COAL ASH IMPOUNDMENT SITE ASSESSMENT FINAL REPORT

Stanton Station
Great River Energy

Prepared by:

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KLEINFELDER PROJECT NUMBER 118953-2

October 26, 2012

KLEINFELDER

I acknowledge that the management units referenced herein:

- North Ash Pond
- Center Drainage Pond
- South Ash Pond

Were assessed on May 18, 2011

Signature: [signature] Date: 10/26/12

Charles E. Larson, P.E.
Lead Civil Engineer

EXECUTIVE SUMMARY

Background information taken from the U. S. Environmental Protection Agency's (EPA's) website:

> "Following the December 22, 2008 dike failure at the TVA/Kingston, Tennessee coal combustion waste (CCW) ash pond dredging cell that resulted in a spill of over 1 billion gallons of coal ash slurry, covered more than 300 acres and impacted residences and infrastructure, the EPA is embarking on an initiative to prevent the catastrophic failure from occurring at other such facilities located at electric utilities in an effort to protect lives and property from the consequences of a impoundment or impoundment failure of the improper release of impounded slurry."

As part of the EPA's effort to protect lives and the environment from a disaster similar to that experienced in 2008, Kleinfelder was contracted to perform a site assessment at the Stanton Power Generating Station that is owned and operated by Great River Energy. This report summarizes the observations and findings of the site assessment that occurred on May 18, 2011.

The coal combustion waste impoundments observed during the site assessment included:

- North Ash Pond – Commissioned in 1994 (current configuration)
- Center Drainage Pond – Commissioned in 1994 (current configuration)
- South Ash Pond – Commissioned in 1994 (current configuration)

Preliminary observations made during the site assessment are documented on the Site Assessment Checklists presented in Appendix A. A copy of this checklist was transmitted to the EPA following the field walk-through. A more detailed discussion of the observations is presented in Section 4, "Site Observations".

All three impoundments are regulated by the North Dakota Department of Health – Waste Management Division. While that agency has not established a hazard rating, Barr Engineering assigned the three impoundments a "Less Than Low" hazard rating in September 2010. That hazard rating was reviewed, and it is agreed that a hazard classification of “Less Than Low” is an appropriate designation for all three impoundments.

Overall, the ponds are reasonably well maintained and engineered, and operated with a few areas of concern as discussed in Section 6, “Recommendations”.

On the date of this site assessment, there appeared to be no immediate threat to the safety of the impoundment embankments. No assurance can be made regarding the impoundments condition after this date. Subsequent adverse weather and other factors may affect the condition.

A brief summary of the Priority 1 and 2 Recommendations is given below. A more detailed discussion is provided in Section 6, “Recommendations”.

Priority 1 Recommendations

1. Prepare an Emergency Action Plan (EAP) for the facility by July 1, 2013.
2. Control burrowing animals on the downstream slopes. Develop and implement an animal control program by July 1, 2013.
3. Perform a hydraulics and hydrology study for the facility by July 1, 2013.

Priority 2 Recommendations

1. Repair embankment scarps and sloughs by July 1, 2013.
2. Maintain a log of maintenance and other activities at the impoundments and supporting facilities by July 1, 2013.
3. Update the Operation and Maintenance (O&M) Manual for the impoundments and the facility by July 1, 2013.

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SECTION 1 – INTRODUCTION

1.1 GENERAL

This report has been prepared for the United States Environmental Protection Agency (EPA) to document findings and observations from a site assessment at the Stanton Station Power Plant on May 18, 2011.

The following sections present a summary of data collection activities, site information, performance history of the facility's impoundment ponds, a summary of site observations, and recommendations resulting from the site investigation.

1.2 PROJECT LOCATION

Stanton Station is located approximately three miles southeast of Stanton, ND, as shown in Plate 1. The power plant is located in Mercer County at approximately 47°17'10''N and 101°19'58''W. The nearby town of Stanton is a rural agricultural community with the town population of about 350.

1.3 SITE DOCUMENTATION

Great River Energy provided the following documents during the time of this assessment to aid in the review of the impoundments:

- Stone & Webster Engineering Corp., Design Report – Stanton Station Ash Pond Modifications, April 25, 1994.
- Stone & Webster Engineering Corp., Operating Plans – Stanton Station Ash Pond Modifications, June 1994.
- Stone & Webster Engineering Corp., Proposed Ash Pond Modifications – Stanton Station Waste Disposal and Ash Handling Project, December 1993.
- Stone & Webster Engineering Corp., Construction Drawings for Stanton Station Ash Pond Modifications, original issue April 13, 1994.
- North Dakota Dept. of Health, Waste Disposal Permit SP-043, March 17, 2005.

- North Dakota Dept. of Health, NPDES Permit No. ND0000299, December 20, 2006.
- Barr Engineering, 2010 Annual Groundwater Monitoring Report, Stanton Station Ash Disposal Facility, February 2011.
- Barr Engineering, Bottom Ash Surface Impoundment, 2010 Summer Inspection Report, Stanton Station, September 27, 2010.
- Golder Associates, Inc., Stability Evaluation of Bottom Ash Surface Impoundment, May 16, 2011.
- Golder Associates, Inc., Stability Evaluation of Bottom Ash Surface Impoundment Addendum, December 22, 2011.
- Golder Associates, Inc., Addendum to Stability Evaluation of Bottom Ash Surface Impoundment Addendum – Seismic Stability Evaluation, March 16, 2012.

SECTION 2 – SITE ASSESSMENT

2.1 ATTENDEES

The site assessment was performed on May 18, 2011 by Charles Larson, P.E. and Brad Piede, E.I.T. of Kleinfelder. Other persons present during the site assessment included:

- Jennifer Charles – Great River Energy
- Erik Silvola – Great River Energy
- Diane Stockdill – Great River Energy
- Steve Smokey – Great River Energy

2.2 IMPOUNDMENTS ASSESSED

Impoundments and associated structures that were observed during the site assessment included:

- North Ash Pond – Commissioned in 1994 (current configuration)
- Center Drainage Pond – Commissioned in 1994 (current configuration)
- South Ash Pond – Commissioned in 1994 (current configuration)

Observations from the site assessment are documented on the Site Assessment Evaluation Checklists presented in Appendix A. A summary of observations from the site assessment is presented in Section 4.

2.3 WEATHER DURING ASSESSMENT

During the assessment of the Great River Energy Stanton Station impoundments, the weather was sunny and breezy. Temperatures ranged from about 60^{o} to 65^{o} F, and wind speeds ranged from about 5 to 10 miles per hour (mph).

SECTION 3 – SITE INFORMATION AND HISTORY

3.1 SITE INFORMATION AND HISTORY

The Stanton Power Generating Station is a coal-fired facility that has been in operation since 1966. The facility currently sluices primarily bottom ash and boiler slag residuals, both by-products of coal fired energy generation, into either the North or South Ash Pond impoundments. The bottom ash settles out and decants off to the Center Drainage Pond, where additional settling occurs before discharging into a pipeline that carries the effluent to the Missouri River outfall. Prior to the current operational layout at the Stanton Station, all three ponds were originally part of the original CCW facility known as Ash Pond A. The Stanton Station converted from a wet to dry process for handling fly ash in 1995. Bottom ash and boiler slag are still handled through a wet process, but the conversion to a dry fly ash process greatly reduced the ash pond storage requirements. Approximately half of Ash Pond A was reconfigured into three ponds to handle the bottom ash and boiler slag. Based on Golder Associates review of the site history, the three ponds comprising the bottom ash surface impoundment are not built over wet ash or other unsuitable materials. An aerial image of these impoundments can be seen on Plate 2.

Both the North and South Ash Ponds function as settling basins for the bottom ash material. Both ponds decant back into the Center Drainage Pond, and that pond releases into the Missouri River under the ND Department of Health – Waste Management Division Permit No. SP-043. According to GRE, it typically takes about two years to fill either the North or South Ash Pond. Bottom ash disposal is then shifted to the other pond that has been cleaned out, and the process continues for another couple of years, then cycles back to the first pond while the material in the pond just removed from service dries out for later removal and permanent disposal in a landfill immediately west of the three impoundments. To our knowledge, none of the bottom ash material is sold for other uses such as shingle grit or abrasives.

All three ponds are earthen embankment impoundments formed by an outer perimeter embankment with two interior dikes that form the three ponds. Sluice pipes transport primarily bottom ash from power generating operations to outlets near the northeast corner of either the North Ash Pond or the South Ash Pond, depending on which pond is in service. From there the bottom ash material in the slurry settles out.

The bottom ash material spreads out or is moved further out into the pond by equipment during its two year filling cycle. Water drains out and collects on the opposite side of the pond, where it then drains into the Center Drainage Pond via a control weir and 36-inch diameter concrete pipe. The water in the Center Drainage Pond further settles, then decants out through a similar outlet weir and an 18-inch diameter concrete pipe that conveys flows to the Missouri River.

The ponds are all interconnected by pipes and concrete intake towers with adjustable control weirs with metal stoplogs. All three ponds have managed inflow that is continuously monitored and thus do not have emergency spillways. Because all ponds are diked impoundment structures, none of the ponds have tributary drainage area outside of the crest perimeter.

In reviewing the response letter to the EPA's section 104(e) request for information, shown in Appendix B, it is noted that there has never been a release of impounded water at Stanton Station.

3.2 PERTINENT DATA

A. GENERAL

1. Name .... Stanton Station
2. State .... North Dakota
3. County .... Mercer
4. Latitude .... 47^{o} 17' 10'' North
5. Longitude .... 101^{o} 19' 58'' West
6. River used for operations .... Missouri
7. Year Constructed 1966
8. Modifications .... Orig. Ash Pond A reconfigured to 3 current ponds in1994
9. Current Hazard Classification .... None
10. Proposed Hazard Classification .... Less Than Low
11. Size .... See below

B. IMPOUNDMENTS

NORTH ASH POND

1. Type .... Earthen – Diked
2. Crest Elevation .... ±1720[1]
3. Crest Length .... ~ 1,650 ft[2]
4. Crest Width .... 20 ft
5. Impoundment Height .... ~ 16 ft
6. Upstream Slope 3H:1V
7. Downstream Slope 3H:1V
8. Volume of Stored Ash .... ~5.7 acre-feet[2] (as of 7/10)

CENTER DRAINAGE POND

1. Type .... Earthen – Diked
2. Crest Elevation .... ±1720[1]
3. Crest Length .... ~ 1,550 ft[2]
4. Crest Width .... 20 ft
5. Impoundment Height .... ~ 16 ft
6. Upstream Slope 3H:1V
7. Downstream Slope 3H:1V
8. Volume of Stored Ash .... ~3.1 acre-feet[2] (as of 7/10)

SOUTH ASH POND

1. Type .... Earthen – Diked
2. Crest Elevation .... ±1720[1]
3. Crest Length .... ~ 1,800 ft[2]
4. Crest Width .... 20 ft
5. Impoundment Height .... ~ 16 ft
6. Upstream Slope 3H:1V
7. Downstream Slope 3H:1V
8. Volume of Stored Ash .... ~22 acre-feet[2] (as of 11/09)

C. DRAINAGE BASIN

1. Area of Drainage Basin .... Impoundment area
2. Downstream Description: .... Missouri River

D. RESERVOIR INLET

NORTH ASH POND

1. Reservoir Inlet .... Double sluice pipes from plant

CENTER DRAINAGE POND

1. Reservoir Inlet .... Weir structure w/ 36-inch pipe from both N and S Ash Ponds ~ elev. 1703

SOUTH ASH POND

1. Reservoir Inlet .... Double sluice pipes from plant

E. RESERVOIR

NORTH ASH POND

1. Reservoir Capacity .... Maximum storage is approximately 37 acre-feet[1]

CENTER DRAINAGE POND

1. Reservoir Capacity .... Maximum storage is approximately 38 acre-feet[1]

SOUTH ASH POND

1. Reservoir Capacity .... Maximum storage is approximately 40 acre-feet[1]

F. PRIMARY SPILLWAY

NORTH ASH POND

1. Description .... N/A – No Spillway Present

CENTER DRAINAGE POND

1. Description.......... N/A – No Spillway Present

SOUTH ASH POND

1. Description.......... N/A – No Spillway Present

G. OUTLET WORKS

NORTH ASH POND

1. Description..........Concrete weir structure w/ 36-inch dia. concrete pipe to Center Pond
2. Location .... In shared embankment between North Ash Pond and Center Drainage Pond
3. Intake Structure .... Concrete Intake w/ adjustable weir
   a. Intake Invert Elevation..........1703[1,3]
4. Discharge Conduit .... Concrete pipe
   a. Length .... 60 ft.
   b. Diameter .... 36 inches
5. Outlet Structure .... Concrete outlet w/ adjustable weir
   a. Outlet Invert Elevation..........1703[1,3]
   b. Energy Dissipation .... Concrete apron in pool
6. Discharge Channel .... None
7. Discharge Capacity with Water Surface at Top of Impoundment..........Unknown

CENTER DRAINAGE POND

1. Description.......... Concrete weir structure w/ 18-inch dia. concrete pipe to Missouri River
2. Location .... East embankment
3. Intake Structure .... Concrete Intake w/ adjustable weir
   a. Intake Invert Elevation..........1702[1,3]
4. Discharge Conduit .... Concrete pipe
   a. Length ....~1,900 ft
   b. Diameter .... 18 inches
5. Outlet Structure .... Pipe Outfall to Missouri River
   a. Outlet Invert Elevation..........Unknown
   b. Energy Dissipation ....Unknown
6. Discharge Channel .... None
7. Discharge Capacity with Water Surface at Top of Impoundment..........Unknown

SOUTH ASH POND

1. Description..........Concrete weir structure w/ 36-inch dia. concrete pipe to Center Pond
2. Location .... In shared embankment between South Ash Pond and Center Drainage Pond
3. Intake Structure .... Concrete Intake w/ adjustable weir
   a. Intake Invert Elevation..........1703[1,3]
4. Discharge Conduit .... Concrete pipe
   a. Length .... 60 ft.
   b. Diameter .... 36 inches
5. Outlet Structure .... Concrete outlet w/ adjustable weir
   a. Outlet Invert Elevation..........1703[1,3]
   b. Energy Dissipation .... Concrete apron in pool
6. Discharge Channel .... None
7. Discharge Capacity with Water Surface at Top of Impoundment..........Unknown

H. MANAGEMENT

1. Owner .... Great River Energy
2. Purpose .... Coal Fired Energy Generation

Notes:
1. Data provided by plant staff or obtained from Barr Engineering or Stone & Webster reports
2. Pond shares common embankment with adjacent pond
3. Feature was submerged and unable to be visually inspected

3.3 REGIONAL GEOLOGY AND SEISMICITY

Based on our review of previous reports, the subsurface conditions at the plant site consist of river sediment overlaying the Bullion Creek Formation. The plant site consists primarily of Missouri River terrace and alluvial deposits about 30 feet thick. The Bullion Creek Formation generally consists of sandstones, silty clays, shales, and lignite.

The plant site is situated in a Seismic Zone 0 area with the largest historic earthquake in North Dakota registering magnitude 5.5 in May, 1909. The plant area is considered to have a very low seismic risk. Seismic stability analyses of the embankments are discussed below.

3.4 HYDROLOGY AND HYDRAULICS

All three ponds are designed and situated in such a manner that there is no watershed drainage contributing to the stored volume of the ponds. Pond operations are limited to pumping of ash slurry and precipitation that falls within the impoundments themselves.

During the assessment, the design report by Stone & Webster was reviewed. That report covered details such as pond geometry, operations, waste stream volumes and rates, pipe interconnects, capacities, and freeboard. The report did not contain any discussion of site hydrology or impoundment break analyses, nor were any subsequent documents located that covered those topics. Although no formal hydrologic and hydraulic analysis was completed, stability analysis at full pool (Elevation 1720) showed acceptable factors of safety as discussed in the next section. However, Barr Engineering prepared a report assessing the integrity of the ponds and assigning a hazard rating based on EPA assessment criteria. All three ponds were assigned a “Less Than Low” hazard rating. Considering that all three ponds have managed inflow and pool levels that are regularly monitored by plant personnel, and the levels are managed with sufficient freeboard to provide adequate storage during a very significant hydrologic event, we would concur with that assessment. However, a formal hazard classification should be performed.

3.5 GEOTECHNICAL CONSIDERATIONS

Regarding stability of the embankment slopes, we have reviewed the Design Report for Stanton Station Ash Pond Modifications dated April 25, 1994 by Stone & Webster Engineering Corp. That report included stability analyses for the most critical loading condition and pool levels. All three ponds are stable under a normal pool loading condition and conservatively assuming the planned geomembrane liners were not present and steady-state seepage conditions had developed. Upstream slopes were also evaluated for rapid drawdown. Under all evaluation scenarios, the computed factor of safety exceeded 1.5. In addition, Golder completed a stability evaluation report in May 2011 that confirmed factors of safety greater than 1.5 are expected under anticipated loading conditions. Golder also noted several areas of minor slope failures, animal burrows, and several punctures and tears in the geomembrane liner. Golder recommended review of surface water drainage, instrumentation and monitoring of the embankments, and future physical evaluation.

Seismic stability analyses were completed by Golder Associates for all of the embankments of the bottom ash surface impoundment. The same loading condition scenarios for the static stability evaluations completed earlier and discussed above were evaluated, and in all cases the seismic stability factors of safety were all well in excess of 1.0 and thus meet the 1995 EPA guidelines. As such, the embankments are expected to remain stable under the anticipated seismic loading conditions. Below is the summary table of the Golder, 2011 stability analysis. It should be noted that the dynamic factor of safety of 2.5 calculated for the upstream, no water, and saturated berm appears to be erroneously reported and is actually an analysis of an unsaturated berm scenario.

Description	Geomembrane	Water Level	Static Factor of Safety	Dynamic Factor of Safety
North/South	Intact	1720 ft.	2.4	2.2
	None	Phreatic Surface through Berm	2.3	2.2
West	Intact	1720 ft.	2.4	2.1
	None	Phreatic Surface through Berm	2.4	2.1
East	Intact	1720 ft.	2.4	2.5
	None	Phreatic Surface through Berm	2.4	2.5
Upstream	Intact	No Water	3.0	2.5
	None	No Water, Saturated Berm	1.9	2.5*
Minimum Accepted Factor of Safety According to USACE			**1.5**	**1.0**

Instrumentation in the vicinity of the impoundment is limited to a single monitoring well on the west embankment at the corner of the North Ash Pond and Center Drainage Pond shown in Photo 27. Other monitoring wells exist; however, they are a significant distance from the impoundment facility, and it is our understanding that the monitoring wells are used for groundwater data collection. No instrumentation exists relating to seepage and stability monitoring of the impoundment embankment.

3.6 STRUCTURAL CONSIDERATIONS

There are five concrete intake towers in the three ponds. The tower tops are level with the crest of the ponds and provide a means of placing stoplogs in the tower openings to control pond levels. One tower is located each in the North and South Ash Ponds, and three towers are located in the Center Drainage Pond. Four of the towers are at each end of the two interconnect pipes between the North or South Ash Ponds and the Center Drainage Pond. The fifth tower is the outlet structure from the Center Drainage Pond. The towers are connected to the pond embankments by grated walkways. The tower structures were not assessed in detail, but appeared visually to be in satisfactory condition with no evidence of movement, concrete spalling, excessive rust or corrosion of metal parts, or any structural distress. The outlet tower from the Center Drainage Pond had a trashrack in place to prevent debris from entering the 18-inch diameter outlet pipe.

There are also three manholes constructed in the east outer embankment for the North Ash Pond and Center Drainage Pond. No internal assessment was made of those features, but no distress was noted from our external assessment of the visible cover portion. There is also a truss structure to support the sluice piping from the plant to the northeast corners of the North and South Ash Ponds. The pipe support structure is supported on the old Ash Pond A dike located east of the raised dike that was part of the 1994 Ash Ponds modifications project. The pipe support structure did not exhibit any signs of excessive loading on the dike or any movement or structural distress.

3.7 Performance Evaluations

There have been no previous federal or state assessments of the Stanton Station Ash Ponds to our knowledge. Based on written observations by Great River Energy in their monthly walk-around assessments, there have been no significant incidents involving any of the three impoundments. In September 2010 a small leak occurred in an overhead slurry pipeline as a result of a loose fitting in the pipeline. The slurry leak caused minimal surface erosion due to a relatively low flow and multiple layers of plant monitoring that detected the leak in sufficient time to shut off flow very quickly. The issue was initially considered as a potential failure mode. However, after discussing the incident with plant personnel and considering the low flow rate in the pipe, intermittent use of the pipe, multiple pipeline flow controls, and extensive monitoring of the facility, the probability of an embankment failure occurring was judged to be essentially zero. Further, the pipe joint malfunction and subsequent leak occurred prior to ash slurry being deposited into the impoundment, and therefore was considered an operational malfunction and not an uncontrolled release from the impoundment. Great River Energy's local plant personnel perform more frequent informal observations of the impoundments and their associated structures. In addition, Great River Energy retained Golder Associates to perform site evaluations in the fall of 2009 and Barr Engineering to perform a site inspection and assessment in September 2010 as part of their surface impoundment inspection and hazard assessment report discussed previously.

3.8 Hazard Classification

The Stanton Station's three impoundments are regulated by the North Dakota Department of Health – Waste Management Division, but do not currently have a designated hazard rating assigned by that agency. However, the three ponds were rated by Barr Engineering (one of Great River Energy's ash pond impoundment consultants) as being "Less Than Low Hazard" impoundments based on US EPA guidelines. Considering that pond volumes are very small and there is essentially no potential for loss of life or significant economic or environmental damages from a failure of any of the pond embankments, we would concur with that rating. While it is only a relatively short distance before the pond material would enter the nearby Missouri River, the material is free draining, and thus is not likely to flow like a conventional high-density sludge. No private homes, recreational facilities, businesses, paved roads or other structures outside of the plant area would be impacted.

3.9 SITE ACCESS

We were required to seek permission from Great River Energy to gain access to the plant site. After arriving at the site and meeting with representatives of Great River Energy, we were escorted by facility personnel to assess the impoundments. The impoundments can be accessed by standard passenger vehicle during normal weather conditions via gravel-surfaced roadways on the Stanton Station property.

SECTION 4 – SITE OBSERVATIONS

The impoundment outer embankments, downstream toes, and outlet works components (portions not inundated at the time of assessment) of the North and South Ash Ponds and the Center Drainage Pond were observed during the May 18, 2011 site assessment. The interior dikes separating the three ponds were also observed. General observations of these features are presented below; more specific observations of the site and facilities are documented in the Site Assessment Evaluation Checklist provided in Appendix A. Captioned site photographs are presented at the end of this section.

4.1 NORTH ASH POND

4.1.1 Upstream Slope

Overall, the upstream slope of the impoundment was in satisfactory condition. Photos 1, 25, 29, and 30 show the conditions of the upstream slope. Specific observations include:

- The upstream slope was in satisfactory condition, appeared stable, and was in general accordance with the 1994 design report and drawings prepared by Stone & Webster.
- The upstream slope has a geomembrane liner that appeared to be in satisfactory condition above the water surface. The portion of liner below the water surface was not visible and could not be assessed. The liner was free of grasses and woody brush over the entire inside perimeter of the impoundment.
- There is no riprap placed on the upstream slope.

4.1.2 Crest

Overall, the crest of the impoundment was in satisfactory condition. Photos 25, 28, and 29 show the condition of the crest. Specific observations include:

- The impoundment crest also serves as a gravel road.

- No major depressions, erosion, or rutting was noted on the impoundment crest.
- Transecting the crest near the northeast corner with minimal cover are two bottom ash sluice lines. Photo 1 shows these sluice lines.
- Sluice pipe structure support columns for the pipeline that runs along the east lower bench of the North Ash Pond and the Center Drainage Pond rest on small concrete foundation pads that penetrate the crest in multiple locations, as shown in Photo 2.

4.1.3 Downstream Slope

Overall, the downstream slope was in Fair condition. Photos 3, 4, 31, and 32 show the conditions of the downstream slope. Specific observations include:

- The slopes were well vegetated and appeared stable.
- The east embankment had a small erosion-related scarp feature on the slope. While that condition did not appear to present an imminent threat to the embankment stability, the area should be repaired and revegetated to prevent progressive failures. It should be noted that the scarp shown in Photo 4 occurred due to a small leak in September 2010 resulting from a loose fitting in the overhead slurry pipeline. The slurry leak caused minimal surface erosion due to a relatively low flow and multiple layers of plant monitoring that detected the leak in sufficient time to shut off flow very quickly. The issue was initially considered as a potential failure mode. However, after discussing the incident with plant personnel and considering the low flow rate in the pipe, intermittent use of the pipe, multiple pipeline flow controls, and extensive monitoring of the facility, the probability of an embankment failure occurring was judged to be essentially zero. Further, the pipe joint malfunction and subsequent leak occurred prior to ash slurry being deposited into the impoundment, and therefore was considered an operational malfunction and not an uncontrolled release from the impoundment.

- A few animal burrows were noted.

4.1.4 Downstream Toe Areas

The toe areas of the embankment were in Fair condition. See Photos 3, 32, and 33 for the condition of these areas. Key features and observations of these areas include:

- The embankment toe was located along a low area with ponded water on the east side. It was not evident whether the ponded water was related to a high groundwater table or recent rains. It did not appear that any noticeable seepage was occurring, but that condition would be difficult to detect with ponded water present.
- The north embankment has a small scarp feature near the toe. While that does not appear to present an imminent threat to the embankment stability, plant staff should continue to monitor for any signs of further displacement that would indicate a slope failure could be occurring.
- The west embankment downstream toe area is buttressed by the adjacent bottom ash landfill, and thus the pond embankment receives additional strength as subsequent layers of ash are placed in the landfill.
- The embankment toe was well vegetated and clear of any woody bushes and small trees.

4.1.5 Outlet Works

The outlet works of the North Ash Pond consists of a 36-inch diameter pipe connecting the pond with the Center Drainage Pond immediately to the south. The pipe is level, and flow and pond water levels are controlled by a stoplog structure on each end of the pipe. The pipe was submerged and could not be observed. The design drawings show a concrete apron and wingwalls for erosion protection at either end. Key observations include:

- The intake portion of the outlet pipe was not able to be observed because it was inundated at the time of the assessment.

- The intake tower of the outlet structure had stop logs in place to set the water level, and did not have any trashrack in place (nor did one seem necessary).
- The discharge location of the outlet pipe into the Center Drainage Pond could not be observed as it was inundated at the time of assessment.
- No video monitoring of the pipe was available at the time of assessment.
- The pipe material is indicated on the drawings to be RCP.
- Overall, the outlet works system appeared to be functioning as intended at the time of assessment.

4.1.6 Impoundment Inlet

Inflow into the North Ash Pond is by slurry pipes directly from the plant. Bottom ash and other constituents of coal combustion are slurried into the pond at the northeast corner in two 12-inch (est.) steel pipes, as shown on Photo 1. From the inlet location the slurry gradually dewaters and the water then collects on the opposite (southwest) part of the pond and eventually decants into the Center Drainage Pond for disposal to the Missouri River (discussed previously and below). The steel inlet pipes appeared to be in satisfactory condition.

4.2 CENTER DRAINAGE POND

4.2.1 Upstream Slope

Overall, the upstream slope of the impoundment was in satisfactory condition. Photos 20, 22, and 24 show the conditions of the upstream slope. Specific observations include:

- The upstream slope was in satisfactory condition, appeared stable, and was in general accordance with the 1994 design report and drawings prepared by Stone & Webster.
- The upstream slope has a geomembrane liner that appeared to be in satisfactory condition above the water surface. The portion of liner below the water surface was not visible and could not be assessed. The liner was

free of grasses and woody brush over the entire inside perimeter of the impoundment.

- There is no riprap placed on the upstream slope.

4.2.2 Crest

Overall, the crest of the impoundment was in satisfactory condition. Photos 17 and 24 show the condition of the crest. Specific observations include:

- The impoundment crest also serves as a gravel road.
- No major depressions, erosion, or rutting was noted on the impoundment crest.
- Sluice pipe structure support columns for the pipeline that runs along the east lower bench of the North Ash Pond and the Center Drainage Pond rest on small concrete foundation pads that penetrate the crest in multiple locations.

4.2.3 Downstream Slope

Overall, the downstream slope was in Fair condition. Photos 5, 7, and 8 show the conditions of the downstream slope. Specific observations include:

- The slopes were well vegetated and appeared stable.
- The east embankment had a small scarp feature on the slope. While that condition did not appear to present an imminent threat to the embankment stability, the area should be repaired and revegetated to prevent progressive failures.
- A few animal burrows were noted on the slopes.

4.2.4 Downstream Toe Areas

The toe areas of the embankment were in Fair condition. See Photos 7 and 8 for the condition of these areas. Key features and observations of these areas include:

- The embankment toe was located along a low area with ponded water on the east side. It was not evident whether the ponded water was related to a high groundwater table or recent rains. It did not appear that any noticeable seepage was occurring, but that condition would be difficult to detect with ponded water present.
- The west embankment downstream toe area is buttressed by the adjacent bottom ash landfill, and thus the pond embankment receives additional strength as subsequent layers of ash are placed in the landfill.
- The outer embankment toe was well vegetated and clear of any woody bushes and small trees.

4.2.5 Outlet Works

The outlet works of the Center Drainage Pond consists of an 18-inch diameter RCP connecting to a manhole that then connects to the outfall line to the Missouri River. The outlet pipe is connected to an intake tower with stoplog slots. Key observations include:

- The intake portion of the outlet pipe was not able to be observed because it was inundated at the time of the assessment.
- The intake tower of the outlet structure had stop logs in place to set the water level, and had a trashrack in place to prevent debris from entering the outlet pipe.
- The discharge location of the outlet pipe into the Missouri River was not able to be observed.
- No video monitoring of the pipe was available at the time of assessment.
- The pipe material is indicated on the drawings to be RCP.
- Overall, the outlet works system appeared to be functioning as intended at the time of the assessment.

4.2.6 Impoundment Inlet

Inflow into the Center Drainage Pond is via 36-inch diameter RCPs located in the divider dikes for both the North and South Ash Ponds. Each inlet location has an intake tower on each end of the pipe through the divider dikes, with stoplog slots. Typically either the North Ash Pond or South Ash Pond will be discharging into the Center Drainage Pond, but not both simultaneously. The inlet pipes appeared to be in functional condition.

4.3 SOUTH ASH POND

4.3.1 Upstream Slope

Overall, the upstream slope of the impoundment was in satisfactory condition. Photos 14, 15 and 19 show the conditions of the upstream slope. Specific observations include:

- The upstream slope was in satisfactory condition, appeared stable, and was in general accordance with the 1994 design report and drawings prepared by Stone & Webster.
- The upstream slope has a geomembrane liner that appeared to be in satisfactory condition above the water surface. The portion of liner below the water surface was not visible and could not be assessed. The liner was free of grasses and woody brush over the entire inside perimeter of the impoundment.
- There is no riprap placed on the upstream slope.

4.3.2 Crest

Overall, the crest of the impoundment was in satisfactory condition. Photos 15 and 17 show the condition of the crest. Specific observations include:

- The impoundment crest also serves as a gravel road.
- No major depressions, erosion, or rutting was noted on the impoundment crest.

- Transecting the crest near the northeast corner with minimal cover are two bottom ash sluice lines (currently not in service).

4.3.3 Downstream Slope

Overall, the downstream slope was in reasonably Fair condition. Photos 10, 35, 38, and 39 show the conditions of the downstream slope. Specific observations include:

- The slopes were well vegetated and appeared stable.
- The east embankment had a small scarp feature and an area of bulging on the slope. While the conditions did not appear to present an imminent threat to the embankment stability, the areas should be repaired and revegetated to prevent progressive failures.
- The west embankment downstream slope is buttressed by the adjacent bottom ash landfill, and thus the pond embankment receives additional strength as subsequent layers of ash are placed in the landfill.
- A few animal burrows were noted, with some sizable (8 to 10-inch diameter) holes on the south embankment.

4.3.4 Downstream Toe Areas

The toe areas of the embankment were in Fair condition. See Photos 10 and 12 for the condition of these areas. Key features and observations of these areas include:

- The embankment toe was located along a low area with ponded water on the east side. It was not evident whether the ponded water was related to a high groundwater table or recent rains. It did not appear that any noticeable seepage was occurring, but that condition would be difficult to detect with ponded water present.

- The west embankment downstream toe area is buttressed by the adjacent bottom ash landfill, and thus the pond embankment receives additional strength as subsequent layers of ash are placed in the landfill.
- The embankment toe was well vegetated and clear of any woody bushes and small trees.

4.3.5 Outlet Works

The outlet works of the South Ash Pond consists of a 36-inch diameter pipe connecting the pond with the Center Drainage Pond immediately to the north. The pipe is level, and flow and pond water levels are controlled by a stoplog structure on each end of the pipe. The pipes were submerged and could not be observed during the assessment. The design drawings show a concrete apron and wingwalls for erosion protection at either end. Key observations include:

- The intake portion of the outlet pipe was not able to be observed because it was inundated at the time of the assessment.
- The intake tower of the outlet structure had stoplogs in place to set the water level, and did not have any trashrack in place (nor did one seem necessary). Water was not flowing to the Center Drainage Pond because the South Ash Pond is currently not in service.
- The discharge location of the outlet pipe into the Center Drainage Pond was not able to be observed as it was inundated at the time of assessment.
- No video monitoring of the pipe was available at the time of assessment.
- The pipe material is indicated on the drawings to be RCP.
- Overall, the outlet works system appeared to be functioning as intended at the time of the assessment.

4.3.6 Impoundment Inlet

Inflow into the South Ash Pond is by two slurry pipes directly from the plant. When the pond is in service, bottom ash and other constituents of coal combustion are slurried into the pond at the northeast corner in two 12-inch (est.)

steel pipes. From the inlet location the slurry gradually dewaters and the water then collects on the western half of the pond and eventually decants into the Center Drainage Pond for disposal to the Missouri River (discussed above). The steel inlet pipes were not attached to the slurry pipeline at the time of the assessment because the South Pond was not in service.

4.3.7 Other

We inquired if Great River Energy had developed an Emergency Action Plan (EAP) related to a potential failure of the impoundments. We understand that an EAP has not been developed for the site because of no probable loss of human life and the majority of any ash material released during a failure would be contained on the GRE property and any impacts would be limited to GRE facilities.

We also inquired if Great River Energy had developed an Operations & Maintenance (O&M) Manual for the Stanton Station Ash Ponds. That document was prepared by Stone & Webster and was provided to us. The O&M Manual discusses operation of the cells, removal and disposal of ash, and presents closure plan details. There is also a discussion of contingency plans should there be damage to one of the cells that would make it inoperable until repair. However, the contingency discussion does not provide action items in the event of a failure of the pond, and thus is not sufficient to serve as an EAP. The above referenced EAP should be part of this O&M Manual if prepared, but should also be capable of being a stand-alone document.

1-North Ash Pond 12" and 16" Steel Pipe Inlets (looking south)

2-Landside View of East Embankment Modification and Sluice Pipes (looking south)

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Stanton Station
Great River Energy
Stanton, North Dakota

FIGURE 1

3-Landside View of Original (Lower) East Embankment (looking south)

4-Landside Erosion on Original East Embankment
from Sluice Pipe Leak (looking south)

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FIGURE

2

5-Scarp on Original Landside East Embankment (looking southwest)

6-Surface Erosion on Original Landside East Embankment (looking south)

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7-Erosion on Original Landside East Embankment (looking southeast)

8-Erosion Rills on Original Landside East Embankment (looking southeast)

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FIGURE

4

9-Bulging of Original Landside East Embankment (looking south)

10-Erosion and Vegetation on Slope of Original Landside East Embankment (looking south)

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11-Animal Burrow on Landside East Embankment

12-Toe of Original East Embankment Over Steepened (looking south)

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FIGURE 6

13-Erosion Channel on Original Landside East Embankment (looking east)

14-South Ash Pond Waterside East Embankment, Not in Use (looking north)

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15-South Ash Pond Waterside South Embankment (looking east)

16-West Landside Embankment (looking north)

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FIGURE 8

17-Divider Dike between South and Center Ponds with Decant Structure (looking east)

18-South Pond Decant Inlet Structure, Not in Use

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FIGURE
9

19-Divider Dike Liner on North Side of South Pond (looking east)

20-Divider Dike Liner on South Side of Center Pond (looking east)

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21-Center Pond Northern Decant Inlet and North Divider Dike (looking north)

22-Center Pond Outfall Structure (looking west)

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FIGURE
11

23-Center Pond Outfall Structure and Trashrack

24-Divider Dike Liner on North Side of Center Pond (looking west)

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FIGURE

12

25-Divider Dike Liner on South Side of North Pond (looking west)

26-North Pond Decant Intake with Stop Logs

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FIGURE
13

27-Monitoring Well on West Corner between North and Center Ponds (looking northeast)

28-Landside of West Embankment (looking south)

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29-North Pond Waterside West Embankment (looking south)

30-North Pond Waterside North Embankment (looking east)

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31-Landside of North Embankment (looking east)

32-Approximately 100' Long Scarp Along Toe of North Embankment (looking east)

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33-Scarp at Toe of North Embankment Approximately 8" Deep

34-Landside North Embankment (looking west)

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FIGURE
17

35-South Pond Landside Embankment from Southeast Corner (looking west)

36-Animal Burrows Approximately 6” to 12” Diameter

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FIGURE
18

37-Animal Burrows Approximately 6” to 12” Diameter

38-Animal Burrows Approximately 6” to 12” Diameter

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39-Animal Burrows Approximately 6” to 12” Diameter

40-Animal Burrows Approximately 6” to 12” Diameter

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FIGURE
20

SECTION 5 – OVERALL CONDITION OF THE FACILITY IMPOUNDMENTS

5.1 ANALYSIS AND CONCLUSIONS

Our analysis is summarized in three general considerations that are presented as follows:

Structural Stability

All three impoundment (North Ash Pond, South Ash Pond, and Center Drainage Pond) embankments were evaluated by Golder for static and seismic stability. All perimeter and interior berms were evaluated for dual scenarios assuming the water level at the crest of the embankment and with and without the geomembrane pond liners. The minimum computed factor of safety (FOS) of 1.9 exceeds the minimum desired FOS of 1.5 for permanent structures. The minimum dynamic FOS for any of the seismic loading conditions was 2.1, which exceeds the required minimum value of 1.0 necessary to meet criteria. As stated in Section 3.5, the dynamic factor of safety calculated for the saturated upstream berm with no water was erroneously reported and the calculated FOS of 2.5 appears to be calculated from an unsaturated scenario based on Golder's 2011 Stability Evaluation of Bottom Ash Surface Impoundment Report. The dynamic FOS should be calculated with the saturated berm case to ensure an adequate FOS. The Golder static and seismic stability evaluation reports are presented in Appendix C as stated in Section 3.5.

Safety of the Impoundments Including Maintenance and Methods of Operation

We understand that the impoundments have a history of safe performance. However, the future performance of these impoundments will depend on a variety of factors that may change over time, including changes in groundwater levels, maintenance and monitoring procedures, changes in embankment integrity, etc. In light of this situation, we have noted several items as follows that present some concern in this regard:

- Several animal burrows were observed. Some of the burrows were quite large – up to a 10-inch diameter opening. This condition should be remedied with a more aggressive animal control program, as the entire pond complex is constructed of earth and clay embankment. While the ponds do have a plastic liner on the inside of the pools, that component could be torn or chewed through.

- Several areas of minor surface sloughs and scarps were observed on the lower east embankment. One small erosion scarp occurred in September 2010 due to a small leak in an overhead slurry line resulting from a loose pipe joint. That incident was quickly detected and corrected by plant personnel. These areas should be repaired with an engineered fill and revegetated to prevent further erosion. Kleinfelder understands that GRE documented this issue as an "Action Item." The outlet culvert from the Center Drainage Pond was submerged and could not be observed. There is currently no evidence of distress within the outlet pipe, but it should be internally inspected if the plant is taken offline for a sufficient amount of time to allow dewatering of the pond and outlet piping.
- An EAP is not currently in place at the site to mitigate damage in the event of an emergency related to breach failure of the impoundment(s). While a failure of an embankment would not constitute a life threatening situation, a short, simple document should be prepared to formally outline the procedures to undertake in the event of such a failure. We do not envision that any type of detailed dambreak analyses would be necessary. The EAP should be added to the O&M Manual, and should also serve as a stand alone document.
- An O&M Manual for pond operations is currently in place for the site. The O&M document should be updated to include the EAP and discussion of a more robust animal control program.

<u>Adequacy of Program for Monitoring Performance of the Impoundments</u>

The present monitoring program primarily involves visual inspections by plant personnel and by Great River Energy and outside consultant technical staff on occasion. These visual inspections seem to be adequate to address issues such as surface erosion and general condition of the impoundments. However, a more detailed monitoring program is recommended to be established to quantify various important factors associated with embankment stability and integrity. Those factors include, but are not limited to monitoring for seepage, monitoring condition of minor scarps observed, noting effectiveness of animal control measures, and documenting any fluctuations of groundwater levels.

5.2 SUMMARY STATEMENT

I acknowledge that the management unit(s) referenced herein:

- North Ash Pond
- Center Drainage Pond
- South Ash Pond

were personally assessed by me and found to be in the following condition:

SATISFACTORY

Signature: ______________________ Date: 10/26/12

Charles E. Larson, P.E.
Lead Civil Engineer

SECTION 6 – RECOMMENDATIONS

6.1 PRIORITY 1 RECOMMENDATIONS

1. **Prepare an Emergency Action Plan (EAP) for the facility by July 1, 2013.** An EAP should be prepared for the Ash Pond Facilities. The EAP could be a very short and straightforward document that basically documents that sufficient volume exists on GRE property to contain releases, and outlines procedures to undertake in the event of an unplanned release, including spill mitigation procedures and phone calls to key plant personnel and any interested and potentially impacted parties.
2. **Control burrowing animals on the downstream slopes. Develop and implement an animal control program by July 1, 2013.** Refer to FEMA publication 473, *Technical Manual for Dam Owners, Impacts of Animals on Earthen Dams*. That manual is available on the FEMA website.
3. **Perform a hydraulics and hydrology study for the facility by July 1, 2013.** An analysis should be performed *that* compares the impoundment freeboard with the Probable Maximum Precipitation (PMP) to determine potential for overtopping.

6.2 PRIORITY 2 RECOMMENDATIONS

1. **Repair embankment scarps and sloughs by July 1, 2013.** Minor surface scarps or sloughs were noted at the toe of the north outer embankment at the North Ash Pond and on the slope of the east outer embankment of all three ponds. These minor scarps should be repaired and revegetated to prevent progressive failures.
2. **Maintain a log of maintenance and other activities at the impoundments and supporting facilities by July 1, 2013.** We have seen examples of monthly walk around inspection reports of the ponds. Other documentation may exist that catalogs routine maintenance and repair activities, and if so, those should be collected and bound in a notebook in a secure location if that practice

is not being followed currently. We believe that this log will provide continuity during periods of staff change.

3. **Update the Operation and Maintenance (O&M) Manual for the impoundments and the facility by July 1, 2013.** The O&M manual should include the EAP (discussed above) and a section on animal control.

6.3 DEFINITIONS

Priority 1 Recommendation: Priority 1 Recommendations involve the correction of more severe deficiencies where action is required to ensure the structural safety, operational integrity of a facility, and that may threaten the safety of the impoundment.

Priority 2 Recommendation: Priority 2 Recommendations where action is needed or required to prevent or reduce further damage or impair operation and/or improve or enhance the O&M of the facility, that do not appear to threaten the safety of the impoundment.

Based on observations during the site assessment, it is recommended that the following actions be taken at the Stanton Station facility.

SECTION 7 – GLOSSARY OF TERMS

For the EPA Ash Pond Assessment program, the following glossary of terms shall be used for classification unless otherwise noted.

Hazard Potential Rating

"Hazard potential" means the possible adverse incremental consequences that result from the release of water or stored contents due to the failure of the impoundment or reservoir or the misoperation of the impoundment, reservoir, or appurtenances. The hazard potential classification of a impoundment or reservoir shall not reflect in any way on the current condition of the impoundment or reservoir and its appurtenant works, including the impoundment's or reservoir's safety, structural integrity, or flood routing capacity. These classifications are as described below:

1. **Less than Low Hazard Potential**

   "Less than Low Hazard" means failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

2. **Low Hazard Potential**

   "Low Hazard" means an impoundment's or reservoir's failure will result in no probable loss of human life and low economic loss or environmental loss, or both. Economic losses are principally limited to the owner's property.

3. **Significant Hazard Potential**

   "Significant Hazard" means a impoundment's or reservoir's failure will result in no probable loss of human life but can cause major economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant Hazard Potential classification impoundments or reservoirs are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

4. **High Hazard Potential**

   "High Hazard" means a impoundment's or reservoir's failure will result in probable loss of human life.

North Dakota State Hazard Classification

According to the North Dakota Dam Design Handbook, dated June 1985, dams are categorized according to the potential hazard to property or loss of life if the dam should suddenly fall.

- Low - Dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails;
- Medium - Dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails;
- High - Dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings and major public utilities. There is a potential for the loss of more than a few lives if the dam fails.

After a dam has been classified according to failure hazard, it will also be classified for dam design criteria. Design criteria shall be based on the hazard classification and the height of the dam. ("Height of the dam" is defined as the distance in feet from the stream channel bottom at the centerline of the dam to the top of the settled embankment.)

The table below is based on dam height and hazard categories and outlines five classifications for dam design. Each classification will require varying degrees of intensity of investigation for hydrology, foundation and borrow explorations, soil testing, structural design, etc.

Dam Design Classifications

Dam Height (ft)	Hazard Categories		
	Low	Medium	High
Less than 10	I	II	IV
10 to 24	II	III	IV
25 to 39	III	III	IV
40 to 55	III	IV	V
Over 55	III	IV	V

Overall Classification of Impoundment

In a system similar to the New Jersey Department of Environmental Protection Impoundment Safety Guidelines for the Inspection of Existing Impoundments (January 2008), when the following terms are capitalized they denote and shall be used to describe the overall classification of the impoundment as follows:

SATISFACTORY - No existing or potential impoundment safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria. Minor maintenance items may be required.

FAIR – Acceptable performance is expected* under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations.

POOR - A management unit safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable impoundment safety regulatory criteria. Remedial action is necessary. POOR also applies when further critical studies or investigations are needed to identify any potential impoundment safety deficiencies.

UNSATISFACTORY – Considered unsafe. A impoundment safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary.

**the term expected is to be defined as likely*

Recommendation Listing

Recommendations shall be written concisely and identify the specific actions to be taken. The first word in the recommendation should be an action word (i.e. “Prepare”, “Perform”, or ”Submit”). The recommendations shall be prioritized and numbered to provide easy reference. Impoundment Safety recommendations shall be grouped, listed or categorized similar to the U.S. Department of Interior, Reclamation Manual - Directives and Standards - Review/Examination Program for High- and Significant-Hazard Impoundments (July, 1998 FAC 01-07) as follows:

Priority 1 Recommendations: Priority 1 Recommendations involve the correction of severe deficiencies where action is required to ensure the structural safety, operational integrity of a facility, and that may threaten the safety of the impoundment.

Priority 2 Recommendations: Priority 2 Recommendations where action is needed or required to prevent or reduce further damage or impair operation and/or improve or enhance the O&M of the facility, that do not appear to threaten the safety of the impoundment.

SECTION 8 – LIMITATIONS

The scope of this work is for a preliminary screening for the EPA and plant owner/operator of the visible performance and apparent stability of the impoundment embankments based only on the observable surface features and information provided by the owner/operator. Other features below the ground surface may exist or may be obscured by vegetation, water, debris, or other features that could not be identified and reported. This site assessment and report were performed without the benefit of any soil drilling, sampling, or testing of the subsurface materials, calculations of capacities, quantities, or stability, or any other engineering analyses. The purpose of this assessment is to provide information to the EPA and the plant owner/operator about recommended actions and/or studies that need to be performed to document the stability and safety of the impoundments.

This work was performed by qualified personnel in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession, practicing in the same locality, under similar conditions, and at the date the services are provided. Kleinfelder's conclusions, opinions, and recommendations are based on a limited number of observations. It is possible that conditions could vary between or beyond the observations made. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided. Kleinfelder makes no warranty or guaranty of future embankment stability or safety.

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Recommendations contained in this report are based on preliminary field observations without the benefit of subsurface explorations, laboratory tests, or detailed knowledge of the existing construction. If the scope of the proposed recommendations changes from that described in this report, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed and the conclusions of this report are modified or approved in writing by Kleinfelder. Kleinfelder cannot be responsible for interpretation by others of this report or the conditions encountered in the field.

SECTION 9 – REFERENCES

Google Inc. (2011). Google Earth Pro (Version 6.0.2.2074) [Software]. Available from http://www.google.com/earth/index.html

North Dakota State Engineer, North Dakota Dam Design Handbook, Chapter IV – Classification of Dams, June 1985

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US Department of Interior, Reclamation Manual – Directives and Standards – Review/Examination Program for High and Significant Hazard Impoundments, July 1998

US Geologic Survey, North Dakota Geologic Map Data, March 18, 2011. http://tin.er.usgs.gov/geology/state/state.php?state=ND

Documents provided by Great River Energy are listed in Section 1.3.

Plates

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PROJECT NO. 118953-2	**GREAT RIVER ENERGY CRITICAL INFRASTRUCTURE MAP**	PLATE
DATE: 6-6-11		**1**
DRAWN BY: B. Piede		
CHECKED BY: C. Larson	STANTON STATON GREAT RIVER ENERGY STANTON, NORTH DAKOTA	
FILE NAME: Stanton Plates		

Barr Footer: Date: 2/24/2011 3:22:16 AM File: I:\Projects\34\29\020\Maps\2010 Annual Monitoring Report\Figure 2 Existing Conditions and Monitoring Units.mxd User: JJL2

MW10 — Monitoring Wells

*MW2 — Monitoring Wells (decommissioned)

Outwash — Geologic Unit within Screened Interval

Approximate Limits of Ash Facilities

Groundwater Flow Direction

Note: Survey of monitoring well locations conducted by Bartlett & West on 7/23/2010.

Photo: Farm Service Agency, National Agriculture Imagery Program, taken 7/8/2005.

0 400 800

Feet

1 Inch = 400 Feet

Figure 2

EXISTING CONDITIONS AND MONITORING UNITS

September 1, 2010

Stanton Generating Station

Great River Energy

Stanton, North Dakota

Note: Figure from Barr Engineering, 2010 Annual Groundwater Monitoring Report, Stanton Station Ash Disposal Facility, February 2011.

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FILE NAME:	Stanton Plates

GREAT RIVER ENERGY
STANTON STATION AERIAL MAP

STANTON STATON
GREAT RIVER ENERGY
STANTON, NORTH DAKOTA

PLATE
2

Notes: 1) Image is a general features map and does not reflect conditions on the date of inspection.
2) North Pond was active and South Pond was inactive during the time of inspection .

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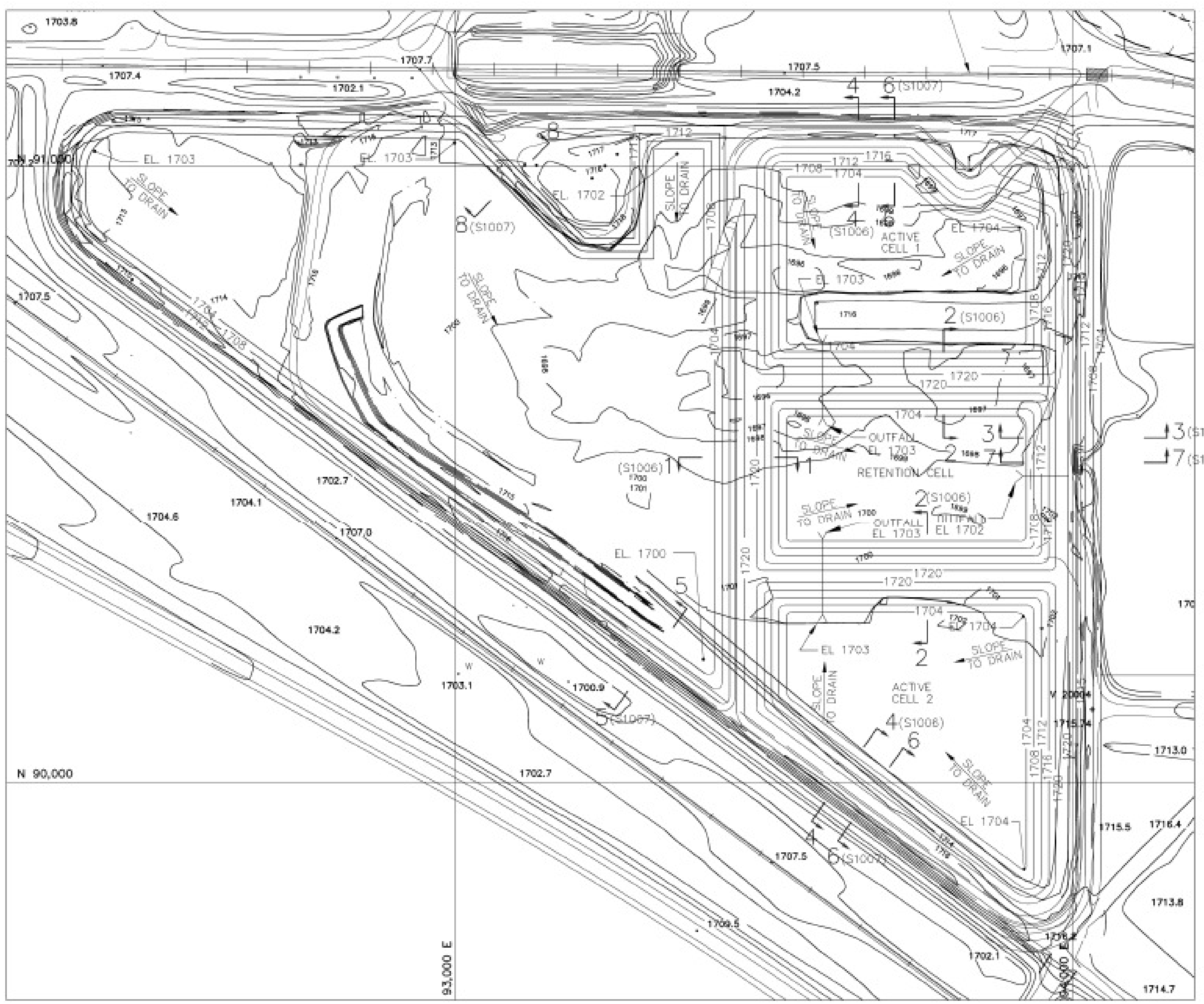
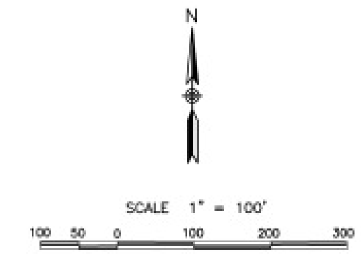
FILE NAME:	Stanton Plates

ASH PONDS
SITE FEATURES MAP

STANTON STATON
GREAT RIVER ENERGY
STANTON, NORTH DAKOTA

PLATE
3





LEGEND:

- EXISTING GROUND ELEVATION CONTOUR
- NEW GROUND ELEVATION CONTOUR

NOTES:

1. SEE GENERAL NOTES, DRAWING S1002.
2. ELEVATIONS SHOWN AT THE BOTTOM OF IMPOUNDMENT CELLS ARE OF THE TOP OF THE CLAY FILL.

REFERENCE DRAWINGS:

S1002	FACILITIES SITE PLAN
S1006	POND A SECTIONS & DETAILS – SH. 1
S1007	POND A SECTIONS & DETAILS – SH. 2
S1008	POND A SECTIONS & DETAILS – SH. 3
S1009	OUTFALL STRUCTURES OUTLINE – PLAN & SECTIONS
S1010	OUTFALL STRUCTURES – REINFORCEMENT SH. 1
S1011	OUTFALL STRUCTURES – REINFORCEMENT SH. 2

UPA PROJECT	UNITED POWER ASSOCIATION STANTON STATION ASH POND MODIFICATIONS	DRAWING NO.	REV
4177	POND A CONVERSION PLAN	S1005	1

STONE & WEBSTER ENGINEERING CORPORATION
DENVER, CO.

ISSUE	DESCRIPTION
3	
2	
1	FOR CONSTRUCTION
0	ORIGINAL ISSUE FOR UPA REVIEW

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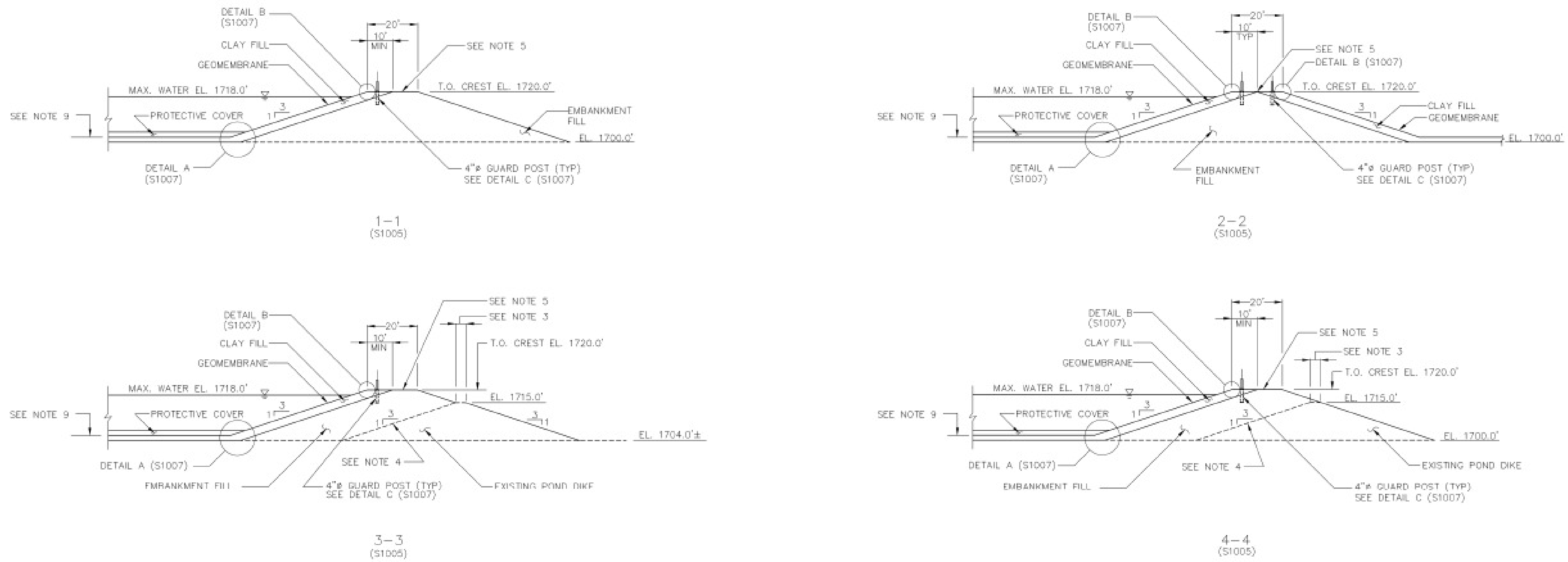
FILE NAME:	Stanton Plates

CONVERSION PLAN
NORTH, SOUTH AND CENTER PONDS

STANTON STATON
GREAT RIVER ENERGY
STANTON, NORTH DAKOTA

PLATE **4**



NOTES:

1. SCALE: 1" = 20' UNLESS NOTED.
2. SEE GENERAL NOTES, DRAWING S1002.
3. THE EXISTING POND DIKES WERE REPORTEDLY CONSTRUCTED TO HAVE 4 FOOT WIDE CRESTS AT ELEVATION 1715 FEET, AND 3:1 (HORIZONTAL VERTICAL) SIDE SLOPES. ACTUAL POND DIKE WIDTHS, ELEVATIONS AND SLOPES MAY VARY.
4. ASH, PVC LININGS AND OTHER NON-SOIL MATERIALS FOUND ALONG THE INSIDE OF EXISTING POND A DIKES SHALL BE REMOVED TO EXPOSE THE EXISTING DIKE SOIL FILL. EMBANKMENT FILL SHALL BE PLACED, AS NEEDED, TO FILL AREAS WHERE EXCAVATIONS TO REMOVE THE ASH, LININGS AND OTHER NON-SOIL MATERIALS EXTEND BEYOND THE LINE SHOWN.
5. THE TOP OF THE EMBANKMENT FILL OF THE SURFACE IMPOUNDMENT EMBANKMENTS SHALL BE GRADED TO BE AT ELEVATION 1720'-3" AT THE CENTERLINE AND TO SLOPE TO ELEVATION 1720'-0" AT 6 FEET EITHER SIDE OF THE CENTERLINE, AND SHALL BE COVERED WITH 6 INCHES OF COMPACTED BASE COURSE.
6. AN ANCHOR GUARD POST FOR THE SAFETY CABLE SHALL BE LOCATED AT EACH CORNER OF EACH IMPOUNDMENT CELL. LINE GUARD POSTS SHALL BE SPACED AT INTERVALS NO WIDER THAN 50 FEET BETWEEN THE CORNER ANCHOR POSTS. ANCHOR GUARD POSTS SHALL ALSO BE PLACED TO PROVIDE A 20 FOOT WIDE OPENING ALONG THE EAST SIDE OF ACTIVE CELLS 1 AND 2, AND A 10 FOOT WIDE OPENING AT EACH OUTFALL LOCATION, AS DIRECTED BY THE OWNER. THE WIRE ROPE SHALL BE INSTALLED TO BE A MINIMUM OF 3 FEET ABOVE THE GROUND SURFACE.
7. A ONE INCH DIAMETER, POLYPROPYLENE, TWISTED ROPE SHALL BE FASTENED TO THE BOTTOM OF EACH GUARD POST. THE ROPE SHALL BE FASTENED TO THE POSTS USING CABLE CLAMPS OR AN EQUIVALENT FITTING APPROVED BY THE OWNER. THE BOTTOM OF THE ROPE SHALL BE SECURELY ATTACHED TO A HEAVY DUTY POLYPROPYLENE BAG FILLED WITH A MINIMUM OF 50 LBS. OF CLEAN SAND, AND SHALL EXTEND TO WITHIN 3 FEET OF THE BOTTOM OF THE ADJACENT IMPOUNDMENT CELL.
8. IF ASH EXTENDS TO WITHIN 10 FEET OF EXISTING POWER POLES, THE POLES SHALL BE TEMPORARILY SUPPORTED WHILE THE ASH IS REMOVED AND THE EXCAVATION IS REFILLED WITH EMBANKMENT FILL.
9. SEE DRAWING S1005 FOR COMPLETED GRADE ELEVATIONS.

REFERENCE DRAWINGS:

S1002	FACILITIES SITE PLAN
S1005	POND A CONVERSION PLAN
S1007	POND A SECTIONS & DETAILS – SH.2
S1008	POND A SECTIONS & DETAILS – SH.3

UPA PROJECT 4177	UNITED POWER ASSOCIATION STANTON STATION ASH POND MODIFICATIONS	DRAWING NO. S1006	REV 1
	POND A SECTIONS & DETAILS – SH. 1		
STONE & WEBSTER ENGINEERING CORPORATION DENVER, CO.			

Revisions: 1 FOR CONSTRUCTION; 0 ORIGINAL ISSUE FOR UPA REVIEW

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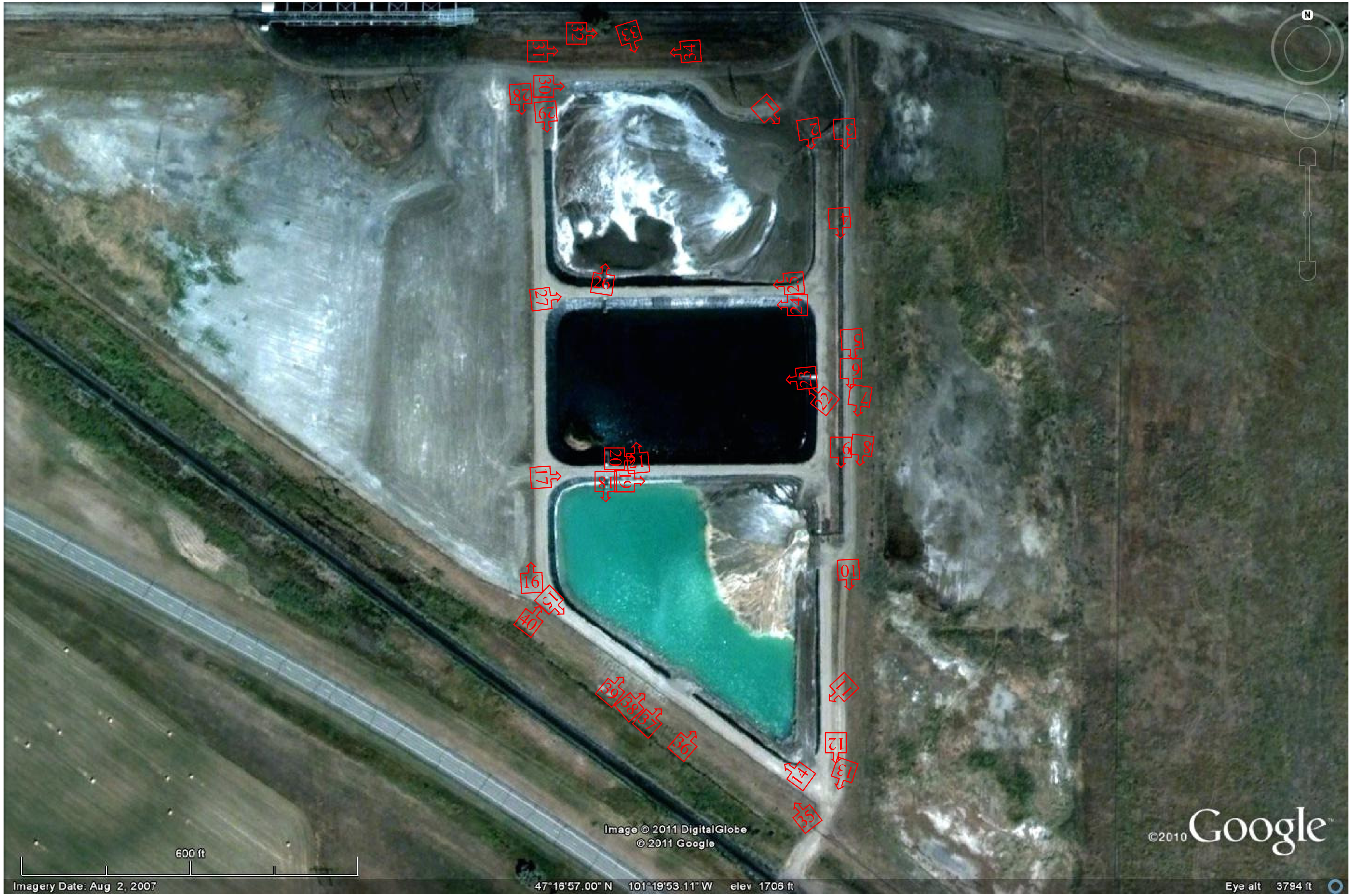
FILE NAME:	Stanton Plates

TYPICAL CROSS-SECTIONS NORTH, SOUTH AND CENTER PONDS

STANTON STATON
GREAT RIVER ENERGY
STANTON, NORTH DAKOTA

PLATE 5



Legend:

- Photo number, location, and direction

Notes: 1) Photograph locations are approximate and may not exactly coincide with the coordinates shown on the photo.

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DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Stanton Plates

LOCATIONS OF SITE ASSESSMENT PHOTOS

STANTON STATON
GREAT RIVER ENERGY
STANTON, NORTH DAKOTA

PLATE 6

Appendix A

Site Assessment Evaluation Checklists

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Stanton Station	Date:	5-18-11
Unit Name:	North Ash Pond	Operator's Name:	Great River Energy
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓
Inspector's Name:	Kleinfelder - Charles Larson PE, Brad Piede EIT		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Monthly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)?	1,715.1		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	1,703.0		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	1,720.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)		✓	At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?		✓	From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?	✓		24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments

17. Minor Scarp on the North Embankment Toe

Based on Golder Associates review of the site history, no part of the impoundment was built over wet ash, slag, or other unsuitable materials.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # ND0000299 INSPECTOR Kleinfelder (C. Larson, B. Piede)

Date 5-18-11

Impoundment Name Stanton Station
Impoundment Company Great River Energy
EPA Region 8
State Agency (Field Office) Addresss N/A - no US EPA field office in ND

Name of Impoundment North Ash Pond
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update _X________

	Yes	No
Is impoundment currently under construction?	_______	_X____
Is water or ccw currently being pumped into the impoundment?	__X___	_______

IMPOUNDMENT FUNCTION: Bottom Ash and Boiler Slag Settling Pond

Nearest Downstream Town : Name Washburn, ND
Distance from the impoundment ___15 miles____________________
Impoundment
Location: Longitude __101_ Degrees _19___ Minutes _53___ Seconds
Latitude _47___ Degrees _17___ Minutes _01___ Seconds
State _ND______ County _Mercer_____________________

Does a state agency regulate this impoundment? YES __X___ NO ______

If So Which State Agency? North Dakota Dept. of Health - Waste Management Div.

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

__X___ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

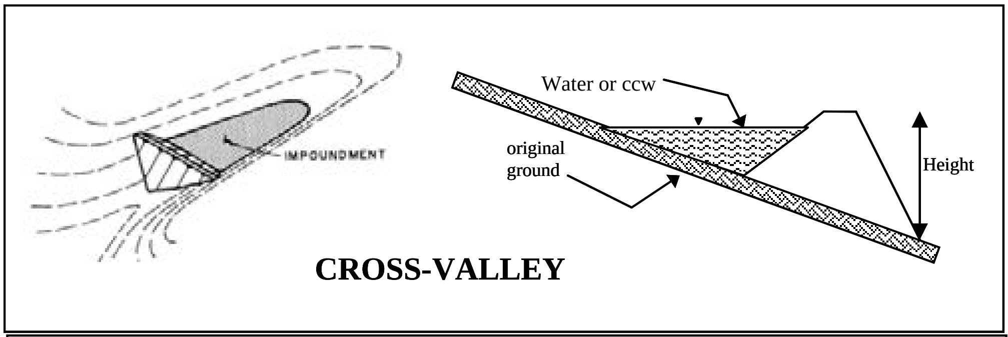
______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

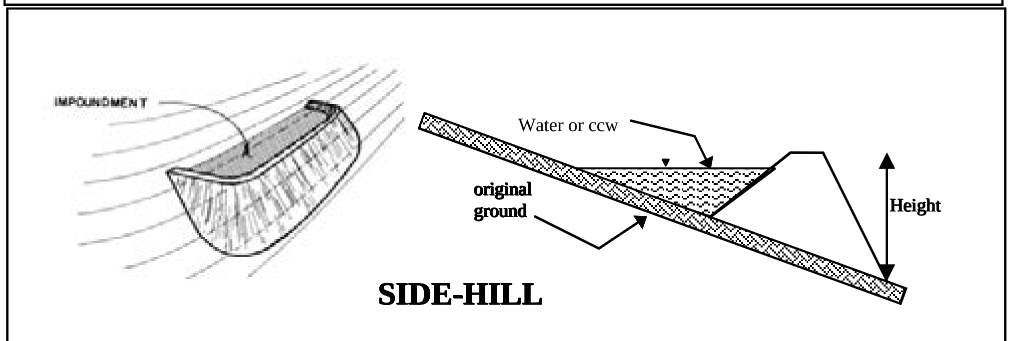
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

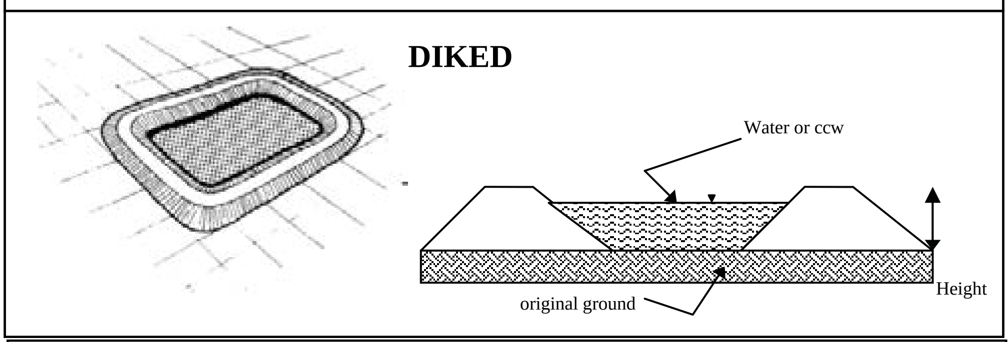
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

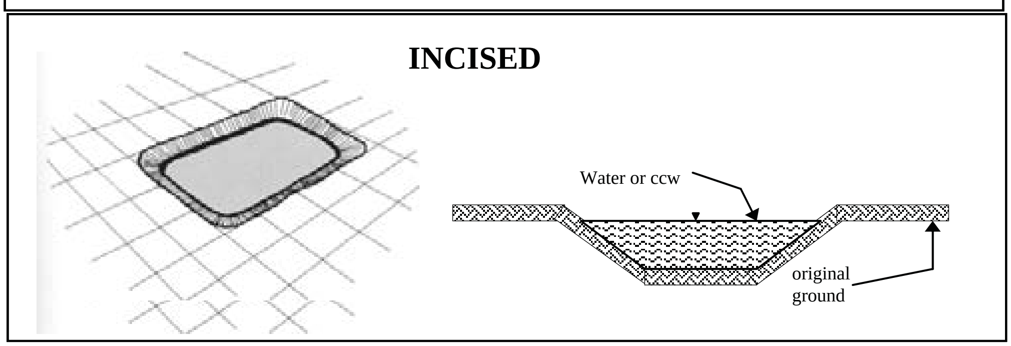
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:
___-No loss of human life anticipated__________________________________
___-Pond volume is small and any failure or misoperation related______
______release would be contained on Great River Energy's property._____
___-Failure would have essentially no environmental or economic impact.___ ____________

CONFIGURATION:









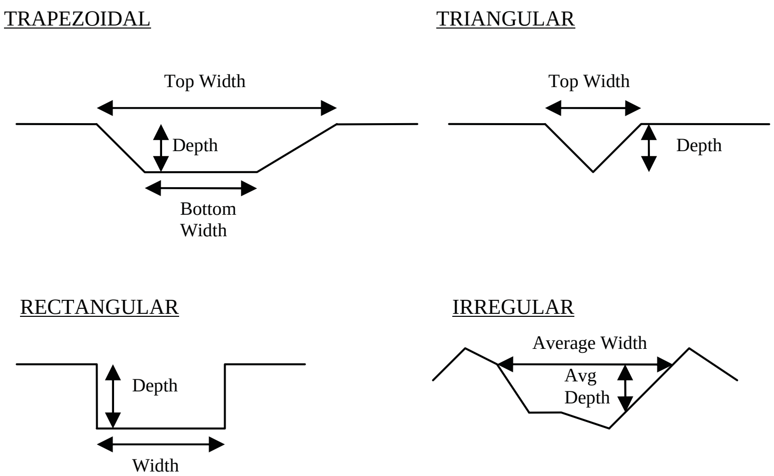
_____ Cross-Valley
_____ Side-Hill
__X__ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

Embankment Height 13 feet   Embankment Material Earthfill
Pool Area 3.2 acres   Liner HDPE
Current Freeboard Approx. 5 feet   Liner Permeability Approx. 0

<u>TYPE OF OUTLET</u> (Mark all that apply)

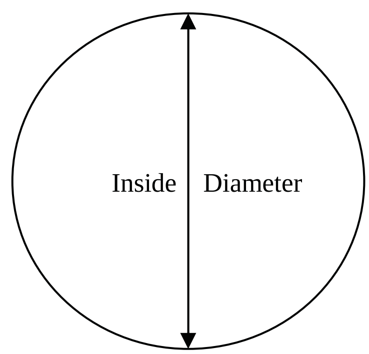
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width



X_____ **Outlet**

36"___ inside diameter



Material
_____ corrugated metal
_____ welded steel
X____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES _X_____ NO _______

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ___________________________________

The Impoundment was Designed By Stone and Webster
____

Has there ever been a failure at this site? YES __________ NO X__________

If So When? ___________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO X_______

If So When? ______________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower
Phreatic water table levels based on past seepages or breaches
at this site? YES ________NO X_______

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe : ____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Stanton Station	Date:	5-18-11
Unit Name:	Center Drainage Pond	Operator's Name:	Great River Energy
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓
Inspector's Name:	Kleinfelder - Charles Larson PE, Brad Piede EIT		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Monthly		18. Sloughing or bulging on slopes?	✓	
2. Pool elevation (operator records)?	1,712.3		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	1,702.0		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	1,720.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)		✓	At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # Comments

18. Minor sloughing and a few animal burrows on east embankment.

Based on Golder Associates review of the site history, no part of the impoundment was built over wet ash, slag, or other unsuitable materials.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # ND0000299________ INSPECTOR Kleinfelder (C. Larson, B. Piede)

Date 5-18-11

Impoundment Name Stanton Station

Impoundment Company Great River Energy

EPA Region 8

State Agency (Field Office) Addresss N/A - No US EPA field office in ND

Name of Impoundment Center Drainage Pond

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update _X_______

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Final settling and water decanting pond

Nearest Downstream Town : Name Washburn, ND

Distance from the impoundment 15 miles

Impoundment

Location: Longitude _101__ Degrees _19___ Minutes _53___ Seconds

Latitude __47__ Degrees _16___ Minutes _58___ Seconds

State _ND______ County __Mercer____________________

Does a state agency regulate this impoundment? YES __X___ NO ______

If So Which State Agency? North Dakota Dept. of Health - Waste Management Div.

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

__X___ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

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______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

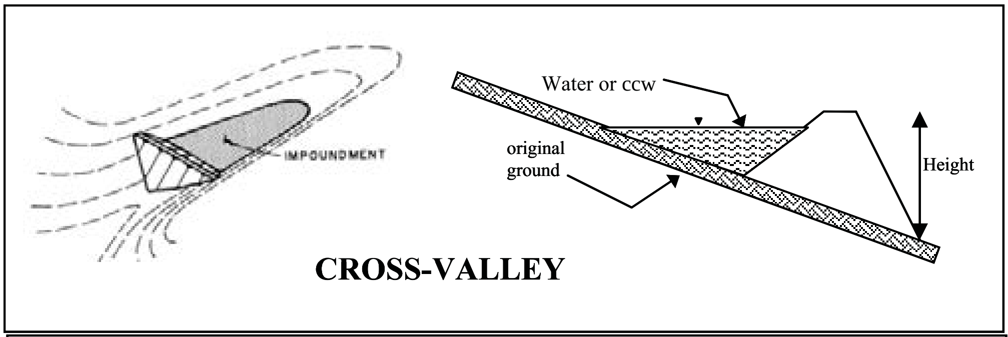
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

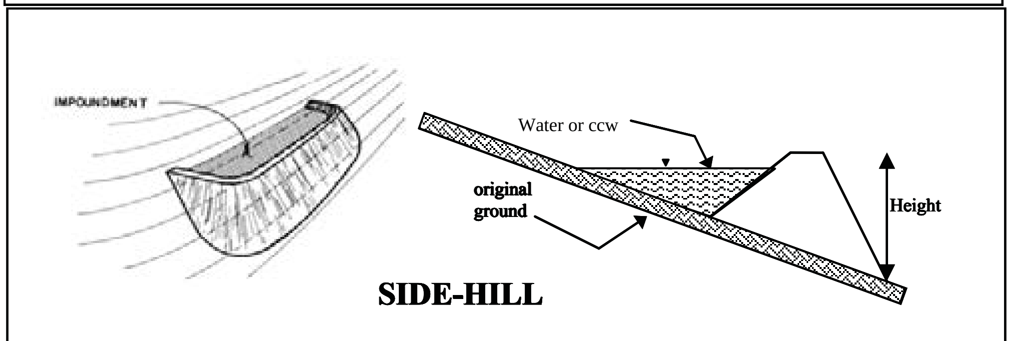
-No loss of human life is anticipated

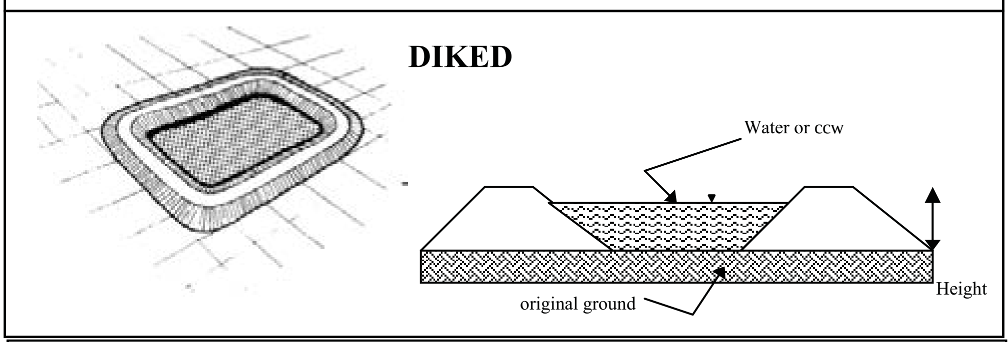
-Pond volume is small, and any failure or misoperation related release would be contained on Great River Energy's property.

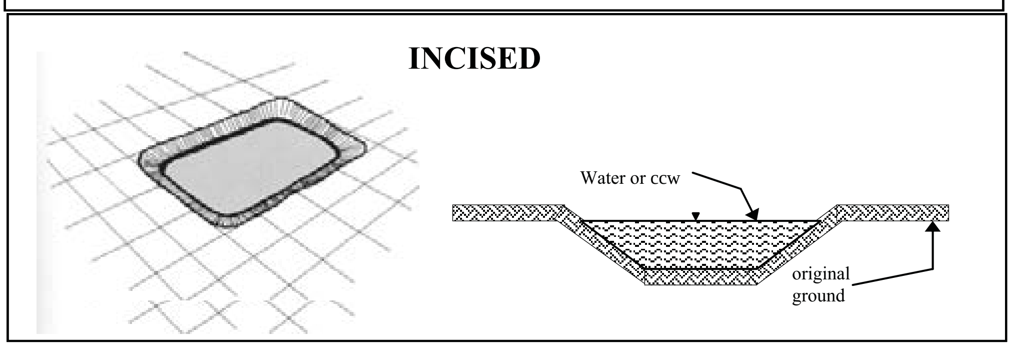
-Failure would result in essentially no environmental or economic consequences.

CONFIGURATION:









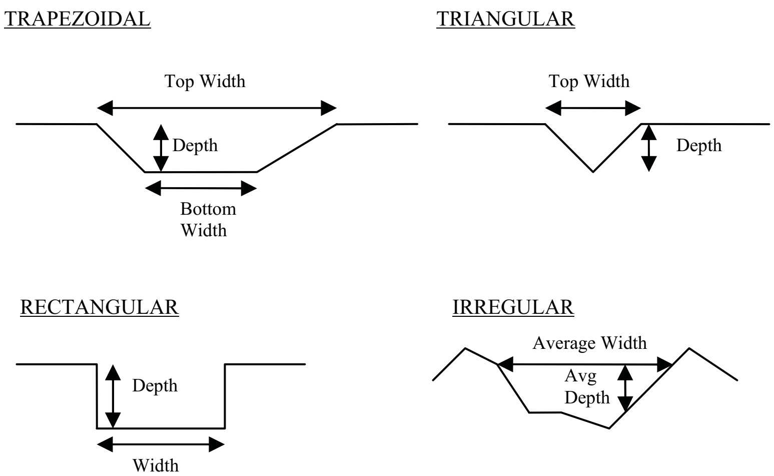
______ Cross-Valley
______ Side-Hill
__X__ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

Embankment Height 13 feet   Embankment Material Earthfill
Pool Area 3.0 acres   Liner HDPE
Current Freeboard Approx. 7.7 feet   Liner Permeability Approx. 0

TYPE OF OUTLET (Mark all that apply)

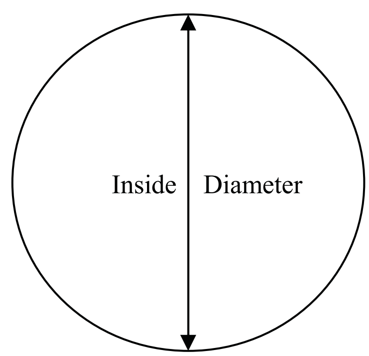
______ **Open Channel Spillway**
______ Trapezoidal
______ Triangular
______ Rectangular
______ Irregular

______ depth
______ bottom (or average) width
______ top width



X ______ **Outlet**

18" ______ inside diameter



Material
______ corrugated metal
______ welded steel
X ______ concrete
______ plastic (hdpe, pvc, etc.)
______ other (specify) ______________________

Is water flowing through the outlet? YES X ______ NO ______

______ **No Outlet**

______ **Other Type of Outlet** (specify) ______________________

The Impoundment was Designed By Stone and Webster

Has there ever been a failure at this site? YES __________ NO X__________

If So When? ____________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES __ __ __ NO X ______

If So When? ____________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________ NO X________

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe : ____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Stanton Station	Date:	5-18-11
Unit Name:	South Ash Pond	Operator's Name:	Great River Energy
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓

Inspector's Name: Kleinfelder - Charles Larson PE, Brad Piede EIT

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	Monthly		18. Sloughing or bulging on slopes?	✓	
2. Pool elevation (operator records)?	1,715.1		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	1,703.0		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	1,720.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?		✓	Is water exiting outlet flowing clear?		✓
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)		✓	At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?		✓	From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?		✓
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue # | Comments

18. Minor sloughing and a few large animal burrows on east and south embankment.

6, 20. Pond is not currently in service.

Based on Golder Associates review of the site history, no part of the impoundment was built over wet ash, slag, or other unsuitable materials.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # ND0000299 INSPECTOR Kleinfelder (C. Larson, B. Piede)
Date 5-18-11

Impoundment Name Stanton Station
Impoundment Company Great River Energy
EPA Region 8
State Agency (Field Office) Addresss N/A - No US EPA field office in ND

Name of Impoundment South Ash Pond
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ________ Update _X_______

	Yes	No
Is impoundment currently under construction?	______	_X____
Is water or ccw currently being pumped into the impoundment?	______	_X____

IMPOUNDMENT FUNCTION: Bottom Ash and Boiler Slag Settling Pond

Nearest Downstream Town : Name Underwood, ND
Distance from the impoundment __15 miles________________________
Impoundment
Location: Longitude _101__ Degrees _19___ Minutes _53___ Seconds
Latitude ___47_ Degrees __16__ Minutes _55___ Seconds
State _ND______ County ___Mercer___________________

Does a state agency regulate this impoundment? YES _X____ NO ______

If So Which State Agency? North Dakota Dept. of Health - Waste Management Div.

HAZARD POTENTIAL (In the event the impoundment should fail, the following would occur):

_X____ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:
__-No loss of human life anticipated.___________________________________
__-Pond volume is small and any failure or misoperation related release ______
__ __would be contained on Great River Energy's property._______
__-Failure would have essentially no environmental and economic impact.______________
____
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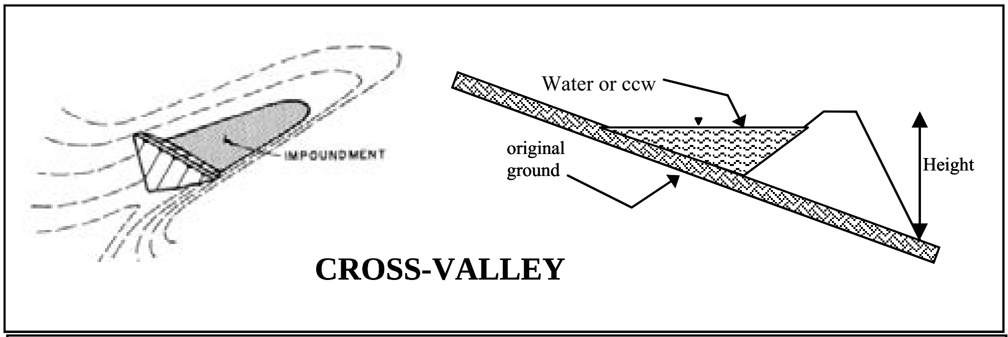
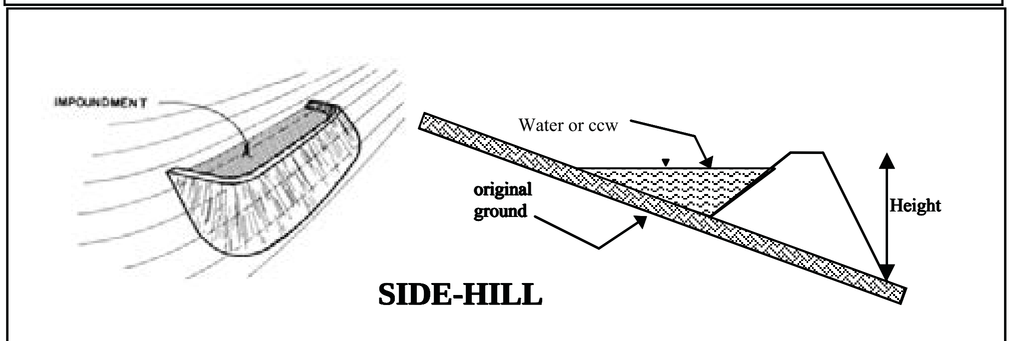
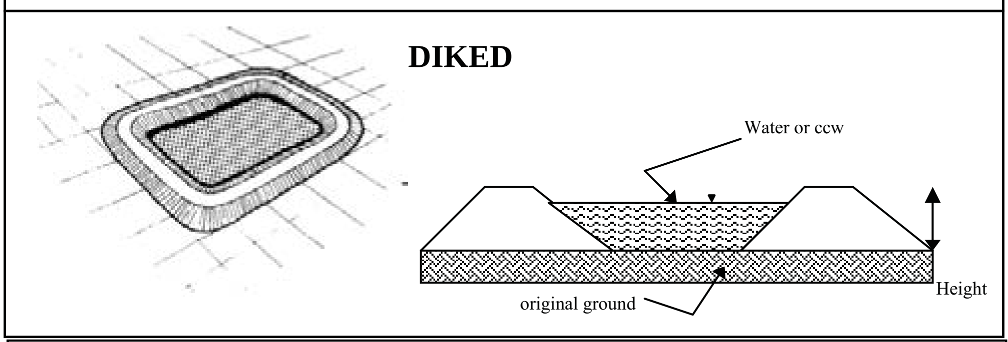
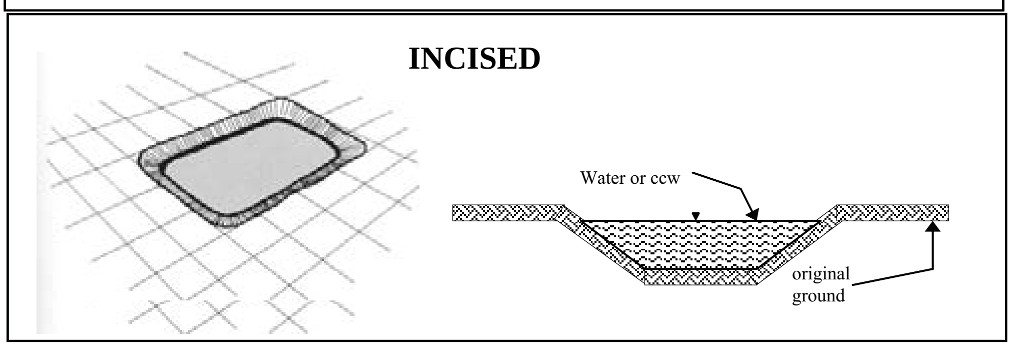
CONFIGURATION:









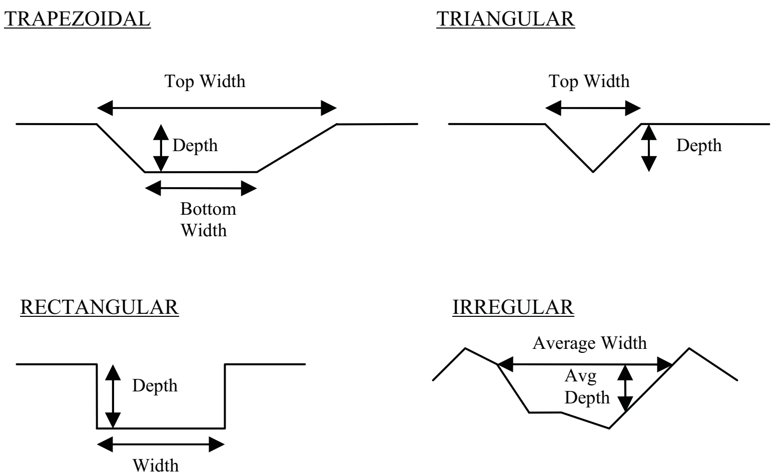
_____ Cross-Valley
_____ Side-Hill
__X__ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

Embankment Height 13__________ feet   Embankment Material Earthfill______________
Pool Area _____~3.5____________ acres   Liner HDPE______________________________
Current Freeboard Not in Service_____ feet   Liner Permeability Approx. 0______________

TYPE OF OUTLET (Mark all that apply)

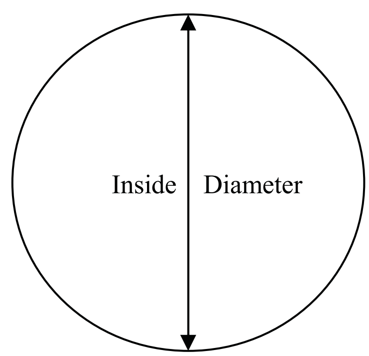
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width



X_____ **Outlet**

_36"_ inside diameter



Material
_____ corrugated metal
_____ welded steel
X_____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) ______________________

Is water flowing through the outlet? YES _______ NO X_______

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) ________________________________

The Impoundment was Designed By Stone and Webster

Has there ever been a failure at this site? YES __________ NO X__________

If So When? ___________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES _______ NO X_______

If So When? ____________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________ NO X________

If so, which method (e.g., piezometers, gw pumping,...)? ______________________

If so Please Describe : ____

Additional questions To Ask While conducting Coal Ash Site assessments

The purpose of the following questions is to identify each part of the equipment sequence that handles fly ash, bottom ash, boiler slag, and Flue gas desulfurization sludges from the point of generation to the CCR impoundments or into "dry" disposal.

Ask the same 4 questions for fly ash, bottom ash, boiler slag, Flue gas desulfurization sludge:

And take pictures of equipment and storage device

FLY ASH

1. Exactly how is it generated at the boiler? Describe equipment used to initially collect it (steel box, etc).

Fly ash is generated through coal combustion. An electrostatic precipitator collects the fly ash on Unit 1. A baghouse and spray dryer collect the fly ash on Unit 10.

2. How is it moved from point of generation to storage? Describe each piece of equipment used to move it. Does this equipment have containment?

From the electrostatic precipitator, baghouse, and spray dryer the fly ash goes into hoppers that discharge to a pipe which conveys the fly ash to the storage facility. Yes, they all have containment.

3. Describe the type of equipment is used to store it. Describe the engineering characteristics of each of these storage units (silos, tanks, size, construction type (steel). Does this equipment have containment?

Fly ash is stored in steel silos until it is transported to final destination. Yes, there is containment.

4. How is it moved from storage to final disposal? Describe each piece of equipment Does this equipment have containment?

A majority of the fly ash is sold into the beneficial use market with the remaining going to a landfill. The fly ash is moved via truck to market or the landfill. There is containment on site and at the landfill.

Bottom Ash

5. Exactly how is it generated at the boiler? Describe equipment used to initially collect it (steel box, etc).

Bottom ash is generated through coal combustion. The bottom ash hopper collects the bottom ash.

6. How is it moved from point of generation to storage? Describe each piece of equipment used to move it. Does this equipment have containment?

The hopper discharges to the crusher which is emptied by a jet pump to a pipe that conveys the bottom ash sluice to the impoundment. Yes, there is containment.

7. Describe the type of equipment is used to store it. Describe the engineering characteristics of each of these storage units (silos, tanks, size, construction type (steel). Does this equipment have containment?

An engineered, lined impoundment stores the material. Yes, there is containment. Additional information was provided in the ICR.

8. How is it moved from storage to final disposal? Describe each piece of equipment Does this equipment have containment?

The bottom ash is dozed to dewater and placed in a truck via a back hoe. Yes, there is containment.

Boiler Slag

9. Exactly how is it generated at the boiler? Describe equipment used to initially collect it (steel box, etc).

See bottom ash section.

10. How is it moved from point of generation to storage? Describe each piece of equipment used to move it. Does this equipment have containment?

See bottom ash section.

11. Describe the type of equipment is used to store it. Describe the engineering characteristics of each of these storage units (silos, tanks, size, construction type (steel). Does this equipment have containment?

See bottom ash section.

12. How is it moved from storage to final disposal? Describe each piece of equipment Does this equipment have containment?

See bottom ash section.

Flue Gas Desulfurization Sludge

13. Exactly how is it generated at the boiler? Describe equipment used to initially collect it (steel box, etc).

Facility has a dry scrubber. Does not apply.

14. How is it moved from point of generation to storage? Describe each piece of equipment used to move it. Does this equipment have containment?

Facility has a dry scrubber. Does not apply.

15. Describe the type of equipment is used to store it. Describe the engineering characteristics of each of these storage units (silos, tanks, size, construction type (steel). Does this equipment have containment?

Facility has a dry scrubber. Does not apply.

16. How is it moved from storage to final disposal? Describe each piece of equipment Does this equipment have containment?

Facility has a dry scrubber. Does not apply.

KLEINFELDER

Appendix B

Response Letter to the EPA's Section 104(e) Request for Information

September 22, 2010

CERTIFIED MAIL

Mr. Craig Dufficy
US Environmental Protection Agency
Two Potomac Yard
2733 S. Crystal Dr.
5th Floor; N-5831
Arlington, VA 22202-2733

RE: Request for Information under Section 104(e) of the Comprehensive Environmental Response, Compensation, and Liability Act 42 U.S.C. 9604(e) – Stanton Plant

Dear Mr. Dufficy;

This letter is in response to your August 24, 2010 letter that was received by Great River Energy (GRE) August 27, 2010. The letter requested information pursuant to Section 104(e) of CERCLA. September 2, GRE requested and was granted a 15 day extension to the information request.

GRE has reviewed the instructions in Enclosure A and determined that three surface impoundments meet the definition of surface impoundments or similar diked or bermed management unit(s) designated as landfills which receive liquid-borne material from a surface impoundment used for the storage or disposal of residuals or by-products from the combustion of coal, including but limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals.

Enclosure A contains responses to information for the GRE, Stanton Plant.

Your letter states that EPA has requested this information pursuant to authority granted under provisions of CERCLA which provides in relevant part that whenever the Agency has reason to believe that there may be a release or threat of a release of a pollutant or contaminant, they may require any person who has or may have information to furnish information or documents relating to the matter. GRE feels strongly that none of the impoundments at Stanton Plant presents the threat of release.

GRE has exercised the utmost care and diligence in preparing our responses. Please direct any questions concerning this submittal to my attention at the address listed below.

Sincerely,

John Pelerine
Plant Manager,
Stanton Plant
4001 Hwy 200A
Stanton, ND 58571

CERTIFICATION

I certify that the information contained in this response to EPA's request for information and the accompanying document is true, accurate, and complete. As to the identified portions of this response for which I cannot personally verify their accuracy, I certify under penalty of law that this response and all attachments were prepared in accordance which a system designed to assure that qualified personnel properly gather and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

John Pelerine: ______________________
Plant Manager, Stanton Plant

Enclosure A: US EPA Request under Section 104(e) CERCLA
September 22, 2010

1. Relative to the National Inventory of Dams criteria for High, Significant, Low or Less-than-Low, please provide the potential hazard rating for each management unit and indicate who established the rating, what the basis of the rating is and what federal, or state agency regulates the unit(s). If the unit(s) does not have a rating, please note that fact.

The bottom ash ponds (designated north, middle, and south ponds) have not been rated by any agency under the National Inventory of Dams criteria. An independent engineer, hired by GRE, has rated the management units using the National Inventory of Dams criteria. Ratings are provided below.

Management Unit	Potential Hazard Rating	Ratings Established By	Rating Basis	Regulating Agency
North Bottom Ash Pond / Cell 1	Less Than Low	Barr Engineering Company September, 2010	No probable loss of human life. Small impoundment capacity, low dam height, water does not contain pollutants at concentrations of concern (limited or no risk of environmental damage), and areas next to the pond are not susceptible to damage.	North Dakota Department of Health (NDDH) Division of Waste Management Permit SP-043
Middle Bottom Ash Pond / Retention Cell	Less Than Low	Barr Engineering Company September, 2010	No probable loss of human life. Small impoundment capacity, low dam height, water does not contain pollutants at concentrations of concern (limited or no risk of environmental damage), and areas next to the pond are not susceptible to damage.	North Dakota Department of Health (NDDH) Division of Waste Management Permit SP-043
South Bottom Ash Pond / Cell 2	Less Than Low	Barr Engineering Company September, 2010	No probable loss of human life. Small impoundment capacity, low dam height, water does not contain pollutants at concentrations of concern (limited or no risk of environmental damage), and areas next to the pond are not susceptible to damage.	North Dakota Department of Health (NDDH) Division of Waste Management Permit SP-043

2. What year was each management unit commissioned and expanded?

All current impoundments were commissioned in 1994 and have not been expanded since operations started.

3. What materials are temporarily or permanently contained in the unit? Use the following categories to respond to this question: (1) fly ash; (2) bottom ash; (3) boiler slag; (4) flue gas emission control residuals; (5) other. If the management unit contains more than one type of material, please identify all that apply. Also, if you identify "other" please specify the other type of materials that are temporarily or permanently contained in the unit(s).

Impoundment Name	Material	Temporary/Permanent
North Bottom Ash Pond / Cell 1	3, 4, and 5 (coal mill rejects)	Temporary
Middle Bottom Ash Pond / Retention Cell	3, 4, and 5 (coal mill rejects)	Temporary
South Bottom Ash Pond / Cell 2	3, 4, and 5 (coal mill rejects)	Temporary

4. Was the management unit(s) designed by a professional Engineer? Is or was the construction of the waste management units(s) under the supervision of a Professional Engineer? Is inspection and monitoring of the safety of the waste management unit(s) under the supervision of a Professional Engineer?

All management units have been designed by independent engineering firms. Quality Control/Quality Assurance (QA/QC) during the construction of all impoundments was conducted by an independent testing firm and QA/QC results are analyzed by both the State of North Dakota and the design engineer.

GRE performs monthly inspections on all impoundments. All inspections are documented in the plant Computerized Maintenance Management System (CMMS). Impoundments are inspected for all applicable rules and regulations. GRE has conducted training for all personnel performing inspections. In addition to monthly inspections, operations personnel are trained to observe abnormalities during routine rounds.

Inspection and monitoring activity is under the supervision of a professional engineer registered in the state of North Dakota.

operation of the impoundments. The next inspection is expected to occur in October 2010.

7. Have assessments, evaluations, or inspections conducted by State or Federal regulatory officials conducted within the past year uncovered a safety issue(s) with the management unit(s), and, if so, describe the actions that have been or are being taken to deal with the issue or issues. Please provide any documentation that you have for these actions.

   No safety issues have been found.

8. What is the surface area (acres) and total storage capacity of each of the management unit(s)? What is the volume of material currently stored in each of the management unit(s)? Please provide the date that the volume measurement(s) was taken. Please provide the maximum height of the management units(s). The basis for determining maximum height is explained later in the Enclosure.

Impoundment Name	Surface Area Acres	Total Storage Capacity
North Bottom Ash Pond / Cell 1	3.56	59,000 cubic yards
Middle Bottom Ash Pond / Retention Cell	3.11	62,000 cubic yards
South Bottom Ash Pond / Cell 2	3.83	65,000 cubic yards

Impoundment Name	Date	Volume of material currently stored
North Bottom Ash Pond / Cell 1	7/1/10	9259 cubic yards
Middle Bottom Ash Pond / Retention Cell	7/1/10	5017 cubic yards
South Bottom Ash Pond / Cell 2	11/15/09 Engineering Est.	35,185 cubic yards

Impoundment Name	Maximum Height Feet
North Bottom Ash Pond	13
Middle Bottom Ash Pond	13
South Bottom Ash Pond	13

9. Please provide a brief history of known spills or unpermitted releases from the unit within the last ten years, wheather or not these were reported to State or federal regulatory agencies. For purposes of this question, please include only releases to surface water or to the land (do not include releases to groundwater).

   No spills or unpermitted releases from the units.

10. Please identify all current legal owner(s) and operator(s) at the facility.

    The current legal owner and operator of the facility:
    Great River Energy
    12300 Elm Creek Boulevard
    Maple Grove, Minnesota 55369-4718

Appendix C

Golder Associates Reports

- **Stability Evaluation of Bottom Ash Surface Impoundment**
- **Stability Evaluation of Bottom Ash Surface Impoundment Addendum**
- **Addendum to Stability Evaluation of Bottom Ash Surface Impoundment Addendum – Seismic Stability Evaluation**

REPORT

STABILITY EVALUATION OF BOTTOM ASH SURFACE IMPOUNDMENT

Submitted to: Great River Energy
Stanton Station
4001 Highway 200A
Stanton, North Dakota 58571

Submitted by: Golder Associates Inc.
44 Union Boulevard, Suite 300
Lakewood, Colorado 80228

Distribution: 2 Copies – Great River Energy
2 Copies – Golder Associates Inc.

May 16, 2011 **113-81645**

A world of capabilities delivered locally

Golder Associates

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1.0 INTRODUCTION

1.1 Background

Golder Associates Inc. (Golder) has prepared this report to provide Great River Energy (GRE) with the results of Golder's site observations and stability evaluation for GRE's Bottom Ash Surface Impoundments at Stanton Station (SS). This report presents a general history of the facility and the geologic setting, the basis and results for Golder's stability evaluation, a summary of observations made by Golder while visually assessing the facility, and a summary of Golder's recommendations and conclusions.

1.2 Site History

SS is located in Section 16 and 21, Township 144N and Range 84W of Mercer County, three miles southeast of Stanton, North Dakota (see Figure 1). Three surface impoundments and a bottom ash waste landfill are located at SS (see Figure 2).

The three surface impoundments include the north, south and center cells. The north and south cells are active cells used for dewatering bottom ash and the center cell functions as a retention cell. Bottom ash is placed into one of the active cells until the cell reaches capacity. Once capacity is reached bottom ash deposition is directed to the other active cell and the filled cell is dewatered. Bottom ash remaining in the active cell is excavated and hauled to the adjacent landfill for disposal. Each active cell is sized to hold at least two years of plant bottom ash production (Stone & Webster 1994c). The capacity of the bottom ash facilities are:

- North Cell – 36.5 acre-feet
- Middle Cell – 38.4 acre-feet
- South Cell – 40.3 acre-feet
- Bottom Ash Landfill – 427,000 cubic yards

Approximately 20,000 tons of bottom ash is generated annually (GRE 2004). Additional materials permitted for discharge to the surface impoundment are: water from the plant storm water retention pond, water from the coal unloading pit sump, mineralizer reject water, boiler blowdown and overflow water, and water from miscellaneous plant drains.

Stanton Station began operations in the mid-1960s and originally burned North Dakota lignite. SS was converted to Powder River Basin coal from Wyoming in November 2004. All ash was originally deposited wet into a series of ash ponds (Ponds A, B, and C), see drawing S1002 included in Appendix A (Stone & Webster 1994b). In the mid-1990s, SS was converted to a dry fly ash handling system, and the past coal combustion product (CCP) management units were consolidated and capped. CCP facilities that were consolidated and capped were: a previously closed 1970s ash disposal area; and the three surface impoundment disposal areas (Ponds A, B and C).

CCPs from the previously covered fly ash/bottom ash disposal area from the 1970s, and Pond A were excavated and hauled to the Pond B and C area. Ponds B and C were further consolidated and closed with a protective cover. Construction quality documentation concerning the closure construction was submitted on March 6, 1998 (UPA 1998). Pond A was modified to include three composite-lined surface impoundments and an inert waste disposal cell. Construction quality documentation concerning the construction of the three Bottom Ash Surface Impoundment cells was submitted on September 6, 1996 (UPA 1996).

1.3 Impoundment Embankments

The berm surrounding the Bottom Ash Surface Impoundment and two interior berms have a top elevation of 1720 feet above mean sea level (ft amsl). The bottom elevation of the cells varies between 1700 and 1704 feet according to original construction drawings. The perimeter berm along the north, east, and south sides of the impoundment complex consists of a historic embankment to elevation 1715 with a berm extension to 1720 feet. The west perimeter berm and two interior berms were completely new construction. The berm extension and new berms were constructed in 1994 and 1995. The interior and exterior slopes of the berm are 3:1. The cells have bottom liners consisting of 2-foot protective cover, 60-mil high density polyethylene (HDPE), and 2-foot compacted clay fill (top to bottom). The liner along the side slopes is 60-mil high density polyethylene (HDPE) and 3.16 feet compacted clay fill (10' horizontal width). These design dimensions are shown on drawings S1005 and S1006 provided in Appendix A (Stone & Webster 1994b).

1.4 Geological Conditions

Stanton Station is located in the Missouri Slope district of the glaciated Missouri Plateau of the Great Plains physiographic province (NDDH 2005). The Bottom Ash Surface Impoundment is constructed in Missouri River alluvial deposits. The alluvial deposits have two distinct subunits: upper and lower. The upper subunit consists of a silty sand and clay and the lower subunit is an outwash sand and gravel (Barr 2010).

1.5 Dam Oversight/Permits

The North Dakota State Engineer regulates, controls, and supervises the construction and operation of dams within the state of North Dakota. All dams and impoundments that contain more than 50 ac-ft of water require a construction permit (NDDC 2003). The Bottom Ash Surface Impoundment was issued Construction Permit 918 in September 1994.

The North Dakota Department of Health (NDDH) Division of Waste Management is the environmental regulatory body for the CCP facilities at SS. The three Bottom Ash Surface Impoundment cells are permitted as a surface water impoundment under permit SP-043. The permit is effective from March 17, 2005 to March 17, 2015.

Water exiting the retention pond (center cell) is permitted under National Pollutant Discharge Elimination System (NPDES) Permit No.: ND-0000299. The permit was issued by NDDH Division of Water Quality and is effective from January 1, 2007 through December 31, 2011. Water from the retention pond (center cell) is mixed with cooling water discharge prior to release into the Missouri river.

1.6 Routine Inspections

GRE staff conduct inspections of the Bottom Ash Surface Impoundment on a monthly basis. Observed conditions, implementation or recommendation for corrective measures, and additional comments are documented on the Inspection Logs. Inspections Logs are included in the Stanton Station Annual Report for Special Waste Landfill SP-043 (GRE 2010).

2.0 SLOPE GEOMETRIES

Golder developed cross sections through the Bottom Ash Surface Impoundment to analyze the exterior and interior (upstream) stability of the facility. The cross sections that were evaluated for stability are the north/south, west, and east downstream (outside) slopes, and the upstream (interior) slope (Figure 2). Two scenarios for each cross section were evaluated. The first scenario examined the stability for an intact geomembrane and the second analysis examined the stability if no geomembrane is present. A total of eight stability scenarios were analyzed. The geometries of each cross section are as follows:

North and South Berms

The geometry of the north and south downstream slopes are the same; therefore, one stability analysis was performed to examine both downstream slopes. The stability of the downstream slopes was examined according to design grades. The design indicates a 20-foot wide crest at an elevation of 1720 feet with 3:1 side slopes to approximately 1700 feet. Grades from a 2001 aerial survey were used to confirm the design slope geometry. The cross section for the north and south downstream slope is shown on Figure 3.

West Berm

The west downstream slope has a design crest width of 20 feet at an elevation of 1720 feet and extends at an approximate 3:1 slope down to an elevation of 1700 feet (approximately). This section geometry was also verified with grades from the 2001 aerial survey. The cross section for the west downstream slope is shown on Figure 7.

East Berm

The east downstream slope has a design crest width of 20 feet at an elevation of 1720 feet and extends at an approximate 3:1 slope down to an elevation of 1715 feet. There is a 4-foot wide bench at elevation 1715 then 3:1 slope down to an elevation of 1700 feet (approximately). Site observations, as-built drawings and sections developed using the 2001 aerial survey do not match the design geometry. The bench at elevation 1715 is substantially wider than the design and was modeled as 20 feet. The cross section for the east downstream slope is shown on Figure 11.

Upstream (Interior) Berm

The upstream slope has an approximate 3:1 slope from elevation 1720 feet down to elevation 1702 feet. This section geometry was verified with the as-built drawings and grades from the 2001 aerial survey. The cross section for the upstream slope is shown on Figure 15. The analysis of the upstream slope did not look at bottom ash on the smooth geomembrane but focused on the underlying clay liner and berm.

2.1 Engineering Parameters

Soil and material properties were collected from several sources including historical design reports for the Bottom Ash Surface Impoundment at SS and current geotechnical reference documents. The material properties for each soil included in the stability analysis of the Bottom Ash Surface impoundment are provided in Table 1 and discussed subsequently.

2.1.1 Historic Embankment Fill

Historic Embankment Fill properties were based on test boring results from September 1993 (Stone and Webster, 1993). The Historic Embankment Fill were classified as clean to silty sands (SP, SM) with some layers of lean to fat clays (CL, CH) and some silts (ML). Test borings were advanced through the historic embankment and laboratory analyses were performed on eight soil samples to determine dry density, moisture content, Atterberg Limits, specific gravity, and gradation.

Dry unit weight values ranged from 103.7 to 120.6 pounds per cubic foot (pcf) with moisture contents between 12.2 and 27.6 percent (Stone & Webster 1993). Weighted averages are used in the stability analysis to account for the varying thickness of sand, silt, and clay lenses in the Historic Embankment Fill. Assuming a construction specification of 95 percent maximum dry density and optimum moisture, the dry unit weight chosen is 116 pounds per cubic foot (pcf) with a moisture content of 14. This results in a moist unit weight of 132 pcf.

Published values for void ratio of sand with a dry unit weight of 115 pcf are 0.45 (Das 2002). Specific gravities from the 1993 test borings ranged from 2.68 to 2.71. The specific gravity weighted average is 2.71. Void ratio (0.45) and specific gravity (2.71) were used to calculate the saturated unit weight and saturated moisture content. This resulted in a saturated unit weight of 135 pcf with a saturated water content of 17 percent.

The predominant soil in the embankment fill is sand (SP, SM). Published values for effective stress friction angle for silty sands (SM) are 33.6 degrees and 37.4 degrees for clean sands (SP) with negligible cohesion (DOI 1987). The effective friction angle used for the Historic Embankment fill was 30 degrees and the effective cohesion intercept is assumed to be 0 psf.

Typical hydraulic conductivities for silt, sandy silts, clayey sands, and till range from 10^{-6} to 10^{-4} cm/sec (Fetter 2001). The hydraulic conductivity of the Historic Embankment Fill was estimated at 10^{-5} cm/sec.

2.1.2 Natural Soil

Natural Soil properties were based on the same test borings used to characterize the Historical Embankment Fill. The Natural Soils are mostly clean to silty sands (SP, SM) with some layers of lean to fat clays (CL, CH) and some silts (ML).

The Natural Soil properties are similar to the Historic Embankment Fill properties in that most of the soil is sand (SP, SM). Assuming the Natural Soil is similar to the Historic Embankment Fill, but is compacted to 85 percent maximum dry density, the dry unit weight chosen is 104 pcf. The moist unit weight is assumed to be the same as the Historic Embankment Fill, 14 percent. This results in a moist unit weight of approximately 119 pcf

The hydraulic conductivity, void ratio, and effective friction angle for the Natural Soils are the same as the Historic Embankment Fill properties previously described.

2.1.3 New Embankment Fill

The New Embankment was constructed from clayey soil from the Glenharold Mine site. Construction testing of the new embankment fill placed in 1994 and 1996 indicate that the material is predominantly fat clay (CH) with some lean clay (CL) (UPA 1996). In-Situ dry density of the constructed embankment ranged between 87 and 107 pcf with an average of 98 pcf. The in-situ moisture content of the constructed embankment ranged between 16 and 33 percent with an average of 22 percent. The moist unit weight from these averages is approximately 120 pcf.

The void ratio was assumed to be 0.9 per reference Das, 2002 for soft clay with a dry unit weight ranging from 73 to 93 pcf. Saturated unit weight and moisture content were calculated using the assumed void ratio and specific gravity. The average specific gravity determined from soil tests performed in 1996 and 1997 is 2.63 (Midwest 1996 and 1997). The saturated unit weight is 132 pcf with a saturated water content of 34 percent.

The effective stress friction angle used in analyses was 16 degrees and the effective cohesion intercept is 500 pounds per square foot (psf). These values are based on published values from the Design of Small Dams (DOI 1987).

Permeability tests were performed on the Glenharold Mine clay as part of the Ash Pond Modification Design Report. The average hydraulic conductivity of the clay was 2.4×10^{-8} cm/sec.

2.1.4 Compacted Fill

The Compacted Fill was assumed to be taken from the Glenharold Mine site. Therefore, the Compacted Fill is assumed to be fat clay and has the same material properties as the Glenharold Mine clay.

2.1.5 Geomembrane

Geomembrane interface inputs are based on previous experience by Golder and published values. The interfaces of interest are a smooth HDPE against Compacted Fill (Glenharold Mine clay) and smooth HDPE against bottom ash. The geomembrane/clay interface is more critical than the geomembrane/bottom ash interface; therefore, the geomembrane/bottom ash interface will not be included in analyses. A residual friction angle of 7.5 degrees and a residual adhesion intercept of approximately 190 psf are used in the stability analysis (Koerner 2005). These values are considered conservative and are considered appropriate for use in the Stanton Station stability analyses.

The hydraulic conductivity for HDPE liner was taken from HELP program documentation as 2.0×10^{-13} cm/sec (Schroeder 1994).

2.1.6 Bottom Ash

During the Ash Pond Modification, bottom ash from Unit 1 and Unit 10 were analyzed for moisture content, percent solids, specific gravity and absorption. The moist unit weight for bottom ash is 80 pcf (Stone & Webster 1994a). The moisture content from tests performed at similar sites of drained and saturated bottom ash ranged between 12% and 61%. For unsaturated conditions, a moisture content of 18.5% was assumed. This results in a dry unit weight of 68 pcf. The moisture content was reported at 48.5 from Unit 1 and 69.1 from Unit 10. These moisture contents are likely saturated bottom ash conditions; therefore, the moisture content of bottom ash for saturated conditions was determined to be the average, 58.8 percent. Using the calculated dry unit weight, saturated unit weight of bottom ash is 107 pcf.

Based on previous experience by Golder, the effective cohesion of bottom ash was chosen as 0 psf and an effective friction value of 40 degrees was chosen for analysis.

The saturated hydraulic conductivity for bottom ash used in the stability analysis is 3.0×10^{-2} cm/sec. This value is based on previous experience by Golder and published values.

2.2 Groundwater Information

Groundwater generally flows north under the Bottom Ash Surface Water Impoundment toward the Missouri River. Groundwater is typically within 10 feet below the final construction grades of the Impoundment and is at an approximate elevation of 1700 feet amsl near the South Cell and 1690 near the North Cell (Barr 2011). Since the impoundment is lined, the flux of water from the impoundment to the groundwater is expected to be minimal.

2.3 Stability Analysis

Golder performed stability analyses using SLIDE (Rocscience 2011). Factors of safety were computed for circular failure surfaces using Spencer's method for force and moment equilibrium. Global stability was analyzed, which evaluates the overall stability of a cross section through the entire facility that may include both historic and expansion berms. Surficial failures at depths less than 5 feet were not evaluated in this stability analysis.

For the north/south, east and west downstream sections, the stability of each cross section was analyzed for the condition of an intact geomembrane and if no geomembrane is present reflective of a severely compromised geomembrane liner. For both analyses, the water level in the impoundment was set at elevation 1720 feet to represent maximum conditions. With an intact geomembrane, there was no flux assumed between the impoundment and the groundwater. The stability analysis for the condition of no geomembrane required the development of a phreatic surface through the berm. The phreatic surface was determined using groundwater finite element modeling within SLIDE. This surface was then modeled in the slope stability analysis as a piezometric surface through the berm. The finite element model for the phreatic surface through the north/south, west and east cross sections is shown on Figures 5, 9, and 13, respectively.

For the upstream slopes four different conditions were evaluated: the stability with the impoundment empty, the stability with the impoundment full (Elevation 1720 feet) and intact geomembrane, the stability with the impoundment full and no geomembrane, and the stability of the impoundment empty with the berm being saturated. This last condition was included to model the potential for draining of the impoundment faster than the pore pressure can dissipate in the berm.

For permanent civil engineering structures (long-term conditions), a factor of safety greater than or equal to 1.5 is desired. All of the scenarios evaluated have a factor of safety greater than 1.5 and are expected to remain stable under the anticipated loading conditions. A summary of factors of safety calculated for each scenario are provided in the following table:

Factors of Safety for Each Scenario

Description	Geomembrane	Water Level	Factor of Safety	Figure - Stability Analysis Results
North/South	Intact	1720 ft.	1.8	4
	None	Phreatic Surface through Berm	1.7	6
West	Intact	1720 ft.	2.2	8
	None	Phreatic Surface through Berm	2.1	10
East	Intact	1720 ft.	1.8	12
	None	Phreatic Surface through Berm	1.8	14
Upstream	NA	No Water	2.8	16
	Intact	1720 ft.	6.6	17
	None	1720 ft.	3.7	18
	None	Saturated Berm	1.9	19

This stability analysis relies on typical values for shear strength based on material types identified from site geotechnical information. The analysis should be updated when site-specific material testing for shear strength is performed.

2.4 Sensitivity Analysis

The material properties used in the stability analysis were based on limited site specific geotechnical testing (blow counts, moisture, and density) with no site specific testing for shear strength. A sensitivity analysis was performed in SLIDE to evaluate the impact on slope stability due to the potential variability in the material properties. In SLIDE, a sensitivity analysis is performed by varying the value of an individual parameter over a specified range for the critical failure surface identified using the mean value. In a sensitivity analysis, only a single parameter is varied at a time, while all the other parameters are held constant at their mean values. The range over which a variable is evaluated is defined by the user.

The minimum and maximum values for the material unit weights were based on the historic in-situ moisture and density testing (Stone and Webster 1993, UPA 1996). The minimum and maximum values for the shear strength parameters were based on published values for SM/SP materials for the Historic Embankment Fill and Natural Soil, and based on published values for CL/CH materials for the New Embankment Fill and Compacted Fill (DOI 1987). These minimum and maximum values are summarized in Table 2.

A sensitivity analysis was performed for three of the stability scenarios evaluated; the North and South Berms with no geomembrane, The East Berm with no geomembrane, and the Upstream Berm with no geomembrane and a saturated berm. Resulting sensitivity plots for these scenarios are provided as Figures 20-22. The sensitivity plots show the resultant factor of safety for a percent variability in the material property value. For the range in material properties, and the scenarios evaluated, the factors of safety for slope stability are still all above 1.5, indicating that the slopes are expected to remain stable.

3.0 VISUAL INSPECTION

3.1 Summary of Visual Inspection Terms

Visual inspection terms used in the following discussions are described and understood as follows:

Condition of Impoundment Component

Good: A condition that is generally better than what is minimally expected from the design criteria and maintenance performed at the facility.

Fair: A condition that generally meets what is expected from the design criteria and maintenance performed at the facility.

Poor: A condition that is generally below what is minimally expected from the design criteria and maintenance performed at the facility.

Severity of Deficiency

Minor: An observed deficiency where current maintenance is below what is desired, but does not currently pose a threat to the structural safety or stability.

Significant: An observed deficiency where current maintenance has neglected to improve a condition. Typically, these conditions are identified, but no remedial action has been implemented.

Excessive: An observed deficiency where current maintenance is worse than what is desired and hinders the ability of the observer to evaluate the structure or poses a significant threat to structural safety and stability.

3.2 Visual Observations

Visual observations of the Bottom Ash Surface Impoundment were performed on May 3, 2011 by Todd Stong, a registered professional engineer (P.E.) in North Dakota. Golder observed the condition of inflow and outflow structures, upstream berm slopes, the berm crest, downstream berm slopes, and the berm toe. Inspection checklist logs are included in Appendix B and a map identifying the photo locations, and photos taken during the visual observations are included in Appendix C. During the time of the observations, the North Cell was actively receiving bottom ash, the Center Cell was active, and the South Cell was not active.

3.2.1 Inflow and Outflow Structures

North Cell

Inflow to the North Cell includes the bottom ash discharge pipes (Photo 001), the retention pond inlet pipe and the coal pit sump inlet pipe (Photo 002). The bottom ash pipes discharge into the impoundment over previously deposited bottom ash and were in fair condition with minor corrosion and erosion of the pipe. The retention pond inlet and coal pit sump inlet pipes discharge into the impoundment onto a sacrificial HDPE wear-liner and were in good condition with no indications of wear or penetration of the liner or cracking of the inlet pipes.

Outflow from the North Cell is through the concrete outflow structure located on the south upstream slope (Photo 013). The structure was in good shape with no signs of blockage, corrosion, erosion or cracking. The stop logs were placed in the outfall structure to control the cell water surface at approximately elevation 1715 feet.

Center Cell

Inflow to the Center Cell is through the outflow structures from the North Cell (Photo 042) and The South Cell (Photo 050) located on the north and south upstream slopes respectively. These structures were in good shape with no signs of blockage, corrosion, erosion or cracking. The HDPE liner connection to these outflow structures (Photo 052) appeared to be intact and in fair condition.

Outflow from the Center Cell is through the outflow structure located on the east upstream slope (Photo 054). The structure was in good shape with no signs of blockage, corrosion, erosion or cracking. The weir in the outfall structure was situated to maintain the cell water surface at approximately elevation 1712.5 feet

South Cell

Inflow to the South Cell includes the bottom ash discharge pipes (Photo 091), the retention pond inlet pipe and the coal pit sump inlet pipe (Photo 090). The bottom ash pipes discharge into the impoundment over previously deposited bottom ash and were in fair condition with minor corrosion and erosion of the pipe. The retention pond inlet and coal pit sump inlet pipes discharge into the impoundment onto a sacrificial HDPE wear-liner. These inlet pipes were in good condition, but water was identified between the clay liner and HDPE liner. Further inspection identified that the pipe boots for these inlets were in poor condition and had openings allowing water to get under the HDPE liner.

Outflow from the South Cell is through the concrete outflow structure located on the north upstream slope (Photo 087). The structure was in good shape with no signs of blockage, corrosion, erosion or cracking. The outflow weir elevation appeared to be set without any stop logs maintaining the cell at approximately elevation 1712.5 feet.

3.2.2 Upstream Slope

North Cell

The upstream slopes above the water level and not covered with bottom ash were evaluated. The slopes appeared to match the design slopes of 3:1 with no observed sections of significant slope difference. The geomembrane liner is exposed on the slopes with no protective cover. Some small punctures were identified on the slopes near the top of the berms (Photo 006) that require patching. There were no signs of vegetation or rodent burrows on the upstream slopes. The North Cell upstream slopes appear to be in fair condition.

Center Cell

The upstream slopes above the water level were evaluated. The slopes appeared to match the design slopes of 3:1 to about 4' down (approximately elevation 1716') at which point the slopes curved inward to a steeper concave shape (Photos 054, 056, 058). This displacement of the lower slope may be due to slope movement, piping of material, settlement and/or consolidation, and requires further evaluation. The geomembrane liner is exposed on the slopes with no protective cover. Some small punctures were identified on the slopes near the top of the berms that require patching. Due to the displaced lower slopes, the Center Cell upstream slopes are given a poor condition rating until they can be further evaluated.

South Cell

The upstream slopes above the water level and not covered with bottom ash were evaluated. The slopes appeared to match the design slopes of 3:1 with no observed sections of significant slope difference. The geomembrane liner is exposed on the slopes with no protective cover. Some significant tears in the geomembrane were identified (Photos 082, 088, 089, 095) that require patching. There was also some ripped geomembrane at the equipment crossing into the cell suggesting that the underlying liner may be torn (Photo 096). As discussed above, the pipe boots on the retention pond inlet and coal pit sump inlet pipes appeared to be compromised and water was found between the geomembrane and clay liner. The South Cell upstream slopes appear to be in fair structural condition with poor geomembrane liner conditions.

3.2.3 Crest

The berm crest around the Bottom Ash Surface Impoundment is surfaced with gravel at a constant elevation of 1720 feet (Photos 010, 051, 061, 073, 074). The crest roadway is primarily used for light vehicle traffic, but is exposed to heavy construction equipment when the North and South Cells are cleaned out. The crest appears to be in good condition with no vegetation, rodent burrows, or settlement, and appears to be well maintained. There was one potential crack identified along the west crest of the Center Cell (Photo 046). The crack is very slight and may be limited to the gravel roadway.

3.2.4 Downstream Slope

North Cell

The downstream slopes on the north and east sides are approximately 20 feet high and the downstream slope on the west side is approximately 5 feet high. The slopes are graded at approximately 3H:1V and are well vegetated with grasses with no bushes or trees. Small rodent burrows were observed on the downstream slopes (Photo 024). Localized sloughing and scarps were observed on the north downstream slope, particularly near the toe where a surface water drainage ditch exists (Photo 023). An area of erosion and bottom ash deposition was identified on the east downstream slope (Photo 027) in the original berm below elevation 1715 feet. The downstream slopes are generally in fair condition.

Center Cell

The downstream slope on the east side is approximately 20 feet high and the downstream slope on the west side is approximately 5 feet high. The slopes are graded at approximately 3H:1V and are well vegetated with grasses with no bushes and one dead tree observed at the toe of the east slope (Photo 070). Small rodent burrows were observed on the downstream slopes (Photo 048). Several areas of minor surface erosion and localized surface failures were observed along the downstream slopes. Several erosion rills were observed on the east downstream slope (Photos 064, 065, 066, and 068). The erosion rills were located in the original berm below elevation 1715 feet, and varied from small rills to rills running fifteen feet vertical, one foot deep and up to six feet wide. The downstream slope on the west side is in fair condition and the downstream slope on the east side is in poor condition due to the erosion rills.

South Cell

The downstream slope on the east and south sides are approximately 20 feet high and the downstream slope on the west side is approximately 5 feet high. The slopes are graded at approximately 3H:1V and are well vegetated with grasses with no bushes and one dead tree observed at the toe of the east slope (Photo 104). Small rodent burrows were observed on the east and west downstream slopes (Photo 079) and several larger rodent burrows were observed on the south downstream slope (Photos 110 and 112). Several areas of minor surface erosion and localized surface failures were observed along the downstream slopes. Several erosion rills and surficial failures were observed on the east downstream slope (Photos 098, 099, 101, 103, and 114). The erosion rills were located in the original berm below elevation 1715 feet, and varied from small rills to rills running fifteen feet vertical, one foot deep and up to four feet wide. An area of bottom ash deposition was observed on the south downstream slopes running the length of the slope (Photo 113). The downstream slope on the west side is in fair condition and the downstream slopes on the east and south sides are in poor condition due to the erosion rills and larger rodent burrows.

3.2.5 Toe

North Cell

The toe of the west berm is in the bottom ash deposition area and has no observed seepage, standing water, rodent burrows, settlement or excessive vegetation. The toe of the north berm is in a surface water drainage ditch with no observed seepage, standing water, rodent burrows, settlement or excessive vegetation. The toe of the west berm is in a low area that has standing water and some dead woody vegetation (Photo 028). There were no observed indications of seepage, rodent burrows, settlement or excessive vegetation. The toe of the berms around the North Cell is in fair condition.

Center Cell

The toe of the west berm is in the bottom ash deposition area and has no observed seepage, standing water, rodent burrows, settlement or excessive vegetation. The toe of the west berm is in a low area that has standing water and some dead woody vegetation (Photo 062). There were no observed indications of seepage, rodent burrows, settlement or excessive vegetation. The toe of the berms around the Center Cell is in fair condition.

South Cell

The toe of the west berm is in the bottom ash deposition area and has no observed seepage, standing water, rodent burrows, settlement or excessive vegetation. The toe of the west berm is in a low area that has standing water and some dead woody vegetation (Photo 108). There were no observed indications of seepage, rodent burrows, settlement or excessive vegetation. The toe of the south berm is in a surface water drainage ditch filled with standing water. There were no observed indications of seepage, rodent burrows, settlement or excessive vegetation.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Hazard Classification

The North Dakota Dam Design Handbook (North Dakota State Engineer 1985) defines dam hazard classification as:

> Although it is recognized that loss of life is possible with any dam failure, the following hazard categories of dams have been established for North Dakota:
>
> **Low** – dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails.
>
> **Medium** – dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails.
>
> **High** – dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings and major public utilities. There is a potential for the loss of more than a few lives if the dam fails.

The USEPA has developed a classification system associated with impoundment inspections as:

> **Less Than Low Hazard Potential**: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.
>
> **Low Hazard Potential**: Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
>
> **Significant Hazard Potential**: Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
>
> **High Hazard Potential**: Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

Based on these Dam Hazard classification systems, our review of the site and stability evaluation, Golder recommends the Bottom Ash Surface Impoundment be categorized with a Low Hazard potential. This recommended designation is based on the following:

- There are no residences or occupied structures directly adjacent to the facility and loss of human life is not deemed probable.
- A discharge of bottom ash transport water is unlikely to have a significant environmental impact as bottom ash is an inert waste and the conveyance water is currently being discharged to the river.
- The economic impacts associated with a failure will primarily be to the owner's property with the exception that failure of the south berm could damage the rail line and county road.

4.2 Recommendations

Recommendations for inspection, maintenance, and stability evaluation are detailed in the following sections. These recommendations are based on the visual observations, stability analysis, and Golder's experience with the design and operation of surface water impoundments.

4.2.1 Inspections/Training

Golder recommends that GRE continue to perform monthly documented inspections of the Bottom Ash Surface Impoundment by site personnel. Inspections should also be performed after heavy rainfall and/or severe weather. These inspections should be done by employees trained in the operation and inspection of the Bottom Ash Surface Impoundment and should include observations of the inlet and outlet structures, upstream slopes, crest, downstream slopes and toe. General conditions to watch include seepage, sloughing, cracking, excessive settlement, geomembrane integrity, animal burrowing, erosion, and abnormal vegetation.

Golder recommends that all personnel associated with the operation and maintenance of the Bottom Ash Surface Impoundment be provided with surface water impoundment training on a regular basis. This training should highlight the safety of the impoundment, maintenance of the impoundment structural and environmental controls, and operation of the impoundment.

4.2.2 Maintenance

There were several maintenance items observed during the site evaluation that could lead to instability if not addressed in a timely manner. These items include:

Erosion Protection and Repair

Erosion rills, surficial slope failures and over-steepened slopes were observed on all the downstream slopes. If not repaired, the erosion rills could increase in depth and lead to progressive failure of the downstream slopes.

Golder recommends that all un-compacted, eroded material, and organics (vegetation) in the erosion areas be excavated to undisturbed material. Structural fill should then be placed and compacted to restore the original slope geometry. The disturbed area should then be seeded with a suitable mix of native grasses.

In addition, Golder recommends that the surface water drainage of the Bottom Ash Surface Impoundment and immediate vicinity be reviewed, and that erosion controls such as berms, channels and armoring be installed as necessary to reduce the development of future erosion rills and over-steepened slopes.

Animal Control

There were several small rodent burrows observed on all the downstream slopes, and larger burrows observed on the south downstream slope. Rodent burrows could lead to loss of downstream slope material, alteration of the phreatic surface through the berm, and potentially affect the berm stability.

Golder recommends that GRE remove the burrowing animals and backfill the burrows with compacted structural fill. For the small burrows, Golder suggests that bentonite chips or pellets be poured into the holes to fill and seal them.

Geomembrane Liner

The exposed HDPE geomembrane liner is susceptible to puncture and tears due to animals, human traffic, equipment loading, and material deposition. Several punctures and tears were identified on the geomembrane liner ranges from small pinholes to 1 foot tears. In the vicinity of the retention pond inlet at the South Cell, water was found between the geomembrane liner and the clay liner, and the geomembrane pipe boot at the inlets was found to have openings.

Golder recommends that all identified geomembrane punctures and tears be repaired according to industry standards for geomembrane patches and welding. At the retention pond inlet to the South Cell, the trapped water should be removed by cutting a hole in the geomembrane liner and the hole and pipe boots should be repaired. In the future, Golder recommends the liner integrity be included in the monthly inspections and that identified punctures and tears be recorded and repaired as soon as practical.

Vegetation

The vegetation observed on the downstream slopes was comprised mostly of grasses with no bushes or living trees. Golder identified a few areas where bottom ash had been deposited on the slopes and was preventing vegetative growth.

Golder recommends that the bottom ash deposited on the downstream slopes be removed and that growth medium be placed in these areas to re-establish the original slope geometry. The disturbed area should then be seeded with a suitable mix of native grasses. Additionally, Golder recommends that the slopes be mowed every few years to promote growth and to allow for better evaluation of downstream slope conditions during the monthly inspections.

4.2.3 Stability

There were several surficial slope failures observed on the downstream slopes, and slope displacement was observed on the lower portion of the Center Cell upstream slopes. The identification of punctures in the geomembrane liner, and softer material below the liner indicate the potential for leakage by the geomembrane liner that can saturate and reduce the strength of the impoundment berms.

Based on these observations, Golder recommends that the following actions be done to better evaluate the stability of the Bottom Ash Surface Impoundment.

Instrumentation

Golder recommends that piezometers be installed in the Bottom Ash Surface Impoundment slopes to monitor the phreatic surface through the berms. The quantity, location, and depth of the piezometers to be installed should be evaluated by an engineer to provide a reasonable understanding of the phreatic surface through the berms.

Geotechnical Testing

Golder recommends that soil samples of the berm materials be collected at the time of piezometer installation. Samples should be collected of all distinct material types identified in the berms. At a minimum this should include the original silty sand fill and the newer clay fill. Laboratory testing of the soil samples may include in-situ moisture and density, grain size distribution, Atterberg limits, and shear strength (triaxial or direct shear depending upon material type). The site-specific materials properties should then be used to update the slope stability analysis.

Inspection of Crest

A slight crack was identified across the Center Cell west berm crest. The crack had no apparent opening width or depth. Golder recommends that a shallow excavation be done at this location to evaluate the extent and cause of the surface crack.

Inspection of Upstream Slopes

The displacement observed on the lower portion of the Center Cell upstream slopes may be due to shallow slope failure, consolidation, settlement, material piping or a combination of these mechanisms. Due to the level of bottom ash and water in the North and South Cells, conditions could not be identified in these cells.

Golder recommends that as the different cells can be isolated, cleaned of material, and dewatered, that a more thorough evaluation of the upstream slopes be undertaken. This may include visual observations of the slopes, survey of the slopes, removal of portions of the geomembrane liner to evaluate the underling liner, and collection of soil samples to evaluate the moisture condition and strength of the underlying materials.

4.3 Closing

This report summarizes the results of Golder's stability analysis and visual observations to evaluate the stability of the Bottom Ash Surface Impoundment at Great River Energy's Stanton Station. The evaluation of the Bottom Ash Surface Impoundment is based upon available data and visual observations of field conditions at the time of the assessment.

For permanent civil engineering structures (long-term conditions), a factor of safety greater than or equal to 1.5 is desired. All of the scenarios evaluated have a factor of safety greater than 1.5 and are expected to remain stable under the anticipated loading conditions. It should be noted that the condition of the Bottom Ash Surface Impoundment is constantly changing dependent upon many internal and external conditions, and that continued monitoring and evaluation are required to identify unsafe conditions that may develop.

The various components of the Bottom Ash Surface Impoundment were found to be in both fair and poor condition. Areas identified with poor conditions included the downstream slopes with evidence of erosion rills, surficial slope failures, and rodent burrows, and the upstream slopes with evidence of geomembrane liner puncture and slope displacement.

Golder recommends that GRE continue to perform monthly inspections, that the maintenance issues be addressed as soon as practical, and that the stability of the upstream slopes be further evaluated through instrumentation, soil testing and future physical evaluation.

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TABLES

Great River Energy - Stanton Station
Table 1
Material Properties

	Hydraulic Conductivity	Specific Gravity, G_s	Moisture / Density						Shear Strength	
	k_{sat} cm/sec		γ_{dry} pcf	ω %	γ_{wet} pcf	e	ω (sat) %	γ_{sat} pcf	ϕ/δ degrees	c/a psf
Historic Embankment Fill - Sand/Silt/Clay	1.0E-05	2.71	116.0	14.0	132	0.45	16.6	135	30	NA
Natural Soil - Sand/Silt/Clay	1.0E-05	2.71	104.0	14.0	119	0.45	16.6	121	30	NA
New Embankment Fill - Clay from Glenharold Mine	2.4E-08	2.63	98.0	22.0	120	0.9	34.2	132	16	500
Compacted Fill – Clay from Glenharold Mine	2.4E-08	2.63	98.0	22.0	120	0.9	34.2	132	16	500
Smooth HDPE / Clay	2.0E-13	NA	NA	NA	NA	NA	NA	NA	7.5	190
Bottom Ash	3.0E-02	2.41	68	18.5	80	NA	58.8	107	40	NA

Void ratios from Table 3.2 pg. 53 Principles of Geotechnical Engineering (Das 2002)

Great River Energy - Stanton Station
Table 2
Material Properties Sensitivity Range

Material	Paramater	Mean	Min	Max
Historic Embankment Fill - Sand/Silt/Clay	ϕ (degrees)	30	23	45
	γ_{wet} (pcf)	132	119	135
Natural Soil - Sand/Silt/Clay	ϕ (degrees)	30	23	45
	γ_{wet} (pcf)	119	107	121
New Embankment Fill - Clay from Glenharold Mine	ϕ (degrees)	16	4	34
	c (psf)	500	130	3400
	γ_{wet} (pcf)	120	109	128
Compacted Fill – Clay from Glenharold Mine	ϕ (degrees)	16	4	34
	c (psf)	500	130	3400
	γ_{wet} (pcf)	120	109	128

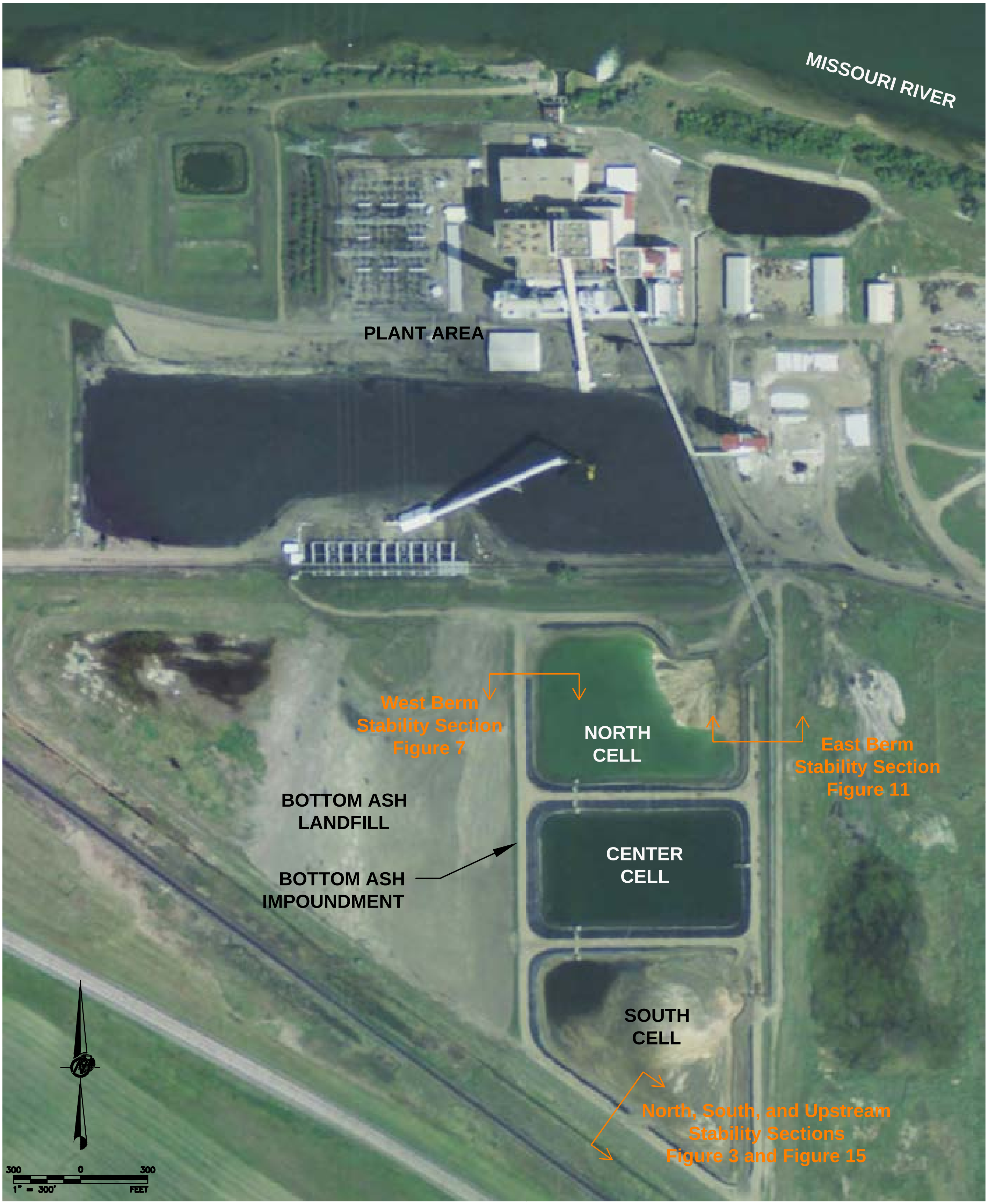
FIGURES

GREAT RIVER ENERGY
STANTON STATION
SITE LOCATION

Golder Associates

FIGURE 1

PROJECT No. 113-81645 CADD CCS DATE 05/05/11 FILE No. Stanton Aerial.dwg



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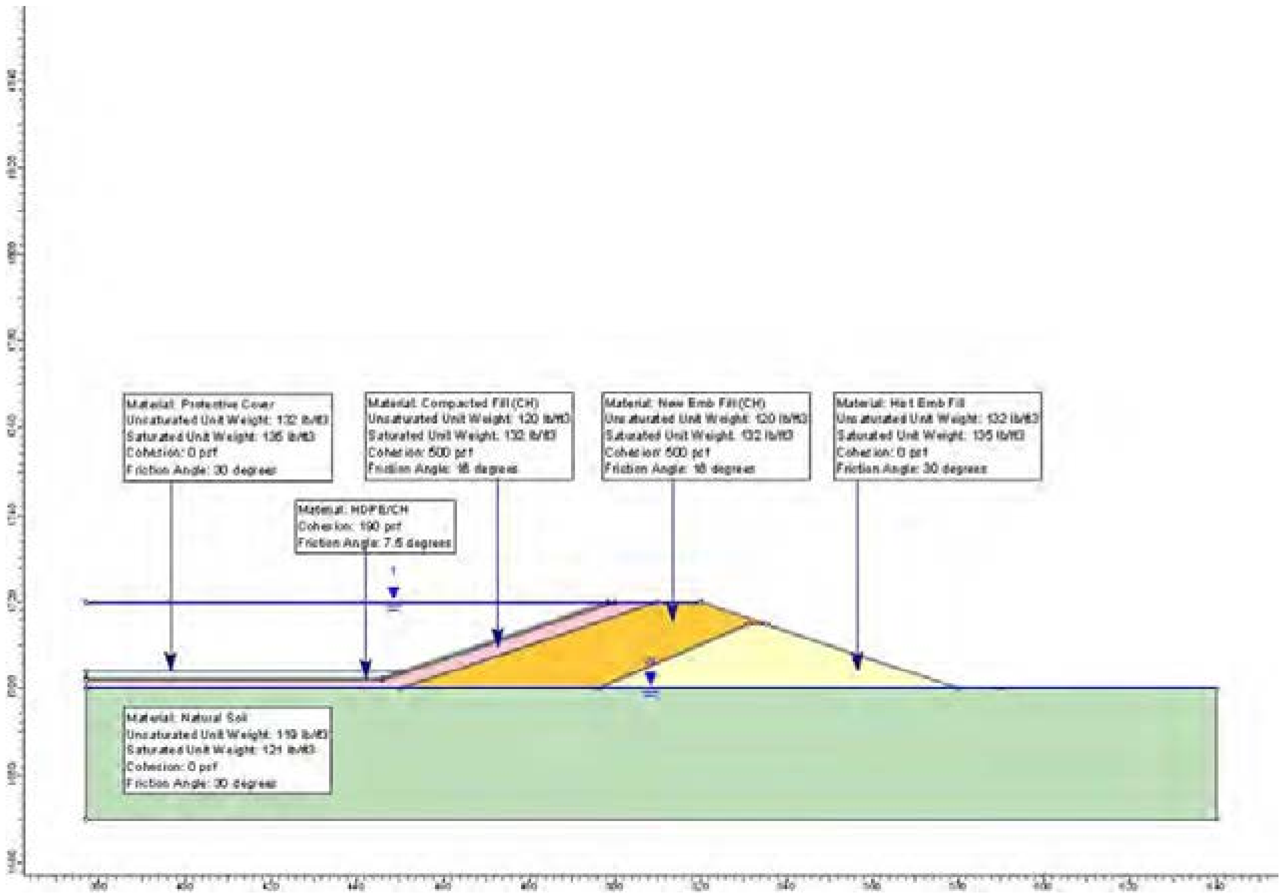
GREAT RIVER ENERGY STANTON STATION PLANT AREA

FIGURE 2

PROJECT No. 113-81645 CADD CCS DATE 05/05/11 FILE No. Stanton Aerial_12May11.dwg

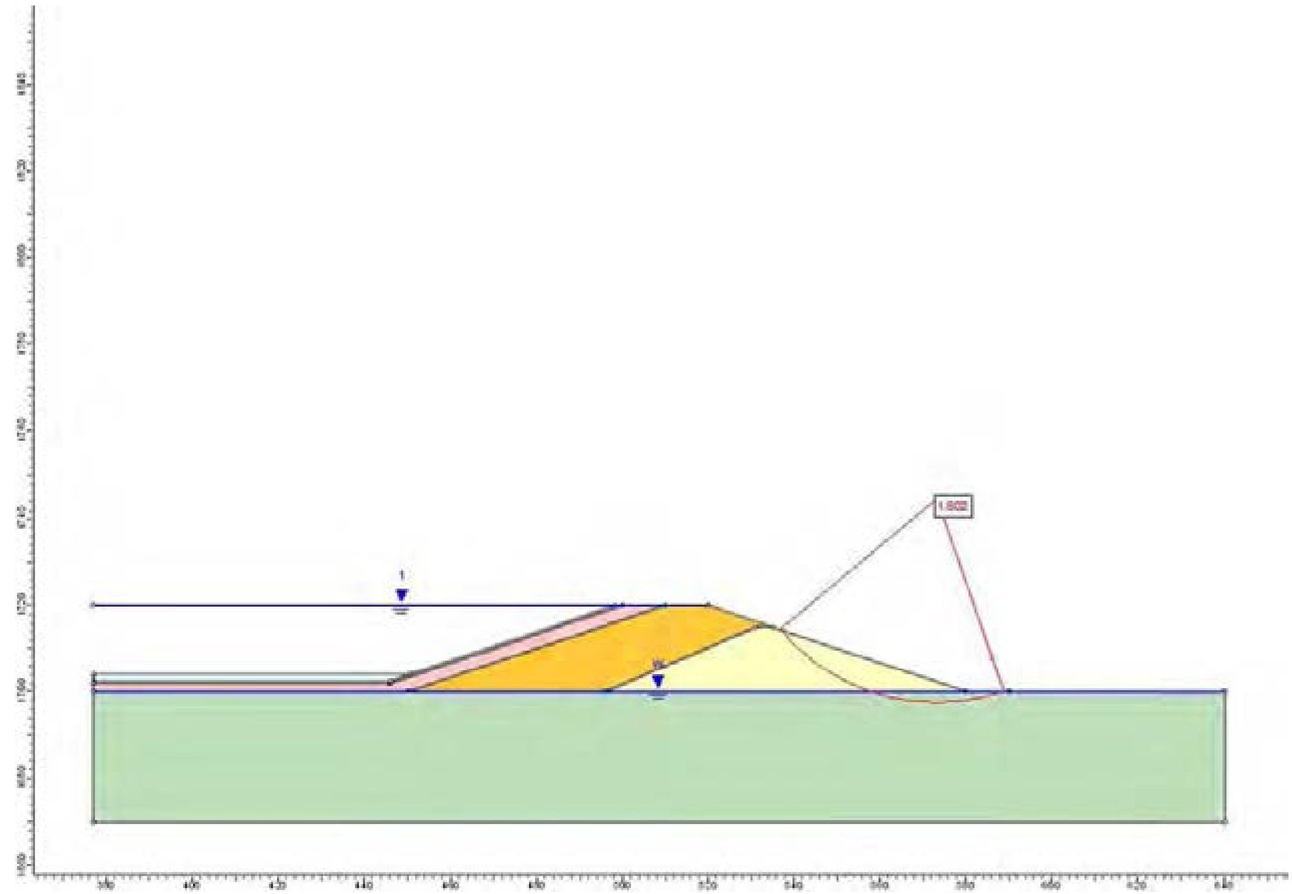


NORTH AND SOUTH BERMS CROSS SECTION

Golder Associates
DENVER, COLORADO

FIGURE 3

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

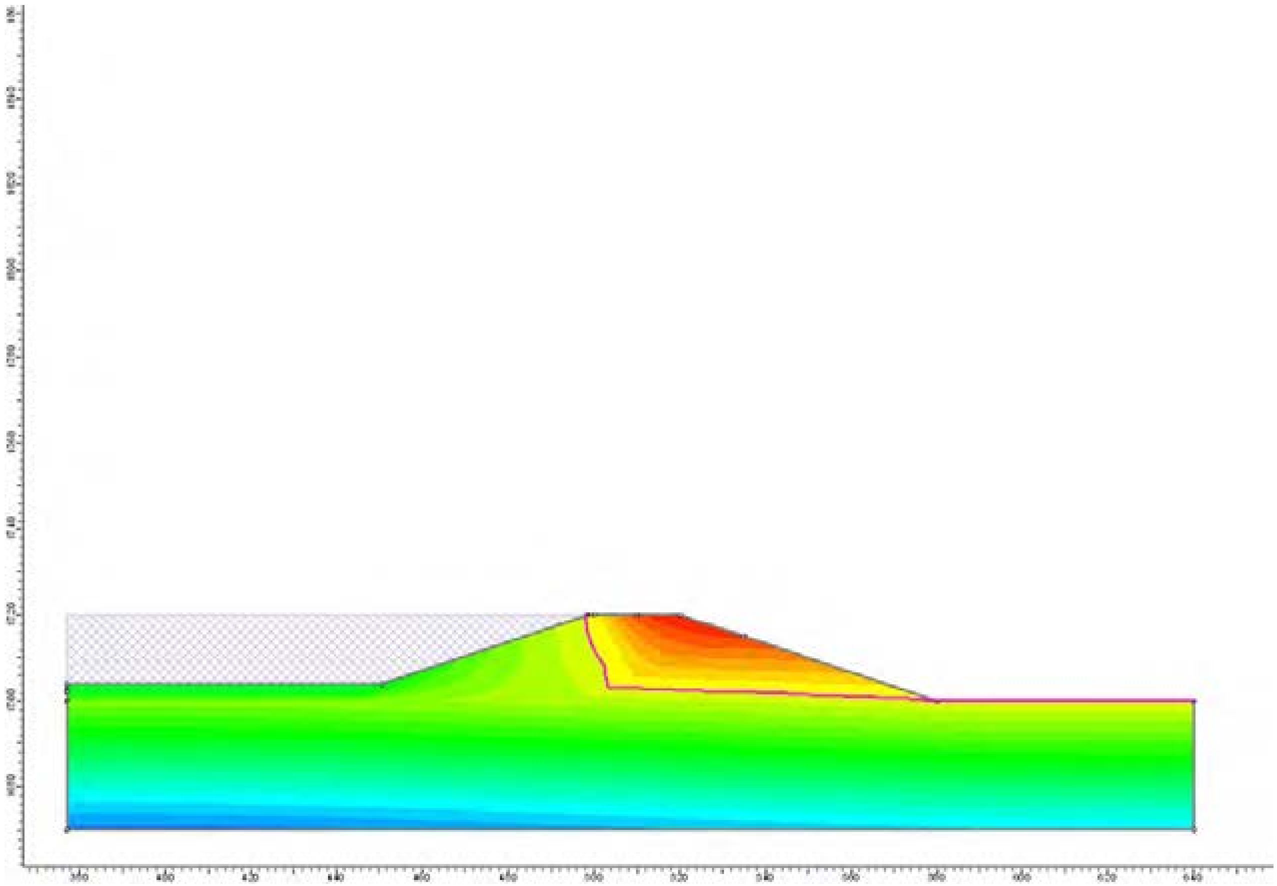


NORTH AND SOUTH BERMS WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 4

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

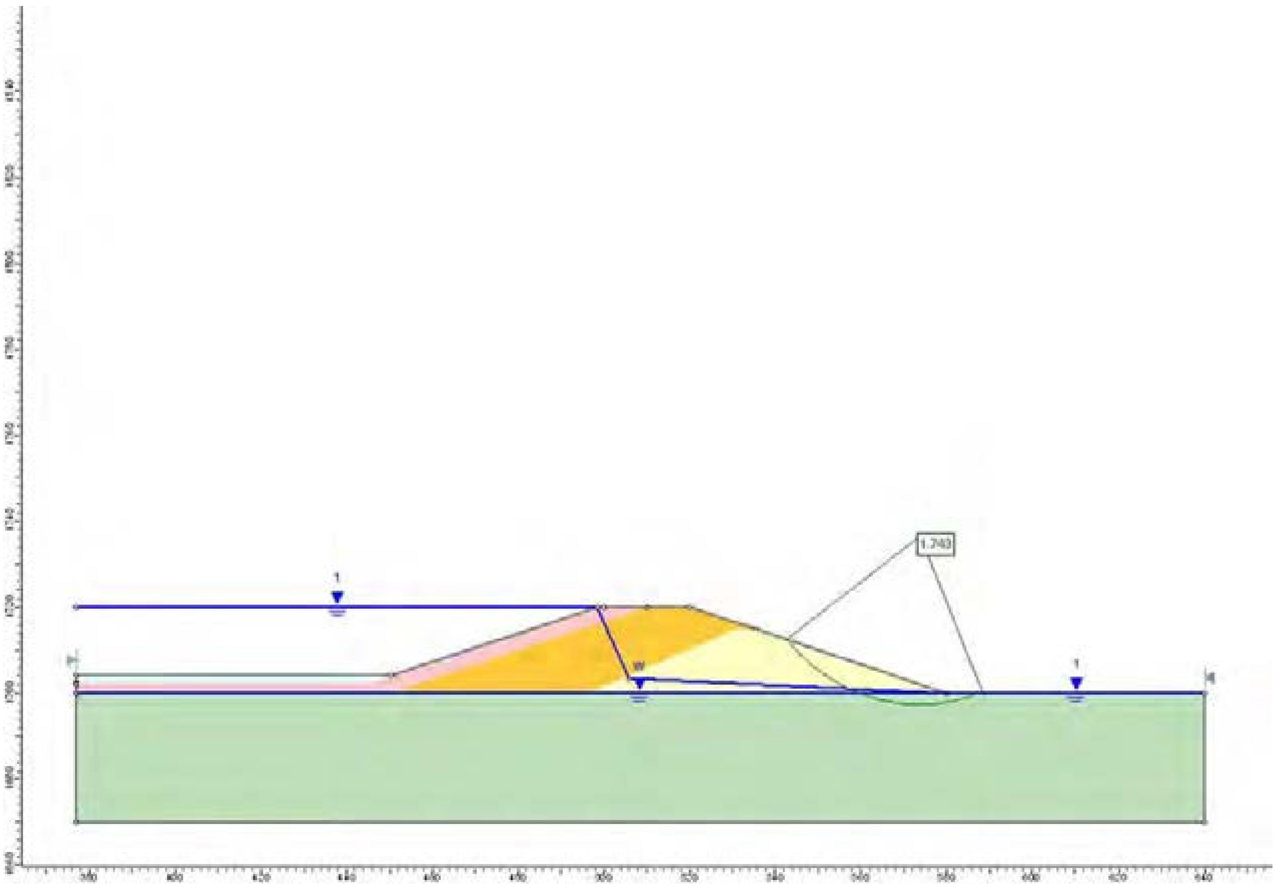


NORTH AND SOUTH BERMS WITH NO GEOMEMBRANE WATER TABLE ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 5

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

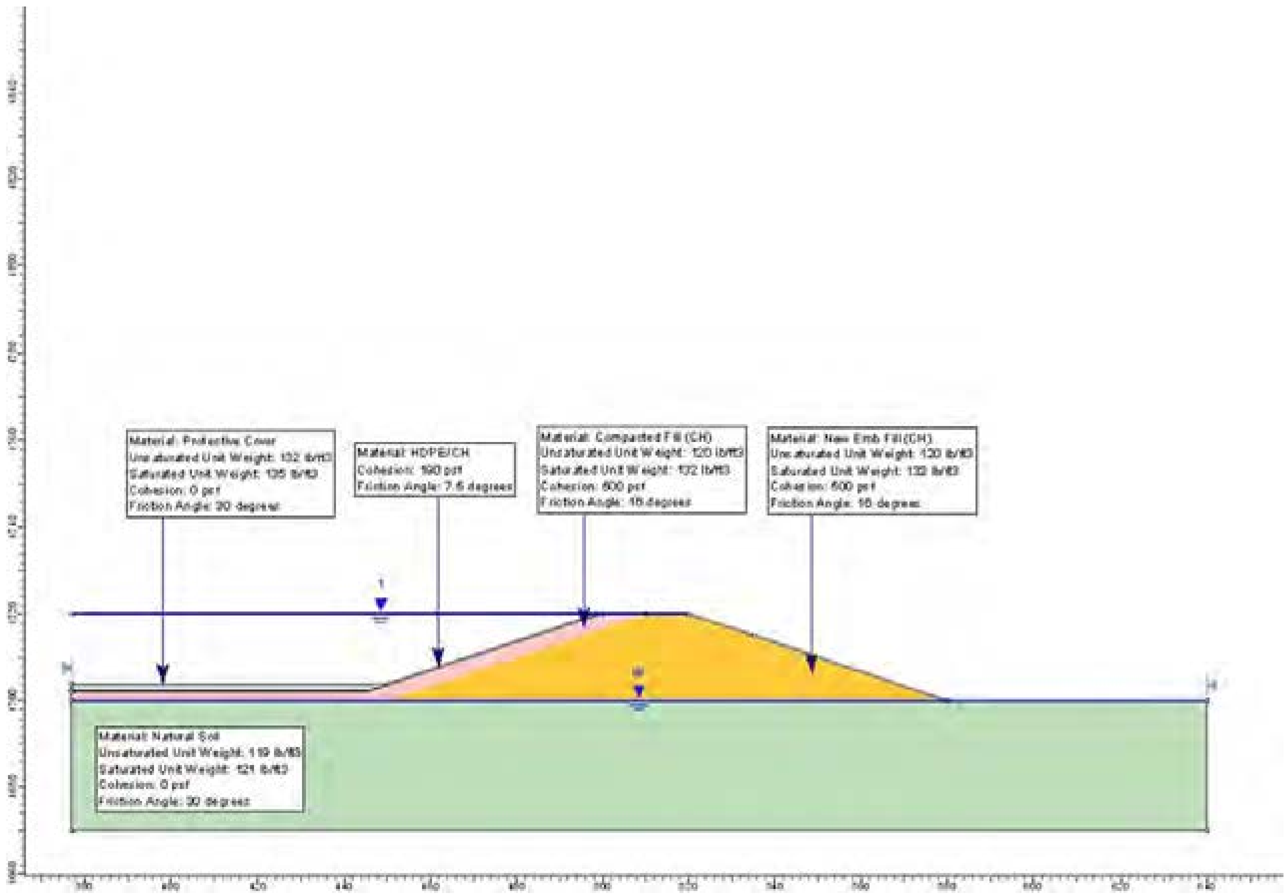


NORTH AND SOUTH BERMS WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 6

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

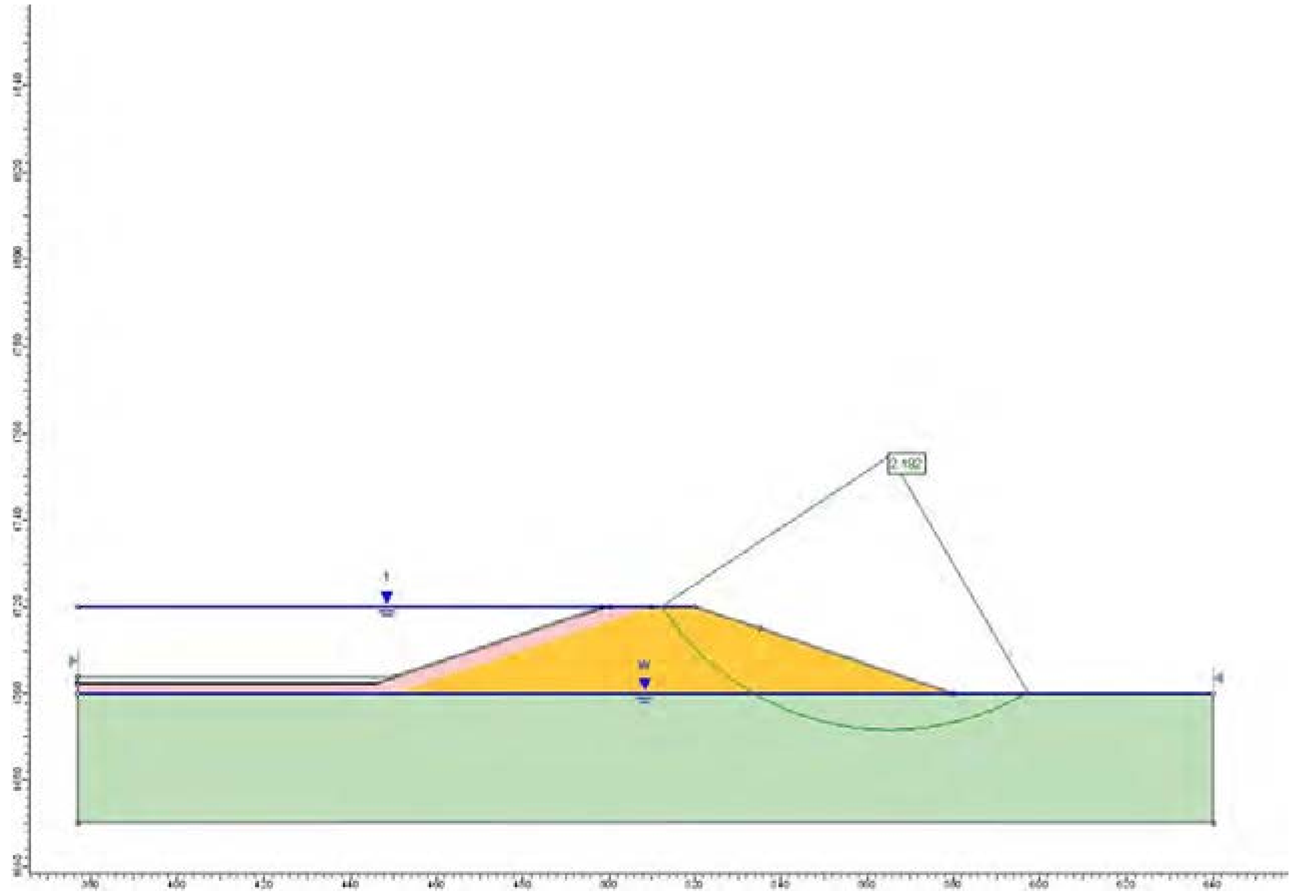


WEST BERM CROSS SECTION

FIGURE 7

Golder Associates
DENVER, COLORADO

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

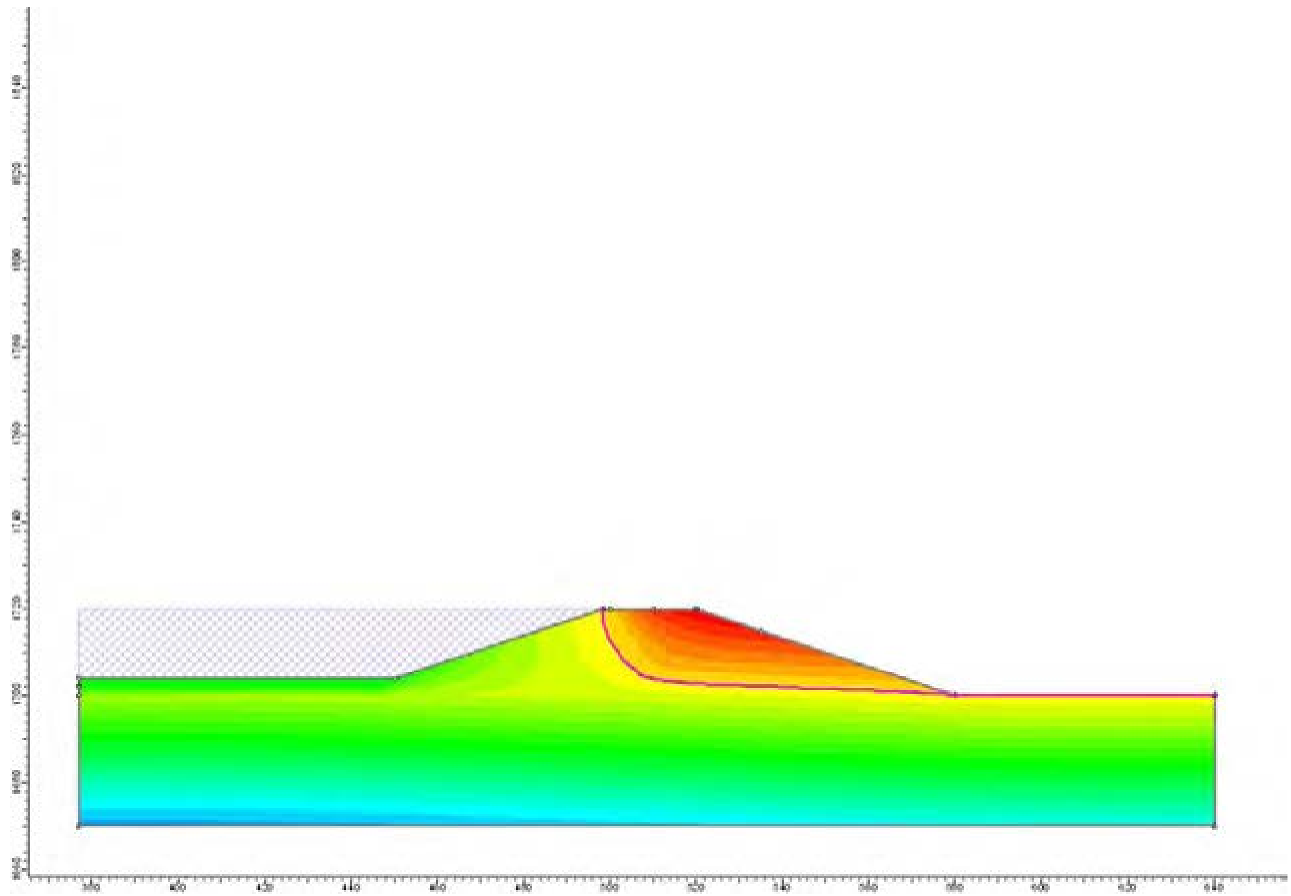


WEST BERM WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 8

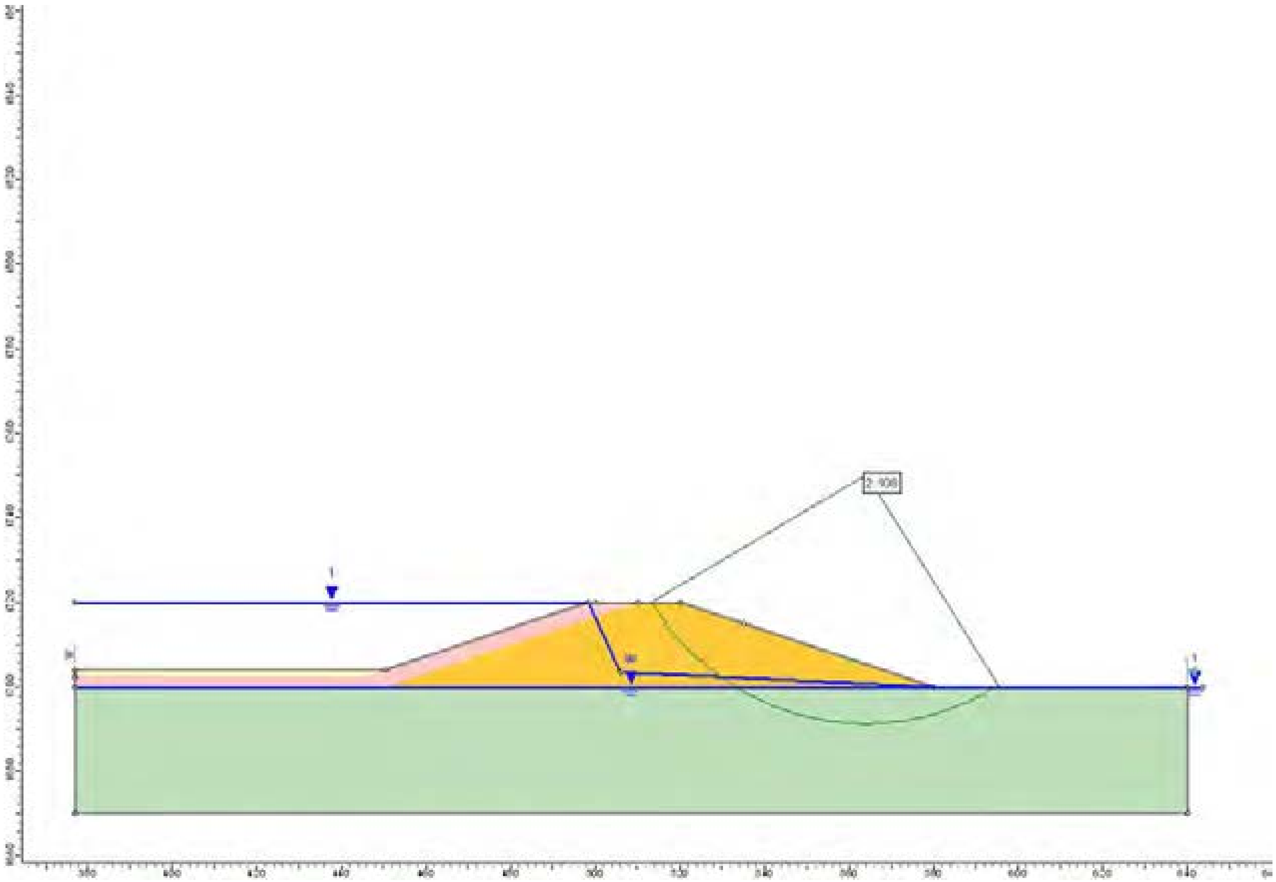
PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg



WEST BERM WITH NO GEOMEMBRANE WATER TABLE ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 9

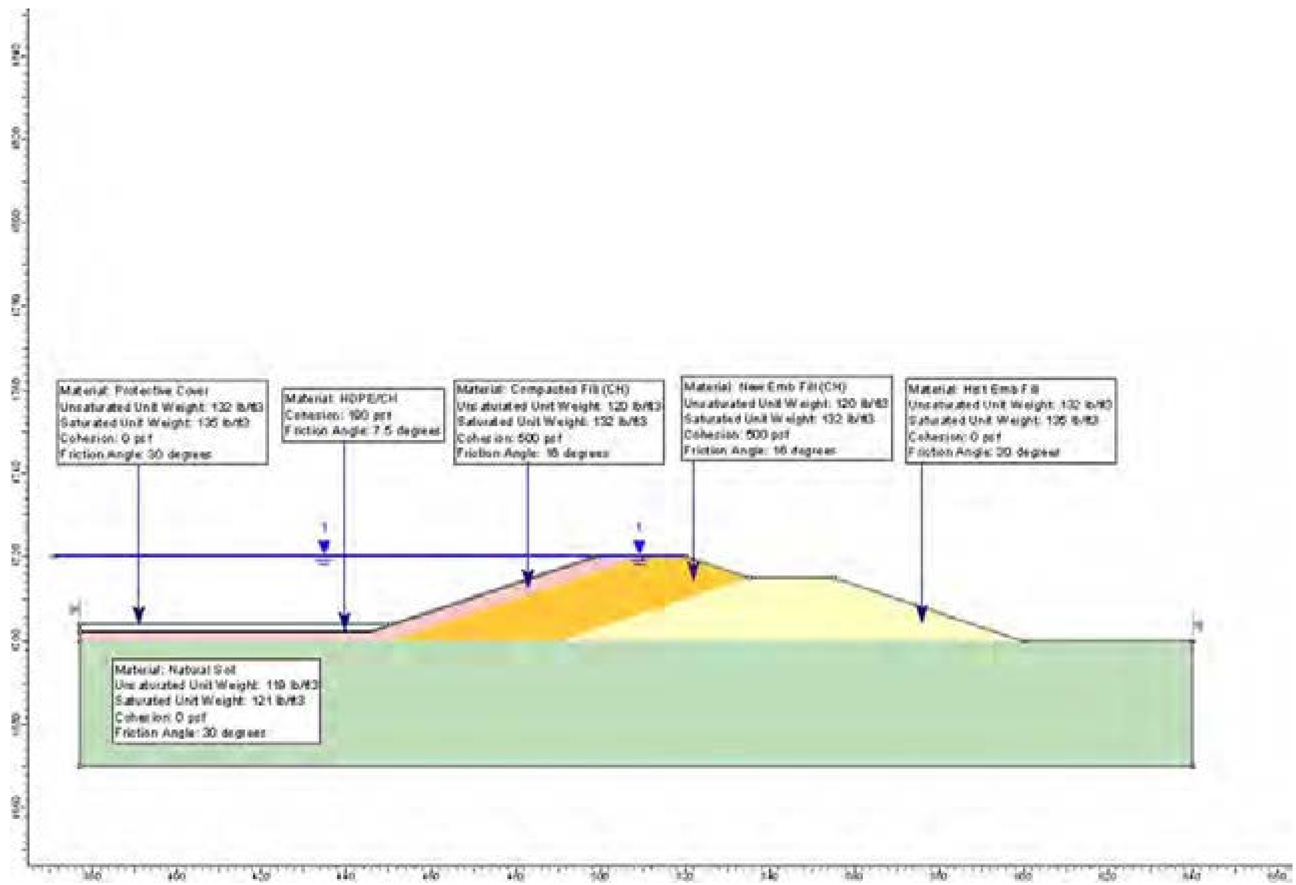


WEST BERM WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 10

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg



EAST BERM CROSS SECTION

Golder Associates
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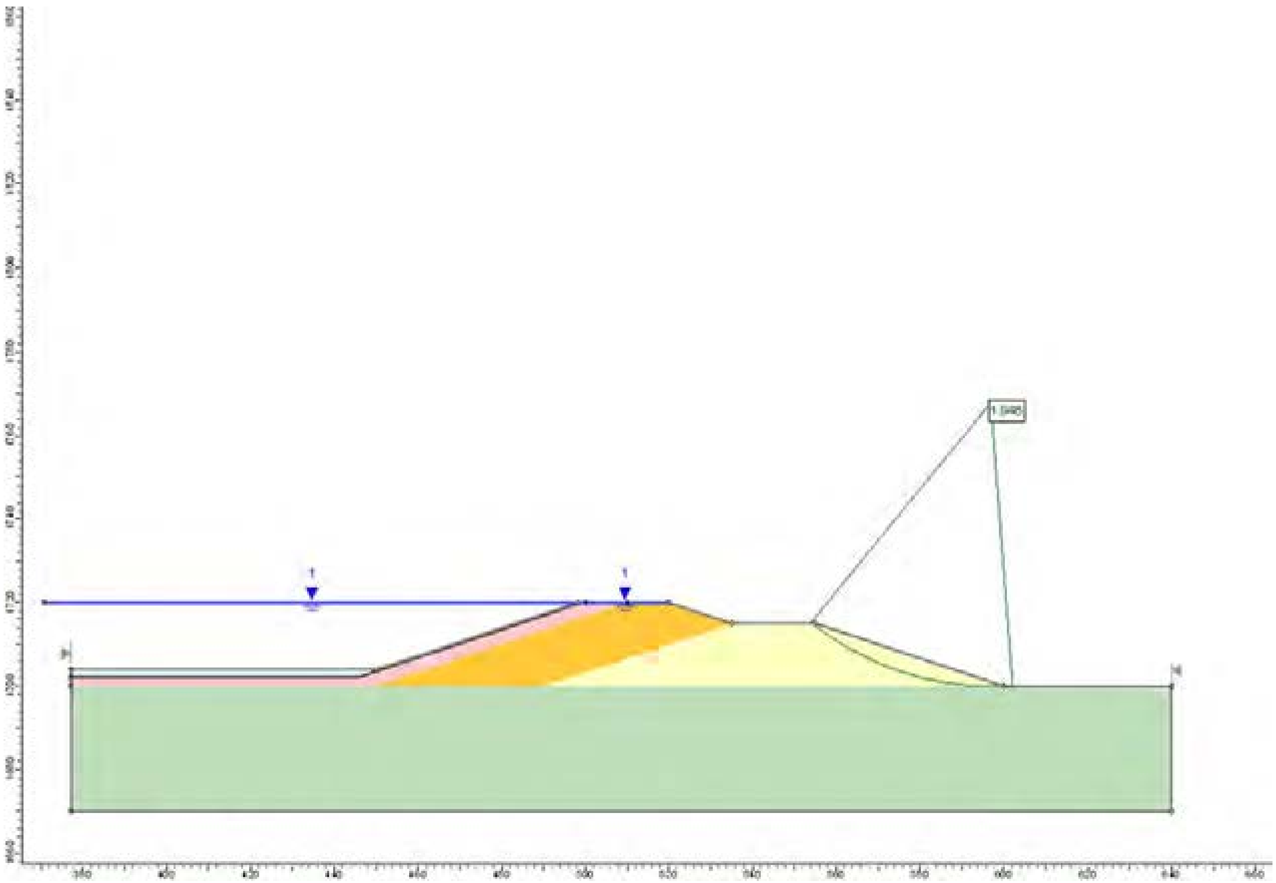
FIGURE 11

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

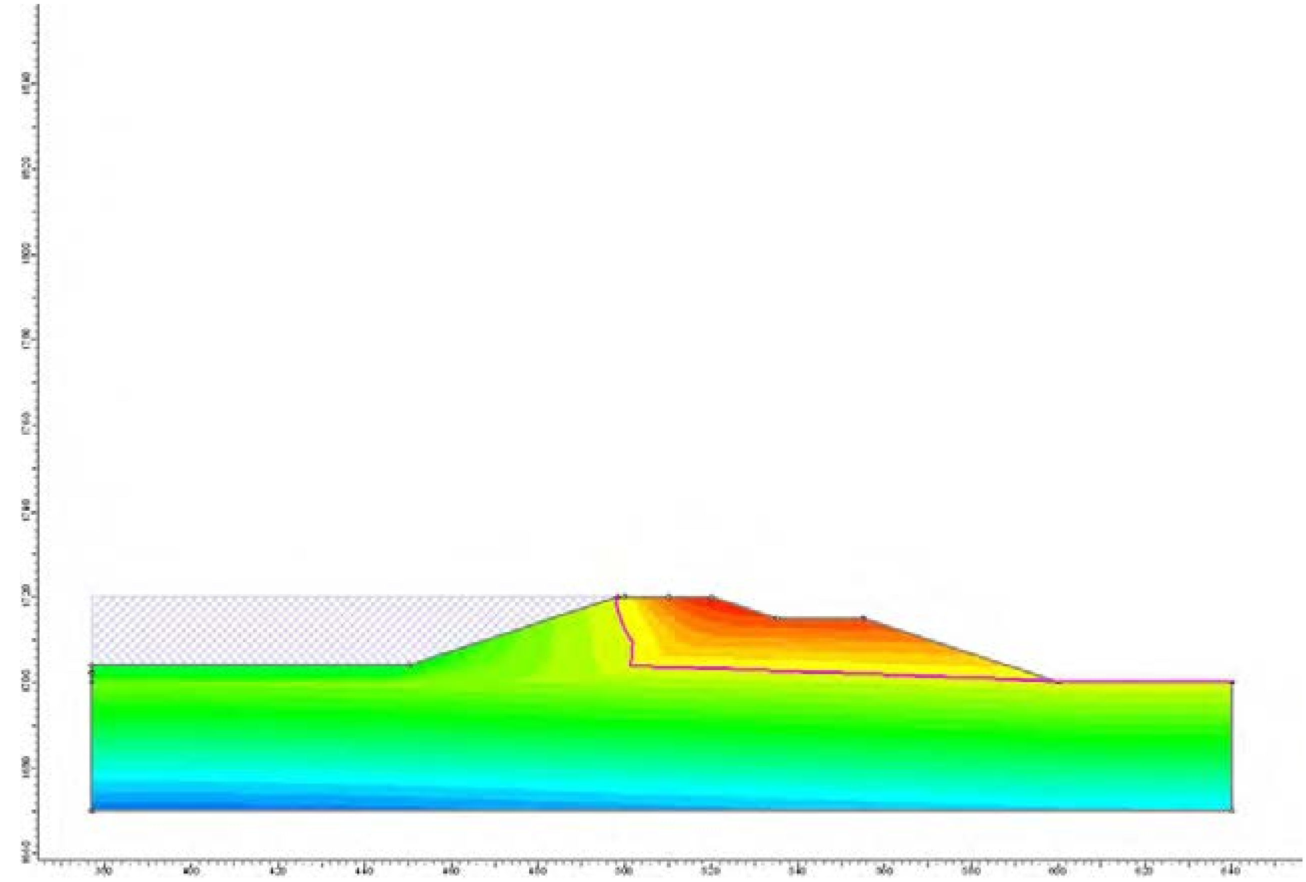


EAST BERM WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 12

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

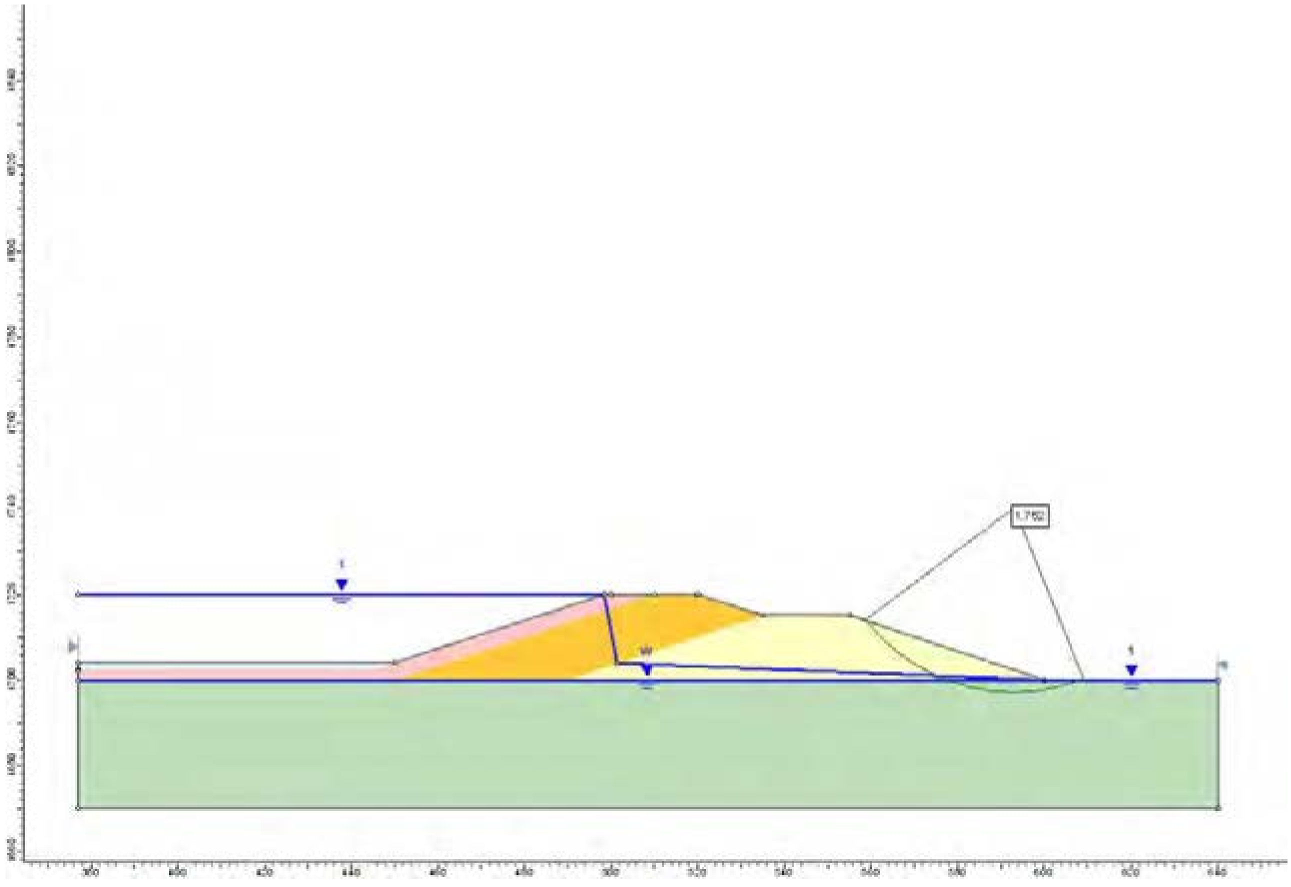


EAST BERM WITH NO GEOMEMBRANE WATER TABLE ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 13

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

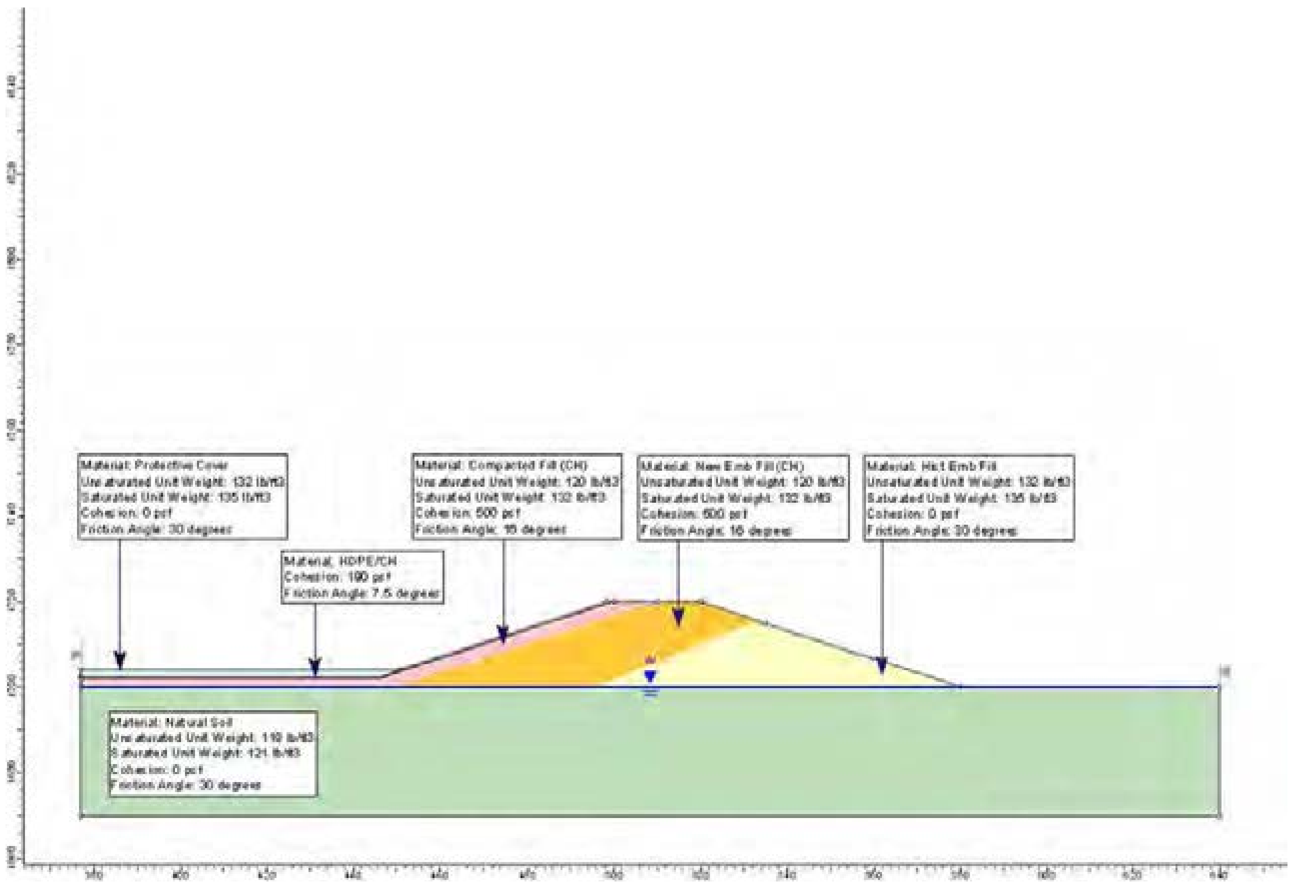


EAST BERM WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 14

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg



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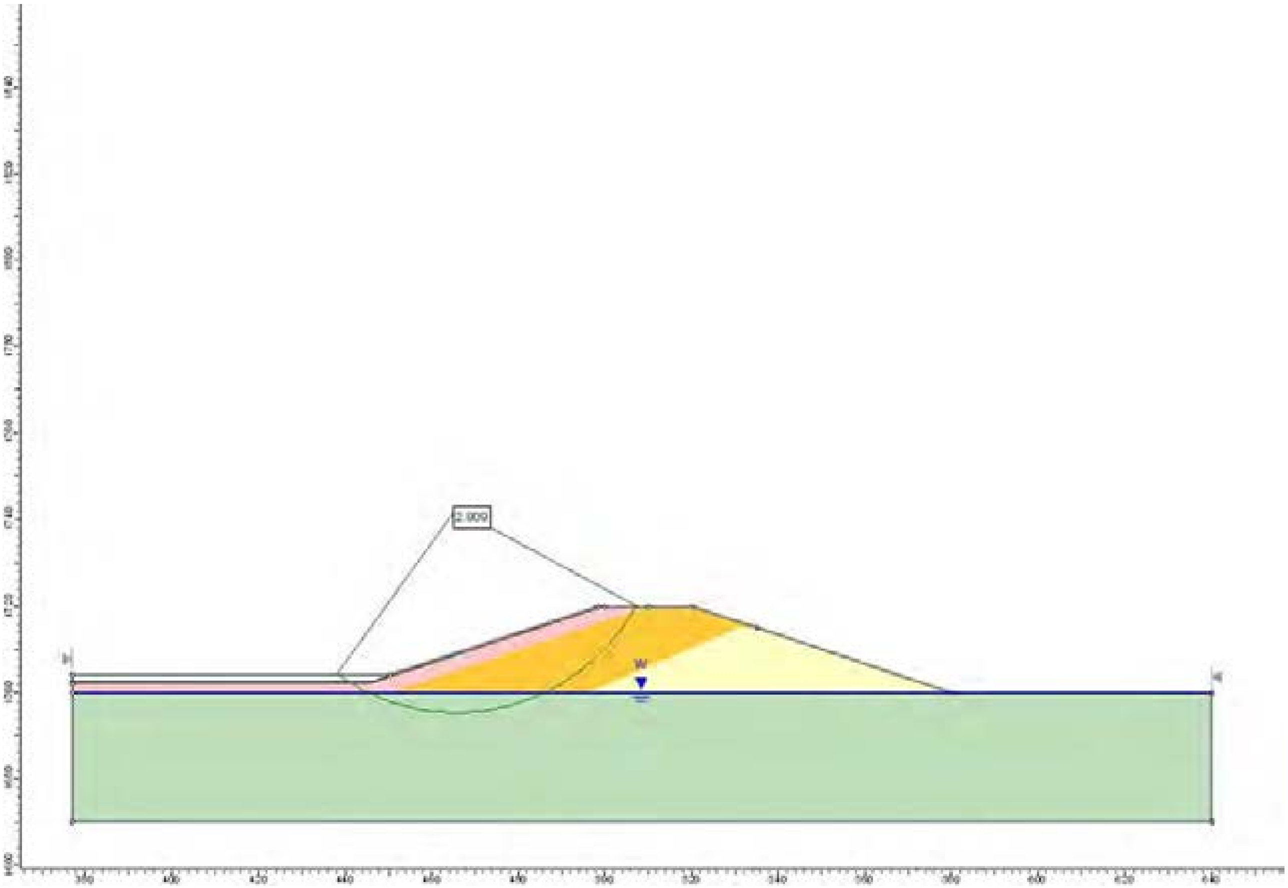
UPSTREAM CROSS SECTION

FIGURE 15

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

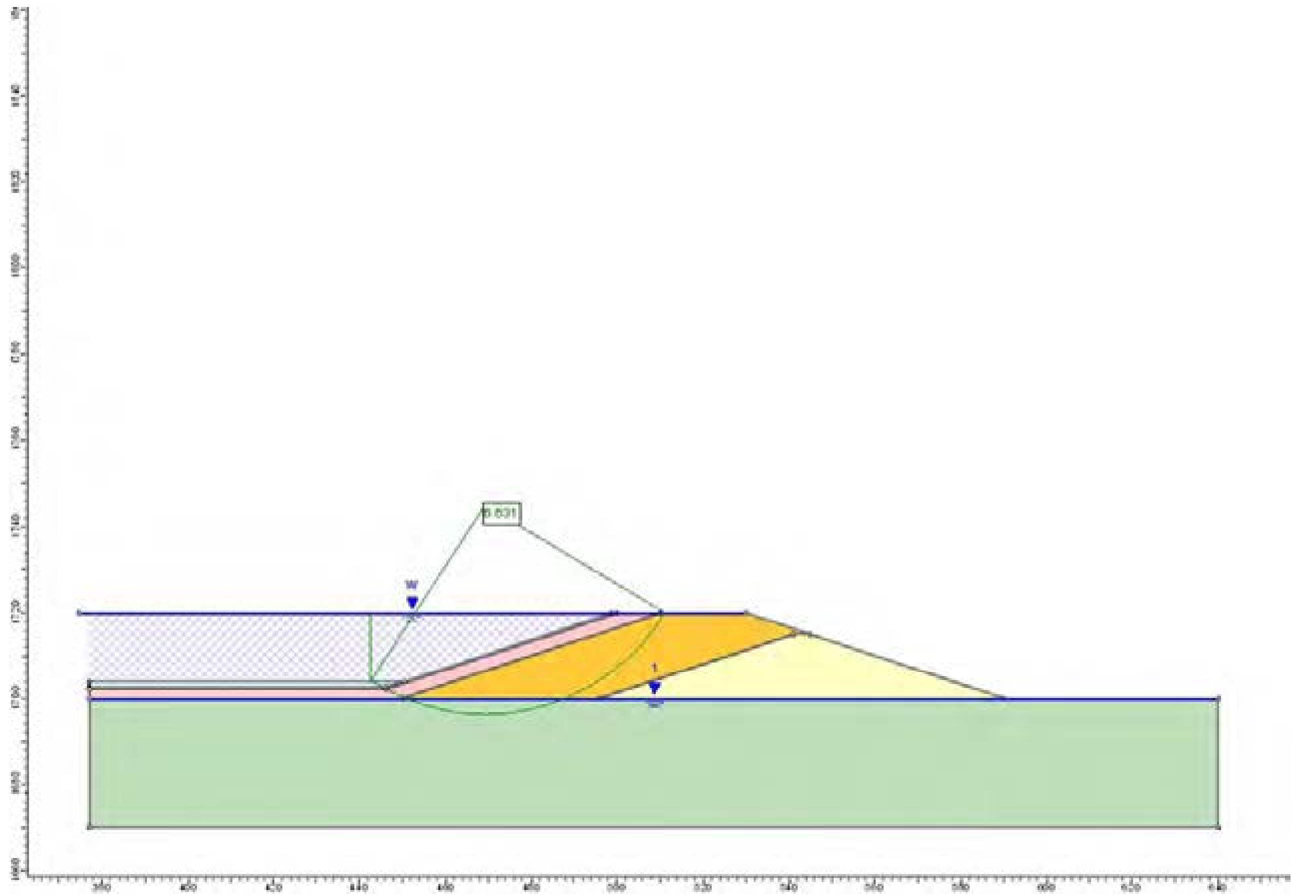


UPSTREAM BERM WITH EMPTY IMPOUNDMENT
STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 16

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

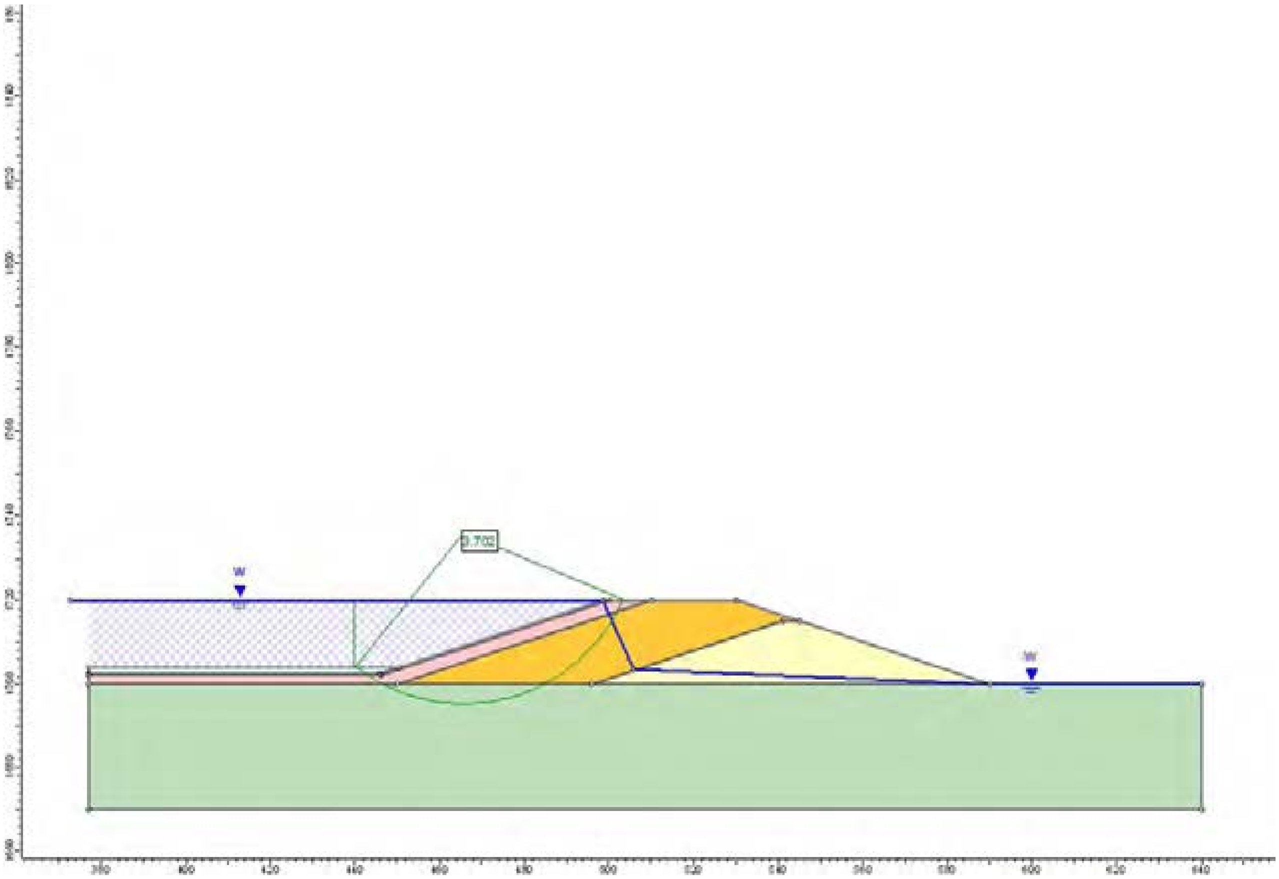


UPSTREAM BERM WITH INTACT GEOMEMBRANE AND FULL IMPOUNDMENT STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 17

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg



UPSTREAM BERM WITH NO GEOMEMBRANE AND FULL IMPOUNDMENT STABILITY ANALYSIS RESULT

Golder Associates
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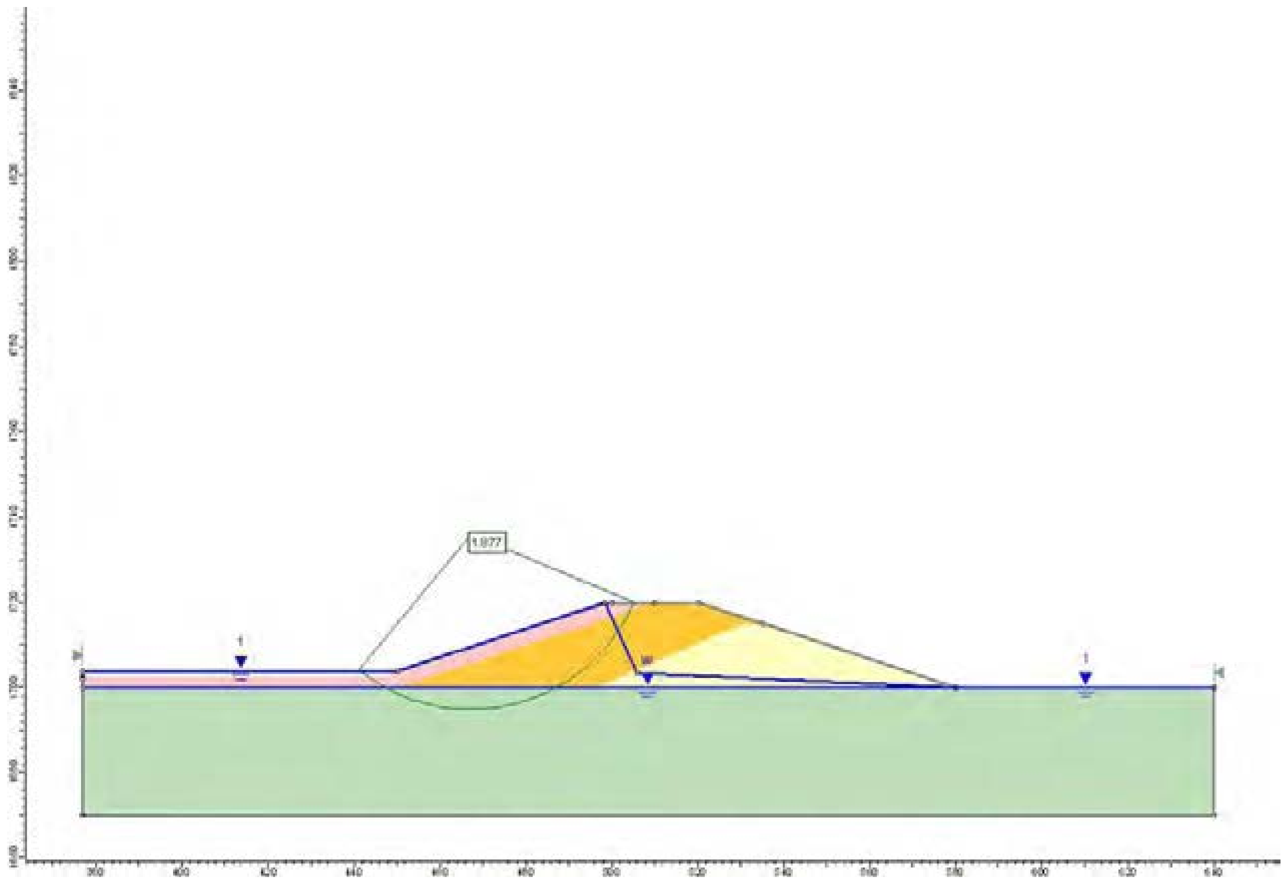
FIGURE 18

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg



UPSTREAM BERM WITH NO GEOMEMBRANE AND SATURATED BERM STABILITY ANALYSIS RESULT

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FIGURE 19

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

FIGURE 20 - NORTH AND SOUTH BERMS WITH NO GEOMEMBRANE MATERIAL SENSITIVITY ANALYSIS

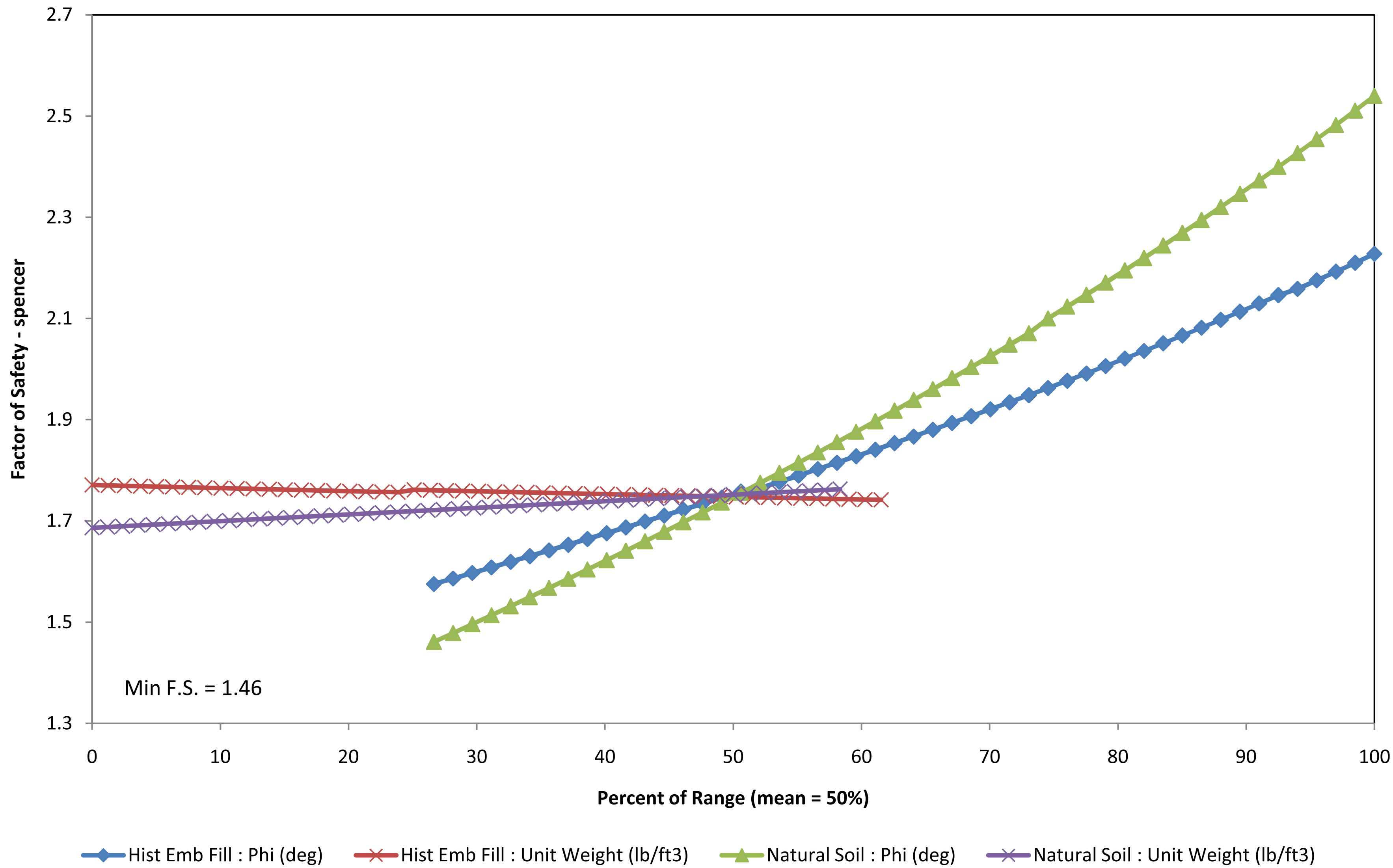


FIGURE 21 - EAST BERM WITH NO GEOMEMBRANE MATERIAL SENSITIVITY ANALYSIS

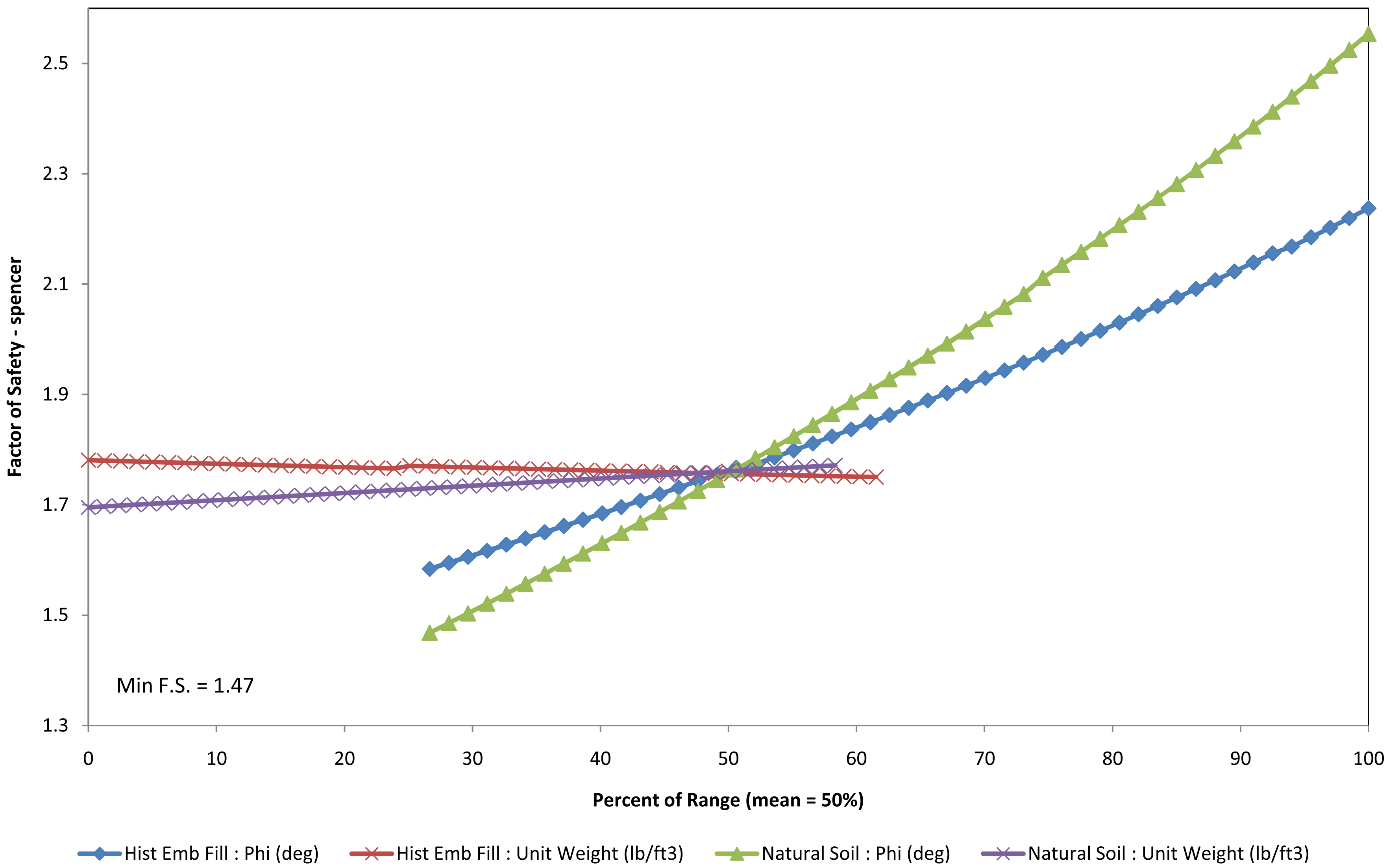
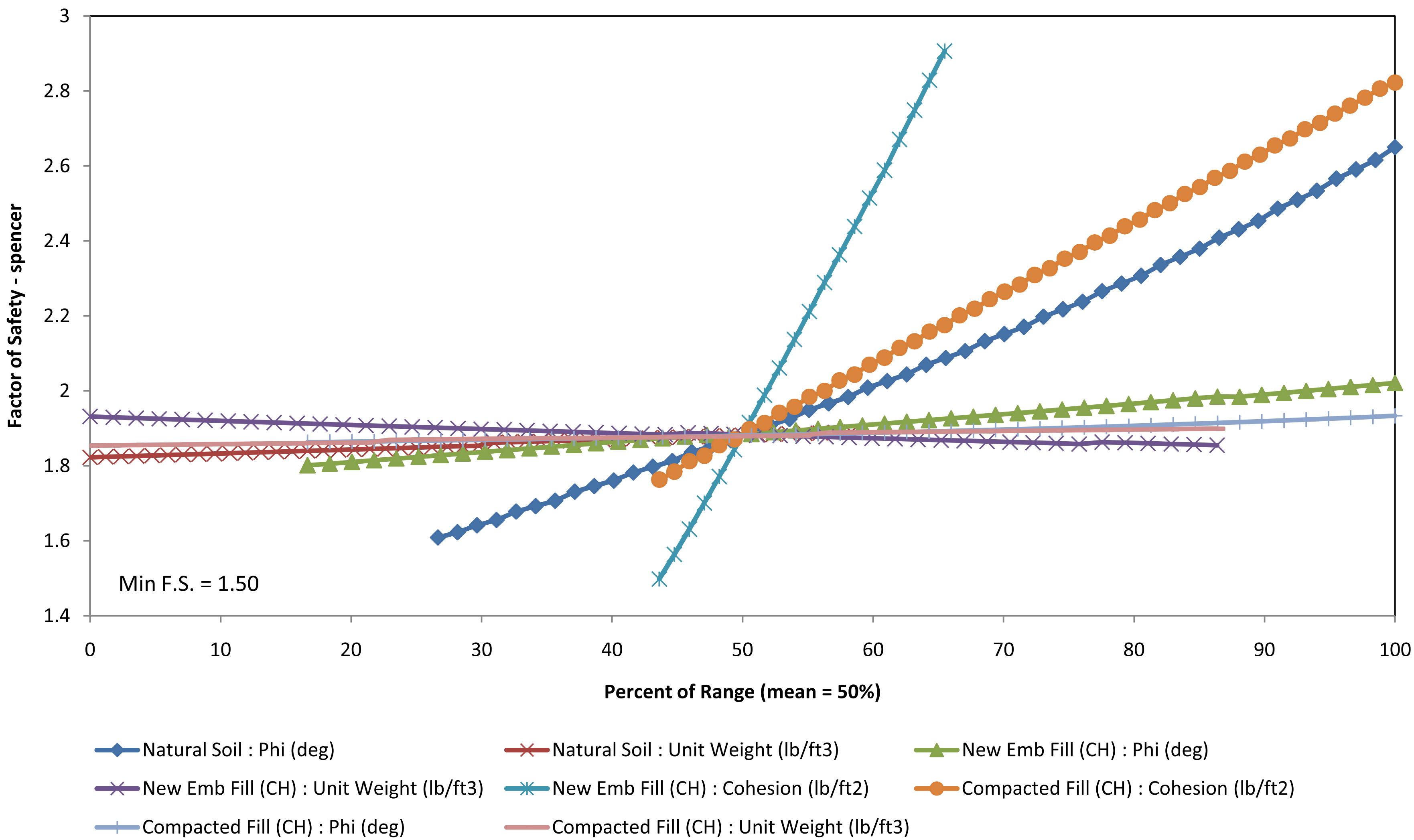
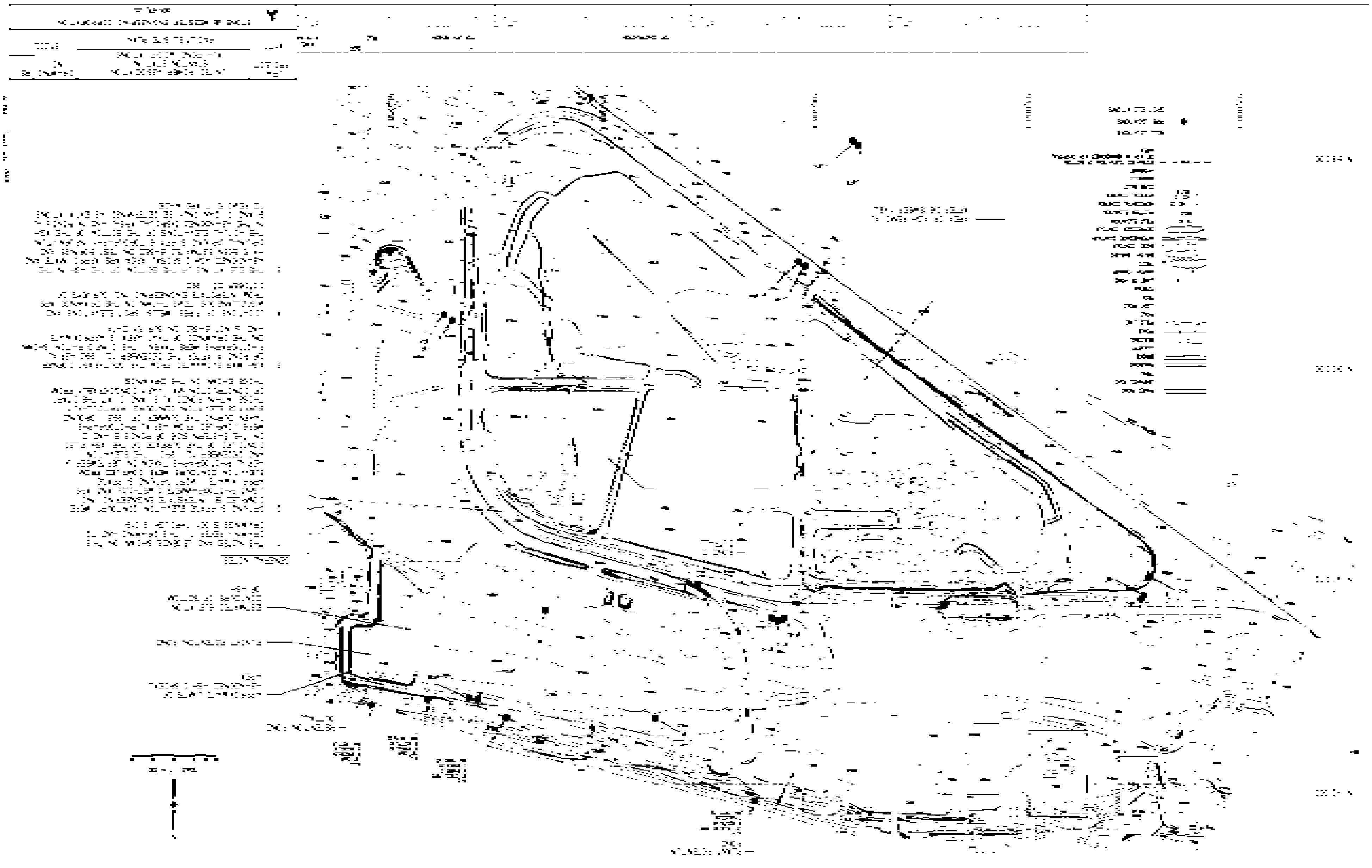


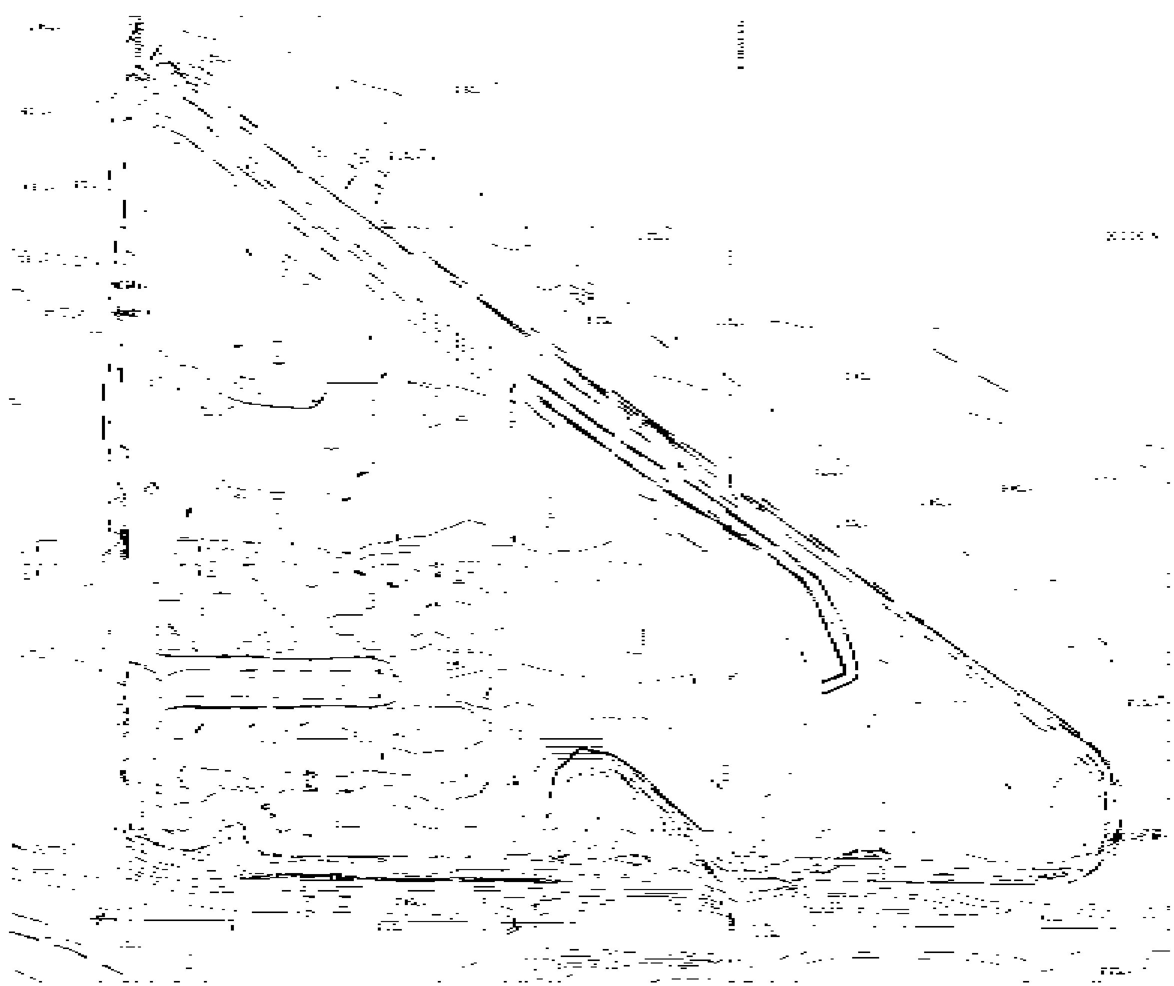
FIGURE 22 - UPSTREAM BERM WITH NO GEOMEMBRANE AND SATURATED BERM MATERIAL SENSITIVITY ANALYSIS

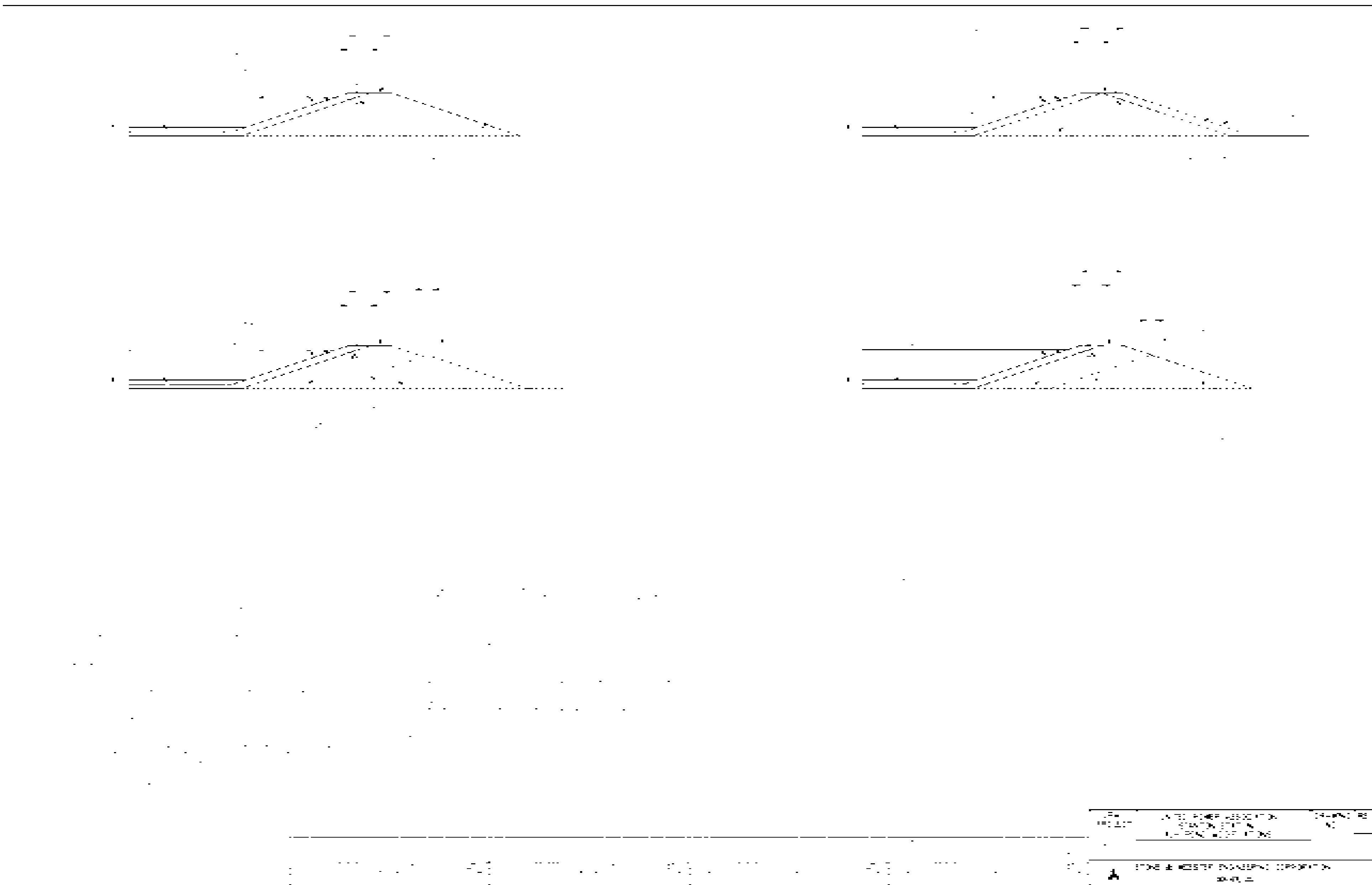


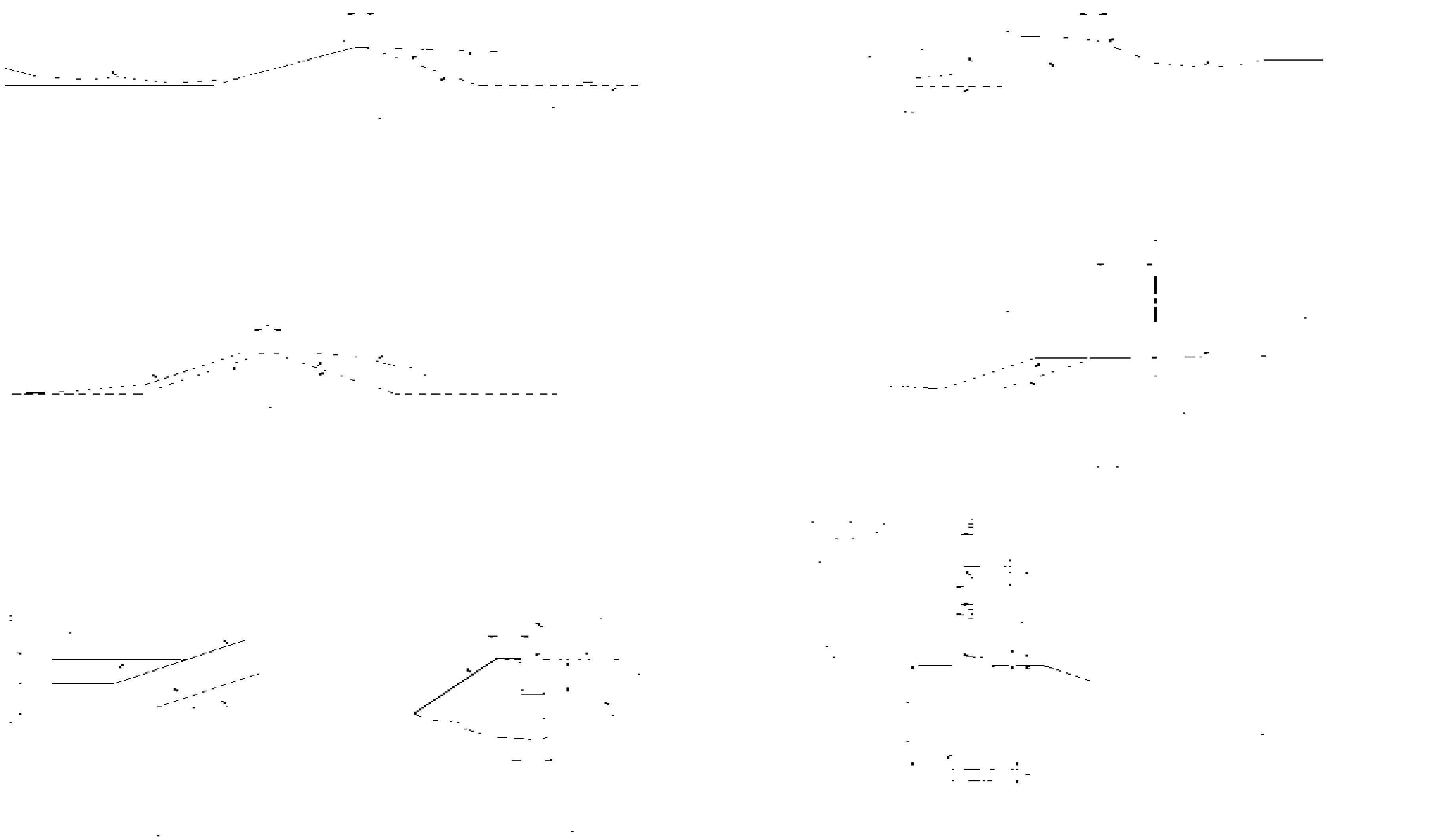
APPENDIX A

REFERENCE DRAWINGS



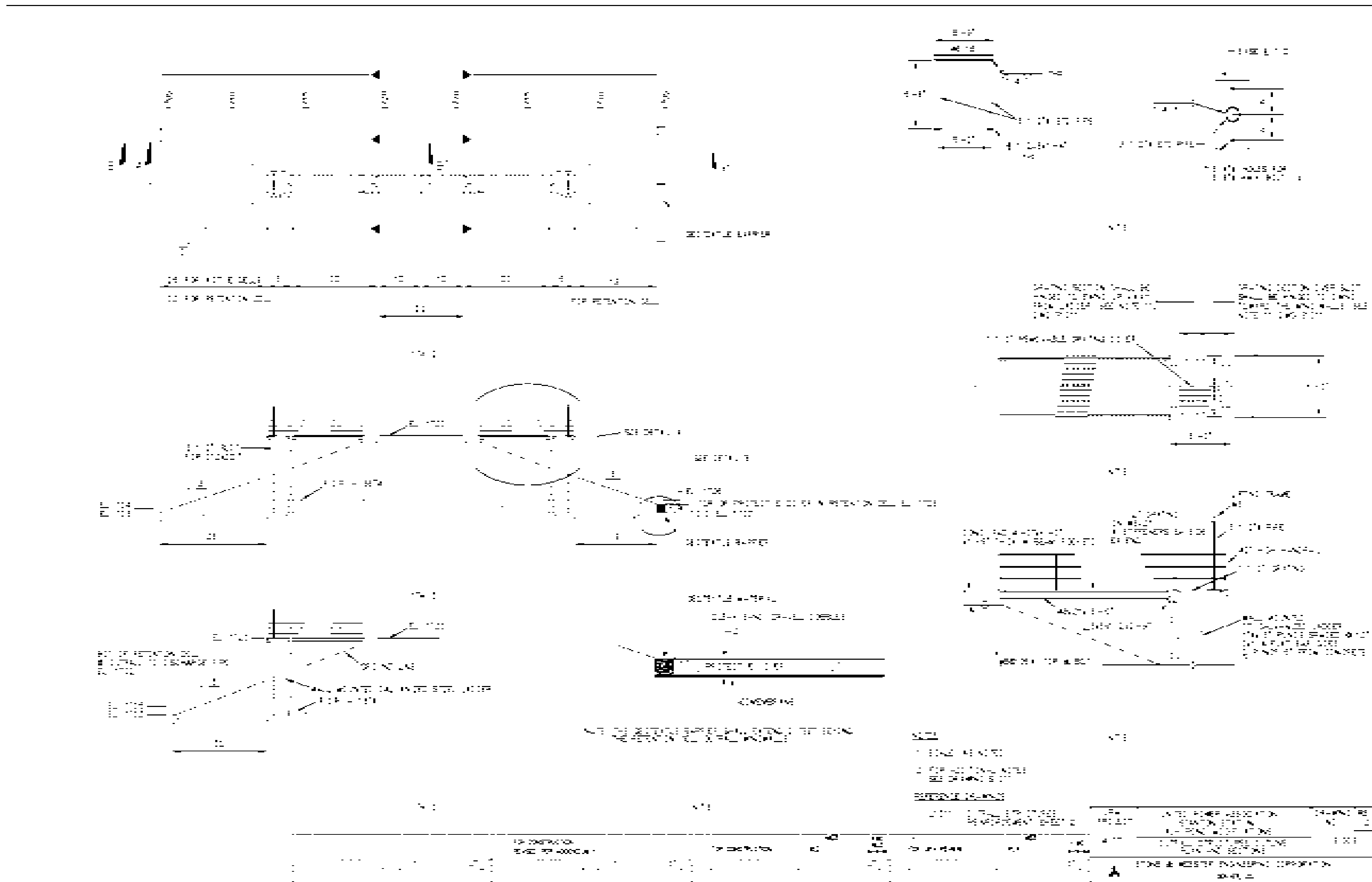



STONE & WEBSTER ENGINEERING CORPORATION

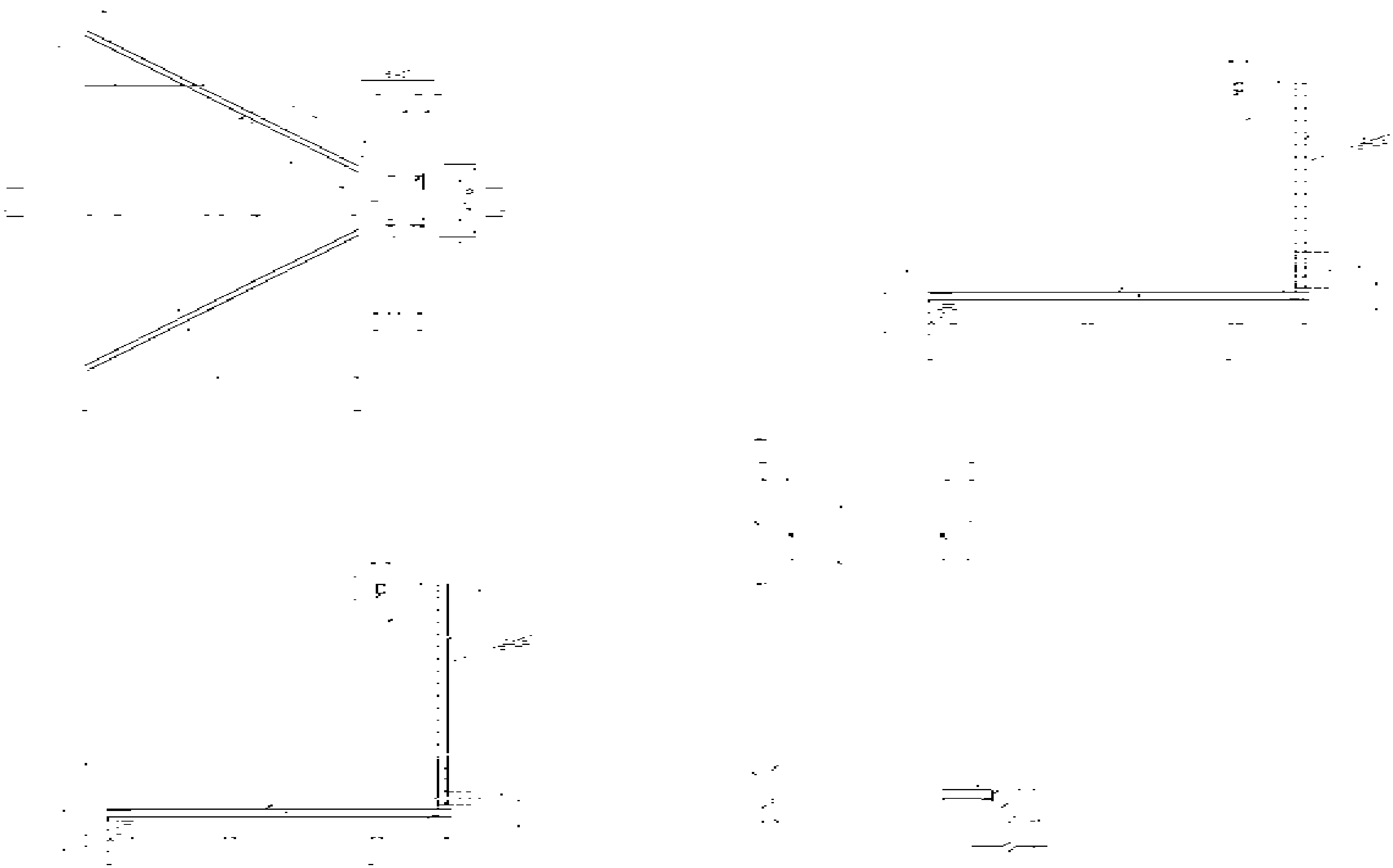


UNITED POWER ASSOCIATION
STANTON STATION

STONE & WEBSTER ENGINEERING CORPORATION



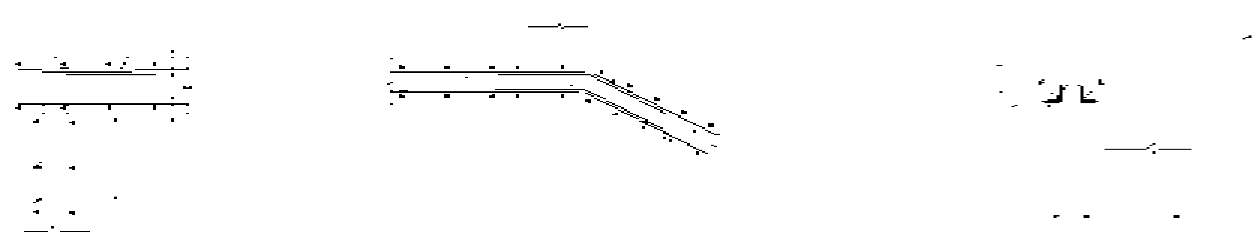
NOTES
1. SCALE: AS NOTED
2. FOR ADDITIONAL NOTES SEE DRAWING
REFERENCE DRAWINGS
UNITED POWER ASSOCIATION
STONE & WEBSTER ENGINEERING CORPORATION

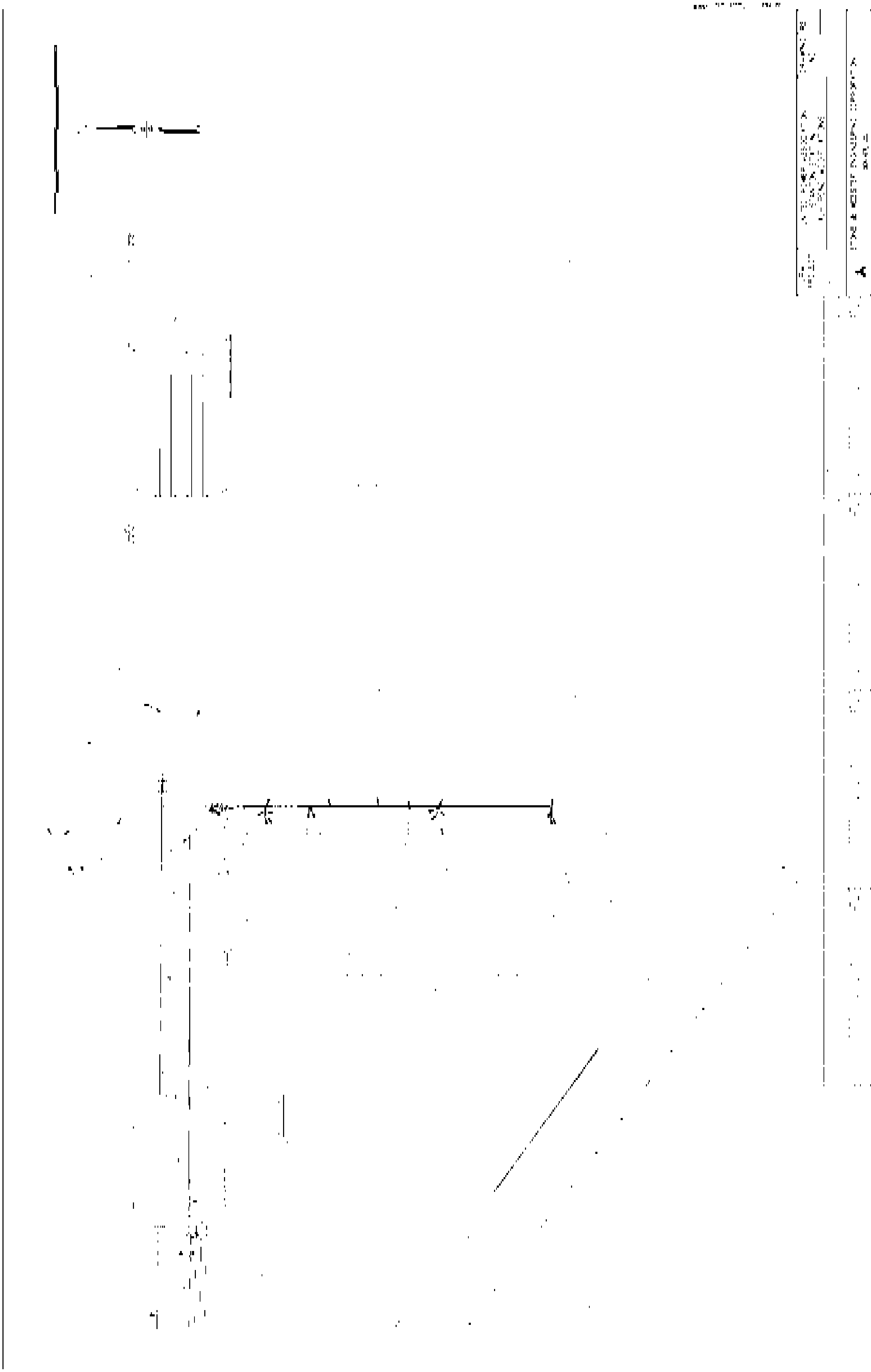


PROJECT

DRAWING NO. REV.

STONE & WEBSTER ENGINEERING CORPORATION





J.O. #
PROJECT

UNITED POWER ASSOCIATION
STANTON STATION
ASH POND MODIFICATIONS

DRAWING NO.

REV

STONE & WEBSTER ENGINEERING CORPORATION

APPENDIX B

VISUAL OBSERVATIONS

NORTH

IMPOUNDMENT INSPECTION CHECKLIST

Facility Name: Bottom Ash Impoundment (North Cell)

Owner and Address: Great River Energy – Stanton Station
4001 Highway 200A, Stanton, ND 58571

Purpose of Facility: Bottom ash dewatering and temporary storage

Legal: Section: 16 and 21 **Township:** 144N **Range:** 84W

County: Mercer

Inspected By: Todd Stong **Inspection Date:** May 3, 2011

Weather: Sunny, clear, 50°F, windy

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations		X		
b. Development of downstream plain		X		
c. Grass cover	X			
d. Settlement/misalignment/cracks		X		
e. High water mark			X	Elevation: --
f. Current water level	X			Elevation: 1715 ft
g. Sudden drops in water level?		X		
2. Inflow Structure				
a. Settlement		X		
b. Cracking		X		
c. Corrosion	X			Corrosion on bottom ash pipes
d. Obstacles in inlet		X		
e. Riprap/erosion control			X	Wear liner at retention pond pipe inlet
3. Outflow Structure				
a. Settlement		X		
b. Cracking		X		
c. Corrosion		X		
d. Obstacles in outlet		X		
e. Riprap/erosion control			X	
4. Upstream slope				
a. Erosion – liner exposed?	X			Some small punctures in exposed GM
b. Rodent burrows		X		
c. Vegetation		X		
d. Cracks/settlement		X		
e. Riprap/other erosion protection			X	
5. Crest				
a. Soil condition	X			Firm gravel roadway
b. Comparable to design width	X			
c. Vegetation		X		
d. Rodent burrows		X		
e. Exposed to heavy traffic	X			Large equipment used to clean-out cells
f. Damage from vehicles/machinery		X		
6. Downstream slope				
a. Erosion	X			Several rills
b. Vegetation	X			Good stand of grass
c. Rodent burrows	X			Small rodent burrows
d. Cracks/settlement/scarps	X			Scarp on north side near toe, erosion
e. Drain conditions			X	No drain in the design
f. Seepage		X		
7. Toe				
a. Vegetation	X			Good stand of grass
b. Rodent burrows		X		
c. Settlement		X		
d. Drainage conditions	X			Large surface water drainages
e. Seepage		X		Some erosion at toe on north side

General Remarks:

- Erosion and small scarps on downstream slopes
- Small punctures in exposed Geomembrane cover
- Rodent burrows on downstream slopes

Name of Engineer: Todd Stong

Date: May 3, 2011

Engineering Firm: Golder Associates Inc.

Signature: Todd Stong

REGISTERED PROFESSIONAL ENGINEER
TODD J. STONG
PE-6144
DATE 5/3/11
NORTH DAKOTA
PROFESSIONAL ENGINEER SEAL

CENTER

IMPOUNDMENT INSPECTION CHECKLIST

Facility Name: Bottom Ash Impoundment (Center cell)

Owner and Address: Great River Energy – Stanton Station
4001 Highway 200A, Stanton, ND 58571

Purpose of Facility: Bottom ash dewatering and temporary storage

Legal: Section 16 and 21 **Township:** 144N **Range:** 84W

County: Mercer

Inspected By: Todd Stong **Inspection Date:** May 3, 2011

Weather: Sunny, clear, 50°F, windy changing to cloudy & 60°F

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations		X		
b. Development of downstream plain		X		
c. Grass cover	X			
d. Settlement/misalignment/cracks		X		
e. High water mark			X	Elevation: —
f. Current water level	X			Elevation: 1712.5 ft (approximate)
g. Sudden drops in water level?		X		
2. Inflow Structure				
a. Settlement		X		
b. Cracking		X		
c. Corrosion		X		
d. Obstacles in inlet		X		
e. Riprap/erosion control			X	
3. Outflow Structure				
a. Settlement		X		
b. Cracking		X		
c. Corrosion		X		
d. Obstacles in outlet		X		
e. Riprap/erosion control			X	
4. Upstream slope				
a. Erosion - liner exposed?	X			Small punctures in exposed GM
b. Rodent burrows		X		
c. Vegetation		X		
d. Cracks/settlement	X			Lower half of slopes have displaced
e. Riprap/other erosion protection			X	
5. Crest				
a. Soil condition	X			Firm gravel roadway
b. Comparable to design width	X			
c. Vegetation		X		
d. Rodent burrows		X		
e. Exposed to heavy traffic	X			Large equipment when cleaned
f. Damage from vehicles/machinery		X		
6. Downstream slope				
a. Erosion	X			Several rills / gullies
b. Vegetation	X			Good stand of grass
c. Rodent burrows	X			Small burrows
d. Cracks/settlement/scarps	X			Scarps in erosion rills
e. Drain conditions			X	No drain
f. Seepage		X		
7. Toe				
a. Vegetation	X			Good stand of grass
b. Rodent burrows		X		
c. Settlement		X		
d. Drainage conditions	X			
e. Seepage		X		

General Remarks:

- Lower half of upstream slopes have displaced (consolidation settlement, shallow failure [illegible])
- Erosion, small scarps & animal burrows on downstream slopes
- Small punctures in exposed geomembrane liner

Name of Engineer: Todd Stong

Date: May 3, 2011

Engineering Firm: Golder Associates Inc.

Signature: Todd J. Stong

REGISTERED PROFESSIONAL ENGINEER
TODD J. STONG
PE-6144
DATE 5/3/11
NORTH DAKOTA

SOUTH

IMPOUNDMENT INSPECTION CHECKLIST

Facility Name: Bottom Ash Impoundment (South Cell)
Owner and Address: Great River Energy – Stanton Station
4001 Highway 200A, Stanton, ND 58571
Purpose of Facility: Bottom ash dewatering and temporary storage
Legal: Section. 16 and 21 **Township:** 144N **Range:** 84W
County: Mercer
Inspected By: Todd Stong **Inspection Date:** May 3, 2011
Weather: Sunny, clear, 50°F, windy

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations		X		
b. Development of downstream plain		X		
c. Grass cover	X			
d. Settlement/misalignment/cracks		X		
e. High water mark			X	Elevation: —
f. Current water level			X	Elevation: Not currently active
g. Sudden drops in water level?		X		
2. Inflow Structure				
a. Settlement		X		
b. Cracking		X		
c. Corrosion	X			Corrosion on bottom ash pipes
d. Obstacles in inlet		X		
e. Riprap/erosion control	X			HDPE wear liner at retention pond pipe inlet
3. Outflow Structure				
a. Settlement		X		
b. Cracking		X		
c. Corrosion		X		
d. Obstacles in outlet		X		
e. Riprap/erosion control			X	
4. Upstream slope				
a. Erosion – liner exposed?	X			Several punctures in exposed GM
b. Rodent burrows		X		
c. Vegetation		X		
d. Cracks/settlement		X		
e. Riprap/other erosion protection			X	
5. Crest				
a. Soil condition	X			Firm gravel roadway
b. Comparable to design width	X			
c. Vegetation		X		
d. Rodent burrows		X		
e. Exposed to heavy traffic	X			Large equipment during clean-out
f. Damage from vehicles/machinery		X		
6. Downstream slope				
a. Erosion	X			Rills & gully erosion
b. Vegetation	X			Good stand of grass
c. Rodent burrows	X			Large burrows on south slope
d. Cracks/settlement/scarps	X			Scarps in erosion rills
e. Drain conditions			X	No drain
f. Seepage		X		
7. Toe				
a. Vegetation	X			Good stand of grass
b. Rodent burrows		X		
c. Settlement		X		
d. Drainage conditions	X			Surface water ditch & ponding area
e. Seepage		X		

General Remarks:
- Erosion, small scarps & rodent burrows on downstream slopes
- Punctures in exposed geomembrane liner
- Water under geomembrane at retention pond pipe inlet

Name of Engineer: Todd Stong
Date: May 3, 2011
Engineering Firm: Golder Associates Inc.
Signature: Todd J. Stong

REGISTERED PROFESSIONAL ENGINEER
TODD J. STONG
PE-6144
DATE 5/3/11
NORTH DAKOTA
PROFESSIONAL ENGINEER SEAL

APPENDIX C

PHOTOGRAPHS

Dwg Name: J:\11JOBS\113-8164 ... Photo Maps\Appendix C1.DWG
Layout Name: May3-C Machine: DEN1-L-TSTONG
Last Update: May 13, 2011 14:56 By: tstong
Last Plot: May 13, 2011 14:58 By: tstong

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SOUTH POND PHOTO LOCATIONS

MAP 3

PROJECT No.113-81645 CADD TJS DATE 05/13/11 FILE No. Appendix C1.DWG

Plot Time: 05/13/11 14:58

Dwg Name: J:\11JOBS\113-8164 ... Photo Maps\Appendix C1.DWG
Layout Name: May3-D Machine: DEN1-L-TSTONG
Last Update: May 13, 2011 14:56 By: tstong
Last Plot: May 13, 2011 14:58 By: tstong

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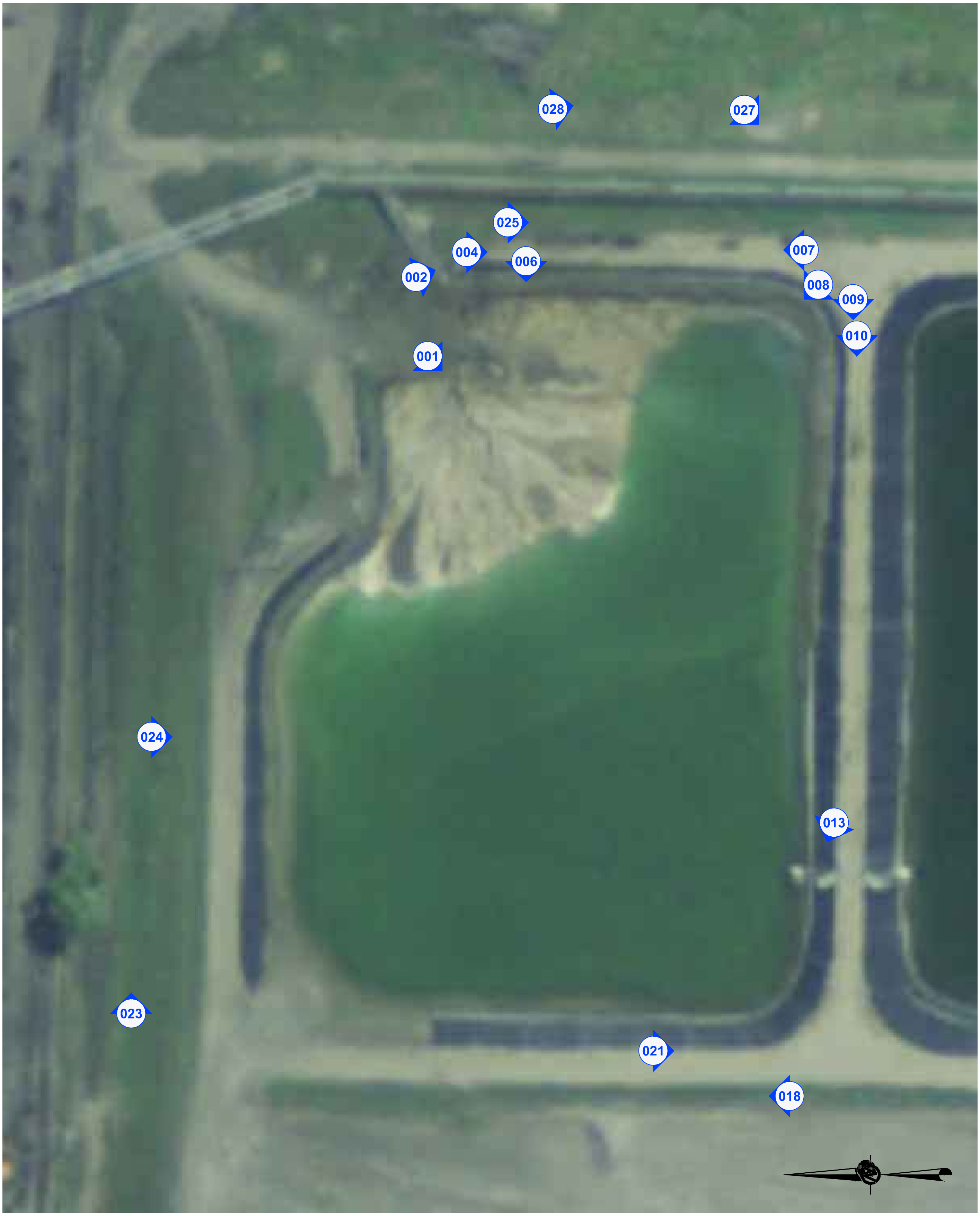
DENVER, COLORADO

CENTER POND PHOTO LOCATIONS

MAP 2

PROJECT No.113-81645 CADD TJS DATE 05/13/11 FILE No. Appendix C1.DWG

Plot Time: 05/13/11 14:58



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Layout Name: May3-D (2) Machine: DEN1-L-TSTONG
Last Update: May 13, 2011 14:56 By: tstong
Last Plot: May 13, 2011 14:58 By: tstong

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NORTH POND PHOTO LOCATIONS

MAP 1

PROJECT No.113-81645 CADD TJS DATE 05/13/11 FILE No. Appendix C1.DWG

Plot Time: 05/13/11 14:58

Bottom Ash Inlet Pipes (001)

Coal Pit and Retention Ponds Inlets (002)

Exposed Geomembrane on East Upstream Slope (004)

Small Puncture in Geomembrane Liner (006)

North Cell from SE Corner, 1 of 3 (007)

North Cell from SE Corner, 2 of 3 (008)

North Cell from SE Corner, 3 of 3 (009)

Crest between North and Center Cells (010)

Outlet Structure (013)

West Downstream Slope (018)

Crack in Shallow Cover over Anchor Trench (021)

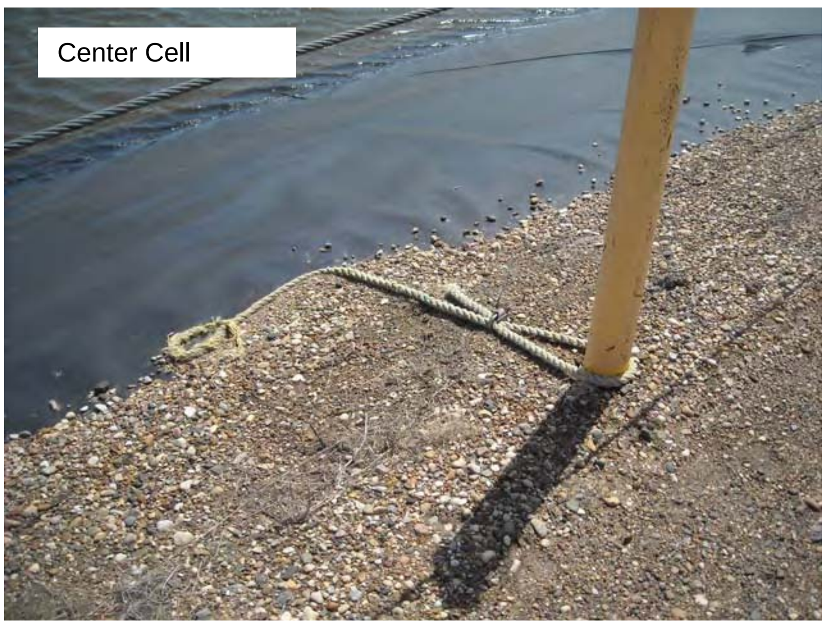
Steepened Toe of North Downstream Slope (023)

Small Animal Burrow on North Downstream Slope (024)

East Upper Downstream Slope (025)

Ponded Water at Toe of East Downstream Slope (028)

Erosion and Bottom Ash on East Downstream Slope (027)

	
Inlet Structure from North Cell (042)	Monitoring Well MW-100 in Berm (044)
	
Damaged/Broken Egress Safety Rope (045)	Slight Crack Across West Berm (046)

Small Animal Burrow on West Downstream Slope (048)

West Downstream Slope (049)

Inlet Structure from South Cell (050)

Crest between Center and South Cells (051)

Geomembrane Attachment to Inlet Structure (052)

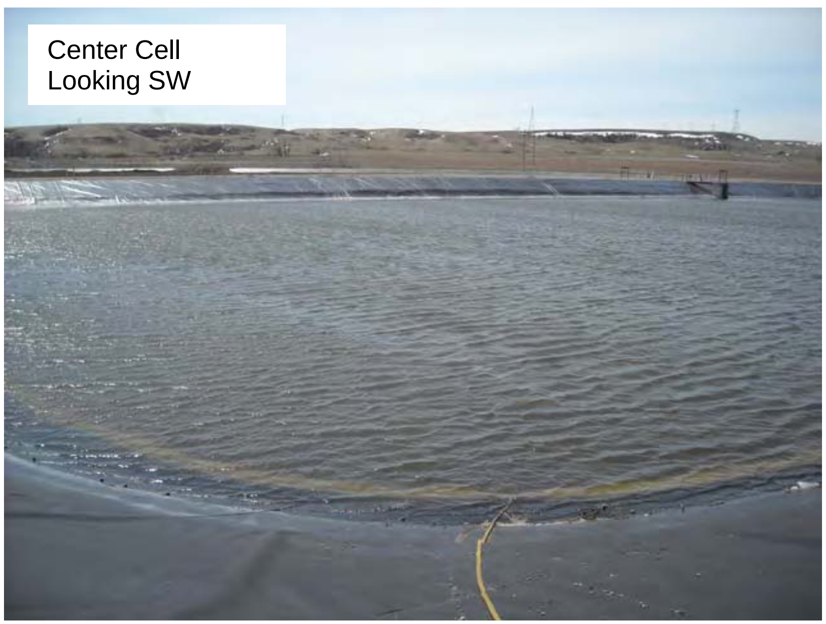
Displacement of Lower Upstream Slope, East Berm (054)

East Berm Downstream Slope (055)

Displacement of Lower Upstream Slope, East Berm (056)

Vent in Geomembrane Liner (057)

Center Cell from NE Corner, 1 of 3 (058)



Center Cell from NE Corner, 2 of 3 (059)

Center Cell from NE Corner, 3 of 3 (060)

Crest of East Berm (061)

Toe of East Downstream Slope (062)

East Downstream Slope, Road at 1715 (063)

Erosion Rill/Slough/Scarp on East Downstream Slope (064)

Erosion Rill/Slough/Scarp on East Downstream Slope (065)

Erosion Rill/Slough/Scarp on East Downstream Slope (066)

Dead Tree at East Downstream Toe (070)

Erosion Rill/Slough/Scarp on East Downstream Slope (068)

	
Crest of South Berm (073)	Crest of East Berm (074)
	
South Cell from SW Corner 1 of 3 (076)	South Cell from SW Corner 2 of 3 (077)

South Cell from SW Corner 3 of 3 (078)

Small Animal Burrow in East Downstream Slope (079)

West Downstream Slope (080)

Open Geomembrane Seam on West Upstream Slope (082)

Crest of West Berm (083)

Outlet Structure on North Berm (087)

Puncture of Geomembrane Liner on North Upstream Slope (088)

Puncture of Geomembrane Liner on North Upstream Slope (089)

Coal Pit and Retention Ponds Inlets (090)
Trapped Water Between Geomembrane and Clay Liners

Bottom Ash Inlet Pipes (091)

Torn Geomembrane Liner on East Upstream Slope (095)

Ripped Liner at Equipment Crossing of East UpstreamSlope (096)

Downstream Slope of East Berm, Road at 1715 (097)

South Cell
Looking W

Erosion Rill/Slough/Scarp on East Downstream Slope (098)

Steepened Toe of East Downstream Slope (099)

South Cell
Looking W

Erosion Rill/Slough/Scarp on East Downstream Slope (101)

Erosion Rill/Slough/Scarp on East Downstream Slope (103)

Dead Tree at East Downstream Toe (104)

Ditch at Toe of South Downstream Slope (108)

South Downstream Slope (109)

Larger Animal Burrow on South Downstream Slope (110)

Larger Animal Burrow on South Downstream Slope (112)

Bottom Ash on South Downstream Slope (113)

Slough/Scarp Line Along South Downstream Slope (114)

December 22, 2011 113-81645

Jennifer Charles
Great River Energy
Stanton Station
40001 Highway 200A
Stanton, North Dakota 58571

RE: STABILITY EVALUATION OF BOTTOM ASH SURFACE IMPOUNDMENT ADDENDUM

Dear Jennifer Charles:

Golder Associates Inc. (Golder) has prepared this addendum to the *Stability Evaluation of Bottom Ash Surface Impoundment* (*Stability Evaluation*) report to provide Great River Energy (GRE) with an updated stability evaluation for GRE's Bottom Ash Surface Impoundments at Stanton Station (SS) (Figure 1). The stability evaluation provided in this addendum will include a summary of the site-specific engineering parameters, an updated stability analysis based on the site-specific soil properties, and final recommendations and conclusions. The information provided in this addendum is intended to update Section 2.0, Slope Geomoetries, and Section 4.0, Conclusion and Recommendations, from the *Stability Evaluation* dated May 16, 2011.

1.0 PIEZOMETERS

Site-specific material properties were determined from soils collected during the installation of two piezometers in the Bottom Ash Impoundment embankment. Piezometers were installed by Midwest Testing Laboratory, Inc. (A Terracon Company) on October 4, 2011. Russ Nelson and Todd Stong from Golder provided oversight and observed the installations. Boring logs and lab analyses are provided in Attachment A.

Piezometer P-1 was installed south of the intake structure on the middle cell, close to the geomembrane anchor trench. Piezometer P-2 was installed south of the intake structure and east of the pipe rack. The approximate location of each piezometer is shown on Figure 2. The piezometers were installed through the embankment and completed in the natural soil. The total depth of P-1 is 31 feet below ground surface (ft bgs) and the total depth of P-2 is 25 ft bgs. The piezometers were constructed with 2-inch PVC and a 20-foot slotted screen. Complete construction details are provided in Attachment B and summarized in Table 1.

Interstate Engineering surveyed the piezometers (P-1 and P-2). The northing and easting coordinates for the piezometers could not be correlated to the coordinate system used by SS. Therefore, the piezometer locations shown on Figure 1 are approximate. The top of PVC pipe elevation and ground surface elevation are accurate and provided in Table 1 and on Figure 2.

2.0 SLOPE GEOMETRIES

The cross sections through the Bottom Ash Surface Impoundment remain unchanged from the initial *Stability Evaluation.* The description of each cross section is provided subsequently for completeness.

The cross sections that were evaluated for stability are the north/south, west, and east downstream (outside) slopes, and the upstream (interior) slope (Figure 3). Two scenarios for each cross section were evaluated. The first scenario examined the stability for an intact geomembrane and the second analysis

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examined the stability if no geomembrane is present. A total of eight stability scenarios were analyzed. The geometries of each cross section are as follows:

North and South Berms

The geometry of the north and south downstream slopes are the same; therefore, one stability analysis was performed to examine both downstream slopes. The stability of the downstream slopes was examined according to design grades. The design indicates a 20-foot wide crest at an elevation of 1720 feet with 3:1 side slopes to approximately 1700 feet. Grades from a 2001 aerial survey were used to confirm the design slope geometry. The cross section for the north and south downstream slope is shown on Figure 4.

West Berm

The west downstream slope has a design crest width of 20 feet at an elevation of 1720 feet and extends at an approximate 3:1 slope down to an elevation of 1700 feet (approximately). This section geometry was also verified with grades from the 2001 aerial survey. The cross section for the west downstream slope is shown on Figure 8.

East Berm

The east downstream slope has a design crest width of 20 feet at an elevation of 1720 feet and extends at an approximate 3:1 slope down to an elevation of 1715 feet. There is a 4-foot wide bench at elevation 1715 then a 3:1 slope down to an elevation of 1700 feet (approximately). Site observations, as-built drawings and sections developed using the 2001 aerial survey do not match the design geometry. The bench at elevation 1715 is substantially wider than the design and was modeled as 20 feet. The cross section for the east downstream slope is shown on Figure 12.

Upstream (Interior) Berm

The upstream slope has an approximate 3:1 slope from elevation 1720 feet down to elevation 1702 feet. This section geometry was verified with the as-built drawings and grades from the 2001 aerial survey. The cross section for the upstream slope is shown on Figure 16. The analysis of the upstream slope did not look at bottom ash on the smooth geomembrane but focused on the underlying clay liner and berm.

2.1 Engineering Parameters

Soil properties were determined from geotechnical material testing performed on the soil collected during the installation of the piezometers on October 4, 2011. Soils were tested for moisture, density, grain-size distribution, shear strength and hydraulic conductivity. The material properties for each soil included in the stability analysis of the Bottom Ash Surface impoundment are provided in Table 2 and discussed subsequently. Lab results are provided in Attachment A and C.

2.1.1 Historic Embankment Fill

Historic Embankment Fill properties were based on the borings for piezometers P-1 and P-2. The Historic Embankment Fill was classified as a silty sand (SM). Piezometer borings were advanced through the historic embankment and laboratory analyses were performed on three soil samples to determine dry density, five soil samples to determined moisture content, and two soil samples to determine plasticity and gradation.

Dry unit weight values were 108.8, 111.0 and 114.9 pounds per cubic foot (pcf) with moisture contents between 9.0 and 13.6 percent. Averages are used in the stability analysis to account for the material variability in the Historic Embankment Fill. The dry unit weight chosen is 112 pcf with a moisture content of 11 percent. This results in a moist unit weight of 124 pcf.

The saturated unit weight was determined by applying the saturated moisture content of the silty sand from the Natural Soil. The Natural Soils were assumed to be saturated because the soil was observed at or below the water table. The saturated unit weight of the Historic Embankment Fill is 133 pcf with a saturated water content of 19 percent.

The predominant soil in the embankment fill is silty sand (SM). A three-point tiaxial shear test was performed to determine the effective stress shear strength parameters. The effective stress friction angle was 35.4 degrees with cohesion of 31 pounds per square foot (psf). A more conservative failure envelope was evaluated by eliminating the second point at 10 pounds per square inch (psi) confining pressure, which resulted in an effective stress of 30.1 psi and cohesion of 246 psf. For this analysis, an effective stress friction angle of 30 degrees and an effective cohesion intercept of 100 psf were conservatively chosen.

The hydraulic conductivity is based on the results of the flexible wall permeameter test performed on silty sand collected in a Shelby tube from the Historic Embankment. The hydraulic conductivity for the Historic Embankment Fill used in the stability analysis is 3×10^{-6} cm/sec.

2.1.2 Natural Soil

The Natural Soils are predominantly silty sands (SM) with layers of fat clay (CH). The dry unit weight of the Natural Soil chosen is 104 pcf and is based on the dry unit weight of a silty sand layer collected 22 ft bgs from Boring 1. The moist unit weight was determined from averaging the moisture content of five silty sand samples collected from Borings 1 and 2 and is 19 percent.

The hydraulic conductivity for the Natural Soils was based on the flexible wall permeameter test results of the silty sand from the Historic Embankment Fill. The friction angle and cohesion were also based on the silty sand from the Historic Embankment Fill previously described.

2.1.3 New Embankment Fill

The New Embankment was constructed from clayey soil from the Glenharold Mine site. The material is predominantly fat clay (CH). Dry density of the constructed embankment ranges between 94 and 108.8 pcf with an average of approximately 100 pcf. The moisture content of the constructed embankment ranged between 20.4 and 26 percent with an average of 23 percent. The moist unit weight from these averages is approximately 123 pcf.

The saturated unit weight of the New Embankment Fill is based on the water content of the Natural Clay Soil. Two soil samples were collected from the Natural Clay Soil with moisture contents of 29 and 30 percent. The Natural Soils were assumed to be at or below the water table. Therefore, the saturated water content of the New Embankment Fill is 28 percent with a saturated unit weight of 128 pcf.

Soil strength values are based on effective stress shear strength parameters determined from a three-point triaxial shear test performed on the clay collected from the New Embankment in a Shelby tube. The effective stress friction angle was 30.2 degrees with cohesion of 365 psf. For this analysis, an effective stress friction angle of 30 degrees and an effective cohesion intercept of 200 psf were conservatively chosen.

The hydraulic conductivity used in the stability analysis for the New Embankment Fill is 2×10^{-8} cm/sec. The hydraulic conductivity is based on the results of the flexible wall permeameter test performed on the fat clay collected in a Shelby tube from the New Embankment.

2.1.4 Compacted Fill

The Compacted Fill was assumed to be taken from the Glenharold Mine site. Therefore, the Compacted Fill is assumed to be fat clay and has the same material properties as the Glenharold Mine clay/New Embankment.

2.1.5 Geomembrane

Geomembrane interface inputs are based on previous experience by Golder and published values. The interfaces of interest are a smooth HDPE against Compacted Fill (Glenharold Mine clay) and smooth HDPE against bottom ash. The geomembrane/clay interface is more critical than the geomembrane/bottom ash interface; therefore, the geomembrane/bottom ash interface will not be included in analyses. A residual friction angle of 7.5 degrees and a residual adhesion intercept of approximately 190 psf are used in the stability analysis (Koerner 2005). These values are considered conservative and are considered appropriate for use in the Stanton Station stability analyses.

The hydraulic conductivity for HDPE liner was taken from HELP program documentation as 2.0×10^{-13} cm/sec (Schroeder 1994).

2.2 Groundwater Information

Groundwater generally flows north under the Bottom Ash Surface Water Impoundment toward the Missouri River. Groundwater is typically within 10 feet below the final construction grades of the Impoundment and is at an approximate elevation of 1700 feet amsl near the South Cell and 1690 near the North Cell (Barr 2011). Water elevations observed in piezometers P-1 and P-2 directly after well construction were: 1,698.3 feet above mean sea level (ft amsl) at P-1 and 1,695.9 ft amsl at P-2. The flux of water from the impoundment to the groundwater is expected to be minimal since the impoundment is lined.

2.3 Stability Analysis

Golder performed stability analyses using SLIDE (Rocscience 2011). Factors of safety were computed for circular failure surfaces using Spencer's method for force and moment equilibrium. Global stability was analyzed, which evaluates the overall stability of a cross section through the entire facility that may include both historic and expansion berms. Surficial failures at depths less than 5 feet were not evaluated in this stability analysis.

For the north/south, east and west downstream sections, the stability of each cross section was analyzed for the condition of an intact geomembrane and if no geomembrane is present reflective of a severely compromised geomembrane liner. For both analyses, the water level in the impoundment was set at elevation 1720 feet to represent maximum conditions. With an intact geomembrane, there was no flux assumed between the impoundment and the groundwater. The stability analysis for the condition of no geomembrane required the development of a phreatic surface through the berm. The phreatic surface was determined using groundwater finite element modeling within SLIDE. This surface was then modeled in the slope stability analysis as a piezometric surface through the berm. The finite element model for the phreatic surface through the north/south, west and east cross sections is shown on Figures 6, 10, and 14, respectively.

For the upstream slopes four different conditions were evaluated: the stability with the impoundment empty, the stability with the impoundment full (Elevation 1720 feet) and intact geomembrane, the stability with the impoundment full and no geomembrane, and the stability of the impoundment empty with the berm being saturated. This last condition was included to model the potential for draining of the impoundment faster than the pore pressure can dissipate in the berm. Rapid drawdown conditions were not applicable to operations of the Bottom Ash Impoundment and were not evaluated in this stability analysis.

For permanent civil engineering structures (long-term conditions), a factor of safety greater than or equal to 1.5 is desired. All of the scenarios evaluated have a factor of safety greater than 1.5 and are expected to remain stable under the anticipated loading conditions. A summary of factors of safety calculated for each scenario are provided in the following table:

Factors of Safety for Each Scenario

Description	Geomembrane	Water Level	Factor of Safety based on Site-Specific Soil Properties	Figure - Stability Analysis Results
North/South	Intact	1720 ft.	2.4	5
	None	Phreatic Surface through Berm	2.3	7
West	Intact	1720 ft.	2.4	9
	None	Phreatic Surface through Berm	2.4	11
East	Intact	1720 ft.	2.4	13
	None	Phreatic Surface through Berm	2.4	15
Upstream	NA	No Water	3.0	17
	Intact	1720 ft.	8.1	18
	None	1720 ft.	4.0	19
	None	Saturated Berm	1.9	20

This stability analysis relies on site-specific material values for shear strength based on geotechnical material tests performed on the soil collected during the installation of piezometers through the Bottom Ash impoundment berm.

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Hazard Classification

The North Dakota Dam Design Handbook (North Dakota State Engineer 1985) defines dam hazard classification as:

> Although it is recognized that loss of life is possible with any dam failure, the following hazard categories of dams have been established for North Dakota:
>
> **Low** – dams located in rural or agricultural areas where there is little possibility of future development. Failure of low hazard dams may result in damage to agricultural land, township and county roads, and farm buildings other than residences. No loss of life is expected if the dam fails.
>
> **Medium** – dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways, railroads or cause interruption of minor public utilities. The potential for the loss of a few lives may be expected if the dam fails.
>
> **High** – dams located upstream of developed and urban areas where failure may cause serious damage to homes, industrial and commercial buildings and major public utilities. There is a potential for the loss of more than a few lives if the dam fails.

The USEPA has developed a classification system associated with impoundment inspections as:

> **Less Than Low Hazard Potential**: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.
>
> **Low Hazard Potential**: Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
>
> **Significant Hazard Potential**: Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
>
> **High Hazard Potential**: Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

Based on these Dam Hazard classification systems, our review of the site and stability evaluation, Golder recommends the Bottom Ash Surface Impoundment be categorized with a Low Hazard potential. This recommended designation is based on the following:

- There are no residences or occupied structures directly adjacent to the facility and loss of human life is not deemed probable.
- A discharge of bottom ash transport water is unlikely to have a significant environmental impact as bottom ash is an inert waste and the conveyance water is currently being discharged to the river.
- The economic impacts associated with a failure will primarily be to the owner's property with the exception that failure of the south berm could damage the rail line and county road.

3.2 Recommendations

Recommendations for inspection, maintenance, and stability evaluation are detailed in the following sections. These recommendations are based on the visual observations, stability analysis, and Golder's experience with the design and operation of surface water impoundments.

3.2.1 *Inspections/Training*

An Ash Management Training session was held at Stanton Station on October 4, 2011 by Todd Stong, PE, a registered professional engineer (P.E.) in North Dakota. Attendees included ash management operators and personnel, and site engineers.

Inspection forms for the ash facilities were prepared for monthly inspections. The forms have been integrated into the inspection program and are completed during monthly inspections.

Golder recommends that GRE continue to perform monthly documented inspections of the Bottom Ash Surface Impoundment by site personnel. Inspections should also be performed after heavy rainfall and/or severe weather. These inspections should be done by employees trained in the operation and inspection of the Bottom Ash Surface Impoundment and should include observations of the inlet and outlet structures, upstream slopes, crest, downstream slopes and toe, and measurement of the water levels in the piezometers. General conditions to watch include seepage, sloughing, cracking, excessive settlement, geomembrane integrity, animal burrowing, erosion, and abnormal vegetation.

3.2.2 *Maintenance*

There were several maintenance items observed during the site evaluation on May 3, 2011 that have been repaired or are planned for repair. These items include:

- Erosion Protection and Repair
- Animal Control
- Vegetation
- Geomembrane Liner

Repairs were performed on the geomembrane of the South Cell on May 12, 2011. Geosynthetics, Inc. (GSI) performed the repairs and non-destructive testing of visible defects. Construction Quality Assurance was provided by Golder.

A Repair Plan has been prepared to address erosion, animal control, and vegetation maintenance items observed on the downstream slopes Bottom Ash Impoundment. A Repair Bid Package is being prepared to perform this scope of work.

3.2.3 *Stability*

There were several surficial slope failures observed on the downstream slopes, and slope displacement was observed on the lower portion of the Center Cell upstream slopes. The identification of punctures in the geomembrane liner, and softer material below the liner indicate the potential for leakage by the geomembrane liner that can saturate and reduce the strength of the impoundment berms.

Based on these observations, Golder recommends that the following actions be done to better evaluate the stability of the Bottom Ash Surface Impoundment.

Inspection of Crest

A slight crack was identified across the Center Cell west berm crest. The crack had no apparent opening width or depth. Golder recommends photo documenting the crack during inspections and measuring the width of gap during each inspection to monitor any movement.

Inspection of Upstream Slopes

The displacement observed on the lower portion of the Center Cell upstream slopes may be due to shallow slope failure, consolidation, settlement, material piping, wave action or a combination of these mechanisms. Due to the level of bottom ash and water in the North and South Cells, conditions could not be identified in these cells.

Golder recommends that as the different cells can be isolated, cleaned of material, and dewatered, that a more thorough evaluation of the upstream slopes be undertaken. This may include visual observations of the slopes, survey of the slopes, removal of portions of the geomembrane liner to evaluate the underling liner, and collection of soil samples to evaluate the moisture condition and strength of the underlying materials.

3.3 Closing

This report summarizes the results of Golder's stability analysis and visual observations to evaluate the stability of the Bottom Ash Surface Impoundment at Great River Energy's Stanton Station. The evaluation of the Bottom Ash Surface Impoundment is based upon available data and visual observations of field conditions at the time of the assessment.

For permanent civil engineering structures (long-term conditions), a factor of safety greater than or equal to 1.5 is desired. All of the scenarios evaluated have a factor of safety greater than 1.5 and are expected to remain stable under the anticipated loading conditions. It should be noted that the condition of the Bottom Ash Surface Impoundment is constantly changing dependent upon many internal and external conditions, and that continued monitoring and evaluation are required to identify unsafe conditions that may develop.

The various components of the Bottom Ash Surface Impoundment were found to be in both fair and poor condition. Areas identified with poor conditions included the downstream slopes with evidence of erosion rills, surficial slope failures, and rodent burrows, and the upstream slopes with evidence of geomembrane liner puncture and slope displacement.

Golder recommends that GRE continue to perform monthly inspections, that the maintenance issues be addressed as soon as practical, the water levels in the piezometers are measured during inspections, and that the stability of the upstream slopes be further evaluated future physical evaluation.

Sincerely,

GOLDER ASSOCIATES INC.

Ron Jorgenson
Principal and Practice Leader

Todd Stong, PE
Senior Engineer

Tammy Rauen, PE
Project Engineer

REFERENCES

Stone & Webster, 1994a. *Design Report Stanton Station Ash Pond Modifications.* Prepared for United Power Association, Project No. 4177. April 25, 1994.

List of Attachments

Table 1	Piezometer Summary
Table 2	Material Properties
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Attachment B	Well Registrations and Monitoring Well Construction Diagrams
Attachment C	Effective Stress Shear Strength Test Lab Reports

TABLES

Table 1: Piezometer Summary

ID	Top of PVC Pipe Elevation (ft amsl)	Ground Surface Elevation (ft amsl)	Total Depth (ft bgs)	Depth to Water (ft bgs) 10/4/11	Elevation of Water (ft amsl)
P-1	1,724.08	1,721.31	31	23	1,698.31
P-2	1,718.32	1,715.40	25	20	1,695.90

ft amsl - feet above mean sea level
ft bgs - feet below ground surface

Table 2: Material Properties

	Hydraulic Conductivity	Moisture / Density					Shear Strength	
	k_{sat} cm/sec	γ_{dry} pcf	ω %	γ_{wet} pcf	ω (sat) %	γ_{sat} pcf	ϕ'/δ degrees	c'/a psf
Historic Embankment Fill - Sand/Silt/Clay	3.0E-06	112.0	11.0	124	19.0	133	30.0	100
Natural Soil - Sand/Silt/Clay	3.0E-06	104.0	19.0	124	19.0	133	30.0	100
New Embankment Fill - Clay from Glenharold Mine	2.0E-08	100.0	23.0	123	28.0	128	30.0	200
Compacted Fill – Clay from Glenharold Mine	2.0E-08	100.0	23.0	123	28.0	128	30.0	200
Smooth HDPE / Clay	2.0E-13	NA	NA	NA	NA	NA	7.5	190
Bottom Ash	3.0E-02	68	18.5	80	58.8	107	40	NA

FIGURES

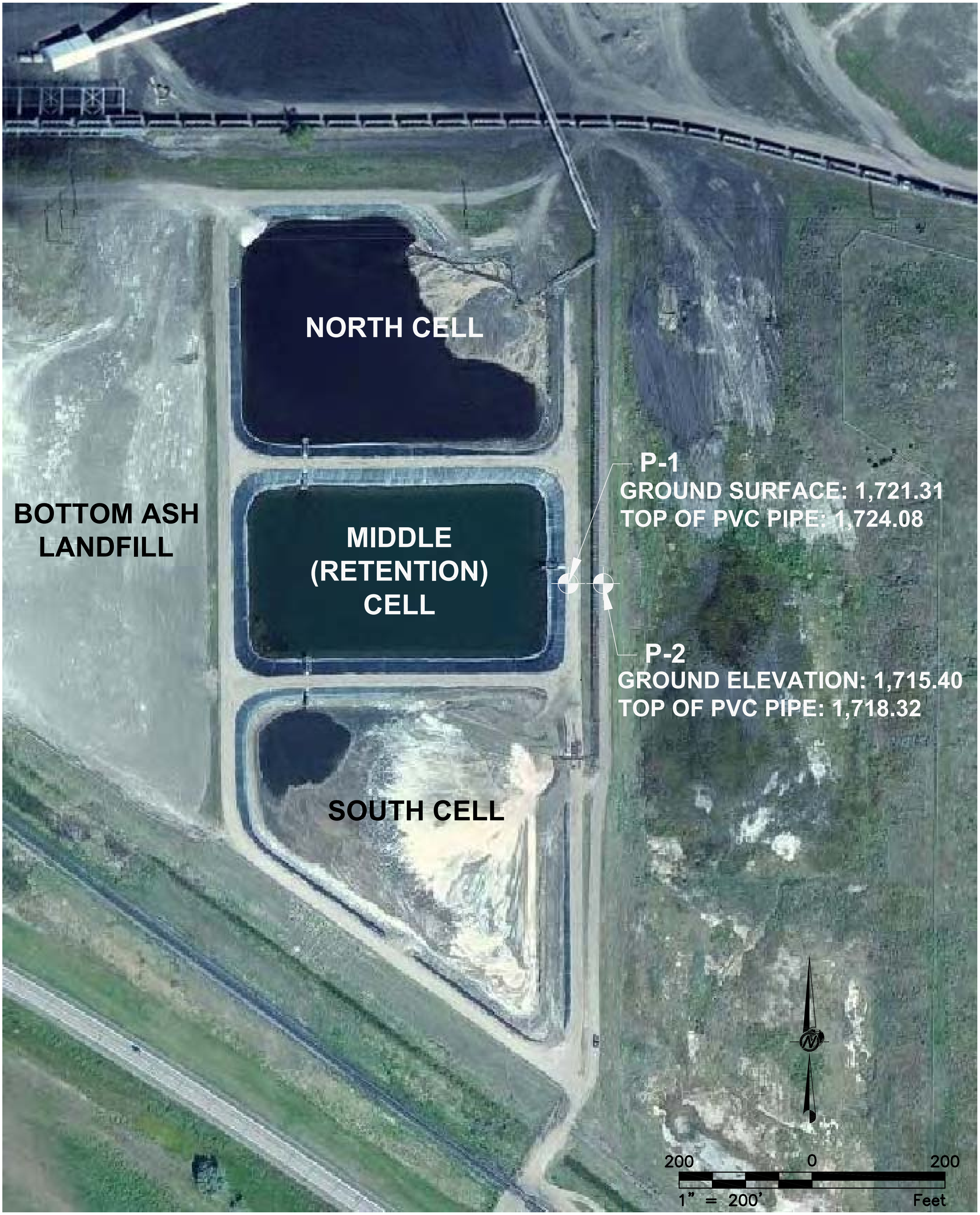
GREAT RIVER ENERGY
STANTON STATION
SITE LOCATION

Golder Associates

FIGURE 1

PROJECT No. 113–81645 CADD TLR DATE 12/16/2011 FILE No. Stanton Aerial_21Dec2011.dwg

Drawing File: \\DEN1-S-FS1-vm.golder.gds\projects\11JOBS\113-81645 GRE - Stanton Station\Aerial\ Stanton Aerial_21Dec2011.dwg | Layout: FIGURE 1 | Modified: Dec 21, 2011 15:36 TRauen | Plotted: 12/21/11 3:41pm CSchuettpelz

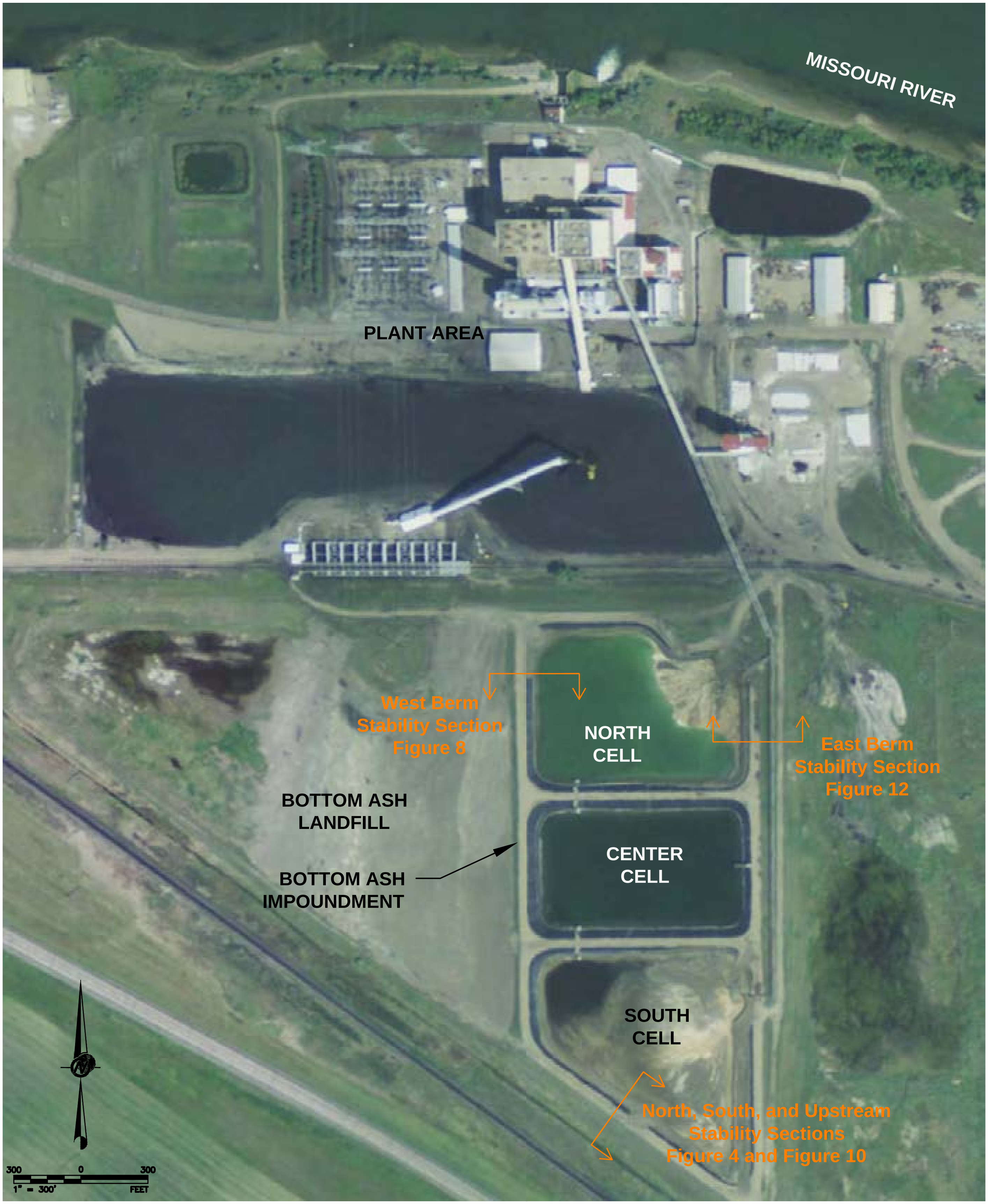


PIEZOMETER LOCATIONS AND ELEVATIONS

Golder Associates
DENVER, COLORADO

FIGURE 2

PROJECT No.113-81645 CADD TLR DATE 12/13/2011 FILE No. Stability Addendum_21Dec2011.dwg



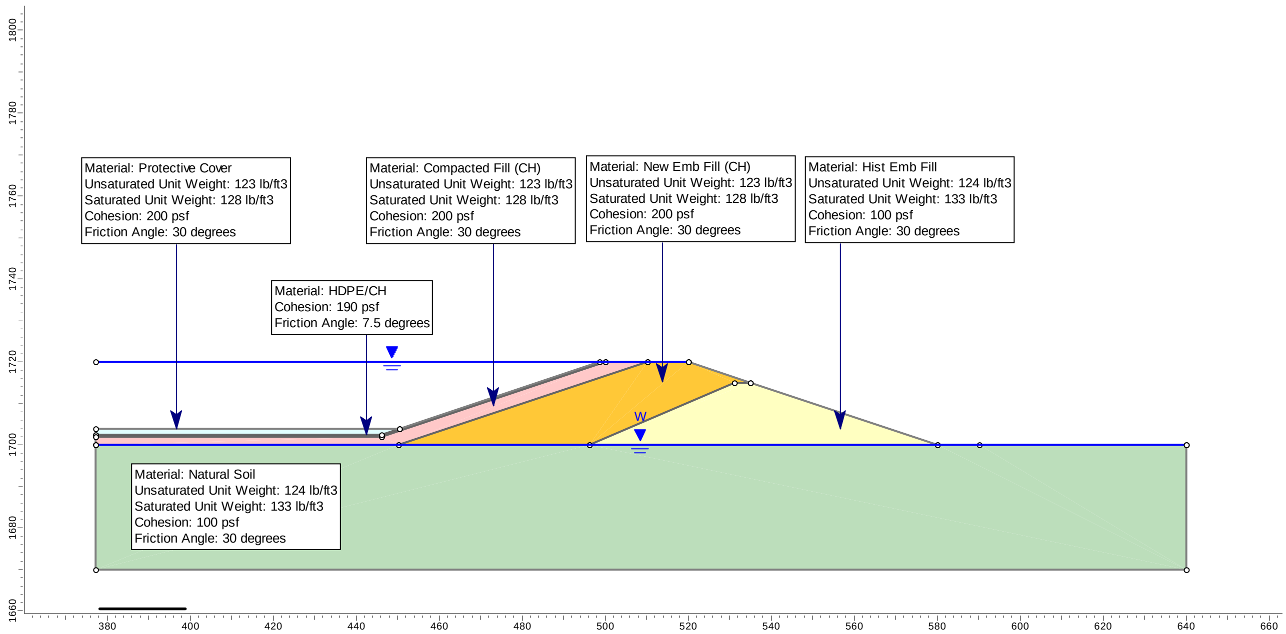
GREAT RIVER ENERGY
STANTON STATION
PLANT AREA

Golder Associates

FIGURE 3

PROJECT No. 113–81645 CADD TLR DATE 12/16/2011 FILE No. Stanton Aerial_21Dec2011.dwg

Drawing File: \\DEN1-S-FS1-vm.golder.gds\projects\11JOBS\113-81645 GRE – Stanton Station\Aerial\ Stanton Aerial_21Dec2011.dwg | Layout: FIGURE 3 | Modified: Dec 21, 2011 15:36 TRauen | Plotted: 12/21/11 3:43pm CSchuettpelz

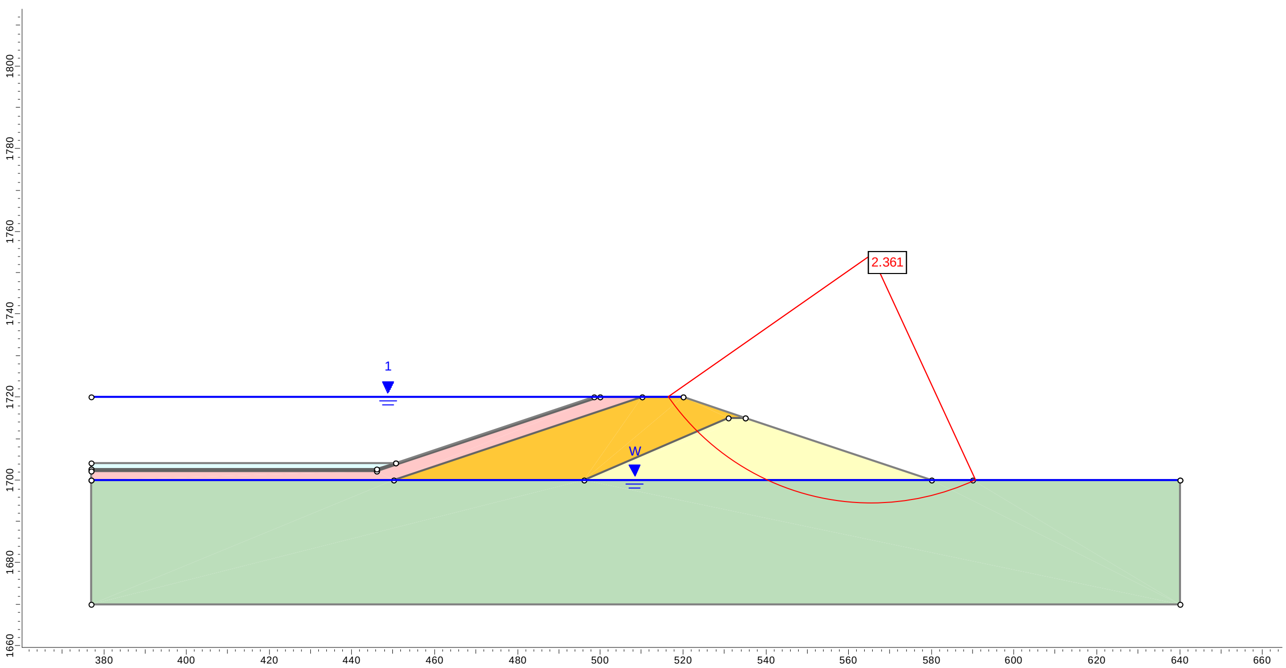


NORTH AND SOUTH BERMS CROSS SECTION

Golder Associates
DENVER, COLORADO

FIGURE 4

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

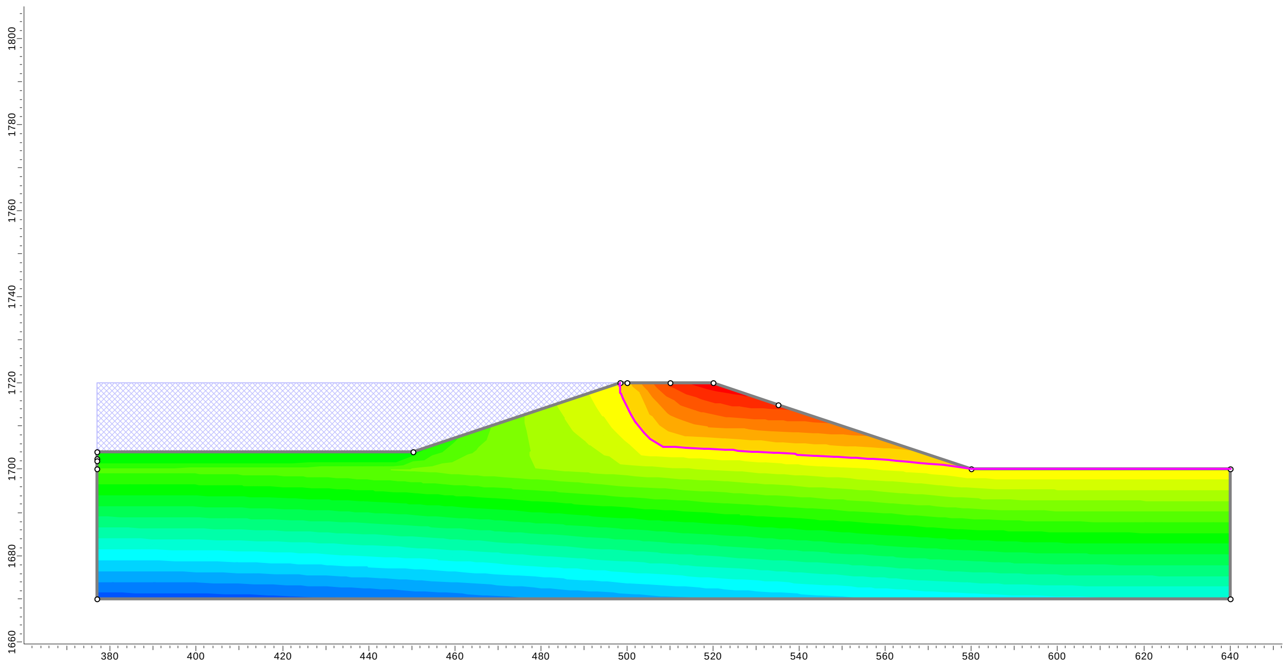


NORTH AND SOUTH BERMS WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 5

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

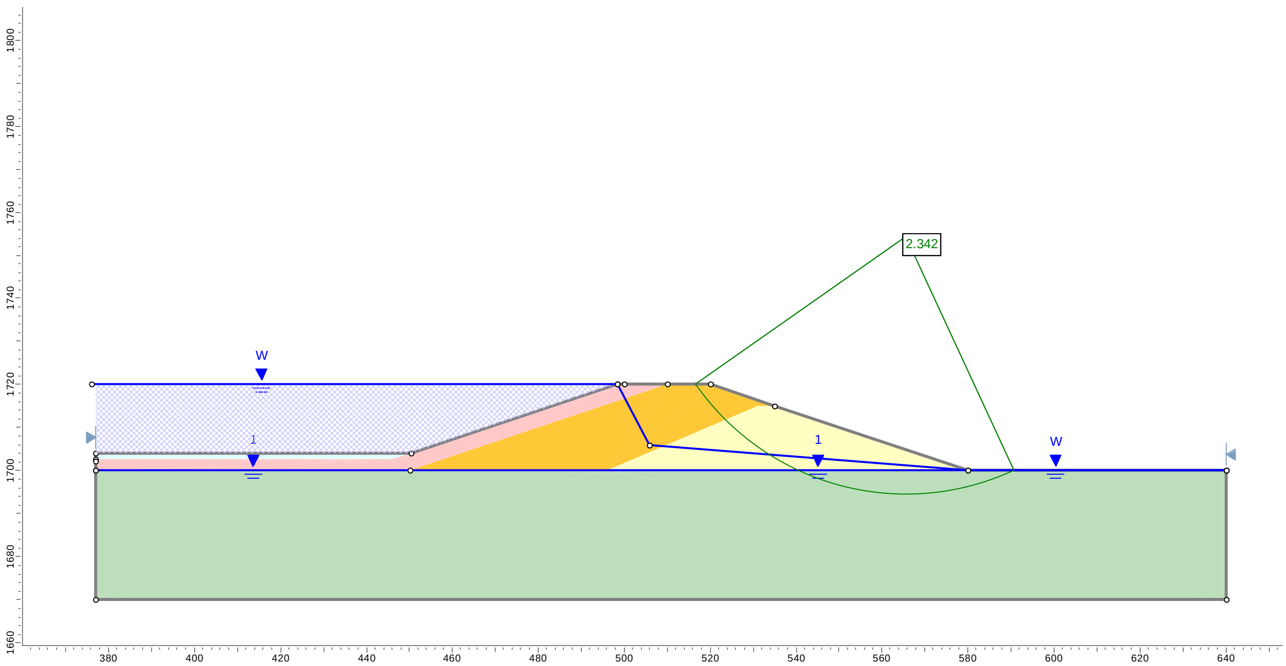


NORTH AND SOUTH BERMS WITH NO GEOMEMBRANE
WATER TABLE ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 6

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

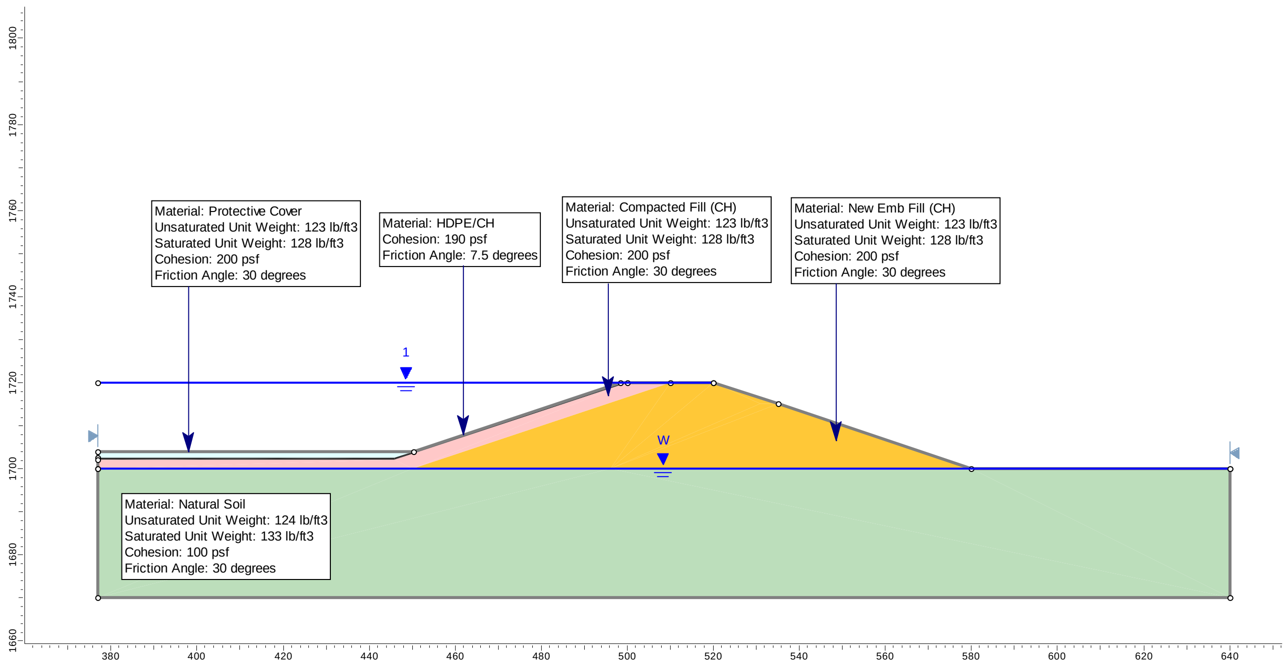


NORTH AND SOUTH BERMS WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 7

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

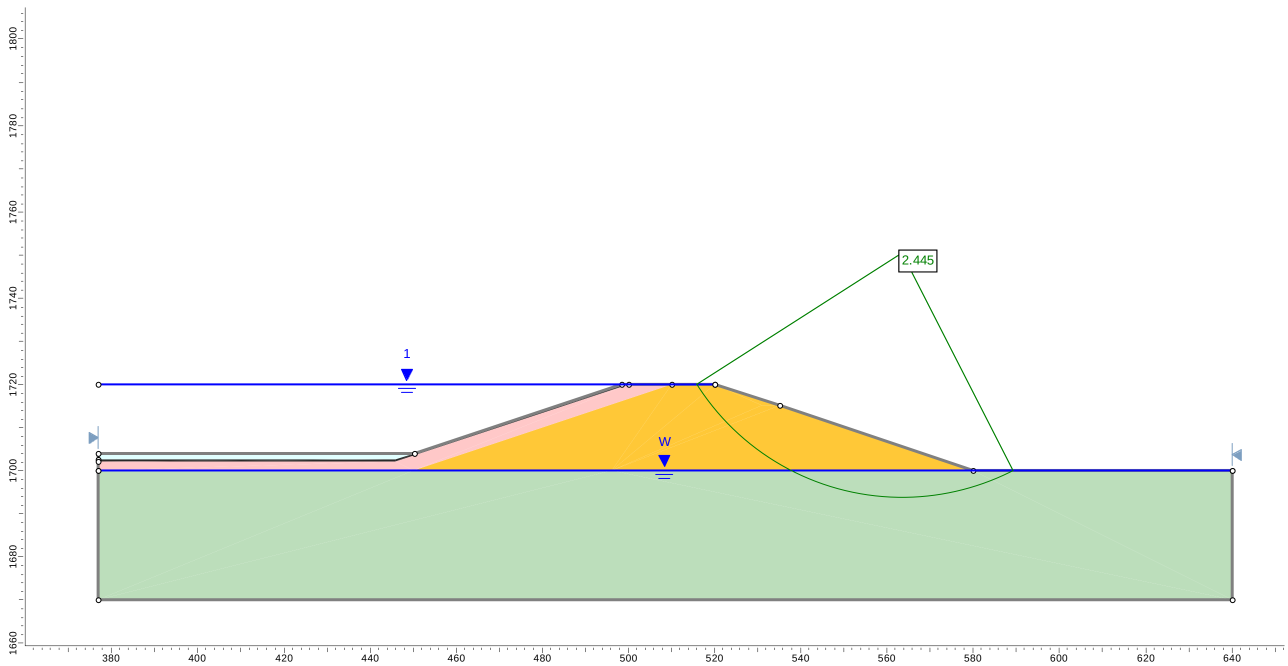


Golder Associates
DENVER, COLORADO

WEST BERM CROSS SECTION

FIGURE 8

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

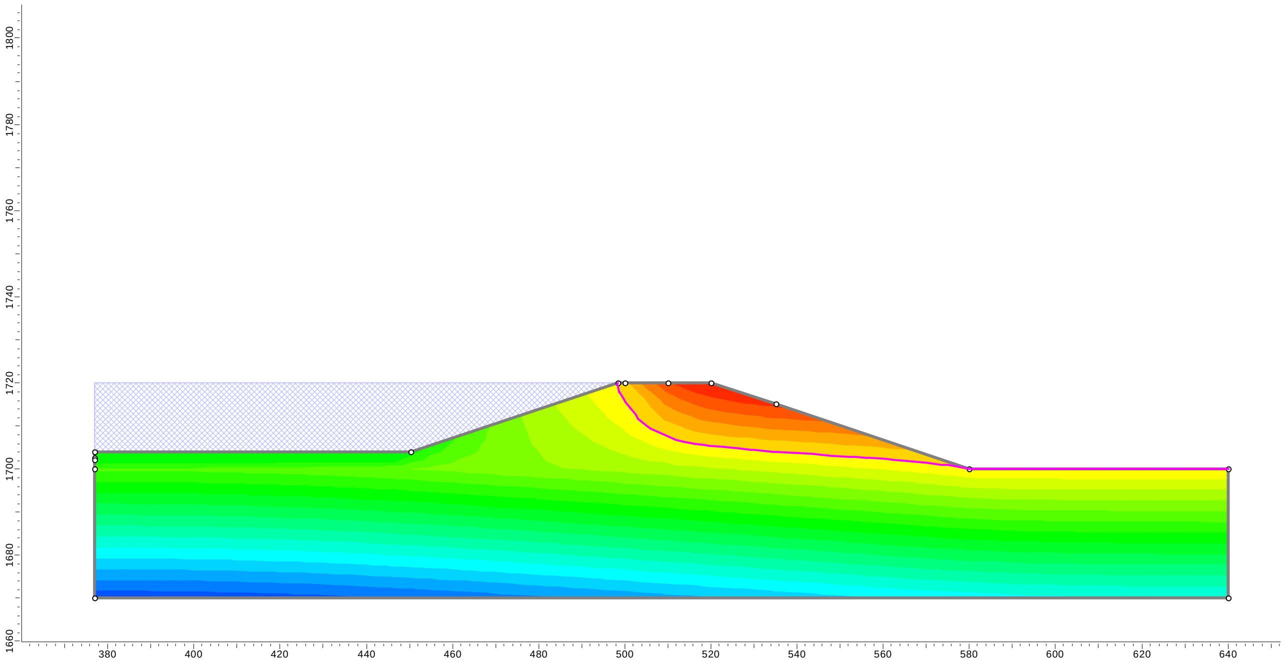


WEST BERM WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 9

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

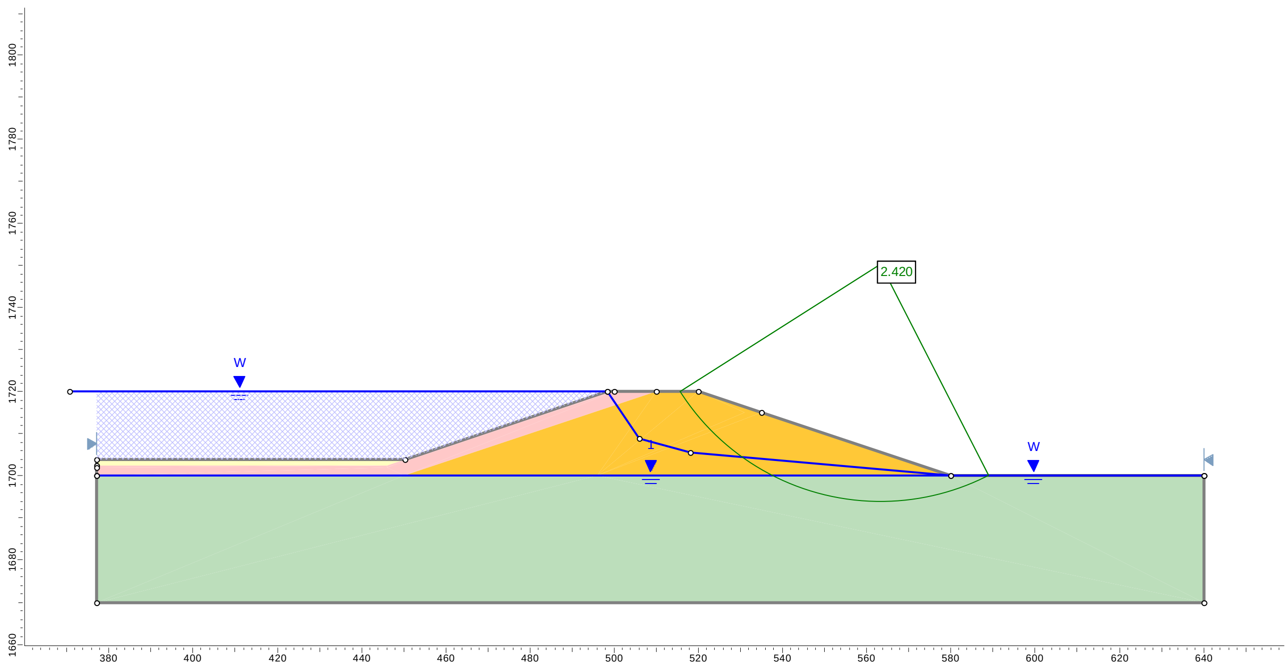


WEST BERM WITH NO GEOMEMBRANE WATER TABLE ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 10

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

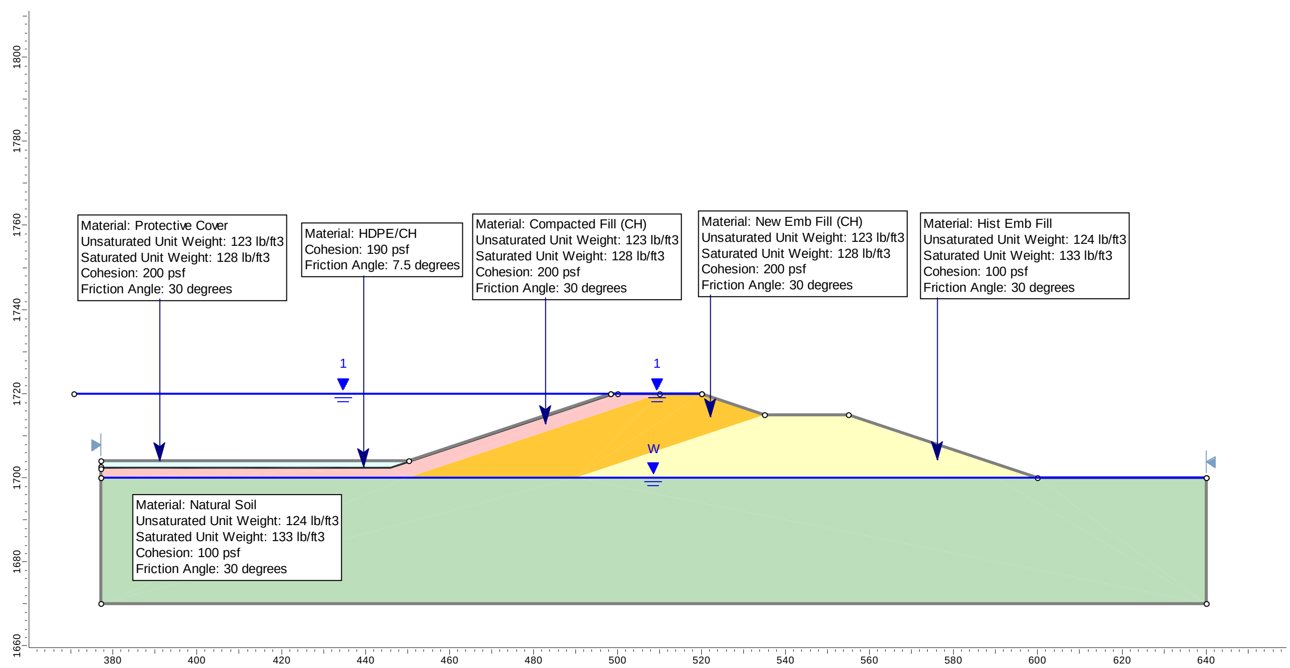


WEST BERM WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 11

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

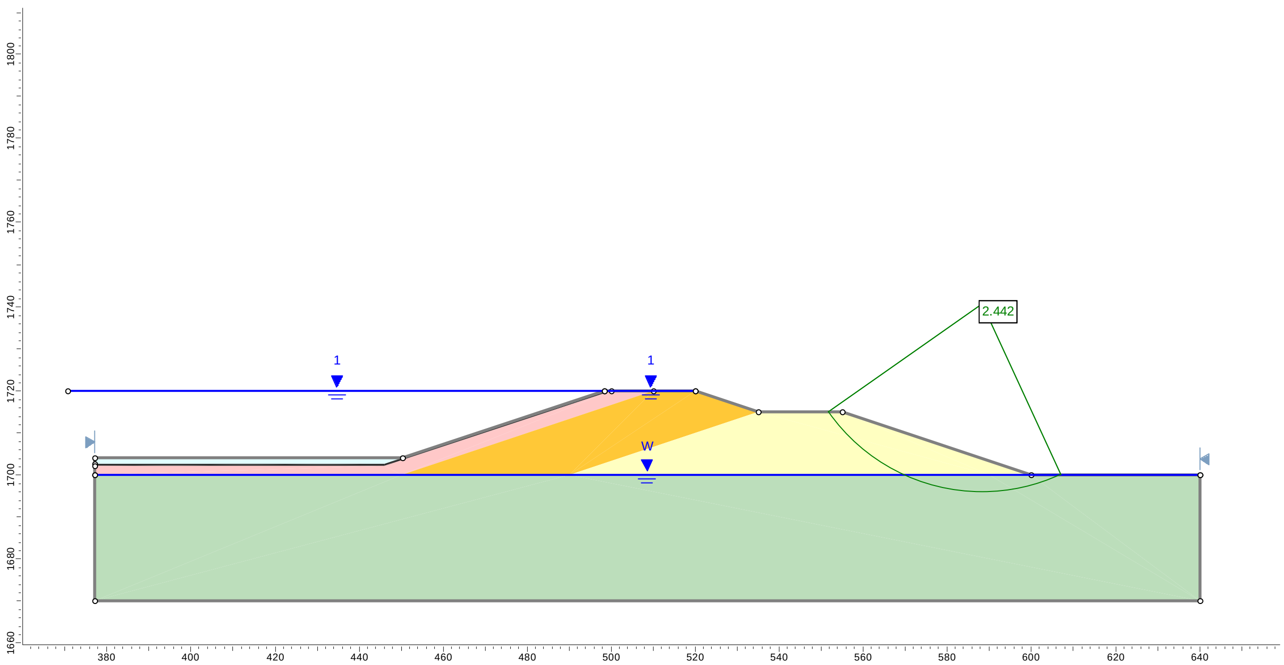


EAST BERM CROSS SECTION

Golder Associates
DENVER, COLORADO

FIGURE 12

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

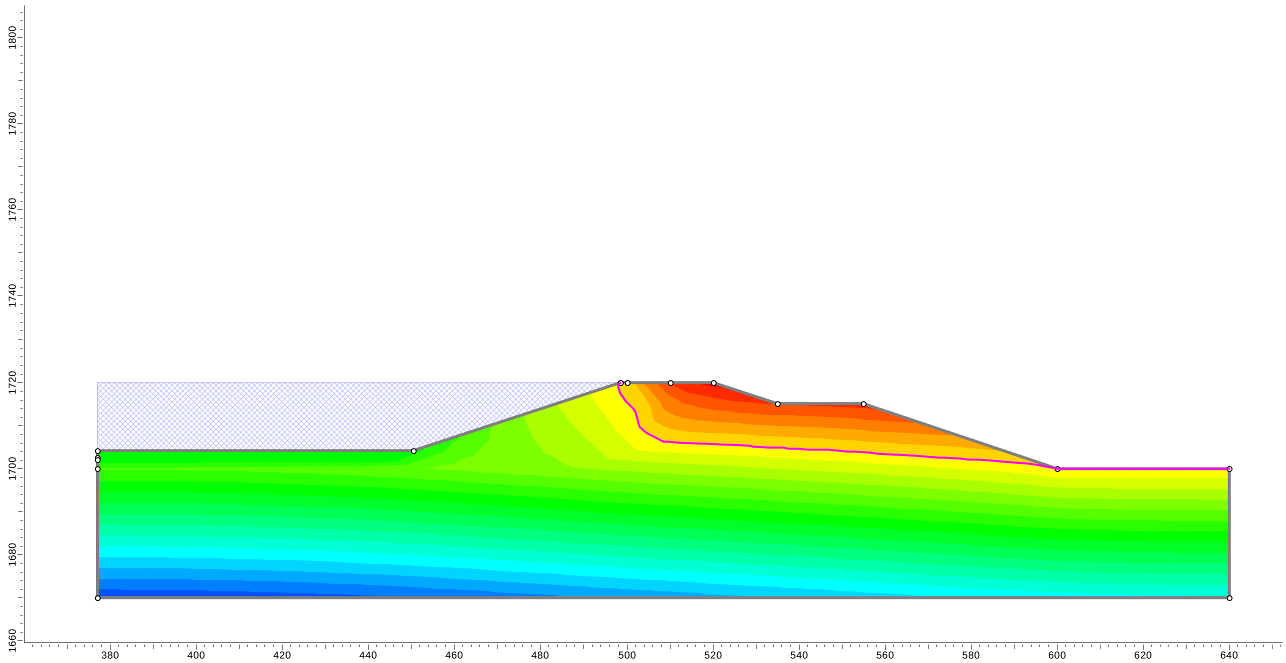


EAST BERM WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 13

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

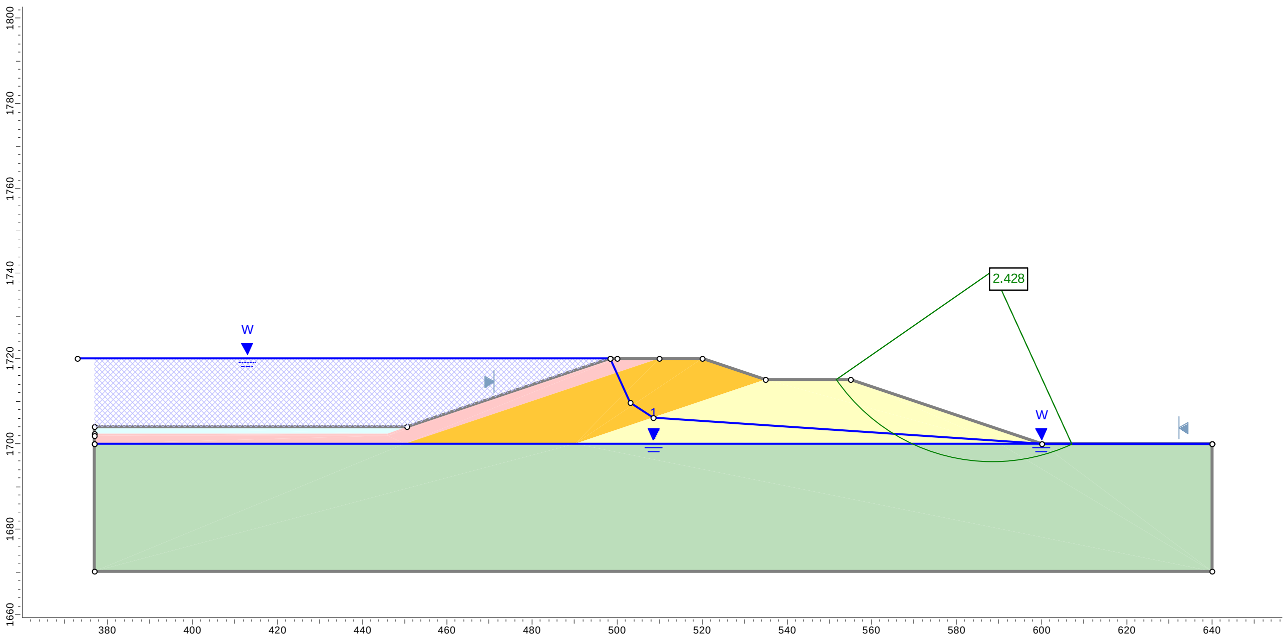


EAST BERM WITH NO GEOMEMBRANE WATER TABLE ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 14

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

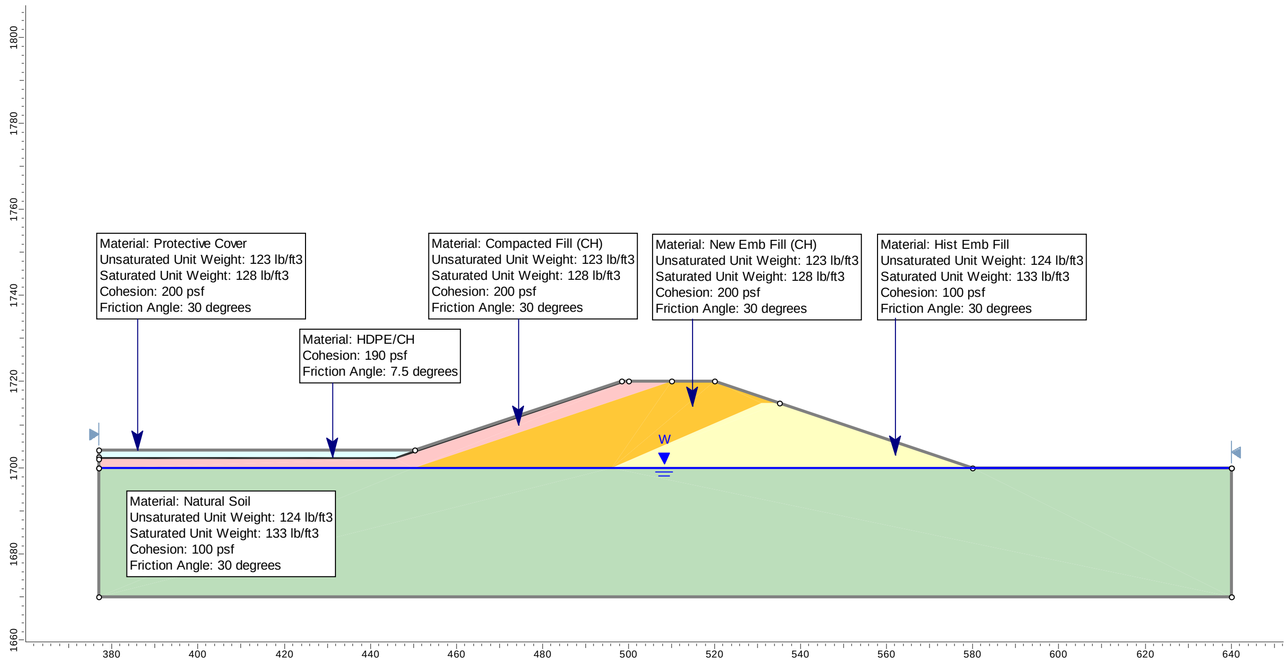


EAST BERM WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 15

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

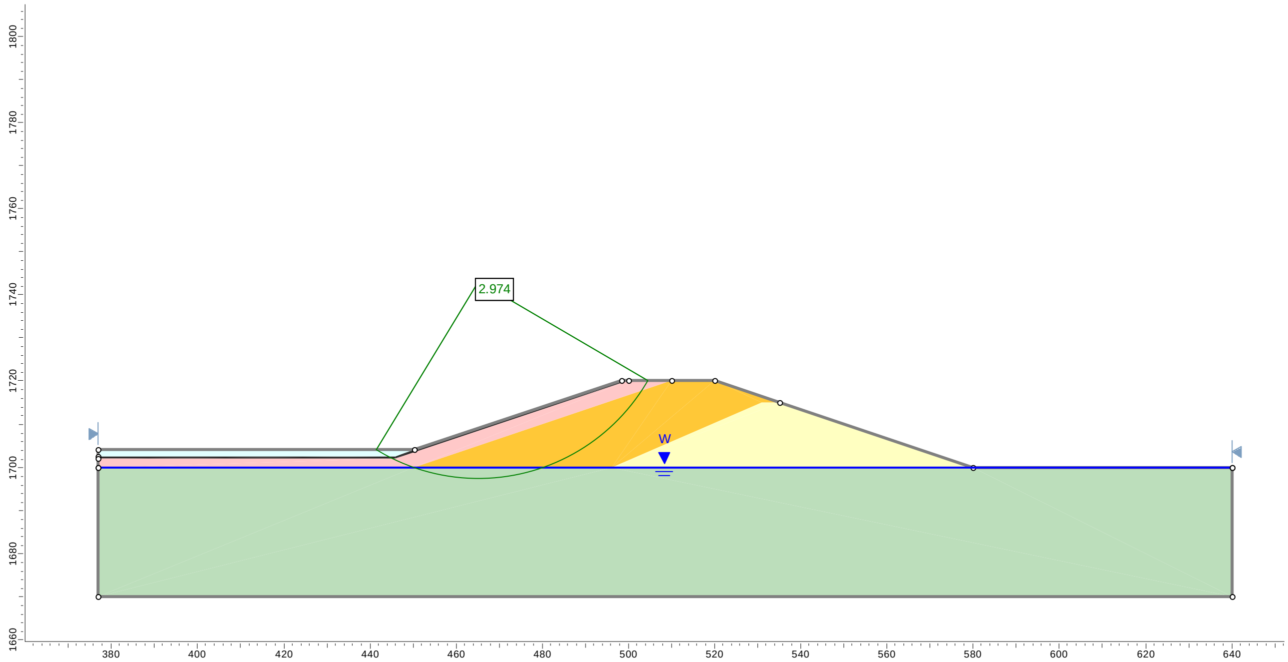


UPSTREAM CROSS SECTION

Golder Associates
DENVER, COLORADO

FIGURE 16

PROJECT No.113–81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

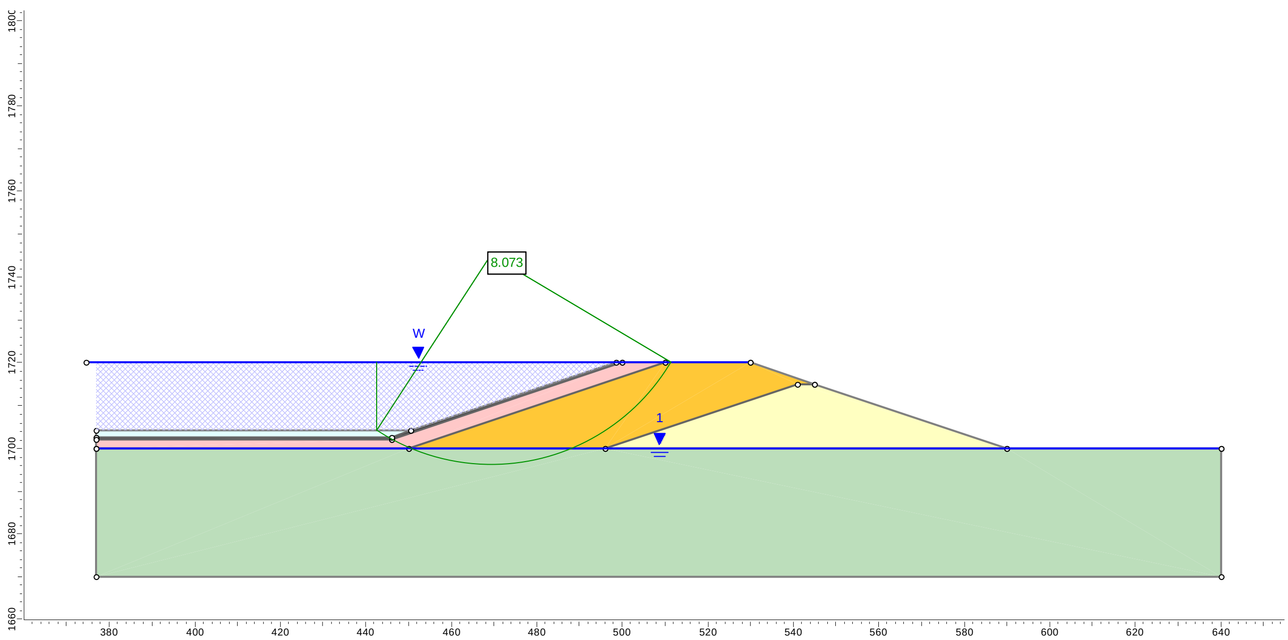


UPSTREAM BERM WITH EMPTY IMPOUNDMENT STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 17

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

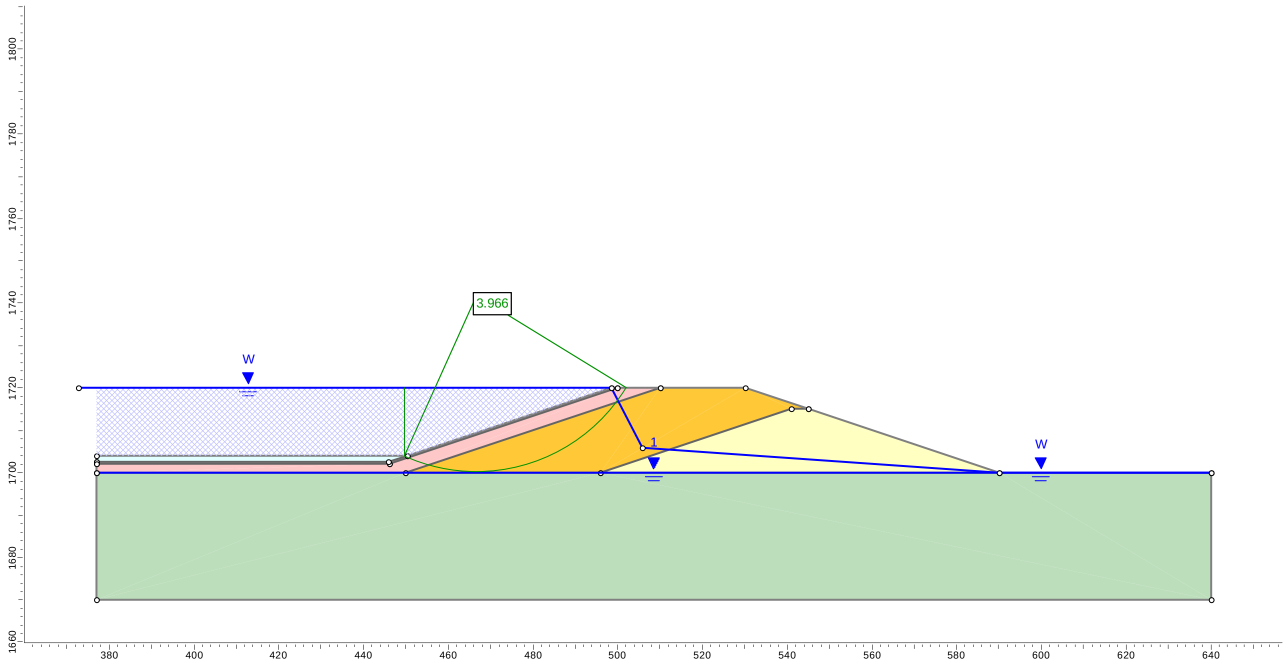


UPSTREAM BERM WITH INTACT GEOMEMBRANE AND FULL IMPOUNDMENT STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 18

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

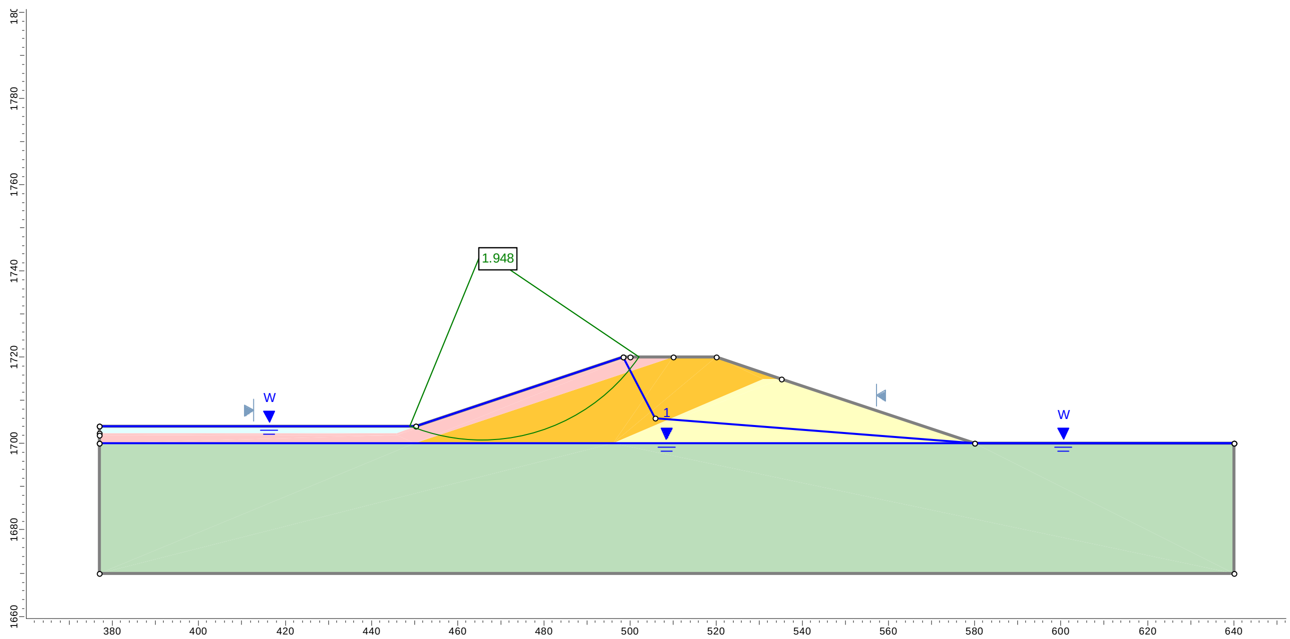


UPSTREAM BERM WITH NO GEOMEMBRANE AND FULL IMPOUNDMENT STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 19

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg



UPSTREAM BERM WITH NO GEOMEMBRANE AND SATURATED BERM STABILITY ANALYSIS RESULT

Golder Associates
DENVER, COLORADO

FIGURE 20

PROJECT No.113-81645 CADD TLR DATE 5/2/2011 FILE No. Evaluation Figures.dwg

ATTACHMENT A
BORING LOGS AND MIDWEST TESTING LABORATORIES
SOIL TEST RESULTS

Midwest Testing Laboratory, Inc.
A Terracon Company

October 19, 2011

Golder Associates, Inc
44 Union Blvd, Suite 300
Lakewood, CO 80228-1856

Attn: Todd Stong

RE: Piezometer Installations
Great River Energy – Stanton Station
Stanton, North Dakota
GAI #113-81645, MTL Project M2115282

Dear Todd:

Attached please find logs of the two borings advanced for the above-referenced project. These borings were converted to piezometers installations.

Piezometer construction diagrams and the state of North Dakota required monitoring well reports will be sent to you after the appropriate ownership information and survey data has been obtained.

As requested, several soil samples were selected for laboratory analysis. The testing program included determining moisture content, dry density, Atterberg limits and grain-size distribution. Additionally, moisture-density relationships were determined on three bag samples. All test results are included on the attached boring logs opposite of the samples on which they were performed and on the attached summary reports.

Should you have any questions or require further assistance, please contact us.

Sincerely,

MIDWEST TESTING LABORATORY

Steven S. Smith, P.E.
Senior Project Engineer

SSS/cb

Attachments: test boring logs (2)
tests of soils (2)
grain-size distributions (6)
moisture-density relationships
soil classifications
descriptive terminology

cc: Golder Associates, Inc\Tammy Rauen

Midwest Testing
LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Dr, PO Box 2084
Bismarck, ND 58502-2084
Phone (701) 258-2833 Fax (701) 258-2857

JOB NO.: M21115282 LOG OR TEST BORING NO.: 1 VERTICAL SCALE: 1"=5'

PROJECT: Piezometer Installations, Great River Energy-Stanton Station, Stanton, North Dakota

DEPTH IN FEET	SOIL DESCRIPTION SURFACE ELEVATION:	SAMPLE NO	SAMPLE TYPE	N	LABORATORY TESTS MOISTURE	DENSITY	LL/PL	Q_u (psf)
2"	GRAVEL							
	FILL-FAT CLAY-grayish brown, soft to stiff, moist (CH)	1	SS	3				
		2	SS	4	26	94		
		3	TW	--				
		4	SS	9	24	98		
		5	TW	–				
		6	SS	13	24	97		
12	FILL-FAT CLAY WITH SAND-brown, stiff, coal inclusions (CH)							
14	FILL-FAT CLAY-grayish brown, stiff, coal inclusions (CH)	7	TW	–				
		8	SS	14	22	102		
		9	TW	–				
20	SILTY SAND-brownish gray, fine-grained, medium dense, waterbearing @ 23' (SM)	10	SS	10	19	104		
		11	SS	13	18			
		12	SS	12	17			
27½		13	SS	10	30	94		
	FAT CLAY-grayish brown, mottled, stiff, moist (CH)							
28½	SILTY SAND-grayish brown, fine to medium-*							
29½	FAT CLAY-grayish brown, mottled, stiff, moist (CH)							
31	END OF BORING *grained, waterbearing (SM)							

WATER LEVEL DATA

DATE	TIME	CAVE IN DEPTH	WATER LEVEL
10-4-11	11:25	HSA 22½'	23'
10-4-11	11:35	HSA 29½'	28'
10-4-11	12:00	30'	None

BORING DATA

STARTED: 10-4-11 COMPLETED: 10-4-11 @ 11:35

METHOD USED: 3¼" ID HSA 0-29½'

CREW CHIEF: M. Roberts

Midwest Testing LABORATORY, INC.
A Terracon COMPANY

1805 Hancock Dr, PO Box 2084
Bismarck, ND 58502-2084
Phone (701) 258-2833 Fax (701) 258-2857

JOB NO.: M21115282 LOG OR TEST BORING NO.: 2 VERTICAL SCALE: 1"=4'

PROJECT: Piezometer Installations, Great River Energy-Stanton Station, Stanton, North Dakota

DEPTH IN FEET	SOIL DESCRIPTION SURFACE ELEVATION:	SAMPLE NO.	SAMPLE TYPE	N	LABORATORY TESTS MOISTURE	DENSITY	LL/PL	Q_u (psf)
4"	FILL-FAT CLAY WITH SAND-brown, coal *	1	SS	22				
	FILL-SILTY SAND-brown, fine to medium-grained, medium dense (SM)	2	SS	9	9			
2	SILTY SAND-dark brown to brown, fine-grained, loose to medium dense to very loose (SM)	3	TW	--				
		4	SS	20	7			
	*inclusions (CH)							
		5	TW	--				
		6	SS	3	11	111		
		7	TW	–				
17	SAND WITH SILT-light brown, fine-grained, medium dense to loose, waterbearing @ 19½' (SP-SM)	8	SS	11	18			
		9	SS	6	21			
		10	SS	11	29	94		
22½	FAT CLAY-grayish brown, mottled, stiff, moist (CH)							
		11	TW	--				
26	END OF BORING							

WATER LEVEL DATA

DATE	TIME	CAVE IN DEPTH	WATER LEVEL
10-4-11	14:00	HSA 19½'	19½'
10-4-11	14:15	HSA 24½'	20'
10-4-11	14:30	25'	23'

BORING DATA

STARTED: 10-4-11 **COMPLETED:** 10-4-11 @ 14:15

METHOD USED: 3¼" ID HSA 0-24½'

CREW CHIEF: M. Roberts

MIDWEST TESTING LABORATORY

1805 Hancock Dr / PO Box 2084 / Bismarck, North Dakota 58502
Telephone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: TESTS OF SOILS

PROJECT: Piezometer Installations
Great River Energy – Stanton Station
Stanton, North Dakota
GAI #113-81645

DATE: October 19, 2011

REPORTED TO: Golder Associates, Inc
Attn: Todd Stong
44 Union Blvd, Suite 300
Lakewood, CO 80228-1856

COPIES: Golder Associates, Inc
Attn: Tammy Rauen

PROJECT NO: M2115282

SAMPLE NUMBER:	1	2	3
LOCATION:	Test boring 1, depth 1-17'	Test boring 2, depth 1-15'	Test boring 2, depth 1-15'
CLASSIFICATION:	FAT CLAY (CH)	SILTY SAND (SM)	SILTY SAND (SM)
COLOR:	Grayish brown	Grayish brown	Grayish brown
PARTICLE DISTRIBUTION (see attached curves):			
Gravel (%)			
Coarse (plus 30 mm)			
Fine (30-5 mm)			
Sand (%)			
Coarse (5-2 mm)			
Medium (2-.44 mm)	2	3	3
Fine (.44 mm-.074)	6	70	67
Fines (%)			
Silt (.074-.005 mm)	42	14	17
Clay (.005-.001 mm)	17	4	4
Colloids (less than .001 mm)	33	9	9
ATTERBERG LIMITS:			
Liquid Limit	63	NP	NP
Plastic Limit	17	NP	NP
Plasticity Index	46	NP	NP
LABORATORY MOISTURE-DENSITY RELATIONS (see attached curves):			
Method	Standard proctor, ASTM:D698, Method "A"		
Optimum Moisture (%)	20.9	11.4	12.2
Maximum Density (pcf)	103.0	119.0	117.4

REMARKS: Samples were obtained at the locations shown above by Midwest Testing Laboratory on October 4, 2011.

Signed: [signature]

MIDWEST TESTING LABORATORY

Project No.: M2115282

Sample Source: 1, Borehole #1, Depth: 1'-17'

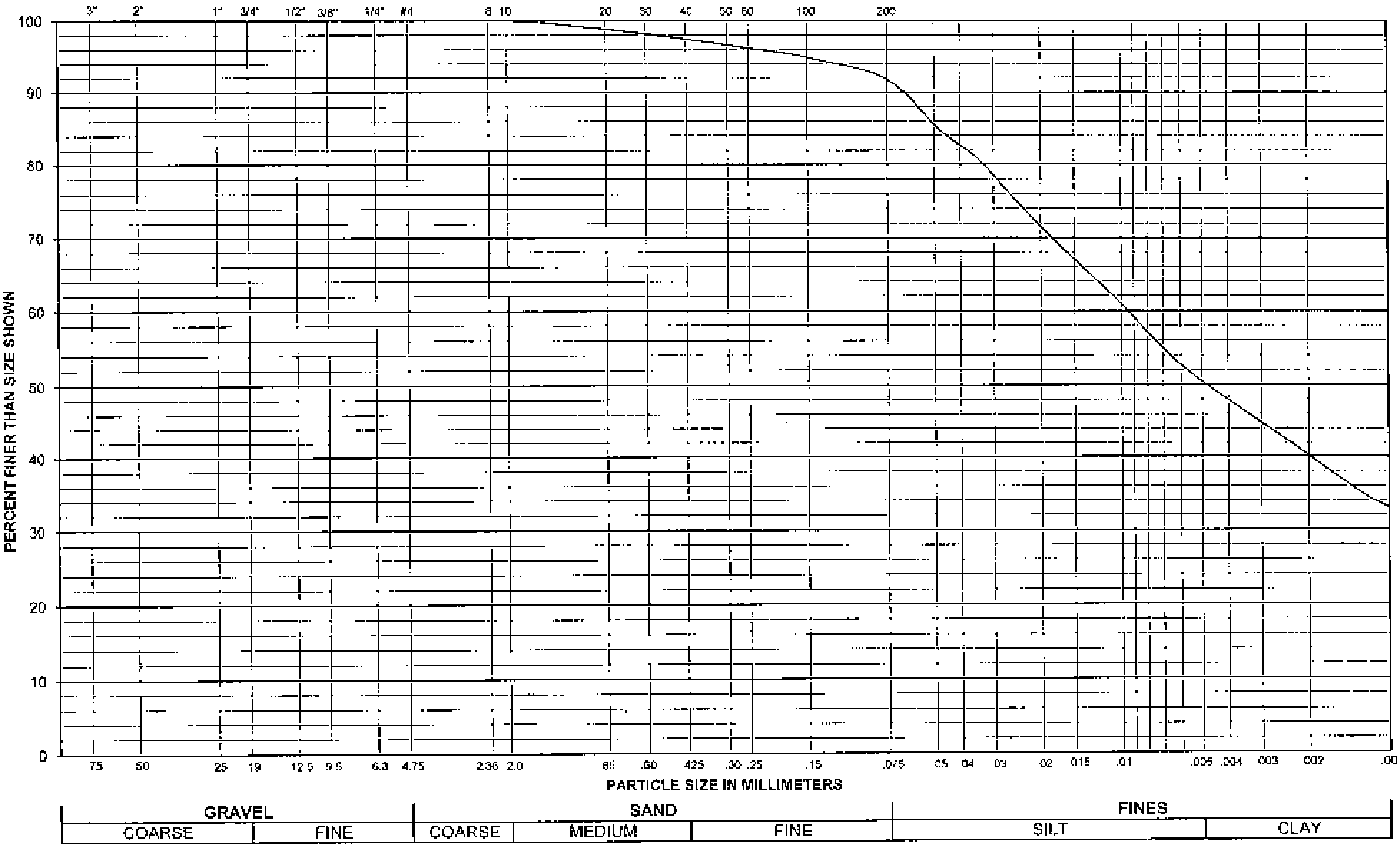
Classification: FAT CLAY - grayish brown (CH)

Project: Piezometer Installations
GRE - Stanton Station
Stanton, ND

Reported to: Golder Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

U.S. Standard Sieve Sizes



MIDWEST TESTING LABORATORY

1805 Hancock Dr. / P.O. Box 2084 / Bismarck, North Dakota 58502
Phone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: MOISTURE-DENSITY RELATIONS OF SOIL

PROJECT: Piezometer Installations
Great River Energy – Stanton Station
Stanton, North Dakota
GAI #113-81645

DATE: October 19, 2011

REPORTED TO: Golder Associates, Inc
Attn: Todd Stong
44 Union Blvd, Suite 300
Lakewood, CO 80228-1856

COPIES: Golder Associates, Inc
Attn: Tammy Rauen

PROJECT NO: M2115282

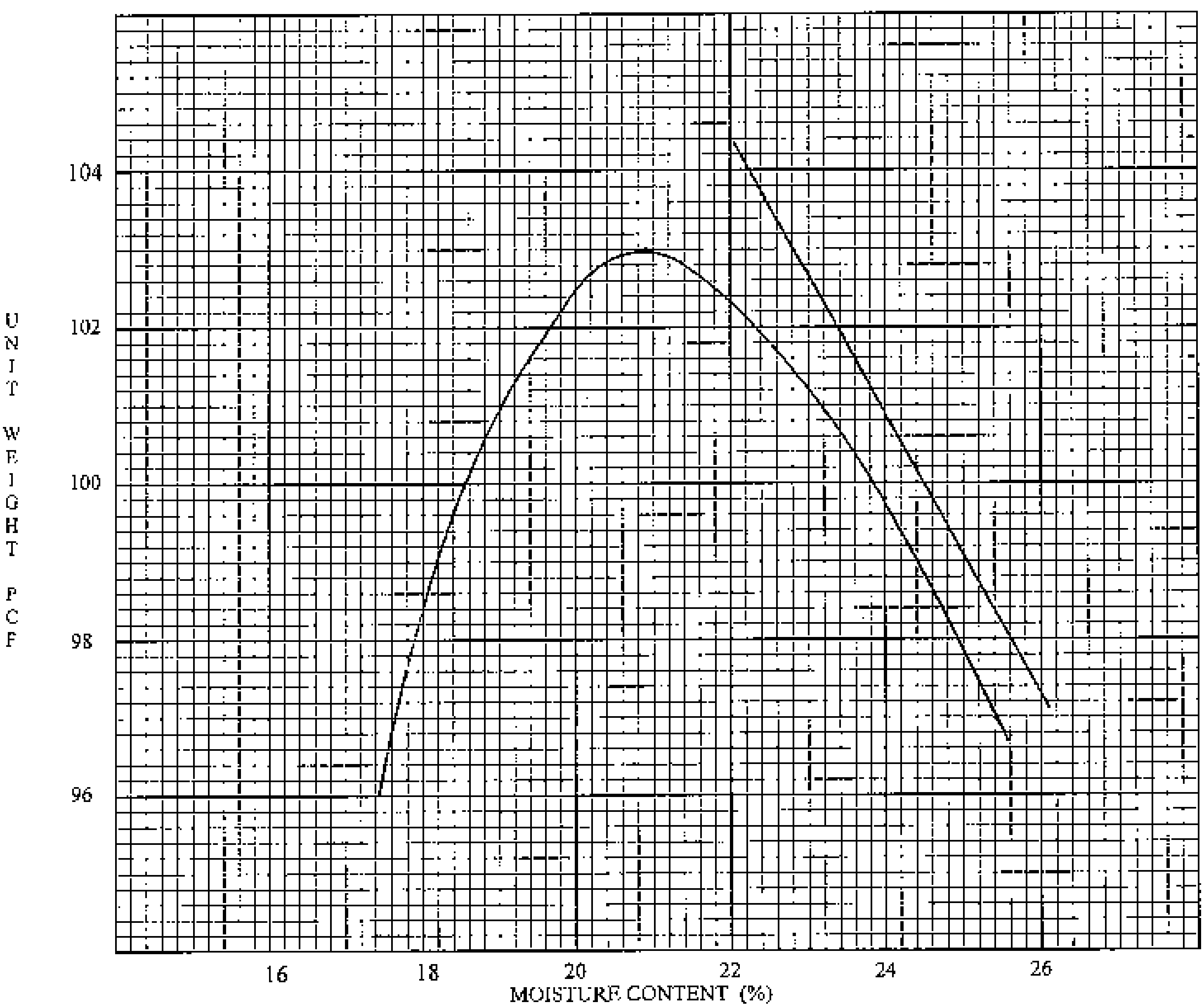
SAMPLE NUMBER: 1 (Test boring 1, depth 1-17')

METHOD: Standard proctor, ASTM:D698, Method "A"

MAXIMUM DENSITY: 103.0 pcf

SOIL TYPE: FAT CLAY-grayish brown (CH)

OPTIMUM MOISTURE: 20.9%

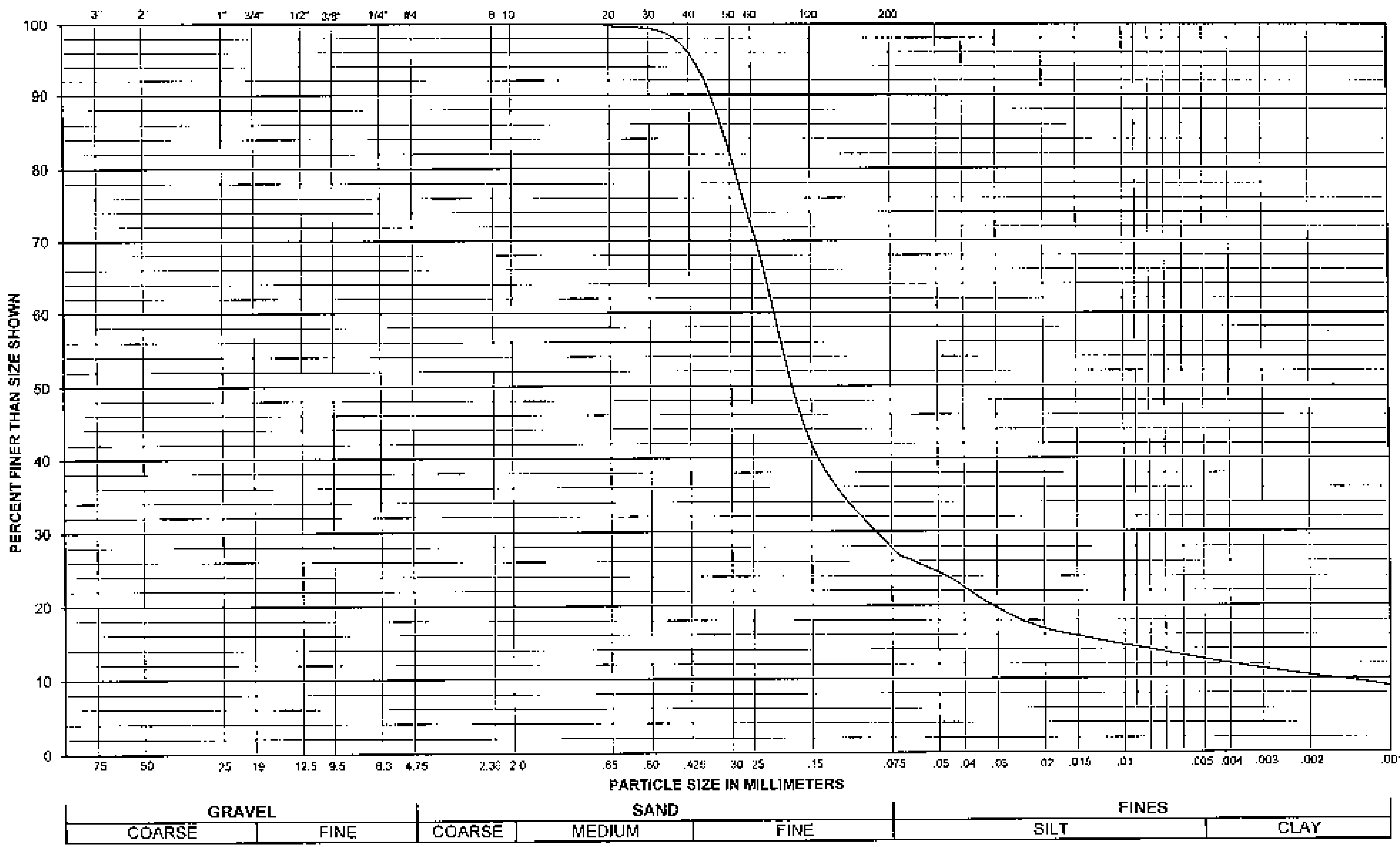


MIDWEST TESTING LABORATORY

Project No.:	M2115282	Project:	Piezometer Installations GRE - Stanton Station Stanton, ND
Sample Source:	2, Borehole #2, Depth: 1'-15'		
Classification:	SILTY SAND - grayish brown (SM)	Reported to:	Golder Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

U.S. Standard Sieve Sizes



MIDWEST TESTING LABORATORY

1805 Hancock Dr. / P.O. Box 2084 / Bismarck, North Dakota 58502
Phone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: MOISTURE-DENSITY RELATIONS OF SOIL

PROJECT: Piezometer Installations
Great River Energy – Stanton Station
Stanton, North Dakota
GAI #113-81645

DATE: October 19, 2011

REPORTED TO: Golder Associates, Inc
Attn: Todd Stong
44 Union Blvd, Suite 300
Lakewood, CO 80228-1856

COPIES: Golder Associates, Inc
Attn: Tammy Rauen

PROJECT NO: M2115282

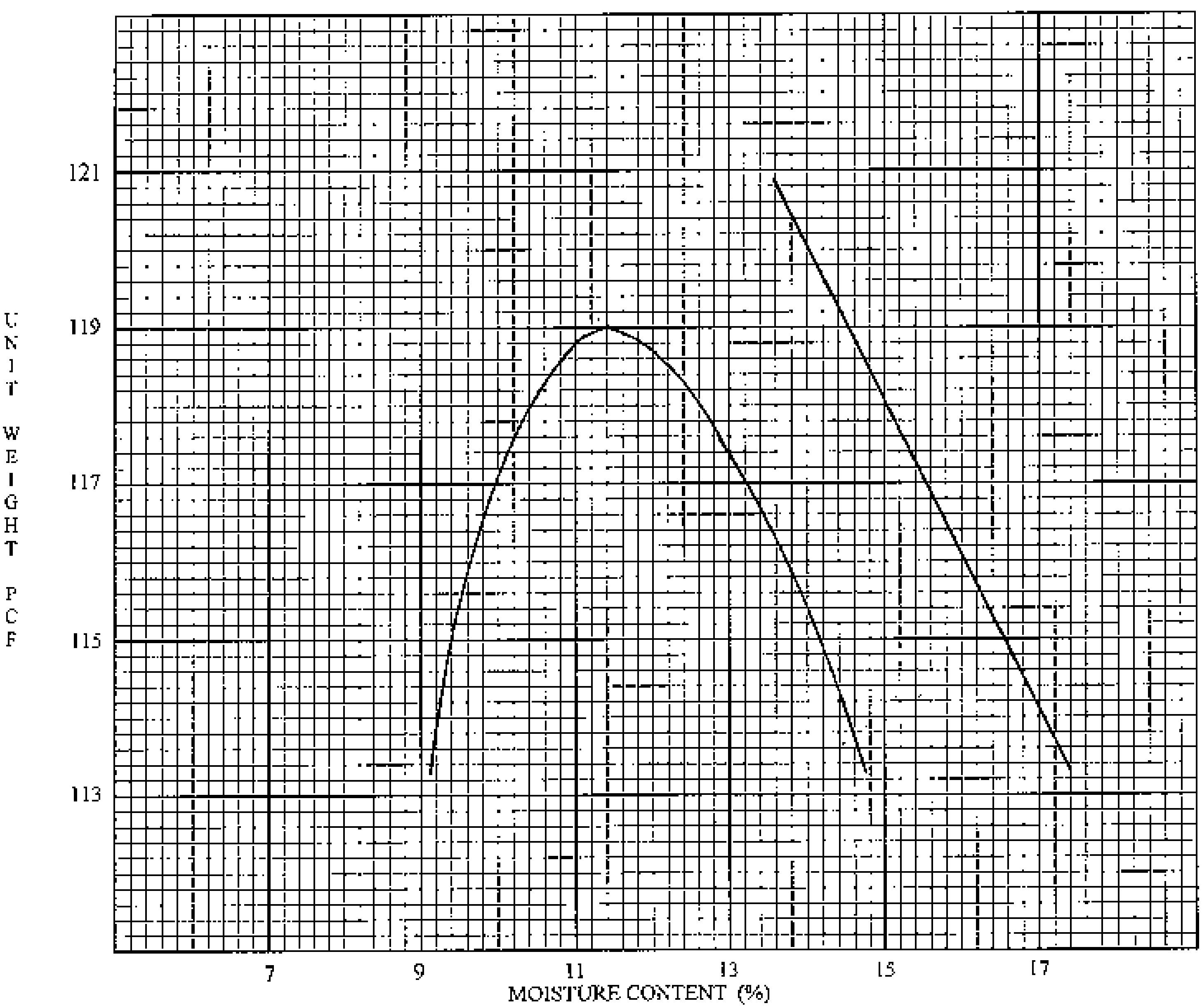
SAMPLE NUMBER: 2 (Test boring 2, depth 1-17')

METHOD: Standard proctor, ASTM:D698, Method "A"

MAXIMUM DENSITY: 119.0 pcf

SOIL TYPE: SILTY SAND-grayish brown (SM)

OPTIMUM MOISTURE: 11.4%



MIDWEST TESTING LABORATORY

Project No.: M2115282

Sample Source: 3, Borehole #2, Depth: 1'-15'

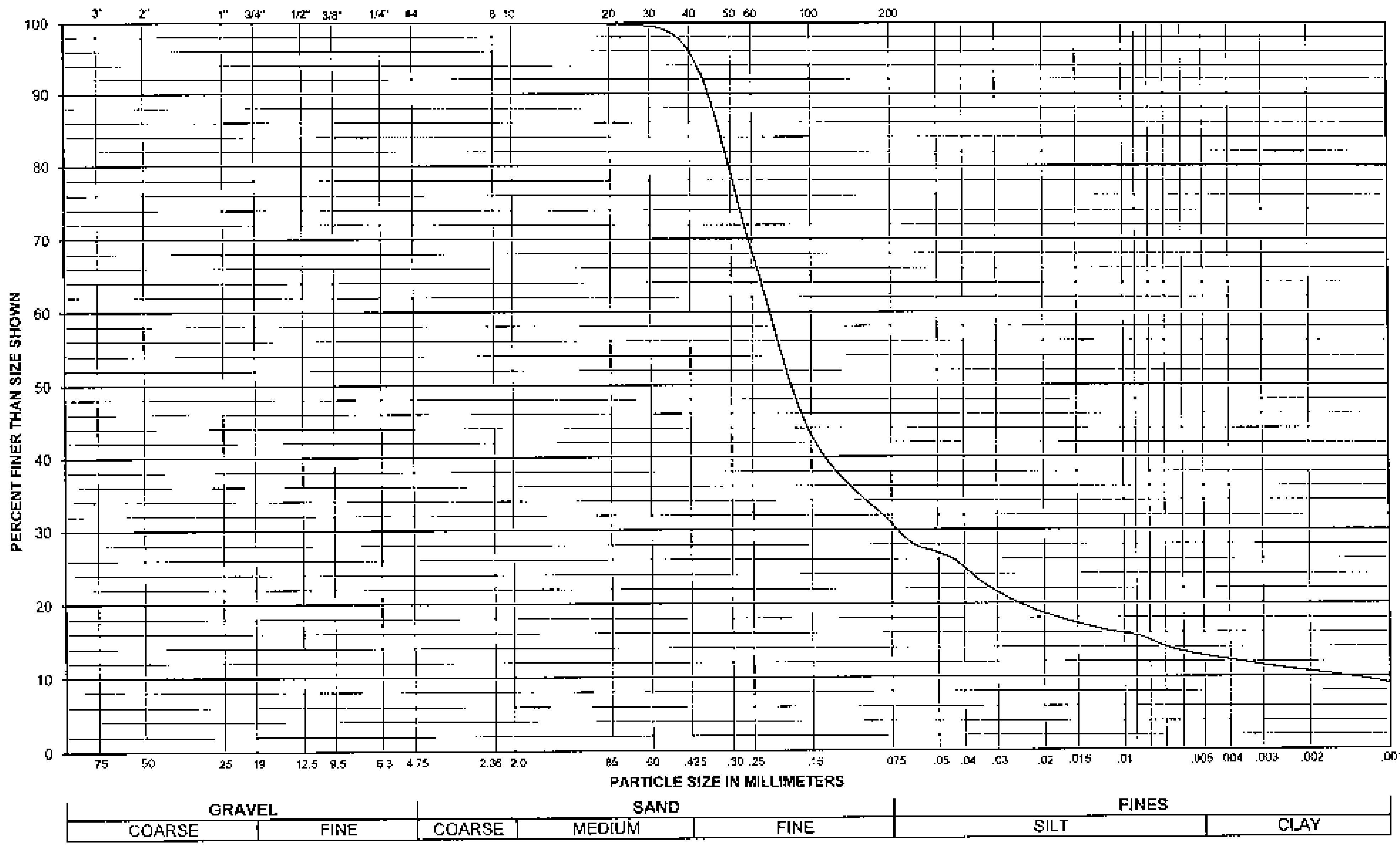
Classification: SILTY SAND - grayish brown (SM)

Project: Piezometer Installations
GRE - Stanton Station
Stanton, ND

Reported to: Golder Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

U.S. Standard Sieve Sizes



MIDWEST TESTING LABORATORY

1805 Hancock Dr. / P.O. Box 2084 / Bismarck, North Dakota 58502
Phone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: MOISTURE-DENSITY RELATIONS OF SOIL

PROJECT: Piezometer Installations
Great River Energy – Stanton Station
Stanton, North Dakota
GAI #113-81645

DATE: October 19, 2011

REPORTED TO: Golder Associates, Inc
Attn: Todd Stong
44 Union Blvd, Suite 300
Lakewood, CO 80228-1856

COPIES: Golder Associates, Inc
Attn: Tammy Rauen

PROJECT NO: M2115282

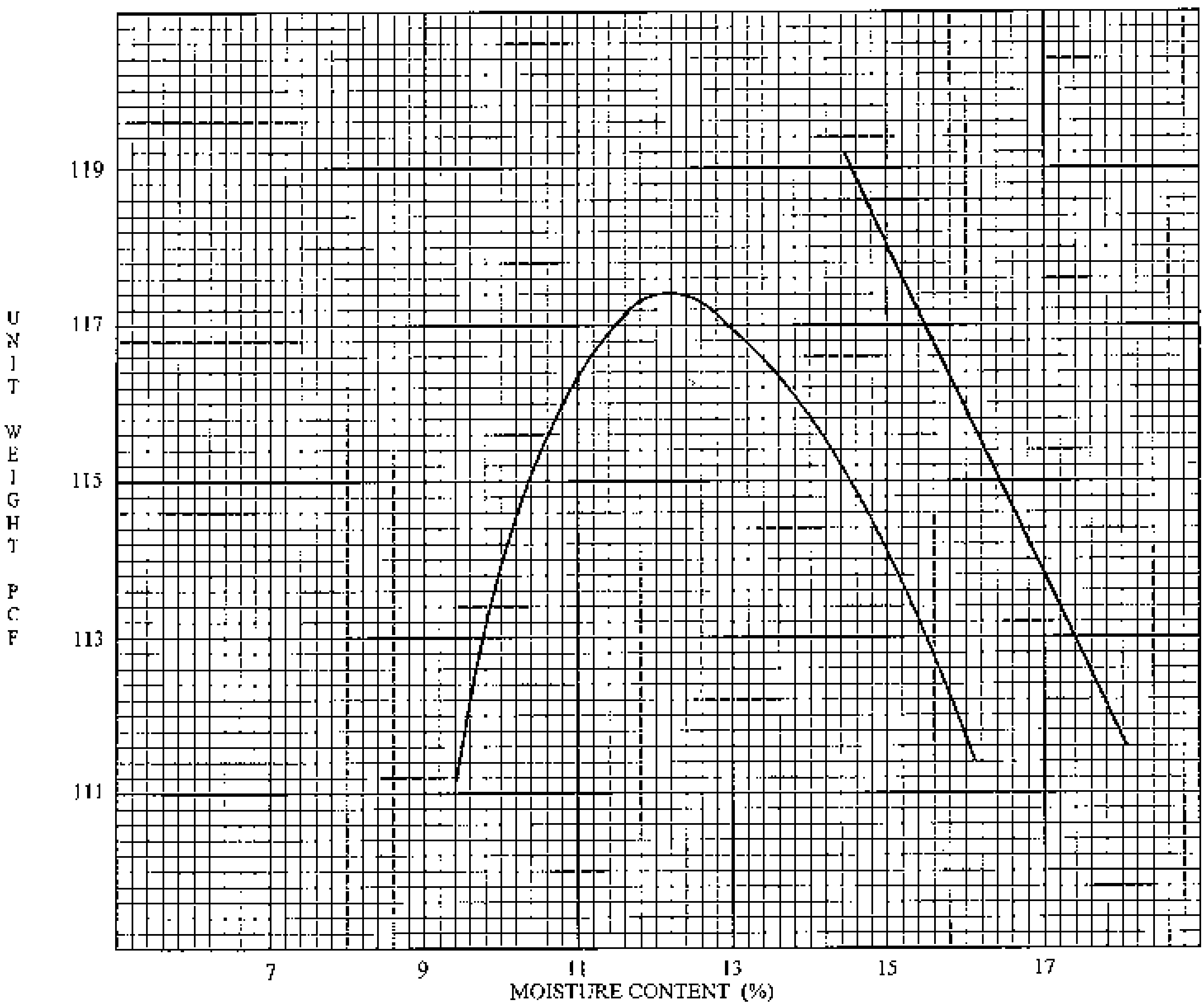
SAMPLE NUMBER: 3 (Test boring 2, depth 1-17')

METHOD: Standard proctor, ASTM:D698, Method "A"

MAXIMUM DENSITY: 117.4 pcf

SOIL TYPE: SILTY SAND-grayish brown (SM)

OPTIMUM MOISTURE: 12.2%



MIDWEST TESTING LABORATORY

1805 Hancock Dr / PO Box 2084 / Bismarck, North Dakota 58502
Telephone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: TESTS OF SOILS

PROJECT: Piezometer Installations
Great River Energy – Stanton Station
Stanton, North Dakota
GAI #113-81645

DATE: October 19, 2011

REPORTED TO: Golder Associates, Inc
Attn: Todd Stong
44 Union Blvd, Suite 300
Lakewood, CO 80228-1856

COPIES: Golder Associates, Inc
Attn: Tammy Rauen

PROJECT NO: M2115282

SAMPLE NUMBER:	C1	C2	C3
LOCATION:	Test boring 1, Composite of Samples 2, 4, 6 & 8	Composite of Test boring 1, Samples 10, 11 & 12 and test boring 2, Samples 8 & 9	Composite of Test boring 1, Sample 13 & test boring 2, Sample 10
CLASSIFICATION:	FAT CLAY (CH)	POORLY-GRADED SAND WITH SILT (SP-SM)	FAT CLAY (CH)
COLOR:	Grayish brown	Brown	Brown
PARTICLE DISTRIBUTION (see attached curves):			
Gravel (%)			
Coarse (plus 30 mm)			
Fine (30-5 mm)			
Sand (%)			
Coarse (5-2 mm)			
Medium (2-.44 mm)	3	4	1
Fine (.44 mm-.074)	6	85	7
Fines (%)			
Silt (.074-.005 mm)	46	4	14
Clay (.005-.001 mm)	15	3	21
Colloids (less than .001 mm)	30	4	57
ATTERBERG LIMITS:			
Liquid Limit	56	NP	79
Plastic Limit	18	NP	18
Plasticity Index	38	NP	61

REMARKS: Samples were obtained at the locations shown above by Midwest Testing Laboratory on October 4, 2011.

Signed: Steven S. Smith

MIDWEST TESTING LABORATORY

Project No.: M2115282

Sample Source: C1, Boring 1, Samples 2, 4, 6, 8

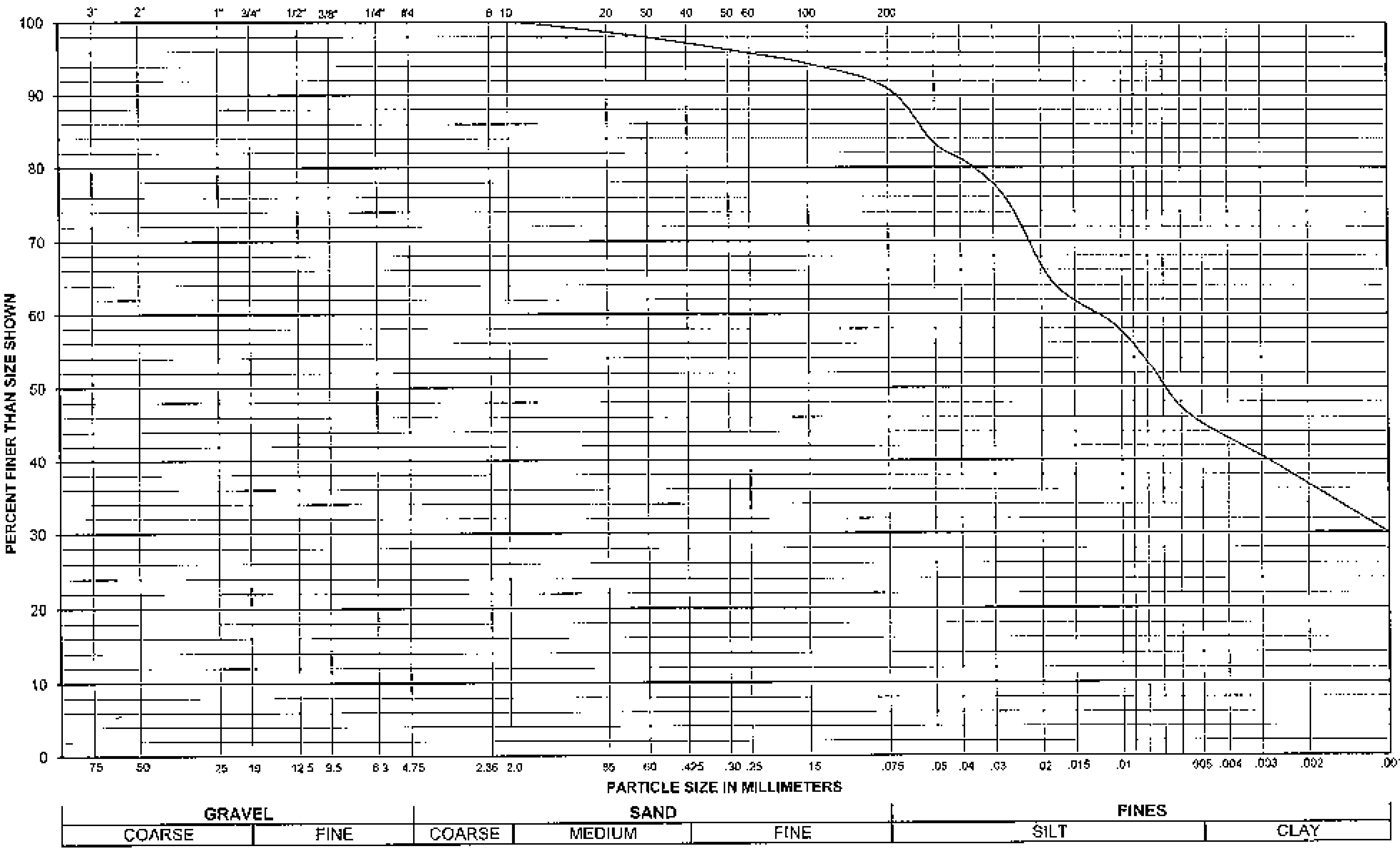
Classification: FAT CLAY - grayish brown

Project: Piezometer Installations
GRE - Stanton Station
Stanton, ND

Reported to: Golder Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

U.S. Standard Sieve Sizes



MIDWEST TESTING LABORATORY

Project No.: M2115282

Sample Source: C2, Boring 1, Samples 10,11,12; and Boring 2, Samples 8, 9

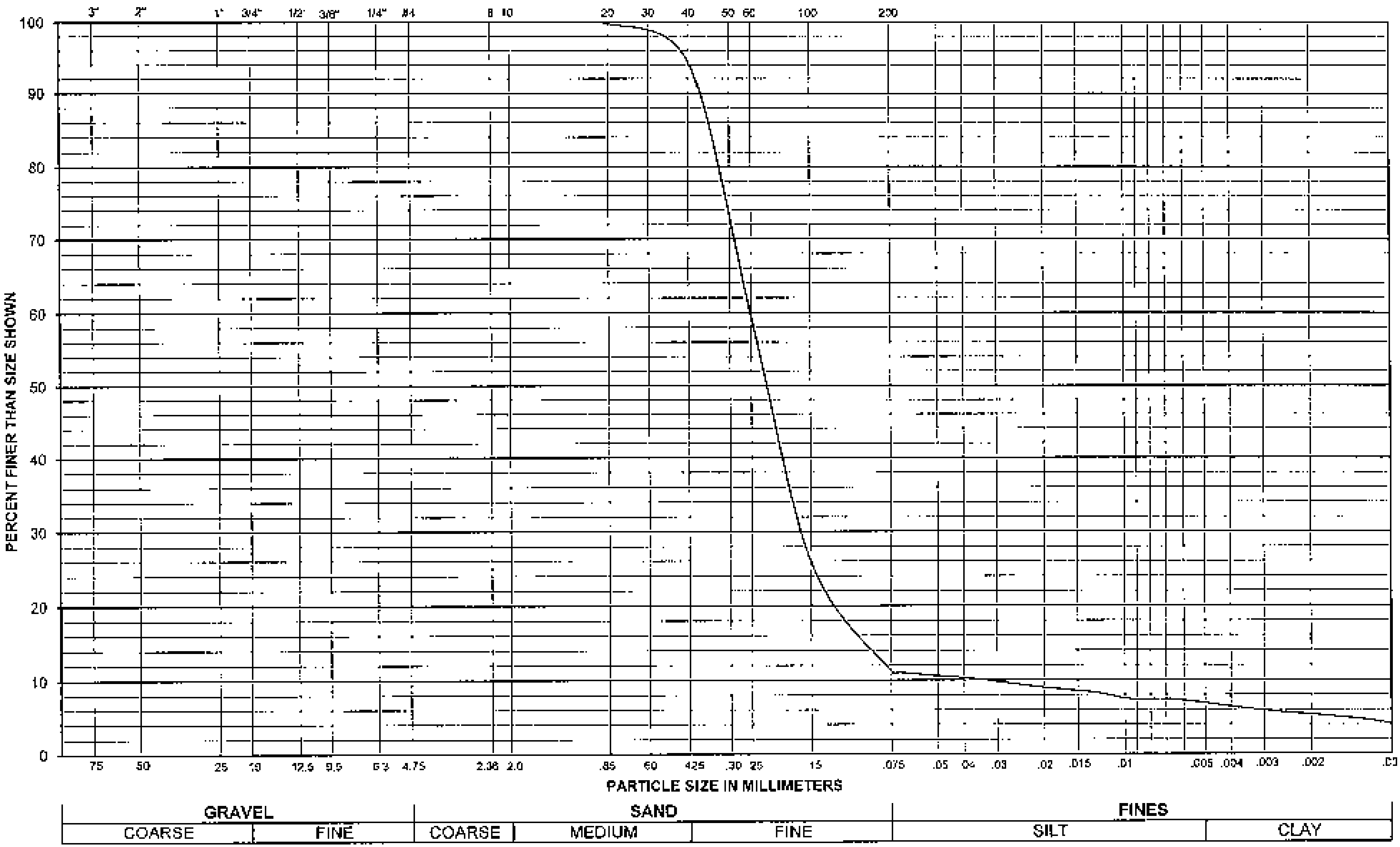
Classification: POORLY GRADED SAND WITH SILT - brown (SP-SM)

Project: Piezometer Installations
GRE - Stanton Station
Stanton, ND

Reported to: Golder Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

U.S. Standard Sieve Sizes

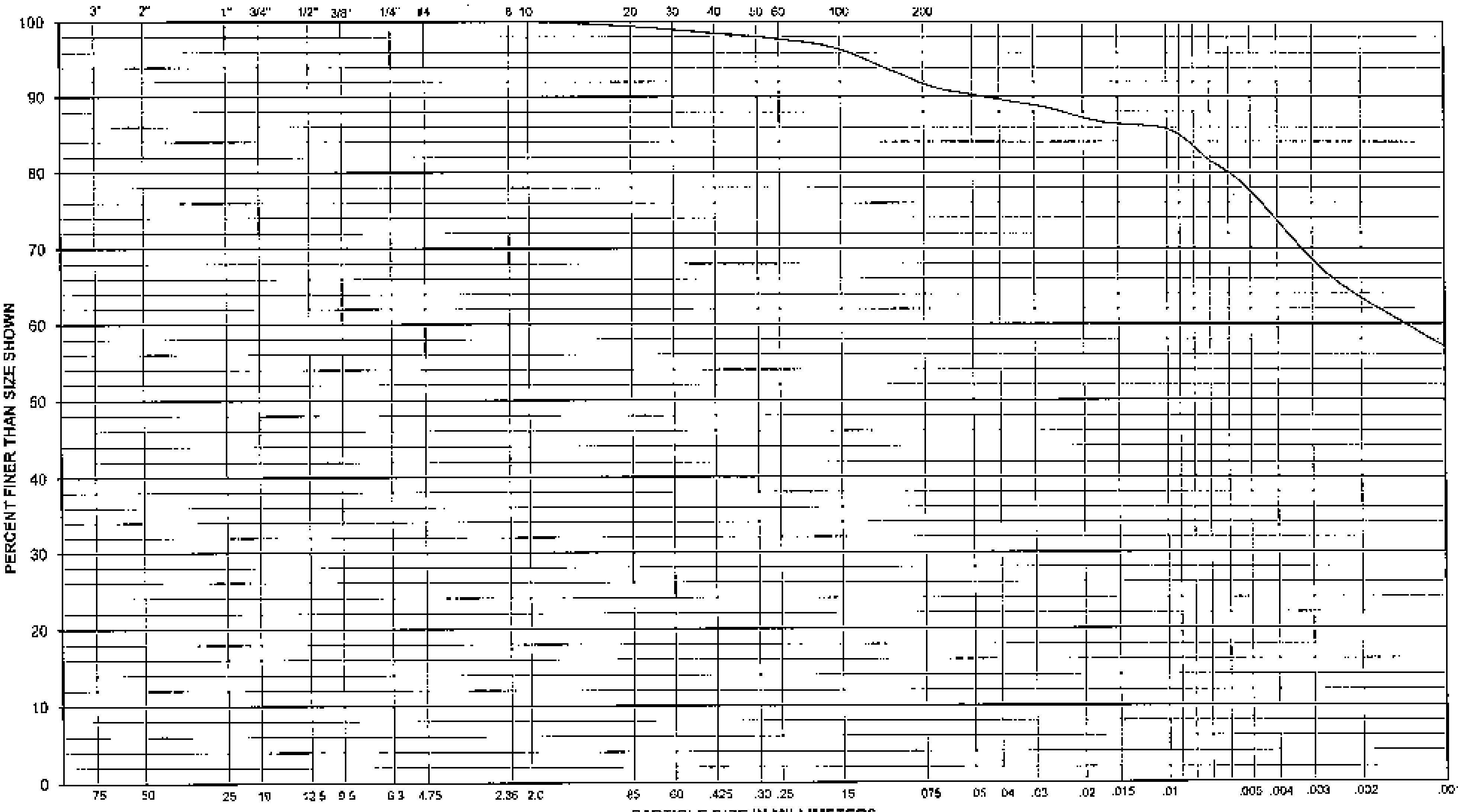


MIDWEST TESTING LABORATORY

Project No.:	M2115282	Project:	Piezometer Installations GRE - Stanton Station Stanton, ND
Sample Source:	C3, Boring 1, Sample 13; and Boring 2, Sample 10		
Classification:	FAT CLAY - brown	Reported to:	Golder Associates, Inc

GRAIN SIZE DISTRIBUTION CURVE

U.S. Standard Sieve Sizes



GRAVEL		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT	CLAY

Classification of Soils For Engineering Purposes

ASTM:D 2487-98

	Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]			Soil Classification Group Symbol	Soil Classification Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 Sieve	Gravels More than 50% coarse fraction retained on No. 4 Sieve	Clean Gravels Less than 5% fines[C]	Cu≥4 and 1≤Cc≤3[E]	GW	Well graded gravel[F]
			Cu<4 and/or 1>Cc>3[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 Sieve	Clean Sands Less than 5% fines	Cu≥6 and 1≤Cc≤3[E]	SW	Well-graded sand[I]
			Cu<6 and/or 1>Cc>3[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 Sieve	Silts and Clays Liquid limit less than 50	Inorganic	PI> 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		Organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OL	Organic clay[K,L,M,N]
					Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		Organic	Liquid limit - oven dried / Liquid limit - not dried <0.75	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils Fibric Peat > 67% Fiber	Primary organic matter, dark in color, and organic odor Hemic Peat 33%-67% Fibers			PT	Peat Sapric Peat < 33% Fibers

[A]Based on the material passing the 3-in. (75mm) sieve.

[B]If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C]Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D]Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E]$Cu = D_{60} / D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F]If soil contains ≥15% sand, add "with sand" to group name.

[G]If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H]If fines, are organic, add " with organic fines" to group name.

[I]If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J]If Atterberg limits plot in hatched area, soil is CL-ML, silty clay.

[K]If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

[L]If soil contains ≥ 30% plus no. 200, predominantly sand, add "sandy" to group name.

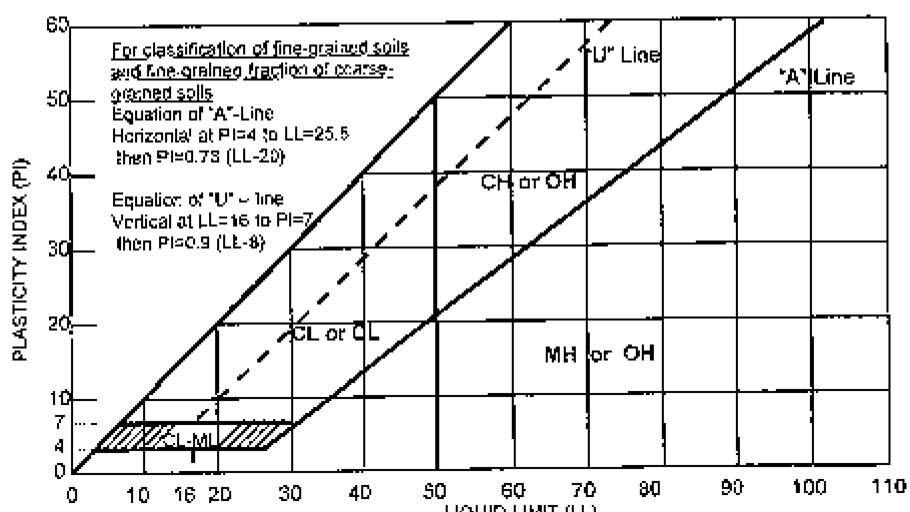
[M]If soil contains ≥ 30% plus no. 200, predominantly gravel, add "gravelly" to group name.

[N]PI≥ 4 and plots on or above "A"line.

[O]PI<4 or plots below "A" line.

[P]PI plots on or above "A" line.

[Q]PI plots below "A" line.



DESCRIPTIVE TERMINOLOGY

RELATIVE DENSITY

Term	"N" Value
Very Loose	0-4
Loose	5 – 9
Medium Dense	10 – 30
Dense	31 – 50
Very Dense	Greater than 50

THICKNESS OF SOIL INTRUSIONS

Term	Range
Lense / Lamination	0 – 1/8"
Seam	1/8" – 1"
Layer	1" – 12"

CONSISTENCY OF COHESIVE SOILS

Term	"N" Value
Very soft	Less than 2
Soft	2 – 4
Medium stiff	5 – 8
Stiff	9 – 15
Very Stiff	16 – 30
Hard	Greater than 30

PARTICLES SIZES

Term	Range
Boulders	Over 12"
Cobbles	3"– 12"
Gravel	
Coarse	3/4" – 3"
Fine	#4 – 3/4"
Sand	
Coarse	#4 - #10
Medium	#10 - #40
Fine	#40 - #200
Silt	#200 – 0.005 mm
Clay	Less than 0.005 mm

Note: Sieve sizes shown are U.S. Standard

RELATIVE PROPORTIONS

Term	Range
Trace	0 – 5%
A Little	5 – 15%
With	15 – 50%

DRILLING & SAMPLING SYMBOLS

Symbol	Definition
FA	Flight Auger
SS	Split Spoon
TW	Thin-Walled Tube
HSA	Hollow Stem Auger
N	Penetration Resistance: blows required to drive a two-inch OD split spoon sampler one foot by means of a 140-pound hammer falling 30 inches

LABORATORY TEST SYMBOLS

Symbols	Definition
LL	Liquid Limit, %
PL	Plastic Limit, %
Q_u	Unconfined Compressive Strength, psf

Additional insertions in Q_u column

Symbols	Definition
G	Specific Gravity
SL	Shrinkage Limit, %
pH	Hydrogen Ion Content-Meter Method
O	Organic Content, % - Combustion Method
M.A.	Grain Size Analysis - Mechanical Method
Hyd.	Grain Size Analysis - Hydrometer Method
C	One-Dimensional Consolidation
Q_c	Triaxial Compression
K	Coefficient of Permeability

WATER LEVEL INFORMATION

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

SOIL STRATIFICATION BOUNDARIES

The soil stratification lines shown on the boring logs indicate the approximate boundary between different soil types. In the field, the transition between soil types may be gradual.

ATTACHMENT B
WELL REGISTRATIONS AND MONITORING WELL CONSTRUCTION DIAGRAMS

Midwest Testing LABORATORY, INC.
A Terracon COMPANY

October 27, 2011

Golder Associates, Inc
44 Union Blvd, Suite 300
Lakewood, CO 80228-1856

Attn: Todd Stong

RE: Piezometer Installations
Great River Energy – Stanton Station
Stanton, North Dakota
GAI #113-81645, MTL Project M2115282

Dear Todd:

Attached please find copies of the two Monitoring Well Reports submitted to the State of North Dakota Board of Water Well Contractors for the two piezometers installed in conjunction with the above-referenced project.

Also attached of copies of the two Monitoring Well Construction Diagrams prepared for the same piezometers.

We are also sending copies to Ms. Jennifer Charles with Great River Energy.

Should you have any questions or require further assistance, please contact us.

Sincerely,

MIDWEST TESTING LABORATORY

Steven S. Smith, P.E.
Senior Project Engineer

SSS/cb

Attachments: monitoring well reports (2)
monitoring well diagrams (2)

cc: Golder Associates, Inc\Tammy Rauen
Great River Energy\Jennifer Charles

State of North Dakota

BOARD OF WATER WELL CONTRACTORS

900 E. BOULEVARD • BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name: Great River Energy – Stanton Station

Address: 4001 Hwy 200A
Stanton, ND 58571-9402

2. WELL LOCATION (Well P-2)

Address (if in city): ______

County: Mercer

SW ¼ NW ¼ NE ¼ Sec. 21 Twp. 144 N. Rge. 84 W.

Lat. 47° 16' 57.95" N Long.: 101° 19' 48.73" W

Altitude: 1715.40 (ground elevation)

3. METHOD DRILLED

■ Auger Other hollow stem

4. WELL CONSTRUCTION

Diameter of Hole 6 1/4 inches Depth 25 feet

Riser. ■ PVC □ Other

■ Threaded □ Solvent □ Other

Riser rating SDR ______ Schedule 40

Diameter 2.0 inches

From -3 ft. to 5 ft.

Was a well screen installed? ■ Yes □ No

Material Schedule 40 PVC Diameter 2.0 inches

Slot Size #10 set from 5 feet to 25 feet

Sand packed from 3' to 25'

Depth grouted from 1' to 3'

Grouting Material

Bentonite x Other ______

If other explain:

One foot thick concrete collar at the surface

Well head completion:

24" above grade ______ Other x

If other, specify 4" x 4" x 5' steel cover

Was protective casing installed? ■ Yes □ No

Was well disinfected upon completion? □ Yes ■ No

5. WATER LEVEL

Static water level 20 feet below surface

If flowing: closed in pressure -- psi or ft. above land surface

6. WELL LOG

Formation	Depth (Ft.) From	To
SILTY SAND	0	17
SAND WITH SILT	17	22½
FAT CLAY	22½	25

(Use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OR ABANDONED?

□ Yes ■ No

If so, how? ______

8. REMARKS

9. DATE COMPLETED 10-4-11

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Midwest Testing Laboratory, Inc. 444

Monitoring Well Contractor Certificate No.

P.O. Box 2084, Bismarck, ND 58502-2084

Address

[signature] 10-26-11

Signature Date

State of North Dakota

BOARD OF WATER WELL CONTRACTORS

900 E. BOULEVARD • BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name: Great River Energy – Stanton Station

Address: 4001 Hwy 200A

Stanton, ND 58571-9402

2. WELL LOCATION **(Well P-1)**

Address (if in city): ____

County: Mercer

SW ¼ NW ¼ NE ¼ Sec. 21 Twp. 144 N. Rge. 84 W.

Lat. 47° 16' 57.95" N Long.: 101° 19' 49.14" W

Altitude: 1721.31 (ground elevation)

3. METHOD DRILLED

■ Auger Other hollow stem

4. WELL CONSTRUCTION

Diameter of Hole 6 1/4 inches Depth 30 feet

Riser: ■ PVC □ Other

■ Threaded □ Solvent □ Other

Riser rating SDR ____ Schedule 40

Diameter 2.0 inches

From +3 ft. to 5 ft.

Was a well screen installed? ■ Yes □ No

Material Schedule 40 PVC Diameter 2.0 inches

Slot Size #10 set from 5 feet to 30 feet

Sand packed from 3' to 30'

Depth grouted from 1' to 3'

Grouting Material

Bentonite x Other ____

If other explain:

One foot thick concrete collar at the surface

Well head completion:

24" above grade ____ Other x

If other, specify 4" x 4" x 5' steel cover

Was protective casing installed? ■ Yes □ No

Was well disinfected upon completion? □ Yes ■ No

5. WATER LEVEL

Static water level 20 feet below surface

If flowing: closed in pressure ____ = ____ psi or ft. above land surface

6. WELL LOG

Formation	Depth (Ft.) From	To
FAT CLAY	0	20
SILTY SAND	20	27½
FAT CLAY	27½	28½
SILTY SAND	28½	29½
FAT CLAY	29½	30

(Use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OR ABANDONED?

□ Yes ■ No

If so, how? ____

8. REMARKS

9. DATE COMPLETED 10-4-11

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

Midwest Testing Laboratory, Inc. 444

Monitoring Well Contractor Certificate No.

P.O. Box 2084, Bismarck, ND 58502-2084

Address

[signature] 10-26-11

Signature Date

MIDWEST TESTING LABORATORY

MONITORING WELL CONSTRUCTION DIAGRAM

PROJECT: Great River Energy – Stanton Station

PROJECT NO: M2115282

Monitoring Well No: P-2
Ground Surface Elevation: 1715.40

Date of Installation: 10-4-11
Top of Riser Elevation: 1718.32

Crew Chief: Mike Roberts

Protective Casing
Material: Steel
Diameter x Length: 4" x 4" x 5'
Length Above Ground: 3 1/2'

Riser Pipe
Material: Schedule 40 PVC
Diameter x Length: 2" x 8'
Length Above Existing Grade: 3'

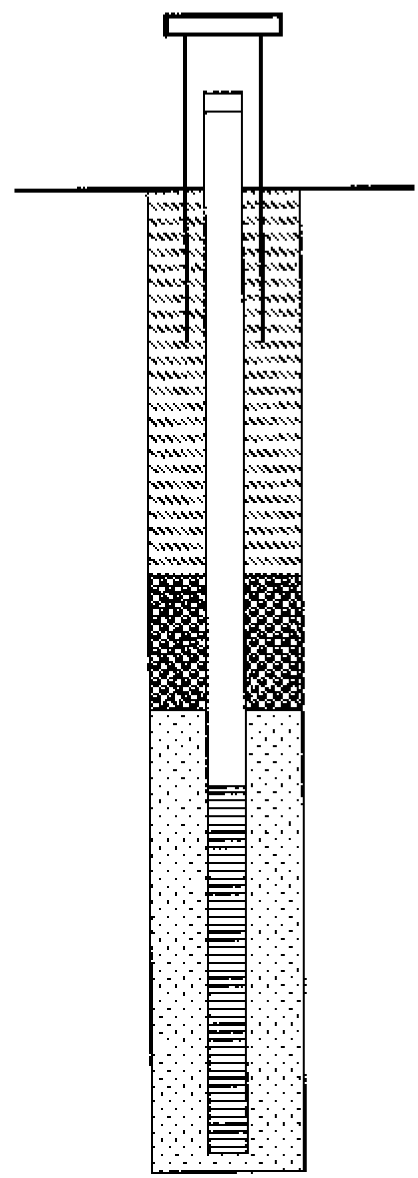
Annular Space Backfill Material: 1' Concrete collar

Seal Above Screen
Material: Bentonite
Thickness: 2'

Filter Sand
Material: #10 Silica sand
Depth to Top of Filter Sand: 3'
Depth to Bottom of Filter Sand: 25'

Well Screen
Material: Schedule 40 PVC
Diameter x Length: 2" x 20'
Slot No. or Size: #10 Slot
Depth to Bottom of Screen: 25'

Borehole
Diameter: 6 1/4"
Depth to Bottom of Borehole: 25'
Method of Advancement: Hollow stem auger



WATER LEVEL MEASUREMENTS BELOW TOP OF RISER PIPE

DATE	TIME	WATER LEVEL
10-4-11	14:15	20'

MIDWEST TESTING LABORATORY

MONITORING WELL CONSTRUCTION DIAGRAM

PROJECT: Great River Energy – Stanton Station

PROJECT NO: M2115282

Monitoring Well No: P-1
Date of Installation: 10-4-11
Crew Chief: Mike Roberts

Ground Surface Elevation: 1721.31
Top of Riser Elevation: 1724.08

Protective Casing
Material: Steel
Diameter x Length: 4" x 4" x 5'
Length Above Ground: 3 1/2'

Riser Pipe
Material: Schedule 40 PVC
Diameter x Length: 2" x 8'
Length Above Existing Grade: 3'

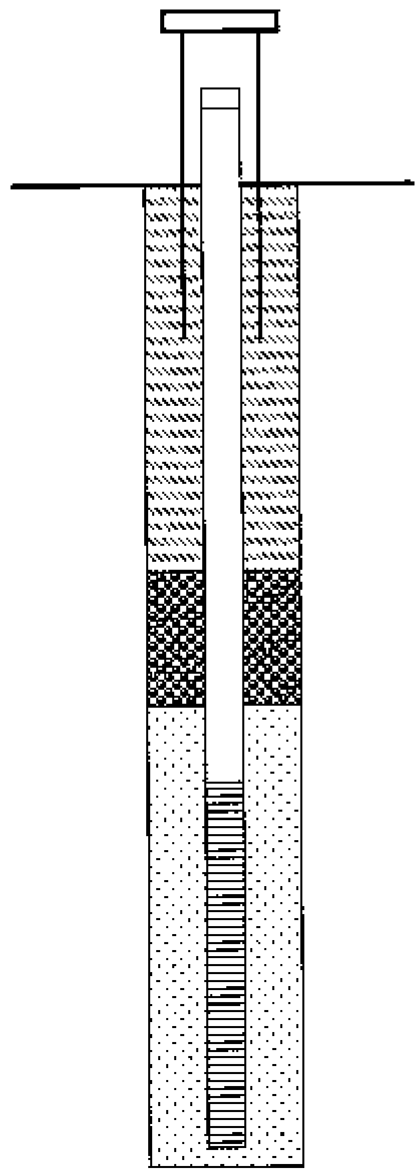
Annular Space Backfill Material: 1' Concrete collar

Seal Above Screen
Material: Bentonite
Thickness: 2'

Filter Sand
Material: #10 Silica sand
Depth to Top of Filter Sand: 3'
Depth to Bottom of Filter Sand: 30'

Well Screen
Material: Schedule 40 PVC
Diameter x Length: 2" x 25'
Slot No. or Size: #10 Slot
Depth to Bottom of Screen: 30'

Borehole
Diameter: 6 1/4"
Depth to Bottom of Borehole: 31'
Method of Advancement: Hollow stem auger



WATER LEVEL MEASUREMENTS BELOW TOP OF RISER PIPE

DATE	TIME	WATER LEVEL
10-4-11	11:35	28'

ATTACHMENT C
EFFECTIVE STRESS SHEAR STRENGTH TEST LAB REPORTS

CLAY FILL

	Clay Fill 2A		Clay Fill 2A		Clay Fill 2B	
Sample # =	Clay Fill 2A		Clay Fill 2A		Clay Fill 2B	
Point # =	1 (staged)		2 (staged)		3	
	Initial		**Initial**		**Initial**	
Length =	14.74	cm	14.74	cm	17.58	cm
Diameter =	7.28	cm	7.28	cm	7.29	cm
Wet Weight =	1231.20	g	1231.20	g	1540.40	g
Area =	41.6	cm^2	41.6	cm^2	41.7	cm^2
Sample Area =	6.45	in^2	6.45	in^2	6.47	in^2
Volume =	613.5	cm^3	613.5	cm^3	733.8	cm^3
Moisture Content =	21.4%		21.4%		20.4%	
Specific Gravity =	-		-		-	
Dry Weight of Solids =	1014.17	g	1014.17	g	1279.40	g
Wet Unit Weight =	2.01	g/cm^3	2.01	g/cm^3	2.10	g/cm^3
Dry Unit Weight =	1.65	g/cm^3	1.65	g/cm^3	1.74	g/cm^3
Wet Unit Weight =	125.2	pcf	125.2	pcf	131.0	pcf
Dry Unit Weight =	103.1	pcf	103.1	pcf	108.8	pcf
Cell Pressure =	65	psi	70	psi	90	psi
Back Pressure =	60	psi	60	psi	70	psi
Confining Pressure =	5	psi	10	psi	20	psi

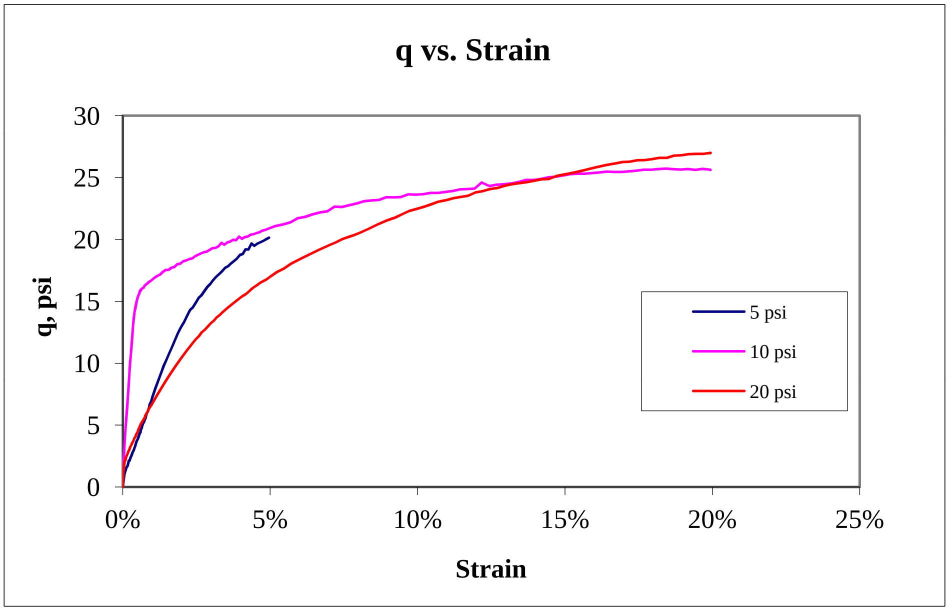
Notes: Intact sample with ends trimmed flush
Sample 2A was staged (points 1 & 2)

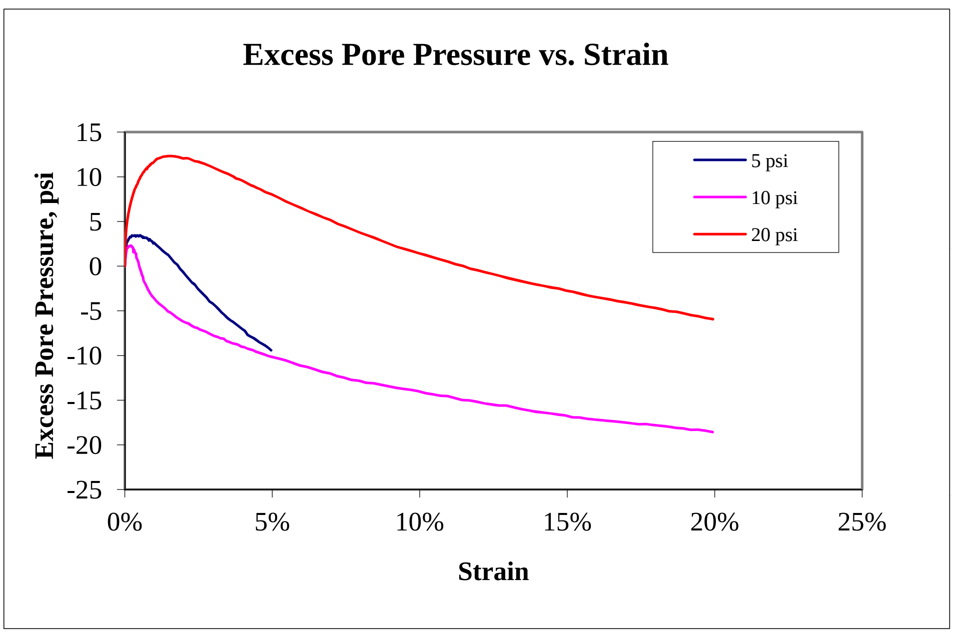
Golder Associates, Inc.
Denver, Colorado

Title: **TRIAXIAL SHEAR TEST REPORT**
SAMPLE DATA AND CALCULATIONS

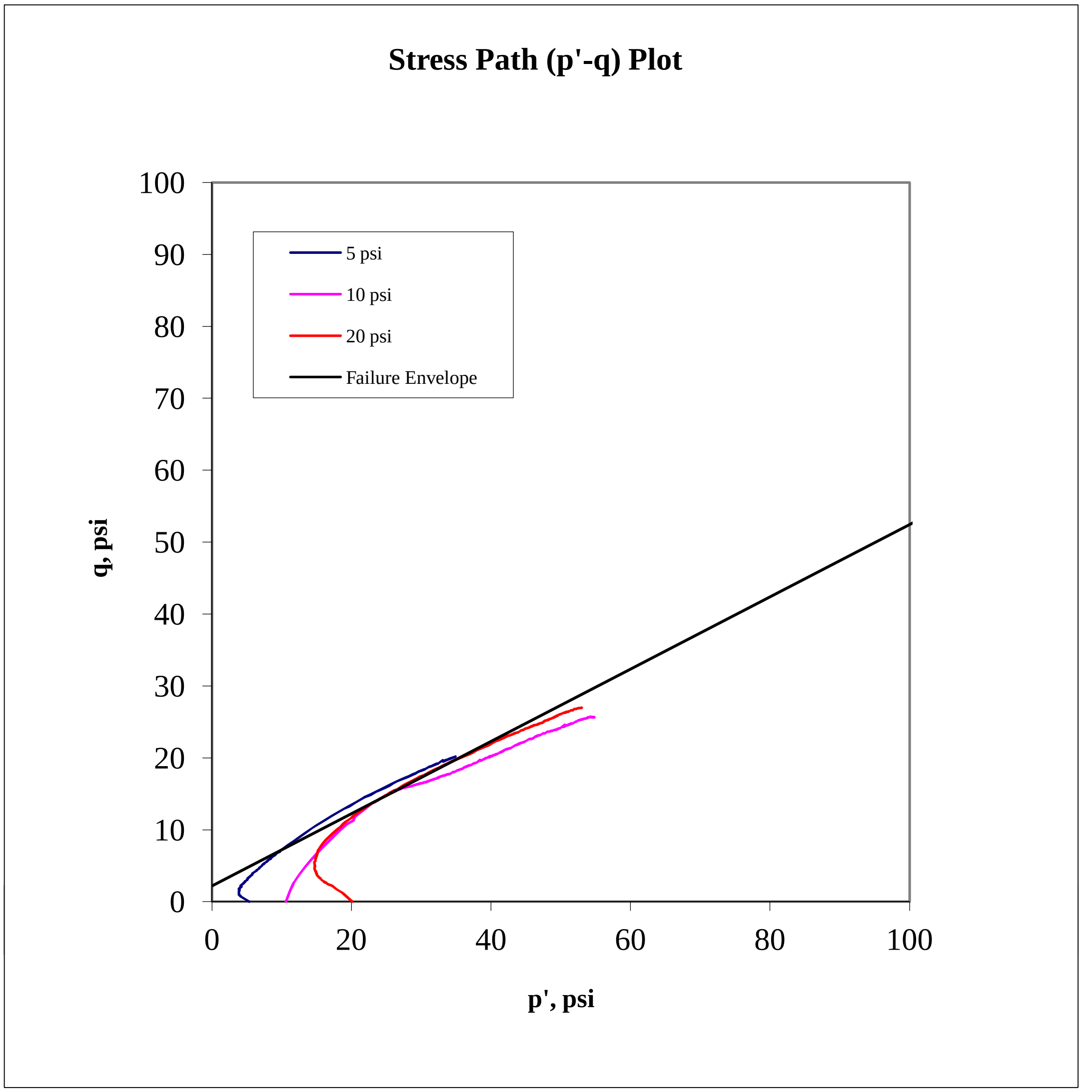
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND

Sample Number:	Reviewed:	Date:	Job Number:	Figure:
Clay Fill 2	TJS	11/21/11	113-81645	1





Golder Associates, Inc. **Denver, Colorado**		**Title:** C-U TRIAXIAL SHEAR DATA q AND EXCESS PORE PRESSURE PLOTS		
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND				
Sample Number: Clay Fill 2	**Reviewed:** TJS	**Date:** 11/21/11	**Job Number:** 113-81645	**Figure:** 2

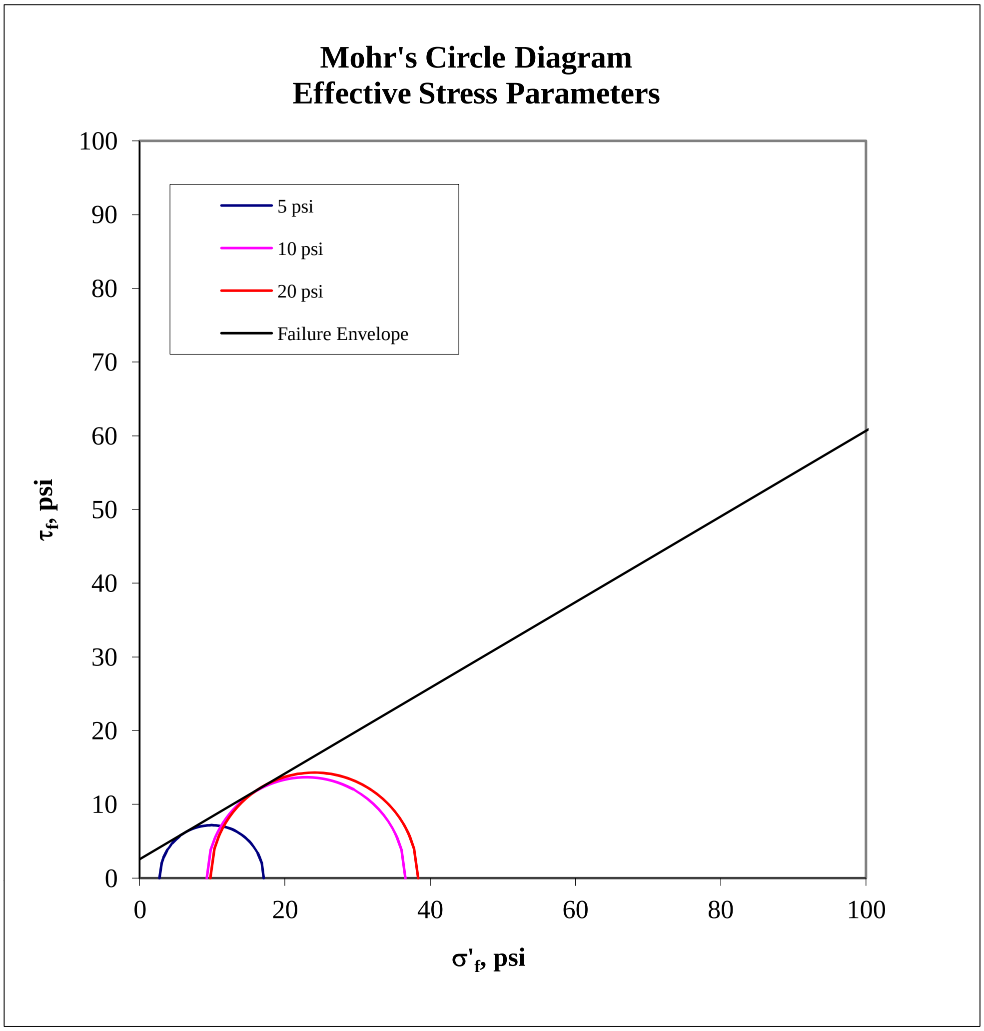


Stress Path Parameters

ψ' = 26.7 degrees

a' = 2.2 psi

Golder Associates, Inc. Denver, Colorado	**Title:** C-U TRIAXIAL SHEAR DATA STRESS PATH PLOT			
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND				
Sample Number: Clay Fill 2	**Reviewed:** TJS	**Date:** 11/21/11	**Job Number:** 113-81645	**Figure:** 3



Effective Stress Shear Strength Parameters

ϕ' = 30.2 degrees
c' = 2.5 psi

Golder Associates, Inc. Denver, Colorado	Title: C-U TRIAXIAL SHEAR DATA MOHR'S CIRCLE DIAGRAM			
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND				
Sample Number: Clay Fill 2	Reviewed: TJS	Date: 11/21/11	Job Number: 113-81645	Figure: 4

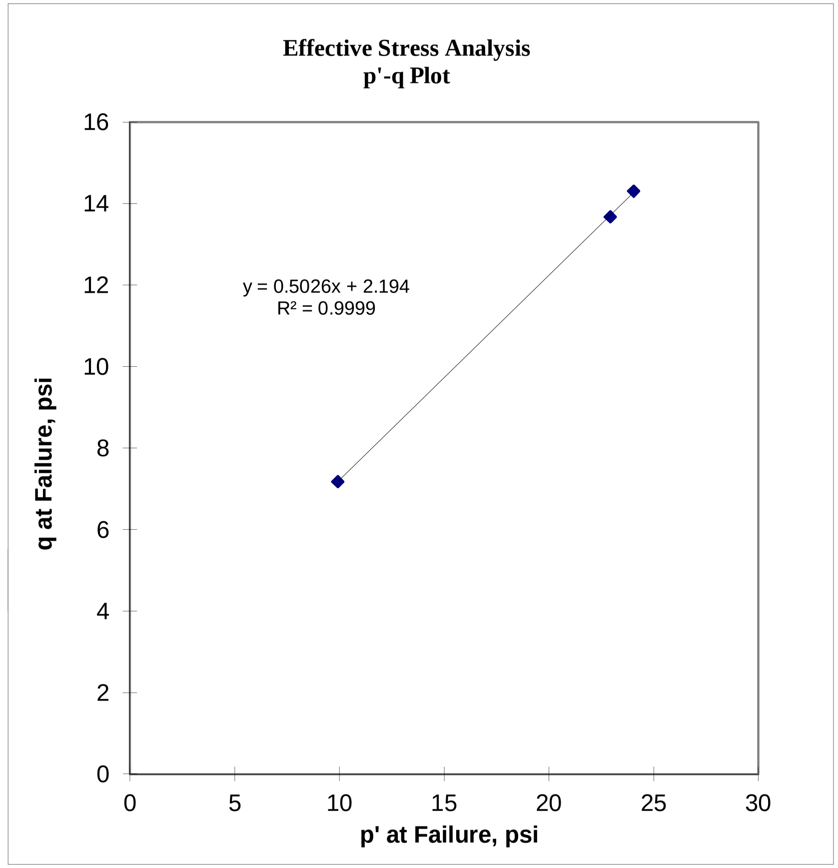
Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: **GRE/2011 STANTON STAT ENG SRVC/ND**
Project Number: **113-81645**

Sample Number	Clay Fill 2
Effective Stress Analysis	

Point Number	p' (psi)	q (psi)
1 (staged)	9.9	7.2
2 (staged)	22.9	13.7
3	24.0	14.3

tan(ψ') = 0.50
a' = 2.2 psi

ϕ' = 30.2 degrees
c' = 2.5 psi



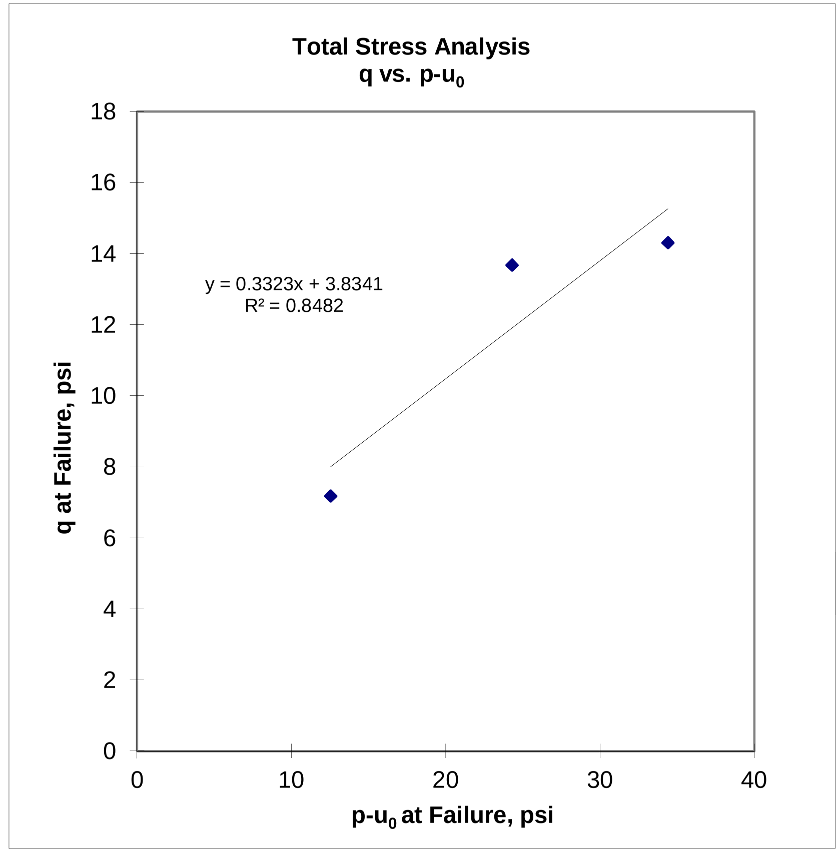
Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: **GRE/2011 STANTON STAT ENG SRVC/ND**
Project Number: **113-81645**

Sample Number	Clay Fill 2
Total Stress Analysis	

Point Number	$p-u_o$ (psi)	q (psi)
1 (staged)	12.5	7.2
2 (staged)	24.3	13.7
3	34.4	14.3

tan(ψ) = 0.33
a = 3.8 psi

ϕ = 19.4 degrees
c = 4.1 psi



Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: GRE/2011 STANTON STAT ENG SRVC/ND
Project Number: 113-81645

Mohr-Coulomb Failure Criteria:

$$\tau_{ff} = c' + \sigma'_{ff} \tan(\phi')$$
$$\tau_{ff} = c + \sigma_{ff} \tan(\phi)$$

Where:
c', c = effective and total stress cohesion intercepts
ϕ', ϕ = effective and total stress friction angles
τ_{ff} = shear strength on the failure surface at failure
σ'_{ff}, σ_{ff} = effective and total normal stresses on the failure surface at failure

Stress Path Space:

$$q = \frac{\sigma_1 - \sigma_3}{2} \qquad p' = \frac{\sigma'_1 + \sigma'_3}{2} \qquad p = \frac{\sigma_1 + \sigma_3}{2}$$

Where:
q = maximum shear stress
p', p = mean effective and total stresses
σ'_1, σ_1 = effective and total axial stresses
σ'_3, σ_3 = effective and total confining stresses

Stress Path Failure Criteria:

$$q = a' + p' \tan(\psi')$$
$$q = a + (p - u_0) \tan(\psi)$$

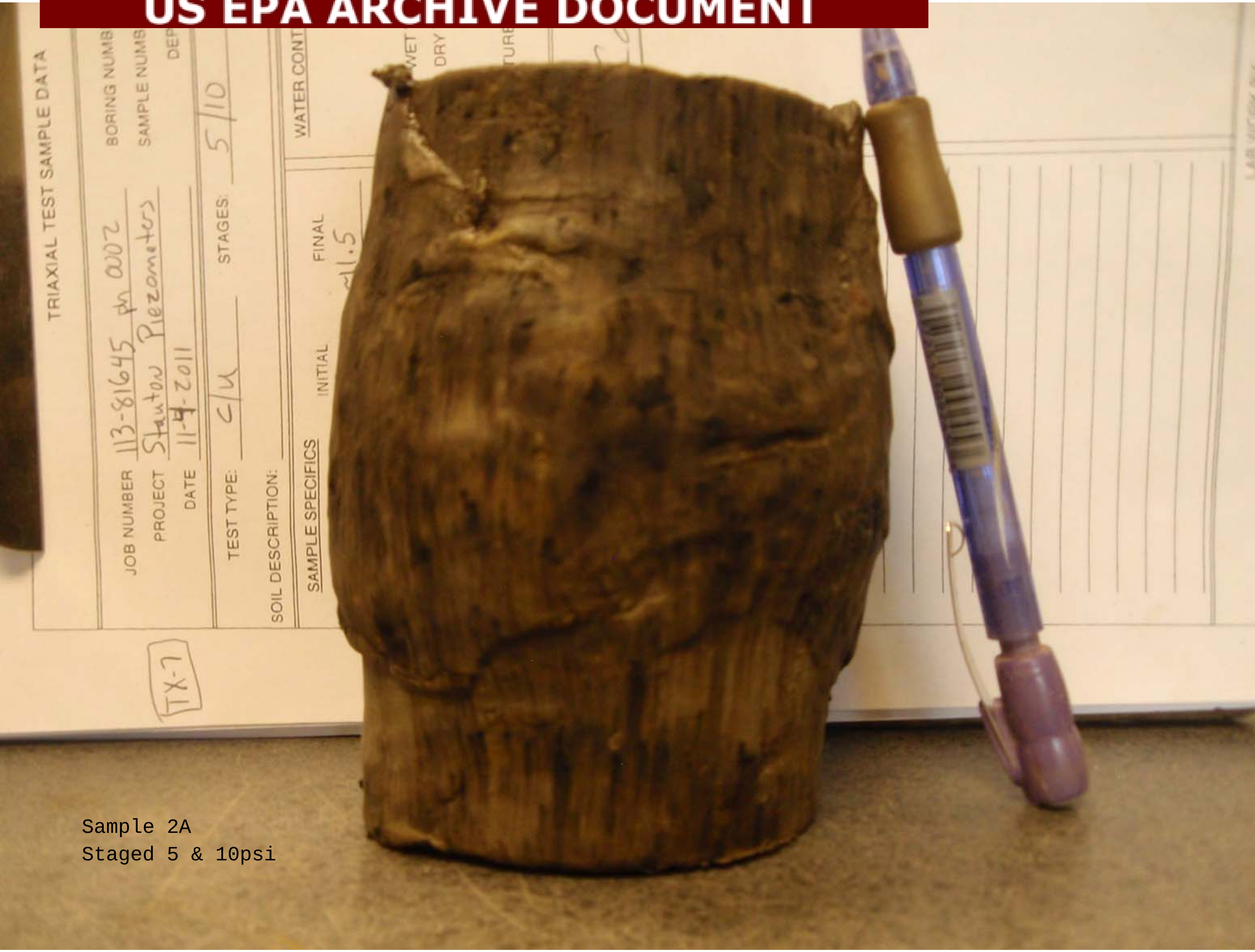
Where:
a', a = intercepts of the q-axis in effective stress and total stress spaces
ψ', ψ = angles of the failure envelopes in effective stress and total stress spaces
q = maximum shear stress at failure
p' = mean effective stress at failure
$p-u_0$ = mean total stress at failure minus the initial pore pressure

The relationships between ψ and ϕ and a and c are as follows:

$$\tan(\psi) = \sin(\phi)$$
$$a = c \cos(\phi)$$

The relationships between ψ' and ϕ' and a' and c' are as follows:

$$\tan(\psi') = \sin(\phi')$$
$$a' = c' \cos(\phi')$$



Sample 2A
Staged 5 & 10psi

Sample 2B
20psi

FLOW PUMP #2

FLEXIBLE WALL PERMEABILITY
ASTM D 5084
METHOD D, CONSTANT RATE OF FLOW

PROJECT TITLE	GRE/2011 STANTON STAT ENG SRVC/ND		BOARD #	3
PROJECT NUMBER	113-81645.0002		CELL #	TX-5
SAMPLE ID	Clay Fill 2B	--	Flow Pump Speed	12
SAMPLE TYPE	Inplace		Technician	RJM

COMMENTS
1. Water used as permeant
2. Specific gravity is assumed

Sample Data, Initial

Height, cm	17.58	B-Value, f	95.0
Diameter, cm	7.29	Cell Pres. (psi)	80.0
Area, cm²	41.74	Bot. Pres. (psi)	70.0
Volume, cm³	733.78	Top Pres. (psi)	70.0
Mass, g	1540.40	Eff. Stress (psi)	10.0
Moisture Content, %	20.4	Head, max.	137
Dry Density, pcf	108.8	Head, min.	136
Spec. Gravity	2.70	Max. Grad.	7.79
Volume Solids, cm³	473.76	Min. Grad.	7.74
Volume Voids, cm³	260.02		
Void Ratio	0.55		
Saturation, %	100.5%		

Flow Pump Rate 5.50E-06 cm³/sec

Sample Data, Final

Height, cm	
Diameter, cm	
Area, cm²	
Volume, cm³	
Mass, g	1560.30
Moisture Content,%	16.0
Dry Density, pcf	
Volume Solids, cm³	498.03
Volume Voids, cm³	
Void Ratio	
Saturation, %	

WATER CONTENTS		Trimmings Initial	Sample Final
Wt Soil & Tare, i	g	374.42	1712.8
Wt Soil & Tare, f	g	316.08	1497.20
Wt Tare	g	30.43	152.65
Wt Moisture Lost	g	58.34	215.60
Wt Dry Soil	g	285.65	1344.55
Water Content	%	20.4%	16.0%

DESCRIPTION
--

DATE	TIME	dt (min)	TEMP (°C)	Speed (1-12)	Speed Coeff.	DH (cm)	L (cm)	A (cm²)	i (Gradient))	q (cm³/sec)	v (cm/sec)	Permeability (cm/sec)
11/14/11	12:15											
11/14/11	12:30	15	20.7	12	1	137	17.58	41.74	7.79	5.5E-06	1.3E-07	1.7E-08
11/14/11	12:45	30	20.7	12	1	136	17.58	41.74	7.74	5.5E-06	1.3E-07	1.7E-08
11/14/11	13:00	45	20.7	12	1	136	17.58	41.74	7.74	5.5E-06	1.3E-07	1.7E-08
11/14/11	13:15	60	20.7	12	1	136	17.58	41.74	7.74	5.5E-06	1.3E-07	1.7E-08

PERMEABILITY REPORTED AS ** 1.7E-08 cm/sec **

DATE	11/14/2011
REVIEW	MB

Golder Associates Inc.

SILT FILL

Boring =	# 2		Boring =	# 2		Boring =	# 2	
Sample # =	4A		Sample # =	4A		Sample # =	3A	
Depth (ft) =	5.0-7.0		Depth (ft) =	5.0-7.0		Depth (ft) =	10.0-12.0	
Point # =	1 (staged)		Point # =	2 (staged)		Point # =	3	
	Initial			**Initial**			**Initial**	
Length =	15.50	cm	Length =	14.71	cm	Length =	17.10	cm
Diameter =	7.30	cm	Diameter =	7.47	cm	Diameter =	7.27	cm
Wet Weight =	1356.60	g	Wet Weight =	1356.60	g	Wet Weight =	1398.00	g
Area =	41.9	cm^2	Area =	43.8	cm^2	Area =	41.5	cm^2
Sample Area =	6.49	in^2	Sample Area =	6.79	in^2	Sample Area =	6.43	in^2
Volume =	648.7	cm^3	Volume =	644.7	cm^3	Volume =	709.8	cm^3
Moisture Content =	13.6%		Moisture Content =	13.6%		Moisture Content =	13.0%	
Specific Gravity =	na		Specific Gravity =	na		Specific Gravity =	na	
Dry Weight of Solids =	1194.19	g	Dry Weight of Solids =	1194.19	g	Dry Weight of Solids =	1237.17	g
Wet Unit Weight =	2.09	g/cm^3	Wet Unit Weight =	2.10	g/cm^3	Wet Unit Weight =	1.97	g/cm^3
Dry Unit Weight =	1.84	g/cm^3	Dry Unit Weight =	1.85	g/cm^3	Dry Unit Weight =	1.74	g/cm^3
Wet Unit Weight =	130.5	pcf	Wet Unit Weight =	131.3	pcf	Wet Unit Weight =	122.9	pcf
Dry Unit Weight =	114.9	pcf	Dry Unit Weight =	115.6	pcf	Dry Unit Weight =	108.8	pcf
Cell Pressure =	65	psi	Cell Pressure =	70	psi	Cell Pressure =	90	psi
Back Pressure =	60	psi	Back Pressure =	60	psi	Back Pressure =	70	psi
Confining Pressure =	5	psi	Confining Pressure =	10	psi	Confining Pressure =	20	psi

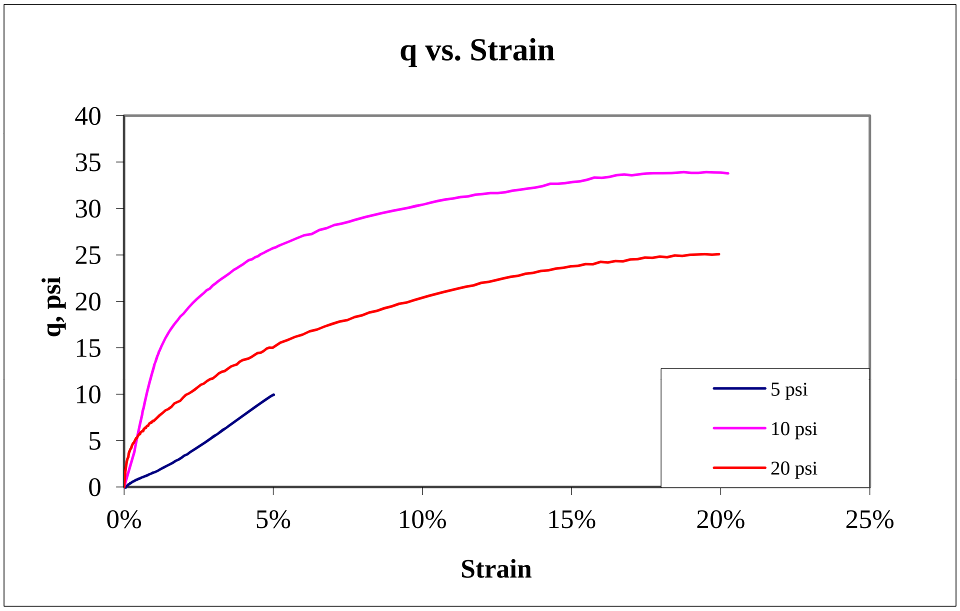
Notes: Undisturbed core sample
Points 1 and 2 were staged

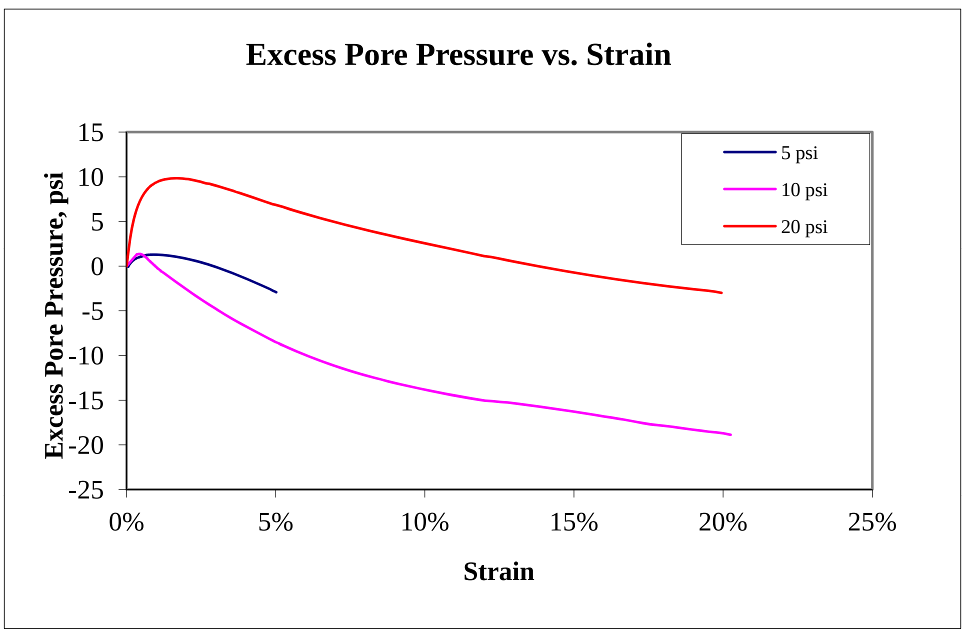
Golder Associates Inc.
Denver, Colorado

Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND

Title:
TRIAXIAL SHEAR TEST REPORT
SAMPLE DATA AND CALCULATIONS

Sample Number:	Reviewed:	Date:	Job Number:	Figure:
Silt Fill	**TJS**	**12/7/11**	**113-81645**	**1**



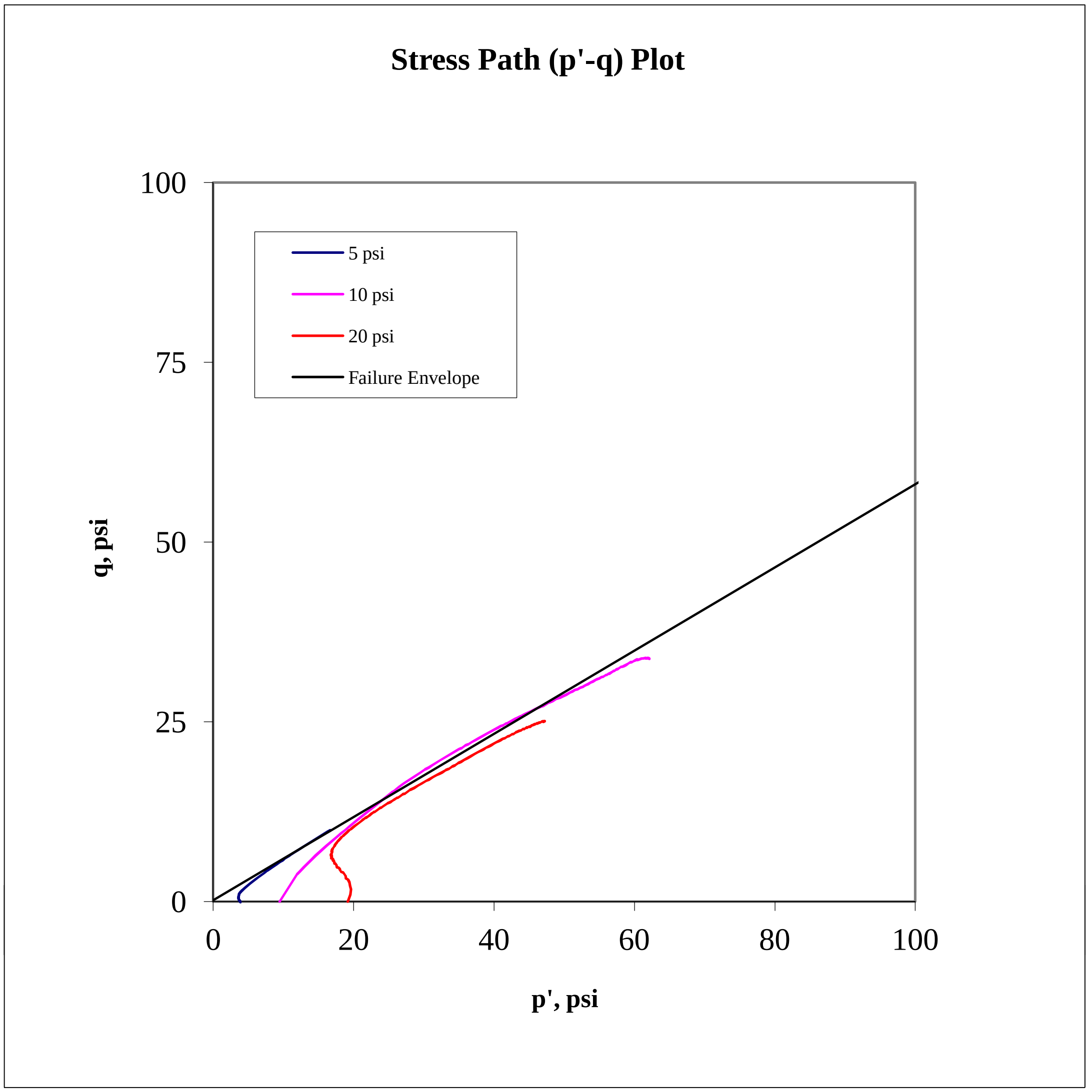


Golder Associates Inc.
Denver, Colorado

Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND

Title:
C-U TRIAXIAL SHEAR DATA
q AND EXCESS PORE PRESSURE PLOTS

Sample Number:	Reviewed:	Date:	Job Number:	Figure:
Silt Fill	TJS	12/7/11	113-81645	2

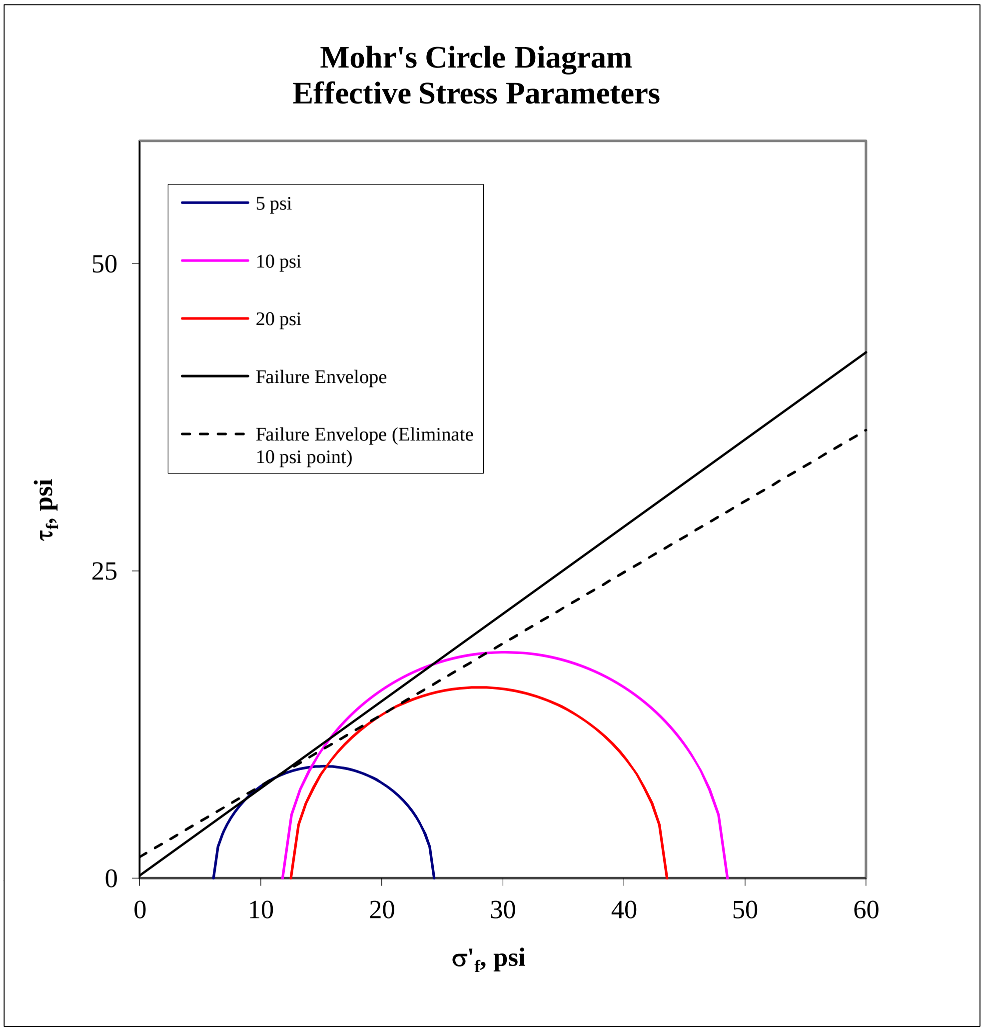


Stress Path Parameters

ψ' = 30.1 degrees
a' = 0.2 psi

Golder Associates Inc. Denver, Colorado	Title: C-U TRIAXIAL SHEAR DATA STRESS PATH PLOT
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND	

Sample Number:	Reviewed:	Date:	Job Number:	Figure:
Silt Fill	TJS	12/7/11	113-81645	3



Effective Stress Shear Strength Parameters

ϕ' = 35.4 degrees

c' = 0.2 psi

Golder Associates Inc. Denver, Colorado	**Title:**
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND	**C-U TRIAXIAL SHEAR DATA MOHR'S CIRCLE DIAGRAM**

Sample Number:	**Reviewed:**	**Date:**	**Job Number:**	**Figure:**
Silt Fill	TJS	12/7/11	113-81645	4

Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: **GRE/2011 STANTON STAT ENG SRVC/ND**
Project Number: **113-81645**

Sample Number	Silt Fill
Effective Stress Analysis	

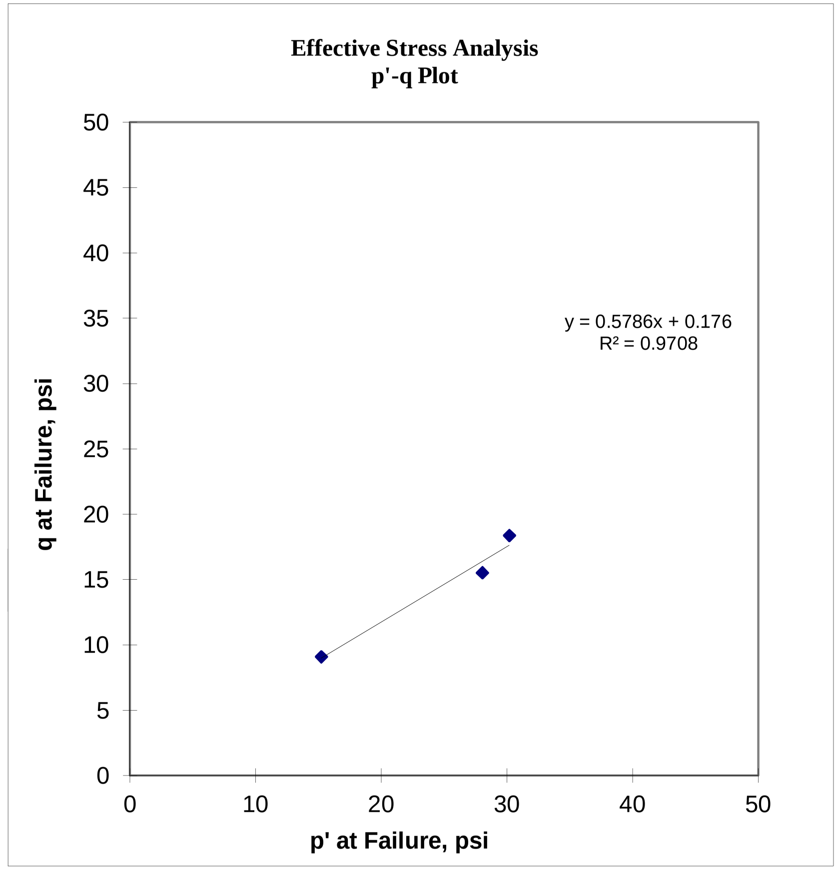
Point Number	p' (psi)	q (psi)
1 (staged)	15.2	9.1
2 (staged)	30.2	18.4
3	28.0	15.5

tan(ψ') = 0.58
a' = 0.2 psi

ϕ' = 35.4 degrees
c' = 0.2 psi

If eliminate the second point at 10 psi.
tan(ψ') = 0.50
a' = 1.5 psi

ϕ' = 30.1 degrees
c' = 1.7 psi



Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: **GRE/2011 STANTON STAT ENG SRVC/ND**
Project Number: **113-81645**

Sample Number	Silt Fill
Total Stress Analysis	

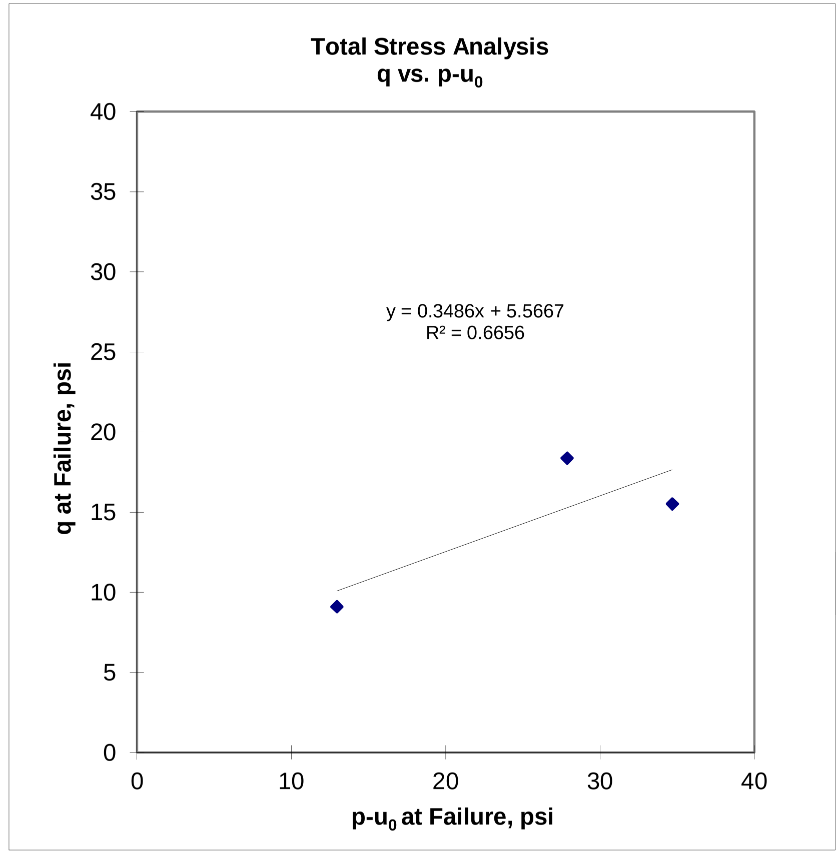
Point Number	$p-u_o$ (psi)	q (psi)
1 (staged)	12.9	9.1
2 (staged)	27.9	18.4
3	34.7	15.5

tan(ψ) = 0.35
a = 5.6 psi

ϕ = 20.4 degrees
c = 5.9 psi

If eliminate the second point at 10 psi.
tan(ψ) = 0.30
a = 5.3 psi

ϕ = 17.2 degrees
c = 5.5 psi



Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: GRE/2011 STANTON STAT ENG SRVC/ND
Project Number: 113-81645

Mohr-Coulomb Failure Criteria:

$$\tau_{ff} = c' + \sigma'_{ff} \tan(\phi')$$
$$\tau_{ff} = c + \sigma_{ff} \tan(\phi)$$

Where:
c', c = effective and total stress cohesion intercepts

ϕ', ϕ = effective and total stress friction angles

τ_{ff} = shear strength on the failure surface at failure

σ'_{ff}, σ_{ff} = effective and total normal stresses on the failure surface at failure

Stress Path Space:

$$q = \frac{\sigma_1 - \sigma_3}{2} \qquad p' = \frac{\sigma'_1 + \sigma'_3}{2} \qquad p = \frac{\sigma_1 + \sigma_3}{2}$$

Where:
q = maximum shear stress

p', p = mean effective and total stresses
σ'_1, σ_1 = effective and total axial stresses

σ'_3, σ_3 = effective and total confining stresses

Stress Path Failure Criteria:

$$q = a' + p' \tan(\psi')$$
$$q = a + (p - u_0) \tan(\psi)$$

Where:
a', a = intercepts of the q-axis in effective stress and total stress spaces

ψ', ψ = angles of the failure envelopes in effective stress and total stress spaces

q = maximum shear stress at failure

p' = mean effective stress at failure

$p-u_0$ = mean total stress at failure minus the initial pore pressure

The relationships between ψ and ϕ and a and c are as follows:

$$\tan(\psi) = \sin(\phi)$$
$$a = c \cos(\phi)$$

The relationships between ψ' and ϕ' and a' and c' are as follows:

$$\tan(\psi') = \sin(\phi')$$
$$a' = c' \cos(\phi')$$

Sample 4a
Staged 5 & 10psi

Sample 3a
20psi

FLOW PUMP #2

FLEXIBLE WALL PERMEABILITY
ASTM D 5084
METHOD D, CONSTANT RATE OF FLOW

PROJECT TITLE	GRE/2011 STANTON STAT ENG SRVC/ND		BOARD #	2	COMMENTS: 1. Water used as permeant
PROJECT NUMBER	113-81645		CELL #	5	2. Specific gravity is assumed
SAMPLE ID	Silt Fill (#2 / 3A @ 10-12')	--	Flow Pump Speed	6	3. Sample was sheared after permeability test performed
SAMPLE TYPE	Inplace		Technician	PRH	

Sample Data, Initial

Height, cm	17.10	B-Value, f	95.0
Diameter, cm	7.27	Cell Pres. (psi)	80.0
Area, cm²	41.51	Bot. Pres. (psi)	70.0
Volume, cm³	709.83	Top Pres. (psi)	70.0
Mass, g	1398.00	Eff. Stress (psi)	10.0
Moisture Content, %	13.0	Head, max.	85
Dry Density, pcf	108.8	Head, min.	82
Spec. Gravity	2.70	Max. Grad.	4.97
Volume Solids, cm³	458.23	Min. Grad.	4.80
Volume Voids, cm³	251.60		
Void Ratio	0.55		
Saturation, %	63.9%		

Flow Pump Rate 5.50E-04 cm³/sec

Sample Data, Final

Height, cm	
Diameter, cm	
Area, cm²	0.00
Volume, cm³	0.00
Mass, g	
Moisture Content,%	#DIV/0!
Dry Density, pcf	#DIV/0!
Volume Solids, cm³	#DIV/0!
Volume Voids, cm³	#DIV/0!
Void Ratio	#DIV/0!
Saturation, %	#DIV/0!

WATER CONTENTS		Trimmings Initial	Sample Final
Wt Soil & Tare, i	g	392.67	
Wt Soil & Tare, f	g	362.08	
Wt Tare	g	126.70	
Wt Moisture Lost	g	30.59	0.00
Wt Dry Soil	g	235.38	0.00
Water Content	%	13.0%	#DIV/0!

DESCRIPTION
--

DATE/TIME		dt (min)	TEMP (°C)	Speed (1-12)	Speed Coeff.	DH (cm)	L (cm)	A (cm²)	i (Gradient))	q (cm³/sec)	v (cm/sec)	Permeability (cm/sec)
12/4/11	12:45											
12/4/11	13:00	15	20.7	6	1	82	17.10	41.51	4.80	5.5E-04	1.3E-05	2.8E-06
12/4/11	13:15	30	20.7	6	1	85	17.10	41.51	4.97	5.5E-04	1.3E-05	2.7E-06
12/4/11	13:30	45	20.7	6	1	84	17.10	41.51	4.91	5.5E-04	1.3E-05	2.7E-06
12/4/11	13:45	60	20.7	6	1	84	17.10	41.51	4.91	5.5E-04	1.3E-05	2.7E-06

PERMEABILITY REPORTED AS ** 2.7E-06 cm/sec **

DATE 12/4/2011
REVIEW

Golder Associates Inc.

NATURAL CLAY

Boring # =	Natural Clay # 1		Boring # =	Natural Clay # 1		Boring # =	Natural Clay # 1	
Sample # =	5A		Sample # =	5A		Sample # =	5B	
Depth (ft) =	20.0-22.0		Depth (ft) =	20.0-22.0		Depth (ft) =	20.0-22.0	
Point # =	1 (staged)		Point # =	2 (staged)		Point # =	3	
	Initial			**Initial**			**Initial**	
Length =	15.15	cm	Length =	15.15	cm	Length =	15.40	cm
Diameter =	7.29	cm	Diameter =	7.29	cm	Diameter =	7.28	cm
Wet Weight =	1247.40	g	Wet Weight =	1247.40	g	Wet Weight =	1216.30	g
Area =	41.7	cm^2	Area =	41.7	cm^2	Area =	41.6	cm^2
Sample Area =	6.47	in^2	Sample Area =	6.47	in^2	Sample Area =	6.45	in^2
Volume =	632.3	cm^3	Volume =	632.3	cm^3	Volume =	641.0	cm^3
Moisture Content =	25.8%		Moisture Content =	25.8%		Moisture Content =	25.8%	
Specific Gravity =	-		Specific Gravity =	-		Specific Gravity =	-	
Dry Weight of Solids =	991.57	g	Dry Weight of Solids =	991.57	g	Dry Weight of Solids =	966.85	g
Wet Unit Weight =	1.97	g/cm^3	Wet Unit Weight =	1.97	g/cm^3	Wet Unit Weight =	1.90	g/cm^3
Dry Unit Weight =	1.57	g/cm^3	Dry Unit Weight =	1.57	g/cm^3	Dry Unit Weight =	1.51	g/cm^3
Wet Unit Weight =	123.1	pcf	Wet Unit Weight =	123.1	pcf	Wet Unit Weight =	118.4	pcf
Dry Unit Weight =	97.9	pcf	Dry Unit Weight =	97.9	pcf	Dry Unit Weight =	94.1	pcf
Cell Pressure =	37	psi	Cell Pressure =	45	psi	Cell Pressure =	70	psi
Back Pressure =	30	psi	Back Pressure =	30	psi	Back Pressure =	40	psi
Confining Pressure =	7	psi	Confining Pressure =	15	psi	Confining Pressure =	30	psi

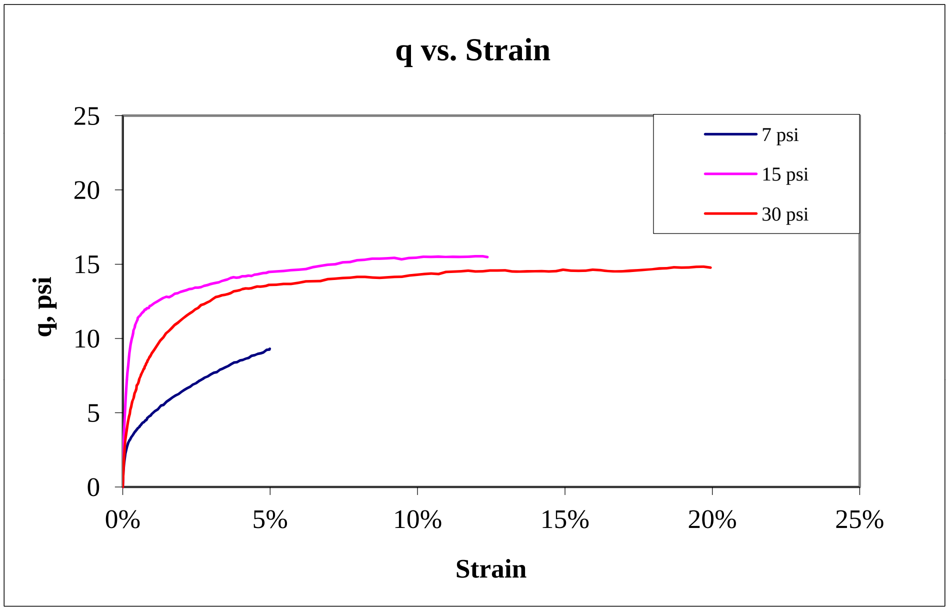
Notes:
Visually observed as dark olive brown silty clay.
Intact sample; ends trimmed flush
Rate of strain = 4.364%/hour; t_{50} = 5.5 minutes.
Points 1 and 2 were staged.
Point 2 lost cell pressure during test; results shown to 12.4% strain

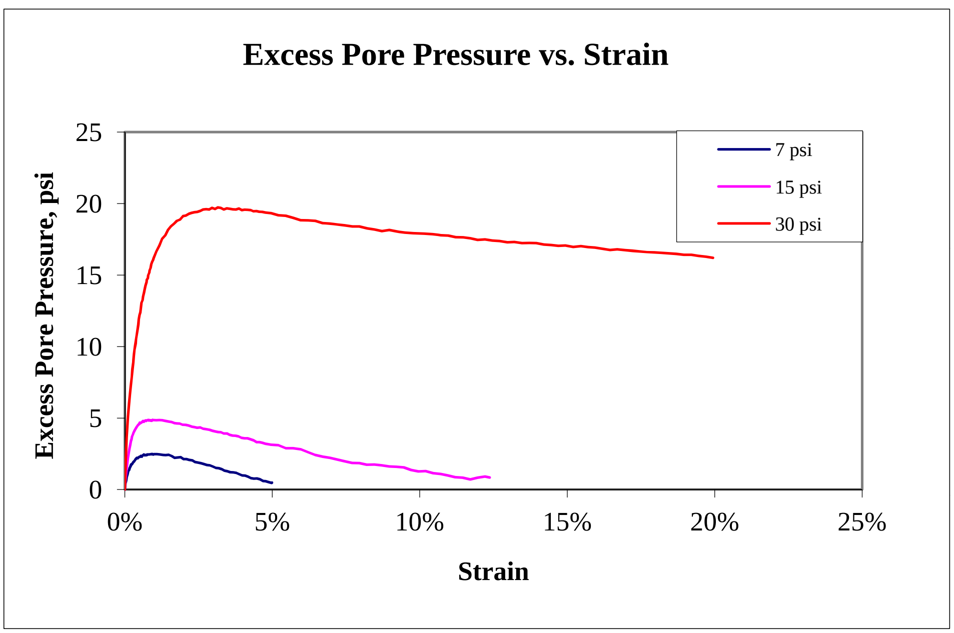
Golder Associates, Inc.
Denver, Colorado

Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND

Title: TRIAXIAL SHEAR TEST REPORT
SAMPLE DATA AND CALCULATIONS

Sample Number:	Reviewed:	Date:	Job Number:	Figure:
Natural Clay # 1 / 5A and 5B	TJS	12/13/11	113-81645	1

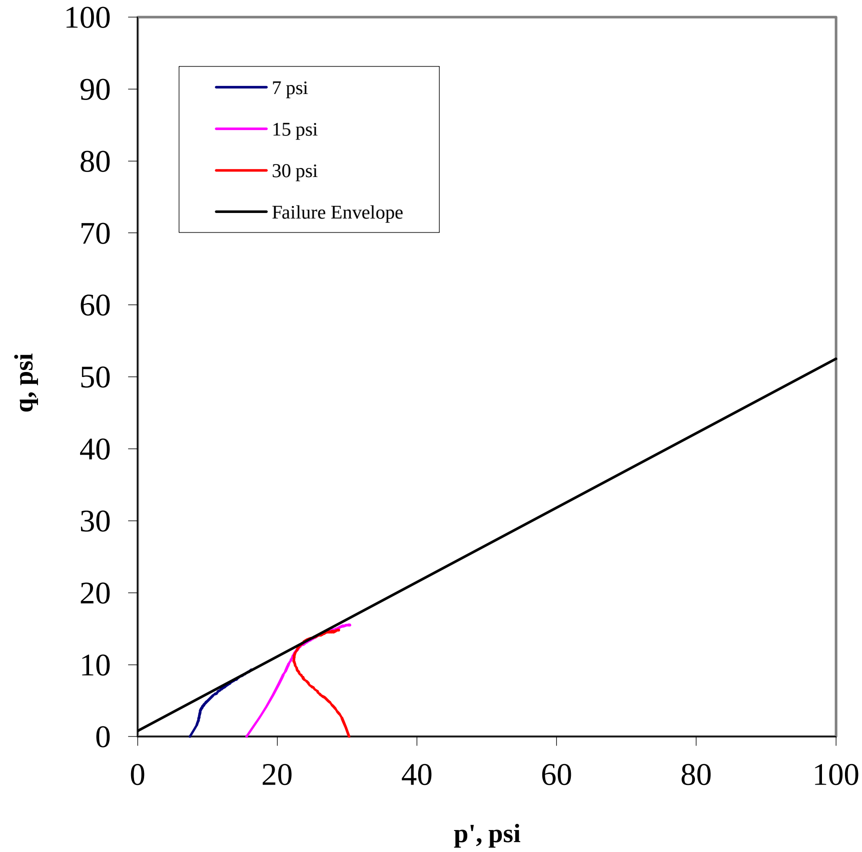




Golder Associates, Inc. Denver, Colorado	Title: C-U TRIAXIAL SHEAR DATA q AND EXCESS PORE PRESSURE PLOTS
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND	

Sample Number:	Reviewed:	Date:	Job Number:	Figure:
Natural Clay # 1 / 5A and 5B	TJS	12/13/11	113-81645	2

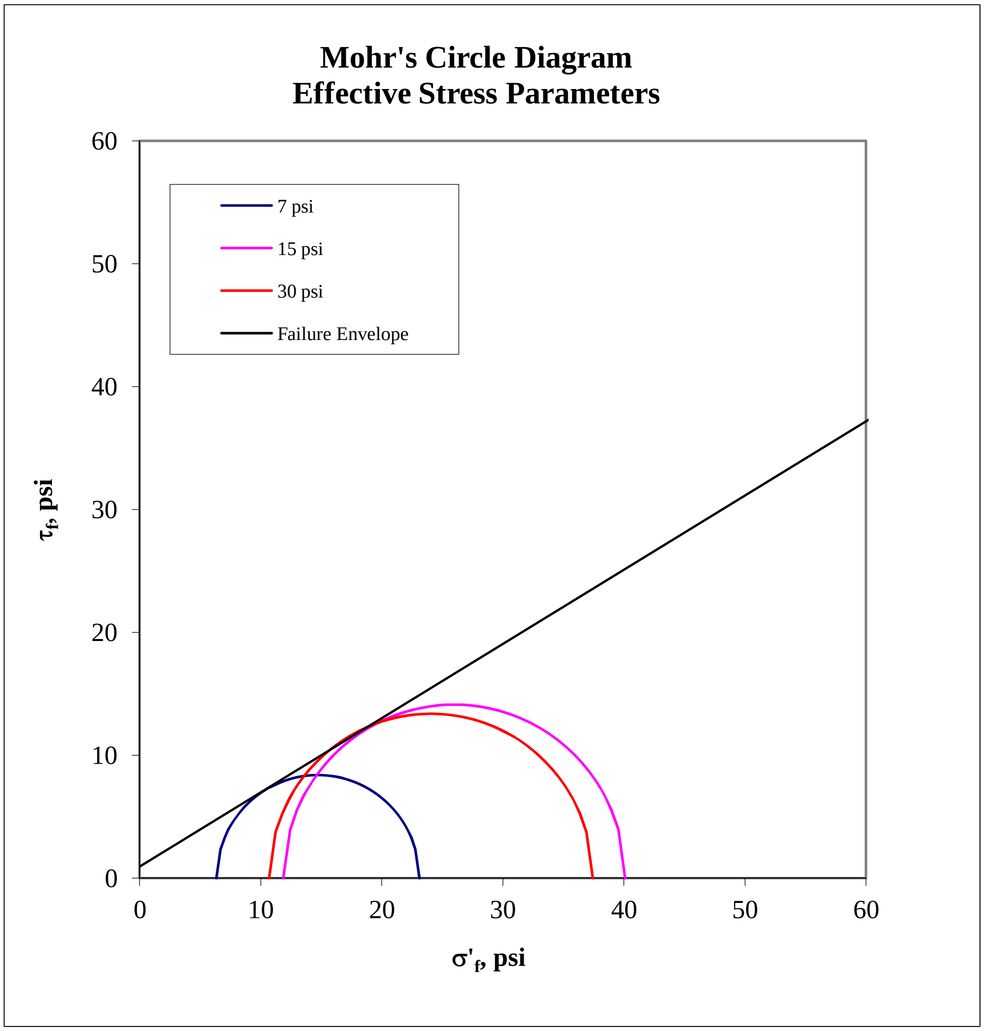
Stress Path (p'-q) Plot



Stress Path Parameters

ψ' = 27.3 degrees
a' = 0.8 psi

Golder Associates, Inc. Denver, Colorado		**Title:**		
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND		**C-U TRIAXIAL SHEAR DATA STRESS PATH PLOT**		
Sample Number: Natural Clay # 1 / 5A and 5B	**Reviewed:** TJS	**Date:** 12/13/11	**Job Number:** 113-81645	**Figure:** 3



Effective Stress Shear Strength Parameters

ϕ' = 31.1 degrees

c' = 0.9 psi

Golder Associates, Inc. **Denver, Colorado**	**Title:** C-U TRIAXIAL SHEAR DATA MOHR'S CIRCLE DIAGRAM
Job Short Title: GRE/2011 STANTON STAT ENG SRVC/ND	

Sample Number:	Reviewed:	Date:	Job Number:	Figure:
Natural Clay # 1 / 5A and 5B	TJS	12/13/11	113-81645	4

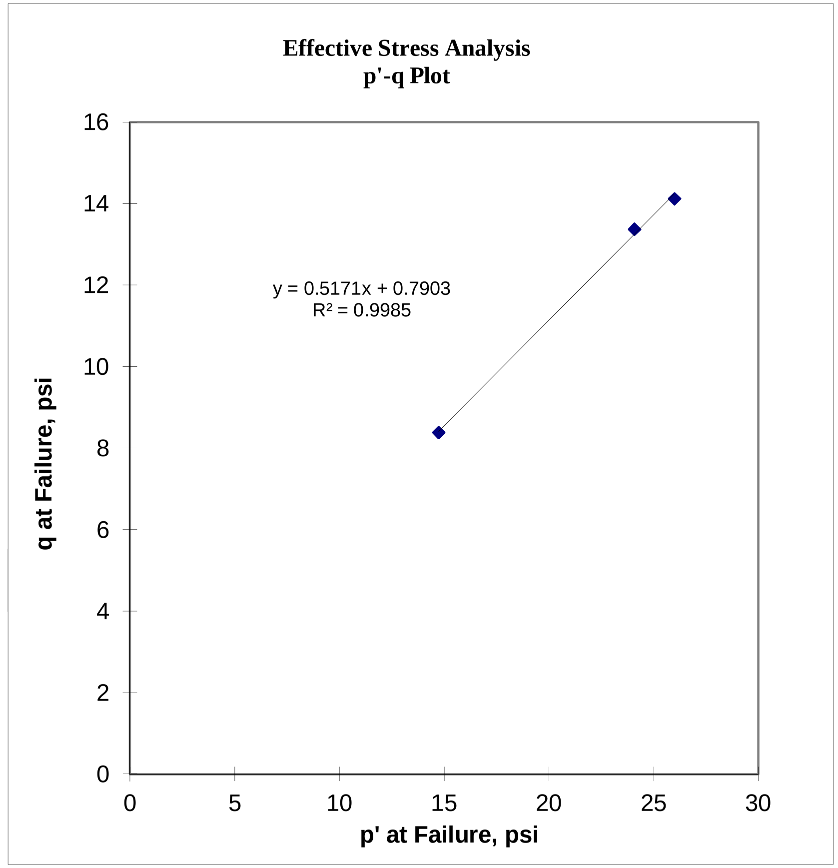
Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: **GRE/2011 STANTON STAT ENG SRVC/ND**
Project Number: **113-81645**

Sample Number	Natural Clay # 1 / 5A and 5E
Effective Stress Analysis	

Point Number	p' (psi)	q (psi)
1 (staged)	14.7	8.4
2 (staged)	26.0	14.1
3	24.1	13.4

tan(ψ') = 0.52
a' = 0.8 psi

ϕ' = 31.1 degrees
c' = 0.9 psi



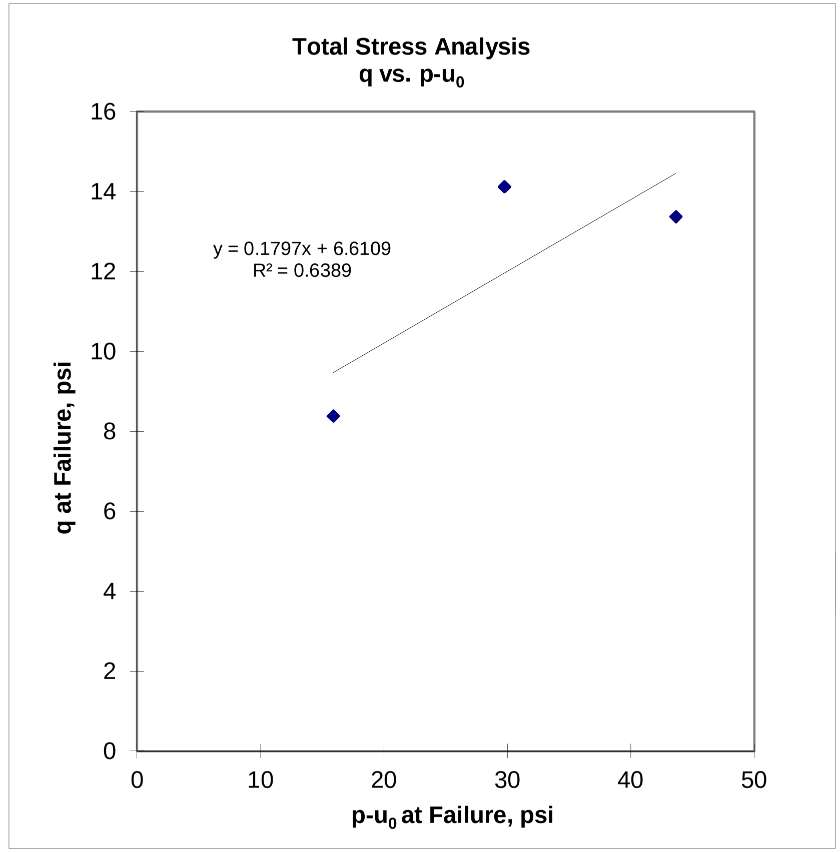
Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: **GRE/2011 STANTON STAT ENG SRVC/ND**
Project Number: **113-81645**

Sample Number	Natural Clay # 1 / 5A and 5B
Total Stress Analysis	

Point Number	$p-u_o$ (psi)	q (psi)
1 (staged)	15.9	8.4
2 (staged)	29.7	14.1
3	43.6	13.4

tan(ψ) = 0.18
a = 6.6 psi

ϕ = 10.4 degrees
c = 6.7 psi



Consolidated-Undrained Triaxial Lab Data
From: GOLDER ASSOCIATES INC.
Project: GRE/2011 STANTON STAT ENG SRVC/ND
Project Number: 113-81645

Mohr-Coulomb Failure Criteria:

$$\tau_{ff} = c' + \sigma'_{ff} \tan(\phi')$$
$$\tau_{ff} = c + \sigma_{ff} \tan(\phi)$$

Where:
c', c = effective and total stress cohesion intercepts
ϕ', ϕ = effective and total stress friction angles
τ_{ff} = shear strength on the failure surface at failure
σ'_{ff}, σ_{ff} = effective and total normal stresses on the failure surface at failure

Stress Path Space:

$$q = \frac{\sigma_1 - \sigma_3}{2} \qquad p' = \frac{\sigma'_1 + \sigma'_3}{2} \qquad p = \frac{\sigma_1 + \sigma_3}{2}$$

Where:
q = maximum shear stress
p', p = mean effective and total stresses
σ'_1, σ_1 = effective and total axial stresses
σ'_3, σ_3 = effective and total confining stresses

Stress Path Failure Criteria:

$$q = a' + p' \tan(\psi')$$
$$q = a + (p - u_0) \tan(\psi)$$

Where:
a', a = intercepts of the q-axis in effective stress and total stress spaces
ψ', ψ = angles of the failure envelopes in effective stress and total stress spaces
q = maximum shear stress at failure
p' = mean effective stress at failure
p-u_0 = mean total stress at failure minus the initial pore pressure

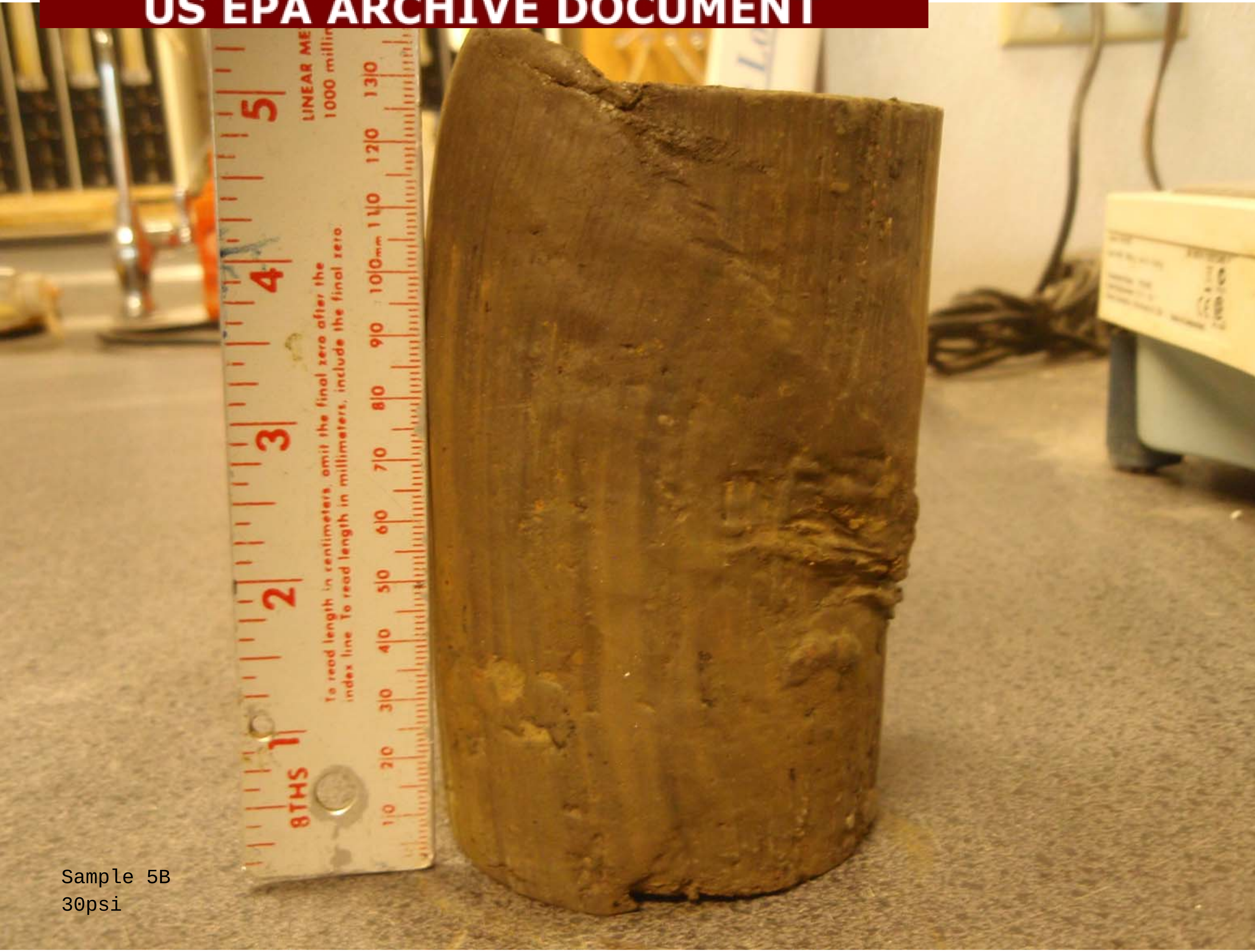
The relationships between ψ and ϕ and a and c are as follows:

$$\tan(\psi) = \sin(\phi)$$
$$a = c \cos(\phi)$$

The relationships between ψ' and ϕ' and a' and c' are as follows:

$$\tan(\psi') = \sin(\phi')$$
$$a' = c' \cos(\phi')$$

Sample 5A
Staged 7 & 15psi



Sample 5B
30psi

FLOW PUMP #2

FLEXIBLE WALL PERMEABILITY
ASTM D 5084
METHOD D, CONSTANT RATE OF FLOW

PROJECT TITLE	GRE/ 2011 STANTON STAT ENG SRVC/ ND
PROJECT NUMBER	113-81645
SAMPLE ID	Natural Clay (#1 / 5B @ 20-22') --
SAMPLE TYPE	Inplace

BOARD #	4
CELL #	TX 3
Flow Pump Speed	11
Technician	RJM

COMMENTS
1. Water used as permeant
2. Specific gravity is assumed
3. Sample was too soft to take final measurements accurately.

Sample Data, Initial

Height, cm	15.40	B-Value, f	97.0
Diameter, cm	7.28	Cell Pres. (psi)	47.0
Area, cm²	41.62	Bot. Pres. (psi)	40.0
Volume, cm³	641.02	Top Pres. (psi)	40.0
Mass, g	1216.30	Eff. Stress (psi)	7.0
Moisture Content, %	25.8	Head, max.	114
Dry Density, pcf	94.1	Head, min.	111
Spec. Gravity	2.70	Max. Grad.	7.40
Volume Solids, cm³	358.09	Min. Grad.	7.21
Volume Voids, cm³	282.93		
Void Ratio	0.79		
Saturation, %	88.2%		

Flow Pump Rate 1.40E-05 cm³/sec

Sample Data, Final

Height, cm	12.40
Diameter, cm	
Area, cm²	0.00
Volume, cm³	0.00
Mass, g	1204.50
Moisture Content,%	23.0
Dry Density, pcf	#DIV/0!
Volume Solids, cm³	362.56
Volume Voids, cm³	-362.56
Void Ratio	-1.00
Saturation, %	-62.2%

WATER CONTENTS		Trimmings Initial	Sample Final
Wt Soil & Tare, i	g	388.84	1286.8
Wt Soil & Tare, f	g	326.15	1061.30
Wt Tare	g	83.17	82.83
Wt Moisture Lost	g	62.69	225.50
Wt Dry Soil	g	242.98	978.47
Water Content	%	25.8%	23.0%

DESCRIPTION
--

DATE/TIME		dt (min)	TEMP (°C)	Speed (1-12)	Speed Coeff.	DH (cm)	L (cm)	A (cm²)	i (Gradient)	q (cm³/sec)	v (cm/sec)	Permeability (cm/sec)
12/9/11	11:30											
12/9/11	11:45	15	20.7	11	1	114	15.40	41.62	7.40	1.4E-05	3.4E-07	4.5E-08
12/9/11	12:00	30	20.7	11	1	112	15.40	41.62	7.27	1.4E-05	3.4E-07	4.6E-08
12/9/11	12:15	45	20.7	11	1	113	15.40	41.62	7.34	1.4E-05	3.4E-07	4.6E-08
12/9/11	12:30	60	20.7	11	1	111	15.40	41.62	7.21	1.4E-05	3.4E-07	4.7E-08

PERMEABILITY REPORTED AS ** 4.6E-08 cm/sec **

DATE 12/9/2011
REVIEW

OBJECTIVE:

Evaluate the seismic (pseudo-static) stability of the Bottom Ash Surface Impoundment at Great River Energy's (GRE) Stanton Station (SS).

METHOD:

Due to the low potential for seismic activity at the site, a pseudo-static analysis was deemed appropriate. Seismic slope stability analyses were performed using the seismic stability method recommended in the Environmental Protection Agency's (EPA) "Resource-Conservation and Recovery Act (RCRA) Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities" document (EPA 1995) and the slope stability analysis computer program SLIDE. Factors of safety were computed for circular slip surfaces using Spencer's method for force and moment equilibrium to determine limiting conditions.

ASSUMPTIONS:

Site

Stanton Station, located in central North Dakota, is in an area with low historic seismic activity. No earthquakes of Magnitude V (i.e. Moderate-Strong) or greater (Mercalli intensity scale) have occurred in North Dakota during historical times (USGS 1975). Additionally, the site is not in a "seismic impact zone" based on RCRA Subtitle D regulations for municipal solid waste landfills (40 CFR 258.14). The peak ground acceleration with a 2% probability of exceedance in 50 years is estimated between 0.02 g and 0.03 g (USGS 2008, see Attachments).

Underlying CCP Materials

The Bottom Ash Surface Impoundment is constructed over the former "A" ash pond which received coal combustion products (CCPs) from Stanton Station until 1992. From 1992 to 1995, ash was removed from this area and hauled to the Glenharold Mine disposal area and the "BC" ash pile. Following removal of ash, berms were constructed and/or extended and a composite liner was installed for the Bottom Ash Surface Impoundment. Based on our review of this site history, the Bottom Ash Surface Impoundment is not built over wet ash or other unsuitable materials.

Geometry

The cross sections through the Bottom Ash Surface Impoundment remain unchanged from the initial *Stability Evaluation.* The description of each cross section is provided subsequently for completeness.

The cross sections that were evaluated for stability are the north/south, west, and east downstream (outside) slopes, and the upstream (interior) slope (Figure 1). Two scenarios for each cross section were evaluated. The first scenario examined the stability for an intact geomembrane and the second analysis examined the stability if no geomembrane is present and seepage progresses through the berm. A total of eight stability scenarios were analyzed. The geometries of each cross section are as follows:

North and South Berms

The geometry of the north and south downstream slopes are the same; therefore, one stability analysis was performed to examine both downstream slopes. The stability of the downstream slopes was examined according to design grades. The design indicates a 20-foot wide crest at an elevation of 1720 feet with 3:1 side slopes to approximately 1700 feet. Grades from a 2001 aerial survey were used to confirm the design slope geometry. The cross section for the north and south downstream slope is shown on Figures 2 and 3.

West Berm

The west downstream slope has a design crest width of 20 feet at an elevation of 1720 feet and extends at an approximate 3:1 slope down to an elevation of approximately 1700 feet. This section geometry was also verified with grades from the 2001 aerial survey. The cross section for the west downstream slope is shown on Figures 4 and 5.

East Berm

The east downstream slope has a design crest width of 20 feet at an elevation of 1720 feet and extends at an approximate 3:1 slope down to an elevation of 1715 feet. The original design includes a 4-foot wide bench at elevation 1715 then a 3:1 slope down to an elevation of approximately 1700 feet. Site observations, as-built drawings and sections developed using the 2001 aerial survey do not match the design geometry. The bench at elevation 1715 is substantially wider than the design and was modeled as 20 feet. The cross section for the east downstream slope is shown on Figures 6 and 7.

Upstream (Interior) Berm

The upstream slope has an approximate 3:1 slope from elevation 1720 feet down to elevation 1702 feet. This section geometry was verified with the as-built drawings and grades from the 2001 aerial survey. The cross section for the upstream slope is shown on Figures 8 and 9. Analysis of the upstream slope did not evaluate bottom ash on the smooth geomembrane, but focused on the underlying clay liner and berm.

Groundwater Information

Groundwater generally flows north under the Bottom Ash Surface Water Impoundment toward the Missouri River. Groundwater is typically less than 10 feet below the final construction grades of the Impoundment and is at an approximate elevation of 1700 feet amsl near the South Cell and 1690 near the North Cell (Barr 2011). Water elevations observed in piezometers P-1 and P-2 directly after well construction were: 1,698.3 feet above mean sea level (ft amsl) at P-1 and 1,695.9 ft amsl at P-2. The flux of water from the impoundment to the groundwater is expected to be minimal since the impoundment is lined. For the analyses, the groundwater is conservatively modeled at the base of the constructed embankments.

Seismic Load Coefficient

The peak (bedrock) ground acceleration with a 2% probability of exceedance in 50 years was conservatively chosen as 0.03 g (USGS 2008, see Attachments). A peak ground surface acceleration of 0.05 g was determined from recommendations presented by the EPA (EPA 1995). Per the seismic stability method (EPA 1995), a seismic load coefficient equal to one-half the peak ground surface acceleration (0.05 g / 2 = 0.025 g) was chosen.

Material Properties

Static material properties (and material testing results) are provided in Golder's Stability Evaluation of Bottom Ash Surface Impoundment Report (dated May 16, 2011) and Addendum (dated December 22, 2011). Per the seismic stability method (EPA 1995), fine grained soils (natural soil, historic embankment fill, and new embankment fill), were assigned strength parameters corresponding to 80 percent of the total stress strength parameters:

- The Historic Embankment Fill was assigned strength parameters based on laboratory testing of the silty sand (SM) predominantly found in the fill. The results (with the 80 percent reduction) were cohesion of 630 psf and a friction angle of 14 degrees.

- The Natural Soil was observed to contain clay, silt, and sand. Strength parameters for this material were based on laboratory testing of clay (CH) material collected from the site with the strength envelope intercepting at zero with zero confining pressure to conservatively model the effects of sand layers. A shear/normal function (with the 80 percent reduction) was used to describe the shear strength of the material and is shown below:

ASSUMED DYNAMIC STRENGTH ENVELOPE	
Normal Stress (psf)	**Sheer Strength** (psf)
0	0
2,188	1,094
14,400	2,879

- The New Embankment Fill and Compacted Fill were assumed to be the same material, and this clay was assigned strength parameters based on laboratory testing of a fat clay (CH) sample collected from the site. The results (with the 80 percent reduction) were cohesion of 470 psf and a friction angle of 15.5 degrees.

The geomembrane interface strength parameters were not modified for pseudo-static stability conditions based on recommendations in documentation provided by the EPA (1995).

- Geomembrane interface inputs are based on previous experience by Golder and published values. The interfaces of interest are a smooth HDPE against Compacted Fill (Glenharold Mine clay) and smooth HDPE against bottom ash. The geomembrane/clay interface is more critical than the geomembrane/bottom ash interface; therefore, the geomembrane/bottom ash interface will not be included in analyses. A residual friction angle of 7.5 degrees and a residual adhesion intercept of approximately 190 psf are used for the smooth HDPE/compacted fill interface in stability analyses. These values are considered conservative and are appropriate for use in the Stanton Station stability analyses.

A summary of the static and pseudo-static material properties is provided in Table 1.

RESULTS:

Golder performed seismic stability analyses using SLIDE. Factors of safety were computed for circular slip surfaces using Spencer's method for force and moment equilibrium. Results of stability analyses are presented in Figures 2-9.

A summary of factors of safety calculated for each scenario are provided in the following table:

Description	Geomembrane	Water Level	Static Factor of Safety	Dynamic Factor of Safety
North/South	Intact	1720 ft.	2.4	2.2
	None	Phreatic Surface through Berm	2.3	2.2
West	Intact	1720 ft.	2.4	2.1
	None	Phreatic Surface through Berm	2.4	2.1
East	Intact	1720 ft.	2.4	2.5
	None	Phreatic Surface through Berm	2.4	2.5
Upstream	Intact	No Water	3.0	2.5
	None	No Water, Saturated Berm	1.9	2.5

For civil engineering structures subjected to seismic loads, a factor of safety greater than or equal to 1.0 is desired in accordance with EPA recommendations (EPA 1995). All of the scenarios evaluated have a factor of safety greater than or equal to 1.0 and are expected to remain stable under the anticipated seismic loading conditions. Based on the maximum ground acceleration expected at this site and stability analysis results, significant deformations are not expected.

REFERENCES

Earthquake Information Bulletin, Volume 7, Number 6, November - December 1975 (USGS 1975). Accessed 2/23/12: http://earthquake.usgs.gov/earthquakes/states/north_dakota/history.php.

Resource-Conservation and Recovery Act (RCRA) Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities, published by Environmental Protection Agency, (EPA 1995).

Electronic Code of Federal Regulations, 40 CFR 258.14. Accessed 2/24/12: http://ecfr.gpoaccess.gov.

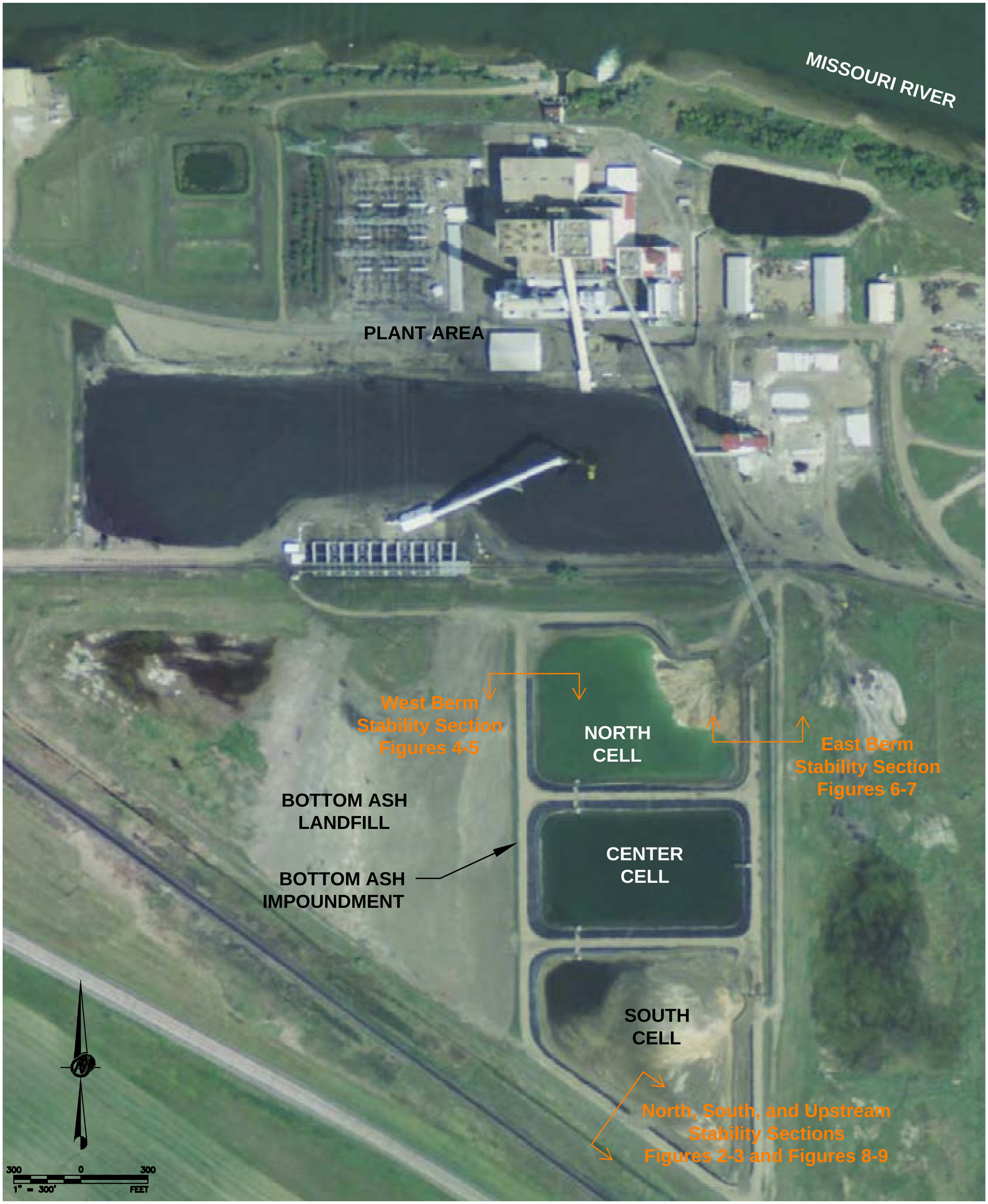
National Seismic Hazard Maps – 2008 (USGS 2008). Accessed 2/23/12: http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/

TABLES

Table 1: Material Properties

	Hydraulic Conductivity	Moisture / Density					Shear Strength			
							Static		Dynamic	
	k_{sat} cm/sec	γ_{dry} pcf	ω %	γ_{wet} pcf	ω (sat) %	γ_{sat} pcf	ϕ'/δ degrees	c'/a psf	ϕ/δ degrees	c/a psf
Historic Embankment Fill - Silt	3.0E-06	112.0	11.0	124	19.0	133	30.0	100	14.0	630
Natural Soil - Silt/Clay	3.0E-06	104.0	-	-	19.0	124	30.0	100	Sheer/Normal Fx	
New Embankment Fill - Clay from Glenharold Mine	2.0E-08	100.0	23.0	123	28.0	128	30.0	200	15.5	470
Compacted Fill – Clay from Glenharold Mine	2.0E-08	100.0	23.0	123	28.0	128	30.0	200	15.5	470
Smooth HDPE / Clay	2.0E-13	NA	NA	NA	NA	NA	7.5	190	7.5	190

FIGURES



GREAT RIVER ENERGY
STANTON STATION
PLANT AREA

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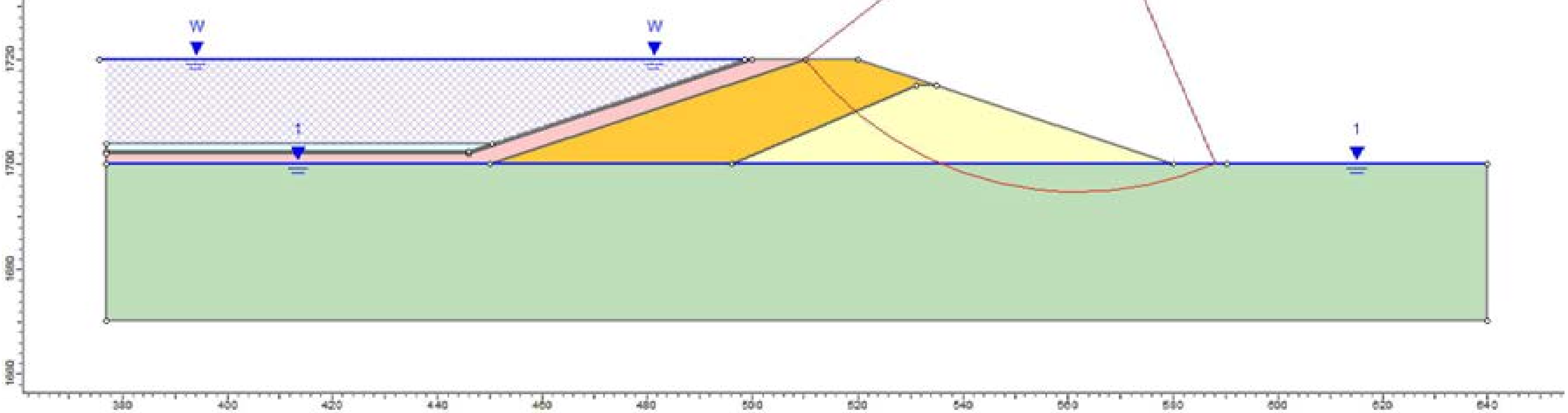
FIGURE 1

PROJECT No. 113-81645 CADD TLR DATE 12/16/2011 FILE No. Figure 1.dwg

Drawing File: J:\12JOBS\123-81645 GRE SS\Seismic Evaluation\ Figure 1.dwg | Layout: FIGURE 3 | Modified: Mar 16, 2012 10:12 JSauer | Plotted: 03/16/12 2:02pm JSauer

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Hist Emb Fill		124	133	Mohr-Coulomb	630	14		None
Natural Soil		124	124	Shear Normal function			User Defined 1	None
New Emb Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
Compacted Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
HDPE/CH		123	128	Mohr-Coulomb	190	7.5		None
Protective Cover		123	128	Mohr-Coulomb	470	15.5		None



NORTH AND SOUTH BERMS WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULTS

FIGURE 2

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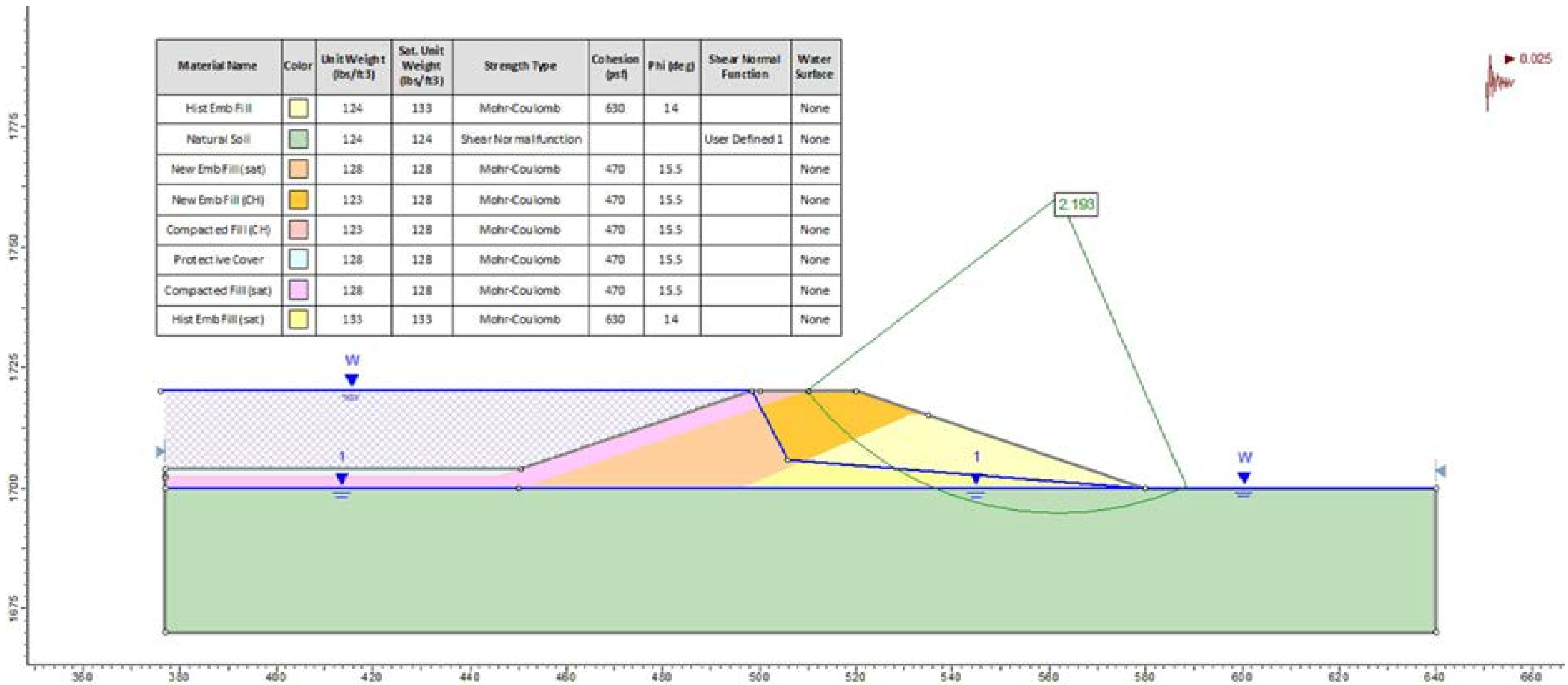
PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

Drawing File: J:\12JOBS\123-81645 GRE SS\Seismic Evaluation\Seismic Slide\ Evaluation Figures.dwg | Layout: Fig 2 | Modified: Mar 16, 2012 13:38 JSauer | Plotted: 03/16/12 3:10pm JSauer

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Hist Emb Fill		124	133	Mohr-Coulomb	630	14		None
Natural Soil		124	124	Shear Normal function			User Defined 1	None
New Emb Fill (sat)		128	128	Mohr-Coulomb	470	15.5		None
New Emb Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
Compacted Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
Protective Cover		128	128	Mohr-Coulomb	470	15.5		None
Compacted Fill (sat)		128	128	Mohr-Coulomb	470	15.5		None
Hist Emb Fill (sat)		133	133	Mohr-Coulomb	630	14		None



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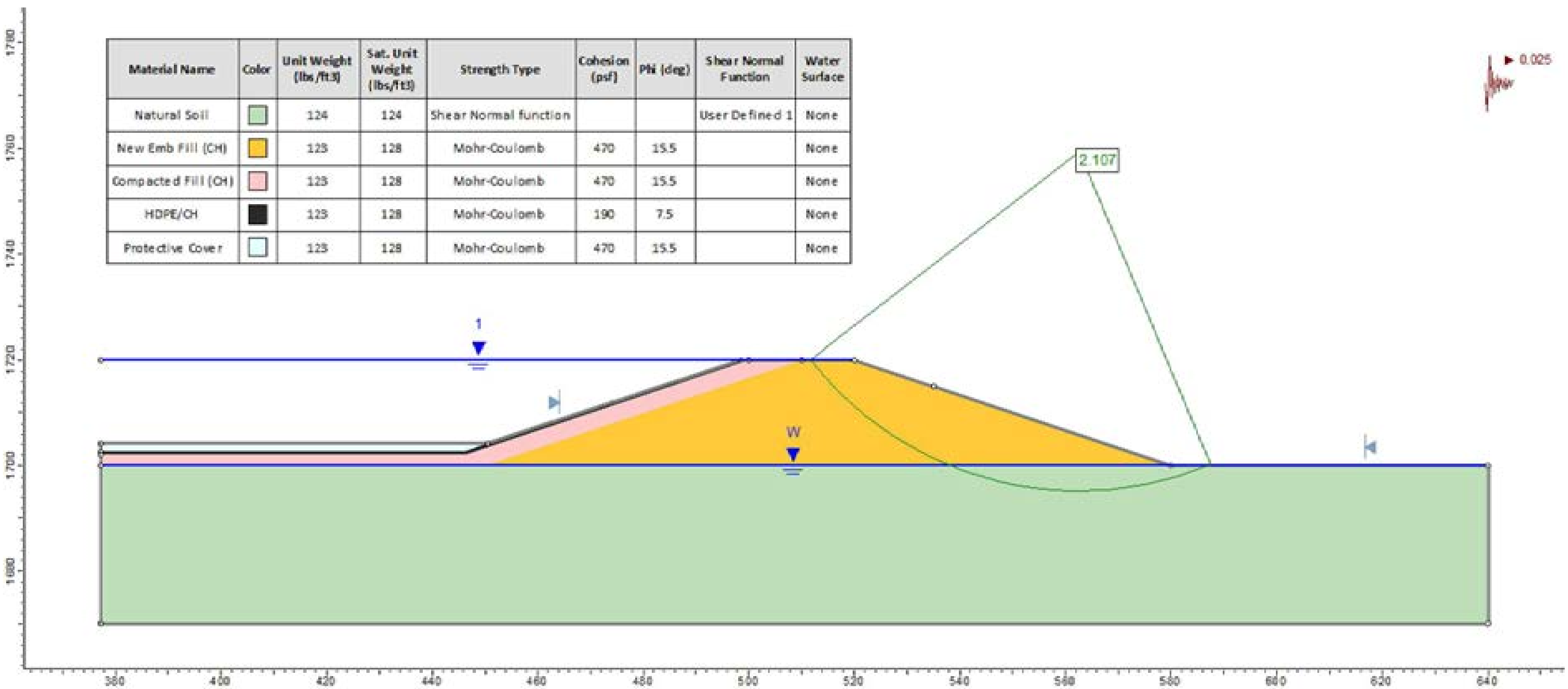
NORTH AND SOUTH BERMS WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULTS

FIGURE 3

PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

Drawing File: J:\12JOBS\123-81645 GRE SS\Seismic Evaluation\Seismic Slide\ Evaluation Figures.dwg | Layout: Fig 3 | Modified: Mar 16, 2012 13:38 JSauer | Plotted: 03/16/12 3:10pm JSauer

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Natural Soil		124	124	Shear Normal function			User Defined 1	None
New Emb Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
Compacted Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
HDPE/CH		123	128	Mohr-Coulomb	190	7.5		None
Protective Cover		123	128	Mohr-Coulomb	470	15.5		None



WEST BERMS WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULTS

FIGURE 4

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PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

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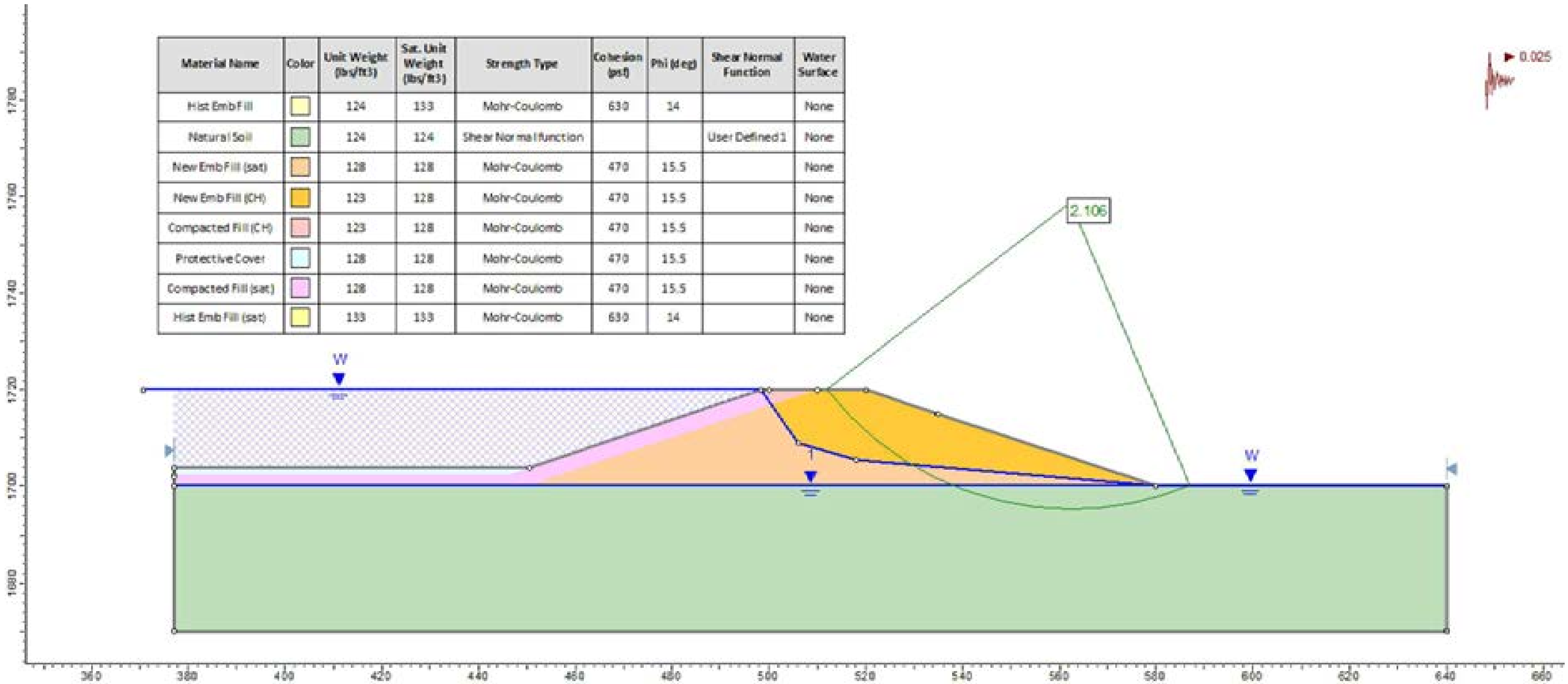
Hist Emb Fill		124	133	Mohr-Coulomb	630	14		None
Natural Soil		124	124	Shear Normal function			User Defined 1	None
New Emb Fill (sat)		128	128	Mohr-Coulomb	470	15.5		None
New Emb Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
Compacted Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
Protective Cover		128	128	Mohr-Coulomb	470	15.5		None
Compacted Fill (sat)		128	128	Mohr-Coulomb	470	15.5		None
Hist Emb Fill (sat)		133	133	Mohr-Coulomb	630	14		None



WEST BERMS WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULTS

FIGURE 5

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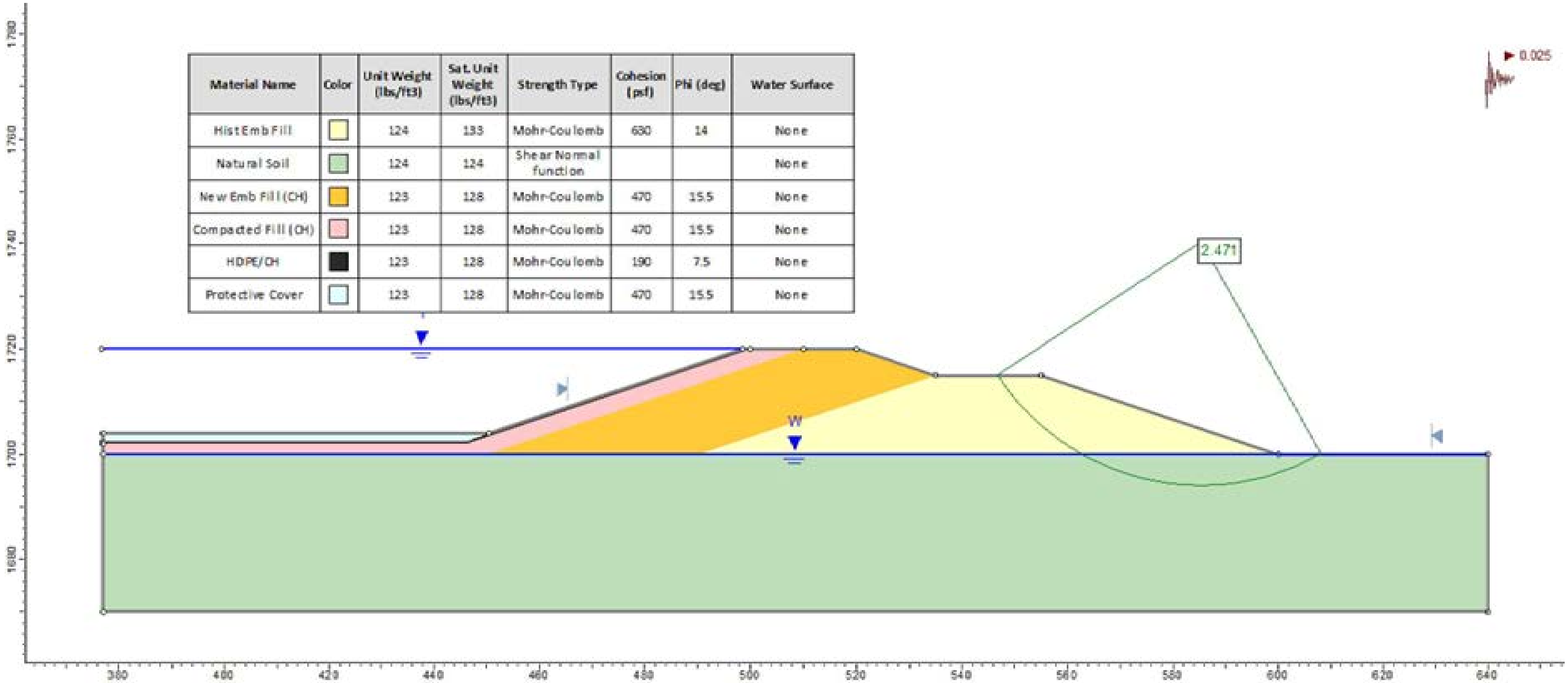
PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

Drawing File: J:\12JOBS\123-81645 GRE SS\Seismic Evaluation\Seismic Slide\ Evaluation Figures.dwg | Layout: Fig 5 | Modified: Mar 16, 2012 13:38 JSauer | Plotted: 03/16/12 3:10pm JSauer

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Hist Emb Fill		124	133	Mohr-Coulomb	630	14	None
Natural Soil		124	124	Shear Normal function			None
New Emb Fill (CH)		123	128	Mohr-Coulomb	470	15.5	None
Compacted Fill (CH)		123	128	Mohr-Coulomb	470	15.5	None
HDPE/CH		123	128	Mohr-Coulomb	190	7.5	None
Protective Cover		123	128	Mohr-Coulomb	470	15.5	None



EAST BERMS WITH INTACT GEOMEMBRANE STABILITY ANALYSIS RESULTS

FIGURE 6

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PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

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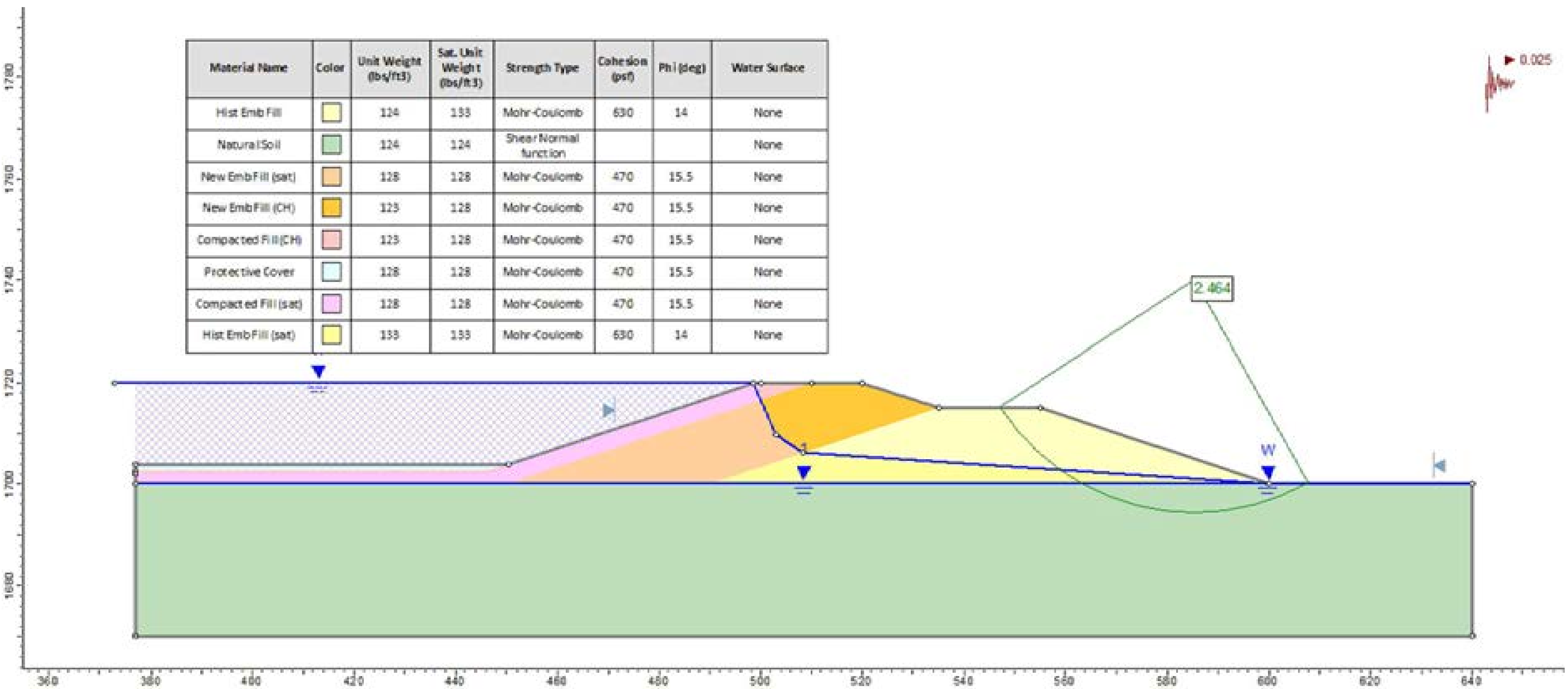

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Hist Emb Fill		124	133	Mohr-Coulomb	630	14	None
Natural Soil		124	124	Shear Normal function			None
New Emb Fill (sat)		128	128	Mohr-Coulomb	470	15.5	None
New Emb Fill (CH)		123	128	Mohr-Coulomb	470	15.5	None
Compacted Fill (CH)		123	128	Mohr-Coulomb	470	15.5	None
Protective Cover		128	128	Mohr-Coulomb	470	15.5	None
Compacted Fill (sat)		128	128	Mohr-Coulomb	470	15.5	None
Hist Emb Fill (sat)		133	133	Mohr-Coulomb	630	14	None

EAST BERMS WITH NO GEOMEMBRANE STABILITY ANALYSIS RESULTS

FIGURE 7

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PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

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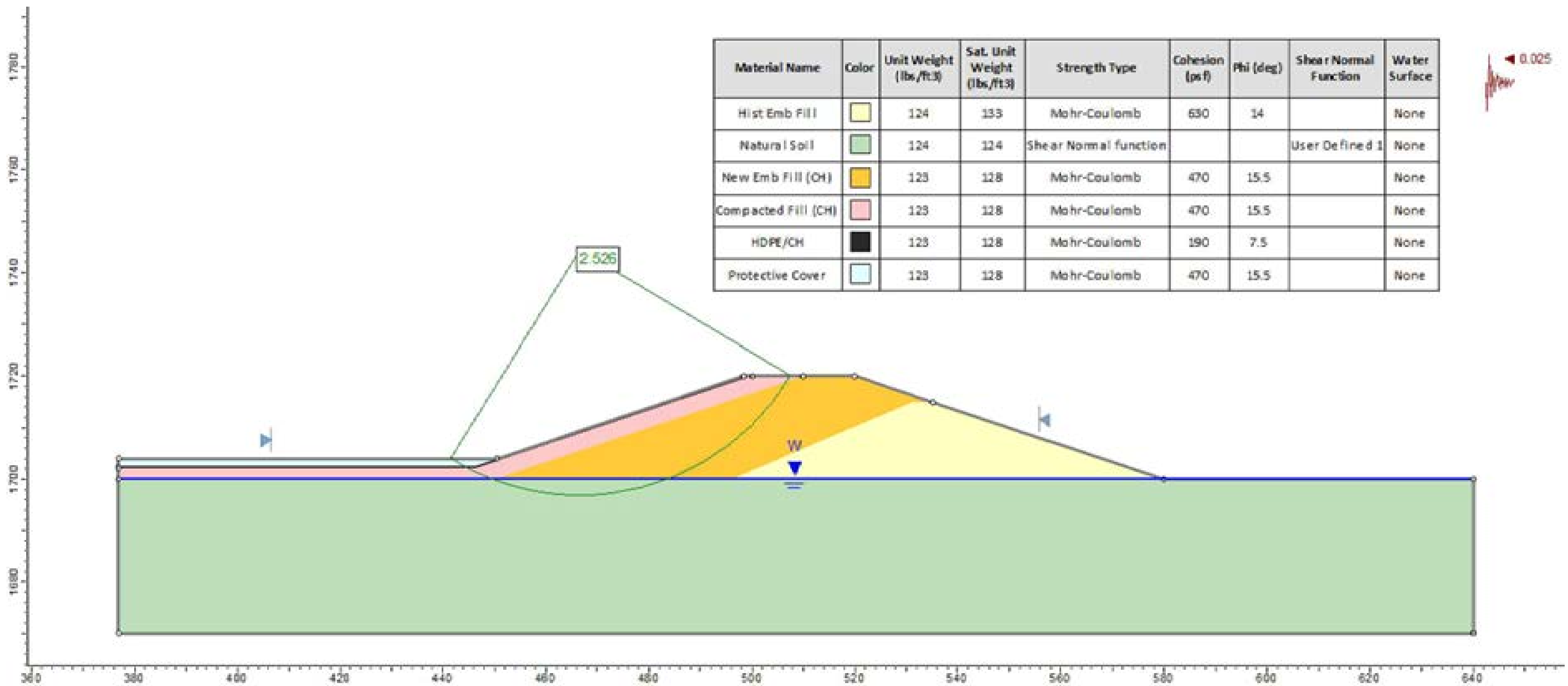

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Hist Emb Fill		124	133	Mohr-Coulomb	630	14		None
Natural Soil		124	124	Shear Normal function			User Defined 1	None
New Emb Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
Compacted Fill (CH)		123	128	Mohr-Coulomb	470	15.5		None
HDPE/CH		123	128	Mohr-Coulomb	190	7.5		None
Protective Cover		123	128	Mohr-Coulomb	470	15.5		None

UPSTREAM BERMS WITH EMPTY IMPOUNDMENT STABILITY ANALYSIS RESULTS

FIGURE 8

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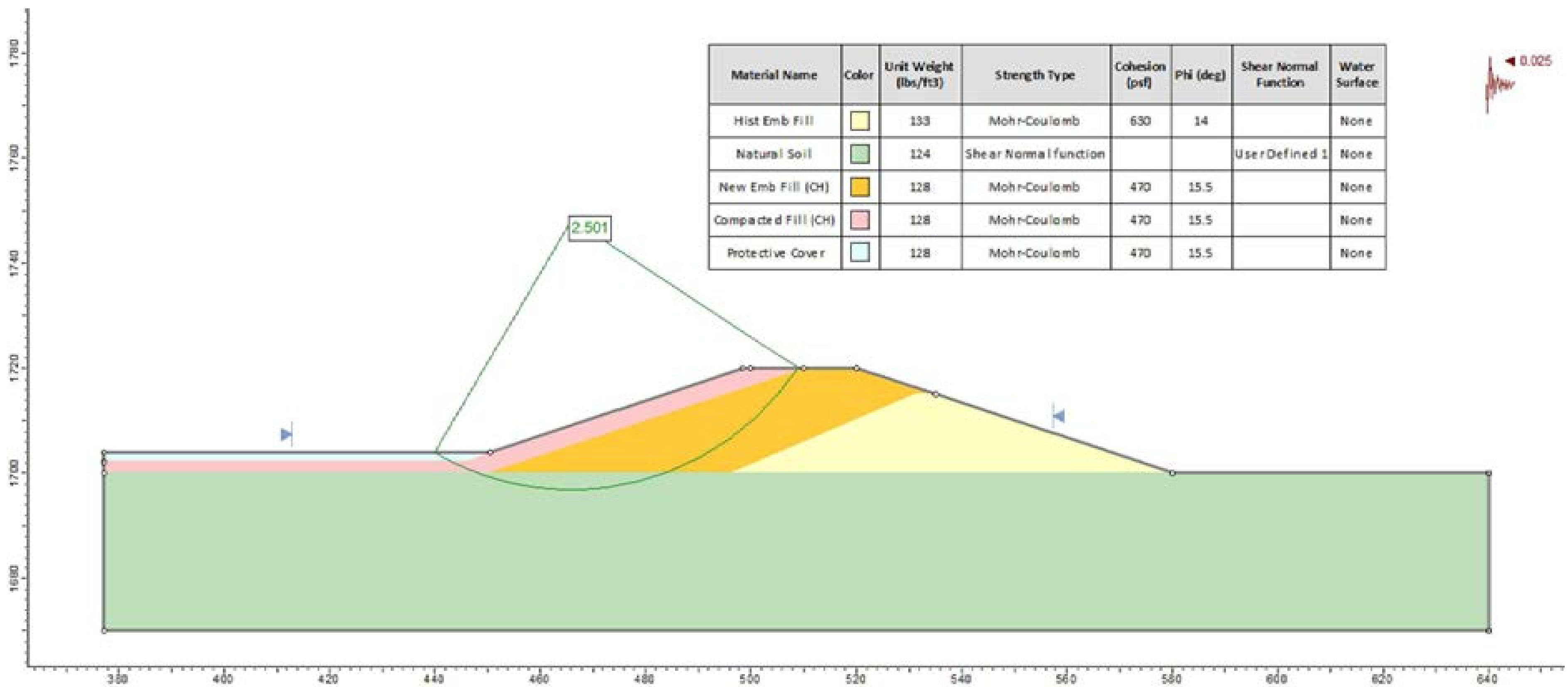
PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

Drawing File: J:\12JOBS\123-81645 GRE SS\Seismic Evaluation\Seismic Slide\ Evaluation Figures.dwg | Layout: Fig 8 | Modified: Mar 16, 2012 13:38 JSauer | Plotted: 03/16/12 3:11pm JSauer



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface
Hist Emb Fill		133	Mohr-Coulomb	630	14		None
Natural Soil		124	Shear Normal function			UserDefined 1	None
New Emb Fill (CH)		128	Mohr-Coulomb	470	15.5		None
Compacted Fill (CH)		128	Mohr-Coulomb	470	15.5		None
Protective Cover		128	Mohr-Coulomb	470	15.5		None

UPSTREAM BERMS WITH EMPTY IMPOUNDMENT AND NO GEMOMEMBRANE STABILITY ANALYSIS RESULTS

FIGURE 9

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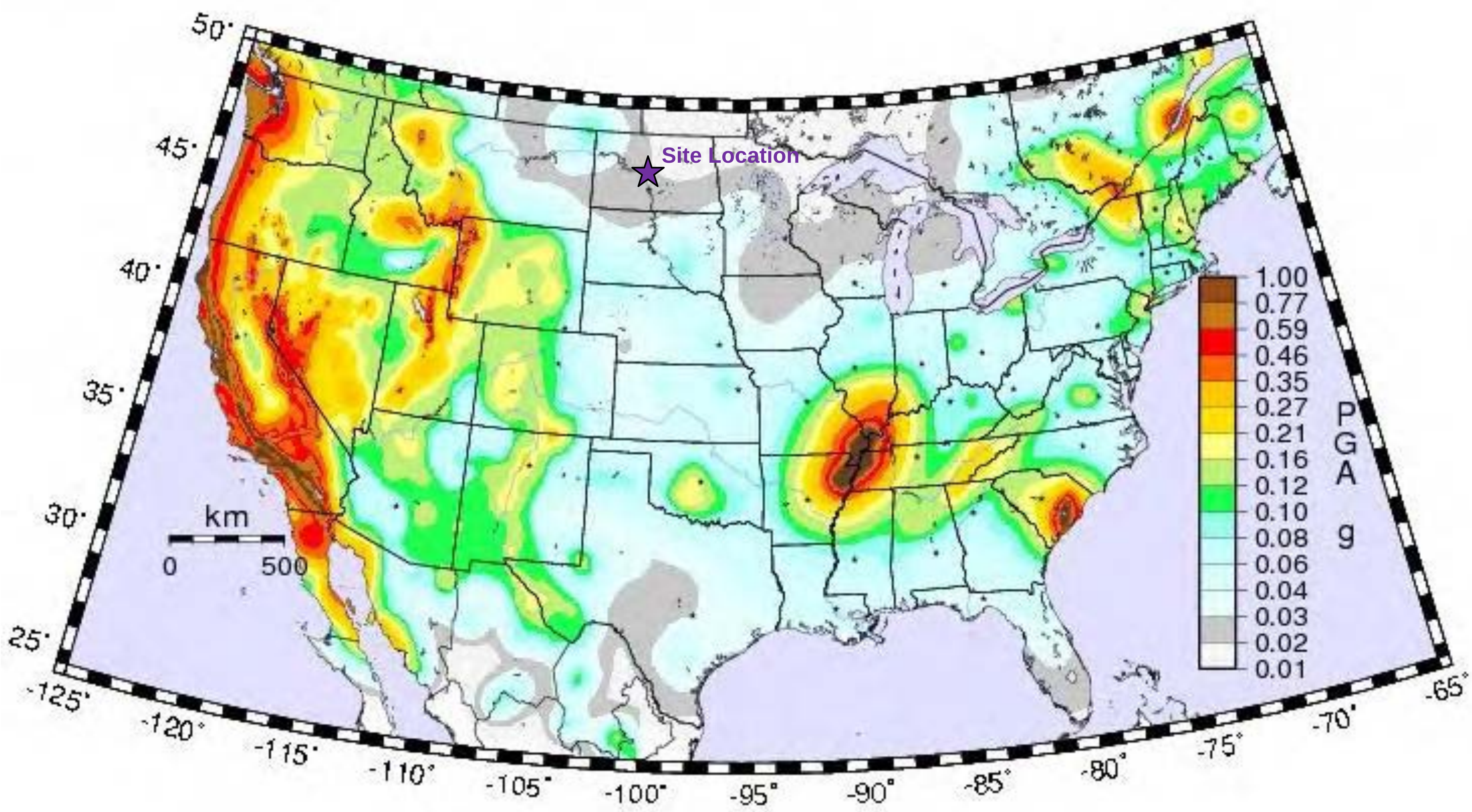
PROJECT No. 123-81645 CADD JJS DATE 03/16/12 FILE No. Evaluation Figures.dwg

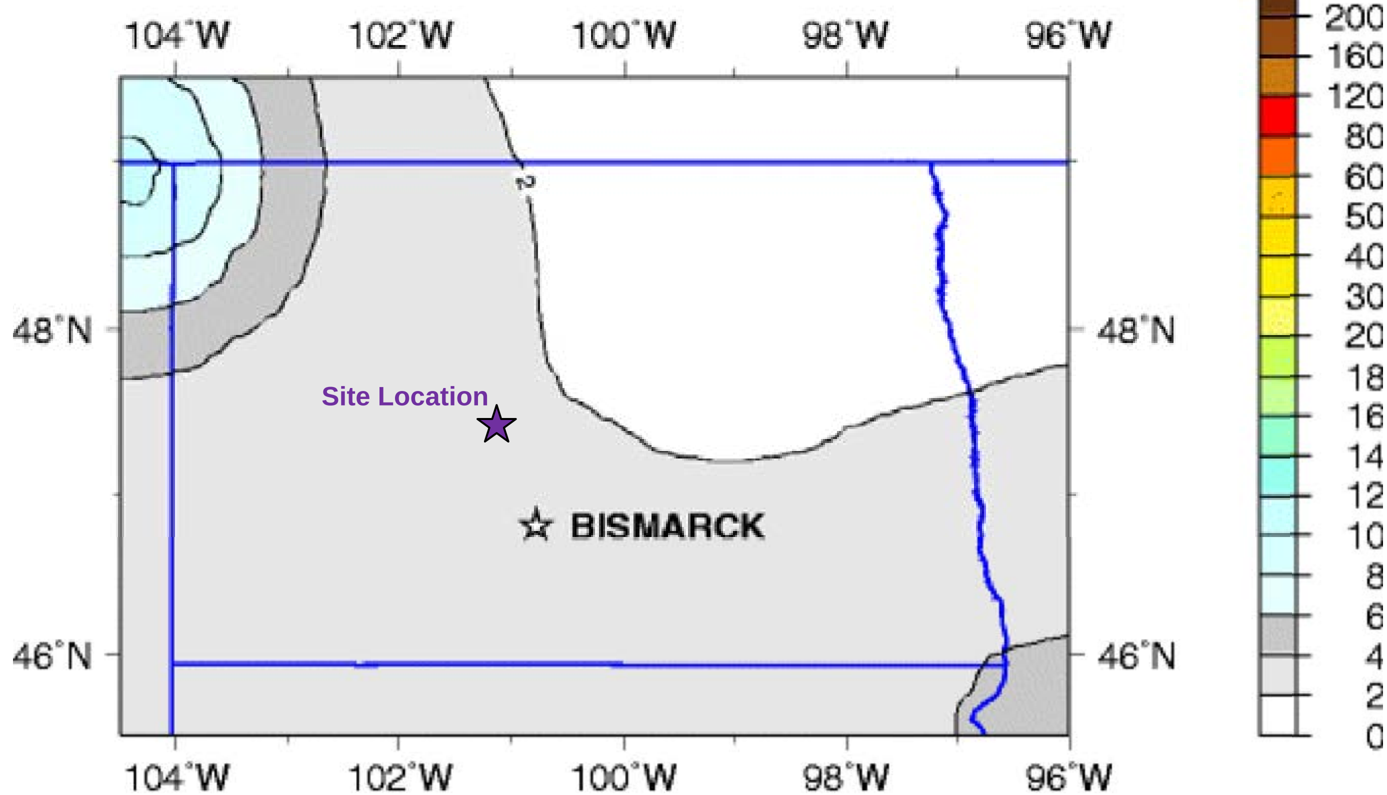
Drawing File: J:\12JOBS\123-81645 GRE SS\Seismic Evaluation\Seismic Slide\ Evaluation Figures.dwg | Layout: Fig 9 | Modified: Mar 16, 2012 13:38 JSauer | Plotted: 03/16/12 3:11pm JSauer

ATTACHMENTS

Peak Ground Acceleration (Conterminous U.S.)
2% in 50 years probability of exceedance
USGS 2008



Peak Ground Acceleration (North Dakota)
2% in 50 years probability of exceedance
USGS 2008



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