
				Brown-dark brown sandy lean clay SCL	25'	
	0	5		Gray sand lean clay trace gravel (SCL) (Glacial Till)	5	
			WL @7.5'			
	0	10		-dark gray after 8'	10	
	0	15			15	
	0	20			20	
				Gray coarse sand (outwash layer)	22' 23	
	0	25		Dark gray sandy lean clay, trace gravel (Glacial Till)	25	
				Dark Gray medium-coarse SAND	27'	
	0	30		Bottom of Boring @30'	30	
	0	35			35	
	0	40			40	

key in through this layer

do not disturb this layer

Water Level			Logged By	Sampled By
While Drilling:	After Drilling:	# Days After Drilling:		
7.5'	NA		Date Started:	Date Completed

HDR

Boring Log

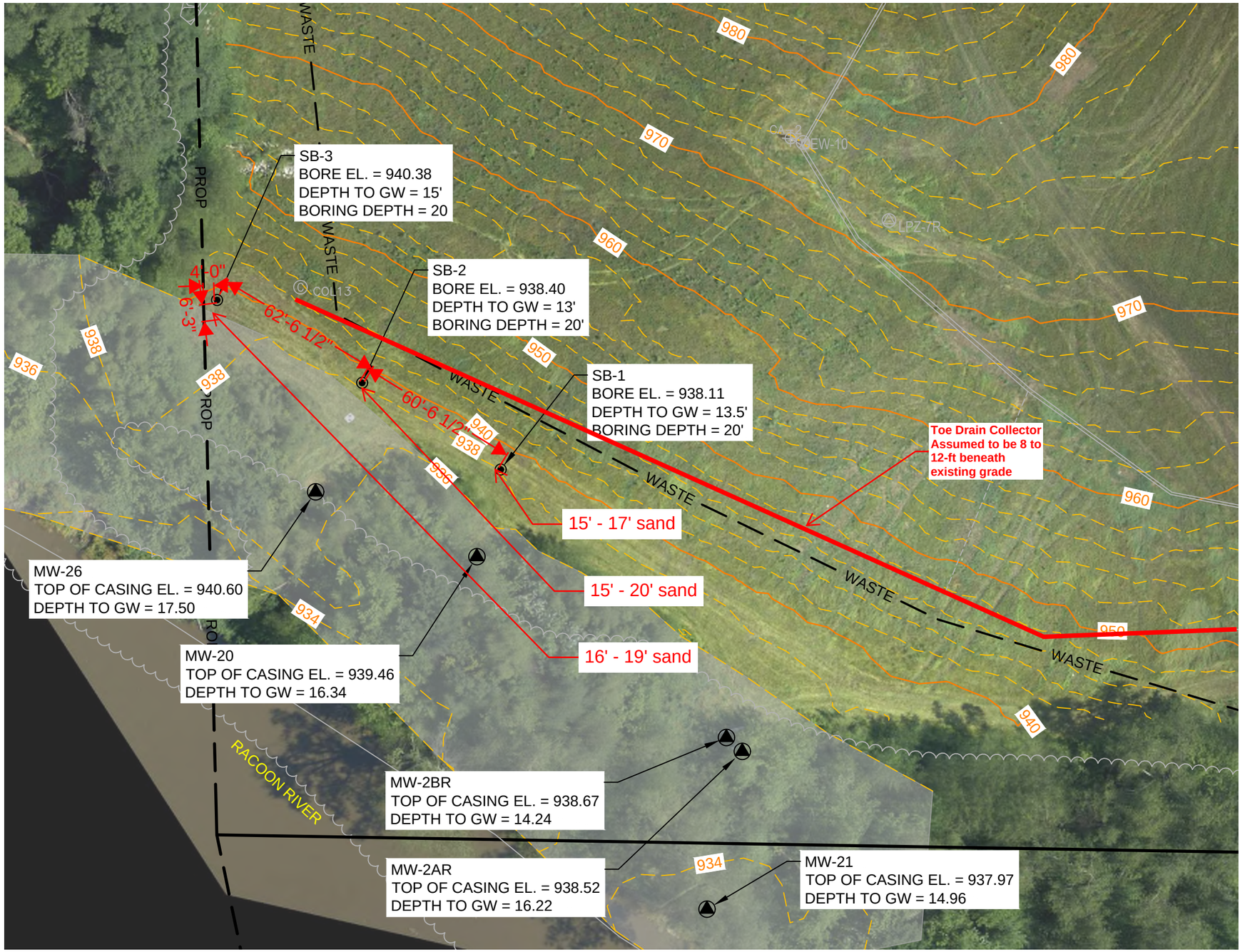
Project Name	Project Number	Drilling Company
MPW Toe Borings		Array Env / EcoSource

Boring No.	Location	Casing El.	Drilling Rig Type and Drilling Method
B3.2022.ACM	MPW		Geoprobe 7822 DT

Sample No.	HNU Reading (ppm)	Depth (feet)	Completion	Description	Elevation (feet)	Remarks
				Dark brown sandy lean clay (SCL	2.5'	
	0	5		Gray sandy lean clay, trace gravel (Glacial T.11)	5	
	wet @ 8'				7'	debris obstruction encountered @ 7' and 9'
	0	10		- dark gray after 8'	10	
	0	15			15	
	0	20			20	
	0	25			25	
				Dark gray medium-coarse SAND	27'	
	0	30		Dark gray Sandy lean clay	29' 30	
				Bottom of Boring @ 30'		
	0	35			35	
	0	40			40	

is this connected to anything?

Water Level			Logged By	Sampled By
While Drilling:	After Drilling:	# Days After Drilling:		
8'	NA		Date Started:	Date Completed



LEGEND

AREA OF ASSUMED GRADE OUTSIDE OF JUNE 2021 SURVEY.

LEGEND

1. EXITING CONTOURS ARE A COMBINATION OF AERIAL SURVEY PROVIDED BY AEROVIEW SERVICES, DATED JUNE 30, 2021 AND ASSUMED GRADE CONTINUATION TOWARDS RACOON RIVER BANK.

N

40 0 40 80

SCALE IN FEET

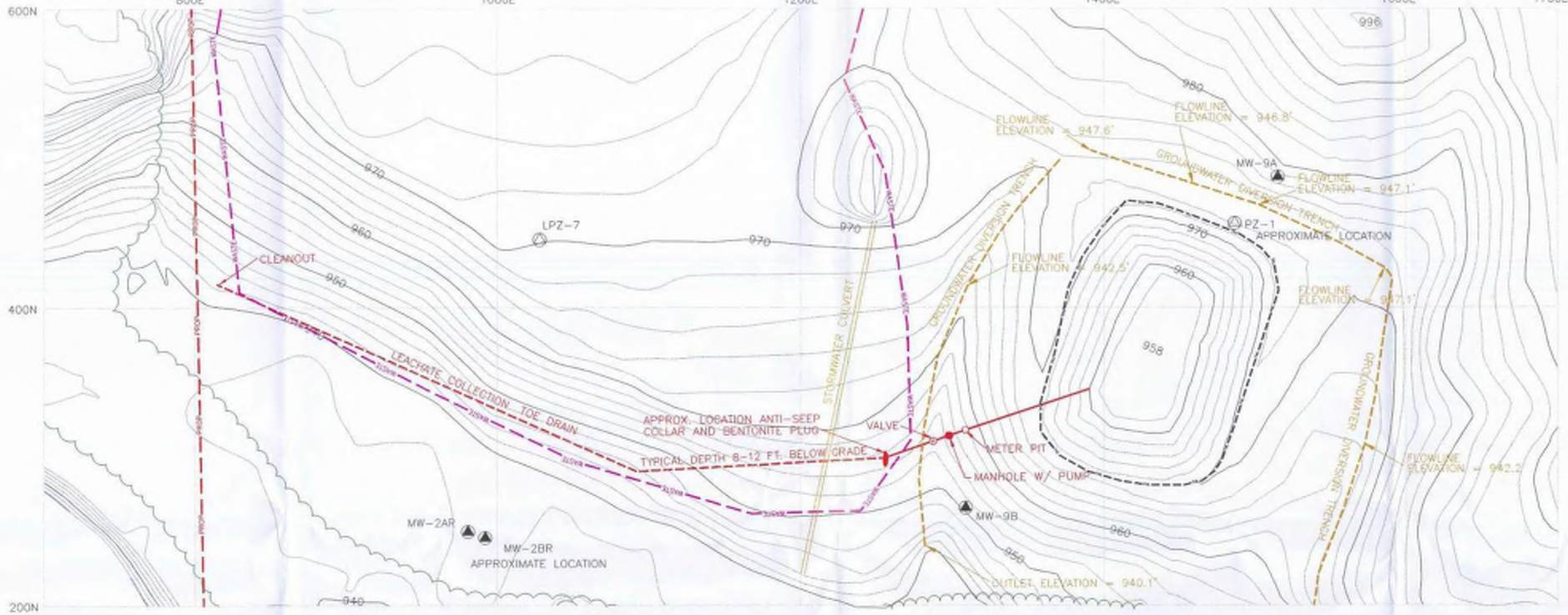
Metro Waste Authority

METRO WASTE AUTHORITY
METRO PARK WEST

PHYTOREMEDIATION ANALYSIS

DATE
JULY 2022

FIGURE
1



SCALE
0 40 FEET
2 FOOT CONTOUR INTERVAL

LEGEND

- MW-1 — MONITORING WELL
- FML — EXISTING FML LINER BOUNDARY
- WASTE — LAGOON SECURITY FENCE
- PROP — GROUNDWATER DRAIN TRENCH ALIGNMENT

LAGOON DESIGN TABLE

LAGOON PARAMETER	
LINER PERIMETER, FT.	525
MAXIMUM ELEVATION (ME), FT.	968
OPERATING ELEVATION (OE), FT.	966
OPERATING FREE BOARD, FT.	2
OPERATING CAPACITY, GAL.	529,000
MAXIMUM CAPACITY, GAL.	766,000
RAIN CAPTURE AREA, FT.^{2}	22,152
EVAPORATION AREA @ ME, FT.^{2}	17,418
EVAPORATION AREA @ OE, FT.^{2}	14,185
AVE. PAN EVAPORATION, IN./YR.	40
AVE. RAINFALL, IN./YR.	32

LEACHATE TOE DRAIN EXCAVATION (LOOKING WEST)

BACKFILLING WITH SHREDDED TIRES (LOOKING WEST)

CONNECTING 6 INCH ADS DRAINAGE TILE

HOT WELDING TWO HDPE LINER SHEETS TOGETHER

RESULTS OF A PRESSURE TEST ON A SEAM

RESULTS OF A VACUUM TEST ON EXTRUSION WELD

Con 12-1-1
Doc # 41623

LEACHATE TOE DRAIN AND LAGOON PLAN
NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA
PROJECT NO. 99018

Barker, Lemar & Associates, Inc.
1300 Cumming Road – Suite 201
Des Moines, Iowa 50315
Phone: (515) 256-8814
Fax: (515) 256-0152

SHEET 2

Soil Boring Log And Monitoring Well Construction Diagram for: SB-1 (East)

Facility Name: Metro Park West Landfill		X Coordinates: 41.863643	Y Coordinates: -94.166123
Well Contractor Name: Jordan Lowry		Drilling Method**: Direct Push	
Well Contractor Registration No: 12145		Boring Depth (ft) x Diameter (in): 20' x 2.0'	
Logged by: Kris Sommer		Ground Surface Elevation (ASL): -	
Start Date: 6/8/2021	Finish Date: 6/8/2021	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type*	PID/FID (PPM)	USCS	Sample Descriptions: soil, color, classification, observation
0		1	CC			(0"-3") Grass and Root Zone
1				0.0	MH CL SP	(3"-1') Dark Brown Silty Clay with Trace Sand
2				0.0	SP	(1'-2') Brown Sand
3				0.0	MH CL	(2'-3') Dark Brown, Dark Gray Silty Clay
4				0.0	MH CL	(4'-7') Gray Silty Clay
5		2	CC	0.0		
6	←			0.0		
7	Backfilled with bentonite upon completion			0.0	SP MH CL	(7'-12') Dark Brown Sandy Silty Clay
8				0.0		
9				0.0		
10		3	CC	0.0		
11				0.0		
12				0.0	SW CL	(12'-15') Dark Brown Fine Sandy Clay
13				0.0		(v 13.5) Groundwater Encountered During Sampling Activities
14				0.0		
15		4	CC	0.0	SP	(15-16') Brown Sand
16				0.0	SW	(16'-17) Gray Fine Sand
17				0.0		
18				0.0		
19				0.0	CH SP	(19'-20') Gray Clay with Trace Sand
20	**End of boring**	5	CC	0.0		
21						
22						
23						
24						
25						

* Sample Types:	** Drilling Method Options:	Symbols to Use:
Split Spoon (SS) Continuous Core (CC)	Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)	v – Static Water Level s – sample collected

Observation Date:	-								
Time:	-								
Static Water Level (ASL):	-								

Soil Boring Log And Monitoring Well Construction Diagram for: SB-2 (Central)

Facility Name: Metro Park West Landfill	X Coordinates: 41.863730	Y Coordinates: -94.166312
Well Contractor Name: Jordan Lowry	Drilling Method**: Direct Push	
Well Contractor Registration No: 12145	Boring Depth (ft) x Diameter (in): 20' x 2.0'	
Logged by: Kris Sommer	Ground Surface Elevation (ASL): -	
Start Date: 6/8/2021 Finish Date: 6/8/2021	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type*	PID/FID (PPM)	USCS	Sample Descriptions: soil, color, classification, observation
0		1	CC			(0"-3") Grass and Root Zone
1				0.0	SP MH CL	(3"-4') Brown Sandy Silty Clay
2				0.0		
3				0.0		
4				0.0	SP CH	(4'-5') Gray Brown Sandy Clay
5		2	CC	0.0	SP CH	(5'-7') Dark Brown Sandy Clay
6	← Backfilled with bentonite upon completion			0.0		
7				0.0	CL CH	(7'-19') Dark Brown Clay
8				0.0		
9				0.0		
10		3	CC	0.0		
11				0.0		
12				0.0	SW CL	(12'-15') Dark Brown Fine Sandy Clay
13				0.0		(v 13.0) Groundwater Encountered During Sampling Activities
14				0.0		
15		4	CC	0.0	SP	(15-16') Brown Sand
16				0.0	SW	(16'-17) Gray Fine Sand
17				0.0		
18				0.0		
19				0.0	SP	(19'-20') Brown Sand
20	**End of boring**	5	CC	0.0		
21						
22						
23						
24						
25						

* Sample Types:	** Drilling Method Options:	Symbols to Use:
Split Spoon (SS) Continuous Core (CC)	Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)	v – Static Water Level s – sample collected

Observation Date:	-									
Time:	-									
Static Water Level (ASL):	-									

Soil Boring Log And Monitoring Well Construction Diagram for: SB-3 (West)

Facility Name: Metro Park West Landfill	X Coordinates: 41.863813	Y Coordinates: -94.166510
Well Contractor Name: Jordan Lowry	Drilling Method**: Direct Push	
Well Contractor Registration No: 12145	Boring Depth (ft) x Diameter (in): 20' x 2.0'	
Logged by: Kris Sommer	Ground Surface Elevation (ASL): -	
Start Date: 6/8/2021 Finish Date: 6/8/2021	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type*	PID/FID (PPM)	USCS	Sample Descriptions: soil, color, classification, observation
0		1	CC			(0"-3") Grass and Root Zone
1				0.0	MH CL	(3"-1') Brown Silty Clay
2				0.0	SW	(1'-2') Light Brown Sand
3				0.0	MH CL SP	(2'-3') Brown Silty Clay Trace Sand
4				0.0	SP CH	(3'-8') Gray Brown Sandy Clay
5		2	CC	0.0		
6	← Backfilled with bentonite upon completion			0.0		
7				0.0		
8				0.0	MH CL	(8'-16') Brown Rust Silty Clay
9				0.0		
10		3	CC	0.0		
11				0.0		
12				0.0		
13				0.0		
14				0.0		
15		4	CC	0.0	SW	(16'-19') Gray Sand
16				0.0		(v 15') Groundwater Encountered During Sampling Activities
17				0.0		
18				0.0		
19				0.0	CH SP	(19'-20') Gray Clay with Trace Sand
20	**End of boring**	5	CC	0.0		
21						
22						
23						
24						
25						

* Sample Types:	** Drilling Method Options:	Symbols to Use:
Split Spoon (SS) Continuous Core (CC)	Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)	v – Static Water Level s – sample collected

Observation Date:	-								
Time:	-								
Static Water Level (ASL):	-								

TABLE 5
GROUNDWATER ELEVATIONS
NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA
BARKER-LEMAR PROJECT NO. E97011

Monitoring Well	Easting Coordinate (feet)	Northing Coordinate (feet)	Top of Casing Elevation (feet)	Ground Water Elevation (feet)
MW-1	877.8	887.0	1003.85	959.41
MW-2AR	980.7	249.6	942.35	925.88
MW-2BR	992.1	245.5	942.53	925.69
MW-3	1267.5	790.3	979.39	976.08
MW-4	1789.5	978.6	997.89	986.02
MW-4R1	1787.6	685.4	1006.37	998.12
MW-4R2	1790.8	451.2	1000.23	992.22
MW-5AR	2421.6	1202.4	1006.33	998.76
MW-5BR	2421.3	1211.1	1005.83	998.84
MW-6A	1449.3	1815.8	1000.60	987.89
MW-6B	1449.8	1807.8	1000.16	988.75
MW-7AR	1382.0	1372.0	997.35	985.65
MW-7BR	1387.5	1373.0	997.69	987.63
MW-8	1415.5	740.0	986.86	981.45
MW-9A	1515.3	487.2	982.77	975.16
MW-9B	1308.9	265.5	950.07	935.42
MW-11	2423.9	605.4	1007.73	993.38

Note: Groundwater elevations measured on December 15, 1997.

LOG OF BORING NO. MW-1

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

TOP OF PROTECTOR PIPE: ft
TOP OF CASING: 1000.74 ft
GROUND SURFACE ELEV.: 997.7 ft

Depth (ft.)	Description	Elevation	Sample Number	Sample Type
0.0–4.0	**SANDY LEAN CLAY, TRACE GRAVEL** Brown	993.7		
4.0–17.0	**SANDY LEAN CLAY WITH GRAVEL** Gray to Brown	980.7	1	SS
			2	ST
			3	SS
17.0–	**SANDY LEAN CLAY WITH GRAVEL** Gray		4	SS
			5	SS
			6	ST

Columns: GRAPHIC LOG, DESCRIPTION, WELL DETAIL, DEPTH (FT.), SAMPLES (USCS SYMBOL, NUMBER, TYPE, RECOVERY), TESTS (SPT - N BLOWS / FT., MOISTURE, %, FIELD VAPOR TESTS)

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	∇ DRY W.D.	▼
WL		
WL		

Terracon

BORING STARTED	10-20-91		
BORING COMPLETED	10-20-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-1

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
			35		7	SS				
			40		8	SS				
			45		9	SS				
			50		10	ST				
			55		11	SS				
	59.0 938.7 BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS		
WL	▽ DRY W.D.	▼
WL		
WL		

Terracon

BORING STARTED	10-20-91		
BORING COMPLETED	10-20-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-2A

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 943.67 ft GROUND SURFACE ELEV.: 939.6 ft									
	SANDY LEAN CLAY Dark Brown				1	SS				
	8.0 ▽ 931.6		5							
	FINE TO MEDIUM SAND Brown				2	SS				
			10							
					3	SS				
			15							
					4	SS				
	21.0 918.6		20							
	BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS			
WL	▽ 8	W.D.	▽
WL			
WL			

Terracon

BORING STARTED	10-21-91		
BORING COMPLETED	10-21-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-2B

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

TOP OF PROTECTOR PIPE: ft
TOP OF CASING: 943.67 ft
GROUND SURFACE ELEV.: 939.6 ft

GRAPHIC LOG	DESCRIPTION	DEPTH (FT.)	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY	TESTS SPT - N BLOWS / FT.	TESTS MOISTURE, %	TESTS FIELD VAPOR TESTS
	SANDY LEAN CLAY Brown	0			HS				
	8.0 — 931.6	5							
	FINE TO MEDIUM SAND Brown	10			HS				
	19.0 — 920.6	15							
	FINE TO MEDIUM SAND WITH GRAVEL Brown	20		1	SS				
	24.0 — 915.6				WB				
	FINE TO VERY COARSE SAND WITH GRAVEL Brown	25		2	SS				
	26.0 — 913.6				WB				
	SANDY LEAN CLAY Gray	30		3	SS				
					HS				

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 4.5 in
WELL DIA.: 2" in

WATER LEVEL OBSERVATIONS

WL	▽ 6	W.D.	▽
WL			
WL			

Terracon

BORING STARTED	12-6-91		
BORING COMPLETED	12-6-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-2B

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
			35		4	SS				
						HS				
			40		5	SS				
						HS				
			45		6	SS				
						HS				
	48.0 891.6									
	49.0 SHALE 890.6 Gray, highly weathered									
	SHALE Black, highly weathered		50		7	SS				
						HS				
	54.0 885.6									
	SHALE Gray		55		8	SS				
						HS				
	58.0 881.6									
	BOTTOM OF BORING AUGER REFUSAL AT 58.0 FT NOTE: Soil classifications are based on obsrevations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

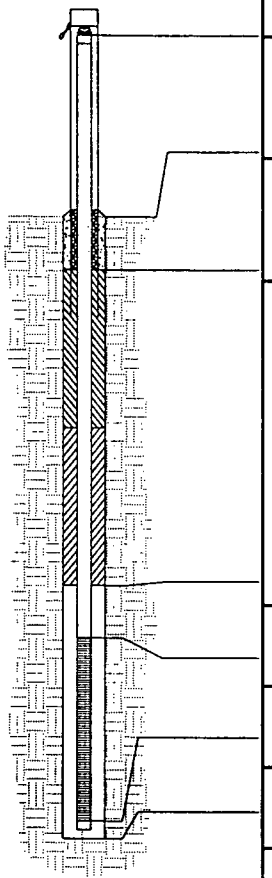
WATER LEVEL OBSERVATIONS			
WL	▽ 6	W.D.	▽
WL			
WL			

Terracon

BORING STARTED	12-6-91		
BORING COMPLETED	12-6-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

BORING LOG/MONITORING WELL CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation Depth
TOC	940.00
Ground	940
Concrete	1
Bentonite Seal	
	40.6
Sand Pack	45.6
Well Screen	50.6
Well Bottom	51
Bottom of Boring	51

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
ST	4 - 6 ft	HS	16"	24"	Dark Gray Sandy Lean Clay
SS	6 - 8 ft	HS	8"		Gray Silty Clay
SS	9 - 11 ft	HS	8"		Gray Med. Sand @ 8 ft.
					Gray Med. Coarse Sand, Trace Gravel to 26 ft.
SS	29 - 31 ft	HS	18"		Gray Sandy Lean Clay
ST	34 - 36 ft	HS	20"	24"	Gray Sandy Lean Clay, Trace Gravel
SS	39 - 41 ft	HS	18"		Gray Sandy Lean Clay
SS	44 - 46 ft	HS	20"		Gray Sandy Lean Clay
SS	49 - 51 ft	HS	20"		Gray Shale @ 49.5 ft.
					Bottom of Boring @ 51.0 ft.

AR-Air Rotary — HS-Hollow Stem Auger
AS-Auger Sample — PA-Power Auger (solid stem)
CS-Continuous Sampler — SS-Split Spoon
HA-Hand Auger — ST-Shelby Tube

Date:	3/23/99	3/30/99			
Time:	10:00	10:15			
Water Level:	6.0	21.72			
Elevation:		918.28			

Driller: Barker-Lemar
Logged By: K. Sperfslage
Date/Time Start: 3/23/99
Date/Time End: 3/23/99

Barker, Lemar & Associates
1300 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: 515-256-8814
Fax: 515-256-0152

Borehole Diameter: 8.25"
Well Casing Diameter: 2"
Well Screen Size: 0.010"

Project: **Project No. 99018**
Location: **Perry, Iowa**
Client: **North Dallas SLF**
Owner: **North Dallas SLF**
Boring/Well No: **MW-2BR**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: North Dallas Sanitary Landfill — Permit # 8-SDP-3-84P
Well or Piezometer #: MW-2BR — Date Started: 3/23/99 — Date Completed: 3/23/99

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):
- Specify corner of site: NE Fence Corner
- Distance and Direction along boundary: 1425 ft West
- Distance and Direction from boundary to well: 1550 ft South

Elevation(+/-0.01 ft. MSL):
- Ground surface: Approx. 940
- Top of Protective Casing: Approx. 943
- Top of Well Casing: Aprox. 940
- Benchmark Elevation: 1004.66
- Benchmark Description: RR spike in the NE face of the power pole at west approach

B. Soil Boring Information
- Name and Address of Construction Company: Barker, Lemar & Associates, Inc., 1300 Cummins Rd. Suite 201, Des Moines, IA 50315
- Name of Driller: Kevin Sperfslage
- Drilling Method: Hollow Stem Augers
- Drilling Fluid: none
- Bore hole Diameter: 8.25 inch
- Soil Sampling Method: CS and ST
- Depth of Boring: 51 ft

C. Monitoring Well Installation
- Casing Material: PVC
- Length of Casing: 51.0 ft
- Outside Casing Diameter: 2.375 inch
- Inside Casing Diameter: 2.0 inch
- Casing Joint Type: threaded
- Casing/Screen joint type: threaded
- Screen material: PVC
- Screen opening size: 0.010 inch
- Screen length: 5.0 ft
- Depth of Well: 51.0 ft

Well Installation, continued:

Filter pack:
- Material: Northern
- Grain Size: #0
- Volume: 3.0 ft^3

Seal (minimum 3 ft. length above filter pack):
- Material: Bentonite
- Placement Method: poured
- Volume: 0.5 ft^3

Backfill (if different from seal):
- Material:
- Placement Method:
- Volume:

Surface seal design:
- Material of Protective Casing: steel
- Material of grout between protective casing and well casing: concrete
- Protective cap material: steel
- Vented? (Y/N) Y — Locking? (Y/N) Y
- Well cap material: PVC
- Vented? (Y/N) Y

D. Groundwater Measurement
- Water level (+/-0.01 ft. below top of inner well casing): 21.72
- Stabilization time: 6 days
- Well development method: Bailing

Upgradient or downgradient well?: downgradient

Average Depth of Frostline: 4-feet

LOG OF BORING NO. MW-3

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

TOP OF PROTECTOR PIPE: ft
TOP OF CASING: 976.37 ft
GROUND SURFACE ELEV.: 973.4 ft

DEPTH (FT.)	DESCRIPTION	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
1.0	SANDY LEAN CLAY, TRACE GRAVEL, Brown							
5			1	SS				
10			2	SS				
15			3	SS				
20			4	SS				
25			5	SS				
26.0	SANDY LEAN CLAY, TRACE GRAVEL, Gray							
947.4	BOTTOM OF BORING							

NOTE: Soil classifications are based on observations made by the field crew.

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	▽ DRY W.D.	▼
WL		
WL		

Terracon

BORING STARTED	10-21-91		
BORING COMPLETED	10-21-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-4

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 994.85 ft GROUND SURFACE ELEV.: 991.9 ft									
	SANDY LEAN CLAY WITH GRAVEL Brown		0							
	2.0 989.9									
	SANDY LEAN CLAY Gray		5			SS				
			10			SS				
			15			SS				
			20			ST				
			25			SS				
			30			ST				

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	▽ 15	W.S. ▼
WL		
WL		

Terracon

BORING STARTED	10-21-91		
BORING COMPLETED	10-21-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-4

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
			35			SS				
	36.0 955.9 Shale observed at bottom of boring BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS			
WL	▽ 15	W.S.	▼
WL			
WL			

Terracon

BORING STARTED	10-21-91		
BORING COMPLETED	10-21-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-5A

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 1004.35 ft GROUND SURFACE ELEV.: 1001.4 ft									
	SANDY LEAN CLAY 1.5 Dark Brown 999.9									
	SANDY LEAN CLAY, TRACE GRAVEL Gray to Brown		5		1	SS				
	7.0 994.4									
	SANDY LEAN CLAY Brown		10		2	SS				
	13.0 988.4									
	SANDY LEAN CLAY WITH GRAVEL 15.0 Gray 986.4		15		3	ST				
	BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	▽ DRY W.D.	▼
WL		
WL		

Terracon

BORING STARTED	10-21-91		
BORING COMPLETED	10-21-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-5B

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

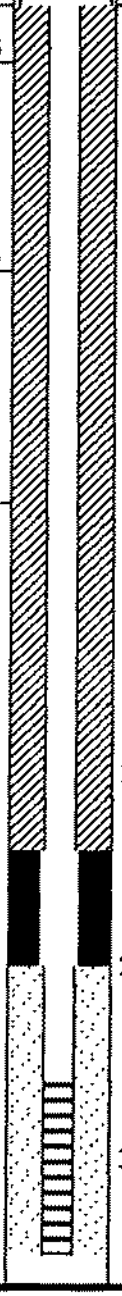
PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

TOP OF PROTECTOR PIPE: ft
TOP OF CASING: 1004.33 ft
GROUND SURFACE ELEV.: 1001.3 ft

DESCRIPTION		
SANDY LEAN CLAY Dark Brown	1.5	999.8
SANDY LEAN CLAY, TRACE GRAVEL Gray to Brown	7.0	994.3
SANDY LEAN CLAY Brown	13.0	988.3
SANDY LEAN CLAY WITH GRAVEL Gray		

Continued Next Page

DEPTH (FT.)	SAMPLES: USCS SYMBOL	NUMBER	TYPE	RECOVERY	TESTS: SPT - N BLOWS / FT.	MOISTURE, %	FIELD VAPOR TESTS
5		1	SS				
10		2	SS				
15		3	ST				
20		4	SS				
25		5	SS				
30		6	ST				



THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	DRY W.D.	
WL		
WL		

Terracon

BORING STARTED	10-21-91
BORING COMPLETED	10-21-91
RIG 37	FOREMAN TSL
APPROVED TSL	JOB # 45905038

LOG OF BORING NO. MW-5B

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	34.7 966.6									
	35.0 SHALE 966.3		35		7	SS				
	BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS		
WL	▽ DRY W.D.	▼
WL		
WL		

Terracon

BORING STARTED	10-21-91		
BORING COMPLETED	10-21-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-6

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 998.97 ft GROUND SURFACE ELEV.: 992.8 ft									
	SANDY LEAN CLAY 1.5 Dark Brown 991.3									
	SANDY LEAN CLAY, TRACE GRAVEL Gray to Brown		5		1	SS				
			10		2	SS				
	13.0 979.8									
	SANDY LEAN CLAY WITH GRAVEL Gray		15		3	ST			14.8	
			20		4	SS				
	21.0 971.8									
	BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	DRY W.D.	
WL		
WL		

Terracon

BORING STARTED	10-21-91		
BORING COMPLETED	10-21-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-7A

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 993.18 ft GROUND SURFACE ELEV.: 990.2 ft									
	MEDIUM SAND [FILL] Dark Brown									
	3.0 987.2									
	SANDY LEAN CLAY WITH GRAVEL Gray to Brown		5		1	SS				
			10		2	SS				
			15		3	SS				
	20.0 970.2		20		4	ST				
	BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	DRY W.D.	
WL		
WL		

Terracon

BORING STARTED	10-20-91		
BORING COMPLETED	10-20-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-7B

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 992.92 ft GROUND SURFACE ELEV.: 989.9 ft									
	MEDIUM SAND (FILL) Dark Brown									
	3.0 — 986.9									
	SANDY LEAN CLAY WITH GRAVEL Gray to Brown		5		1	SS				
			10		2	SS				
			15		3	SS				
			20		4	ST				
	23.0 — 966.9									
	SANDY LEAN CLAY WITH GRAVEL Gray		25		5	SS				
			30		6	SS				

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 7.5 in
WELL DIA.: 2 in

WATER LEVEL OBSERVATIONS		
WL	DRY W.D.	
WL		
WL		

Terracon

BORING STARTED	10-20-91		
BORING COMPLETED	10-20-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. MW-7B

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
			35		7	SS				
			40		8	SS				
			45		9	ST			14.6	
	49.0 940.9 BOTTOM 0F BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS		
WL	▽ DRY W.D.	▼
WL		
WL		

Terracon

BORING STARTED	10-20-91		
BORING COMPLETED	10-20-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. RW-1A

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: N.S. ft GROUND SURFACE ELEV.: 975.4 ft									
	LEAN CLAY Brown									
	4.0 971.4									
	REFUSE									
			25		1	SS				
					2	SS				
			30		3	SS				
					4	SS				

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 6.5 in
WELL DIA.: 4 in

WATER LEVEL OBSERVATIONS			
WL	▽ 6	W.D.	▽
WL			
WL			

Terracon

BORING STARTED	12-9-91		
BORING COMPLETED	12-9-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. RW-1A

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	33.5 941.9									
	SANDY LEAN CLAY				5	SS				
	35.0 Gray 940.4		35							
	BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS			
WL	▽ 6	W.D.	▼
WL			
WL			

Terracon

BORING STARTED	12-9-91		
BORING COMPLETED	12-9-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. RW-2

OWNER
RINEHART CONSTRUCTION

ARCHITECT/ENGINEER

SITE NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT
HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 998.92 ft GROUND SURFACE ELEV.: 993.4 ft									
	LEAN CLAY Brown 3.0 990.4									
	REFUSE		5 10 15 20 25 30							

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 6.5 in
WELL DIA.: 4 in

WATER LEVEL OBSERVATIONS			
WL	8	W.D.	
WL			
WL			

Terracon

BORING STARTED	12-4-91		
BORING COMPLETED	12-4-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. RW-2

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
			35							
			40							
			45							
	50.0 943.4 SANDY LEAN CLAY WITH GRAVEL Gray		50		1	SS				
	52.0 941.4 BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS			
WL	▽ 8	W.D.	▼
WL			
WL			

Terracon

BORING STARTED	12-4-91		
BORING COMPLETED	12-4-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. RW-3

OWNER
RINEHART CONSTRUCTION

ARCHITECT/ENGINEER

SITE NORTH DALLAS SANITARY LANDFILL
PERRY, IOWA

PROJECT
HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: N.S. ft GROUND SURFACE ELEV.: 996.4 ft									
	LEAN CLAY Brown									
	3.0 993.4									
	REFUSE		5 10 15 20 25 30							

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

BOREHOLE DIA.: 6.5 in
WELL DIA.: 4 in

WATER LEVEL OBSERVATIONS			
WL	7	W.D.	
WL			
WL			

Terracon

BORING STARTED	12-5-91		
BORING COMPLETED	12-5-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. RW-3

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
			35							
			40		1	SS				
					2	SS				
			45		3	SS				
					4	SS				
					5	SS				
	48.5 947.9 49.0 SANDY LEAN CLAY 947.4 Gray									

BOTTOM OF BORING

NOTE: Soil classifications are based on observations made by the field crew.

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

WATER LEVEL OBSERVATIONS		
WL	▽ 7	W.D. ▼
WL		
WL		

Terracon

BORING STARTED	12-5-91		
BORING COMPLETED	12-5-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

LOG OF BORING NO. RW-4

OWNER: RINEHART CONSTRUCTION

ARCHITECT/ENGINEER:

SITE: NORTH DALLAS SANITARY LANDFILL, PERRY, IOWA

PROJECT: HYDROGEOLOGICAL ASSESSMENT REPORT

GRAPHIC LOG	DESCRIPTION	WELL DETAIL	DEPTH (FT.)	SAMPLES: USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY	TESTS: SPT - N BLOWS / FT.	TESTS: MOISTURE, %	TESTS: FIELD VAPOR TESTS
	TOP OF PROTECTOR PIPE: ft TOP OF CASING: 1011.54 ft GROUND SURFACE ELEV.: 1004.5 ft									
	LEAN CLAY Brown									
	5.0 — 999.5									
	REFUSE		5							
			10		1	SS				
					2	SS				
			15		3	SS				
					4	SS				
					5	SS				
			20		6	SS				
					7	SS				
	24.0 — 980.5									
	SANDY LEAN CLAY		25		8	SS				
	26.0 Gray to Brown — 978.5									
	BOTTOM OF BORING NOTE: Soil classifications are based on observations made by the field crew.									

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

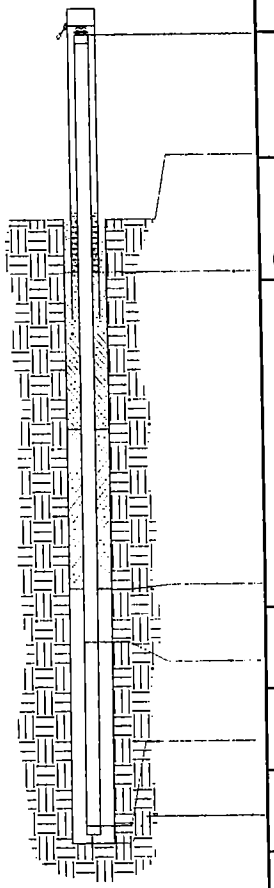
BOREHOLE DIA.: 6.5 in
WELL DIA.: 4 in

WATER LEVEL OBSERVATIONS		
WL	▽ DRY W.D.	▼
WL		
WL		

Terracon

BORING STARTED	12-3-91		
BORING COMPLETED	12-3-91		
RIG	37	FOREMAN	TSL
APPROVED	TSL	JOB #	45905038

BORING LOG/MONITORING WE _ CONSTRUCTION DETAIL



Monitoring Well Detail			Boring Log Detail					
Material	Elevation Depth	Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
TOC	1006.37						
Ground	1003.3						
		CS	0 - 15 ft	HS		0 - 1.5 ft	Brown Sandy Lean Clay, trace of
							Gravel
Concrete	1						
						1.5 - 2 ft	Fine Sand
						2 - 14 ft	Brown Sandy Lean Clay, trace of
Bentonite Seal							Gravel
						14 - 16 ft	Brown to Gray Sandy Lean Clay
		3" ST	15 - 17 ft		2 ft		trace of Gravel
	8.5						
Sand Pack		CS	17 - 20 ft				
	9.2						
Well Screen							
	19.2						
Well Bottom							
	20						
Bottom of Boring							
	20						

AR-Air Rotary	HS-Hollow Stem Auger
AS-Auger Sample	PA-Power Auger (solid stem)
CS-Continuous Sampler	SS-Split Spoon
HA-Hand Auger	ST-Shelby Tube

Date:	8/26/97
Time:	12:00
Water Level:	dry
Elevation:	

Driller:	Shirley Environmental
Logged By:	Krumel
Date/Time Start:	8/26/97 10:45
Date/Time End:	8/26/97 11:30

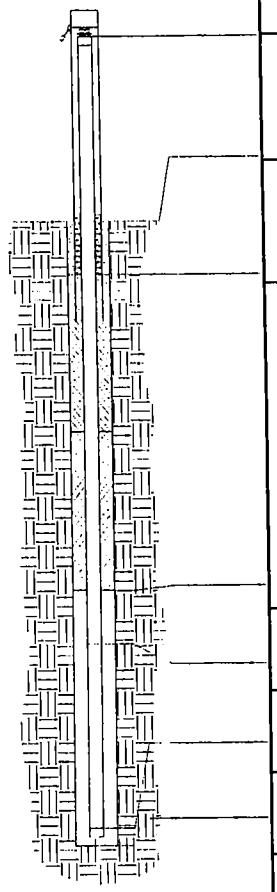
Barker Environmental Services, Inc.
1610 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: 515-289-2214 Fax: 515-289-2215

Borehole Diameter:	8.25"
Well Casing Diameter:	2"
Well Screen Size:	0.010"

Project:	**BES Project No. E97011**
Location:	**Perry, Iowa**
Client:	**North Dallas SLF**
Owner:	**North Dallas SLF**
Boring/Well No:	**MW-4R1**

BORING LOG/MONITORING WE . CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	1000.23
Ground	997.5
Concrete	1
Bentonite Seal	19
Sand Pack	19.7
Well Screen	29.7
Well Bottom	30
Bottom of Boring	30

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
CS	**0 - 25 ft**	**HS**		**0 - 3 ft**	Dark Brown Sandy Lean Clay
				3 - 5 ft	Brown to Gray Sandy Lean Clay,
					trace of Gravel
				5 - 17.5 ft	Brown to Gray Sandy Lean Clay,
					trace of Gravel (moist)
				17.5 - 30 ft	Gray Sandy Lean Clay, trace of
ST	**25 - 27 ft**		**2 ft**		Gravel (wet @ 17.5 ft)
CS	**27 - 30 ft**				

AR-Air Rotary
AS-Auger Sample
CS-Continuous Sampler
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
ST-Shelby Tube

Date:	8/26/97
Time:	13:40
Water Level:	27.2
Elevation:	973.03

Driller:	Shirley Environmental
Logged By:	Krumel
Date/Time Start:	8/26/97 11:45
Date/Time End:	8/26/97 12:35

Barker Environmental Services, Inc.
1600 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: (515) 255-9514 Fax: (515) 255-0152

Borehole Diameter:	8.25"
Well Casing Diameter:	2"
Well Screen Size:	0.010"

Project:	**BES Project No. E97011**
Location:	**Perry, Iowa**
Client:	**North Dallas SLF**
Owner:	**North Dallas SLF**
Boring/Well No:	**MW-4R2**

LOG OF BORING NO. MW6A

OWNER: Rienhart Construction

ARCHITECT/ENGINEER:

SITE: Perry, Iowa

PROJECT: North Dallas Sanitary Landfill

GRAPHIC LOG	DESCRIPTION	DEPTH (FT.)	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY	SAMPLES SPT - N BLOWS / FT.	TESTS MOISTURE, %	TESTS DRY DENSITY PCF	TESTS UNCONFINED STRENGTH PSF
	Approx. Surface Elev.: 999.8 ft.									
	Topsoil -- sandy lean CLAY, dark brown			1	HS	4'				
	3.0 996.8	5								
	Sandy lean CLAY, brown									
	-- color changes to brown-gray at 5'			2	HS	5'				
	-- trace gravel at 7'									
	-- becomes stiff at 10'	10		3	HS	4.5'				
	-- becomes very stiff at 15'	15		4	HS	5'				
	20.0 979.8	20								
	Bottom of Monitoring Well									

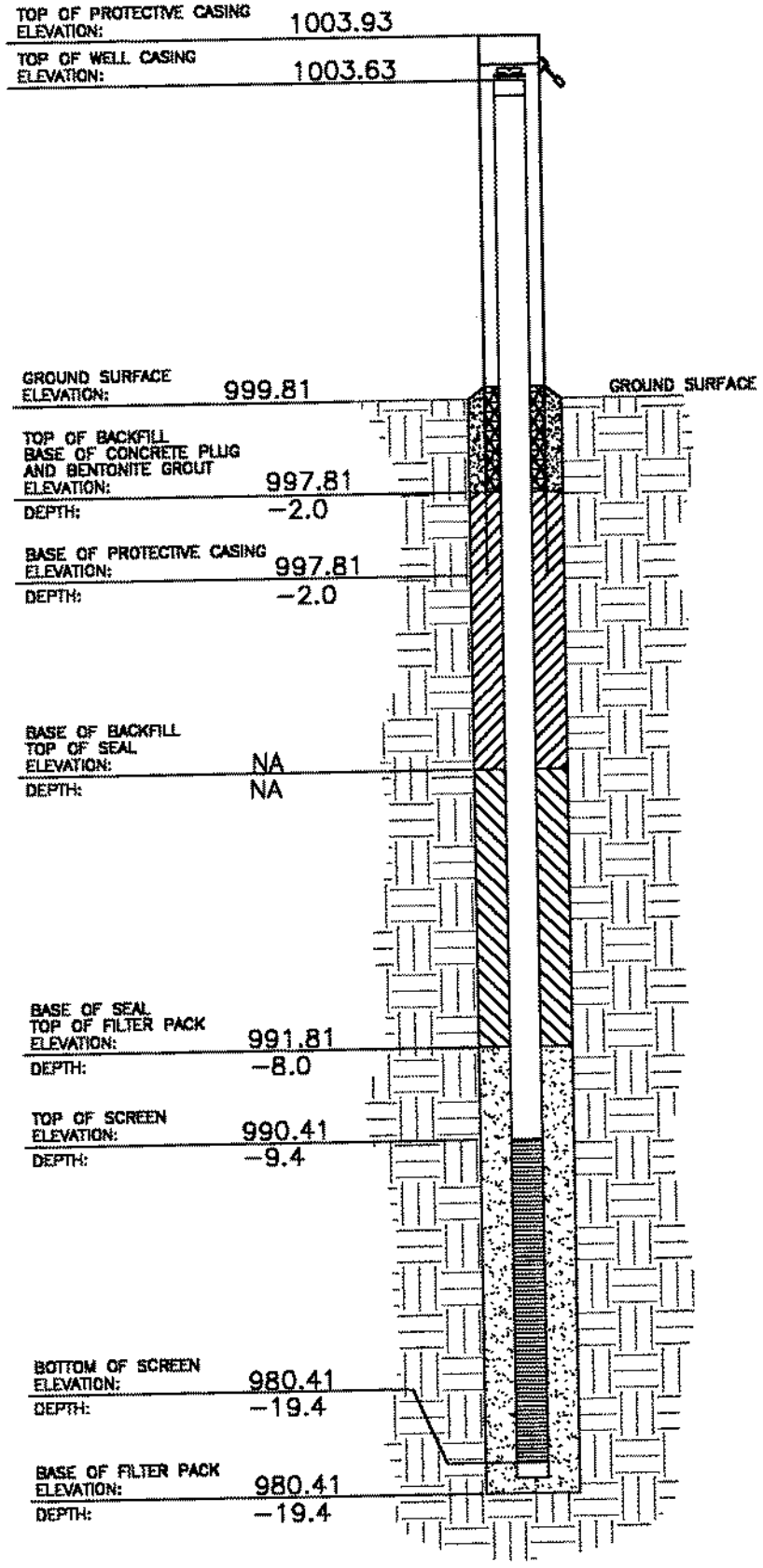
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

Calibrated Hand Penetrometer*

WATER LEVEL OBSERVATIONS				
WL	▽ Dry	WD	▼	
WL	19' 2 hrs AD			
WL				

TEAM Services, Inc.

BORING STARTED	3-19-96		
BORING COMPLETED	3-19-96		
RIG	12-ATV	FOREMAN	J&R
APPROVED	RAK	JOB #	E96016



MW-6A Detail
North Dallas Sanitary Landfill
Perry, Iowa
BES Project No. E97011

Barker Environmental Services, Inc.
1300 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: (515) 256-8814 Fax: (515) 256-0152

WELL DETAIL

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: North Dallas Sanitary Landfill — Permit # 8-SDP-3-84P
Well or Piezometer #: MW-6A — Date Started: 3/19/96 — Date Completed: 3/19/96

A. Surveyed Locations and Elevtions

Locations (+/-0.5 ft.):

Specify corner of site: SE

Distance and Direction along boundary: 1450-feet east, 1810-feet north

Distance and Direction from boundary to well: Well at NW corner of Boone County site

Elevation(+/-0.01 ft. MSL):

Ground surface	999.81ft.
Top of Protective Casing	1003.93 ft.
Top of Well Casing	1003.63 ft.
Benchmark Elevation	997.69 ft.
Benchmark Description	TOC of MW-7AR

B. Soil Boring Information

Name and Address of Construction Company:
J&R Drilling
7922 NW 114th Street
Grime, Iowa 50111

Name of Driller	Rick
Drilling Method	HS auger
Drilling Fluid	none
Bore hole Diameter	7 & 3/4-inch
Soil Sampling Method	continuous
Depth of Boring	19.4 ft.

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	12.4 ft.
Outside Casing Diameter	2.2-inch
Inside Casing Diameter	2-inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010-inch
Screen length	10 ft.
Depth of Well	19.4 ft.

Well Installation, continued:

Filter pack:

Material	Muscatine gravel
Grain Size	#00
Volume	200 lbs.

Seal (minimum 3 ft. length above filter pack):

Material	bentonite grout
Placement Method	poured
Volume	

Backfill (if different from seal):

Material	none
Placement Method	
Volume	

Surface seal design:

Material of Protective Casing:
4-inch steel protector w/ locking lid

Material of grout between protective casing and well casing:
concrete

Protective cap material:
steel

Vented? (Y/N) N — Locking? (Y/N) Y

Well cap material:
expanding rubber cap

Vented? (Y/N) N

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing): 10.60

Stabilization time: 3 weeks

Well development method:
Waterra dedicated pump

Upgradient or downgradient well? (see piezometric map from Hydrogeological study):
upgradient-shallow

Average Depth of Frostline:
4-feet

LOG OF BORING NO. MW6B

OWNER: Rienhart Construction

ARCHITECT/ENGINEER:

SITE: Perry, Iowa

PROJECT: North Dallas Sanitary Landfill

GRAPHIC LOG	DESCRIPTION	DEPTH (FT.)	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY	SAMPLES SPT - N BLOWS / FT.	TESTS MOISTURE, %	TESTS DRY DENSITY PCF	TESTS UNCONFINED STRENGTH PSF
	Approx. Surface Elev.: 999.8 ft.									
	Topsoil -- sandy lean CLAY, dark brown				HS					
	3.0 996.8									
	Sandy lean CLAY, brown									
	-- color changes to brown-gray at 5'	5								
	-- trace gravel at 7'									
	-- becomes stiff at 10'	10								
	-- becomes very stiff at 15'	15								
		20		1	HS	5'				
	-- color changes to gray at 24'	25		2	HS	5'				
		30								

Continued Next Page

THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

Calibrated Hand Penetrometer*

WATER LEVEL OBSERVATIONS			
WL	Dry	WD	
WL	Dry 2 hrs AD		
WL			

TEAM Services, Inc.

BORING STARTED	3-19-96		
BORING COMPLETED	3-19-96		
RIG	12-ATV	FOREMAN	J&R
APPROVED	RAK	JOB #	E96016

LOG OF BORING NO. MW6B

OWNER: Rienhart Construction

ARCHITECT/ENGINEER:

SITE: Perry, Iowa

PROJECT: North Dallas Sanitary Landfill

GRAPHIC LOG	DESCRIPTION	DEPTH (FT.)	USCS SYMBOL	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY	SPT - N BLOWS / FT.	TESTS MOISTURE, %	TESTS DRY DENSITY PCF	TESTS UNCONFINED STRENGTH PSF
	-- sand seam at 32'			3	HS	4.5'				
		35		4	HS	4.5'				
		40		5	HS	4.5'				
	44.0 955.8									
	45.0 Weathered SHALE, gray 954.8	45								
	Bottom of Monitoring Well									

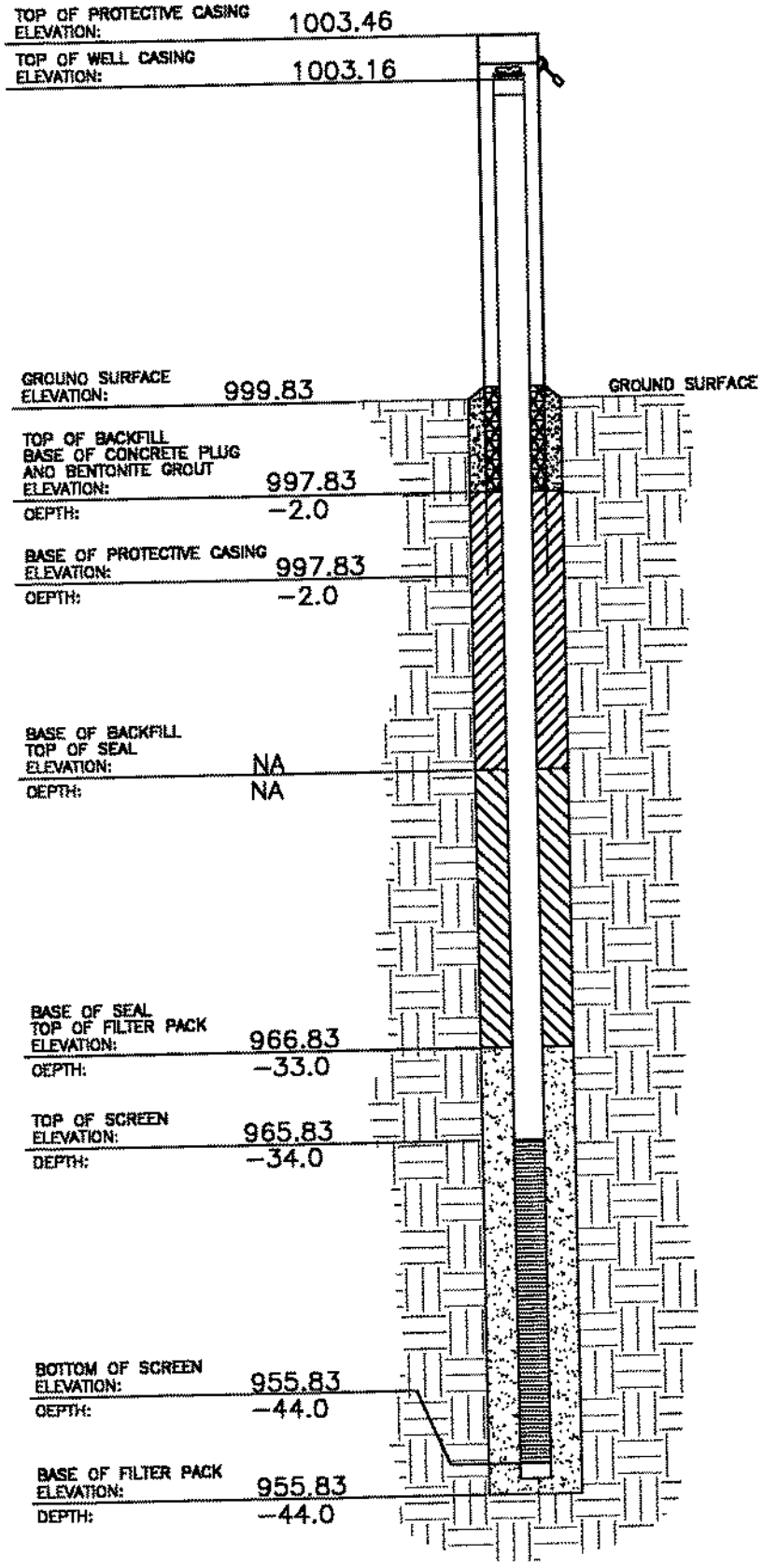
THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY LINES BETWEEN SOIL AND ROCK TYPES: IN-SITU, THE TRANSITION MAY BE GRADUAL.

Calibrated Hand Penetrometer*

WATER LEVEL OBSERVATIONS			
WL	▽ Dry	WD	▽
WL	Dry 2 hrs AD		
WL			

TEAM Services, Inc.

BORING STARTED	3-19-96		
BORING COMPLETED	3-19-96		
RIG	12-ATV	FOREMAN	J&R
APPROVED	RAK	JOB #	E96016



MW-6B Detail
North Dallas Sanitary Landfill
Perry, Iowa
BES Project No. E97011

Barker Environmental Services, Inc.
1300 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: (515) 288-6814 Fax: (515) 288-0182

WELL DETAIL

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: North Dallas Sanitary Landfill — Permit # 8-SDP-3-84P
Well or Piezometer #: MW-6B — Date Started: 3/19/96 — Date Completed: 3/19/96

A. Surveyed Locations and Elevtions

Locations (+/-0.5 ft.):

- Specify corner of site: SE
- Distance and Direction along boundary: 1450-feet east, 1803-feet north
- Distance and Direction from boundary to well: Well at NW corner of Boone County site

Elevation(+/-0.01 ft. MSL):

Ground surface	999.81 ft.
Top of Protective Casing	1003.46 ft.
Top of Well Casing	1003.16 ft.
Benchmark Elevation	997.69 ft.
Benchmark Description	TOC of MW-7AR

B. Soil Boring Information

Name and Address of Construction Company:
J&R Drilling
7922 NW 114th Street
Grime, Iowa 50111

Name of Driller	Rick
Drilling Method	HS auger
Drilling Fluid	none
Bore hole Diameter	7 & 3/4-inch
Soil Sampling Method	continuous
Depth of Boring	44 ft.

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	37 ft.
Outside Casing Diameter	2.2-inch
Inside Casing Diameter	2-inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010-inch
Screen length	10 ft.
Depth of Well	44 ft.

Well Installation, continued:

Filter pack:

Material	Muscatine gravel
Grain Size	#00
Volume	200 lbs.

Seal (minimum 3 ft. length above filter pack):

Material	bentonite grout
Placement Method	poured
Volume	

Backfill (if different from seal):

Material	none
Placement Method	
Volume	

Surface seal design:

Material of Protective Casing:
4-inch steel protector w/ locking lid
Material of grout between protective casing and well casing
concrete
Protective cap material
steel
Vented? (Y/N) N Locking? (Y/N) Y
Well cap material
expanding rubber cap
Vented? (Y/N) N

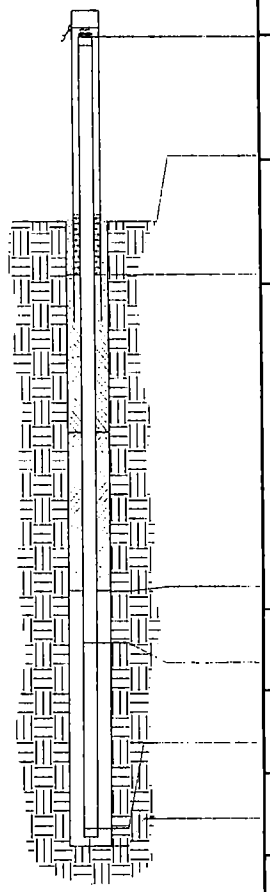
D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing) 10.60
Stabilization time 3 weeks
Well development method
Waterra dedicated pump

Upgradient or downgradient well? (see piezometric map from Hydrogeological study)
upgradient-shallow
Average Depth of Frostline
4-feet

BORING LOG/MONITORING W. L CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation Depth
TOC	986.86
Ground	983.9
Concrete	3
Bentonite Seal	
	23.5
Sand Pack	24.8
Well Screen	34.8
Well Bottom	35
Bottom of Boring	35

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
CS	**0 - 30 ft**	**HS**		**0 - 3 ft**	Brown Sandy Lean Clay
					trace of Gravel
				3 - 19 ft	Dark Gary Sandy Lean Clay
					trace of Gravel
				19.0 - 19.1 ft	Sand/Gravel Seam (wet)
				19.1 - 35 ft	Dark Gray Sandy Lean Clay
					trace of Gravel
ST	**30 - 32 ft**		**1.5 ft**		
CS	**32 - 35 ft**				

AR-Air Rotary
AS-Auger Sample
CS-Continuous Sampler
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
ST-Shelby Tube

Date:	8/14/97
Time:	9:40
Water Level:	33
Elevation:	953.86

Driller:	Shirley Environmental
Logged By:	Krumel
Date/Time Start:	8/14/97 9:30
Date/Time End:	8/14/97 11:30

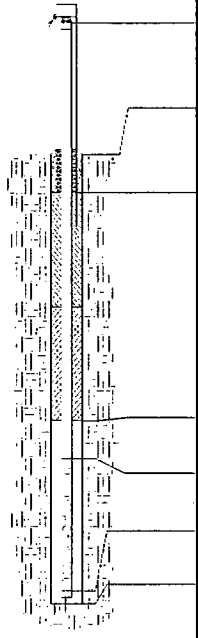
Barker Environmental Services, Inc.
1500 Cummins Road - Suite 241
Des Moines, Iowa 50315
Phone: (515) 288-5514 Fax: (515) 288-0152

Borehole Diameter:	8.25"
Well Casing Diameter:	2"
Well Screen Size:	0.010"

Project:	**BES Project No. E97011**
Location:	**Perry, Iowa**
Client:	**North Dallas SLF**
Owner:	**North Dallas SLF**
Boring/Well No:	**MW-8**

BORING LOG/MONITORING WELL CONSTRUCTION DETAIL

Monitoring Well Detail



Boring Log Detail

Material	Elevation / Depth	Sample Method	Sample Interval	Drilling Method	Recovery (inches)	Strata Depth (ft)	Description
TOC	987.14			AS		0-5'	Light Brown Clay, Sand and Grit
	1.9			AS		5'-10'	Light Brown Clay and Dry
				AS		10'-15'	Light Brown Clay and Moist
Ground	985.22			AS		15'-20'	Brown and Gray Clay
	0.0						
Bentonite Seal	984.22						
	1.0						
Sand Pack	978.80						
	6.4						
Well Screen	969.20						
	15.0						
Well Bottom	964.20						
	20.00						
Bottom of Boring	963.80						
	20.40						

AR-Air Rotary HS-Hollow Stem Auger
AS-Auger Sample PA-Power Auger (solid stem)
GS-Grab Sample SS-Split Spoon
MR-Mud Rotary WB-Wash Boring

Date:	10/10/2007
Time:	3:45 PM
Water Level:	12.00
Elevation:	975.14

Driller:	Kevin Sperfslage
Logged By:	Mike Dixon
Date/Time Start:	12:10 PM
Date/Time End:	3:30 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	7.25 inch
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	08-SDP-03-84P
Project No.:	NDALS 07005

Project:	**North Dallas Sanitary Landfill**
Location:	**Boone, IA**
Client:	**North Dallas Landfill, Inc.**
Owner:	**North Dallas Landfill, Inc.**
Boring/Well No:	**MW-8R**

SWL measured from TOC

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: North Dallas Sanitary Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: MW-8R — Date Started 10/10/2007 — Date Completed 10/10/2007
Project No.: NDALS 07005

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 821.0319 E 1405.146
Distance and Direction from boundry to well	600' N and 601' E of SW property corner

Elevation(+/-0.01 ft. MSL):

Ground surface	985.22
Top of Protective Casing	987.45
Top of Well Casing	987.14
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Kevin Sperfslage
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	7.25 inches
Soil Sampling Method	NA
Depth of Boring *	20.4

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	21.9
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	5'
Depth of Well **	22.94

Well Installation, continued:

Filter pack:

Material	Silica Sand
Grain Size	
Volume	3.84 ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite chips [1]
Placement Method	backfilled
Volume	1.39 ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Metal
Material of grout between protective casing and well casing
Concrete
Protective cap material
Metal
Vented? (Y/N) N — Locking? (Y/N) Y
Well cap material
PVC
Vented? (Y/N) N

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing)	975.14
Stabilization time	< 24 hours

Well development method
NA

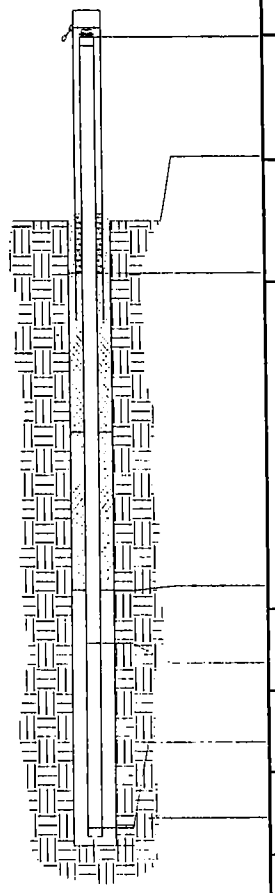
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

[1] Chips instead of grout used.

BORING LOG/MONITORING W' L CONSTRUCTION DETAIL



Monitoring Well Detail			Boring Log Detail					
	Material	Elevation / Depth	Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
	TOC	982.77						
	Ground	980.0						
	Concrete	3	**CS**	**0 - 10 ft**	**HS**		**0 - 4 ft**	Brown to Gray Clay
								trace of Gravel
							4 - 15 ft	Brown to Gray Sandy Lean Clay
	Bentonite Seal	4.5						trace of Gravel
	Sand Pack	4.8						
	Well Screen	14.8	**ST**	**10 - 12 ft**		**2 ft**		
	Well Bottom	15	**CS**	**12 - 15 ft**				
	Bottom of Boring	15						

AR-Air Rotary	HS-Hollow Stem Auger
AS-Auger Sample	PA-Power Auger (solid stem)
CS-Continuous Sampler	SS-Split Spoon
HA-Hand Auger	ST-Shelby Tube

Date:	8/14/97
Time:	14:45
Water Level:	dry
Elevation:	

Driller:	Shirley Environmental
Logged By:	Krumel
Date/Time Start:	8/14/97 13:15
Date/Time End:	8/14/97 14:40

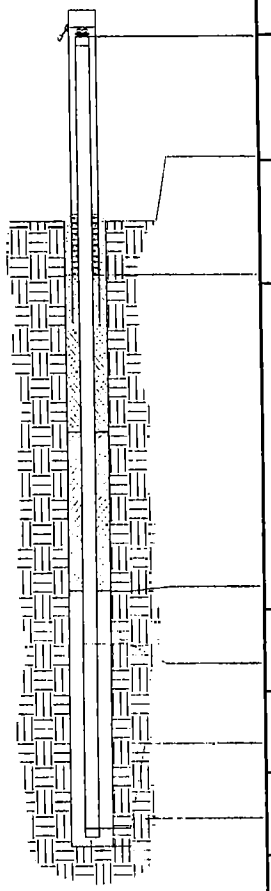
Barker Environmental Services, Inc.
1600 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: (515) 244-4514 Fax: (515) 244-0152

Borehole Diameter:	8.25"
Well Casing Diameter:	2"
Well Screen Size:	0.010"

Project:	**BES Project No. E97011**
Location:	**Perry, Iowa**
Client:	**North Dallas SLF**
Owner:	**North Dallas SLF**
Boring/Well No:	**MW-9A**

BORING LOG/MONITORING WELL CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation Depth
TOC	950.07
Ground	947.2
Concrete	3
Bentonite Seal	22
Sand Pack	22.9
Well Screen	32.9
Well Bottom	33
Bottom of Boring	33

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
CS	**0 - 30 ft**	**HS**		**0 - 6 ft**	Brown Sandy Lean Clay
					trace of Gravel
				6 - 6.5 ft	Gray Fine Sand
				6.5 - 21 ft	Brown Sandy Lean Clay
					trace of Gravel
				21 - 27 ft	Brown to Gray Sandy Lean Clay
					trace of Gravel
				27 - 31.5 ft	Dark Gray Sandy Lean Clay
					trace of Gravel
ST	**30 - 32 ft**		**2 ft**		
				31.5 - 33 ft	Black Weathered Shale
CS	**32 - 33 ft**				

AR-Air Rotary
AS-Auger Sample
CS-Continuous Sampler
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
ST-Shelby Tube

Date:	8/14/97
Time:	16:20
Water Level:	dry
Elevation:	

Driller:	Shirley Environmental
Logged By:	Krumel
Date/Time Start:	8/14/97 15:00
Date/Time End:	8/14/97 16:20

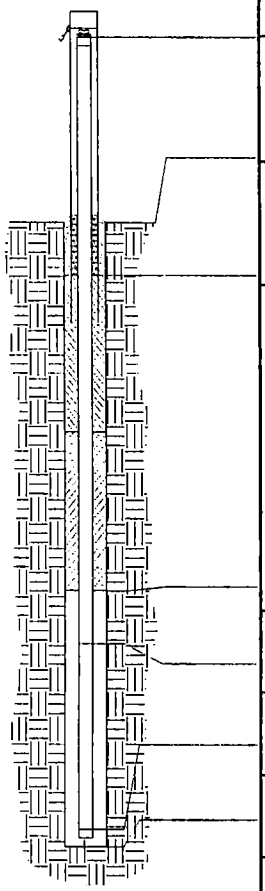
Barker Environmental Services, Inc.
1300 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: (515) 287-9214 Fax: (515) 288-0152

Borehole Diameter:	8.25"
Well Casing Diameter:	2"
Well Screen Size:	0.010"

Project:	**BES Project No. E97011**
Location:	**Perry, Iowa**
Client:	**North Dallas SLF**
Owner:	**North Dallas SLF**
Boring/Well No:	**MW-9B**

BORING LOG/MONITORING WELL CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	1007.73
Ground	1004.9
Concrete	1
Bentonite Seal	19
Sand Pack	20.3
Well Screen	30.3
Well Bottom	32
Bottom of Boring	32

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
CS	**0 - 25 ft**	**HS**		**0 - 4 ft**	Brown Clay
					trace of Gravel
				4 - 18 ft	Brown Sandy Lean Clay
					trace of Gravel
				18 - 32 ft	Gray Sandy Lean Clay
					trace of Gravel
ST	**25 - 27 ft**		**2 ft**		
CS	**27 - 32 ft**				

AR-Air Rotary
AS-Auger Sample
CS-Continuous Sampler
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
ST-Shelby Tube

Date:	8/26/97
Time:	15:20
Water Level:	dry
Elevation:	

Driller:	Shirley Environmental
Logged By:	Krumel
Date/Time Start:	8/26/97 13:45
Date/Time End:	8/26/97 14:35

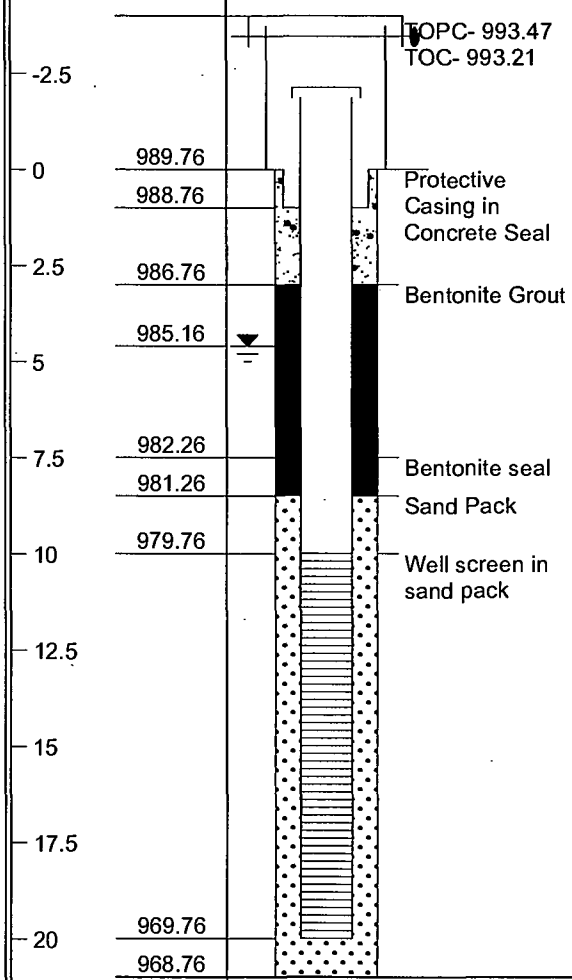
Barker Environmental Services, Inc.
1900 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: (515) 256-8814 Fax: (515) 256-0152

Borehole Diameter:	8.25"
Well Casing Diameter:	2"
Well Screen Size:	0.010"

Project:	**BES Project No. E97011**
Location:	**Perry, Iowa**
Client:	**North Dallas SLF**
Owner:	**North Dallas SLF**
Boring/Well No:	**MW-11**

SOIL BORING LOG & MONITORING WELL CONSTRUCTION DIAGRAM

Boring / Well Number: **MW-12**	Facility Name: **Metro Park West Landfill**	Facility Street Address: **Perry, Iowa**
Boring Depth (ft) X Diameter (in): **21'x12.25"**		Drilling Method: **HS**
Well Contractor Name: **Joe Green** Registration Number: **#2721**		Logged By: **Kris Sommer**
Ground Surface Elevation (ASL): **989.76**		Top of Casing Elevation (ASL): **993.21**
Date: **8/25/10** Start Time: **10:00 AM**	Date **8/25/10** End Time: **11:25**	UST Number / LUST Number



Depth Feet	Well Construction Details	Blow Count if applicable	Sample No.	Sample Type*	PID/FID Reading	Rock Formations, Soil Color and Classifications, Observations (moisture, odor, etc.) First column for USCS
			0-0.5			Grass Cover
			0.5-2			Brown/Light Brown Clay Silt Sand. Damp.
			2-6.5			Dark Brown Clay Silty Sand, Damp
			6.5-8			Brown Grey Mix Clay Silt Trace Sand and Pebbles, Damp to Moist
			8-12.5			Brown Clay Silt with Trace Sand and Pebbles. Moist.
			12.5-19			Brown Grey Mix Clay Trace Silt and Sand with Trace Pebbles. Moist.
			19-21			Grey Clay Trace Silt, Sand and Pebbles. Moist.
						Bottom of Boring at 21 feet

* SS (split spoon) HS (hollow stem auger) HA (hand auger)

Observations	Date:	8/25/10	8/26/10			
Water Levels (ASL)	Level:	985.16	970.75			
Static Water Level Symbol ▽	Time:	12:21 PM	10:15 AM			

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: MW-12 — Date Started 8/25/2010 — Date Completed 8/25/2010
Project No.: METRO 10111

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 680828.466 E 1459508.686
Distance and Direction from boundry to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	989.76
Top of Protective Casing	993.47
Top of Well Casing	993.21
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Joe Green
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	12.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	21.0'

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	13.5'
Outside Casing Diameter	4.5 inch
Inside Casing Diameter	4.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	10.0'
Depth of Well **	23.45'

Well Installation, continued:

Filter pack:

Material	Silica Sand
Grain Size	
Volume	9.84 ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout
Placement Method	treme grouted
Volume	0.79 ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Metal
Material of grout between protective casing and well casing
Concrete
Protective cap material
Metal
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) N

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing) 22.46
Stabilization time > 24 hours
Well development method
Surge Block

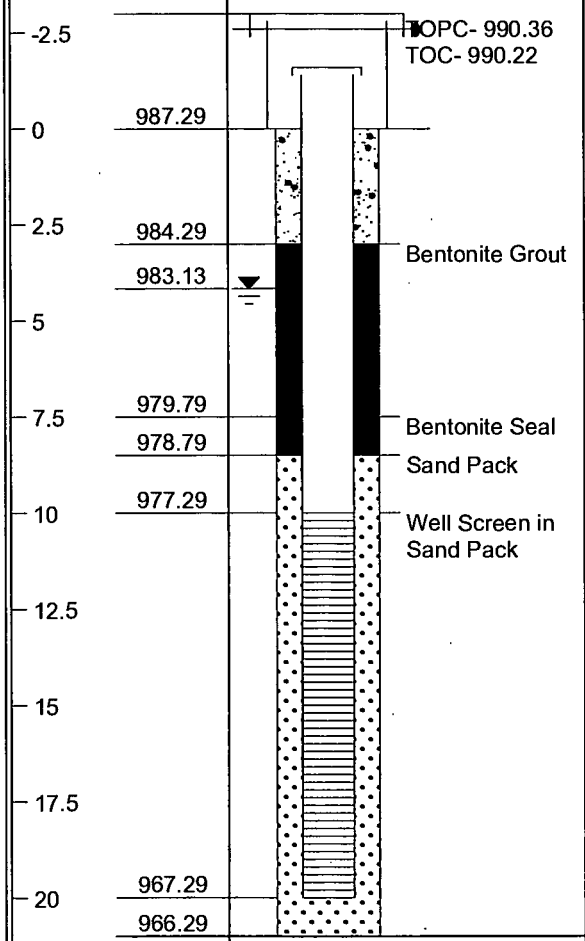
Upgradient or downgradient well?
NA
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

SOIL BORING LOG & MONITORING WELL CONSTRUCTION DIAGRAM

Boring / Well Number: **MW-13**	Facility Name: **Metro Park West Landfill**	Facility Street Address: **Perry, Iowa**
Boring Depth (ft) X Diameter (in): **21'x12.25"**		Drilling Method: **HS**
Well Contractor Name: **Joe Green** Registration Number: **#2721**		Logged By: **Kris Sommer**
Ground Surface Elevation (ASL): **987.29**		Top of Casing Elevation (ASL): **990.22**
Date: **8/25/10** Start Time: **2:00**	Date **8/25/10** End Time: **3:21**	UST Number
		LUST Number



Depth Feet	Well Construction Details	Blow Count if applicable	Sample No.	Sample Type*	PID/FID Reading	Rock Formations, Soil Color and Classifications, Observations (moisture, odor, etc.) First column for USCS
0-4						Brown Clay Silt Sand with Trace Pebbles. Dry to slightly Damp.
4-6						Brown Light Brown Clay Silt with Trace Sand and Pebbles. Damp.
6-9						Grey Silt Sand. Saturated.
9-10						Brown Grey Mix Clay Silt Sand with Trace Pebbles. Moist.
10-14						Grey Clay Silt Sand. Moist.
14-15						Grey Sand with Trace Pebbles Silt and Clay. Saturated.
15-21						Grey Clay, Sand with Trace Pebbles. Moist.
						Bottom of Boring at 21 feet

* SS (split spoon) HS (hollow stem auger) HA (hand auger)

Observations	Date:	8/25/10	8/26/10			
Water Levels (ASL)	Level:	983.13	968.51			
Static Water Level Symbol ▽	Time:	3:40	10:00			

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: MW-13 — Date Started: 8/25/2010 — Date Completed: 8/25/2010
Project No.: METRO 10111

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 680496.308 E 1459503.206
Distance and Direction from boundry to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	987.29
Top of Protective Casing	990.36
Top of Well Casing	990.22
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Joe Green
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	12.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	21.0'

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	12.9'
Outside Casing Diameter	4.5 inch
Inside Casing Diameter	4.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	10.0'
Depth of Well **	22.92'

Well Installation, continued:

Filter pack:

Material	Silica Sand
Grain Size	
Volume	9.84 ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout
Placement Method	treme grouted
Volume	0.79 ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Metal
Material of grout between protective casing and well casing
Concrete
Protective cap material
Metal
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) N

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing) 21.71
Stabilization time > 24 hours
Well development method
Surge Block

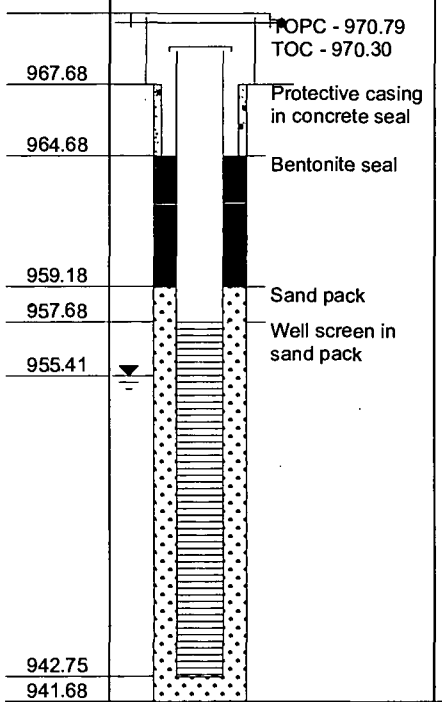
Upgradient or downgradient well?
NA
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

SOIL BORING LOG & MONITORING WELL CONSTRUCTION DIAGRAM

Boring / Well Number: **MW-14**	Facility Name: **Metro Park West Landfill**	Facility Street Address: **Perry, IA**
Boring Depth (ft) X Diameter (in): **26.0 x 8.25**		Drilling Method: **HS**
Well Contractor Name: **Mike Dixon** Registration Number: **8438**		Logged By: **Mike Dixon**
Ground Surface Elevation (ASL): **967.68**		Top of Casing Elevation (ASL): **970.30**
Date: **10/18/2011** Start Time: **11:30 am**	Date End Time: **10/18/2011** **1:00 pm**	UST Number **NA** / LUST Number **NA**



Depth Feet	Well Construction Details	Blow Count if applicable	Sample No.	Sample Type*	PID/FID Reading	Rock Formations, Soil Color and Classifications, Observations (moisture, odor, etc.) First column for USCS
			0-1			Bare ground.
			1-5			Brown, silty clay with traces of rock.
			5-10			Dark brown, silty clay, very moist at 8-10'.
			10-14			Soft and moist, dark brown, silty clay (moist and soft).
			14-15			Gray, silty clay with brown and black colored mottling, traces of rock (moist and soft).
			15-20			Gray, silty clay with brown and black colored mottling, traces of rock (moist and soft). Moisture at 18'.
			20-26			Gray and brown, silty, sandy clay with rust brown colored mottling.
						Bottom of Boring at 26 feet

* SS (split spoon) HS (hollow stem auger) HA (hand auger)

Observations	Date:	**10/31/11**				
Water Levels (ASL)	Level:	**955.41**				
Static Water Level Symbol ▼	Time:	**12:46 pm**				

DNR FORM 542-1392

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name	Metro Park West Landfill			Permit #	08-SDP-03-84P
Well or Piezometer #	MW-14	Date Started	10/18/2011	Date Completed	10/18/2011
Project No.	METRO 11108				

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679,760.76 E 1,459,625.55
Distance and Direction from boundry to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	967.68
Top of Protective Casing	970.79
Top of Well Casing	970.30
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	26.0'

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	13.00'
Outside Casing Diameter	4.5 inch
Inside Casing Diameter	4.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	14.93'
Depth of Well **	27.93'

Well Installation, continued:

Filter pack:

Material	Silica Sand
Grain Size	
Volume	4.56 ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout
Placement Method	treme grouted
Volume	1.43 ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Metal
Material of grout between protective casing and well casing
Concrete
Protective cap material
Metal
Vented? (Y/N) Y Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing) 14.89
Stabilization time 13 days
Well development method
Purge

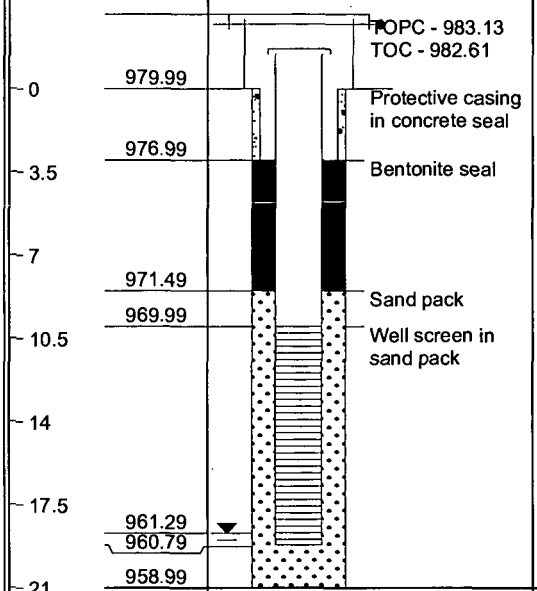
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

SOIL BORING LOG & MONITORING WELL CONSTRUCTION DIAGRAM

Boring / Well Number: **MW-15**	Facility Name: **Metro Park West Landfill**	Facility Street Address: **Perry, IA**
Boring Depth (ft) X Diameter (in): **21.0 x 8.25**		Drilling Method: **HS**
Well Contractor Name: **Mike Dixon** Registration Number: **8438**		Logged By: **Mike Dixon**
Ground Surface Elevation (ASL): **979.99**		Top of Casing Elevation (ASL): **982.61**
Date: **10/18/2011** Start Time: **8:45 am**	Date End Time: **10/18/2011** **10:45 am**	UST Number **NA** / LUST Number **NA**



Depth Feet	Well Construction Details	Blow Count if applicable	Sample No.	Sample Type*	PID/FID Reading	Rock Formations, Soil Color and Classifications, Observations (moisture, odor, etc.) First column for USCS
			0.0-0.5			Bare ground.
			0.5-3			Brown, silty clay with traces of rock.
			3-5			Gray, silty clay with traces of rock.
			5-8			Gray, silty clay with traces of rock.
			8-10			Brown, silty clay with gray mottling and traces of sand. Slightly moist at 8-10'.
			10-15			Gray, silty clay with traces of sand and rock (hard).
			15-21			Gray, silty clay with traces of sand and rock (soft and moist).
						Bottom of Boring at 21 feet

* SS (split spoon) HS (hollow stem auger) HA (hand auger)

Observations	Date:	**11/8/11**				
Water Levels (ASL)	Level:	**961.29**				
Static Water Level Symbol ▼	Time:	**NA**				

DNR FORM 542-1392

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name	Metro Park West Landfill		Permit # 08-SDP-03-84P
Well or Piezometer #	MW-15	Date Started 10/18/2011	Date Completed 10/18/2011
Project No.	METRO 11108		

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 680,106.24 E 1,460,169.04
Distance and Direction from boundry to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	979.99
Top of Protective Casing	983.13
Top of Well Casing	982.61
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	21.0'

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	13.50'
Outside Casing Diameter	4.5 inch
Inside Casing Diameter	4.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	9.20'
Depth of Well **	22.70'

Well Installation, continued:

Filter pack:

Material	Silica Sand
Grain Size	
Volume	3.26 ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout
Placement Method	treme grouted
Volume	1.43 ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Metal
Material of grout between protective casing and well casing
Concrete
Protective cap material
Metal
Vented? (Y/N) Y Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing)	18.70
Stabilization time	21 days

Well development method
Purge

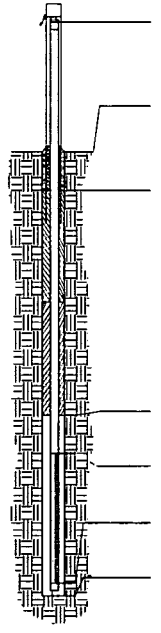
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	2.05
	975.08
Ground	0.0
	973.0
Bentonite Seal	-2.0
	971.0
Sand Pack	-12.3
	960.8
Well Screen	-15.3
	957.8
Well Bottom	-30.3
	942.8
Bottom of Boring	-30.5
	942.5

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
DP	1 ft	HS	Full	0-2	Brown sandy clay, trace gravel
				2-3	Brown/gray sandy clay mix
				3-4	Gray sandy clay, trace brown clay
				4-10	Gray silty clay
				10-15	Gray silty clay, trace gravel
				15-28	Gray sandy clay
				28-30.5	Gray sandy clay, trace gravel

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
DP-Direct Push
WB-Wash Boring

Date:	4/21/2015
Time:	11:40 AM
Water Level:	10.00
Elevation:	965.08

Driller:	Saberprobe, LLC
Logged By:	Austin Banks
Date/Time Start:	-
Date/Time End:	-

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	08-SDP-03-84P
Project No.:	METRO 15104

Project:	**Metro Park West Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-16**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: MW-16 — Date Started: 4/21/2015 — Date Completed: 4/21/2015
Project No.: METRO 15104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679783.9 E 1460032
Distance and Direction from boundary to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	973.0
Top of Protective Casing	975.7
Top of Well Casing	975.08
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Saberprobe, LLC
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	30.5

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	17.3
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	32.30

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	6.21	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	3.49	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
Plastic
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing) 10.00
Stabilization time < 24 hours
Well development method
Hand bailing

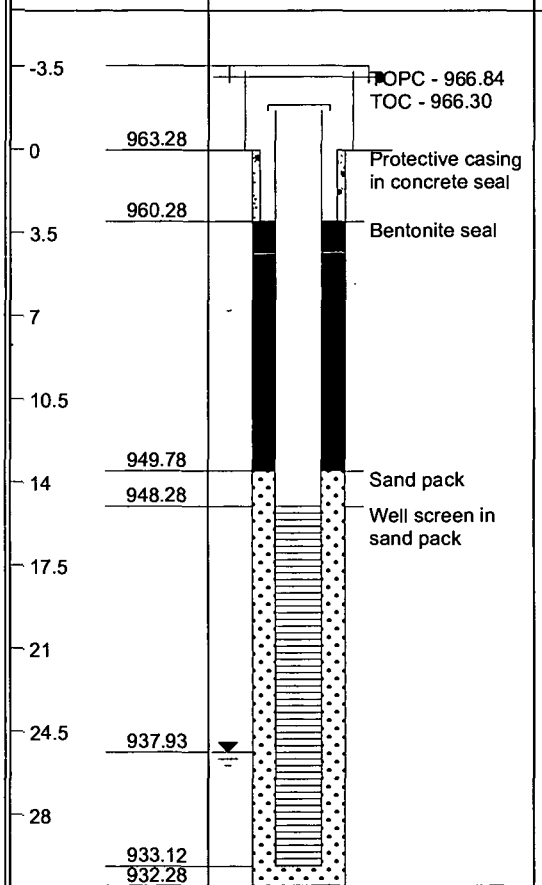
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3 feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

SOIL BORING LOG & MONITORING WELL CONSTRUCTION DIAGRAM

Boring / Well Number: **MW-19**	Facility Name: **Metro Park West Landfill**	Facility Street Address: **Perry, IA**
Boring Depth (ft) X Diameter (in): **31.0 x 8.25**		Drilling Method: **HS**
Well Contractor Name: **Mike Dixon** Registration Number: **8438**		Logged By: **Mike Dixon**
Ground Surface Elevation (ASL): **963.28**		Top of Casing Elevation (ASL): **966.30**
Date: **10/19/2011** Start Time: **8:30 am**	Date **10/19/2011** End Time: **11:00 am**	UST Number **NA** / LUST Number **NA**



Depth Feet	Blow Count if applicable	Sample No.	Sample Type*	PID/FID Reading	Rock Formations, Soil Color and Classifications, Observations (moisture, odor, etc.) First column for USCS
0					
0-5					Brown, silty clay with trace sand and rocks. Moist at 5'.
5-17					Brown, gray, and green silty clay with traces of sand and rock, dark gray/ rust colored mottling (soft and moist).
17-20					No Return.
20-22					Brown and gray silty clay (soft and moist).
22-25					Gray, silty clay with traces of rock and sand and caliche deposits (soft).
25-28					Gray, silty clay with traces of rock and sand and caliche deposits (moist and soft).
28-31					Brown, silty clay with traces of rock and sand (moist and soft).
					Bottom of Boring at 31 feet

* SS (split spoon) HS (hollow stem auger) HA (hand auger)

Observations	Date:	**10/31/11**				
Water Levels (ASL)	Level:	**937.93**				
Static Water Level Symbol ▼	Time:	**12:55 pm**				

DNR FORM 542-1392

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: MW-19 — Date Started 10/19/2011 — Date Completed 10/19/2011
Project No.: METRO 11108

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679,641.06 E 1,459,451.45
Distance and Direction from boundry to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	963.28
Top of Protective Casing	966.84
Top of Well Casing	966.30
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	31.0'

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	18.0'
Outside Casing Diameter	4.5 inch
Inside Casing Diameter	4.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.020 inch
Screen length	15.16'
Depth of Well **	33.16'

Well Installation, continued:

Filter pack:

Material	Silica Sand
Grain Size	
Volume	4.56 ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout
Placement Method	treme grouted
Volume	2.74 ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Metal
Material of grout between protective casing and well casing
Concrete
Protective cap material
Metal
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing) 28.37
Stabilization time 12 days
Well development method
Purge

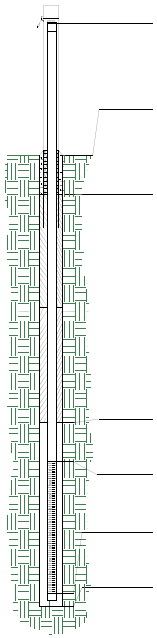
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation Depth
TOC	2.56
	939.46
Ground	0.00
	936.9
Bentonite Seal	-3.00
	933.9
Sand Pack	-8.19
	928.7
Well Screen	-9.69
	927.2
Well Bottom	-24.69
	912.2
Bottom of Boring	-26.00
	910.9

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0	Grass and topsoil
				0-2	Gray sandy silty clay, very moist
				2-3	Blue/gray sandy silty clay, moist
				3-5	Light brown/gray mottling, sandy silty clay
				5-10	Gray sandy silty clay, moist
				10-12.5	Gray/dark gray sandy silty clay, very moist
				12.5-15	Sand, well sorted, damp to wet
				15-20	Gray sand, wet
				20-22	Gray sandy silty clay
				22-26	Gray sand

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	10/25/2013
Time:	2:01 AM
Water Level:	19.50
Elevation:	919.96

Driller:	Mike Dixon
Logged By:	Mike Dixon
Date/Time Start:	10/23/2013 5:15 PM
Date/Time End:	10/24/2013 10:30 AM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	80-SDP-03-84P
Project No.:	METRO 13104

Project:	**MPW Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-20**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-20 — Date Started: 10/23/2013 — Date Completed: 10/24/2013
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679673.7 E 1458956
Distance and Direction from boundary to well	

Elevation(+/-0.01 ft. MSL):

Ground surface	936.9
Top of Protective Casing	939.9
Top of Well Casing	939.46
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	26.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	12.3
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	27.3

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	6.06	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	1.77	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing): 19.50
Stabilization time: > 24 hours
Well development method
Hand bailing

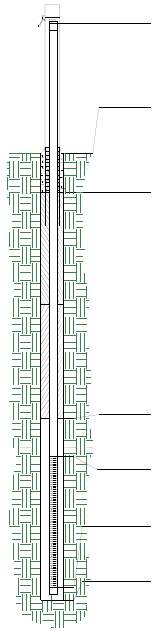
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Boring Log Detail

Material	Elevation / Depth	Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
TOC	2.77			HS		0	Grass and topsoil
	937.97					0-7	Brown sandy silty clay
						7-10	Gray sandy silty clay
Ground	0.00					10-15	Gray sand, unsorted, dry
	935.2					15-20	Gray sand/rock, wet at 18'
						20-26	Gray sandy silty clay, trace gravel
Bentonite Seal	-3.00						
	932.2						
Sand Pack	-8.50						
	926.7						
Well Screen	-10.00						
	925.2						
Well Bottom	-25.00						
	910.2						
Bottom of Boring	-26.00						
	909.2						

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	10/25/2013
Time:	1:30 PM
Water Level:	18.00
Elevation:	919.97

Driller:	Mike Dixon
Logged By:	Mike Dixon
Date/Time Start:	10/23/2013 11:41 AM
Date/Time End:	10/23/2013 5:30 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	80-SDP-03-84P
Project No.:	METRO 13104

Project:	**MPW Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-21**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-21 — Date Started: 10/23/2013 — Date Completed: 10/23/2013
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679543.2 E 1459041
Distance and Direction from boundary to well	

Elevation(+/-0.01 ft. MSL):

Ground surface	935.2
Top of Protective Casing	938.7
Top of Well Casing	937.97
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	26.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	12.8
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	27.8

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	5.96	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	1.87	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing): 18.00
Stabilization time: > 24 hours
Well development method
Hand bailing

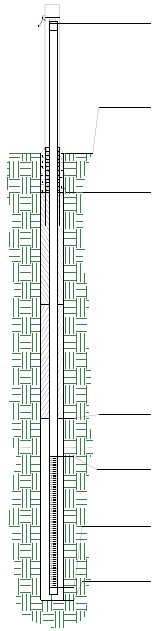
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	2.66
	998.26
Ground	0.00
	995.6
Bentonite Seal	-1.00
	994.6
Sand Pack	-3.00
	992.6
Well Screen	-5.00
	990.6
Well Bottom	-20.00
	975.6
Bottom of Boring	-21.00
	974.6

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0	Crop field
				0-2	Dark brown sandy silty clay
				2-5	Light brown sandy silty clay, soft, moist
				5-16	Light brown sandy silty clay, brown and red/brown mottling,
					very moist at 10'
				16-21	Dark gray sandy silty clay, moist pockets in soil core

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	10/25/2013
Time:	3:40 PM
Water Level:	Dry
Elevation:	NA

Driller:	Mike Dixon
Logged By:	Mike Dixon
Date/Time Start:	10/25/2013 10:30 AM
Date/Time End:	10/25/2013 12:30 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	80-SDP-03-84P
Project No.:	METRO 13104

Project:	**MPW Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-22**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-22 — Date Started 10/25/2013 — Date Completed 10/25/2013
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 681164.5 E 1460950
Distance and Direction from boundary to well	

Elevation(+/-0.01 ft. MSL):

Ground surface	995.6
Top of Protective Casing	998.8
Top of Well Casing	998.26
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	21.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	7.7
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	22.7

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	6.13	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	0.68	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing): Dry
Stabilization time: < 24 hours
Well development method
Hand bailing

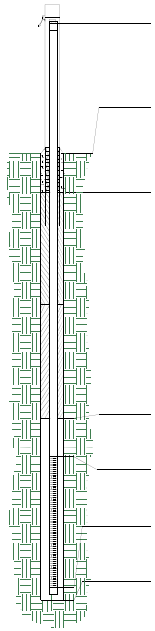
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation Depth
TOC	2.98
	991.18
Ground	0.00
	988.2
Bentonite Seal	-2.00
	986.2
Sand Pack	-3.50
	984.7
Well Screen	-5.00
	983.2
Well Bottom	-20.00
	968.2
Bottom of Boring	-21.00
	967.2

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0	Grass and topsoil
				0-7	Dark brown sandy silty clay, trace gravel
				7-10	Brown/light brown sandy silty clay, trace gravel,
					light brown/dark brown/rust mottling,
					very moist at 9.5-10'
				10-14.5	Brown/light brown sandy silty clay, trace gravel,
					brown/rust brown mottling, weathered granite/quartz rock,
					sand lenses at 14'
				14.5-17	Dark brown/gray sandy silty clay,
					moisture in pockets in soil core
				17-21	Dark gray sandy silty clay, rocky, hard and firm

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	10/25/2013
Time:	3:05 PM
Water Level:	20.00
Elevation:	971.18

Driller:	Mike Dixon
Logged By:	Mike Dixon
Date/Time Start:	10/25/2013 8:30 AM
Date/Time End:	10/25/2013 10:00 AM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	80-SDP-03-84P
Project No.:	METRO 13104

Project:	**MPW Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-23**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-23 — Date Started: 10/25/2013 — Date Completed: 10/25/2013
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 681135.2 E 1461890
Distance and Direction from boundary to well	

Elevation(+/-0.01 ft. MSL):

Ground surface	988.2
Top of Protective Casing	991.7
Top of Well Casing	991.18
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	21.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	8.0
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	23.0

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	5.96	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	0.51	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing): 20.00
Stabilization time: < 24 hours
Well development method
Hand bailing

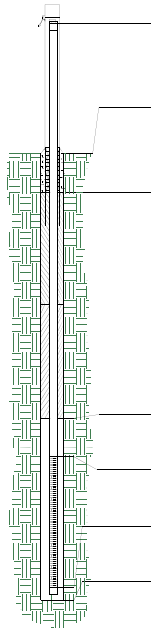
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Boring Log Detail

Material	Elevation / Depth	Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
TOC	2.84			HS		0	Grass and topsoil
	982.44					0-2	Dark brown sandy silty clay, moist
						2-5	Brown/light brown sandy silty clay, gravel at 3'
Ground	0.00					5-10	Brown/light brown sandy silty clay, rust brown mottling,
	979.6						sand lenses, trace gravel, very moist
						10-14.5	Brown sandy silty clay, gray and dark rust mottling,
Bentonite Seal	-1.00						trace gravel
	978.6					14.5-21	Gray sandy silty clay, rocky, hard,
							moisture in pockets of soil core
Sand Pack	-3.50						
	976.1						
Well Screen	-5.00						
	974.6						
Well Bottom	-20.00						
	959.6						
Bottom of Boring	-21.00						
	958.6						

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	10/25/2013	Driller:	Mike Dixon
Time:	2:37 PM	Logged By:	Mike Dixon
Water Level:	Dry	Date/Time Start:	10/24/2013 4:45 PM
Elevation:	NA	Date/Time End:	10/24/2013 6:45 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches	Project:	**MPW Landfill**
Well Casing Diameter:	2 inch	Location:	**Perry, Iowa**
Well Screen Size:	0.010 inch	Client:	**Metro Waste Authority**
LUST/SLF Permit No.:	80-SDP-03-84P	Owner:	**Metro Waste Authority**
Project No.:	METRO 13104	Boring/Well No:	**MW-24**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-24 — Date Started: 10/24/2013 — Date Completed: 10/24/2013
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 680669.1 E 1461983
Distance and Direction from boundary to well	

Elevation(+/-0.01 ft. MSL):

Ground surface	979.6
Top of Protective Casing	982.9
Top of Well Casing	982.44
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	21.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	7.8
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	22.8

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	5.96	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	0.85	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing): Dry
Stabilization time: < 24 hours
Well development method
Hand bailing

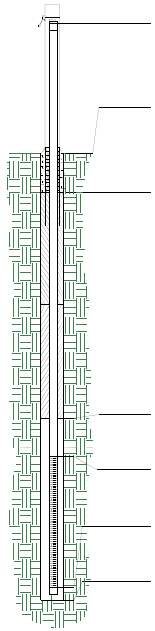
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	2.68
	982.28
Ground	0.00
	979.6
Bentonite Seal	-3.00
	976.6
Sand Pack	-8.50
	971.1
Well Screen	-10.00
	969.6
Well Bottom	-25.00
	954.6
Bottom of Boring	-26.00
	953.6

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0	Grass and topsoil
				0-3	Dark brown sandy silty clay, moist
				3-5	Brown sandy silty clay with trace gravel
				5-20	Light brown sandy silty clay, brown , rust brown mottling,
					sand lenses, moist at 13', gray mottling 15-20'
				20-26	Gray sandy silty clay, hard, moist pockets

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	10/25/2013
Time:	3:23 PM
Water Level:	17.31
Elevation:	964.97

Driller:	Mike Dixon
Logged By:	Mike Dixon
Date/Time Start:	10/24/2013 1:50 PM
Date/Time End:	10/24/2013 4:00 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	80-SDP-03-84P
Project No.:	METRO 13104

Project:	**MPW Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-25**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-25 — Date Started 10/24/2013 — Date Completed 10/24/2013
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679762.1 E 1461147
Distance and Direction from boundary to well	

Elevation(+/-0.01 ft. MSL):

Ground surface	992.6
Top of Protective Casing	995.7
Top of Well Casing	995.28
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	26.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	12.7
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	27.7

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	5.96	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	1.87	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing) 17.31
Stabilization time < 24 hours
Well development method
Hand bailing

Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-26 — Date Started 2/14/2014 — Date Completed 2/14/2014
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679697.6 E 1458895.9
Distance and Direction from boundary to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	937.8
Top of Protective Casing	941.1
Top of Well Casing	940.60
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	31.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	18.2
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	33.15

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	5.96	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	3.57	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing) 23.20
Stabilization time < 24 hours
Well development method
Hand bailing

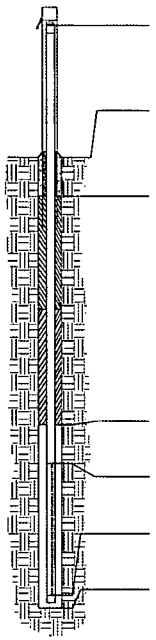
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	2.80
	940.6
Ground	0.00
	937.8
Bentonite Seal	-3.00
	934.8
Sand Pack	-13.50
	924.3
Well Screen	-15.35
	922.5
Well Bottom	-30.35
	907.5
Bottom of Boring	-31.00
	906.8

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0	Grass
				0-1	Topsoil
				1-4	Sand/clayey sand
				4-5	Gray sandy silty clay, moist
				5-10	Dark brown sandy silty clay, moist
				10-13	Dark gray sandy silty clay, moist
				13-15	Gray sand, dry
				15-20	Gray sand, moist, wet at 20'
				20-27	Brown/gray clayey sand (coarse sand)
				27-31	Light brown sandy silty clay

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	2/14/2014
Time:	11:30 AM
Water Level:	23.20
Elevation:	917.40

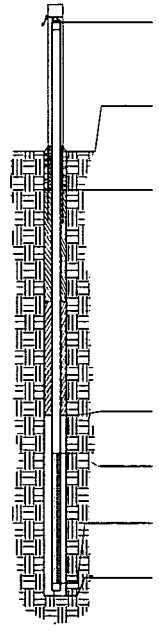
Driller:	Mike Dixon
Logged By:	Mike Dixon
Date/Time Start:	2/14/2014 9:30 AM
Date/Time End:	2/14/2014 12:30 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	80-SDP-03-84P
Project No.:	METRO 13104

Project:	**MPW Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-26**

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL



Monitoring Well Detail			Boring Log Detail					
Material	Elevation / Depth	Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
TOC	2.23	DP	1 ft	HS	Full	0-1	Black organic matter
	943.07						
						1-8	Brown sandy clay
Ground	0.0						
	940.8					8-9	Gray sandy clay, trace brown mottling
Bentonite Seal	-2.0					9-15	Gray sandy clay
	938.8						
						15-20	Gray compressed sand
Sand Pack	-7.0						
	933.8						
Well Screen	-10.0						
	930.8						
Well Bottom	-20.0						
	920.8						
Bottom of Boring	-20.0						
	920.8						

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
DP-Direct Push
WB-Wash Boring

Date:	4/21/2015
Time:	3:50 PM
Water Level:	13.63
Elevation:	929.44

Driller:	Saberprobe, LLC
Logged By:	Austin Banks
Date/Time Start:	-
Date/Time End:	-

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	08-SDP-03-84P
Project No.:	METRO 15104

Project:	**Metro Park West Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-27**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: MW-27 — Date Started: 4/21/2015 — Date Completed: 4/21/2015
Project No.: METRO 15104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679551.3 E 1459267
Distance and Direction from boundary to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	940.8
Top of Protective Casing	943.4
Top of Well Casing	943.07
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Saberprobe, LLC
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	20.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	12.2
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	10
Depth of Well **	22.23

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	4.42	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	1.70	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y Locking? (Y/N) Y
Well cap material
Plastic
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing) 13.63
Stabilization time < 24 hours
Well development method
Hand bailing

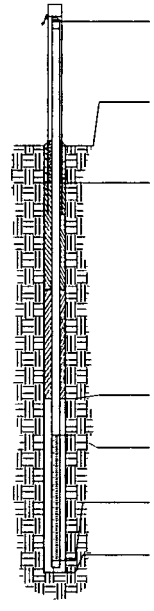
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3 feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	3.15
	946.35
Ground	0.0
	943.2
Bentonite Seal	-3.0
	940.2
Sand Pack	-10.5
	932.7
Well Screen	-12.0
	931.2
Well Bottom	-22.0
	921.2
Bottom of Boring	-23.0
	920.2

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0-4	Brown and black lean clay with organic matter
				4-18	Brown and black soft fine sandy silt (alluvium)
				18-20	Gray and dark gray fine sand, wet (alluvium)
				20-22	Sandy clay with gravel (alluvium)
				22-23	Gray weathered shale
				23	Gray shale, hard

AR-Air Rotary HS-Hollow Stem Auger
AS-Auger Sample PA-Power Auger (solid stem)
GS-Grab Sample SS-Split Spoon DP-Direct Push
HA-Hand Auger WB-Wash Boring

Date:	10/18/2017
Time:	3:15 PM
Water Level:	13.00
Elevation:	933.35

Driller:	Jerome Hobson
Logged By:	Chad Dentlinger
Date/Time Start:	10/18/2017 10:30 AM
Date/Time End:	10/18/2017 3:00 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	7.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	08-SDP-03-84P
Project No.:	METRO 18101

Project:	**Metro Park West Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-28**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: MW-28 — Date Started 10/18/2017 — Date Completed 10/18/2017
Project No.: METRO 18101

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679551.3 E 1459267
Distance and Direction from boundary to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	943.2^
Top of Protective Casing	946.6^
Top of Well Casing	946.35^
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Jerome Hobson
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	7.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	23.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	15.2
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	10
Depth of Well **	25.15

Well Installation, continued:

Filter pack:
Pre-packed screen:
0.125 mm (pre-pack)
0.65 mm (annular space)
3.20 ft^3 (annular space)

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite chips+	
Placement Method	poured	
Volume	1.92	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:
Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y Locking? (Y/N) Y
Well cap material
Plastic
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing) 13.00
Stabilization time < 24 hours
Well development method
Hand bailing

Upgradient or downgradient well?
Upgradient
Average Depth of Frostline
3 feet

^ Elevation approximate due to heavy tree cover.
* Depth of boring measured from ground surface.
** Depth of well measured from Top of Casing (TOC).
+ Access limitations precluded the use of bentonite grout for the seal.

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: LFGW-W1 — Date Started 8/25/2010 — Date Completed 8/25/2010
Project No.: METRO 10111

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 680822.017 E 1459085.398
Distance and Direction from boundry to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	1000.33
Top of Protective Casing	1004.36
Top of Well Casing	1004.08
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Joe Green
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	12.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	18.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	8.75'
Outside Casing Diameter	4.5 inch
Inside Casing Diameter	4.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.020 inch
Screen length	5.0'
Depth of Well **	13.75'

Well Installation, continued:

Filter pack:

Material	Silica Sand
Grain Size	
Volume	15.96 ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout
Placement Method	treme grouted
Volume	1.57 ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Metal
Material of grout between protective casing and well casing
Concrete
Protective cap material
Metal
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) N

D. Groundwater Measurement

Water level (+/-0.01 ft. below top of inner well casing) 13.72
Stabilization time > 12 hours
Well development method
Surge block

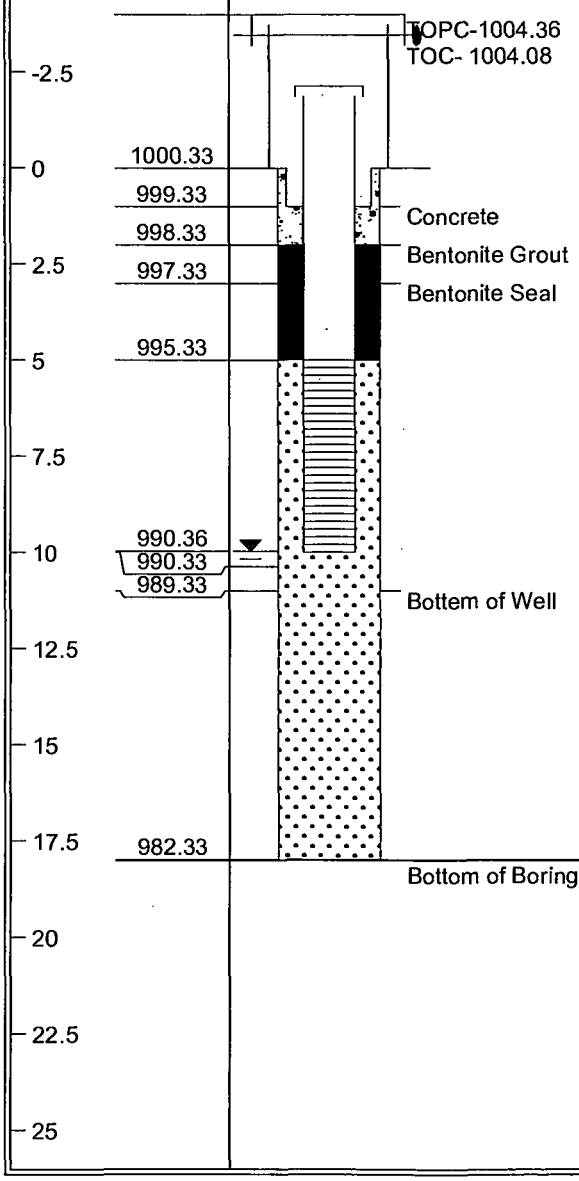
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

SOIL BORING LOG & MONITORING WELL CONSTRUCTION DIAGRAM

Boring / Well Number: **LFGW-W1**	Facility Name: **Metro Park West Landfill**	Facility Street Address: **Perry, Iowa**
Boring Depth (ft) X Diameter (in): **18'x12.25"**		Drilling Method: **HS**
Well Contractor Name: **Joe Green** Registration Number: **#2721**		Logged By: **Kris Sommer**
Ground Surface Elevation (ASL): **1000.33**		Top of Casing Elevation (ASL): **1004.08**
Date: **8/25/10** Start Time: **5:00**	Date **8/25/10** End Time: **6:00**	UST Number / LUST Number



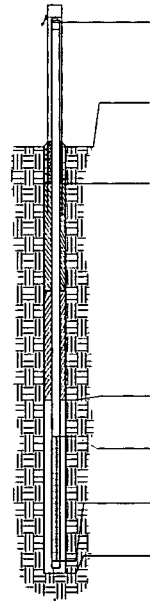
Depth Feet	Well Construction Details	Blow Count if applicable	Sample No.	Sample Type*	PID/FID Reading	Rock Formations, Soil Color and Classifications, Observations (moisture, odor, etc.) First column for USCS
			0-0.5			Grass/Grass Thatch Cover to Topsoil.
			0.5-5			Dark Brown Clay Silt. Damp.
			5-10.5			Grey Clay Silt with Trace Sand and Pebbles. Damp.
			10.5-15			Brown Grey Mix, Clay Silt Trace Sand. Damp.
			15-18			Brown Grey Mix. Clay Silt Sand. Moist.
	Bottom of Boring					*Bottom of Boring at 18 feet*

* SS (split spoon) HS (hollow stem auger) HA (hand auger)

Observations	Date:	**8/26/10**				
Water Levels (ASL)	Level:	**990.36**				
Static Water Level Symbol ▼	Time:	**9:45 A.M.**				

BORING LOG/MONITORING PROBE CONSTRUCTION DETAIL

Monitoring Probe Detail



Material	Elevation / Depth
TOC	3.13
	993.73
Ground	0.0
	990.6
Bentonite Seal	-1.0
	989.6
Sand Pack	-2.0
	988.6
Well Screen	-2.0
	988.6
Well Bottom	-32.0
	958.6
Bottom of Boring	-32.5
	958.1

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0-5	Brown silty clay, trace gravel
				5-21	Brown sandy lean clay (till)
				21-26	Gray sandy lean clay (till)
				26-27	Gray silty clay (till)
				27-32.5	Gray sandy lean clay, stiff (till)

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
DP-Direct Push
WB-Wash Boring

Date:	9/7/2017
Time:	2:30 PM
Water Level:	Dry
Elevation:	NA

Driller:	Jerome Hobson
Logged By:	Chad Dentlinger
Date/Time Start:	9/6/2017 9:30 AM
Date/Time End:	9/7/2017 2:15 PM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	7.25
Well Casing Diameter:	2 inch
Well Screen Size:	0.020 inch
LUST/SLF Permit No.:	08-SDP-03-84P
Project No.:	METRO 18101

Project:	**Metro Park West Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**LFGW-W2**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 08-SDP-03-84P
Well or Piezometer #: LFGW-W2 — Date Started: 9/6/2017 — Date Completed: 9/7/2017
Project No.: METRO 18101

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 680057.3 E 1458834.0
Distance and Direction from boundary to well	_____ _____

Elevation(+/-0.01 ft. MSL):

Ground surface	990.6
Top of Protective Casing	994.0
Top of Well Casing	993.73
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Jerome Hobson
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	7.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	32.5

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	5.1
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.020 inch
Screen length	30
Depth of Well **	35.13

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	7.80	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite chips	
Placement Method	poured	
Volume	0.26	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
Plastic
Vented? (Y/N) N

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing): Dry
Stabilization time: < 24 hours
Well development method
Not applicable

Upgradient or downgradient well?
Not applicable
Average Depth of Frostline
3 feet

* Depth of boring measured from ground surface.
** Depth of well measured from Top of Casing (TOC).

Soil Boring Log And Monitoring Well Construction Diagram for: SB-1/MW-30

Facility Name: Metro Park West Landfill - Perry, Iowa	X Coordinates: 41.867506		Y Coordinates: -94.160504
Well Contractor Name: Kris Sommer	Drilling Method**:	Rotary Auger	
Well Contractor Registration No: 5222	Boring Depth (ft) x Diameter (in):	21' x 6.25"	
Logged by: Dan Bacehowski	Ground Surface Elevation (ASL):	998.09'	
Start Date: 12/7/2021 Finish Date: 12/7/2021	Top of Casing Elevation (ASL):	999.67'	

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0				14		OH	(0"-2') Top Soil - Organic (PP:2.5 tsf)
1	Concrete				40.0		
2					40.0		
3	Riser			15	50.0	CL	(3'-5') Olive Gray, Sandy Silty Clay
4					50.0	CL	(4'-7') Gray Silty Clay
5	v				50.0		
6	Bentonite				-		
7					-		
8					95.0	CL	(8'-9') Light Brown, Sandy Silty Clay
9	Screen				95.0	SC CL	(9'-10') Sand Seam
10					-	CL	10'-13') Dark Gray, Sandy Silty Clay
11					-		
12	Sand				-		
13					75.0	SC CL	(13'-13.5') Light Brown, Sandy Clay
14					75.0	CL	(13.5'-15') Dark Gray, Sandy Silty Clay
15					75.0		
16					-		
17					-		
18					90.0	CL	(18'-20') Dark Gray, Sandy Silty Clay
19	Bottom of Well				90.0		
20	Backfilled with sand upon completion				90.0		
21	End of boring						
22							
23							
24							
25							

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	12/8/2021	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	8:00 a.m.	**Well Casing Diameter:**	2"	**SLF Permit No.:**	08-SDP-03-84P
Static Water Level (ASL):	5.81'	**Well Screen Size:**	0.010"	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-2

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.84020	Y Coordinates: -94.11323
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	33.5' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	993.47'
Start Date: 12/8/2021	Finish Date: 12/8/2021	Top of Casing Elevation (ASL):	-

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0						OH	(0"-6") Top Soil - Organic (PP:2.5 tsf)
1					60.0	CL	(6"-2') Light Brown, Sandy Silty Clay (PP:1.5 tsf)
2					-		
3				27	100.0	CL	(3'-5') Light Brown, Sandy Silty Clay (PP:2.75 tsf)
4					100.0		
5					-		
6					-		
7					-		
8				24	100.0	CL	(8'-10') Light Brown/Olive, Sandy Silty Clay (PP:2.5 tsf)
9	Backfilled with cuttings upon completion				100.0		
10					-		
11					-		
12					-		
13				39	100.0	CL	(13'-15') Dark Gray, Sandy Silty Clay (PP:2.0 tsf)
14					100.0		
15					-		
16					-		
17					-		
18				53	100.0	CL	(18'-20') Dark Gray, Sandy Silty Clay (PP:>4.5 tsf)
19					100.0		
20					-		
21					-		
22					-		
23					100.0	CL	(23'-25') Dark Gray, Sandy Silty Clay (PP:>4.5 tsf)
24					100.0		
25					-		
26					-		
27					-		
28		(28'-30')	SIEVE		80.0	CL	(28'-29') Dark Gray, Sandy Silty Clay (PP:3.5 tsf)
29					80.0	SC	(29'-30') Light Brown, Well-Graded, Sandy Clay
30					-		
31					-		
32					-		
33					-	SC	(33'-33.5') Light Brown, Well-Graded, Sandy Clay
34	**End of boring**						
35							

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	12/9/2021	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	8:00 a.m.	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	8.50'	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-3

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.867222	Y Coordinates: -94.156330
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in): 35' x 6.25"	
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL): 994.65'	
Start Date: 12/8/2021	Finish Date: 12/8/2021	Top of Casing Elevation (ASL): -	

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0						OH	(0"-2') Top Soil - Organic
1					30.0		
2					-		
3					60.0	CL	(3'-5') Light Brown, Sandy Silty Clay (PP:6.5 tsf)
4					60.0		
5					-		
6					-		
7					-		
8					90.0	CL	(8'-10') Light Brown, Sandy Silty Clay (PP:2.75 tsf)
9	Backfilled with cuttings upon completion				90.0		
10					-		
11					-		
12					-		
13					100.0	CL	(13'-15') Light Brown, Sandy Silty Clay (PP:1.75 tsf)
14					100.0		
15					-		
16					-		
17					-		
18		(18'-19.5')	PERM		90.0	CL	(18'-19') Light Brown, Sandy Silty Clay (PP:>4.5 tsf)
19					90.0	CL	(19'-20') Dark Gray, Sandy Silty Clay (PP:>4.5 tsf)
20					-		
21					-		
22					-		
23					90.0	CL	(23'-25') Dark Gray, Sandy Silty Clay (PP:>4.5 tsf)
24					90.0		
25					-		
26					-		
27					-		
28					80.0	CL	(28'-30') Dark Gray, Sandy Silty Clay (PP:4.25 tsf)
29					80.0		
30					-		
31					-		
32					-		
33					100.0	CL	(33'-35') Dark Gray, Sandy Silty Clay (PP:4.0 tsf)
34					100.0		
35	**End of boring**						

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	-	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	-	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	-	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-4

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.866063	Y Coordinates: -94.158615
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	35' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	1,001.45'
Start Date: 12/7/2021	Finish Date: 12/7/2021	Top of Casing Elevation (ASL):	-

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0						OH	(0"-2') Top Soil - Organic (PP:2.5 tsf)
1					20.0		
2					-		
3				18	20.0	CL	(3'-5') Light Brown, Sandy Silty Clay (PP:1.5 tsf)
4					20.0		
5					-		
6					-		
7					-		
8				25	100.0	CL	(8'-10') Light Brown, Sandy Silty Clay (PP:2.0 tsf)
9	Backfilled with cuttings upon completion				100.0		
10					-		
11					-		
12					-		
13				30	100.0	CL	(13'-15') Light Brown, Sandy Silty Clay (PP:1.5 tsf)
14					100.0		
15					-		
16					-		
17					-		
18				47	30.0	CL	(18'-19') Dark Gray, Sandy Silty Clay (PP:2.5 tsf)
19					30.0	SC	(19'-20') Sand Seam (PP:1.0 tsf)
20					-		
21					-		
22					-		
23				27	100.0	CL	(23'-25') Dark Gray, Sandy Silty Clay (PP:3.75 tsf)
24					100.0		
25					-		
26					-		
27					-		
28				46	90.0	CL	(28'-30') Dark Gray, Sandy Silty Clay (PP:2.5 tsf)
29					90.0		
30					-		
31					-		
32					-		
33		(33'-35')	SIEVE		100.0	CL	(33'-35') Dark Gray, Sandy Silty Clay (PP:4.0 tsf)
34			HYDRO		100.0		
35	**End of boring**		ATTER				

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	-	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	-	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	-	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-5

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.865462	Y Coordinates: -94.156160
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	35' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	1,001.45'
Start Date: 12/6/2021	Finish Date: 12/6/2021	Top of Casing Elevation (ASL):	-

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0				14		OH	(0"-6") Top Soil - Organic
1					50.0	CL	(6"-2') Light Brown, Sandy Silty Clay (PP:3.0 tsf)
2					-		
3					80.0	CL	(3'-5') Light Brown, Sandy Silty Clay (PP:3.0 tsf)
4					80.0		
5					-		
6					-		
7					-		
8		(8'-10')	PERM	39	-	CL	(8'-10') Light Brown, Sandy Silty Clay (PP:3.5 tsf)
9	Backfilled with cuttings upon completion				-		
10					-		
11					-		
12					-		
13				33	100.0	CL	(13'-15') Dark Brown, Sandy Silty Clay (PP:3.25 tsf)
14					100.0		
15					-		
16					-		
17					-		
18		(18'-20')	SIEVE	34	20.0	CL	(18'-20') Dark Gray, Sandy Silty Clay, Sand Seam w/ Moisture (PP:3.25 tsf)
19			HYDRO		20.0		
20			ATTER		-		
21					-		
22					-		
23					100.0	CL	(23'-25') Dark Gray, Sandy Silty Clay (PP:1.75 tsf)
24					100.0		
25					-		
26					-		
27					-		
28					100.0	CL	(28'-30') Dark Gray, Sandy Silty Clay (PP:4.5 tsf)
29					100.0		
30					-		
31					-		
32					-		
33					100.0	CL	(33'-35') Dark Gray, Sandy Silty Clay (PP:4.5 tsf)
34					100.0		
35	End of boring						

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	-	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	-	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	-	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-6

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.865383	Y Coordinates: -94.159730
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	32.5' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	987.6'
Start Date: 12/7/2021	Finish Date: 12/7/2021	Top of Casing Elevation (ASL):	-

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0	Backfilled with cuttings upon completion					CL	(0"-2') Light Brown, Sandy Silty Clay
1					-		
2					-		
3					100.0	CL	(3'-5') Light Brown/Olive, Sandy Silty Clay (PP:4.0 tsf)
4					100.0		
5					-		
6					-		
7					-		
8					80.0	CL	(8'-10') Dark Brown, Sandy Silty Clay (PP:2.5 tsf)
9					80.0		
10					-		
11					-		Moist
12					-		
13					100.0	CL	(13'-15') Dark Gray, Sandy Silty Clay (PP:3.25 tsf)
14					100.0		
15					-		
16					-		
17					-		
18					-	CL	(18'-20') Dark Gray, Sandy Silty Clay
19					-		
20					-		
21					-		
22					-		
23					-	CL	(23'-25') Dark Gray, Sandy Silty Clay, Shale Encountered
24					-		
25					-		
26					-		
27					-		
28					-		
29					80.0		(29.5'-31') Weathered Shale (PP:>4.5 tsf)
30					80.0		
31					-		
32					-		(32.5') Limestone
33	**End of Boring**						
34							
35							

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	-	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	-	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	-	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-7

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.865012	Y Coordinates: -94.157978
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	35' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	989.447'
Start Date: 12/6/2021	Finish Date: 12/6/2021	Top of Casing Elevation (ASL):	-

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0						OH	(0"-2') Top Soil - Organic (PP:1.75 tsf)
1					10.0		
2					-		
3					15.0	CL	(3'-5') Organic Silt/Fill (PP:2.0 tsf)
4					15.0		
5					-		
6					-		
7					-		
8				15	30.0	SC CL	(8'-10') Clayey Sand
9	Backfilled with cuttings upon completion				30.0		
10					-		
11					-		
12					-		
13				64	40.0	CL/SC	(13'-15') Clay, Transition Sand
14					40.0		
15					-		
16					-		
17					-		
18				29	80.0	CL/SC	(18'-20') Light Brown Sand, Dark Gray Sandy Silty Clay (PP:4.5)
19					80.0		
20					-		
21					-		
22					-		
23					80.0	CL	(23'-25') Gray, Sandy Silty Clay w/ Sand Seams (PP:3.5 tsf)
24					80.0		
25					-		
26					-		
27					-		
28				19	100.0	CL	(28'-30') Dark Gray, Sandy Silty Clay (PP:2.75 tsf)
29					100.0		
30					-		
31					-		
32					-		
33					100.0	CL	(33'-35') Dark Gray/Olive, Sandy Silty Clay (PP:4.0 tsf)
34					100.0		
35	**End of boring**						

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

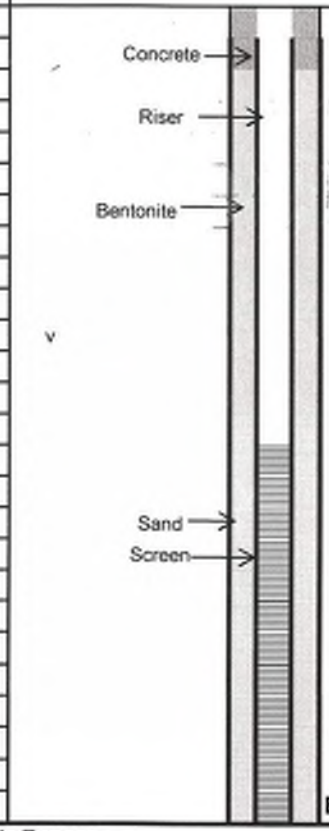
**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	-	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	-	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	-	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-9/MW-31

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.863791	Y Coordinates: -94.160466
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	25' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	980.2819'
Start Date: 12/7/2021	Finish Date: 12/7/2021	Top of Casing Elevation (ASL):	984.5429



Depth (feet)	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0					OH	(0'-2') Top Soil - Organic
1				60.0	CL	Light Brown, Sandy Silty Clay (PP:3.0 tsf)
2				60.0		
3			14	50.0	CL	(3'-5') Light Brown w/ Fill Sandy Silty Clay (PP:3.0 tsf)
4				50.0		
5				-		
6				-		
7				-		
8			15	75.0	CL	(8'-10') Light Brown, Sandy Silty Clay (PP: 2.25 tsf)
9				75.0		
10				-		
11				-		
12				-		
13			40	100.0	CL	(13'-14') Light Brown, Sandy Silty Clay (PP:4.0 tsf)
14				100.0	CL	(14'-15' (Dark Gray, Sandy Silty Clay (PP:2.5 tsf)
15				-		
16				-		
17				-		
18			27	-	CL	(18'-20') Sandy Material/Moist, Likely Sand Seam
19				-		
20				-		
21				-		
22				-		
23			63	50.0	CL	(23'-25) Dark Gray Moist Sandy Silty Clay (PP:0.5 tsf)
24				50.0		
25				-		

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	12/8/2021	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	8:00 a.m.	**Well Casing Diameter:**	2"	**SLF Permit No.:**	08-SDP-03-84P
Static Water Level (ASL):	10.4'	**Well Screen Size:**	0.010"	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-10/MW-32

Facility Name: Metro Park West Landfill - Perry, Iowa	X Coordinates: 41.864460		Y Coordinates: -94.156085
Well Contractor Name: Kris Sommer	Drilling Method**:	Rotary Auger	
Well Contractor Registration No: 5222	Boring Depth (ft) x Diameter (in):	20' x 6.25"	
Logged by: Dan Bacehowski	Ground Surface Elevation (ASL):	966.11'	
Start Date: 12/8/2021 Finish Date: 12/8/2021	Top of Casing Elevation (ASL):	968.58	

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0						OH	(0"-1.5') Top Soil - Organic
1	Concrete				60.0	CL	(1.5'-2') Olive/Brown, Sandy Silty Clay (PP:1.75 tsf)
2					-		
3	Riser				80.0	CL	(3'-5') Light Tan/Brown (PP:1.0 tsf)
4					80.0		
5					-		
6	v Bentonite				-		
7					-		
8		(8'-10')	SIEVE	25	30.0	CL	(8'-10') Light Brown, Sandy Silty Clay (PP:1.25 tsf)
9	Screen		HYDRO		30.0		
10			ATTER		-		
11					-		
12	Sand				-		
13				27	100.0	CL	(13'-15') Light Gray, Sandy Silty Clay (PP:4.0 tsf)
14					100.0		
15					-		
16					-		
17		(17'-19')	SIEVE		-		
18	Backfilled with sand upon completion / Bottom of Well			36	-	CL	(18'-19') Dark Gray, Sandy Silty Clay (PP:4.0 tsf)
19					-	SC	(19'-20') Sand Saturated, Well-Graded
20							
21	End of boring						
22							
23							
24							
25							

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	12/9/2021	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	8:00 a.m.	**Well Casing Diameter:**	2"	**SLF Permit No.:**	08-SDP-03-84P
Static Water Level (ASL):	6.38'	**Well Screen Size:**	0.010"	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-11

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.866283	Y Coordinates: -94.165064
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	25' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	1,003.50
Start Date: 12/8/2021	Finish Date: 12/8/2021	Top of Casing Elevation (ASL):	-

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0				9		OH	(0"-2') Top Soil - Organic
1				13	75		
2				18	-		
3				3,4,6	90.0	CL	(3.5'-5') Olive Gray/Gray, Sandy Silty Clay (PP:2.0 tsf)
4					90.0		
5					-		
6				6,9,14	60.0	CL	(6'-7.5') Olive Gray/Light Brown (PP:>4.5)
7					-		
8				2,4,5	50.0	CL	(8.5'-10') Light Gray/Olive, Sandy Silty Clay (PP:1.75 tsf)
9	Backfilled with cuttings upon completion				50.0		
10					-		
11					-		
12					-		
13				3,5,6	0.0	CL	(13.5'-15') Waste Material in Drill Cuttings, Wet w/ Leachate Odor
14					-		
15					-		
16					-		
17					-		
18				2,3,6	-	CL	(18.5'-20') Additional Waste Material on Drill Cuttings,Dark Gray w/ Waste Material (PP:2.5 tsf)
19					-		
20					-		
21					-		
22					-		
23				2,2,3	-	-	(23.5'-25') Waste Material w/ Liquids
24					-		
25					-		
26	**End of boring**						
27							
28							
29							
30							
31							
32							
33							
34							
35							

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	-	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	-	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	-	**Well Screen Size:**	-	**Project No.:**	10310518

Soil Boring Log And Monitoring Well Construction Diagram for: SB-12

Facility Name: Metro Park West Landfill - Perry, Iowa		X Coordinates: 41.863045	Y Coordinates: -94.158513
Well Contractor Name: Kris Sommer		Drilling Method**: Rotary Auger	
Well Contractor Registration No: 5222		Boring Depth (ft) x Diameter (in):	35' x 6.25"
Logged by: Dan Bacehowski		Ground Surface Elevation (ASL):	984.3219
Start Date: 12/6/2021	Finish Date: 12/6/2021	Top of Casing Elevation (ASL):	-

Depth (feet)	Well Construction Details	Sample No.	Sample Type	Blow Count	Recovery (%)	USCS	Sample Descriptions: soil, color, classification, observation
0				5		OH	(0"-2') Top Soil - Organic (PP:3.0 tsf)
1					50.0		
2				7	5.0	CL	(2'-4') Light Olive Brown Sandy Silty Clay (PP:1.5 tsf)
3					5.0		
4					15.0	CL	(4'-6') Light Olive Brown/Gray Sandy Silty Clay (PP:1.75 tsf)
5					15.0		
6				6	100.0	CL	(6'-8') Light Brown/Olive Sandy Silty Clay (PP:2.5 tsf)
7					100.0		
8					-	CL	(8'-10') Light Olive Brown (PP:4.0 tsf)
9	Backfilled with cuttings upon completion				-		
10					100.0	CL	(10'-12') Light Gray/Brown Sandy Silty Clay (PP:3.5 tsf)
11					100.0		
12					100.0		(12'-14') Light Brown/Olive Sandy Silty Clay (PP:3.5 tsf)
13					100.0		
14					100.0	CL	(14'-16') Gray/Olive Sandy Silty Clay (PP:3.75 tsf)
15					100.0		
16					100.0	CL	(16'-18') Gray Sandy Silty Clay (PP:3.0 tsf)
17					100.0		
18					-	CL	(18'-20') Dark Gray Sandy Silty Clay (PP:2.5 tsf)
19					-		
20					-		
21					-		
22					-		
23					-		
24					-		
25					-		
26					-		
27					-		
28					100.0	CL	(28'-30') Dark Gray, Sandy Silty Clay (PP:2.75 tsf)
29					100.0		
30					100.0		
31					100.0		
32					100.0		
33					100.0	CL	(33'-35') Dark Gray, Sandy Silty Clay (PP:3.75 tsf)
32					100.0		
35	End of boring				100.0		

*** Sample Types:**
Split Spoon (SS)
Continuous Core (CC)

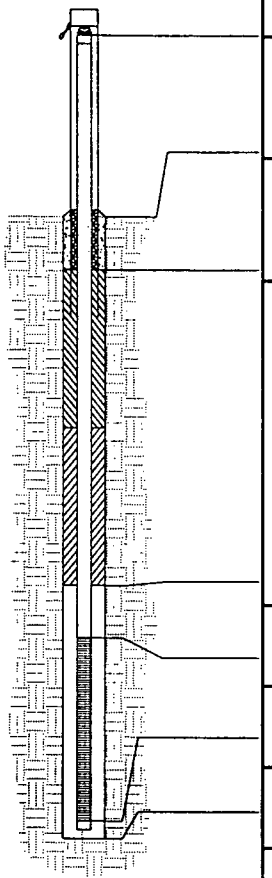
**** Drilling Method Options:**
Rotary Auger, Push Probe, Hand Auger, Air drilling, Hollow Stem Auger, Other (Describe)

Symbols to Use:
v – Static Water Level
s – sample collected

Observation Date:	-	**Borehole Diameter:**	6.25"	**Location:**	MPW Landfill
Time:	-	**Well Casing Diameter:**	-	**SLF Permit No.:**	80-SDP-03-84P
Static Water Level (ASL):	-	**Well Screen Size:**	-	**Project No.:**	10310518

BORING LOG/MONITORING WELL CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation Depth
TOC	940.00
Ground	940
Concrete	1
Bentonite Seal	
	40.6
Sand Pack	45.6
Well Screen	50.6
Well Bottom	51
Bottom of Boring	51

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (feet)	Depth (feet)	Description
ST	4 - 6 ft	HS	16"	24"	Dark Gray Sandy Lean Clay
SS	6 - 8 ft	HS	8"		Gray Silty Clay
SS	9 - 11 ft	HS	8"		Gray Med. Sand @ 8 ft.
					Gray Med. Coarse Sand, Trace Gravel to 26 ft.
SS	29 - 31 ft	HS	18"		Gray Sandy Lean Clay
ST	34 - 36 ft	HS	20"	24"	Gray Sandy Lean Clay, Trace Gravel
SS	39 - 41 ft	HS	18"		Gray Sandy Lean Clay
SS	44 - 46 ft	HS	20"		Gray Sandy Lean Clay
SS	49 - 51 ft	HS	20"		Gray Shale @ 49.5 ft.
					Bottom of Boring @ 51.0 ft.

AR-Air Rotary — HS-Hollow Stem Auger
AS-Auger Sample — PA-Power Auger (solid stem)
CS-Continuous Sampler — SS-Split Spoon
HA-Hand Auger — ST-Shelby Tube

Date:	3/23/99	3/30/99			
Time:	10:00	10:15			
Water Level:	6.0	21.72			
Elevation:		918.28			

Driller: Barker-Lemar
Logged By: K. Sperfslage
Date/Time Start: 3/23/99
Date/Time End: 3/23/99

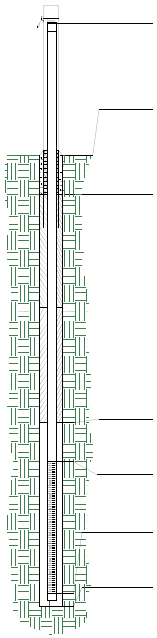
Barker, Lemar & Associates
1300 Cummins Road - Suite 201
Des Moines, Iowa 50315
Phone: 515-256-8814
Fax: 515-256-0152

Borehole Diameter: 8.25"
Well Casing Diameter: 2"
Well Screen Size: 0.010"

Project: **Project No. 99018**
Location: **Perry, Iowa**
Client: **North Dallas SLF**
Owner: **North Dallas SLF**
Boring/Well No: **MW-2BR**

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation Depth
TOC	2.56
	939.46
Ground	0.00
	936.9
Bentonite Seal	-3.00
	933.9
Sand Pack	-8.19
	928.7
Well Screen	-9.69
	927.2
Well Bottom	-24.69
	912.2
Bottom of Boring	-26.00
	910.9

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
		HS		0	Grass and topsoil
				0-2	Gray sandy silty clay, very moist
				2-3	Blue/gray sandy silty clay, moist
				3-5	Light brown/gray mottling, sandy silty clay
				5-10	Gray sandy silty clay, moist
				10-12.5	Gray/dark gray sandy silty clay, very moist
				12.5-15	Sand, well sorted, damp to wet
				15-20	Gray sand, wet
				20-22	Gray sandy silty clay
				22-26	Gray sand

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger

HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
WB-Wash Boring

Date:	10/25/2013
Time:	2:01 AM
Water Level:	19.50
Elevation:	919.96

Driller:	Mike Dixon
Logged By:	Mike Dixon
Date/Time Start:	10/23/2013 5:15 PM
Date/Time End:	10/24/2013 10:30 AM

BARKER LEMAR
ENGINEERING CONSULTANTS

Borehole Diameter:	8.25 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	80-SDP-03-84P
Project No.:	METRO 13104

Project:	**MPW Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-20**

MONITORING WELL/PIEZOMETER CONSTRUCTION FORM

Disposal Site Name: Metro Park West Landfill — Permit # 80-SDP-03-84P
Well or Piezometer #: MW-20 — Date Started: 10/23/2013 — Date Completed: 10/24/2013
Project No.: METRO 13104

A. Surveyed Locations and Elevations

Locations (+/-0.5 ft.):

Surveyed location of Well	N 679673.7 E 1458956
Distance and Direction from boundary to well	

Elevation(+/-0.01 ft. MSL):

Ground surface	936.9
Top of Protective Casing	939.9
Top of Well Casing	939.46
Benchmark Elevation	NA
Benchmark Description	NA

B. Soil Boring Information

Name and Address of Construction Company
Barker Lemar Engineering Consultants (BLEC)
1801 Industrial Circle
West Des Moines, IA 50265

Name of Driller	Mike Dixon
Drilling Method	Hollow Stem
Drilling Fluid	None
Bore hole Diameter	8.25 inches
Soil Sampling Method	Continuous Sampler
Depth of Boring *	26.0

C. Monitoring Well Installation

Casing Material	PVC
Length of Casing	12.3
Outside Casing Diameter	2.375 inch
Inside Casing Diameter	2.0 inch
Casing Joint Type	threaded
Casing/Screen joint type	threaded
Screen material	PVC
Screen opening size	0.010 inch
Screen length	15
Depth of Well **	27.3

Well Installation, continued:

Filter pack:

Material	Silica Sand	
Grain Size		
Volume	6.06	ft^3

Seal (minimum of 3 ft. length above filter pack)

Material	Bentonite grout	
Placement Method	tremie tube	
Volume	1.77	ft^3

Backfill (if different from seal):

Material	NA
Placement Method	NA
Volume	NA

Surface seal design:

Material of Protective Casing:
Steel
Material of grout between protective casing and well casing
Bentonite
Protective cap material
Steel
Vented? (Y/N) Y — Locking? (Y/N) Y
Well cap material
J Plug
Vented? (Y/N) Y

D. Groundwater Measurement

Fluid level (+/-0.01 ft. below top of inner well casing): 19.50
Stabilization time: > 24 hours
Well development method
Hand bailing

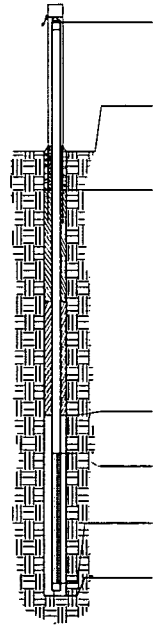
Upgradient or downgradient well?
Downgradient
Average Depth of Frostline
3-feet

* Depth of boring measured from ground surface.

** Depth of well measured from Top of Casing (TOC).

BORING LOG/PIEZOMETER CONSTRUCTION DETAIL

Monitoring Well Detail



Material	Elevation / Depth
TOC	2.23
	943.07
Ground	0.0
	940.8
Bentonite Seal	-2.0
	938.8
Sand Pack	-7.0
	933.8
Well Screen	-10.0
	930.8
Well Bottom	-20.0
	920.8
Bottom of Boring	-20.0
	920.8

Boring Log Detail

Sample Method	Sample Interval	Drill Method	Recovery (inches)	Strata Depth (ft)	Description
DP	1 ft	HS	Full	0-1	Black organic matter
				1-8	Brown sandy clay
				8-9	Gray sandy clay, trace brown mottling
				9-15	Gray sandy clay
				15-20	Gray compressed sand

AR-Air Rotary
AS-Auger Sample
GS-Grab Sample
HA-Hand Auger
HS-Hollow Stem Auger
PA-Power Auger (solid stem)
SS-Split Spoon
DP-Direct Push
WB-Wash Boring

Date:	4/21/2015
Time:	3:50 PM
Water Level:	13.63
Elevation:	929.44

Driller:	Saberprobe, LLC
Logged By:	Austin Banks
Date/Time Start:	-
Date/Time End:	-

BARKER LEMAR
ENGINEERING CONSULTANTS

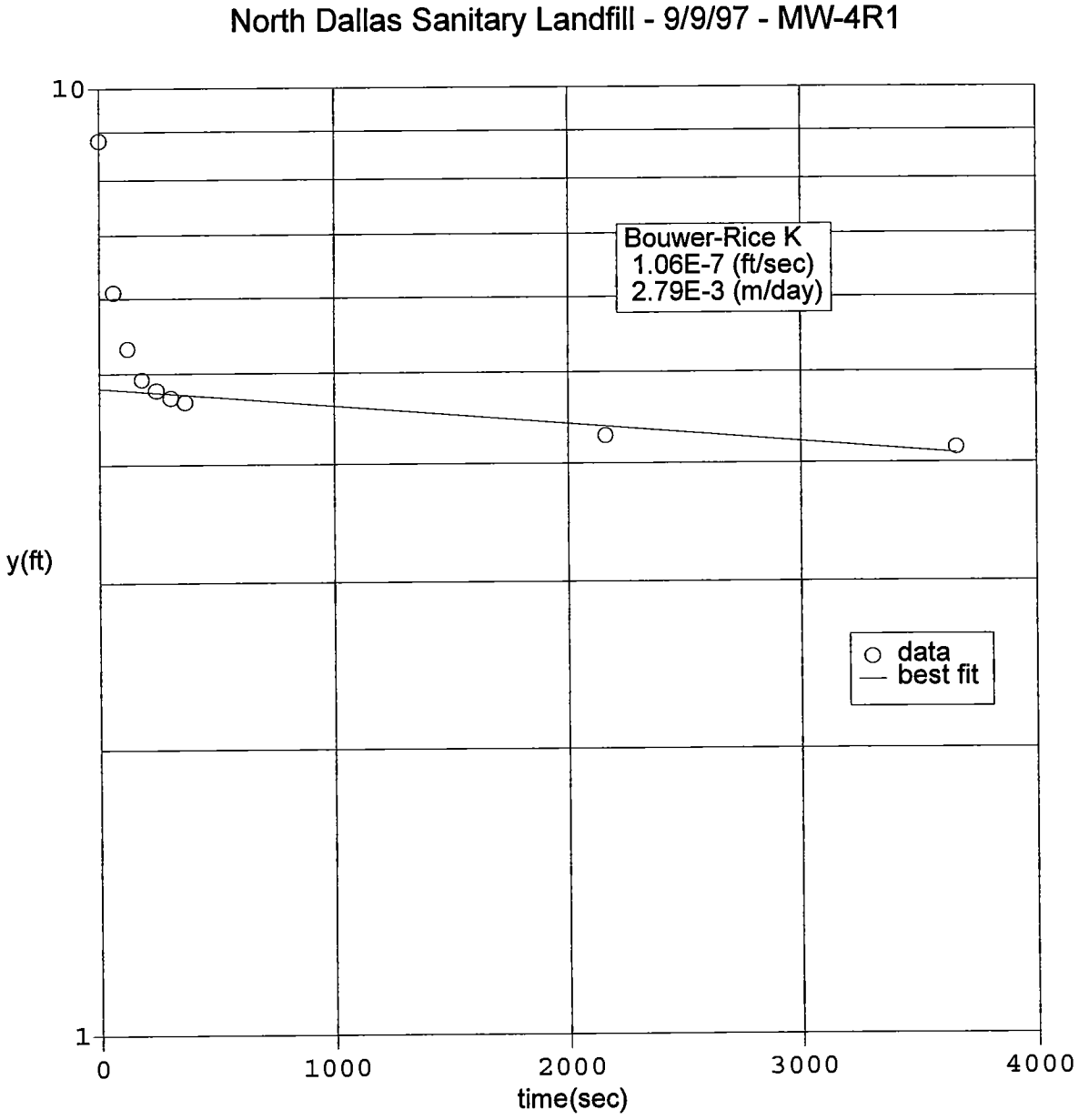
Borehole Diameter:	8 inches
Well Casing Diameter:	2 inch
Well Screen Size:	0.010 inch
LUST/SLF Permit No.:	08-SDP-03-84P
Project No.:	METRO 15104

Project:	**Metro Park West Landfill**
Location:	**Perry, Iowa**
Client:	**Metro Waste Authority**
Owner:	**Metro Waste Authority**
Boring/Well No:	**MW-27**

APPENDIX D

SLUG TEST ANALYSIS WORKSHEETS

CLAY


North Dallas Sanitary Landfill - 9/9/97 - MW-4R1
10
1
y(ft)
0
1000
2000
3000
4000
time(sec)
Bouwer-Rice K
1.06E-7 (ft/sec)
2.79E-3 (m/day)
data
best fit

Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: E97011
Well Number: MW-4R1

Hydraulic Conductivity

Bouwer-Rice: 1.06E-7 (ft/sec), 2.79E-3 (m/day)

Well Geometry (ft)
H: 41.38
Le: 11.5
Lw: 12.08
rc: .083
rw: .344

drainable filter pack porosity: 0.15
effective radius: 1.54E-1 (ft)

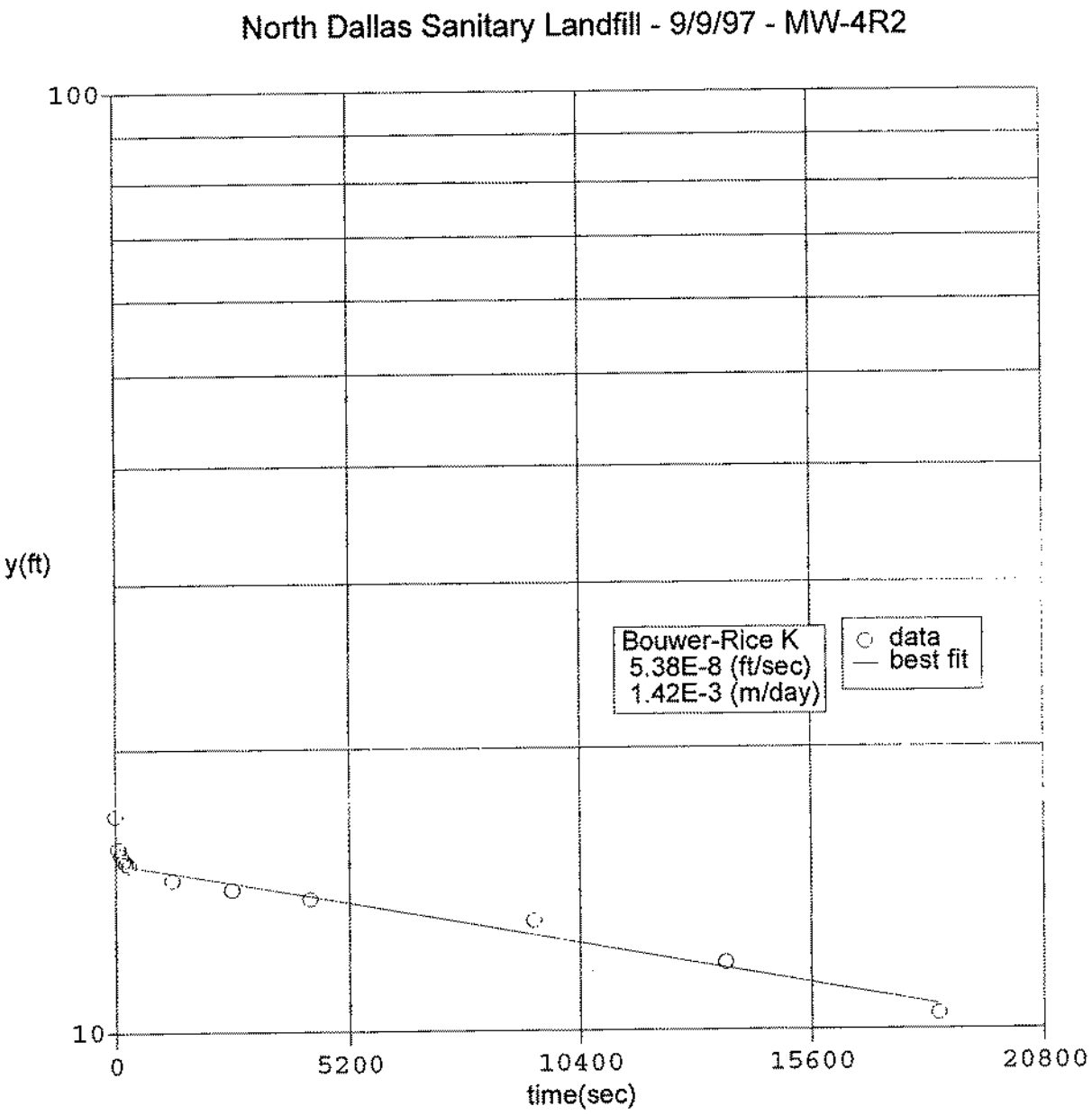
Bouwer Rice Coefficients
Le/rw: 33.455
A: 2.517
B: 0.367
C: 2.109
ln(Re/rw): 2.309

Least Squares Fit
slope: -4.48E-5
intercept: 1.57E+0

Recovery Data and Fit

time(sec)	y(ft)	weight	fit(ft)
0.0	8.810	0.0	4.822
60.0	6.090	0.0	4.809
120.0	5.310	0.0	4.796
180.0	4.930	1.0	4.783
240.0	4.800	1.0	4.770
300.0	4.710	1.0	4.757
360.0	4.660	1.0	4.745
2160.0	4.280	1.0	4.377
3660.0	4.150	1.0	4.093

CLAY


North Dallas Sanitary Landfill - 9/9/97 - MW-4R2
100
10
y(ft)
0
5200
10400
15600
20800
time(sec)
Bouwer-Rice K
5.38E-8 (ft/sec)
1.42E-3 (m/day)
data
best fit

Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: E97011
Well Number: MW-4R2

Hydraulic Conductivity

Bouwer-Rice: 5.38E-8 (ft/sec), 1.42E-3 (m/day)

Well Geometry (ft)
H: 37.21
Le: 11.0
Lw: 22.7
rc: .083
rw: .344

drainable filter pack porosity: 0.15
effective radius: 1.54E-1 (ft)

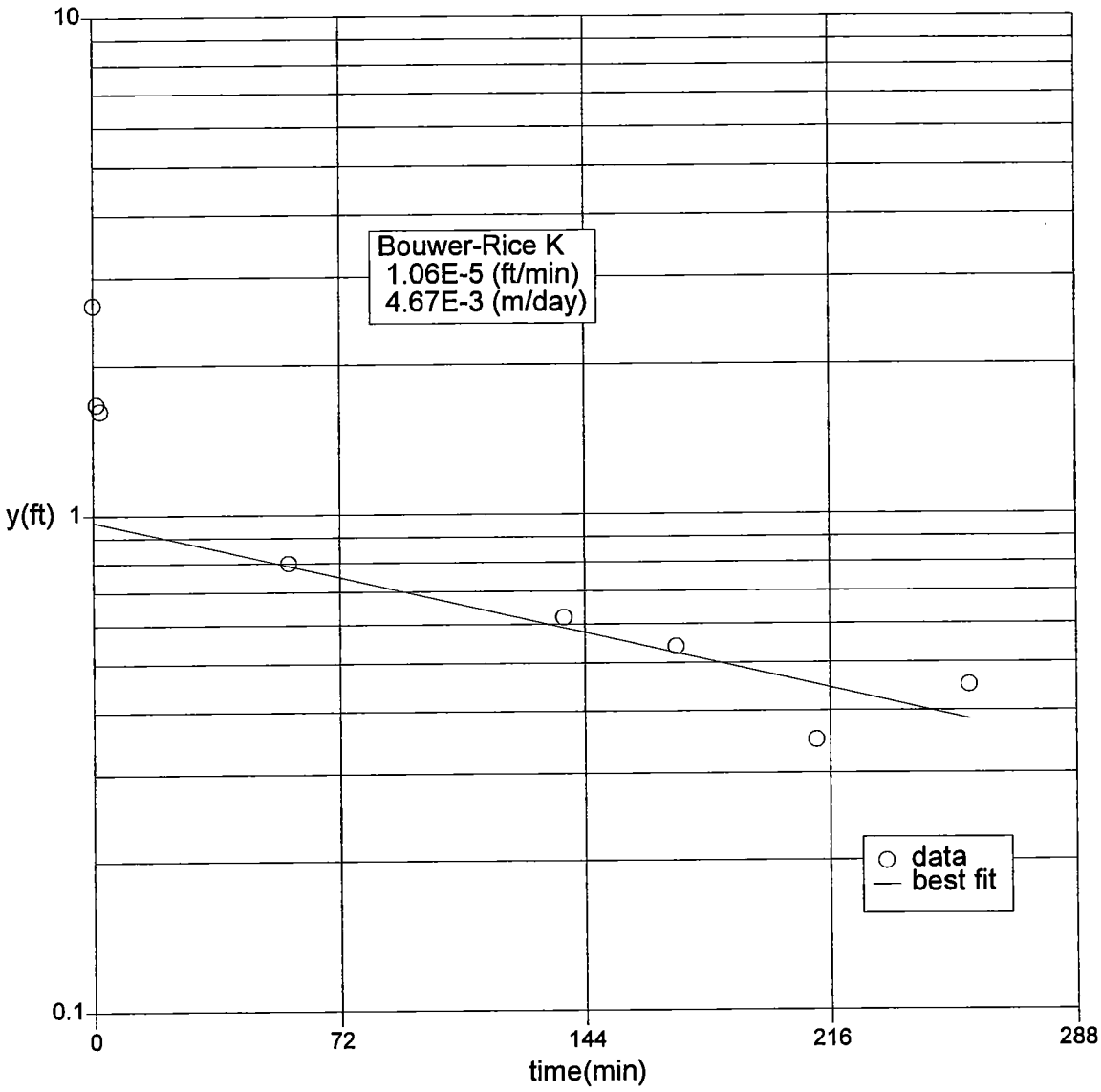
Bouwer Rice Coefficients
Le/rw: 32.0
A: 2.476
B: 0.36
C: 2.063
ln(Re/rw): 2.618

Least Squares Fit
slope: -1.92E-5
intercept: 2.72E+0

Recovery Data and Fit

time(sec)	y(ft)	weight	fit(ft)
0.0	16.980	0.0	15.122
60.0	15.680	0.0	15.105
120.0	15.430	0.0	15.087
180.0	15.230	0.0	15.070
240.0	15.130	0.0	15.053
300.0	15.040	0.0	15.035
1260.0	14.490	0.0	14.761
2580.0	14.150	1.0	14.392
4320.0	13.820	1.0	13.920
9360.0	13.080	1.0	12.638
13680.0	11.780	1.0	11.634
18450.0	10.380	1.0	10.617

CLAY


North Dallas Sanitary Landfill - 1/2/98 - MW-6A
Bouwer-Rice K
1.06E-5 (ft/min)
4.67E-3 (m/day)
data
best fit
y(ft)
10
1
0.1
0
72
144
216
288
time(min)

Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: 97011
Well Number: MW-6A

Hydraulic Conductivity

Bouwer-Rice: 1.06E-5 (ft/min), 4.67E-3 (m/day)

Well Geometry (ft)
H: 12.22
Le: 7.62
Lw: 7.62
rc: .083
rw: .323

drainable filter pack porosity: 0.15
effective radius: 1.47E-1 (ft)

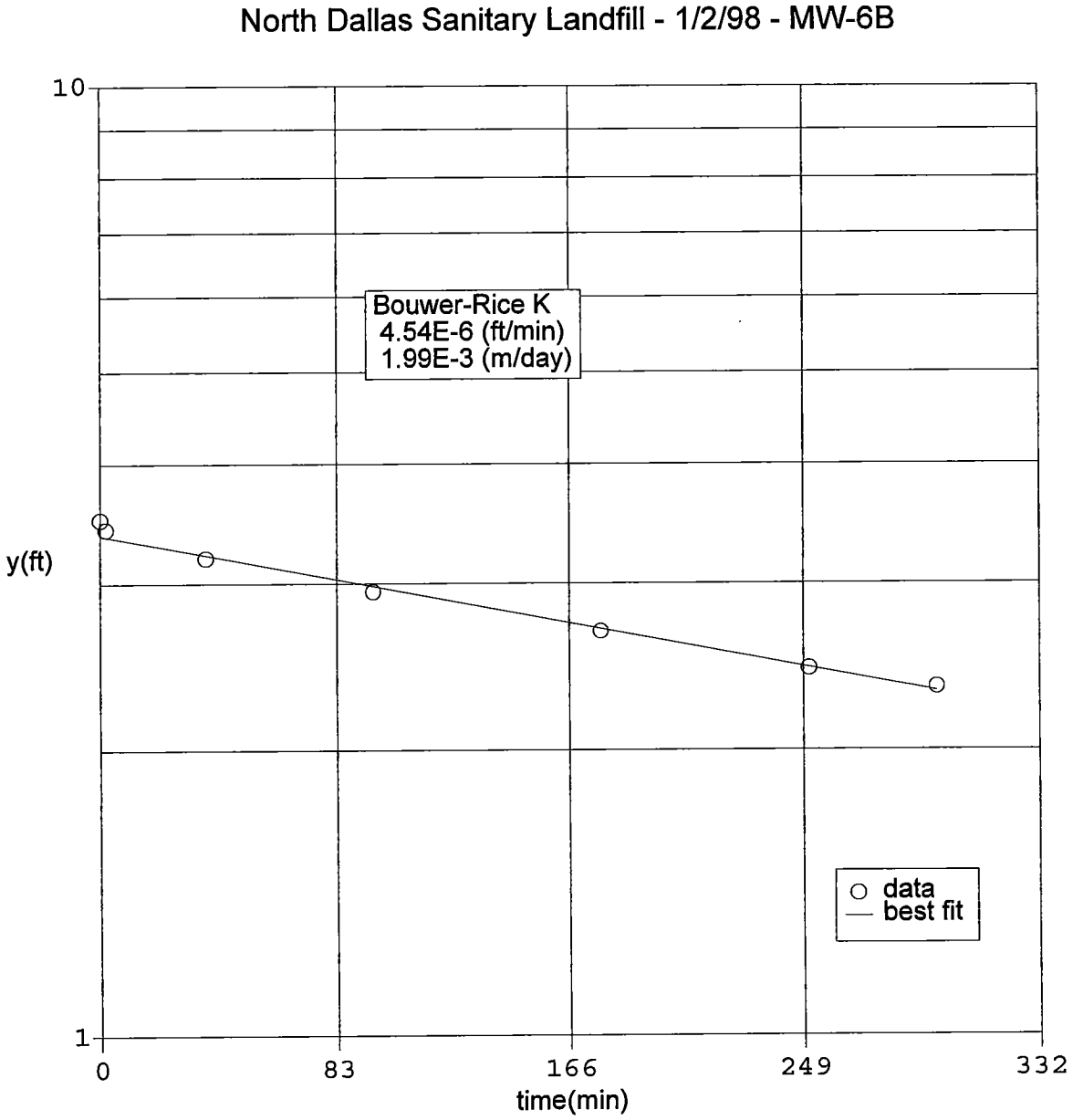
Bouwer Rice Coefficients
Le/rw: 23.599
A: 2.241
B: 0.318
C: 1.682
ln(Re/rw): 2.089

Least Squares Fit
slope: -3.60E-3
intercept: -3.14E-2

Recovery Data and Fit

time(min)	y(ft)	weight	fit(ft)
0.0	2.640	0.0	0.969
1.0	1.670	0.0	0.966
2.0	1.620	0.0	0.962
57.0	0.800	1.0	0.789
138.0	0.620	1.0	0.589
171.0	0.540	1.0	0.523
212.0	0.350	1.0	0.451
257.0	0.450	1.0	0.384

CLAY


North Dallas Sanitary Landfill - 1/2/98 - MW-6B
10
1
y(ft)
Bouwer-Rice K
4.54E-6 (ft/min)
1.99E-3 (m/day)
data
best fit
0
83
166
249
332
time(min)

Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: 97011
Well Number: MW-6B

Hydraulic Conductivity

Bouwer-Rice: 4.54E-6 (ft/min), 1.99E-3 (m/day)

Well Geometry (ft)
H: 32.92
Le: 10.0
Lw: 32.92
rc: .083
rw: .323

drainable filter pack porosity: 0.15
effective radius: 1.47E-1 (ft)

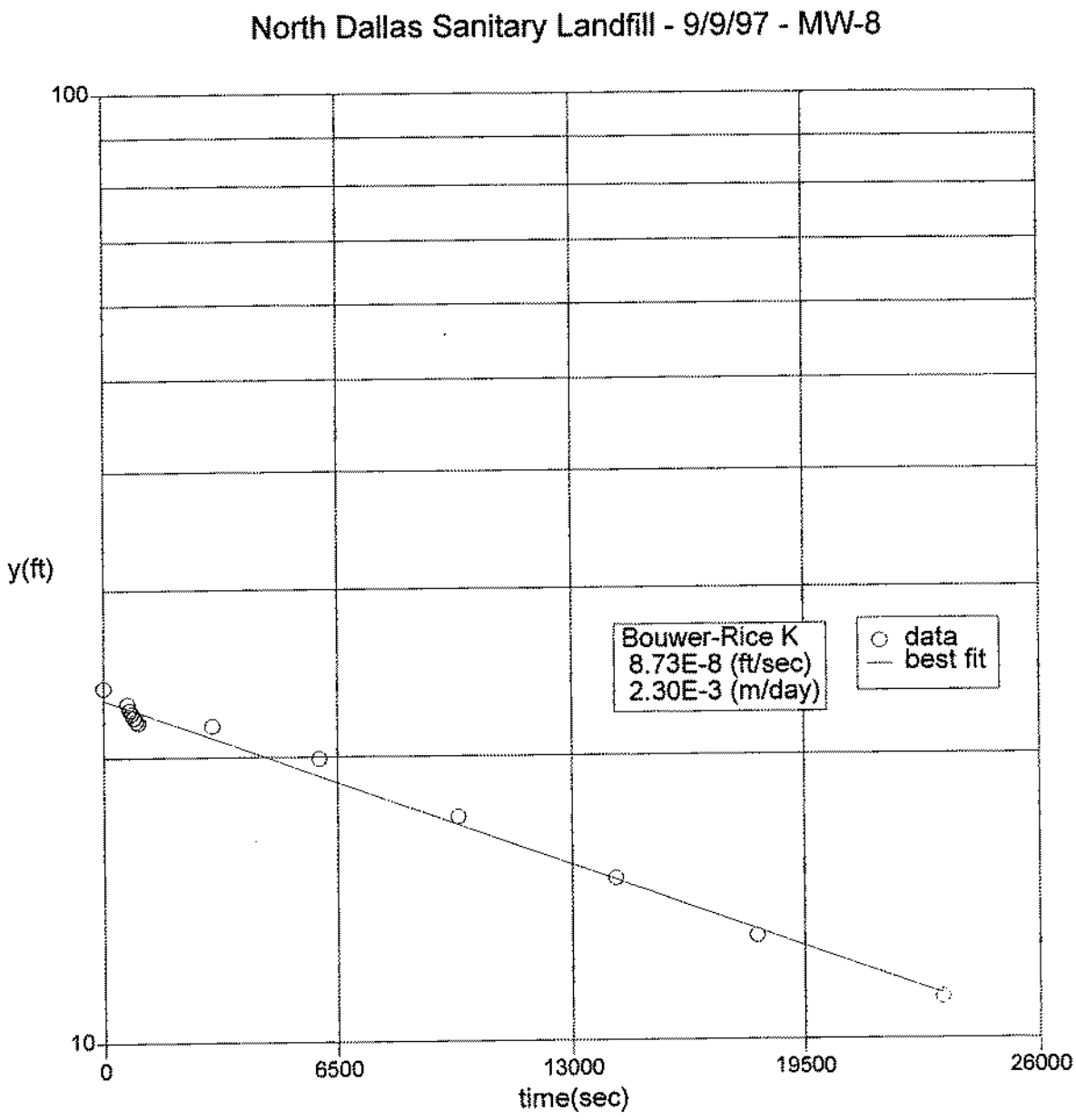
Bouwer Rice Coefficients
Le/rw: 30.969
A: 2.447
B: 0.355
C: 2.03
ln(Re/rw): 3.296

Least Squares Fit
slope: -1.28E-3
intercept: 1.21E+0

Recovery Data and Fit

time(min)	y(ft)	weight	fit(ft)
0.0	3.500	0.0	3.368
2.0	3.420	1.0	3.360
37.0	3.190	1.0	3.213
96.0	2.940	1.0	2.979
177.0	2.670	1.0	2.686
251.0	2.440	1.0	2.444
296.0	2.330	1.0	2.307

CLAY


North Dallas Sanitary Landfill - 9/9/97 - MW-8
100
10
y(ft)
0
6500
13000
19500
26000
time(sec)
Bouwer-Rice K
8.73E-8 (ft/sec)
2.30E-3 (m/day)
data
best fit

Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: E97011
Well Number: MW-8

Hydraulic Conductivity

Bouwer-Rice: 8.73E-8 (ft/sec), 2.30E-3 (m/day)

Well Geometry (ft)
H: 48.31
Le: 11.5
Lw: 30.41
rc: .083
rw: .344

drainable filter pack porosity: 0.15
effective radius: 1.54E-1 (ft)

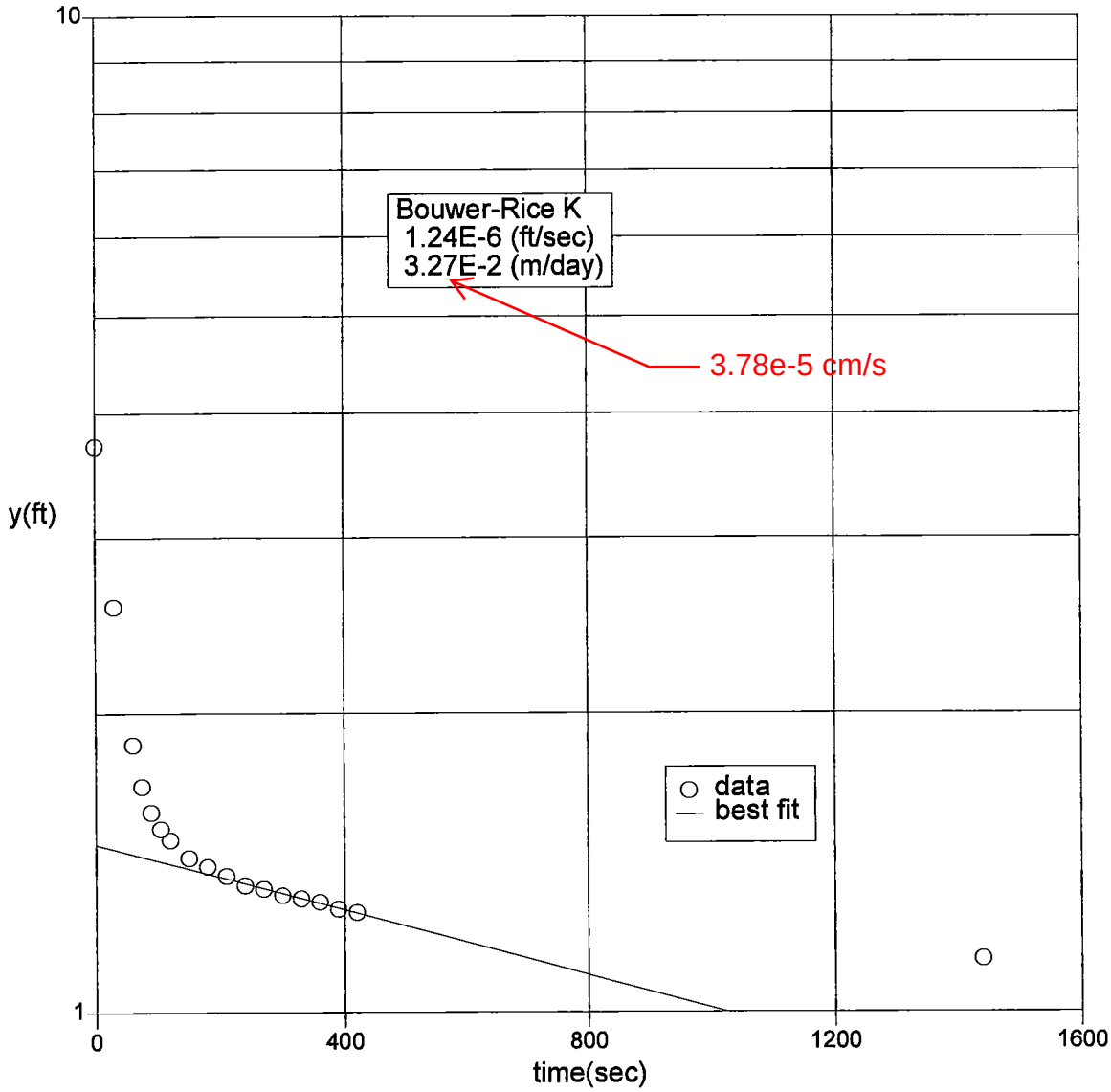
Bouwer Rice Coefficients
Le/rw: 33.455
A: 2.517
B: 0.367
C: 2.109
ln(Re/rw): 2.747

Least Squares Fit
slope: -3.10E-5
intercept: 3.13E+0

Recovery Data and Fit

time(sec)	y(ft)	weight	fit(ft)
0.0	23.650	0.0	22.980
660.0	22.750	1.0	22.514
720.0	22.420	1.0	22.472
780.0	22.230	1.0	22.431
840.0	22.010	1.0	22.389
900.0	21.830	1.0	22.347
960.0	21.740	1.0	22.306
3000.0	21.550	1.0	20.939
6000.0	19.900	1.0	19.080
9840.0	17.250	1.0	16.938
14220.0	14.830	1.0	14.788
18180.0	12.870	1.0	13.080
23310.0	11.060	1.0	11.157

North Dallas Sanitary Landfill - 9/9/97 - MW-9A



Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: E97011
Well Number: MW-9A

Hydraulic Conductivity

Bouwer-Rice: 1.24E-6 (ft/sec), 3.27E-2 (m/day)

Well Geometry (ft)
H: 41.38
Le: 6.38
Lw: 6.38
rc: .083
rw: .344

drainable filter pack porosity: 0.15
effective radius: 1.54E-1 (ft)

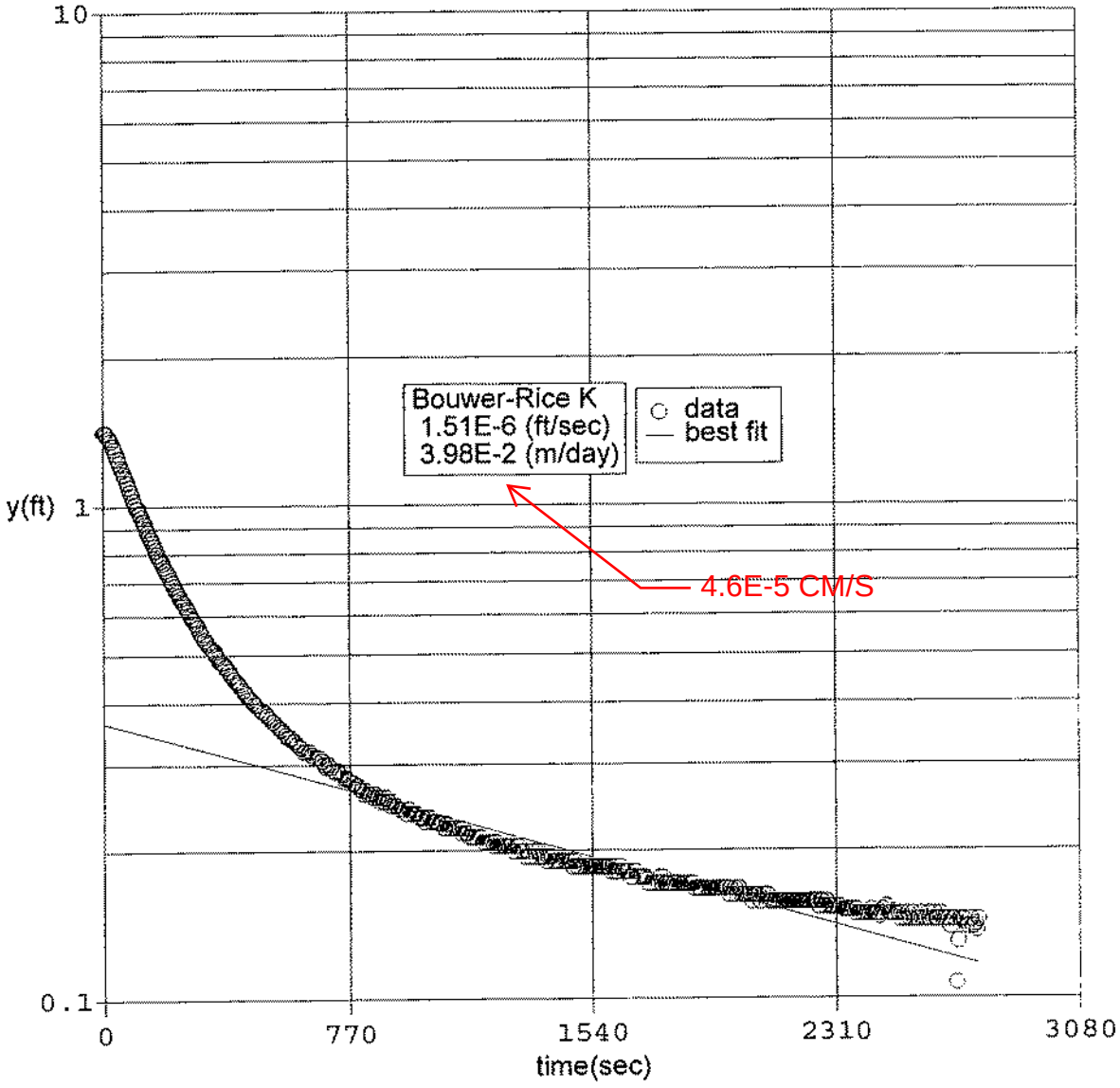
Bouwer Rice Coefficients
Le/rw: 18.56
A: 2.1
B: 0.291
C: 1.432
ln(Re/rw): 1.779

Least Squares Fit
slope: -3.78E-4
intercept: 3.88E-1

Recovery Data and Fit

time(sec)	y(ft)	weight	fit(ft)
0.0	3.710	0.0	1.474
30.0	2.560	0.0	1.457
60.0	1.860	0.0	1.441
75.0	1.690	0.0	1.433
90.0	1.590	0.0	1.425
105.0	1.530	0.0	1.416
120.0	1.490	0.0	1.408
150.0	1.430	0.0	1.393
180.0	1.400	0.0	1.377
210.0	1.370	1.0	1.361
240.0	1.340	1.0	1.346
270.0	1.330	1.0	1.331
300.0	1.310	1.0	1.316
330.0	1.300	1.0	1.301
360.0	1.290	1.0	1.286
390.0	1.270	1.0	1.272
420.0	1.260	1.0	1.257
1440.0	1.130	0.0	0.855

North Dallas Sanitary Landfill - 9/9/97 - MW-9B



Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: E97011
Well Number: MW-9B

Hydraulic Conductivity

Bouwer-Rice: 1.51E-6 (ft/sec), 3.98E-2 (m/day)

Well Geometry (ft)
H: 20.45
Le: 9.5
Lw: 20.45
rc: .083
rw: .344

drainable filter pack porosity: 0.15
effective radius: 1.54E-1 (ft)

Bouwer Rice Coefficients
Le/rw: 27.636
A: 2.354
B: 0.338
C: 1.883
ln(Re/rw): 2.964

Least Squares Fit
slope: -4.11E-4
intercept: -1.01E+0

Recovery Data and Fit

time(sec)	y(ft)	weight	fit(ft)
0.0	1.410	0.0	0.365
5.0	1.410	0.0	0.364
10.0	1.401	0.0	0.363
15.0	1.378	0.0	0.363
20.0	1.375	0.0	0.362
25.0	1.357	0.0	0.361
30.0	1.325	0.0	0.360
35.0	1.306	0.0	0.360
40.0	1.281	0.0	0.359
45.0	1.249	0.0	0.358
50.0	1.225	0.0	0.358
55.0	1.198	0.0	0.357
60.0	1.184	0.0	0.356
65.0	1.161	0.0	0.355
70.0	1.140	0.0	0.355
75.0	1.117	0.0	0.354
80.0	1.094	0.0	0.353
85.0	1.071	0.0	0.352
90.0	1.052	0.0	0.352
95.0	1.027	0.0	0.351
100.0	1.009	0.0	0.350

105.0	0.990	0.0	0.350
110.0	0.990	0.0	0.349
115.0	0.969	0.0	0.348
120.0	0.951	0.0	0.347
125.0	0.933	0.0	0.347
130.0	0.919	0.0	0.346
135.0	0.900	0.0	0.345
140.0	0.886	0.0	0.345
145.0	0.870	0.0	0.344
150.0	0.856	0.0	0.343
155.0	0.843	0.0	0.342
160.0	0.829	0.0	0.342
165.0	0.815	0.0	0.341
170.0	0.799	0.0	0.340
175.0	0.785	0.0	0.340
180.0	0.776	0.0	0.339
185.0	0.766	0.0	0.338
190.0	0.753	0.0	0.338
195.0	0.743	0.0	0.337
200.0	0.732	0.0	0.336
205.0	0.723	0.0	0.335
210.0	0.709	0.0	0.335
215.0	0.700	0.0	0.334
220.0	0.690	0.0	0.333
225.0	0.676	0.0	0.333
230.0	0.672	0.0	0.332
235.0	0.660	0.0	0.331
240.0	0.651	0.0	0.331
245.0	0.642	0.0	0.330
250.0	0.637	0.0	0.329
255.0	0.628	0.0	0.329
260.0	0.619	0.0	0.328
265.0	0.614	0.0	0.327
270.0	0.603	0.0	0.327
275.0	0.593	0.0	0.326
280.0	0.589	0.0	0.325
285.0	0.580	0.0	0.325
290.0	0.575	0.0	0.324
295.0	0.570	0.0	0.323
300.0	0.557	0.0	0.323
305.0	0.552	0.0	0.322
310.0	0.545	0.0	0.321
315.0	0.536	0.0	0.321
320.0	0.531	0.0	0.320
325.0	0.527	0.0	0.319
330.0	0.517	0.0	0.319
335.0	0.517	0.0	0.318
340.0	0.513	0.0	0.317
345.0	0.508	0.0	0.317
350.0	0.499	0.0	0.316
355.0	0.494	0.0	0.315
360.0	0.487	0.0	0.315
365.0	0.483	0.0	0.314
370.0	0.483	0.0	0.313
375.0	0.478	0.0	0.313
380.0	0.473	0.0	0.312
385.0	0.464	0.0	0.312

390.0	0.464	0.0	0.311
395.0	0.455	0.0	0.310
400.0	0.455	0.0	0.310
405.0	0.446	0.0	0.309
410.0	0.441	0.0	0.308
415.0	0.441	0.0	0.308
420.0	0.437	0.0	0.307
425.0	0.432	0.0	0.306
430.0	0.425	0.0	0.306
435.0	0.425	0.0	0.305
440.0	0.420	0.0	0.305
445.0	0.416	0.0	0.304
450.0	0.411	0.0	0.303
455.0	0.407	0.0	0.303
460.0	0.407	0.0	0.302
465.0	0.402	0.0	0.301
470.0	0.397	0.0	0.301
475.0	0.397	0.0	0.300
480.0	0.397	0.0	0.300
485.0	0.388	0.0	0.299
490.0	0.388	0.0	0.298
495.0	0.384	0.0	0.298
500.0	0.384	0.0	0.297
505.0	0.381	0.0	0.296
510.0	0.377	0.0	0.296
515.0	0.372	0.0	0.295
520.0	0.372	0.0	0.295
525.0	0.367	0.0	0.294
530.0	0.367	0.0	0.293
535.0	0.363	0.0	0.293
540.0	0.358	0.0	0.292
545.0	0.358	0.0	0.292
550.0	0.354	0.0	0.291
555.0	0.354	0.0	0.290
560.0	0.349	0.0	0.290
565.0	0.344	0.0	0.289
570.0	0.344	0.0	0.289
575.0	0.340	1.0	0.288
580.0	0.340	1.0	0.287
585.0	0.340	1.0	0.287
590.0	0.335	1.0	0.286
595.0	0.335	1.0	0.286
600.0	0.330	1.0	0.285
605.0	0.330	1.0	0.285
610.0	0.326	1.0	0.284
615.0	0.324	1.0	0.283
620.0	0.319	1.0	0.283
625.0	0.319	1.0	0.282
630.0	0.319	1.0	0.282
635.0	0.319	1.0	0.281
640.0	0.319	1.0	0.280
645.0	0.319	1.0	0.280
650.0	0.314	1.0	0.279
655.0	0.310	1.0	0.279
660.0	0.310	1.0	0.278
665.0	0.310	1.0	0.278
670.0	0.310	1.0	0.277

675.0	0.310	1.0	0.276
680.0	0.305	1.0	0.276
685.0	0.305	1.0	0.275
690.0	0.300	1.0	0.275
695.0	0.296	1.0	0.274
700.0	0.300	1.0	0.274
705.0	0.300	1.0	0.273
710.0	0.296	1.0	0.273
715.0	0.291	1.0	0.272
720.0	0.291	1.0	0.271
725.0	0.291	1.0	0.271
730.0	0.291	1.0	0.270
735.0	0.291	1.0	0.270
740.0	0.287	1.0	0.269
745.0	0.282	1.0	0.269
750.0	0.287	1.0	0.268
755.0	0.282	1.0	0.268
760.0	0.280	1.0	0.267
765.0	0.280	1.0	0.266
770.0	0.280	1.0	0.266
775.0	0.275	1.0	0.265
780.0	0.275	1.0	0.265
785.0	0.275	1.0	0.264
790.0	0.271	1.0	0.264
795.0	0.271	1.0	0.263
800.0	0.271	1.0	0.263
805.0	0.266	1.0	0.262
810.0	0.266	1.0	0.262
815.0	0.261	1.0	0.261
820.0	0.266	1.0	0.260
825.0	0.261	1.0	0.260
830.0	0.261	1.0	0.259
835.0	0.261	1.0	0.259
840.0	0.261	1.0	0.258
845.0	0.257	1.0	0.258
850.0	0.261	1.0	0.257
855.0	0.257	1.0	0.257
860.0	0.257	1.0	0.256
865.0	0.252	1.0	0.256
870.0	0.257	1.0	0.255
875.0	0.252	1.0	0.255
880.0	0.252	1.0	0.254
885.0	0.257	1.0	0.254
890.0	0.252	1.0	0.253
895.0	0.252	1.0	0.253
900.0	0.247	1.0	0.252
905.0	0.252	1.0	0.252
910.0	0.247	1.0	0.251
915.0	0.247	1.0	0.250
920.0	0.247	1.0	0.250
925.0	0.243	1.0	0.249
930.0	0.243	1.0	0.249
935.0	0.243	1.0	0.248
940.0	0.243	1.0	0.248
945.0	0.243	1.0	0.247
950.0	0.238	1.0	0.247
955.0	0.243	1.0	0.246

960.0	0.243	1.0	0.246
965.0	0.238	1.0	0.245
970.0	0.238	1.0	0.245
975.0	0.238	1.0	0.244
980.0	0.238	1.0	0.244
985.0	0.238	1.0	0.243
990.0	0.234	1.0	0.243
995.0	0.234	1.0	0.242
1000.0	0.234	1.0	0.242
1005.0	0.234	1.0	0.241
1010.0	0.229	1.0	0.241
1015.0	0.234	1.0	0.240
1020.0	0.234	1.0	0.240
1025.0	0.234	1.0	0.239
1030.0	0.229	1.0	0.239
1035.0	0.229	1.0	0.238
1040.0	0.229	1.0	0.238
1045.0	0.229	1.0	0.237
1050.0	0.229	1.0	0.237
1055.0	0.227	1.0	0.236
1060.0	0.227	1.0	0.236
1065.0	0.227	1.0	0.236
1070.0	0.222	1.0	0.235
1075.0	0.222	1.0	0.235
1080.0	0.227	1.0	0.234
1085.0	0.222	1.0	0.234
1090.0	0.222	1.0	0.233
1095.0	0.222	1.0	0.233
1100.0	0.222	1.0	0.232
1105.0	0.222	1.0	0.232
1110.0	0.222	1.0	0.231
1115.0	0.222	1.0	0.231
1120.0	0.222	1.0	0.230
1125.0	0.217	1.0	0.230
1130.0	0.222	1.0	0.229
1135.0	0.217	1.0	0.229
1140.0	0.217	1.0	0.228
1145.0	0.217	1.0	0.228
1150.0	0.213	1.0	0.227
1155.0	0.213	1.0	0.227
1160.0	0.213	1.0	0.226
1165.0	0.213	1.0	0.226
1170.0	0.213	1.0	0.226
1175.0	0.213	1.0	0.225
1180.0	0.213	1.0	0.225
1185.0	0.213	1.0	0.224
1190.0	0.213	1.0	0.224
1195.0	0.208	1.0	0.223
1200.0	0.208	1.0	0.223
1205.0	0.208	1.0	0.222
1210.0	0.208	1.0	0.222
1215.0	0.208	1.0	0.221
1220.0	0.208	1.0	0.221
1225.0	0.208	1.0	0.221
1230.0	0.204	1.0	0.220
1235.0	0.208	1.0	0.220
1240.0	0.204	1.0	0.219

1245.0	0.204	1.0	0.219
1250.0	0.204	1.0	0.218
1255.0	0.204	1.0	0.218
1260.0	0.204	1.0	0.217
1265.0	0.204	1.0	0.217
1270.0	0.204	1.0	0.216
1275.0	0.204	1.0	0.216
1280.0	0.204	1.0	0.216
1285.0	0.204	1.0	0.215
1290.0	0.199	1.0	0.215
1295.0	0.199	1.0	0.214
1300.0	0.204	1.0	0.214
1305.0	0.204	1.0	0.213
1310.0	0.204	1.0	0.213
1315.0	0.199	1.0	0.212
1320.0	0.199	1.0	0.212
1325.0	0.199	1.0	0.212
1330.0	0.194	1.0	0.211
1335.0	0.199	1.0	0.211
1340.0	0.194	1.0	0.210
1345.0	0.194	1.0	0.210
1350.0	0.199	1.0	0.209
1355.0	0.194	1.0	0.209
1360.0	0.199	1.0	0.209
1365.0	0.194	1.0	0.208
1370.0	0.199	1.0	0.208
1375.0	0.194	1.0	0.207
1380.0	0.194	1.0	0.207
1385.0	0.194	1.0	0.206
1390.0	0.194	1.0	0.206
1395.0	0.190	1.0	0.206
1400.0	0.194	1.0	0.205
1405.0	0.194	1.0	0.205
1410.0	0.194	1.0	0.204
1415.0	0.190	1.0	0.204
1420.0	0.190	1.0	0.204
1425.0	0.190	1.0	0.203
1430.0	0.190	1.0	0.203
1435.0	0.190	1.0	0.202
1440.0	0.190	1.0	0.202
1445.0	0.190	1.0	0.201
1450.0	0.190	1.0	0.201
1455.0	0.190	1.0	0.201
1460.0	0.190	1.0	0.200
1465.0	0.190	1.0	0.200
1470.0	0.190	1.0	0.199
1475.0	0.190	1.0	0.199
1480.0	0.185	1.0	0.199
1485.0	0.190	1.0	0.198
1490.0	0.185	1.0	0.198
1495.0	0.185	1.0	0.197
1500.0	0.185	1.0	0.197
1505.0	0.185	1.0	0.197
1510.0	0.185	1.0	0.196
1515.0	0.185	1.0	0.196
1520.0	0.185	1.0	0.195
1525.0	0.185	1.0	0.195

1530.0	0.185	1.0	0.195
1535.0	0.185	1.0	0.194
1540.0	0.185	1.0	0.194
1545.0	0.185	1.0	0.193
1550.0	0.185	1.0	0.193
1555.0	0.185	1.0	0.193
1560.0	0.185	1.0	0.192
1565.0	0.185	1.0	0.192
1570.0	0.185	1.0	0.191
1575.0	0.185	1.0	0.191
1580.0	0.185	1.0	0.191
1585.0	0.185	1.0	0.190
1590.0	0.185	1.0	0.190
1595.0	0.185	1.0	0.189
1600.0	0.181	1.0	0.189
1605.0	0.185	1.0	0.189
1610.0	0.181	1.0	0.188
1615.0	0.181	1.0	0.188
1620.0	0.181	1.0	0.187
1625.0	0.181	1.0	0.187
1630.0	0.185	1.0	0.187
1635.0	0.181	1.0	0.186
1640.0	0.181	1.0	0.186
1645.0	0.181	1.0	0.186
1650.0	0.181	1.0	0.185
1655.0	0.181	1.0	0.185
1660.0	0.176	1.0	0.184
1665.0	0.176	1.0	0.184
1670.0	0.181	1.0	0.184
1675.0	0.181	1.0	0.183
1680.0	0.181	1.0	0.183
1685.0	0.176	1.0	0.182
1690.0	0.176	1.0	0.182
1695.0	0.176	1.0	0.182
1700.0	0.176	1.0	0.181
1705.0	0.176	1.0	0.181
1710.0	0.176	1.0	0.181
1715.0	0.171	1.0	0.180
1720.0	0.171	1.0	0.180
1725.0	0.171	1.0	0.180
1730.0	0.171	1.0	0.179
1735.0	0.171	1.0	0.179
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1745.0	0.171	1.0	0.178
1750.0	0.171	1.0	0.178
1755.0	0.176	1.0	0.177
1760.0	0.171	1.0	0.177
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1770.0	0.171	1.0	0.176
1775.0	0.171	1.0	0.176
1780.0	0.171	1.0	0.175
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1825.0	0.171	1.0	0.172
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1845.0	0.171	1.0	0.171
1850.0	0.171	1.0	0.171
1855.0	0.171	1.0	0.170
1860.0	0.171	1.0	0.170
1865.0	0.167	1.0	0.169
1870.0	0.167	1.0	0.169
1875.0	0.167	1.0	0.169
1880.0	0.167	1.0	0.168
1885.0	0.167	1.0	0.168
1890.0	0.167	1.0	0.168
1895.0	0.167	1.0	0.167
1900.0	0.167	1.0	0.167
1905.0	0.167	1.0	0.167
1910.0	0.167	1.0	0.166
1915.0	0.167	1.0	0.166
1920.0	0.167	1.0	0.166
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1975.0	0.167	1.0	0.162
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1990.0	0.167	1.0	0.161
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2040.0	0.162	1.0	0.158
2045.0	0.157	1.0	0.157
2050.0	0.162	1.0	0.157
2055.0	0.162	1.0	0.157
2060.0	0.162	1.0	0.156
2065.0	0.162	1.0	0.156
2070.0	0.157	1.0	0.156
2075.0	0.162	1.0	0.155
2080.0	0.162	1.0	0.155
2085.0	0.162	1.0	0.155
2090.0	0.162	1.0	0.154
2095.0	0.162	1.0	0.154

2100.0	0.157	1.0	0.154
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2265.0	0.157	1.0	0.144
2270.0	0.153	1.0	0.143
2275.0	0.153	1.0	0.143
2280.0	0.157	1.0	0.143
2285.0	0.153	1.0	0.143
2290.0	0.153	1.0	0.142
2295.0	0.153	1.0	0.142
2300.0	0.153	1.0	0.142
2305.0	0.153	1.0	0.141
2310.0	0.153	1.0	0.141
2315.0	0.153	1.0	0.141
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2325.0	0.153	1.0	0.140
2330.0	0.151	1.0	0.140
2335.0	0.151	0.0	0.140
2340.0	0.151	0.0	0.139
2345.0	0.151	0.0	0.139
2350.0	0.151	0.0	0.139
2355.0	0.151	0.0	0.139
2360.0	0.151	0.0	0.138
2365.0	0.151	0.0	0.138
2370.0	0.148	0.0	0.138
2375.0	0.151	0.0	0.137
2380.0	0.148	0.0	0.137

2385.0	0.148	0.0	0.137
2390.0	0.148	0.0	0.137
2395.0	0.148	0.0	0.136
2400.0	0.148	0.0	0.136
2405.0	0.148	0.0	0.136
2410.0	0.148	0.0	0.135
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2480.0	0.148	0.0	0.132
2485.0	0.148	0.0	0.131
2490.0	0.148	0.0	0.131
2495.0	0.148	0.0	0.131
2500.0	0.148	0.0	0.131
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2510.0	0.148	0.0	0.130
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2530.0	0.144	0.0	0.129
2535.0	0.144	0.0	0.129
2540.0	0.148	0.0	0.128
2545.0	0.144	0.0	0.128
2550.0	0.144	0.0	0.128
2555.0	0.148	0.0	0.128
2560.0	0.144	0.0	0.127
2565.0	0.144	0.0	0.127
2570.0	0.144	0.0	0.127
2575.0	0.144	0.0	0.127
2580.0	0.148	0.0	0.126
2585.0	0.144	0.0	0.126
2590.0	0.144	0.0	0.126
2595.0	0.144	0.0	0.126
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2660.0	0.144	0.0	0.122
2665.0	0.144	0.0	0.122

2670.0	0.144	0.0	0.122
2675.0	0.139	0.0	0.121
2680.0	0.144	0.0	0.121
2685.0	0.144	0.0	0.121
2690.0	0.144	0.0	0.121
2695.0	0.107	0.0	0.120
2700.0	0.130	0.0	0.120
2705.0	0.144	0.0	0.120
2710.0	0.144	0.0	0.120
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2720.0	0.144	0.0	0.119
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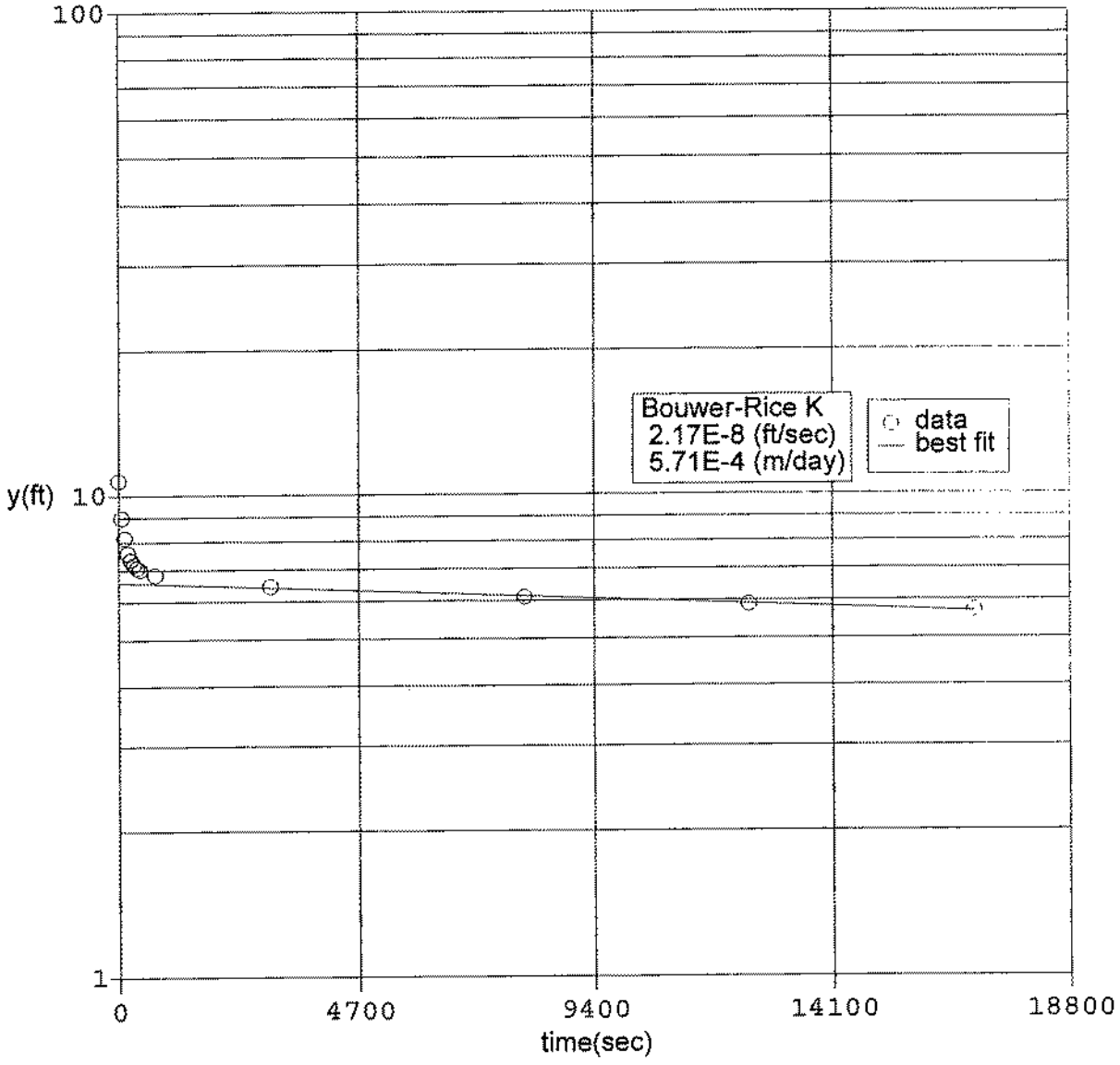
2740.0	0.144	0.0	0.118
2745.0	0.139	0.0	0.118
2750.0	0.139	0.0	0.118
2755.0	0.141	0.0	0.118
2760.0	0.137	0.0	0.117
2765.0	0.144	0.0	0.117

North Dallas Sanitary Landfill - 9/9/97 - MW-11



Slug Test Results

Title: North Dallas Sanitary Landfill
Client: North Dallas Sanitary Landfill
Job Number: E97011
Well Number: MW-11

Hydraulic Conductivity

Bouwer-Rice: 2.17E-8 (ft/sec), 5.71E-4 (m/day)

Well Geometry (ft)
H: 16.26
Le: 13.0
Lw: 15.36
rc: .083
rw: .344

drainable filter pack porosity: 0.15
effective radius: 1.54E-1 (ft)

Bouwer Rice Coefficients
Le/rw: 37.818
A: 2.639
B: 0.389
C: 2.246
ln(Re/rw): 2.709

Least Squares Fit
slope: -8.83E-6
intercept: 1.89E+0

Recovery Data and Fit

time(sec)	y(ft)	weight	fit(ft)
0.0	10.730	0.0	6.588
60.0	8.980	0.0	6.584
120.0	8.150	0.0	6.581
180.0	7.580	0.0	6.577
240.0	7.340	0.0	6.574
300.0	7.170	0.0	6.570
360.0	7.060	0.0	6.567
420.0	6.990	0.0	6.563
720.0	6.820	0.0	6.546
2970.0	6.450	1.0	6.417
8010.0	6.100	1.0	6.138
12450.0	5.880	1.0	5.902
16920.0	5.700	1.0	5.673

APPENDIX E

PERMEABILITY ANALYSIS AND PARTICLE SIZE DISTRIBUTION CURVES

ALLENDER BUTZKE ENGINEERS INC.
GEOTECHNICAL • ENVIRONMENTAL • CONSTRUCTION Q.C.

October 10, 1997

Barker Environmental Services
Attn: Rochelle Shaw
1300 Cummings Rd., Suite 201
Des Moines, IA 50315

RE: Laboratory Soil Analysis
North Dallas County Landfill
PN 971529

Dear Ms. Shaw:

Enclosed are the results of flexible wall permeability and grain size tests performed on two samples submitted from the above project. The soils submitted consisted of undisturbed Shelby Tubes delivered in August 1997. Permeability characteristics of the undisturbed samples were evaluated by conducting flexible wall constant head permeability tests on 2 inches of each sample under a water pressure of 5 psi, i.e., approximately a water head of 11.5 feet. The results of the permeability test are provided on the following Table A. Results of the grain size are provided on the enclosed Figure Nos. 1 and 2.

TABLE A

Sample Designation	Moisture Content (percent)	Dry Density (pcf)	Coefficient of Permeability (cm/sec)
MW-9A (10 - 12 feet)	14.1	113.1	3.1×10^{-8}
MW-11 (25 - 27 feet)	14.2	119.5	1.5×10^{-8}

compare to 3.78e-5 horizontal

If there are any questions concerning these test results, please contact us at your convenience.

Respectfully submitted,
ALLENDER BUTZKE ENGINEERS INC.

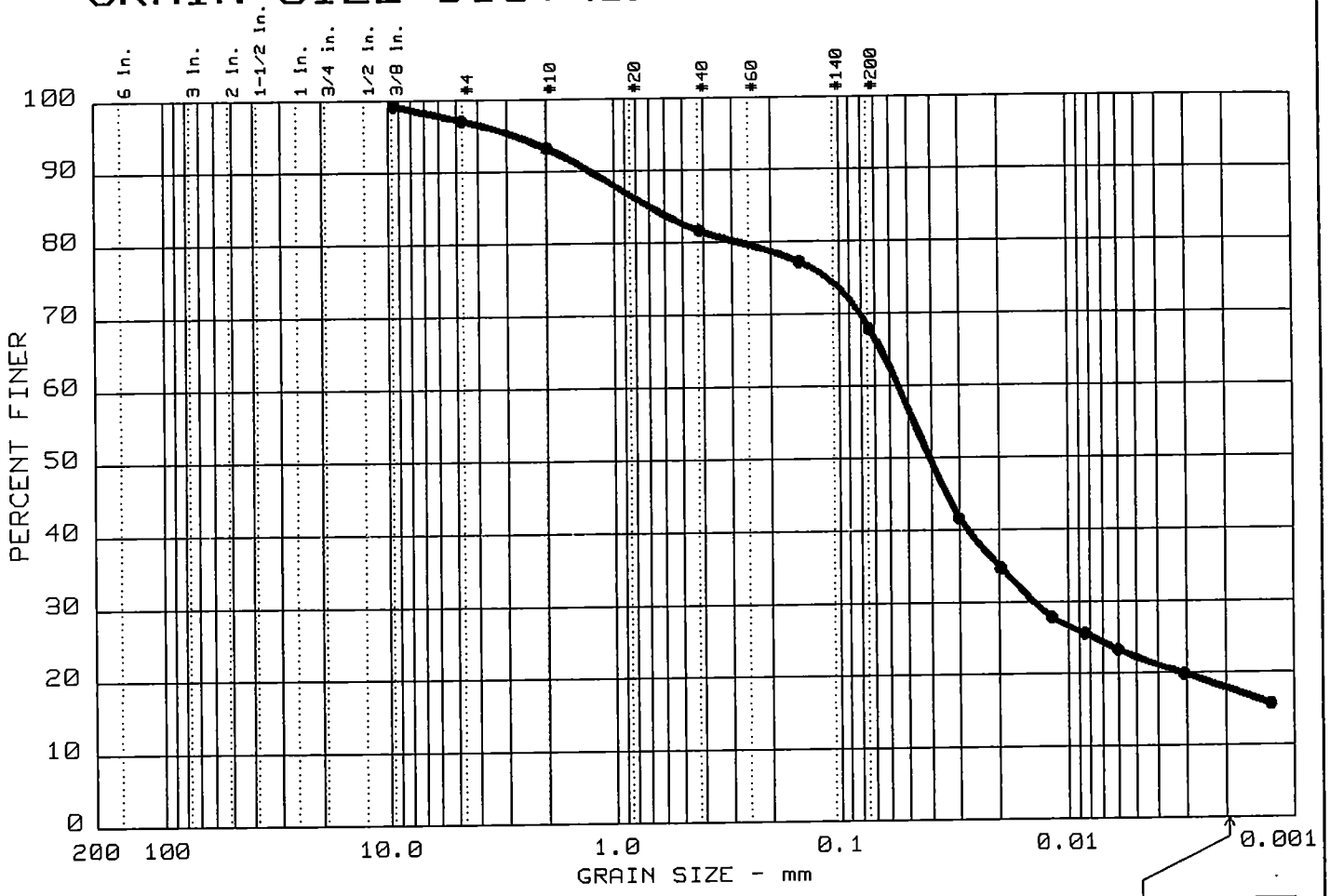
David Logemann, P.E.
Project Engineer

DKL/cg
3 PC Above

POTENTIALLY APPLIES. BORING LOG REPORTS SANDY CLAY/TRACE GRAVEL IN LAYER 15-20' RANGE

3660 109TH STREET • URBANDALE, IOWA 50322 • PHONE 515-252-1885 • FAX 515-252-1888

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	2.9	29.1	50.0	18.0

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.69		0.04	0.014				

MATERIAL DESCRIPTION	USCS	AASHTO
● Brown sandy lean clay trace of gravel		

Project No.: 971529
Project: North Dallas County Landfill
● Location: MW - 9A (10' - 12')

Date: 10/10/97

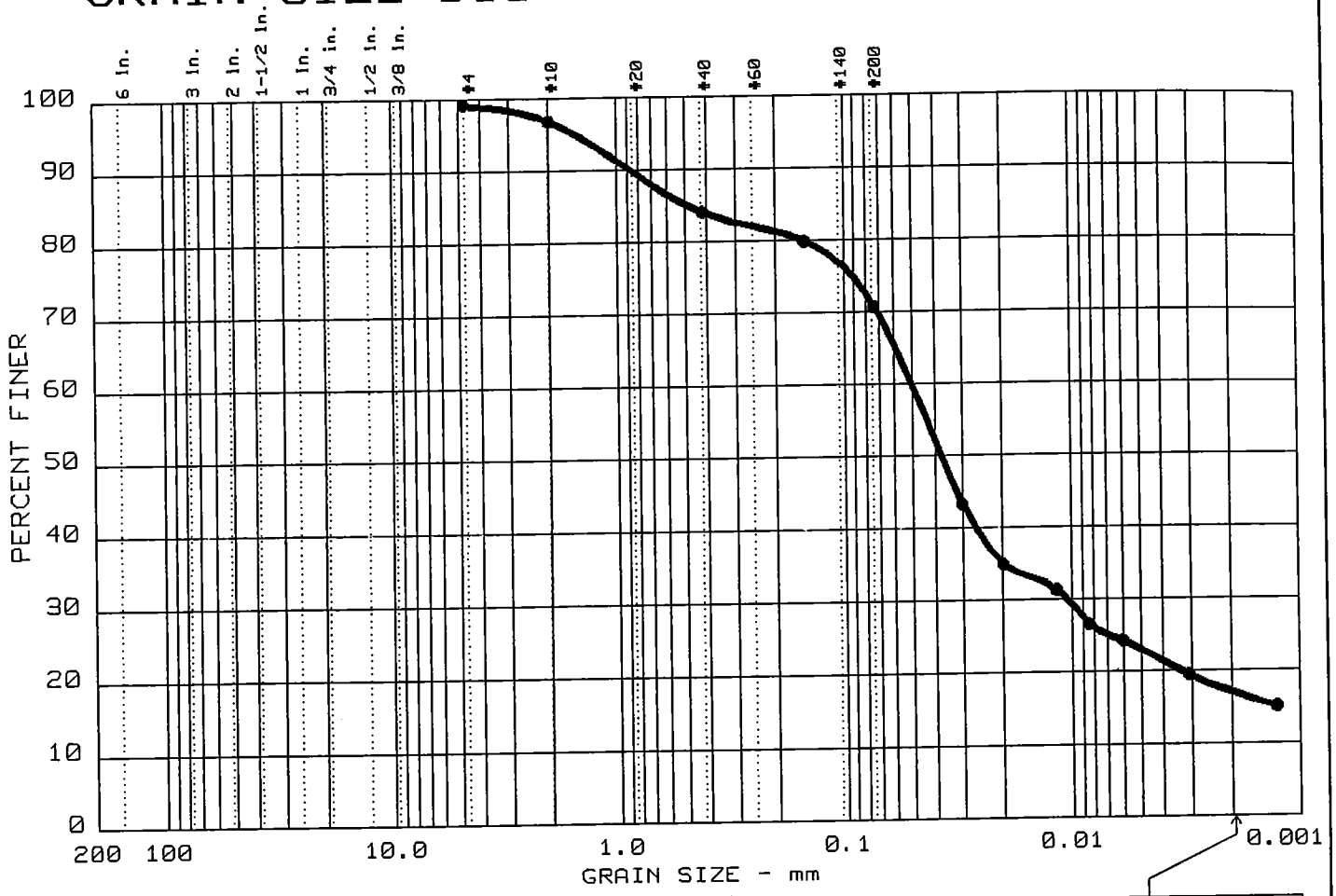
Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT

ALLENDER BUTZKE ENGINEERS INC.

Figure No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +3"	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.8	28.4	53.7	17.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			0.48		0.04	0.010				

MATERIAL DESCRIPTION	USCS	AASHTO
● Gray sandy lean clay trace of gravel		

Project No.: 971529
Project: North Dallas County Landfill
● Location: MW - 11 (25' - 27')

Date: 10/10/97

Remarks:

GRAIN SIZE DISTRIBUTION TEST REPORT

ALLENDER BUTZKE ENGINEERS INC.

Figure No. 2

SEEQUENT

GeoStudio Example File
Reinforcement with Piles

To see the latest GeoStudio learning content, visit Seequent Learning Centre and search the catalogue for “GeoStudio”.

Introduction

Piles are a common stabilization method for geotechnical systems as they can withstand considerable shear. SLOPE/W stability analyses simulate pile reinforcement by including a resisting force in the limit equilibrium formulation representing the shear capacity of a pile row. This example compares the stability of a riverbank under natural conditions and when the riverbank is reinforced with piles.

Background

In SLOPE/W, pile reinforcement only provides shear resistance. The shear resisting force, S, per unit length along the pile row (in the out-of-page direction) is:

$$SR = \frac{SF}{s \cdot RF_S}$$ Equation 1

where SF is the shear force of the piles, s is the pile spacing, and RF_S is the shear reduction factor. The shear resistance is applied at the base of the slice that includes the pile, and may act parallel to the slip surface or perpendicular to the reinforcement.

Numerical Simulation

The simulated geometry was developed to represent a failed riverbank that may continue to move under elevated pore water pressure conditions – for example, due to spring snowmelt (Figure 1). Lacustrine sediments, underlain by a competent till, form the riverbank. Between the lacustrine sediments and till is a weak layer, which is the ultimate source for stability issues in this system. The Mohr-Coulomb material model defines the properties of the lacustrine sediments and weak layer, and the till was set as impenetrable bedrock (Figure 1).

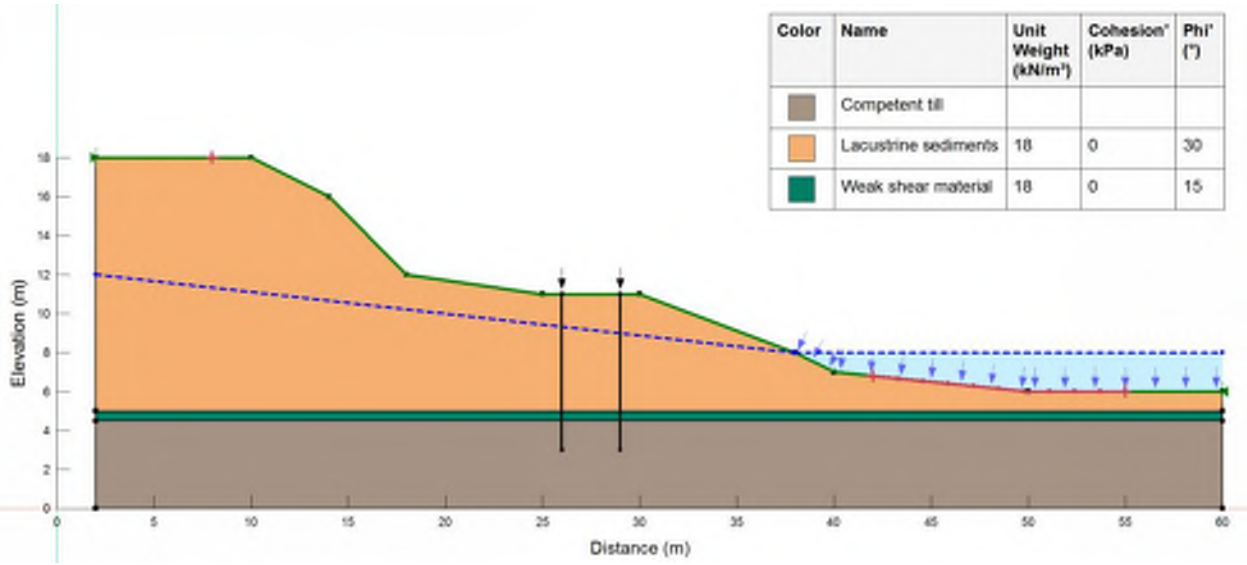


Figure 1. Riverbank configuration including the pile reinforcement, pore water pressure, and trial slip surface definition.

The first analysis in the project file considers the riverbank stability without reinforcement, while the second includes two rows of piles that are founded in the competent till (Figure 1). The piles

are 8 m long, 1 m apart (in the out-of-page direction), and are vertically oriented. A shear force of 100 kN and a shear reduction factor of 2 are assigned to each pile row, such that the shear resisting force per unit length along the river is:

$$SR = \frac{100}{(1)(2)} = 50\ kN$$ Equation 2

This resisting force acts parallel to the slip surface, as defined in the pile reinforcements settings.

The trial slip surfaces are defined using the Entry and Exit method in both analyses. All slip surfaces originate from the same point on the top of the bank and exit at the bottom, under the river. The Morgenstern-Price limit equilibrium method is used to determine the factor of safety of the trial slip surfaces. A piezometric line establishes the pore water pressure conditions throughout the domain (Figure 1).

Results and Discussion

Analysis 1 produced a large band of slip surfaces with a factor of safety between 1.0 and 1.1, with the critical factor of safety just above 1 (Figure 2). Thus, under natural conditions, the riverbank is unstable. With pile reinforcement, the two 50 kN shear resisting forces (one for each pile) are included in the limit equilibrium calculations, causing the factor of safety to increase by approximately 15% (Figure 3). Application of the pile resisting forces is evident in the free body diagrams for the slices containing the piles, Slices 13 and 15 (Figure 4). Thus, the piles provided enough resisting force to prevent movement of the riverbank under the given pore water pressure conditions.

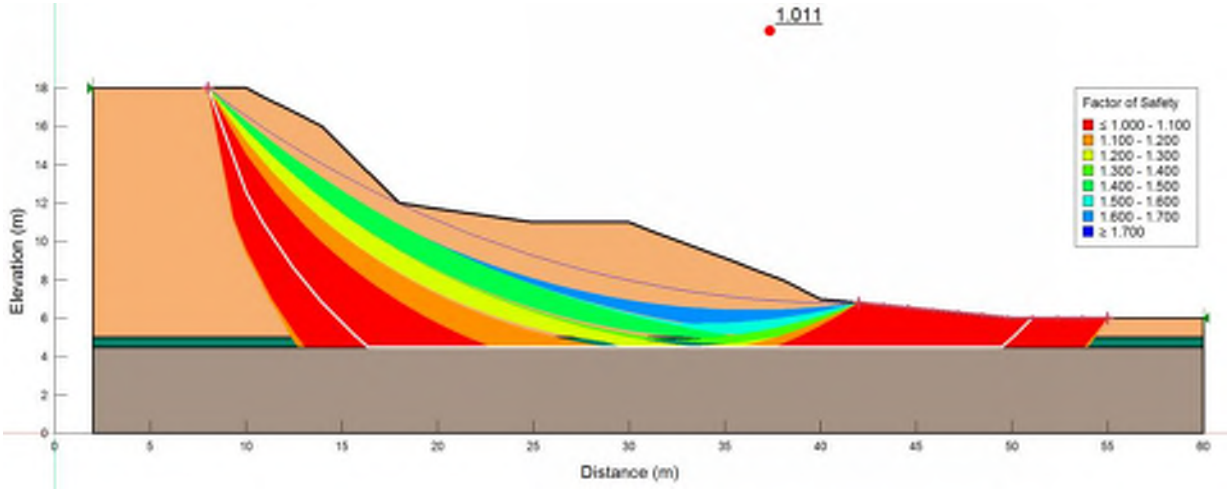


Figure 2. Stability results for the natural state (Analysis 1).

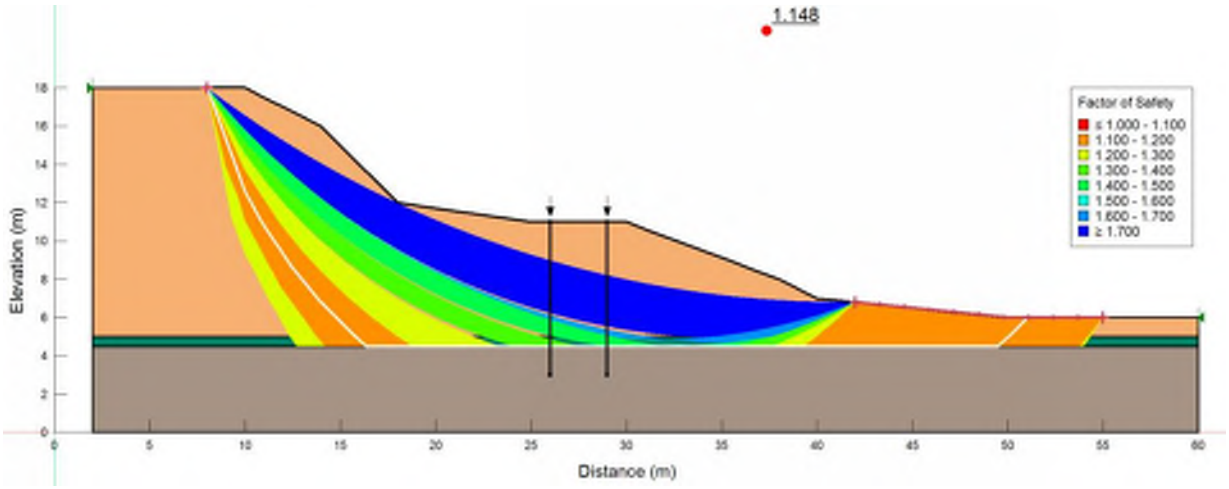


Figure 3. Stability results with pile reinforcement (Analysis 2).

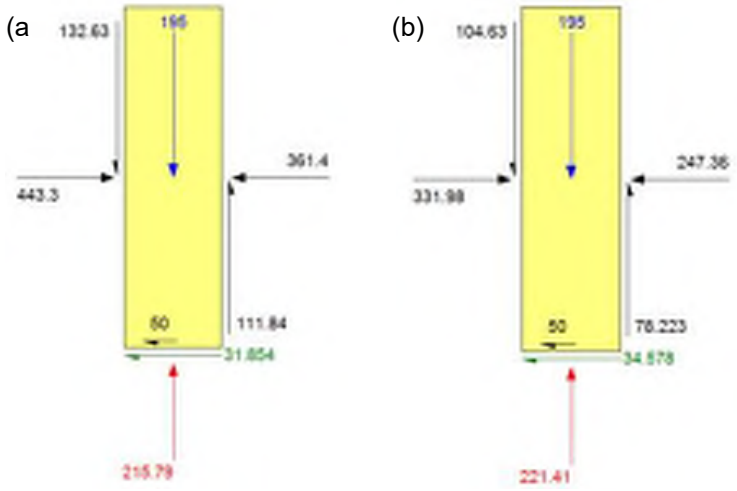


Figure 4. Free body diagrams for (a) Slice 13 and (b) Slice 15 in Analysis 2, with the pile resisting forces (50 kN) acting parallel to the slip surface.

One of the challenges with simulating reinforcement in a limit equilibrium analysis is determining the shear force available from the structural element – which is a true soil-structure interaction problem. For example, the stresses developed in the pile are dependent on the relative stiffness between the pile and the surrounding soil. Thus, SIGMA/W is ideal for assessing stability of systems with reinforcement, as it simulates the shear and moment distributions within the pile.

However, piles can be considered in a SLOPE/W analysis, like this one, with an understanding of the general design philosophy for piles and the implications of using a limitation equilibrium analysis. Pile design ultimately is aimed at halting movement of an unstable slope, as opposed to increasing the factor of safety. Even if the factor of safety of the sliding mass remains around unity, movement ceases as long as the piles remain intact. In this sense, the structural design of piles is more important than the margin of safety against movement.

Summary and Conclusions

Slope stabilization with pile reinforcement can be simulated in SLOPE/W as demonstrated above. In this case, the piles provided enough shear resistance to increase the factor of safety and prevent movement of the riverbank under the applied pore water pressures. SLOPE/W

analyses can be used to determine the shear force, provided by the piles, required to achieve the desired factor of safety.

Attachment B

Slope Stability Run Results and Settlement Calculations

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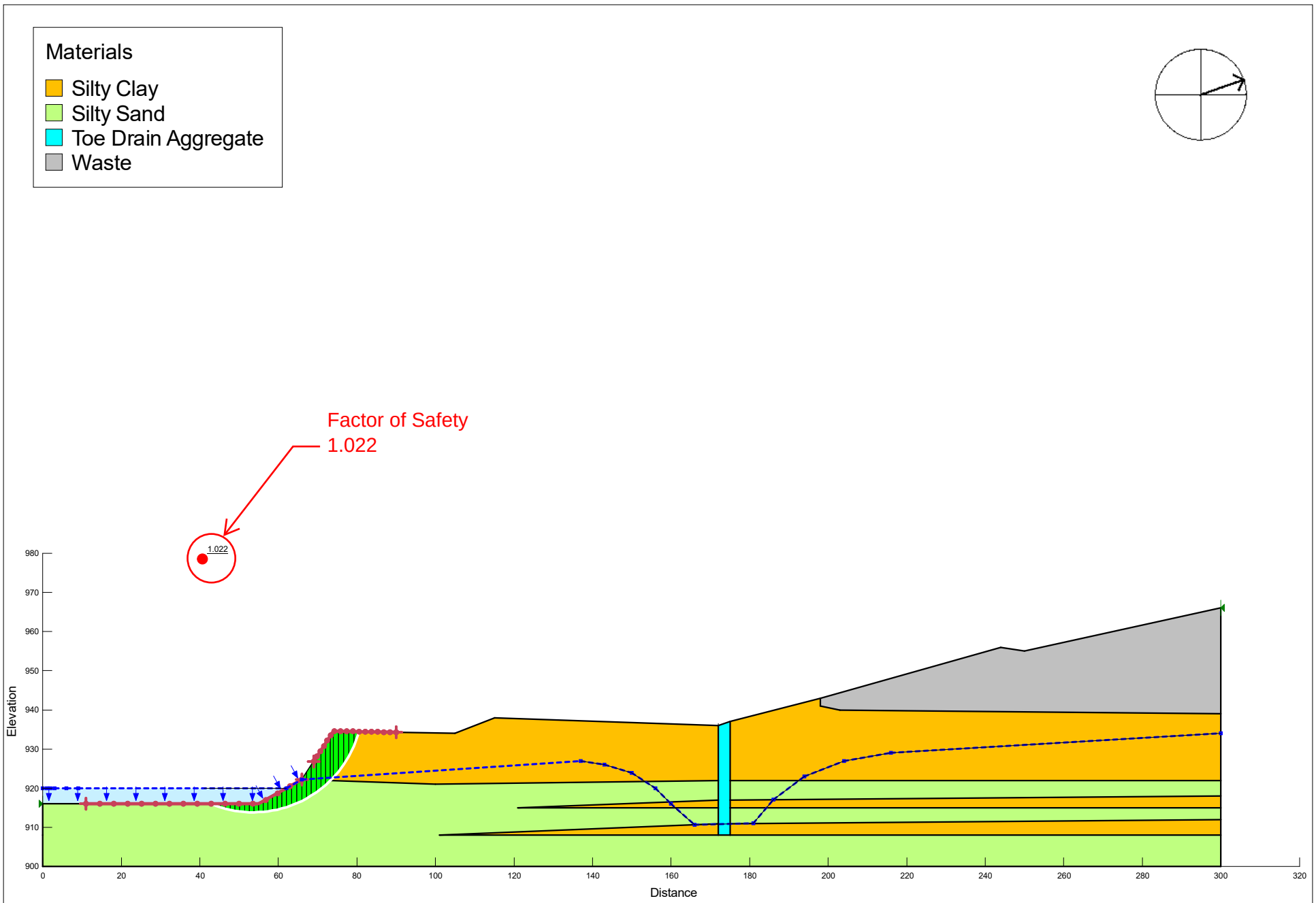
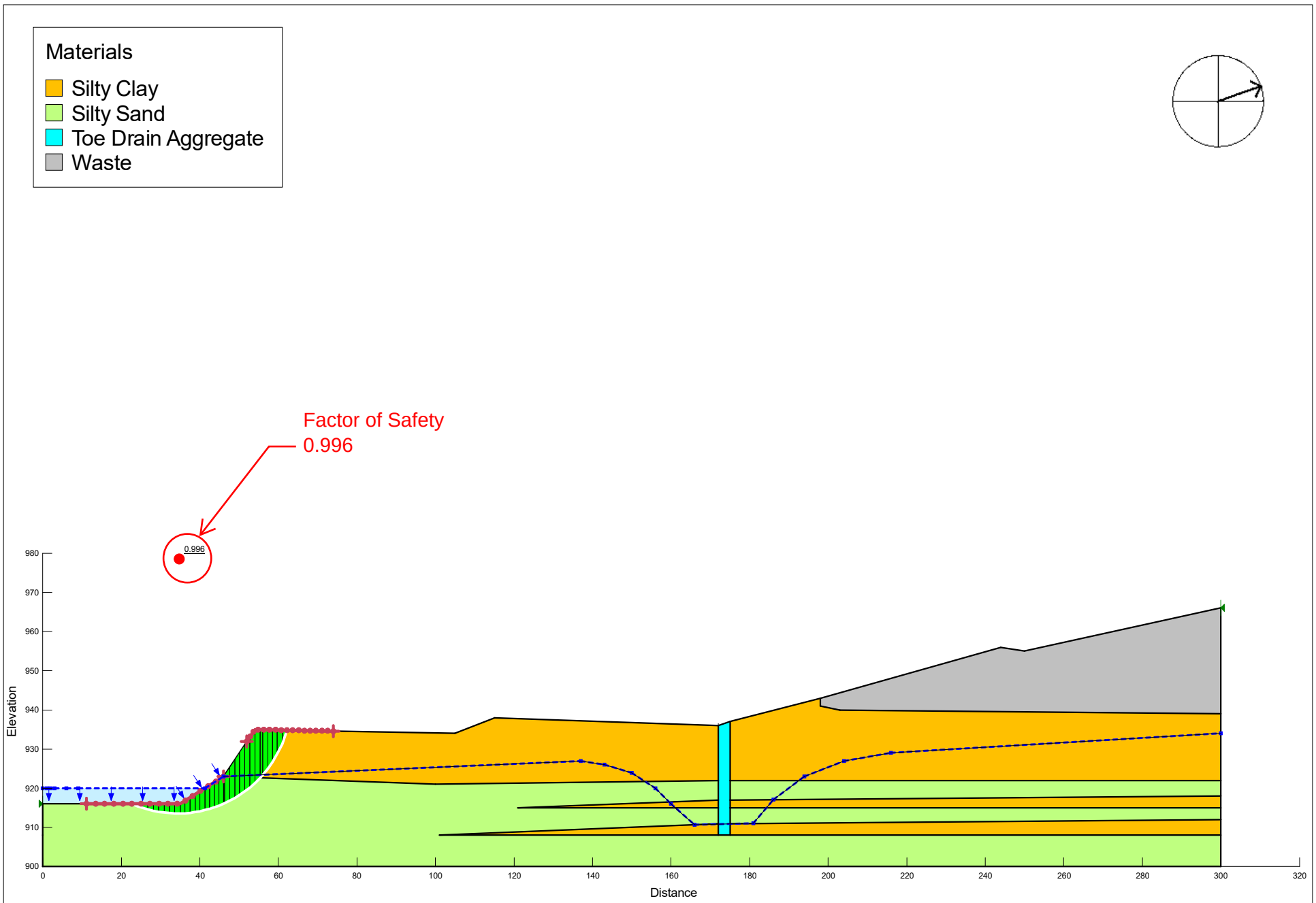
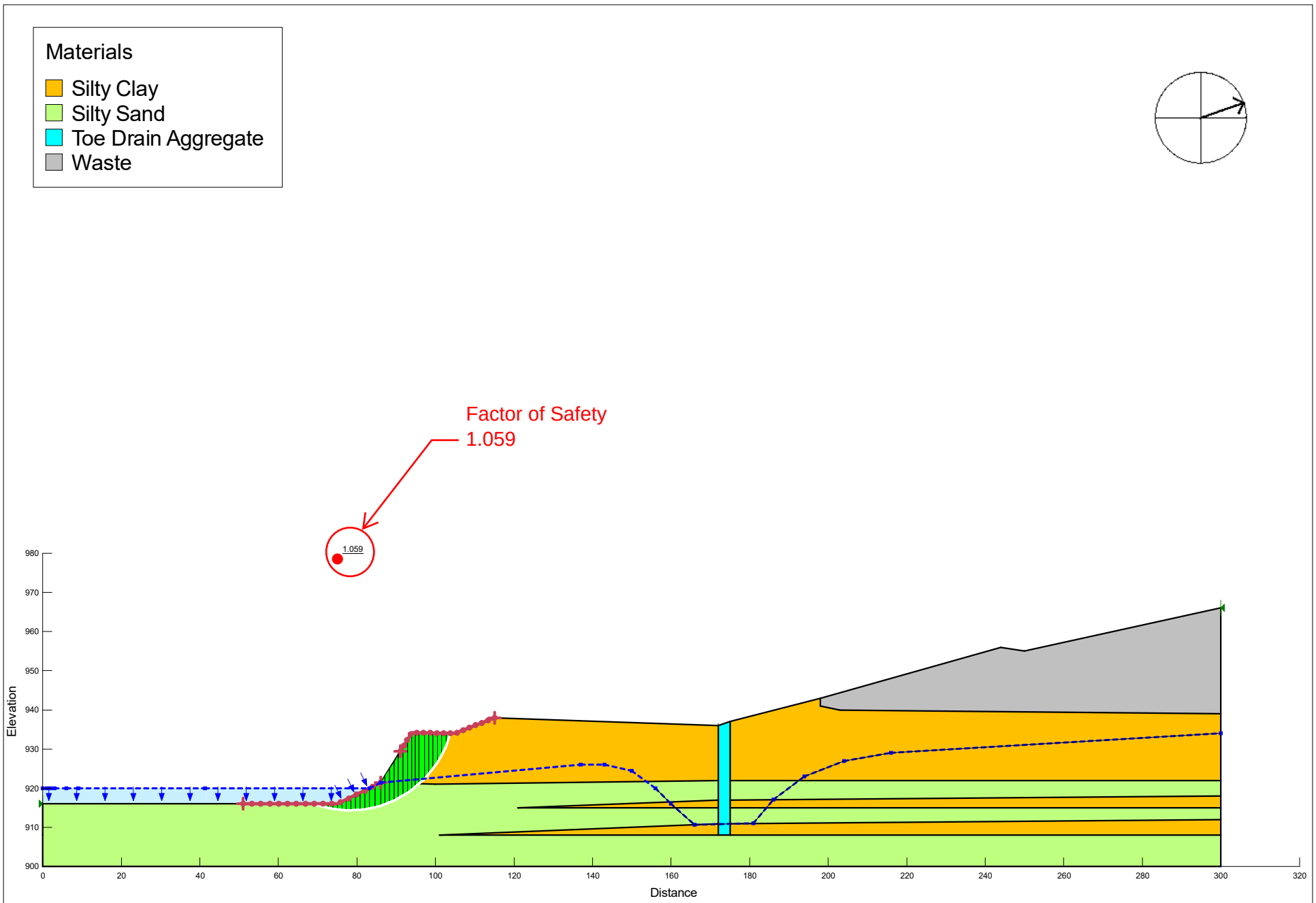
CIRCULAR FAILURE SCENARIOS



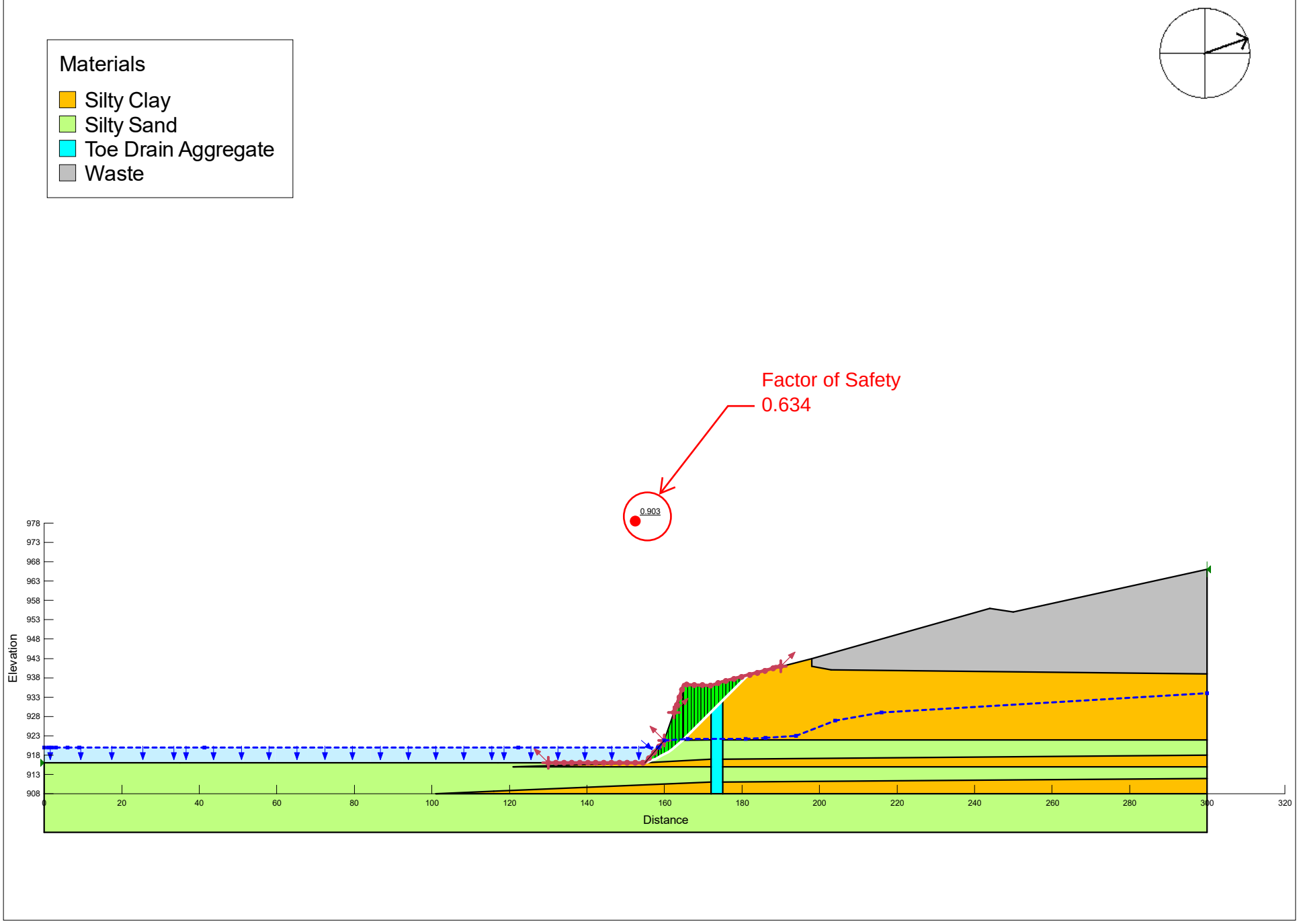
Run 1 - Base Model - Circular Wedge (Critical Slip Surface)



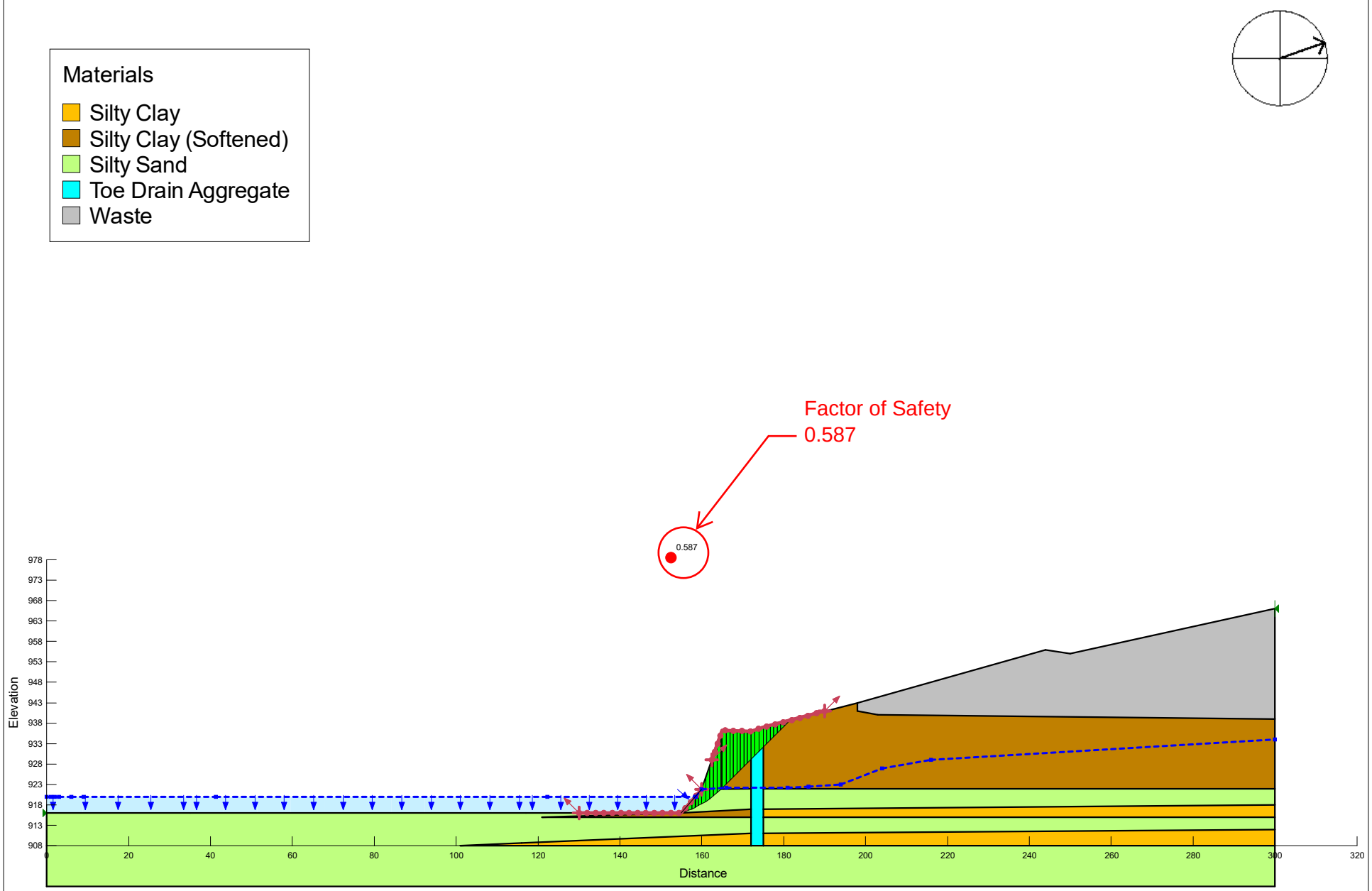
Run 2 - Riverbank 20 ft. NE - Circular Wedge (Critical Slip Surface)



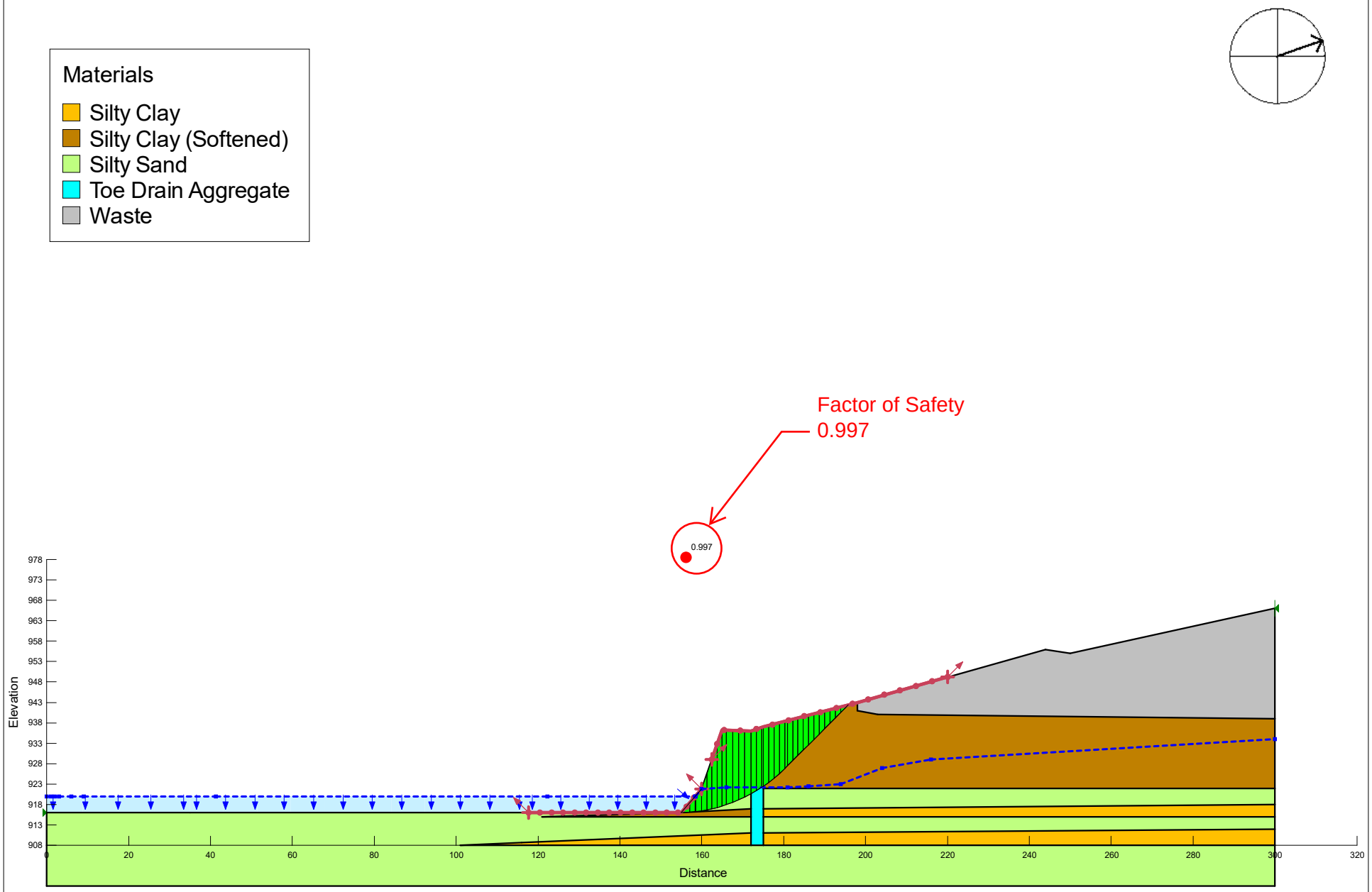
Run 3 - Riverbank 40 ft. NE - Circular Wedge (Critical Slip Surface)



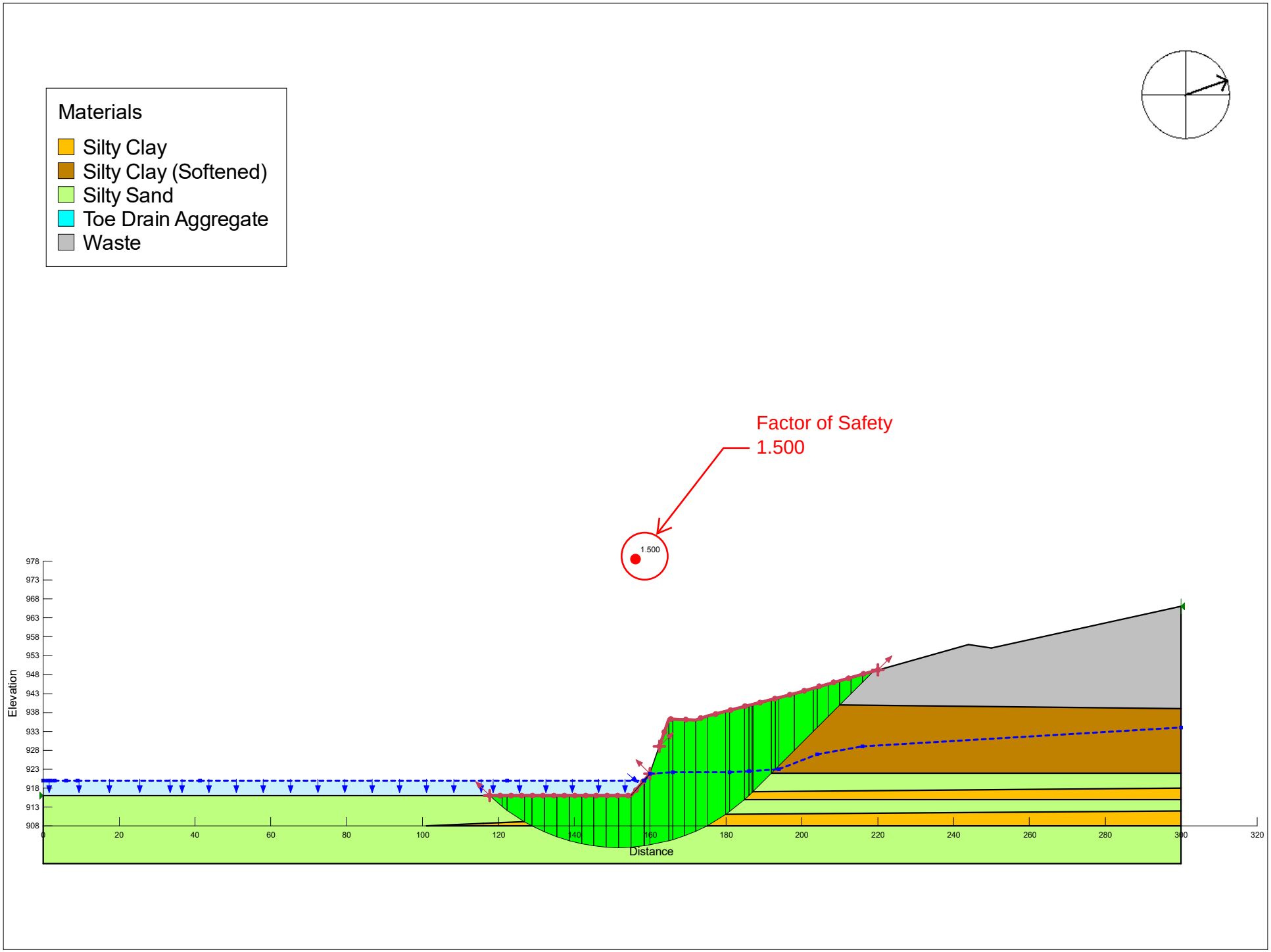
Run 4 - Toe Drain Collapse - Riverbank 120 ft. NE - Circular Wedge (Critical Slip Surface)



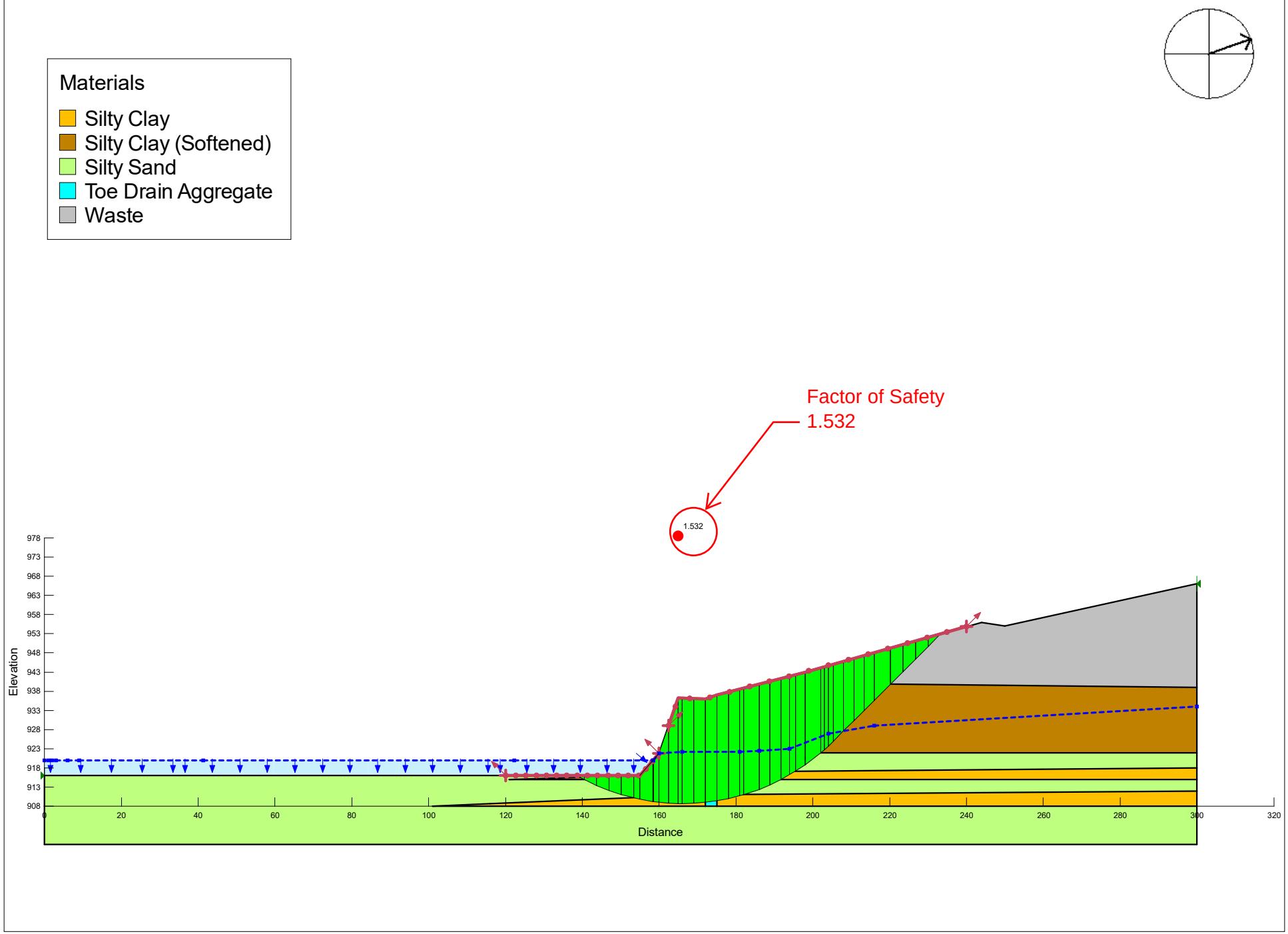
Run 5A - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Circular Wedge (Critical Slip Surface)



Run 5B - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Circular Wedge - FS ~ 1



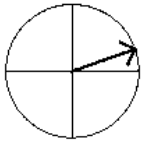
Run 5C - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Circular Wedge - FS ~ 1.5 (Overall Failure)

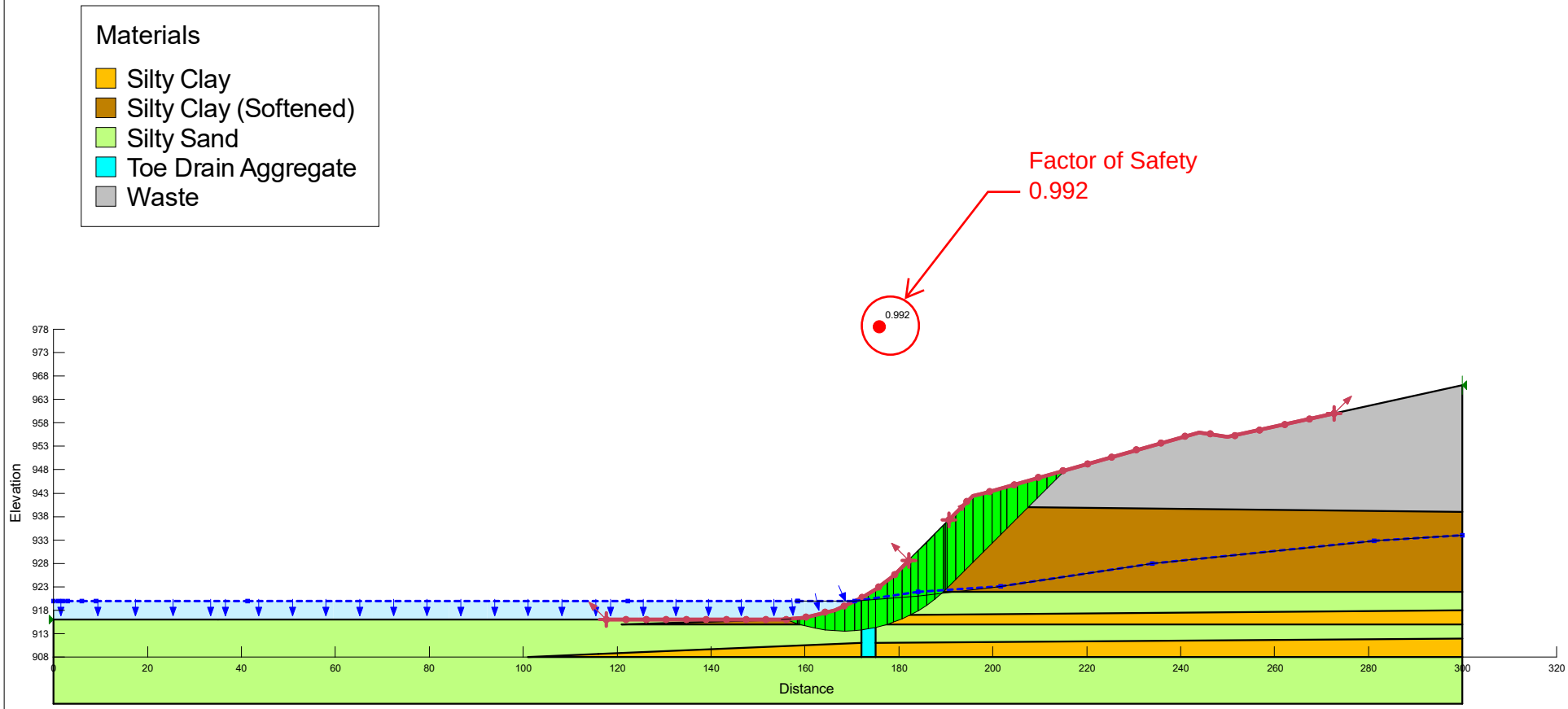


Run 5C - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Circular Wedge - FS ~ 1.5 (Overall Failure)

PROGRESSION OF SLOPE FAILURE

Slip plane at FS ~ 1 as new riverbank surface (Run 5B)

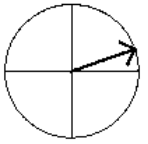


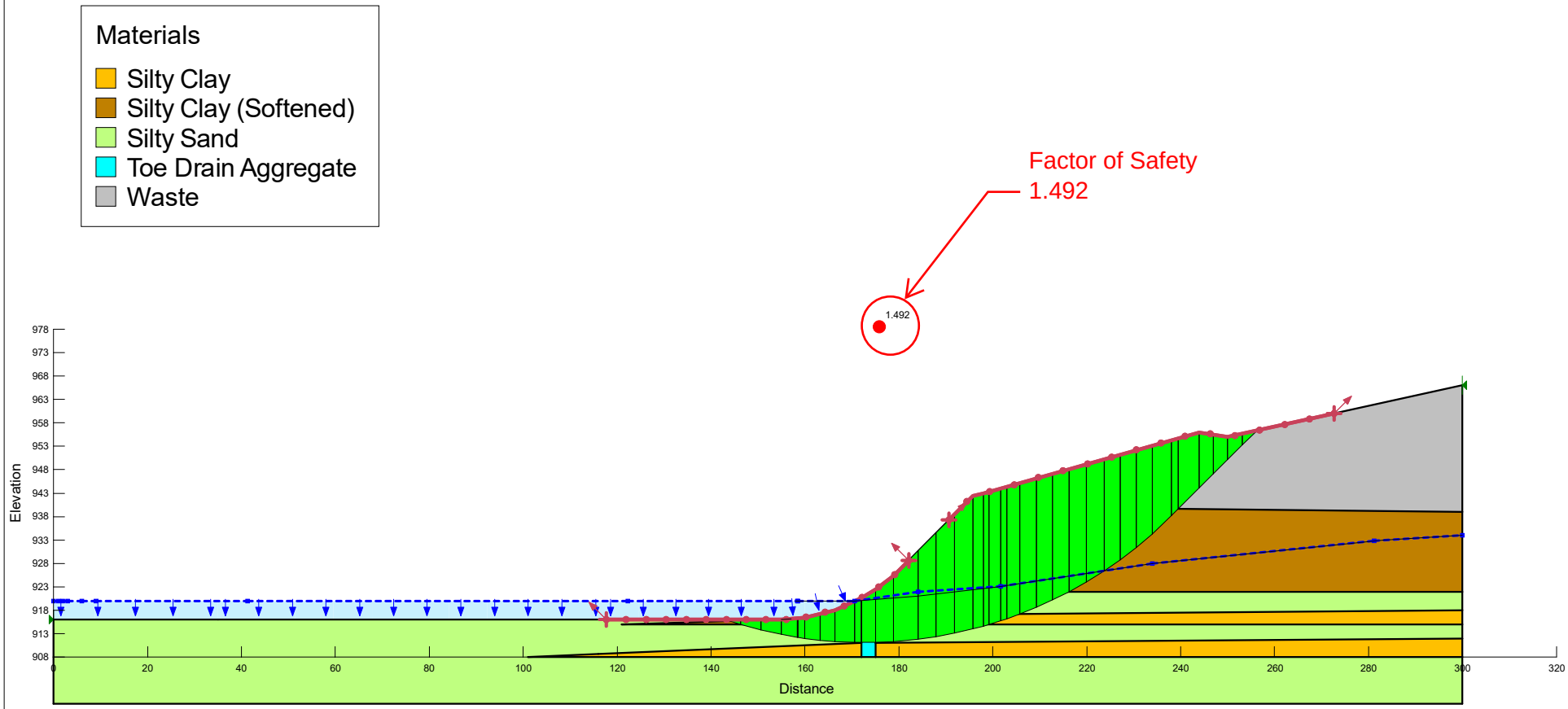


Run 6A - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Circular Wedge - FS ~ 1

PROGRESSION OF SLOPE FAILURE

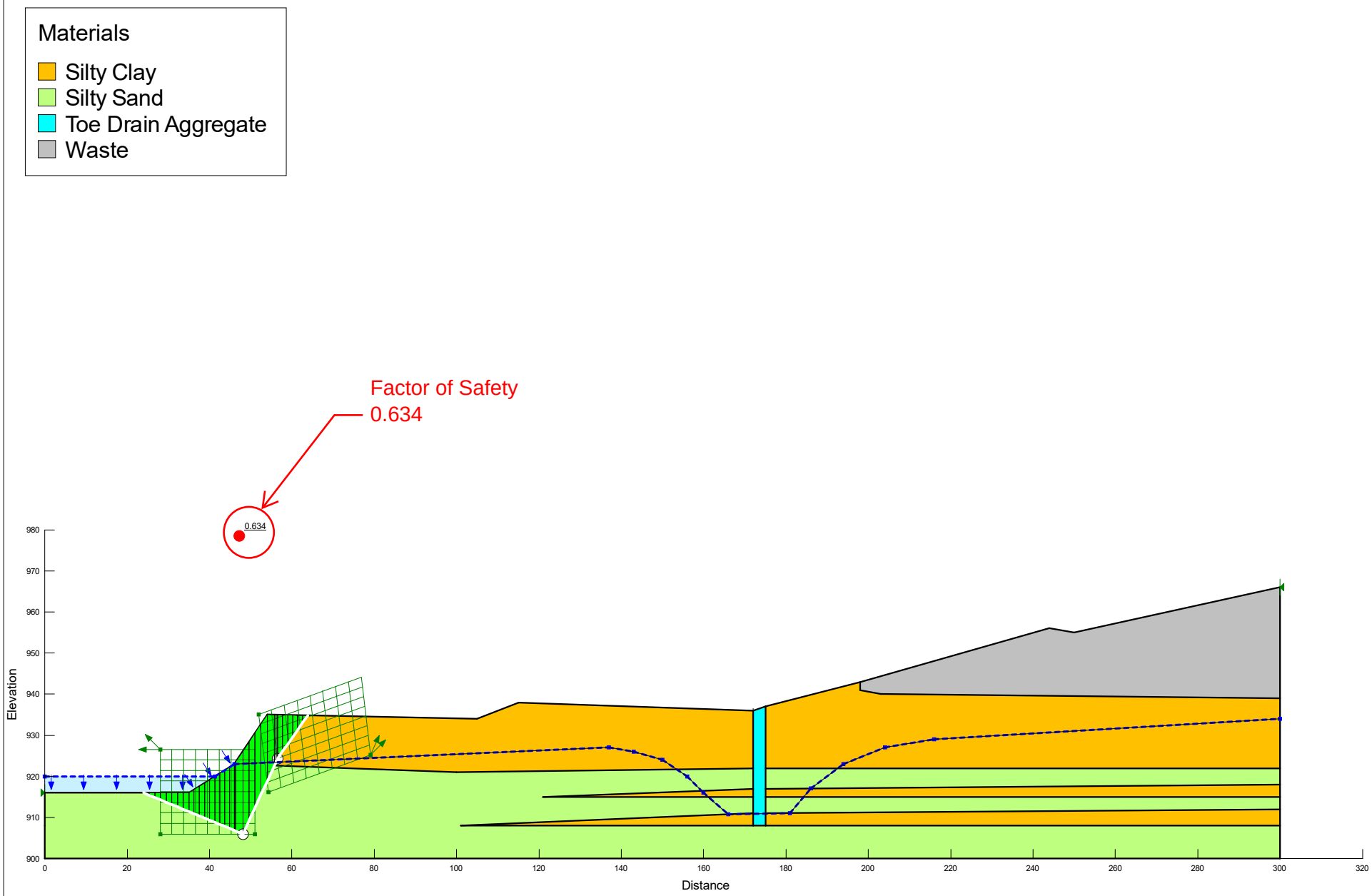
Slip plane at FS ~ 1 as new riverbank surface (Run 5B)



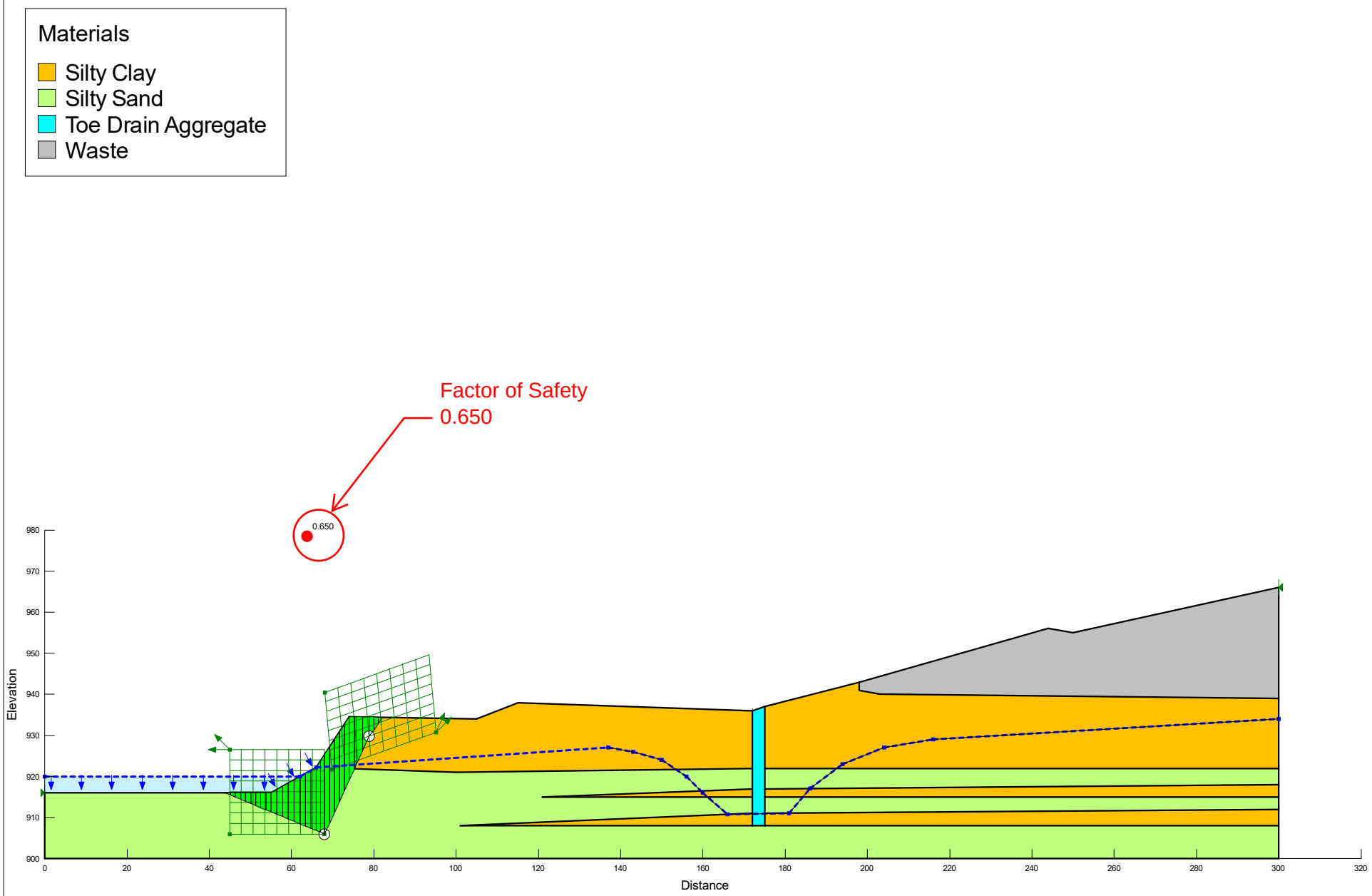


Run 6B - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Circular Wedge - FS ~ 1.5 (Overall Failure)

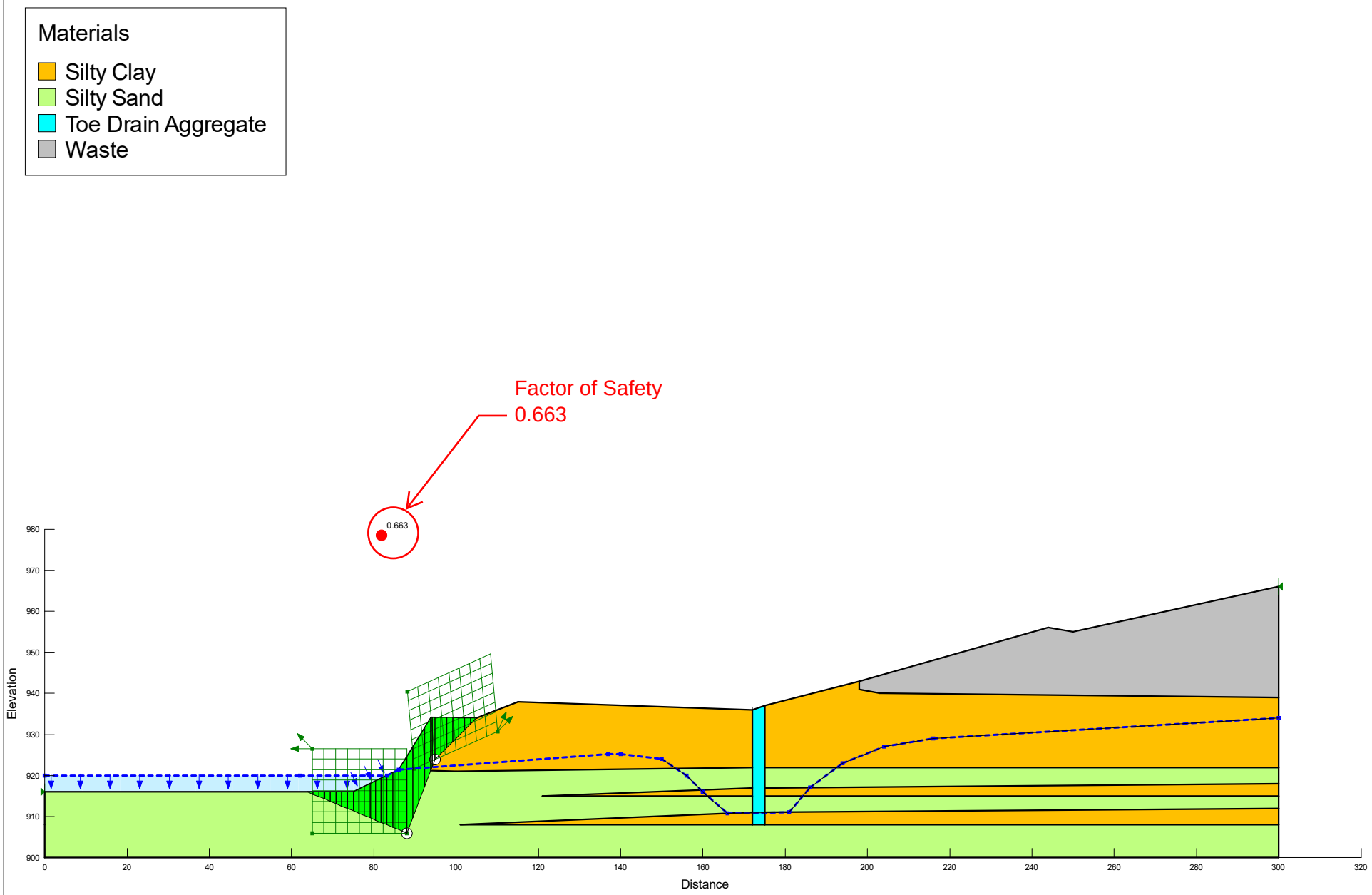
SLIDING BLOCK FAILURE SCENARIOS



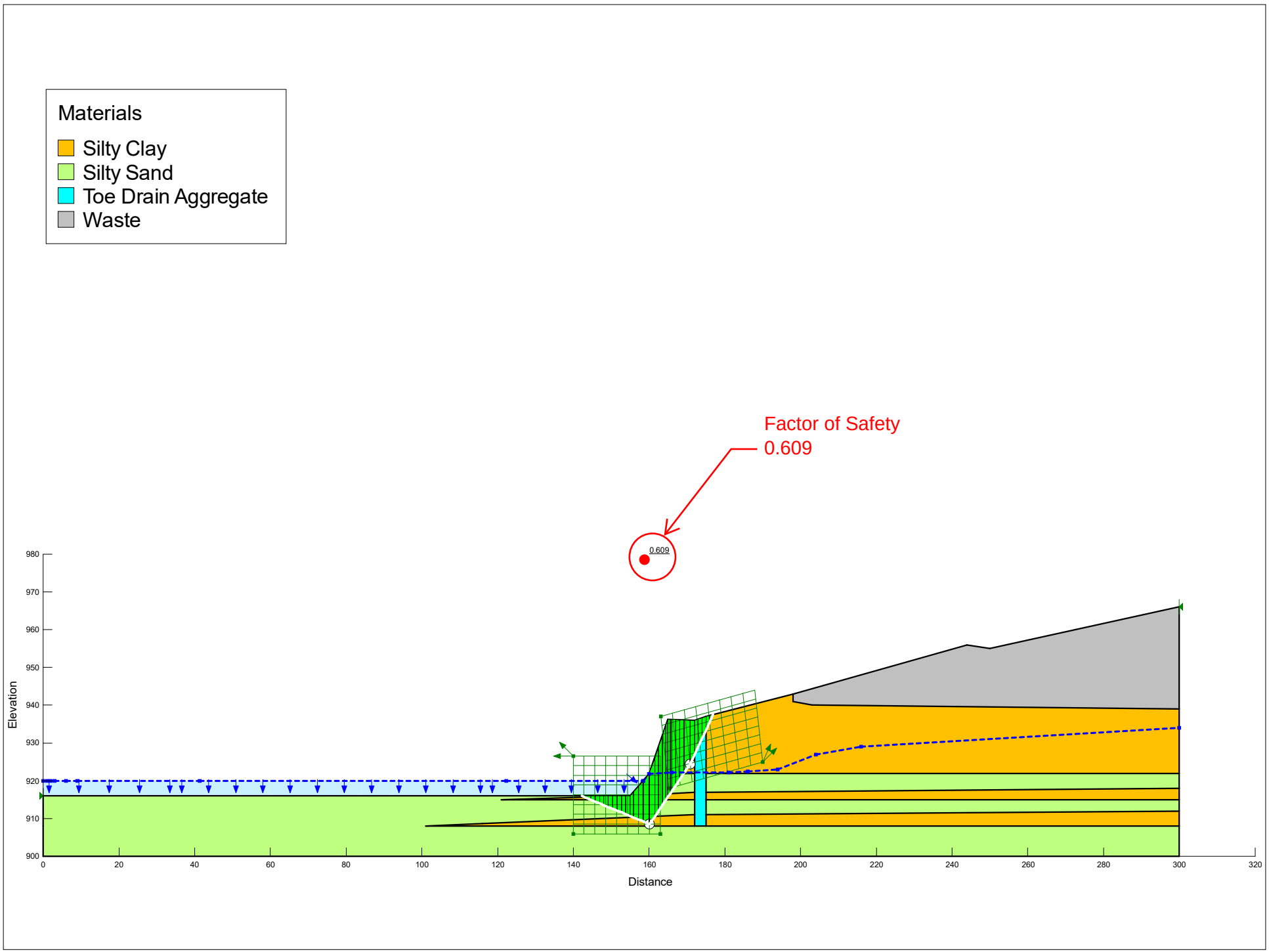
Run 7 - Base Model - Sliding Block (Critical Slip Surface)



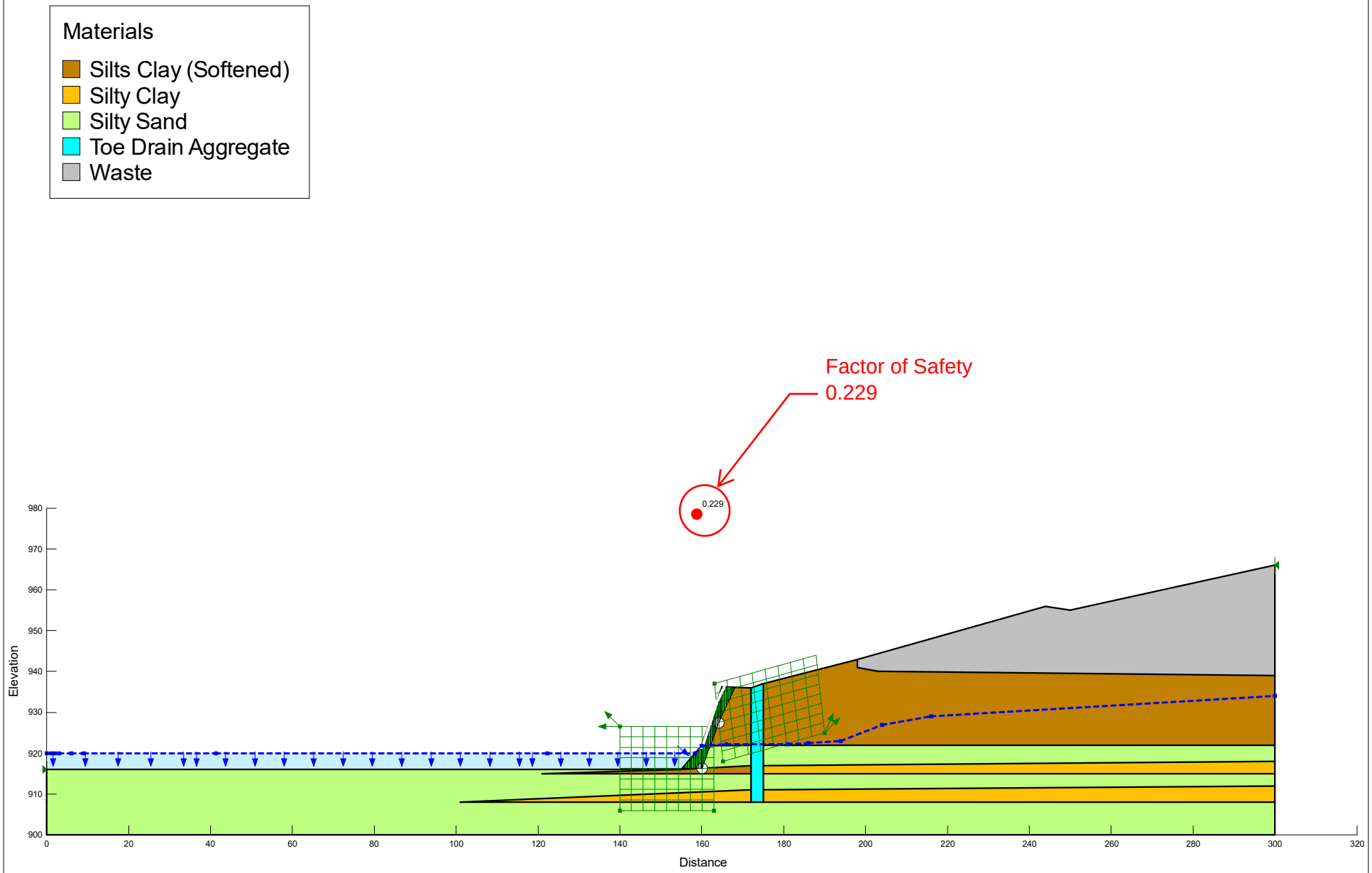
Run 8 - Riverbank 20 ft. NE - Sliding Block (Critical Slip Surface)



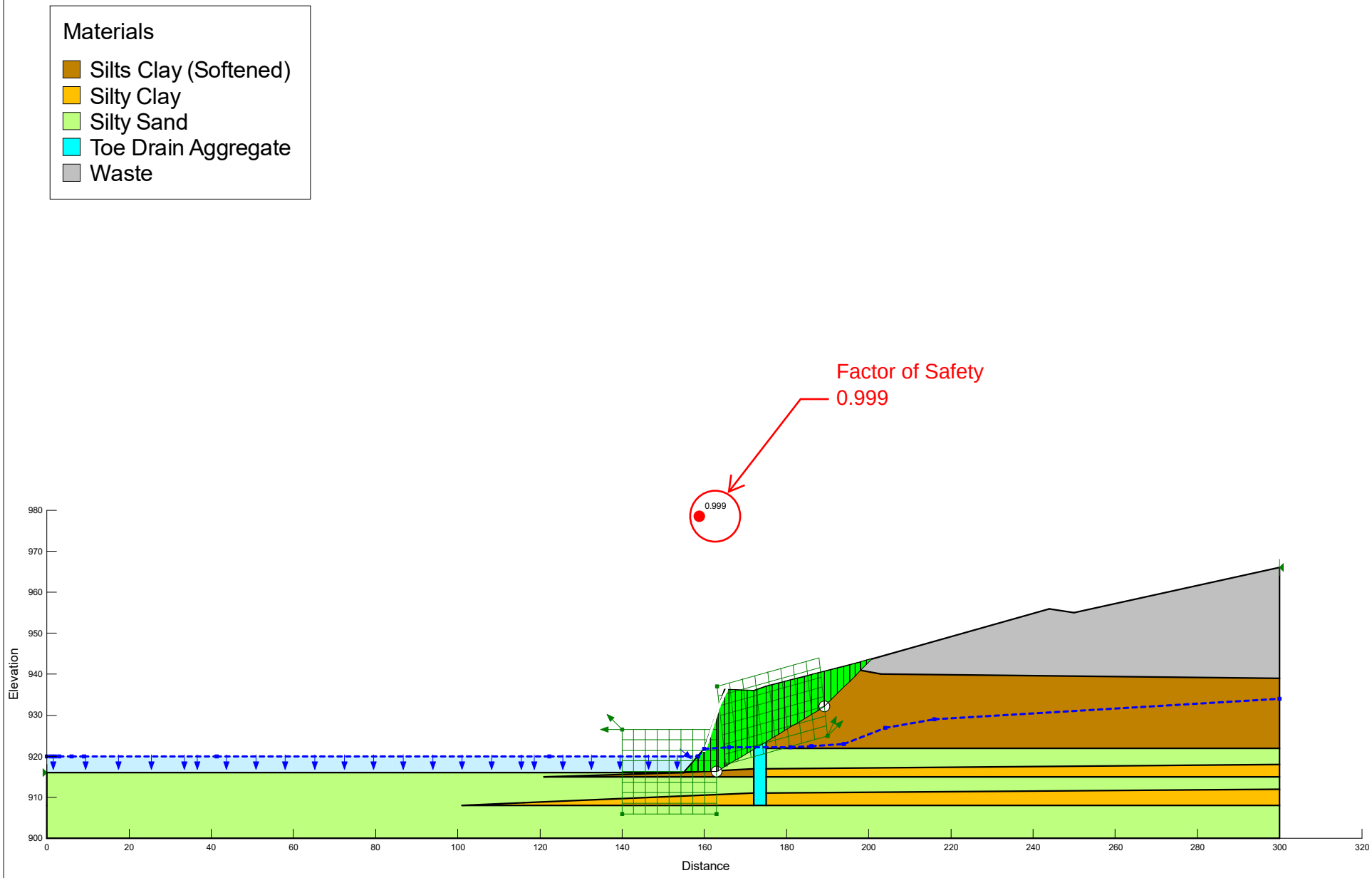
Run 9 - Riverbank 40 ft. NE - Sliding Block (Critical Slip Surface)



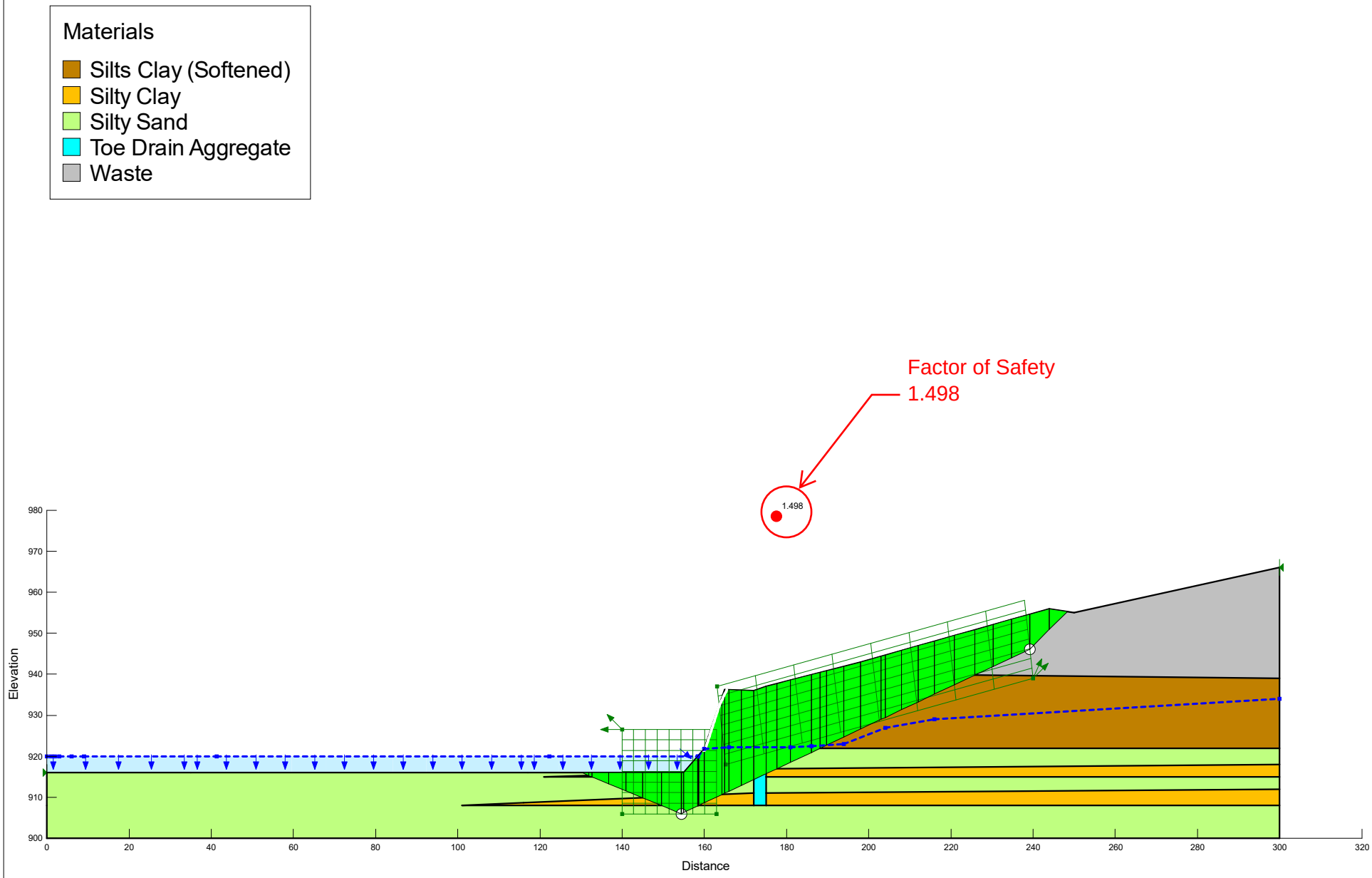
Run 10 - Toe Drain Collapse - Riverbank 120 ft. NE - Sliding Block (Critical Slip Surface)



Run 11A - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Sliding Block (Critical Slip Surface)



Run 11B - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Sliding Block - FS ~ 1



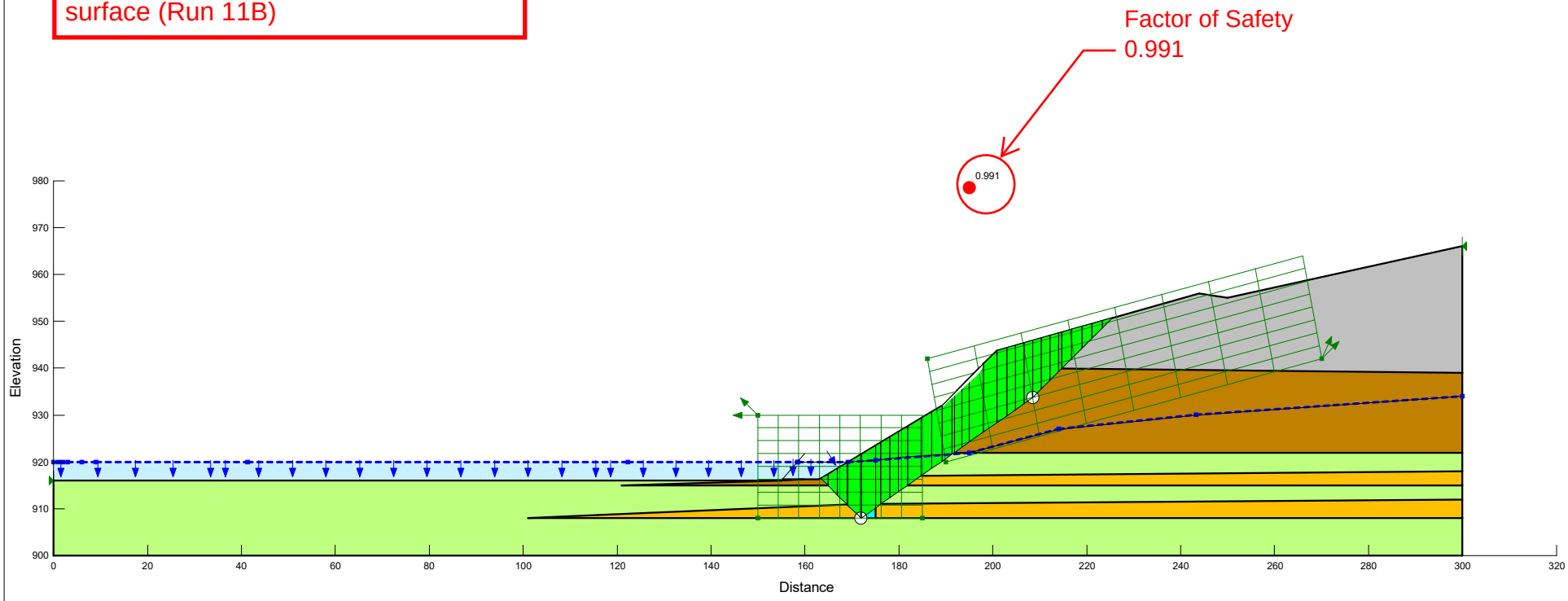
Run 11C - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Sliding Block - FS ~ 1.5 (Overall Failure)

Materials

- Silts Clay (Softened)
- Silty Clay
- Silty Sand
- Toe Drain Aggregate
- Waste

PROGRESSION OF SLOPE FAILURE

Slip plane at FS ~ 1 as new riverbank surface (Run 11B)



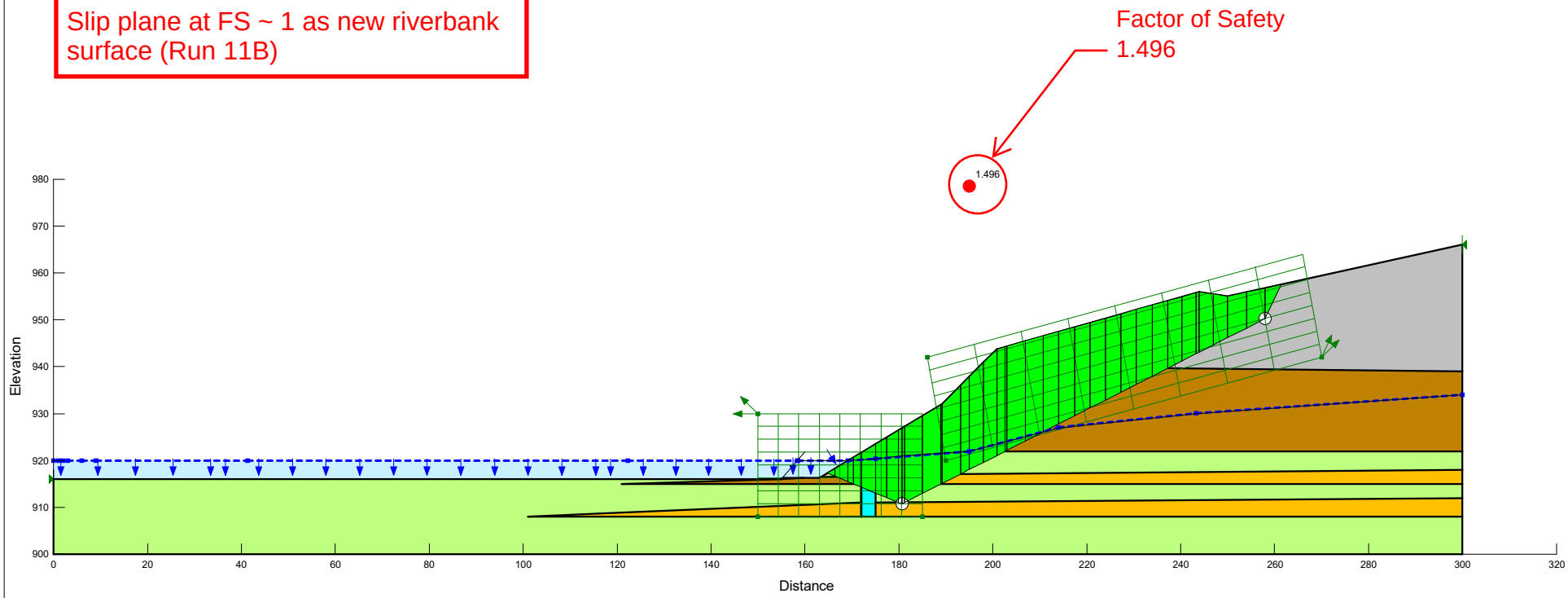
Run 12A - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Sliding Block - FS ~ 1

Materials

- Silts Clay (Softened)
- Silty Clay
- Silty Sand
- Toe Drain Aggregate
- Waste

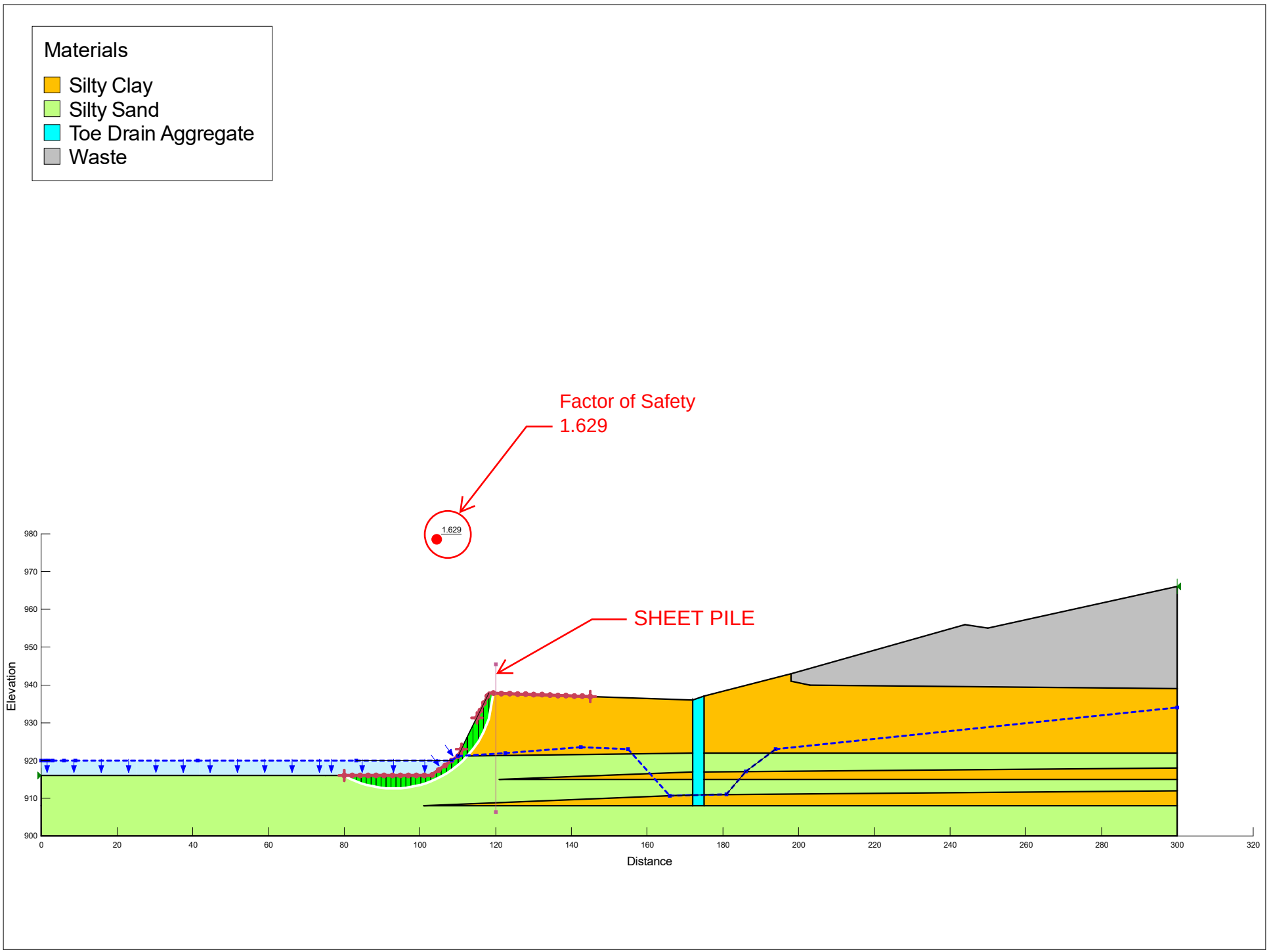
PROGRESSION OF SLOPE FAILURE

Slip plane at FS ~ 1 as new riverbank surface (Run 11B)

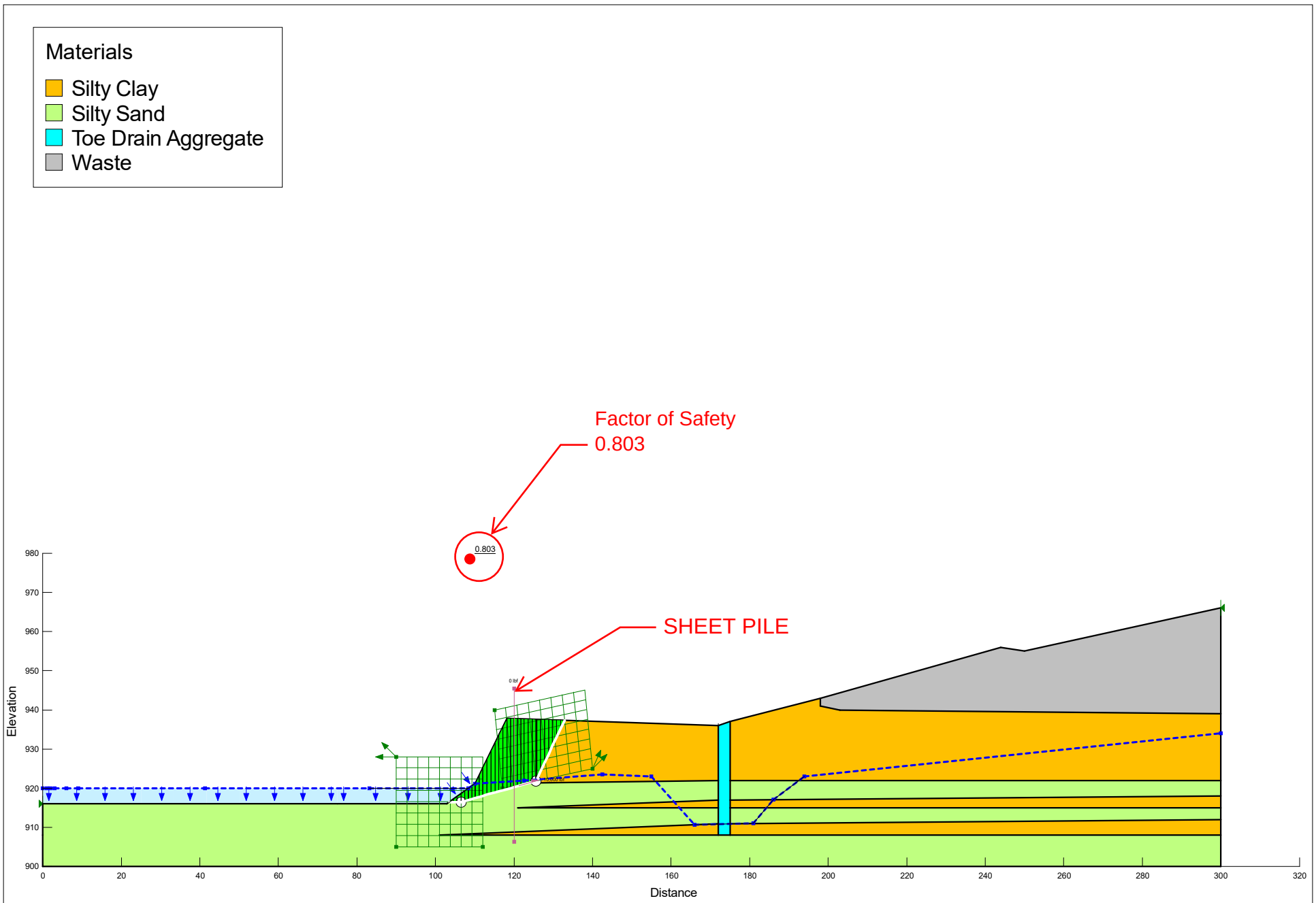


Run 12B - Toe Drain Collapse - Clay Softened - Riverbank 120 ft. NE - Sliding Block - FS ~ 1.5 (Overall Failure)

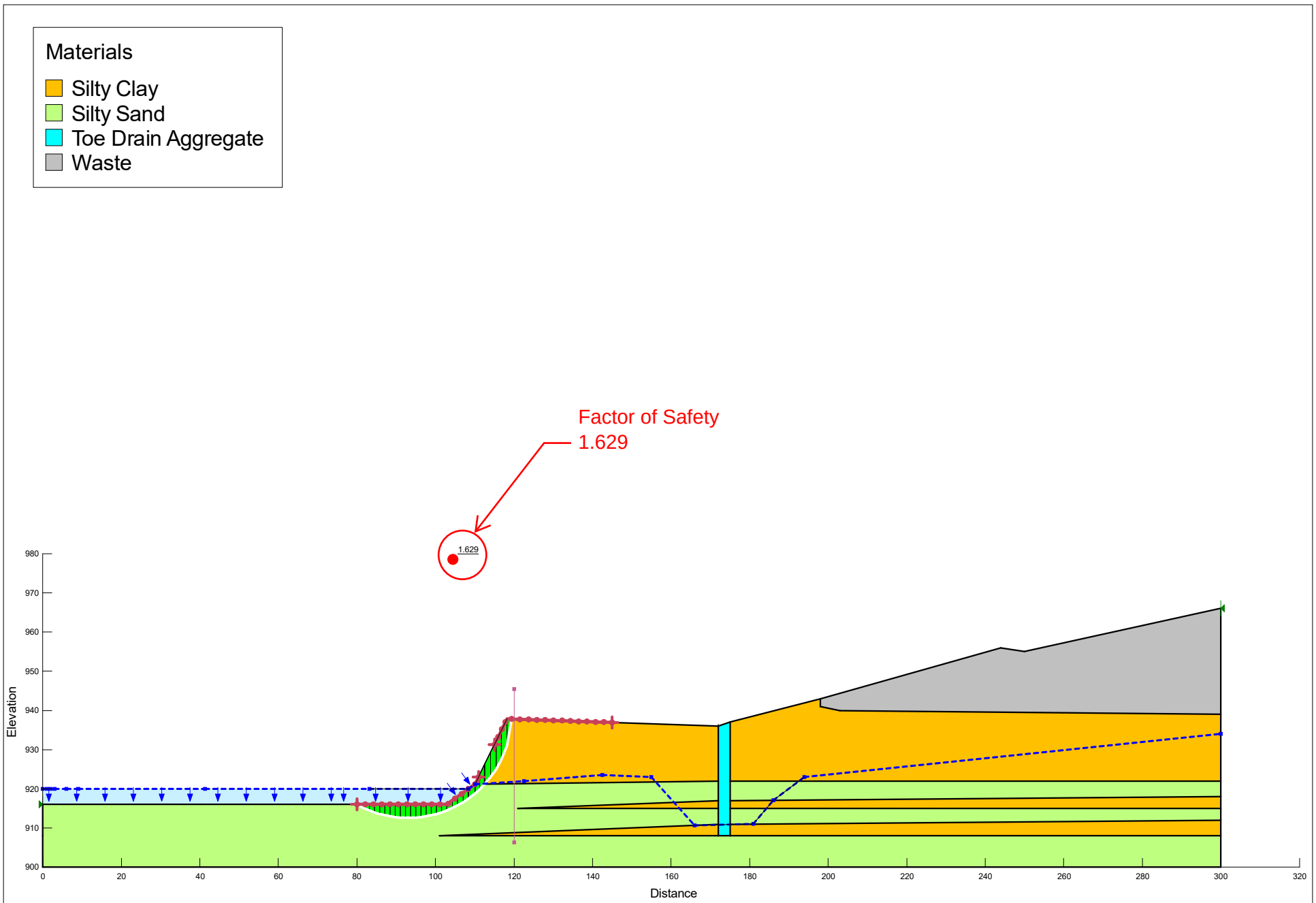
RIVERBANK PROTECTIVE MEASURES



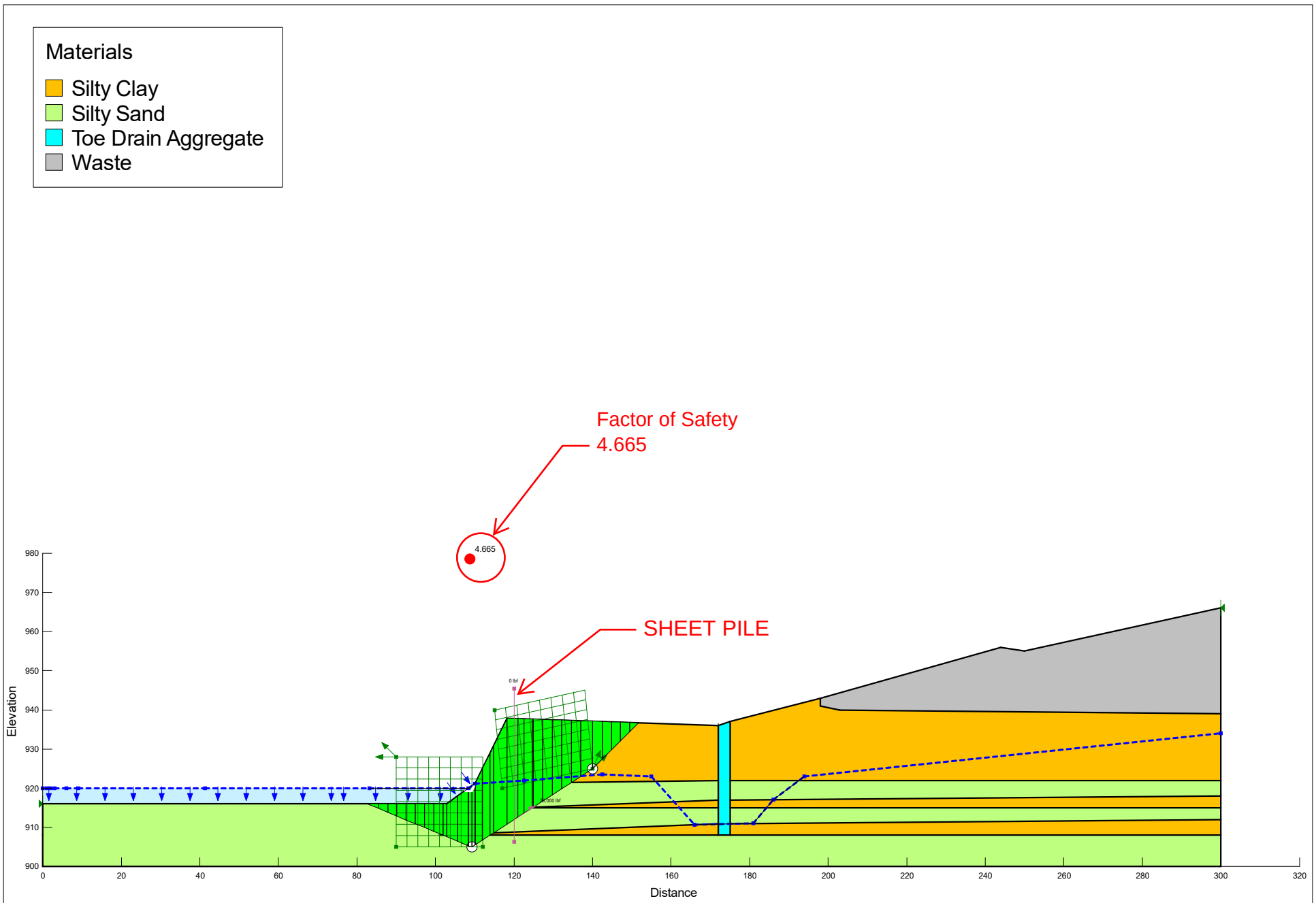
Run 13A - Riverbank 70 ft. NE - Sheet pile shear strength 15,000 lbf - Circular Wedge (Critical Slip Surface)



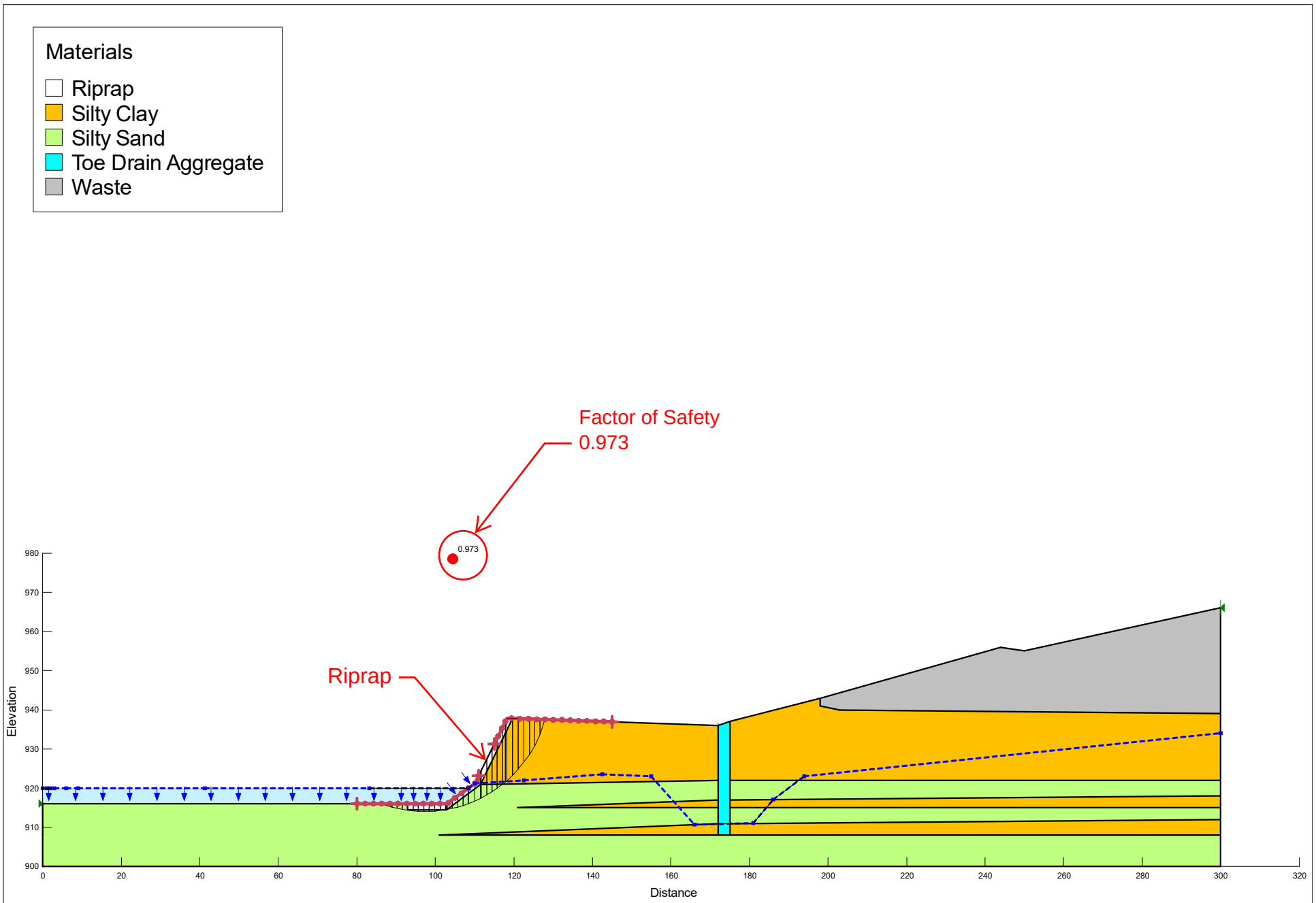
Run 13B - Riverbank 70 ft. NE - Sheet pile shear strength 15,000 lbf - Sliding Block (Critical Slip Surface)



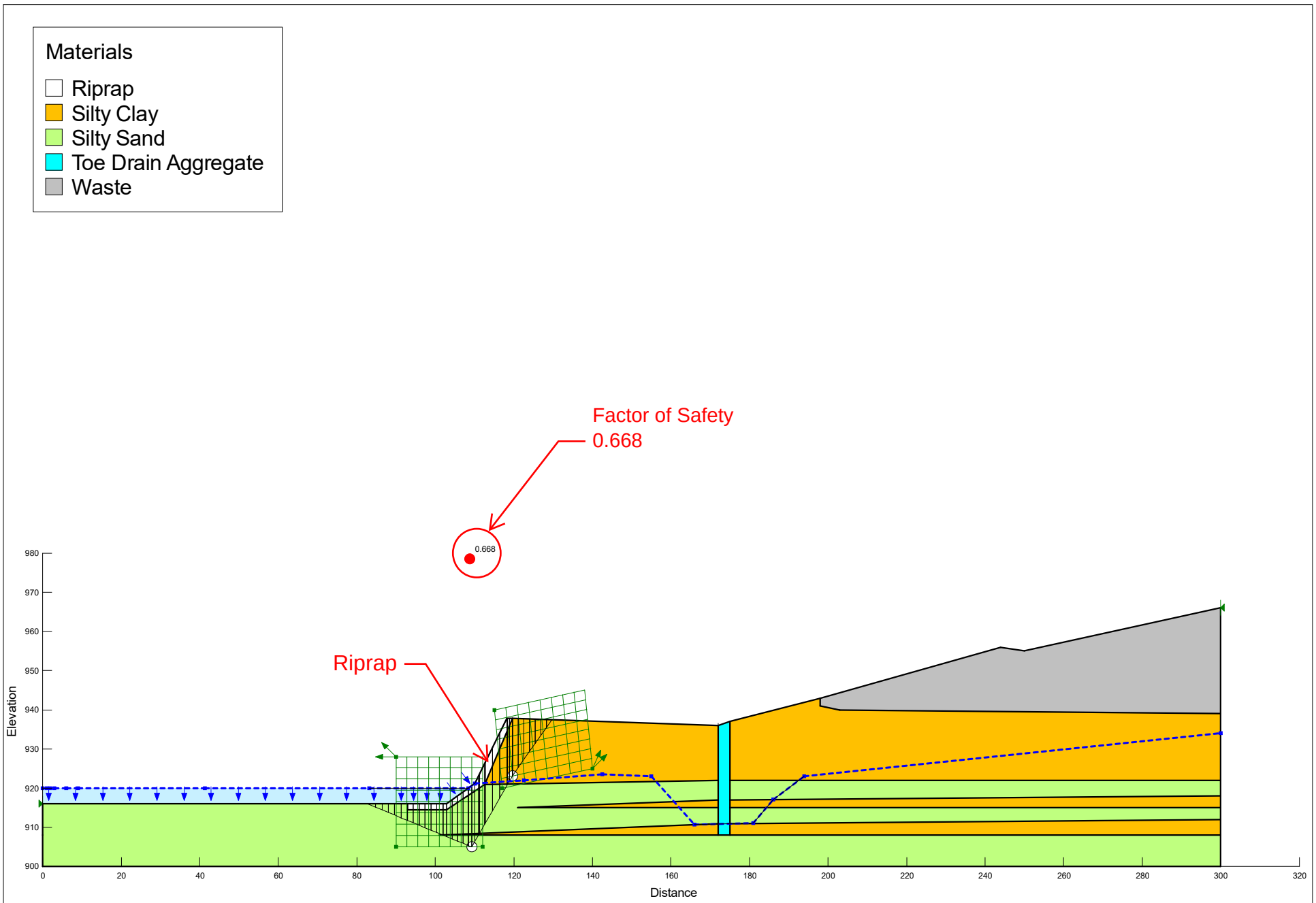
Run 14A - Riverbank 70 ft. NE - Sheet pile shear strength 30,000 lbf - Circular Wedge (Critical Slip Surface)



Run 14B - Riverbank 70 ft. NE - Sheet pile shear strength 30,000 lbf - Sliding Block



Run 15A - Riverbank 70 ft. NE - 18 in. Riprap - Circular Wedge



Run 15B - Riverbank 70 ft. NE - 18 in. Riprap - Sliding Block

Attachment C

Seismic-Hazard Map

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Conterminous U.S. 2014 (v4.0.x)

Spectral Period

Peak Ground Acceleration

Latitude

Decimal degrees

41.864

Time Horizon

Return period in years

2475

Longitude

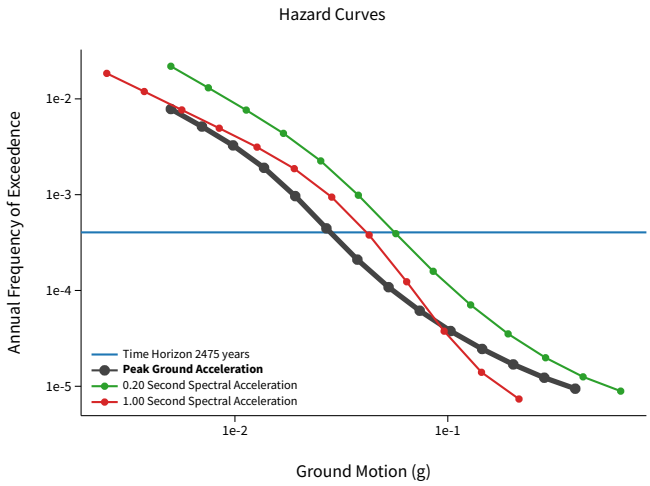
Decimal degrees, negative values for western longitudes

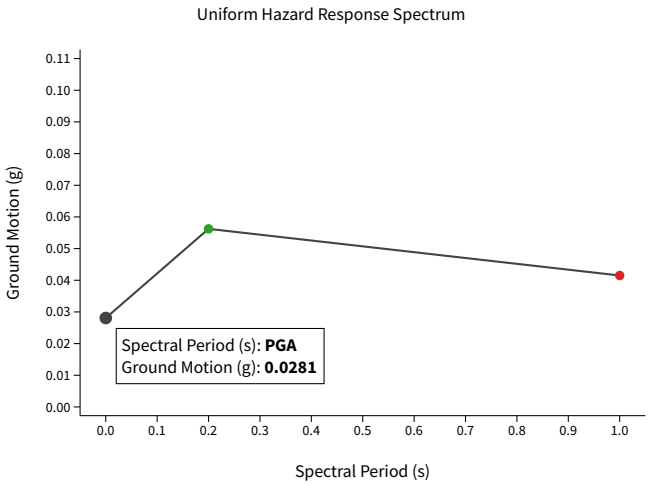
-94.166

Site Class

760 m/s (B/C boundary)

Hazard Curve





View Raw Data