COAL ASH IMPOUNDMENT SITE ASSESSMENT FINAL REPORT

Coal Creek Station
Great River Energy
Underwood, North Dakota

Prepared by:

KLEINFELDER
Bright People. Right Solutions.

611 Corporate Circle, Suite C
Golden, CO 80401

KLEINFELDER PROJECT NUMBER 118953-1

October 31, 2012

KLEINFELDER

I acknowledge that the management units referenced herein:

- Upstream Raise/Ash Pond 92
- Ash Pond 91

Were assessed on May 17, 2011

Signature: [signature] Date: 10/31/12

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 Coal Creek 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 17, 2011.

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

- Upstream Raise/Ash Pond 92 – Originally commissioned in 1979 (significantly reconfigured between 2002 and 2005).
- Ash Pond 91 – Originally commissioned in 1979 (significantly reconfigured in 1992).

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".

The Upstream Raise/Ash Pond 92 and Ash Pond 91 impoundments are regulated by the North Dakota Department of Health – Waste Management Division. While that agency has not established a hazard rating, Golder Associates (Golder) assigned both impoundments a "Low" hazard rating in 2010. That hazard rating was reviewed, and it is agreed that a hazard classification of "Low" is an appropriate designation for both 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 31, 2013.
2. Control vegetation on the downstream slopes. Remove the isolated trees and woody brush, including roots/stumps, at the toe of the embankments by July 31, 2013.

Priority 2 Recommendations

1. Repair erosion of Upstream Raise / Ash Pond 92 embankment by July 31, 2013.
2. Evaluate and repair erosion at the toe on west embankment of Ash Pond 91 by July 31, 2013.
3. Maintain a log of maintenance and other activities at Ash Pond 91 and the Upstream Raise impoundments and supporting facilities by July 31, 2013.
4. Perform video assessments of culvert piping by July 31, 2013.

Table of Contents

List of Plates

List of Appendices

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 Coal Creek Station Power Plant on May 17, 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

Coal Creek Station is located approximately five miles south of Underwood, ND, as shown in Plate 1. The power plant is located in McLean County at approximately 47^{o}22'43''N and 101^{o}09'30''W. The nearby town of Underwood is a rural agricultural community with the town population of about 750 people.

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:

- Golder Associates, Evaluation of Ash Pond 92/SW Section 16 Stability, August 6, 2010 (Rev. December 21, 2010)
- Golder Associates, Evaluation of Ash Pond 91 Berm Stability, April 13, 2010
- Golder Associates, Addendum to Evaluation of Ash Pond 92/SW Section 16 Stability and Evaluation of Ash Pond 91 Stability – Seismic Stability Evaluation, February 27, 2012
- Golder Associates, Letter Response to Kleinfelder Email Dated May 11, 2012 Concerning Slope Stability Factors of Safety, May 14, 2012.
- Golder Associates, Evaluation of Plant Drains Pond Stability, April 13, 2010.
- Cooperative Power Association, Coal Creek Station, Final Construction Report – Evaporation Pond 93 and Ash Pond 91, undated

- Black & Veatch, Site Grading Plan Drawings 9S1006 and 9S1007, 1975
- Black & Veatch, Site Misc. Sections and Details Drawing 9S1022, 1978
- Black & Veatch, South Ash Pond Elevations 1988, Drawing 9S1017, 1989
- Great River Energy, Workorder 2378027, Upstream Raise Monthly Inspection, April 19, 2011
- Great River Energy, Workorder 2385059, Ash Pond 91 Monthly Inspection, May 8, 2011.
- Great River Energy, Draft Revised Permit Modification Document, Permit No. Sp-033, Coal Creek Station, Underwood, North Dakota, July 8, 2004

SECTION 2 – SITE ASSESSMENT

2.1 ATTENDEES

The site assessment was performed on May 17, 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
- Todd Stong, PE – Golder Associates

2.2 IMPOUNDMENTS ASSESSED

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

- Upstream Raise/Ash Pond 92 – Originally commissioned in 1979 (significantly reconfigured between 2002 and 2005)
- Ash Pond 91 – Originally commissioned in 1979 (significantly reconfigured in 1992)

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 Power Station impoundments, the weather was partly cloudy and windy. Temperatures ranged from about 55^{o} to 65^{o} F, and wind speeds ranged from about 25 to 35 miles per hour (mph).

SECTION 3 – SITE INFORMATION AND HISTORY

3.1 SITE INFORMATION AND HISTORY

The Coal Creek Power Generating Station is a coal-fired facility that has been in operation since 1979. The facility currently sluices primarily bottom ash and flue gas desulphurization (FGD) residuals, both by-products of coal fired energy generation, into two separate impoundments. These impoundments are referred to as "Ash Pond 91" and the "Upstream Raise/Ash Pond 92". Prior to the current operational layout at the Coal Creek Station, both Ash Pond 91 and the Upstream Raise/Ash Pond 92 were originally part of the original CCW facility known as the South Ash Pond (SAP). That facility experienced some leakage issues, and was eventually reconfigured and enlarged into what is now known as Ash Pond 91 (1992), Ash Pond 92 (1989), which then was reconfigured and enlarged into the Upstream Raise (2002 - 2005), and the Drains Pond (1992). Prior to construction of the composite liner systems for Ash Pond 91 and the Ash Pond 92 portion of the Upstream Raise, CCPs and unsuitable material in the SAP were removed and disposed of in the Section 5 dry ash landfill. Based on our review of this site history and experience on site, neither Ash Pond 91 nor the Ash Pond 92 portion of the upstream raise are built over wet ash or other unsuitable materials. Fly ash is collected by electrostatic precipitators, and hauled dry to the Upstream Raise pond site by truck to use in the ongoing enlargement of that facility. The bottom ash that is sluiced into Ash Pond 91 is removed and dried for later use as filler and ballast material in the Upstream Raise. An aerial image of these impoundments can be seen on Plate 2.

Both ponds act as settling basins for the bottom ash and FGD residuals. The Upstream Raise/Ash Pond 92 decants back into Ash Pond 91, and that pond is connected to the Drains Pond for reuse within the plant. As such, Coal Creek Station is a zero release power generating facility and therefore does not require an NPDES discharge permit. The majority of fly ash generated at Coal Creek Station is sold and beneficially used with only a small amount being used in the construction of the Upstream Raise. Bottom Ash is also used beneficially on-site in addition to the Upstream Raise Construction.

Ash Pond 91 is an earthen embankment impoundment. A sluice pipe transporting primarily bottom ash from power generating operations outlets near the northeastern corner of the pond. From there the bottom ash slurry is directed through a settling area, where it drains and allows water to flow into a larger portion of the pond for secondary settling. The bottom ash material is continuously removed from the initial settling area by heavy equipment. The water then exits the secondary settling area and flows through a 3,000-foot-long channel along the inner perimeter to the northwest corner of Ash Pond 91, where it connects to the Drains Pond via two underground pipes for eventual reuse within the plant. The intention of the Ash Pond 91 settling channel is to allow additional time for suspended solids to drop out of suspension before entering the Drains Pond. The initial sluice settling area, secondary settling area, and the settling channel are all considered to be components of the larger Ash Pond 91.

The Ash Pond 91 outlet structure consists of three pipes connected to the Drains Pond. Two of the pipes are newer and a third pipe may be abandoned, according to plant staff. Each pipe has a control valve located in the embankment between Ash Pond 91 and the Drains Pond. The pipe diameters are reported to be 18 inches, and the two active pipes are made of SDR-19 flanged HDPE. Ash Pond 91 is a managed inflow pond and thus does not have an emergency spillway. The pond does receive stormwater from a small portion of the plant area, but otherwise does not have any significant offsite flows into the pond.

The Upstream Raise Pond is an earthen embankment pond that is currently about 15 feet below its ultimate buildout height. The pond surface area is roughly equivalent to Ash Pond 91, and the footprint is about 110 acres. The flexible discharge pipe for the FGD residuals slurry is periodically moved around the pond edge to spread the material out. The FGD material settles out, and the water is decanted off to Ash Pond 91.

The Upstream Raise Pond's outlet structure is very simple, and consists of four flexible outlet pipes at two separate locations that connect to Ash Pond 91. The outlet pipes are cantilevered out about 15 feet into the pond, and the inlets are raised manually to set the pond outlet. As such, the pipe outlets can be raised in small increments as the Upstream Raise pond level gradually increases. There is also a connection directly between the Upstream Raise Pond and the Drains Pond to allow Drains Pond water to be directly pumped back up into the Upstream Raise if necessary to control levels in that pond and Ash Pond 91. The Upstream Raise Pond is a managed inflow pond that is continuously monitored and thus does not have an emergency spillway. Because it is a diked impoundment structure, it has no 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 Coal Creek Station.

3.2 PERTINENT DATA

A. GENERAL

1. Name .... Coal Creek Station
2. State .... North Dakota
3. County .... McLean
4. Latitude .... 47^{o} 22' 46'' North
5. Longitude .... 101^{o} 09' 20'' West
6. River used for operations .... None
7. Year Constructed 1979
8. Modifications .... Enlargement to current impoundments
9. Current Hazard Classification .... Low
10. Proposed Hazard Classification .... Low
11. Size .... See below

B. IMPOUNDMENTS

ASH POND 91

1. Type .... Earthen – Diked
2. Crest Elevation .... ±1922[1]
3. Crest Length .... Approximately 6,600 ft
4. Crest Width .... 25 ft
5. Impoundment Height .... Approx. 20 ft
6. Upstream Slope 3H:1V
7. Downstream Slope 3H:1V
8. Volume of Stored Ash........ ~250 acre-feet

UPSTREAM RAISE/ASH POND 92

1. Type .... Earthen – Diked
2. Crest Elevation .... ±1960[1]
3. Crest Length .... Approx. 7,900 ft
4. Crest Width .... Varies:, typ. 35 ft[2]
5. Impoundment Height .... ~ 60 ft
6. Upstream Slope 3H:1V
7. Downstream Slope 3H:1V

8. Volume of Stored Ash…………………………………………………… .... ~325 acre-feet[2]

C. DRAINAGE BASIN

1. Area of Drainage Basin ....Impoundment areas plus 15 acres of plant run-off
2. Downstream Description: ....None – zero discharge plant

D. RESERVOIR INLET

ASH POND 91

1. Reservoir Inlet...................Multiple inlet sluice pipes from plant and Upstream Raise/Ash Pond 92

UPSTREAM RAISE/ASH POND 92

1. Reservoir Inlet... Inlet sluice pipe from plant at crest elev.

E. RESERVOIR

ASH POND 91

1. Reservoir Capacity ....Maximum Storage is approximately 249 acre-feet[1]

UPSTREAM RAISE/ASH POND 92

2. Reservoir Capacity ....Maximum Storage is approximately 769 acre-feet[1]

F. PRIMARY SPILLWAY

ASH POND 91

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

UPSTREAM RAISE/ASH POND 92

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

G. OUTLET WORKS

ASH POND 91

1. Description ....Two 18-inch diameter pipes at pond bottom with valve in middle
2. Location..................................... Middle of north embankment btwn Ash Pond 91 and Drains Pond
3. Intake Structure... None
   a. Intake Invert Elevation .... 1905[1,3]
4. Discharge Conduit ....Unknown
   a. Length...Unknown
   b. Diameter ....18 inches
5. Outlet Structure..None
   a. Outlet Invert Elevation .... 1905[1,3]
   b. Energy Dissipation ....None
6. Discharge Channel...None
7. Discharge Capacity with Water Surface at Top of Impoundment......................................Unknown

UPSTREAM RAISE/ASH POND 92

1. Description ....Two sets of four 18-inch diameter HDPE set ~ 4 ft below current crest
2. Location...Two locations on west embankment
3. Intake Structure..None
   a. Intake Invert Elevation .... Adjustable
4. Discharge Conduit ....HDPE Pipe

a. Length .... ~400 ft
b. Diameter .... 18 inches
5. Outlet Structure .... None
a. Outlet Invert Elevation .... 1918[2]
b. Energy Dissipation .... None
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 Golder Associates reports
2. Value is estimated
3. Feature was submerged and unable to be visually assessed

3.3 REGIONAL GEOLOGY AND SEISMICITY

Based on our review of the United States Geological Survey (USGS), information from the United States Department of Agriculture's Web Soil Survey, and Golder Associates 2010 Ash Pond Evaluation Reports, the subsurface conditions at the plant site are expected to include Quaternary glacial till consisting of unsorted silty and sandy clay, with few cobbles and boulders. The glacial till can be up to several hundred feet thick and is underlain by poorly consolidated siltstone/sandstone bedrock (Golder, 2010).

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

Both Ash Pond 91 and the Upstream Raise/Ash Pond 92 are designed and situated in such a manner that the watershed drainage contributing to the stored volume of the ponds is minimal and limited to pumping operations and storm water that falls within the impoundments themselves. Ash Pond 91 accepts a small amount of storm drainage from about 15 acres draining from the plant area. The Upstream Raise only accepts precipitation falling directly on the crest and inward.

During the assessment, documents such as hydrology studies, hydraulic design calculations and assumptions, and impoundment break analyses were not available for our review. As a result, the design inflow, design freeboard and other important components of the impoundment designs are unknown at this time. However, both ponds do 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. While no formal hydrologic and hydraulic analyses were conducted, the stability analysis examined a full pool condition with acceptable factors of safety. GRE staff has identified that the Ash Pond 91 was designed to store up to 402,000 cubic yards of ash and the Upstream Raise/Ash Pond 92 was designed to store up to 1,240,000 cubic yards of ash.

3.5 GEOTECHNICAL CONSIDERATIONS

Regarding stability of the embankment slopes, we have reviewed reports dated April 13, 2010 (Ash Pond 91) and December 21, 2010 (Upstream Raise/Ash Pond 92) by Golder Associates, and a follow-up letter from Golder Associates dated May 14, 2012 providing additional explanation on the factors of safety for temporary loading condition scenarios on the Upstream Raise/Ash Pond 92. Both reports included stability analyses for the most critical loading condition (Ash Pond 91) or under a variety of loading conditions and pool levels (Upstream Raise/Ash Pond 92). Ash Pond 91 is stable under a full pool loading condition, with a computed factor of safety of 2.3. The Upstream Raise was evaluated for various embankment and pool levels, including the ultimate buildout with a cover. In all cases, the factor of safety met or exceeded 1.5 for permanent civil engineering structures, or met or exceeded 1.3 for temporary loading conditions. In summary, both impoundments have been recently evaluated and demonstrate adequate slope stability.

The above reports did not evaluate seepage. Regarding seepage, plant staff reported that excessive seepage had been observed at various locations along the downstream embankments of the original South Ash Pond and another pond immediately to the north of the Upstream Raise. The pond immediately to the north of the Upstream Raise has long since been decommissioned and essentially removed, and the South Ash Pond is now Ash Pond 91 and the Upstream Raise. There was essentially no visible seepage from Ash Pond 91 that we could detect during our assessment, and seepage from the Upstream Raise is collected in a series of underdrains that daylight into ditches and transport that water back to Ash Pond 91. The standing water at the underdrain outlets did not appear to have significant flow or movement and was clear.

Seismic stability analyses were completed for both Ash Pond 91 and the Upstream Raise/Ash Pond 92 by Golder Associates. 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 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.

3.6 STRUCTURAL CONSIDERATIONS

There is one permanent pump station structure adjacent to Ash Pond 91 at Coal Creek Station. The structure is located in the downstream embankment at the southeast corner of the pond. The structure was not assessed in detail, but appeared visually to be in Satisfactory condition with no evidence of movement or any structural distress. The pump station is used to pump water from Ash Pond 91 to the Drains Pond or Plant.

There are also manholes constructed in the Ash Pond 91 embankment at a couple of locations near the pump station. No internal assessment was made of those features, but no distress was noted from our external assessment of the visible portion. There are no gate, headwall, or tower structures associated with the outlet pipes for the ponds. There are both temporary and permanent pipe support structures for the slurry line from the plant to Ash Pond 91. The permanent concrete pipe support structures appeared to be in Satisfactory condition with no evidence of movement or distress. The temporary pipe supports are wood timbers and are intended to be movable so that the pipe outlet can be moved around to spread the bottom ash around more evenly.

3.7 PERFORMANCE EVALUATIONS

There have been no previous federal or state assessments of the Coal Creek Station Ash Pond 91 or Upstream Raise impoundments. Based on observations by Great River Energy in their monthly and semi-annual assessments, there have been no significant incidents involving either impoundment. Currently Great River Energy's local plant personnel perform almost daily observation of the impoundments and their associated structures. Great River Energy also performs monthly written assessments of both impoundments, similar to this assessment, via their formal work order procedures using trained maintenance personnel. In addition, Great River Energy retained Golder Associates to make site inspections and assessments in the fall of 2009 as part of their 2010 stability analyses reports discussed previously.

3.8 HAZARD CLASSIFICATION

The Coal Creek Station's two 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, Ash Pond 91 and the Upstream Raise were rated by Golder Associates (Great River Energy's ash pond impoundment consultant) as being Low Hazard impoundments. Based on discussion with GRE staff, there is essentially no potential for loss of life, and there is significant storage available in the Samuelson Slough drainageway with the ability to completely contain any ash material within GRE's property via a gated outlet at the rail line just east of the Upstream Raise. Kleinfelder concurs with the Low Hazard rating; however, a hazard classification analysis should be performed for verification. Samuelson Slough enters the Missouri River approximately nine miles downstream of the gated outlet at the railroad, and the slough only traverses undeveloped areas adjacent to farm land. No homes, recreational facilities, businesses, paved roads or other structures 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 Coal Creek Station property.

SECTION 4 – SITE OBSERVATIONS

The impoundment embankments, downstream toes, and outlet works components (portions not inundated at the time of assessment) of both the Upstream Raise/Ash Pond 92 and Ash Pond 91 were observed during the May 17, 2011 site assessment. 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 UPSTREAM RAISE/ASH POND 92

4.1.1 UPSTREAM SLOPE

Overall, the upstream slope of the impoundment was in Satisfactory condition. Photos 26 and 27 show the conditions of the upstream slope. Specific observations include:

- The top four or five feet of the upstream slope appeared to be oversteepened at approximately 0.5H:1V, almost resembling a bluff, due to wave action. The slope below that oversteepened portion and approximately at the waterline appeared to be significantly flatter.
- There was little to no vegetation (grass or woody shrubs) on the upstream slope.

4.1.2 CREST

Overall, the crest of the impoundment was in Satisfactory condition. Photos 6, 26, 27, and 37 show the condition of the crest. Specific observations include:

- The impoundment crest is a drivable road weather permitting.
- Essentially no vegetation was observed on the crest.
- No major depressions or rutting was noted on the impoundment crest.
- Some very minor erosion was noted on the crest. This erosion was typically less than six inches in depth and typically appeared on the edges of the

crest where grade breaks occurred when transitioning to embankment slopes. That condition is not of great concern because the crest is temporary and continually being raised.

4.1.3 DOWNSTREAM SLOPE

Overall, the downstream slope was in Satisfactory condition. Photos 3, 5, 10, 15, 16, 24, 34, and 35 show the conditions of the downstream slope. Specific observations include:

- A very good grass cover has been established on the portions of the north, east, and about half of the south embankment that have been dressed and covered with topsoil.
- There are terrace ditches on the topsoiled and vegetated slopes that appear to be very effective in intercepting surface runoff and diverting that to rundown channels armored with articulated concrete block mats.
- Typically the embankment with vegetative cover was well maintained.
- The western half of the south embankment had been rough graded and was ready for topsoil placement and revegetation.
- A few animal burrows were noted on the slopes. However, the fly ash material used for embankment construction gets very hard when wetted, and thus the animal burrows would be very shallow into the topsoil only and would not likely pose a threat to the embankment.

4.1.4 TOE AREAS

The toe areas of the embankment were in Fair condition. See Photos 11, 12, 13, 17, 18, and 31 for the typical condition of these areas. Key features and observations of these areas include:

- The embankment toe was located along a drainage ditch on both the south and west sides. It did not appear that any noticeable seepage was occurring along the south side, but that condition would be difficult to detect with ponded stormwater water present. The west side ditch is intended to collect storm runoff and Upstream Raise underdrain seepage, and shallow, clear water was present in the ditch during the site assessment.

- There were woody bushes and small isolated trees at the toe of the embankment of the impoundment at a few locations on the south side. These should be removed to prevent them from spreading further up the slope.

4.1.5 OUTLET WORKS

The outlet works of the Upstream Raise/Ash Pond 92 consists of two sets of four 18-inch diameter HDPE pipes approximately 400 feet long and located on the west embankment at two separate locations. Both sets of pipes outlet to Ash Pond 91, and the pipes are set a few feet deep in the crest and cantilevered out about 20 feet into the pond so that the inlet can be easily adjusted to control the water level in the Upstream Raise. There are no gates or valves on the outlet pipes. As the embankment is raised, the pipes can be easily extended to accommodate the raise. According to GRE staff and the provided design drawings, the discharge locations of the outlet pipes do not have any concrete slab or other armoring to protect against erosion during discharge. See photos 20, 21, and 26 for the outlet pipes typical configurations. Specific observations include:

- The discharge location of the outlet pipe was not able to be observed as it was inundated at the time of assessment.
- No video monitoring of the pipes were available at the time of assessment. However, it was noted by GRE staff that when the pipes begin to lose functionality due to scaling or deposition, they are simply replaced. Because the pipes are buried shallow in the embankment, replacement is a fairly simple task.
- Overall, the outlet pipes appeared to be functioning as intended at the time of assessment.

4.1.6 IMPOUNDMENT INLET

Inflow into the Upstream Raise/Ash Pond 92 is via 8-inch diameter HDPE inlet pipes at two locations on the north embankment of the impoundment. From these inlet locations the FGD and water slurry then flows out into the impoundment. The pipes lie on top of the crest and can be easily moved around to spread the slurry more evenly, and only one pipe is typically discharging. Fill material is placed over the pipes to provide ramps for vehicle access around the crest. The inlet pipes appeared to be in functional condition. See photo 27 for a view along the north embankment showing a pipe outlet feeding FGD residuals into the pond.

4.2 ASH POND 91

4.2.1 Upstream Slope

Overall, the upstream slope of the impoundment was in Satisfactory condition. Photos 41, 54, and 61 show the conditions of the upstream slope. Specific observations include:

- The upstream slope appeared stable, and was in general accordance with design drawings and stability analyses sections presented in the April 13, 2010 Golder Associates report.
- The upstream slope was free of grasses and woody brush over the entire inside perimeter of the impoundment.
- The riprap placed on the west, south, and portions of the east slope appeared to be stable and reasonably well graded, albeit somewhat rounded rather than angular rock. The fly ash material at the bottom of the riprap appeared to be eroded slightly, likely due to wave action.

4.2.2 Crest

Overall, the crest of the impoundment was in Satisfactory condition. Photos 54, 60, and 61 show the condition of the crest. Specific observations include:

- The impoundment crest is a gravel road.

- No major depressions 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 66 shows these sluice lines.
- Plant drainage enters the pond at the northwest corner. The inlet culvert can be seen in photo 60.
- Minor erosion was noted on the crest in multiple locations. This erosion was typically less than two or three inches in depth and typically appeared on the edges of the crest where grade breaks occurred when transitioning to embankment slopes.
- Pipe support columns for the pipeline that runs along the crest of the northern embankment separating Ash Pond 91 and the Drains Pond penetrate the crest in multiple locations, as shown in photos 61 through 63 and 68.

4.2.3 Downstream Slope

Overall, the downstream slope was in Satisfactory condition. Photos 43, 44, 48, 50, 53, 54, 63, and 64 show the conditions of the downstream slope. Specific observations include:

- The slopes were well vegetated and appeared stable.
- Some minor areas of erosion on the slope were observed.
- A few animal burrows were noted.
- The east embankment abuts directly to the toe of the Upstream Raise/Ash Pond 92, with a drainage ditch between the two ponds that collects surface runoff and Upstream Raise underdrain seepage. The east embankment is essentially denuded. See photos 16, 17, and 18 for the Ash Pond 91 east embankment location.

4.2.4 Downstream Toe Areas

The toe areas of the embankment were in Fair condition. See photos 45 through 52, 55, and 56 for the condition of these areas. Key features and observations of these areas include:

- The embankment toe was located along a drainage ditch on the south side and a slough on the west side. It could not be determined if any noticeable seepage was occurring, but that condition would be difficult to detect with ponded water present.
- The west embankment toe appears to have a permanent slough feature that is fed by a spring that flows out of a nearby rock outcrop. The toe along the west slough was observed to have small scarps along the slough water line. Wave action and saturated conditions from the slough likely have caused erosion to the toe. A seepage and stability analysis was not performed on the west embankment adjacent to the slough in the Evaluation of Ash Pond 91 Berm Stability Report (Golder, 2010).
- There were woody bushes and small isolated trees at the toe of the embankment of the impoundment at a few locations on the south and west sides. These should be removed to prevent them from spreading further up the slope.

4.2.6 Outlet Works

The outlet works of Ash Pond 91 consists of two 18-inch diameter SDR-19 flanged HDPE pipes connecting the pond with the Drains Pond immediately to the north. The two pipes are level, and are each controlled by a valve in the middle of the embankment. The pipes were submerged and could not be assessed, but the design drawings do not show any type of erosion protection at either end. There is also a third pipe farther east connecting the two ponds noted both in the field and on design drawings. That pipe has been abandoned in place and is no longer used, according to GRE staff. Photo 62 shows the current location of the two pipes in service. Key observations include:

- The discharge location of the outlet pipes was not able to be observed as it was inundated at the time of assessment.
- No video monitoring of the pipes was available at the time of assessment.

- Overall, the outlet works system appeared to be functioning as intended at the time of assessment.

4.2.7 Impoundment Inlet

Inflow into Ash Pond 91 is via two methods:

- Bottom ash and other constituents of coal combustion are slurried into the pond at the northeast corner in two 12-inch steel pipes.
- Water is decanted off of the Upstream Raise/Ash Pond 92 into Ash Pond 91 for further settling using four 18-inch diameter HDPE pipes at two locations along the west embankment of the Upstream Raise.

The slurry inlet pipes can be seen in photo 66, and the Upstream Raise decant pipes near the southwest corner can be seen in photo 26. From all the inlet locations the water then flows through an interior curved settling channel and eventually into the Drains Pond for reuse in the plant process. All inlet pipes appeared to be in satisfactory condition.

4.3 Other

Currently there are five piezometers installed in the embankment that consists mainly of fly ash and bottom ash. Piezometer readings were presented in the August 6, 2010 Golder report that suggest semi-annual readings. The piezometer readings confirm that the seepage collection system in the Upstream Raise is functioning properly. Two of the piezometers on the south embankment are shown on photo 8.

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 expected loss of human life and considering that any pond contents released during a failure could be contained on the GRE property by means of a gated structure at the railroad culvert to the east on Samuelson Slough (photos 69 and 70).

Great River Energy has developed an Operation and Maintenance (O&M) Manual for the Coal Creek Station Ash Pond 91 dated February 3rd, 1989, and the Upstream Raise dated July 8th, 2004. . The above referenced EAP should be part of this O&M Manual, but should also be capable of being a stand-alone document.

1-Ash Pond 92 Upper Drainage Ditch (looking west)

2-Ash Pond 92 Contact Layer (looking north)

3-Ash Pond 92 ACM Run-down on South Slope (looking south)

4-Ash Pond 92 Surface Erosion (looking north)

5-Ash Pond 92 Animal Burrows on ACM

6-Ash Pond 92 Crown on South Side with Piezometer (looking west)

7-Ash Pond 92 Bench on South Side with Piezometers (looking west)

8-Ash Pond 92 Upslope View of Piezometers (looking north)

9-Ash Pond 92 Vertical Pipe with Cap, Water 4 Feet Down

10-Ash Pond 92 Terrace Ditch (damp) with Vertical Pipe (looking east)

11-Ash Pond 92 South Embankment Toe (looking east)

12-Ash Pond 92 Tree and Scarp in South Embankment (looking north)

13-Ash Pond 92 South Embankment Toe (looking west)

14-Ash Pond 92 ACM at Southwest Corner (looking northeast)

15-Ash Pond 92 West Landside Slope (looking north)

16-Ash Pond 92 West Landside Bench (looking north). Ash Pond 91 embankment on left

17-Ash Pond 92 Ditch on West Toe (looking south). Ash Pond 91 Embankment on Right

18-Ash Pond 92 Ditch on West Toe (looking north). Ash Pond 91 Embankment on Left

19-Gravity Drains from Ash Pond 92 Ditch to Ash Pond 91 (looking west)

20-Ash Pond 92 Southern 12” HDPE Decant Pipes to Ash Pond 91 (looking west)

21-Ash Pond 92 Northern 12" HDPE Decant Pipes to Ash Pond 91 (looking west)

22-Gravity Drains from Ash Pond 92 Ditch to Ash Pond 91 (looking northwest)

23-Ash Pond 92 Drainage Culverts on West Toe (looking south)

24-Ash Pond 92 Landside Embankment from Northwest Corner (looking southeast)

25-Ash Pond 92 Pipe Penetration on West Embankment

26-Ash Pond 92 Waterside Embankment at NW Corner (looking south). Outlet Decant Pipes in Background

The information included on this graphic representation has been compiled from a variety of sources and is subject to change without notice. Kleinfelder makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. This document is not intended for use as a land survey product nor is it designed or intended as a construction design document. The use or misuse of the information contained on this graphic representation is at the sole risk of the party using or misusing the information.

27-Ash Pond 92 Waterside Embankment at NW Corner (looking east). Pipe is Discharging Into Pond in Background.

28-Ash Pond 92 Landside Embankment Bench (looking east)

29-Ashpond 92 Movable Inlet Pipes on Northwest Corner (looking south)

30-Lower Samuelson Slough (looking north)

31-Ash Pond 92 North Embankment 18" HDPE Toe Drain Outlet (looking east)

32-Ash Pond 92 Drainage Pipe at Northeast Corner (looking north)

33-Ash Pond 92 18” Drainage Pipe on North Embankment Upper Ditch (looking west)

34-Ash Pond 92 Landside Embankment from Northeast Corner (looking west)

35-Ash Pond 92 East Landside Embankment (looking south)

36-Ash Pond 92 East Landside Drainage Ditch (looking north)

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DRAWN:	6/6/11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Rev. Coal Creek Site Photos

SITE PHOTOGRAPHS 5-17-11

Coal Creek Station
Great River Energy
Underwood, North Dakota

37-Ash Pond 92 View from Crest on Southeast Corner (looking west)

38-Ash Pond 92 Pile of Ash in Drainage Ditch on Southeast Corner (looking north)

39-Detention Basin and Gate at Southeast Corner of Ash Pond 91 (looking south)

40-Pump Station Between Ash Pond 91 and 92 (looking east)

41-Ash Pond 91 Waterside Embankment from Southeast Corner (looking west)

42-Ash Pond 91 Gas Vent Pipe on Landside Slope

43-Ash Pond 91 Landside Erosion near Ramp Groin (looking northeast)

44-Ash Pond 91 Animal Burrow on South Embankment

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO. 118953-1	SITE PHOTOGRAPHS 5-17-11	Page 41
DRAWN: 6/6/11		
DRAWN BY: B. Piede		
CHECKED BY: C. Larson	Coal Creek Station Great River Energy Underwood, North Dakota	
FILE NAME: Rev. Coal Creek Site Photos		

45-Ash Pond 91 Southern Landside Toe and Culvert Under Ramp (looking east)

46-Ash Pond 91 Possible Seepage at Southern Landside Toe

47-Ash Pond 91 Possible Seepage Area Along Southern Landside Toe (looking west)

48-Ash Pond 91 Possible Seepage Area Along Southern Landside Toe (looking west)

49-Ash Pond 91 Vegetation on Landside Toe (looking west)

50-Ash Pond 91 Animal Burrow

51-Ash Pond 91 Tree at Landside Toe on Southern Embankment

52-Ash Pond 91 Oily Seepage Along Landside Toe on Southwest Corner (looking SE). Source Unknown

53-Ash Pond 91 Gas Vent Pipe and Slough Along West Embankment (looking north)

54-Ash Pond 91 West Crest with Slough on Left (looking north)

55-Ash Pond 91 Landside Toe Scarp Adjacent to Slough (looking north)

56-Ash Pond 91 Landside Toe Scarp Adjacent to Slough (looking north)

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DRAWN:	6/6/11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Rev. Coal Creek Site Photos

SITE PHOTOGRAPHS 5-17-11

Coal Creek Station
Great River Energy
Underwood, North Dakota

57-Spillway for Slough West of Ash Pond 91 (looking west)

58-24" RCP Outlet Culvert for West Slough Outflow (looking northwest)

59-Ash Pond 91 Vent Pipe on Northwest Corner

60-Ash Pond 91 Plant Storm Water Drainage Inlet, 24" CMP (looking northwest)

KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com	PROJECT NO.	118953-1	SITE PHOTOGRAPHS 5-17-11	Page 49
	DRAWN:	6/6/11		
	DRAWN BY:	B. Piede		
	CHECKED BY:	C. Larson	Coal Creek Station Great River Energy Underwood, North Dakota	
	FILE NAME:	Rev. Coal Creek Site Photos		

61-Ash Pond 91 North Waterside Embankment (looking east)

62-Ash Pond 91 Outlet Pipe Valve to the Drains Pond (looking north)

63-Ash Pond 91 Landside of North Embankment (looking east)

64-Ash Pond 91 Landside of North Embankment (looking west)

65-Detention Basin North of Ash Pond 91 with Outlet Gate (looking north)

66-Ash Pond 91 Pipe Penetration on North Embankment (looking west)

67-Ash Pond 91 View from Northeast Corner (looking south)

68-Ash Pond 91 Landside Embankment and Waterside of Drains Pond (looking east)

69-Inlet to Slough Outlet Gate Under Railroad Embankment (looking north)

70-30” RCP Slough Outlet Culvert (looking east)

SECTION 5 – OVERALL CONDITION OF THE FACILITY IMPOUNDMENTS

5.1 ANALYSIS AND CONCLUSIONS

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

Structural Stability

Both Ash Pond 91 and the Upstream Raise/Ash Pond 92 embankments were evaluated by Golder for static and seismic stability. Ash Pond 91 was evaluated for a single scenario assuming the water level at the crest of the embankment. The computed factor of safety (FOS) of 2.3 exceeds the minimum desired FOS of 1.5 for permanent structures. Seven scenarios were evaluated for the Upstream Raise/Ash Pond 92 structural stability, with five of those scenarios representing a permanent structure condition and two representing a temporary condition. All of the permanent condition scenarios had a computed FOS greater than 1.5. Both scenarios for a temporary structure condition had a computed FOS of 1.3 or greater, which meets the desired minimum FOS of 1.3 for temporary structures. All seismic loading scenarios for both ponds had FOS greater than 1.0, which meets criteria. The Golder static and seismic stability evaluation reports and documentation are presented in Appendix C.

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 surface water hydrology, changes in groundwater levels, changes in embankment integrity, etc. In light of this situation, we have noted several items as follows that present some minor concern in this regard:

- A few small trees exist at the toe of slope of both Ash Pond 91 and the Upstream Raise/Ash Pond 92. When trees die and the stumps remain, those can decompose over time and eventually create preferential paths for uncontrolled seepage. This is likely not problematic for the Upstream Raise because the fly ash material in the embankment creates a very hard material for the embankment that is unlikely to have significant root penetration. This condition would be considered more serious for Ash Pond 91 since it is an earth and clay embankment.

- The Ash Pond 91 west embankment toe appears to have a permanent slough feature adjacent to the downstream toe. The toe along the west slough was observed to have small scarps along the slough water line likely caused by wave action and saturated conditions. Erosion at the toe can shorten seepage paths and decrease stability of the embankment. Since the slough likely keeps the toe in a saturated condition, a seepage and stability analysis should be performed on the west embankment. The west embankment toe should be repaired and armored based on results of the analysis.
- An Emergency Action Plan (EAP) is not currently in place at the site to mitigate damage in the event of an emergency related to failure of the impoundment(s). While a failure of an embankment would not likely constitute a life threatening situation, a document should be prepared to formally outline the procedures to undertake in the event of such a failure.

Changes in Design or Operation of the Impoundments following Initial Construction

We are not aware of significant changes in the design or operation of the impoundments that have been implemented. According to GRE staff and Golder Associates, the Upstream Raise is being raised in accordance with the design of the facility and it is performing as expected. It is estimated that the Upstream Raise has at least five more years of service remaining before a new FGD disposal facility is needed. Ash Pond 91 is at its full size, continues operating as expected, and is performing well.

Adequacy of Program for Monitoring Performance of the Impoundments

The present monitoring program primarily involves visual inspections by plant personnel and by the Great River Energy and Golder technical staff. These visual inspections seem to be adequate to address issues such as surface erosion and general condition of the impoundments, as well as obtaining periodic piezometer readings and interpreting that data. However, a more detailed monitoring program is recommended to be established to quantify various important factors associated with embankment stability. Those factors include, but are not limited to seepage quantities through the embankment, the amount of sediments carried by the seepage water, and any fluctuations of ground water levels.

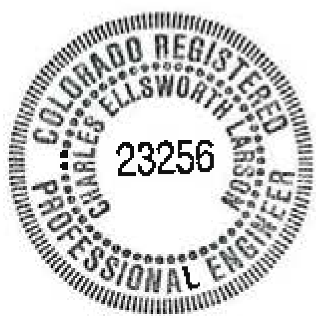
5.2 SUMMARY STATEMENT

I acknowledge that the management unit(s) referenced herein was personally assessed by me and found to be in the following condition:

SATISFACTORY

Signature: Date: 10/31/12

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 31, 2013.** An EAP should be prepared for both Ash Pond 91 and the Upstream Raise. The EAP could be a very short and straightforward document that basically documents that sufficient volume exists in Samuelson Slough to contain releases, and outlines procedures to undertake in the event of an unplanned release, including gate closure and phone calls to interested and potentially impacted parties.
2. **Control vegetation on the downstream slopes. Remove the isolated trees and woody brush, including roots/stumps, at the toe of the embankments by July 31, 2013.** Refer to FEMA Manual 534 (Impact of Plants on Earthen Impoundments) for guidance on vegetation removal. This manual is available on the FEMA website.

6.2 PRIORITY 2 RECOMMENDATIONS

1. **Repair erosion of Upstream Raise / Ash Pond 92 embankment by July 31, 2013.** Minor surface erosion was noted at the Upstream Raise. Areas where erosion has occurred should be filled in and revegetated to prevent erosion from cutting further into the embankments. This action is only necessary on areas that have been topsoiled and vegetated, as it is recognized that parts of the Upstream Raise are under construction and will be dressed and vegetated at the appropriate time.
2. **Evaluate and repair erosion at the toe on west embankment of Ash Pond 91 by July 31, 2013.** Ash Pond 91 west embankment toe appears to have a permanent slough feature adjacent to the downstream toe and was observed to have scarps along the slough water line. Erosion at the toe can shorten seepage paths and decrease stability of the embankment. Since the slough likely keeps the toe in a saturated condition a seepage and stability analysis should be

performed on the west embankment and the toe should be repaired and armored based on results of the analysis.

3. **Maintain a log of maintenance and other activities at Ash Pond 91 and the Upstream Raise impoundments and supporting** facilities **by July 31, 2013.** We have seen examples of Work Orders documenting inspection of the facilities by plant staff. Other Work Orders may exist that document 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.
4. **Perform video assessments of culvert piping by July 31, 2013.** This would include only the permanent culvert piping used for the outlet works of the impoundments, and specifically the cross connection pipes between Ash Pond 91 and the Drains Pond. The video survey should determine the type of pipe material, the condition of the pipes, and the condition of the valves. In addition, the valves should be exercised to assess functionality. Because most of the other piping is moved around or replaced as it loses capacity due to scale deposition, video survey of those pipes in the pond do not appear to be necessary.

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 Coal Creek 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 impoundment results in no probable loss of human life or economic or environmental losses.

2. **Low Hazard Potential**

   "Low hazard" means a 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.

This report may be used only by the client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance but in no event later than one (1) year from the date of the report.

The information, included on graphic representations in this report, has been compiled from a variety of sources and is subject to change without notice. Kleinfelder makes no representations or warranties, expressed or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. These documents are not intended for use as a land survey product nor are they designed or intended as a construction design document. The use or misuse of the information contained on these graphic representations is at the sole risk of the party using or misusing the information.

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

US Department of Agriculture (USDA)/ Natural Resources Conservation Service (NRCS) Web Soil Survey – online

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

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

US Department of the Interior, Safety and Evaluation of Existing Impoundments (SEED), 1995.

New Jersey Department of Environmental Protection, Impoundment Safety Guidelines for the Inspection of Existing Impoundments, January 2008

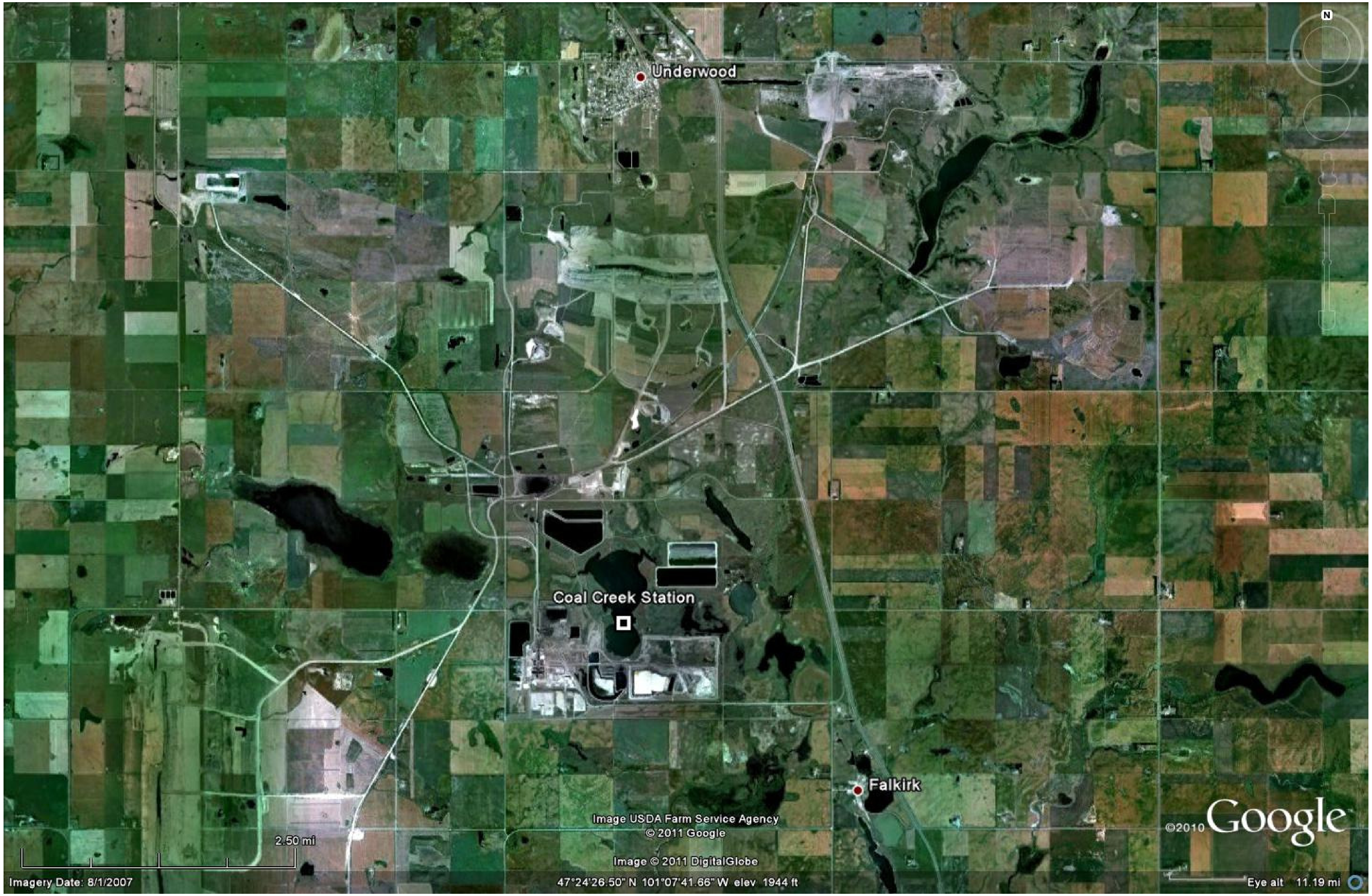
US Department of Interior, Reclamation Manual – Directives and Standards – Review/Examination Program for High and Significant Hazard Impoundments, July 1998.

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

A List of References provided by Great River Energy is included in Section 1.3.

KLEINFELDER

Plates



N

KLEINFELDER Bright People. Right Solutions. www.kleinfelder.com	PROJECT NO. 118953-1 DATE: 6-6-11 DRAWN BY: B. Piede CHECKED BY: C. Larson FILE NAME: Coal Creek Plates	**GREAT RIVER ENERGY** **CRITICAL INFRASTRUCTURE MAP** COAL CREEK STATON GREAT RIVER ENERGY UNDERWOOD, NORTH DAKOTA	PLATE **1**

The information included on this graphic representation has been compiled from a variety of sources and is subject to change without notice. Kleinfelder makes no representations or warranties, express or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. This document is not intended for use as a land survey product nor is it designed or intended as a construction design document. The use or misuse of the information contained on this graphic representation is at the sole risk of the party using or misusing the information.

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Coal Creek Plates

GREAT RIVER ENERGY
COAL CREEK STATION AERIAL MAP

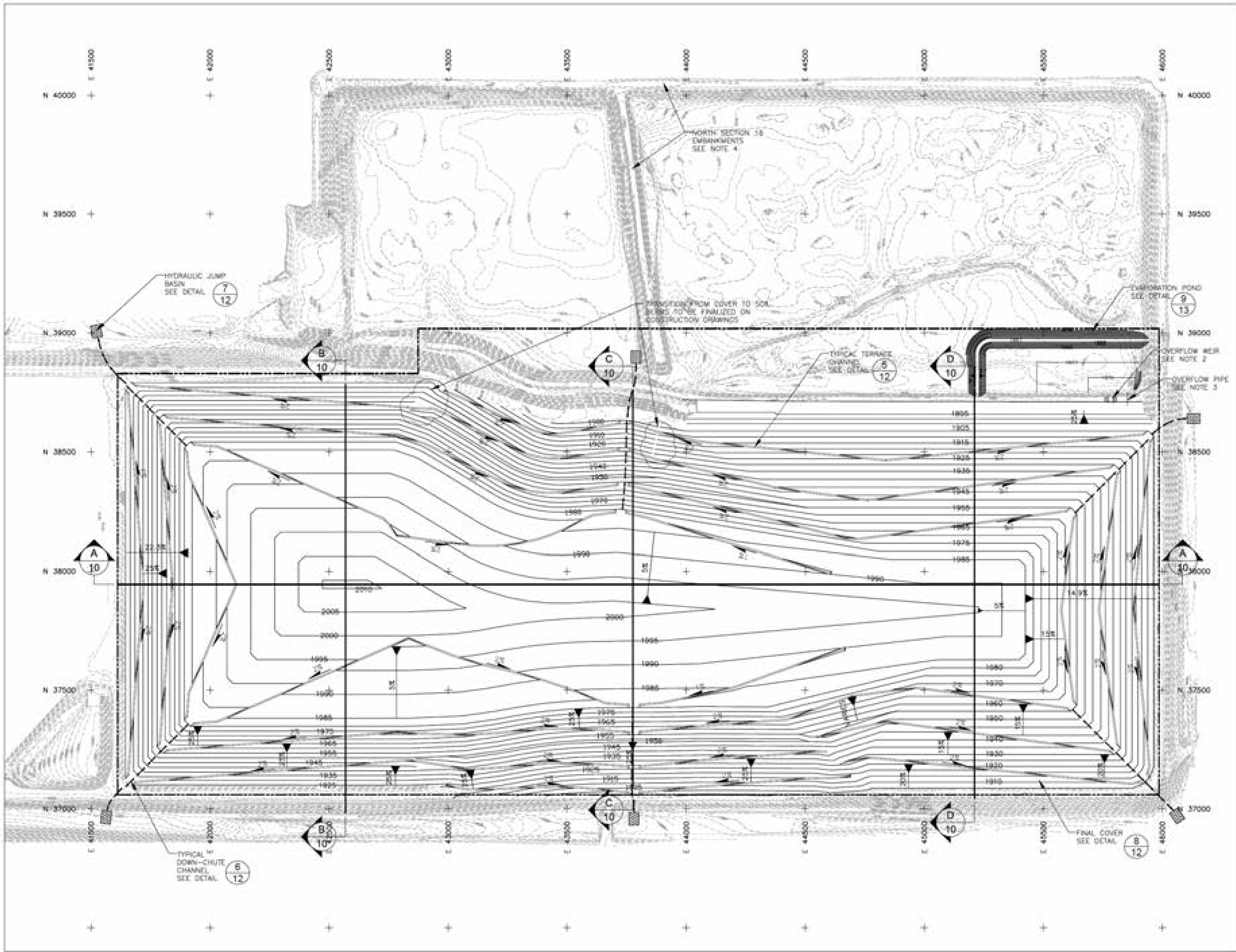
COAL CREEK STATON
GREAT RIVER ENERGY
UNDERWOOD, NORTH DAKOTA

PLATE
2

Notes: 1) Image is a general features map and does not reflect conditions on the date of inspection.

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO. 118953-1	**ASH PONDS SITE FEATURES MAP**	PLATE
DATE: 6-6-11		
DRAWN BY: B. Piede		**3**
CHECKED BY: C. Larson	COAL CREEK STATON GREAT RIVER ENERGY UNDERWOOD, NORTH DAKOTA	
FILE NAME: Coal Creek Plates		



LEGEND

- EXISTING GROUND TOPOGRAPHY (SEE REFERENCES)
- PROPOSED TOP OF FINAL COVER TOPOGRAPHY
- PROPOSED LIMIT OF CCP PLACEMENT

NOTES

1. GRADES REPRESENT TOP OF FINAL COVER.
2. A WEIR WILL BE CONSTRUCTED BEWTEEN THE SE SECTION 16 SUMP AREA AND THE SE SECTION 16 OVERFLOW/EVAPORATION POND. SEE CONTACT WATER ENGINEERING WORKSHEET FOR DETAILS.
3. AN OVERFLOW PIPE WILL BE CONSTRUCTED BEWTEEN THE SE SECTION 16 SUMP AREA AND THE SE SECTION 16 OVERFLOW/EVAPORATION POND. THE PIPE WILL CONTAIN A ONE-WAY CHECK VALVE TO ALLOW FLOW TO THE POND BUT NOT FROM THE POND.
4. THE EMBANKMENTS ON THE NORTH HALF OF THE SECTION 16 FACILITY WILL BE REMOVED AND MATERIAL USED AS STRUCTURAL FILL, LOW PERMEABILITY SOIL LINER, AND COVER MATERIAL. AFTER REMOVAL OF EMBANKMENTS, THE NORTH HALF OF THE SECTION 16 FACILITY WILL BE GRADED TO MATCH ORIGINAL AND SURROUNDING TOPOGRAPHY.
5. SEE THE SURFACE WATER ENGINEERING WORKSHEET FOR FURTHER DETAILS CONCERNING THE SURFACE WATER PLAN.

REGULATORY DESIGN BASIS

1. CONTROL OF RUN-ON AND RUN-OFF DURING OPERATIONS FROM A TWENTY-FIVE-YEAR, TWENTY-FOUR-HOUR STORM EVENT (3.75"), PER SUBDIVISION A OF SUBSECTION 3 OF NDAC SECTION 33-20-04.1-09.
2. OPERATE THE UPSTREAM RAISE (SURFACE IMPOUNDMENT) TO HAVE A FREEBOARD OF AT LEAST TWO FEET, PER SUBDIVISION D OF SUBSECTION 2 OF NDAC SECTION 33-20-08.1-01.
3. MINIMIZE EROSION OF FINAL COVER, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
4. MAXIMUM FINAL SLOPES NOT LESS THAN THREE PERCENT, NOR MORE THAN TWENTY-FIVE PERCENT, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
5. EVALUATE SLOPES STEEPER THAN FIFTEEN PERCENT TO ENSURE STABILITY, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
6. CONTROL OF SURFACE WATER DRAINAGE FROM FINAL SLOPES, PER SUBDIVISIONS B2-B4 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
7. COMPOSITE LINER, PER SUBDIVISION B OF SUBSECTION 2 OF NDAC SECTION 33-20-08.1-01.
8. APPROPRIATE ENGINEERED FINAL COVER DESIGN, PER NDAC SECTION 33-20-07.1-02.
9. ALL OTHER APPLICABLE RULES FROM NDCC CHAPTER 23-29 AND NDAC ARTICLE 33-20.

REFERENCES

1. SITE LOCATION: SECTION 16, T145N, R82W, MCLEAN COUNTY, NORTH DAKOTA.
2. EXISTING GROUND TOPOGRAPHY PROVIDED BY GREAT RIVER ENERGY. PERFORMED BY INTERSTATE ENGINEERING AND KADRMAS, LEE & JACKSON BETWEEN 1996 AND 2003.
3. ELEVATIONS BASED ON MEAN SEA LEVEL DATUM, CONTOUR INTERVAL IS ONE FOOT.
4. HORIZONTAL DATUM BASED ON NORTH DAKOTA STATE PLANE COORDINATE SYSTEM AS FOLLOWS:

   SITE GRID N = N STATE PLANE COORDINATE MINUS 100,000
   SITE GRID E = E STATE PLANE COORDINATE MINUS 1,800,000
5. ALL PROPERTY SHOWN ON THIS MAP IS OPERATED BY GREAT RIVER ENERGY.

1" = 200' FEET

NO.	REVISION DESCRIPTION	DATE	BY	CHK'D	AP'VD
	ISSUED FOR DRAFT REVISED PERMIT MODIFICATION	07/09/04			
	ISSUED FOR PERMIT MODIFICATION	09/24/03	TJS	RRJ	RRJ
	ISSUED FOR CLIENT REVIEW	06/04/03	TJS	–	RRJ

ENGINEER'S STAMP — REFERENCE DRAWINGS — PRINT ISSUE RECORD (DATE, FOR, REVISED, CLIENT, FIELD)

GREAT RIVER ENERGY
COAL CREEK STATION
PERMIT NO. SP-033 PERMIT MODIFICATION

FINAL COVER GRADES AND SURFACE WATER PLAN

Golder Associates, Denver, Colorado

PROJECT No.	023-2411	FILE No.	0232411A024
DESIGN	TJS	05/27/03	SCALE AS SHOWN REV. C
CADD	TJS	05/27/03	
CHECK	RRJ	06/02/03	9
REVIEW	RRJ	06/02/03	

Note: Figure reflects final ash pond configuration. Current elevation is 1962 feet. See Report for more details.

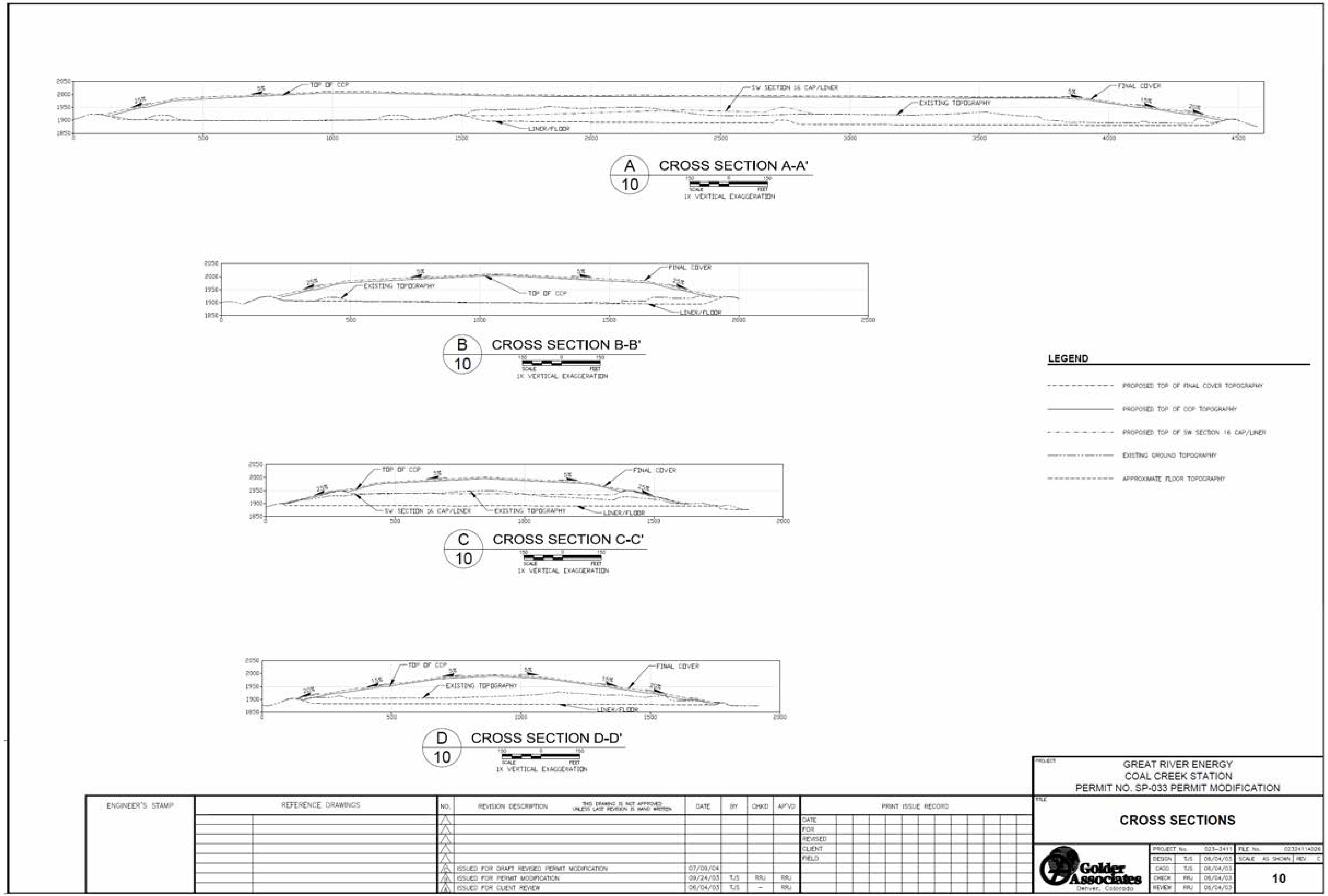
KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Coal Creek Plates

UPSTREAM RAISE / ASH POND 92
FINAL COVER PLAN

COAL CREEK STATON
GREAT RIVER ENERGY
UNDERWOOD, NORTH DAKOTA

PLATE 4



Note: Figure reflects final ash pond configuration. Current elevation is 1962 feet. See Report for more details.

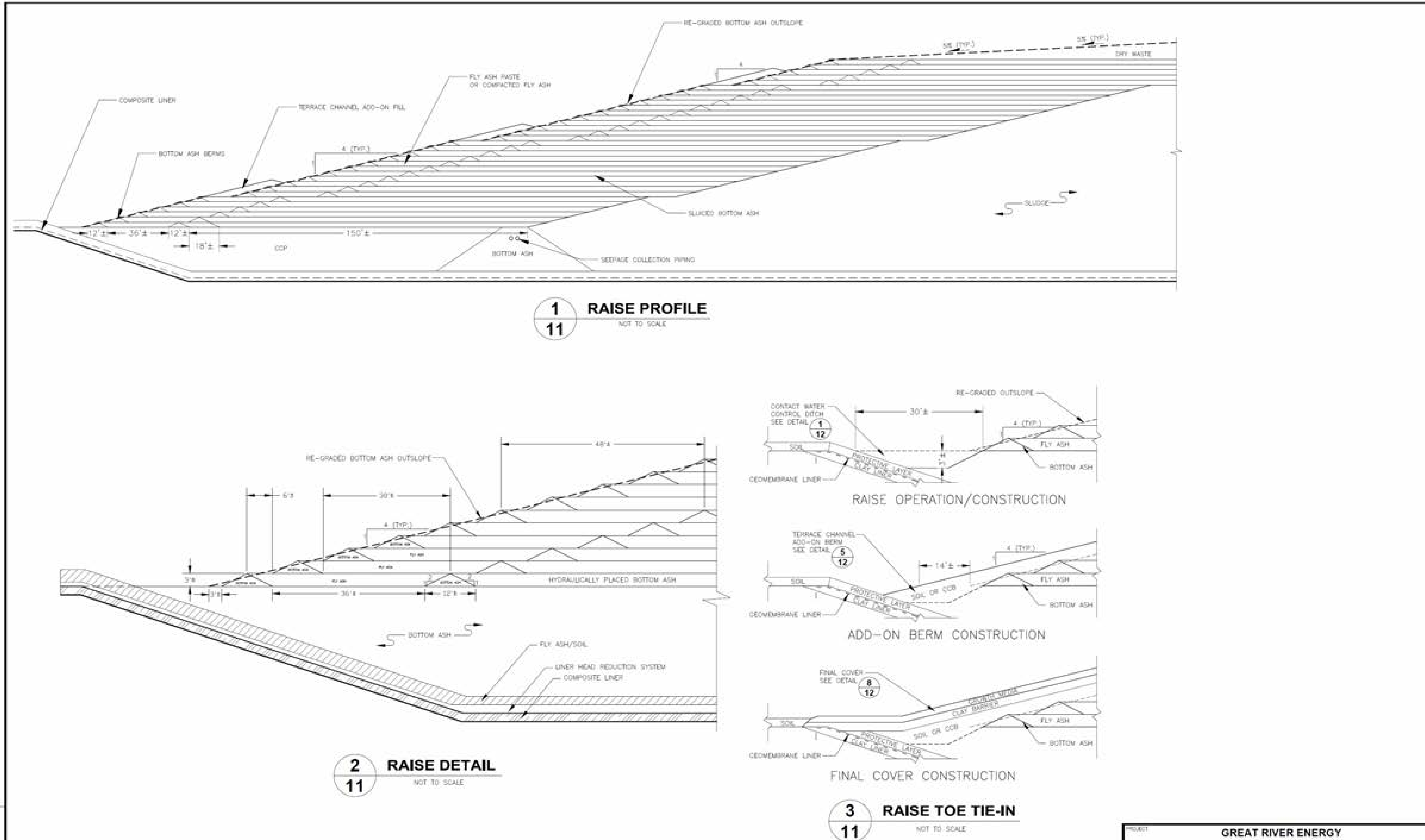
KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Coal Creek Plates

UPSTREAM RAISE / ASH POND 92
FINAL COVER TYPICAL CROSS SECTION

COAL CREEK STATON
GREAT RIVER ENERGY
UNDERWOOD, NORTH DAKOTA

PLATE
5



GREAT RIVER ENERGY
COAL CREEK STATION
PERMIT NO. SP-033 PERMIT MODIFICATION

DETAIL SHEET 1

Golder Associates, Denver, Colorado

PROJECT No.	023-2411	FILE No.	02324114027
DESIGN	TJS	06/02/03	SCALE AS SHOWN REV. C
CADD	TJS	06/02/03	11
CHECK	RRJ	06/02/03	
REVIEW	RRJ	06/02/03	

NO.	REVISION DESCRIPTION (THIS DRAWING IS NOT APPROVED UNLESS LAST REVISION IS HAND WRITTEN)	DATE	BY	CHKD	AP'VD
C	ISSUED FOR REVISED PERMIT MODIFICATION	07/09/04			
B	ISSUED FOR PERMIT MODIFICATION	09/24/03	TJS	RRJ	RRJ
A	ISSUED FOR CLIENT REVIEW	06/04/03	TJS	–	RRJ

ENGINEER'S STAMP — REFERENCE DRAWINGS — PRINT ISSUE RECORD: DATE, FOR, REVISED, CLIENT, FIELD

Note: Figure reflects final ash pond configuration. Current elevation is 1962 feet. See Report for more details.

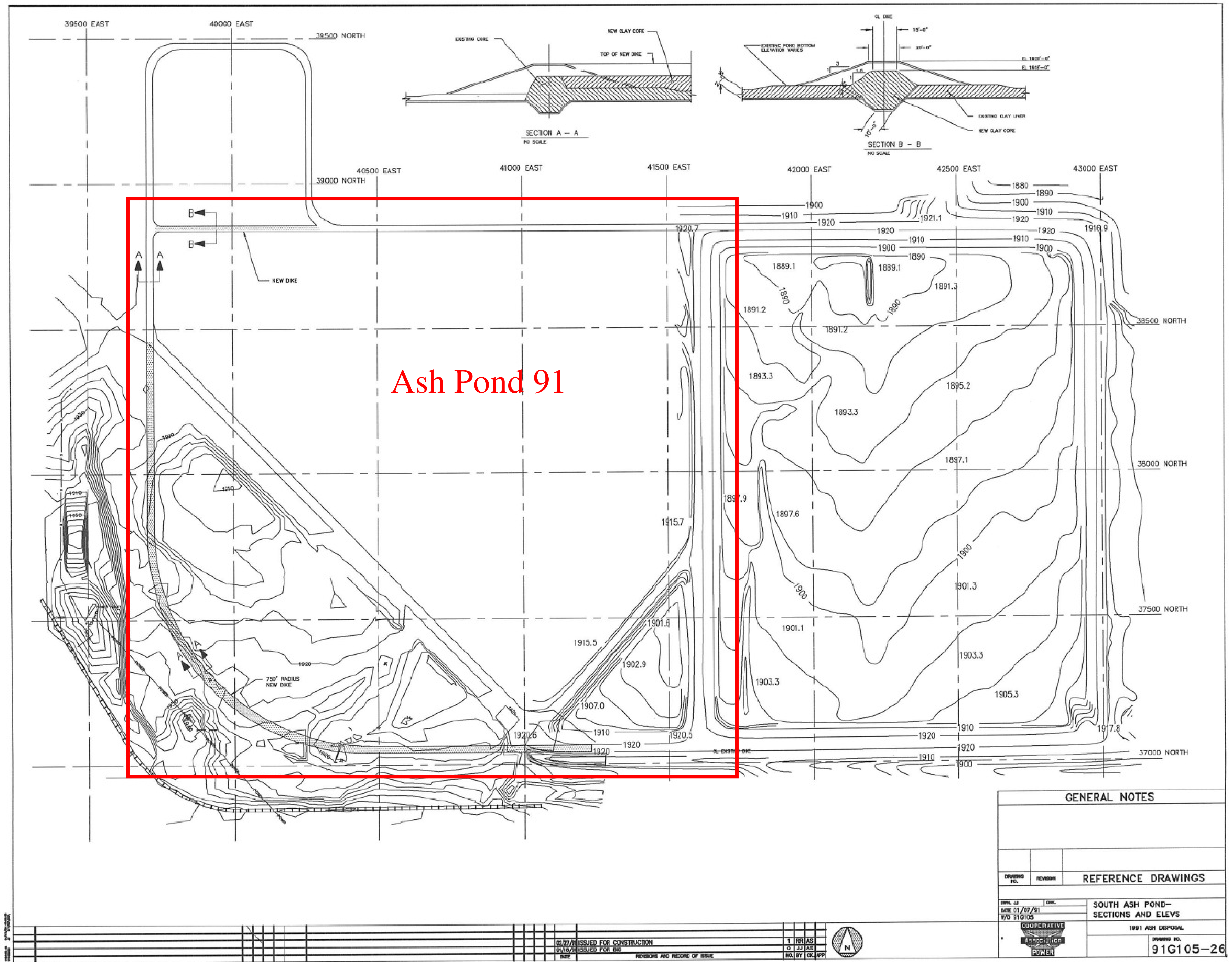
KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Coal Creek Plates

UPSTREAM RAISE / ASH POND 92
EMBANKMENT CROSS SECTION

COAL CREEK STATON
GREAT RIVER ENERGY
UNDERWOOD, NORTH DAKOTA

PLATE 6



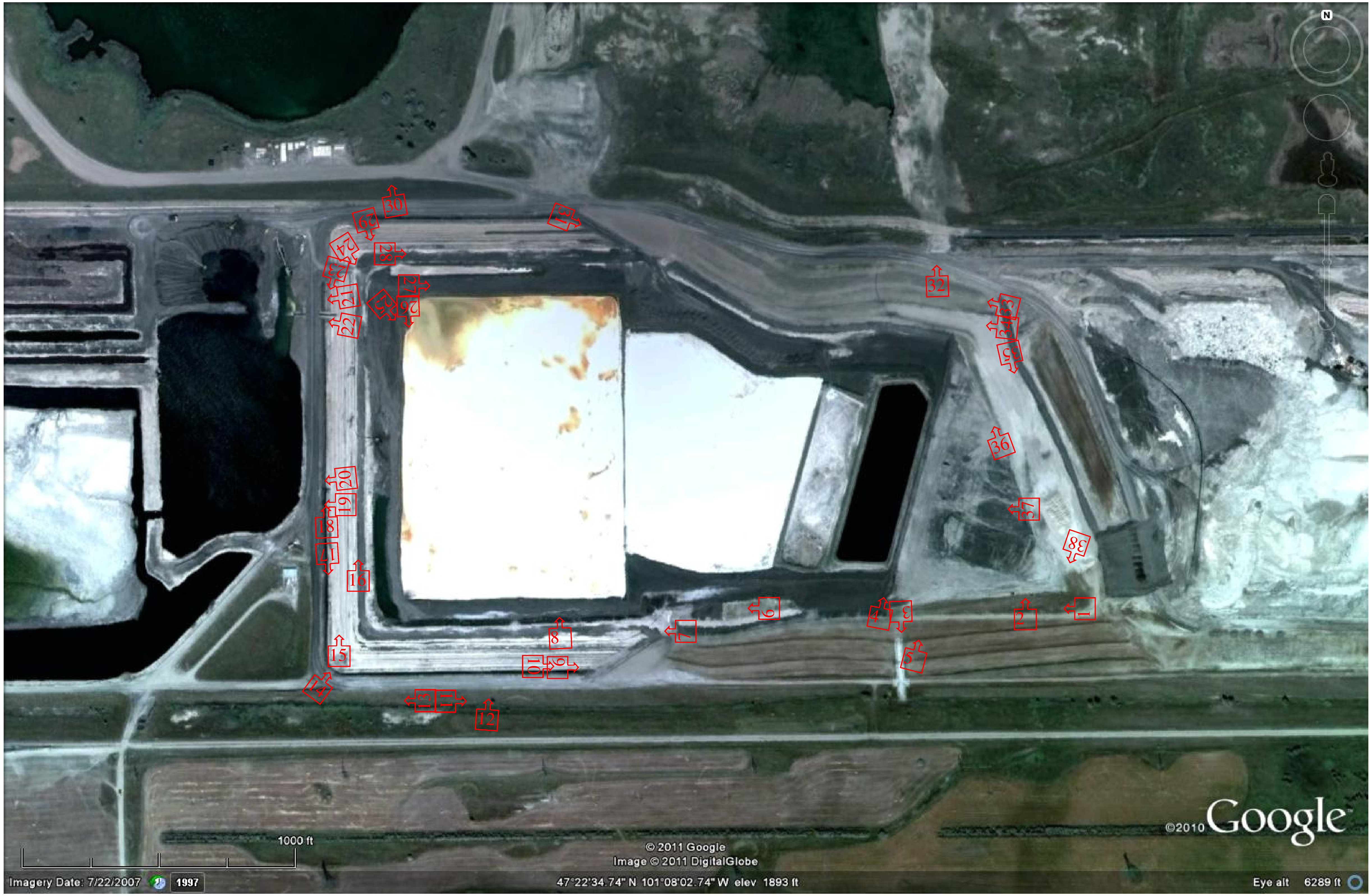
PROJECT NO.	118953-1
DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Coal Creek Plates

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

ASH POND 91
PLAN AND PROFILE

COAL CREEK STATON
GREAT RIVER ENERGY
UNDERWOOD, NORTH DAKOTA

PLATE
7



N

Legend:

21 - Photo number, location, and direction

Notes: 1) Photographs 69 and 70 (outlet gate) are not shown on the map and are approximately 1 mile east of the ash ponds.
2) Photograph locations are approximate and may not exactly coincide with the coordinates shown on the photo.

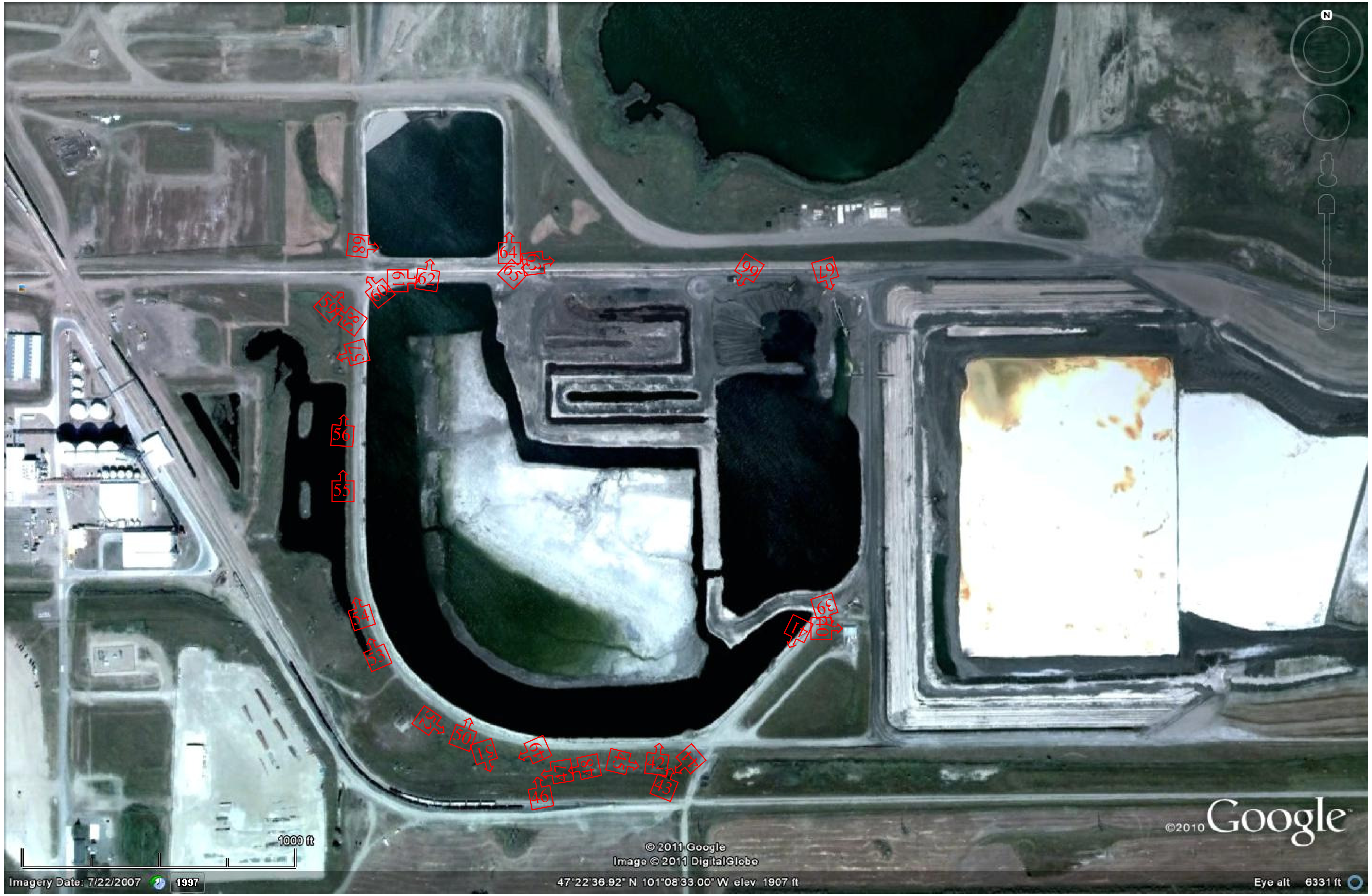
KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Coal Creek Plates

UPSTREAM RAISE / ASH POND 92
PHOTOGRAPH LOCATION MAP

COAL CREEK STATON
GREAT RIVER ENERGY
UNDERWOOD, NORTH DAKOTA

PLATE
8



N

Legend:

- Photo number, location, and direction

Notes: 1) Photographs 69 and 70 (outlet gate) are not shown on the map and are approximately 1 mile east of the ash ponds.
2) Photograph locations are approximate and may not exactly coincide with the coordinates shown on the photo.

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	118953-1
DATE:	6-6-11
DRAWN BY:	B. Piede
CHECKED BY:	C. Larson
FILE NAME:	Coal Creek Plates

ASH POND 91
PHOTOGRAPH LOCATION MAP

COAL CREEK STATON
GREAT RIVER ENERGY
UNDERWOOD, NORTH DAKOTA

PLATE
9

Appendix A

Site Assessment Evaluation Checklists

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Coal Creek Station	Date:	5-17-11
Unit Name:	Upstream Raise Ash Pond 92	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)?	N/A		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	VARIES		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)?	1962		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

3. Water Currently being pumped to upstream raise. Decant pipe is set approx. 4 feet below crest.

7. Embankment is currently being raised in successive steps.

20. Outlet is under water.

21. Clear and collected in toe drain system.

23. From crossover pipes (west side) and under drains (north side).

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 # Not Applicable INSPECTOR Kleinfelder (C. Larson, B. Piede)
Date 5-17-11

Impoundment Name Coal Creek 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 Upstream Raise Ash Pond 92
(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: Flue Gas Desulfurization Disposal

Nearest Downstream Town : Name Underwood, ND
Distance from the impoundment ______5 miles____________________
Impoundment
Location: Longitude __101_ Degrees _08___ Minutes _07___ Seconds
Latitude __47__ Degrees _22___ Minutes _34___ Seconds
State __ND_____ County __McLean__________________

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):

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

x______ **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.

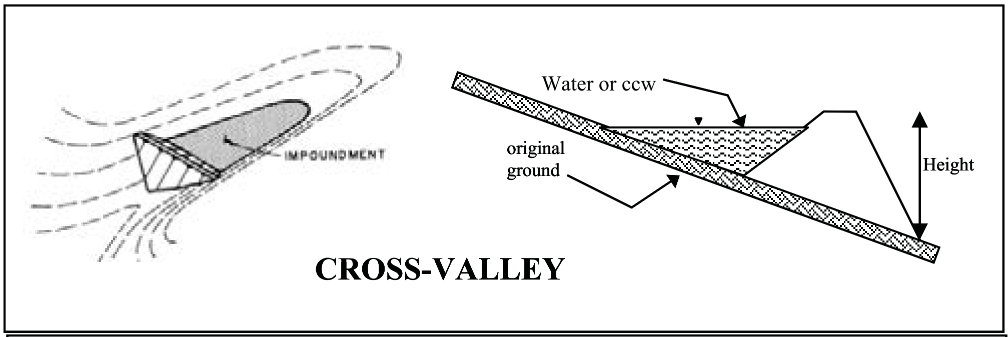
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

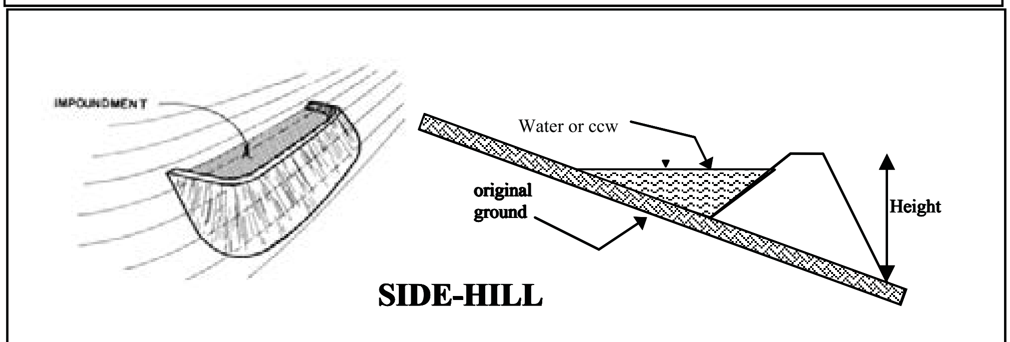
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

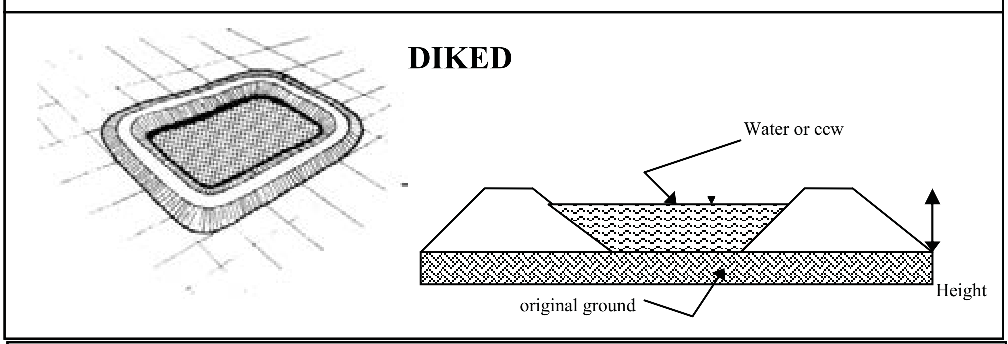
____-No loss of human life is anticipated.________________________________
____-Discharge would be contained to Great River Energy's property.___
____-Surrounding area is open space and water bodies with sufficient
______storage to contain volume of release. Failure would have low ___________________
______economic consequences and environmental impact.____________________________
____-There is a gate closure structure on the open space/water bodies area______________
______which would allow full containment on GRE property, and there ________________
______would be sufficient time to close that gate for containment in the ________________
______event of a pond failure.____
____-The fly ash material used for the construction of the pond forms a________________
______very hard, durable material that would be very difficult to erode.________________

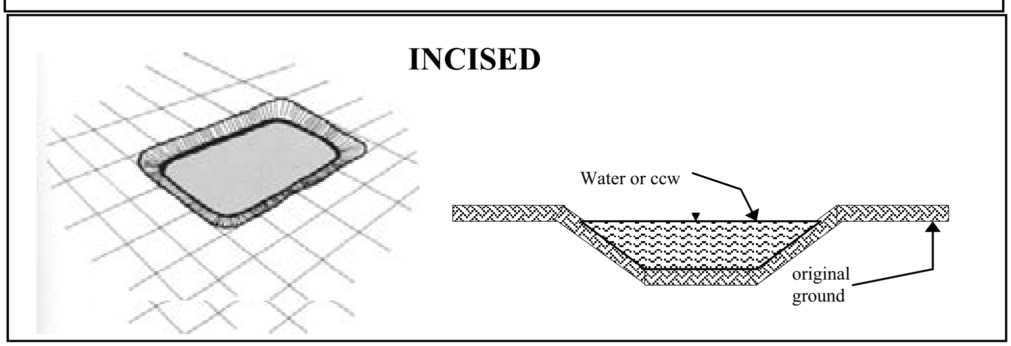
____
____
____

CONFIGURATION:









______ Cross-Valley

______ Side-Hill

X_____ Diked

______ Incised (form completion optional)

______ Combination Incised/Diked

Embankment Height ~60_ft (current)   Embankment Material Bottom Ash and Fly Ash

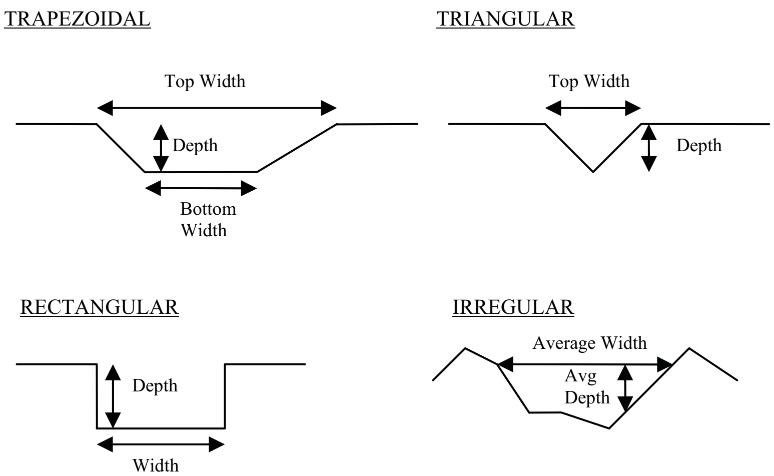
Pool Area 91.6 acres   Liner Clay and HDPE

Current Freeboard Approx. 4 feet   Liner Permeability Approx. 0

TYPE OF OUTLET (Mark all that apply)

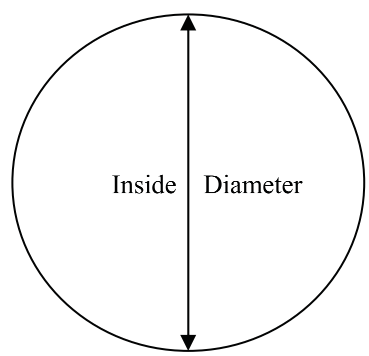
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

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



X _____ **Outlet**

4 x 18" inside diameter



Material
_____ corrugated metal
_____ welded steel
_____ concrete
X _____ 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 Golder Engineering

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 X NO ____

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

If so Please Describe :

Seepage was observed ~~near~~ along an old ash pond that has since been taken out of service. Toe drains were added to current facilities as a precaution and no significant seepage has been observed.

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Coal Creek Station	Date:	5-17-11
Unit Name:	Ash Pond 91	Operator's Name:	Great River Energy
Unit I.D.:	SPD-6	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)?	1918		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	1905		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)?	1922		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

9. A few 4 to 6-inch diameter small trees - at toe

12. Under water, not visible

20. Inlet and outlet under water

21. Possible extremely minor seepage on south side in ditch near slope (est. < 1 gph). Source could be storm runoff

23. Slough on west side.

No part of the impoundment was built over wet ash, slag, or other unsuitable materials.

Coal Combustion Waste (CCW) Impoundment Inspection

Impoundment NPDES Permit # Not Applicable ____ INSPECTOR Kleinfelder (C. Larson, B. Piede)

Date 5-17-11

Impoundment Name Coal Creek 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 Ash Pond 91

(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 Settling Pond

Nearest Downstream Town : Name Underwood, ND

Distance from the impoundment _5 miles________________

Impoundment

Location: Longitude _101__ Degrees _08___ Minutes _37___ Seconds

Latitude _47___ Degrees _22___ Minutes _34___ Seconds

State __ND____ County __Mc:eam__________________

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

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

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

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

__X____ **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:

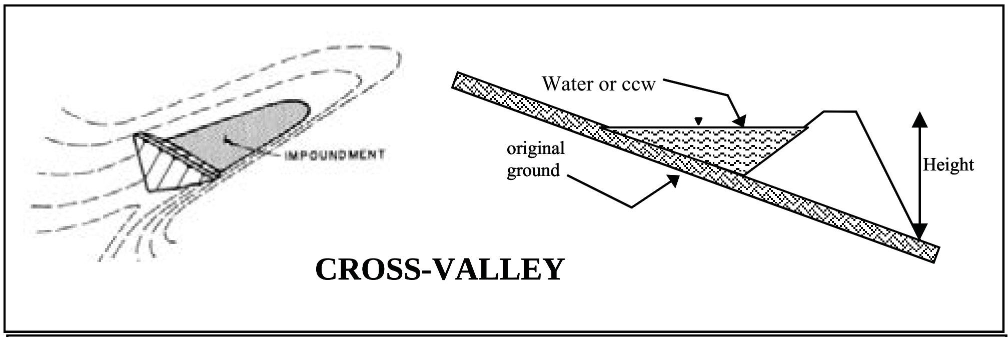
__-No loss of human life anticipated._________________________________

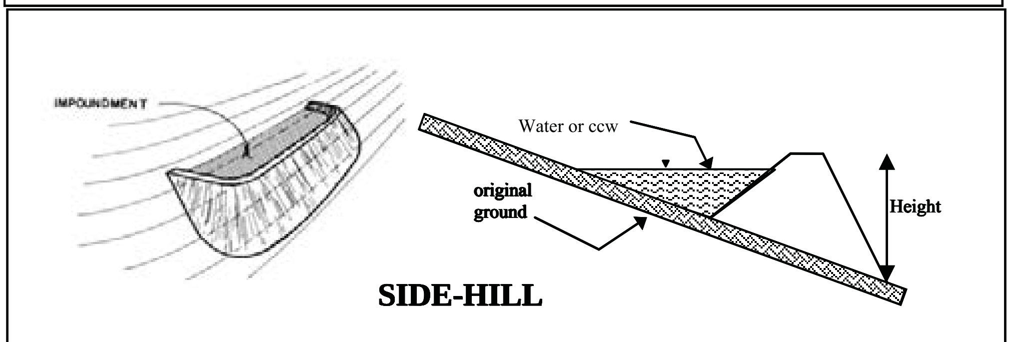
__-Discharge would be contained to Great River Energy's property._______

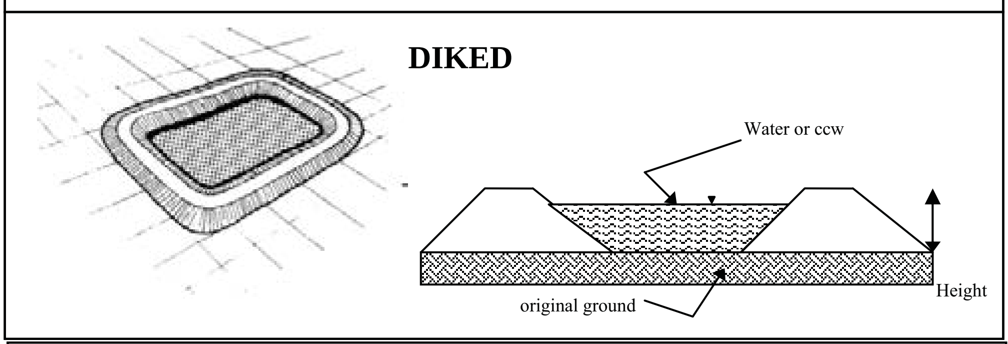
__-Surrounding area is open space and failure would have a low economic__

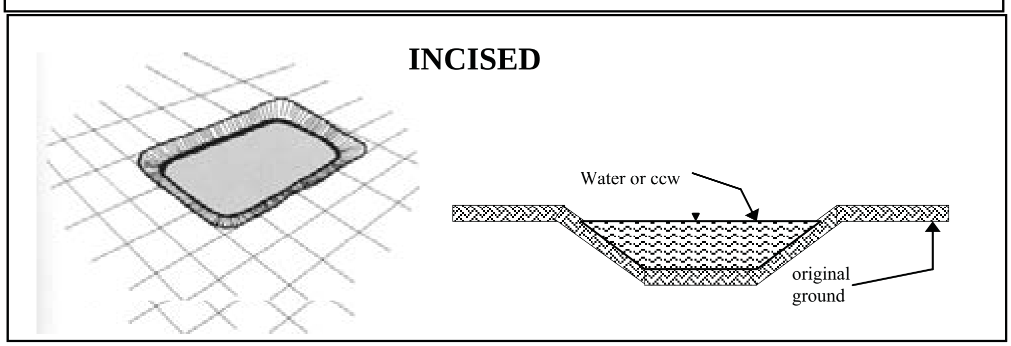
____and environmental impact. ____

CONFIGURATION:









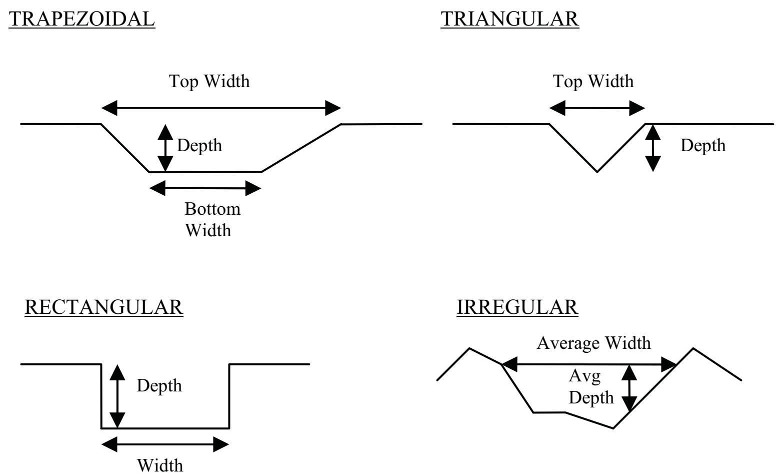
______ Cross-Valley
______ Side-Hill
_X__ Diked
______ Incised (form completion optional)
______ Combination Incised/Diked

Embankment Height 25 feet Embankment Material Earthfill with Clay Core
Pool Area 70 acres Liner Clay and HDPE
Current Freeboard Approx. 4 feet Liner Permeability Approx. 0

TYPE OF OUTLET (Mark all that apply)

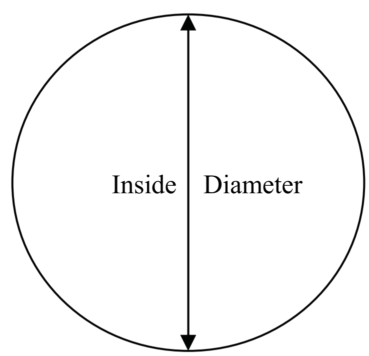
______ **Open Channel Spillway**
______ Trapezoidal
______ Triangular
______ Rectangular
______ Irregular

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



X______ **Outlet**

3 x 18" inside diameter



Material
______ corrugated metal
______ welded steel
______ concrete
______ plastic (hdpe, pvc, etc.)
_x____ other (specify) underwater - not visible______________________

Is water flowing through the outlet? YES X______ NO _______

______ **No Outlet**

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

The Impoundment was Designed By Black and Veatch

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.

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 the fly ash goes into hoppers that discharge to a pipe which conveys the bottom 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?

A majority of CCS fly ash is sold into the beneficial use market. It is stored onsite in steel silos and a concrete dome until it is transported off site or to be beneficially used in constructing an upstream raise. Yes, the storage units have containment.

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

   Fly ash sold into the beneficial use market is taken off site via truck and rail. There is on site containment. Fly ash beneficially used onsite is moved via truck and does have containment.

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.

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).

FGD Sludge is not generated at the boiler. FGD is generated by scrubbing flue gas in the wet scrubber. Absorbers initially collect the material.

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?

From the absorbers the material goes into the reaction tanks which are emptied by a jet pump into a pipe that conveys the slurry to the upstream raise.

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?

An engineered, lined Upstream Raise facility that is contained stores the material. Additional information was provided in the ICR.

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

The storage facility is the final disposal site. Yes it is contained.

Appendix B

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

mailed certified 9/22/2010

GREAT RIVER ENERGY®

Coal Creek Station • 2875 Third Street SW • Underwood, North Dakota 58576-9659 • 701-442-3211 • Fax 701-442-3726

September 21, 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) – Coal Creek Station

Dear Mr. Dufficy;

This letter is in response to your August 24, 2010 letter that was received by Great River Energy (GRE) August 26, 2010. The letter requested information pursuant to Section 104(e) of CERCLA. August 30, GRE requested and was granted a 15 day extension to the information request.

GRE has reviewed the instructions in Enclosure A and determined that two surface impoundments meet the definition of a 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. In addition to the two impoundments, GRE has four Evaporation Ponds that are used exclusively for the management of excess plant process water; these ponds do not receive or store residuals or by-products from the combustion of coal.

Enclosure A contains responses to information for the GRE, Coal Creek Station.

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

GREAT RIVER ENERGY®

Coal Creek Station • 2875 Third Street SW • Underwood, North Dakota 58576-9659 • 701-442-3211 • Fax 701-442-3726

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 Coal Creek Station presents the threat of release. Coal Creek Station is a zero liquid discharge facility; releases would be considered a spill and would have been reported per CERCLA spill reporting guidance.

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 B. Weeda
Plant Manager,
Coal Creek Station
2875 3rd St. SW
Underwood, ND 58576

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 B. Weeda: ______ 9/23/2010
Plant Manager, Coal Creek Station

Enclosure A: US EPA Request under Section 104(e) CERCLA
September 21, 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 having a rating, please note that fact.

   The Upstream Raise and Ash Pond 91 have not been rated by any agency under the National Inventory of Dams criteria. An interdependent 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
Upstream Raise otherwise referred to as: Upstream Raise/ Ash Pond 92/ SW Section 16	Low	Golder Associates Inc. September, 2010	No probable loss of human life. Low economic and/or environmental losses with losses principally limited to the owners property.	North Dakota Department of Health (NDDH) Division of Waste Management Permit SP-033
Ash Pond 91	Low	Golder Associates Inc. September, 2010	No probable loss of human life. Low economic and/or environmental losses with losses principally limited to the owners property.	NDDH Division of Waste Management Permit SP-033

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

   Current impoundments Ash Pond 91 and the Upstream Raise were originally commissioned in 1979 as the South Ash Pond (SAP). Leakage from the SAP was observed and the SAP was removed from service, relined with a clay liner and returned to service.

Leakage was observed again so the SAP was removed from service and divided into three ponds: the Drains Pond, Ash Pond 91 and Ash Pond 92. The footprint for the original SAP and the three new ponds is identical; however, the ponds were deepened prior to liner installation. Composite liners and leachate collection systems were installed in Ash Pond 92 and Ash Pond 91. Ash Ponds 92/91 were returned to service in 1989/1992 respectively.

Ash Pond 92 was converted from an impoundment to a landfill/impoundment for permanent placement of scrubber sludge in 2005. This pond is now called the Upstream Raise. The Upstream Raise was expanded over the Southwest Section 16 landfill. A composite liner and leachate collection system was installed for each expansion.

Impoundment Name	Year Commissioned	Year Expanded	Scope of
Ash Pond 91	1979	1992	Pond deepened and composite liner installed
Upstream Raise	1979	1989	Pond deepened and composite liner installed
• Phase I		2005	Liner construction over existing permitted footprint containing dry CCPs
• Phase II		2006	Liner construction over existing permitted footprint containing dry CCPs
• Phase III		2008	Liner construction over existing permitted footprint containing dry CCPs

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
Ash Pond 91	Bottom Ash	Temporary
	Flue Gas Emission Control Residues	Permanent from historic practices *
	Other: Pulverizer Rejects	Temporary
	Other: Economizer Ash	Temporary
Upstream Raise	Flue gas Emission Control Residues	Permanent

Impoundment Name	Assessment Date	Corrective Action
Ash Pond 91	4-14-10	Nothing Recommended
Upstream Raise	8-6-10	Nothing Recommended

Structural integrity evaluations of all impoundments at Coal Creek Station including the Upstream Raise and Ash Pond 91 were completed under the supervision of a professional engineer registered in the state of North Dakota employed by Golder Associates Inc., an independent engineering consulting firm.

6. When did a State or a Federal regulatory official last inspect or evaluate the safety (structural integrity) of the management unit(s)? If you are aware of a planned state or federal inspection or evaluation in the future, when is it expected to occur? Please identify the Federal or State regulatory agency or department which conducted or is planning the inspection or evaluation. Please provide a copy of the most recent official inspection report or evaluation.

   There have been no Federal regulatory agency inspections or evaluations.

   The North Dakota Department of Health, Waste Management Division performed a Solid Water inspection on 7/13/2010, all impoundments are permitted by NDDH Solid Waste Department. NDDH does not perform dam safety inspections as part of its annual site inspections but does inspect monitoring activities associated with the operation of the impoundments units. NDDH did not provide a written report or evaluation; however, nothing of concern was noted during the inspection.

7. Have assessments or 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.

   Not Applicable – Refer to item 6

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
Ash Pond 91	70	10,851,174 cubic feet
Upstream Raise	91.6	33,484,356 cubic feet

Impoundment Name	Date	Volume of material currently stored
Ash Pond 91	12/2009	690,542 Tons
Upstream Raise	9/1/2010 Engineering Est.	907,140 Tons

Impoundment Name	Maximum Height Feet
Ash Pond 91	25
Upstream Raise	75

9. Please provide a brief history of known spills or unpermitted releases from the unit within the last ten years, whether 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

- Evaluation of Ash Pond 91 Berm Stability
- Evaluation of Ash Pond 92/SW Section 16 Stability
- Addendum to Evaluation of Ash Pond 92/SW Section 16 Stability and Evaluation of Ash Pond 91 Stability – Seismic Stability Evaluation
- Letter Response to Kleinfelder Email Dated May 11, 2012 Concerning Slope Stability Factors of Safety

REPORT

EVALUATION OF ASH POND 92/SW SECTION 16 STABILITY

Submitted to: Great River Energy
Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

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

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

August 6, 2010
Revised December 21, 2010

103-81601

A world of capabilities delivered locally

Golder Associates

Table of Contents

List of Tables

List of Figures

List of Appendices

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 Ash Pond 92/SW Section 16 coal combustion product (CCP) storage facility at Coal Creek Station (CCS). 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

CCS is located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. Various ponds and basins are utilized at CCS to manage the raw water, cooling water, process water, and CCP inventories (see Figure 1). This includes two CCP storage/disposal ponds (Ash Pond 91 and Ash Pond 92/SW Section 16), four evaporation ponds (Evaporation Ponds 91, 92, 93, and 94), a recycle pond (Drains Pond), a runoff/sewage collection pond (Lignite Runoff Basin), a cooling water basin (Extended Basin), and a raw water storage basin (River Water Holding Basin).

Ash Pond 92/SW Section 16 (Figure 2) together cover approximately 110 acres and are used as a combined dewatering and storage facility for CCPs including fly ash, bottom ash, pulverizer rejects, economizer ash, and flue gas desulfurization (FGD) sludge. FGD sludge and water enter Ash Pond 92/SW Section 16 through an 8-inch HDPE pipe at the surface, while bottom ash and fly ash are hauled to the facility. The facility is dewatered using gravity-driven drainage pipes that extend between the west side of Ash Pond 92 and the east side of Ash Pond 91. Ash Pond 92 is bordered by Lower Samuelson Slough to the north, Ash Pond 91 to the west, the plant dry CCP landfill (SE Section 16) to the east, and the entrance road and rail lines to the south.

Ash Pond 92 was originally part of the South Ash Pond. The South Ash Pond was constructed with a clay core dike around the perimeter and a soil liner. A new clay liner was installed over the South Ash Pond in 1982 and the facility remained in operation until 1987 when ash was excavated from the South Ash Pond and transported to the Section 5 dry CCP landfill (Eugene A. Hickok & Associates 1986; Foth & Van Dyke 1988). The South Ash Pond was then divided into Ash Pond 91 and Ash Pond 92. Ash Pond 92 was deepened and a new composite liner consisting of a 2-foot thick clay and 40-mil HDPE liner was completed in 1989. The liner is overlain with 1 foot of sand, 1 foot of Pit Run gravel, and a drainage system. Selected construction drawings from the 1989 work are included in Appendix A. Also included in Appendix A is the topography of the areas surrounding Ash Pond 92/SW Section 16. Ash Pond 92 was modified in 2002 to allow for "vertical" placement of CCPs in the footprint of Ash Pond 92. Since September of 2002, the facility has been constructed with an interior area of FGD sludge, a drainage layer of bottom ash, and an outer shell of fly ash (Figure 3).

SW Section 16 was originally part of the East Ash Pond (EAP). In 1989, the facility was reclassified as a solid waste disposal area and CCPs from the other parts of the EAP were excavated and placed in SW Section 16. SW Section 16 was regraded and a new composite liner consisting of a 1-foot thick clay and 60-mil LLDPE liner was installed in three phases between 2005 and 2008. The liner is overlain with a liner head reduction system consisting of 18 inches of granular material and drainage pipes overlain by a 1-foot clay liner. Selected design drawings for the SW Section 16 regrade and liner are included in Appendix A. SW Section 16 was regraded and relined to allow for "vertical" placement of CCPs in the footprint of SW Section 16 and has been connected with the "vertical" placement at Ash Pond 92. The final design grades for Ash Pond 92 and SW Section 16 are also included in Appendix A.

1.3 Pond Embankments

The design top of the original soil perimeter berm surrounding Ash Pond 92/SW Section 16 is at an approximate elevation between 1900 feet on the east side and 1920 feet on the west side of the facility. This berm surrounding the facility has a gravel paved roadway supporting both light passenger vehicles and heavy construction equipment (Cat-777). Original upstream slopes have an approximate 3:1 slope from this original soil perimeter berm to the base of the facility between 1892 feet and 1910 feet. The facility was designed with 4:1 slopes from the original soil perimeter berm toward the top of the facility with a completed ash elevation of the vertical expansion of approximately 2005 feet.

Slopes from the original soil perimeter berm down to the surrounding ditches generally have 3:1 or 2.5:1 slopes based on existing topography. The downstream slopes from the gravel paved roadway to the toe of slope have grass vegetation. Topography surrounding Ash Pond 92/SW Section 16 has elevations varying from approximately 1880 feet to 1900 feet.

An expansion berm surrounding SW Section 16 was built during the regrading and liner construction with a combination of soil and CCPs that extends from an elevation of approximately 1900 feet to an elevation of 1950 feet at 3.5:1 to 4:1 slopes. The south side of SW Section 16 has final cover on the side slopes with terraces approximately every 20 vertical feet and down-chute drainage channels along the side slopes.

1.4 Geological Conditions

Ash Pond 92/SW Section 16 is generally constructed over a glacial till layer consisting of sandy and silty-clay soils. Glacial till varies in thickness from 20 feet to several hundred feet in the area of Coal Creek Station. Silty-sand and sand lenses are present throughout the glacial till formation, which is underlain by poorly consolidated siltstone/sandstone bedrock (Barr Engineering 1982; Cooperative Power and United Power Association 1989).

2.0 STABILITY EVALUATION

2.1 Slope Geometries

Golder developed several cross sections through both Ash Pond 92 and SW Section 16 to analyze exterior stability of the facility. In addition, the stability of interior bottom ash and sludge slopes was evaluated. Seven stability scenarios were analyzed with the following geometries:

Scenario 1 – Ash Pond 92 – Perimeter Berm

Scenario 1 (Figures 3 and 4) examines the stability of the outer soil perimeter berm of Ash Pond 92 on the south side of the facility. The soil perimeter berm extends from an elevation of approximately 1925 feet (gravel road) down to the bottom of the ditch on the south side of the facility (elevation 1897 feet) at an approximate 2.5:1 slope. Scenario 1 is performed using the final design cover grades.

Scenario 2 – Ash Pond 92 – Geomembrane Interface

Scenario 2 (Figures 3 and 5) examines the stability of CCP materials along the geomembrane interface on the interior of the perimeter berm using final design cover grades. At final design, the facility is expected to have a top of cover elevation of 2010 feet with 4:1 side slopes from the perimeter berm to approximately 1982 feet. A 5% slope continues from 1982 feet to 2010 feet.

Scenario 3 – Ash Pond 92 – Intermediate Sludge Level

Scenario 3 (Figures 6 and 7) examines the stability of the CCP materials along the geomembrane interface on the interior of the perimeter berm with an intermediate sludge level of approximately 1968 feet. In this scenario, cover soil and CCPs are not actively being placed. The slope geometries are the same as those of Scenario 2.

Scenario 4 – SW Section 16 – Perimeter Berm

Scenario 4 (Figures 8 and 10) examines the stability of the outer original soil perimeter berm on the southeast corner of SW Section 16. The perimeter berm has a maximum elevation of approximately 1900 feet and extends at an approximate 3:1 slope down to a minimum elevation of 1878 feet. Scenario 4 is performed with CCP placement on the interior of the facility at final design cover grades.

Scenario 5 – SW Section 16 – Global

Scenario 5 (Figures 8 and 11) examines the global stability of the CCP materials within SW Section 16 when at the final design height. The global stability section analyzes the overall stability of a cross section through the entire facility that may include both historic and recently deposited CCP materials. For this scenario, a large zone of historic sludge deposition below the newer composite liner is modeled to reflect conservative conditions. Side slopes at approximately 4:1 slopes extend from an elevation of 1950 feet to 1982 feet. A 5% slope continues from 1982 feet to 2010 feet.

Scenario 6 – SW Section 16 – Geomembrane Interface

Scenario 6 (Figures 8 and 12) examines the stability of CCP materials along the geomembrane interface on the interior of the perimeter berm using final design cover grades.

Scenario 7 – Interior Bottom Ash / Sludge

Scenario 7 (Figures 13, 14, and 15) examines the upstream side of Ash Pond 92/SW Section 16 near the bottom ash/sludge material interface. Since heavy equipment is used during construction of the facility, interior slopes were analyzed at an intermediate sludge level elevation of 1938 feet with and without loading due to a Caterpillar low ground pressure (LGP) D6 Dozer. The Caterpillar LGP D6 has been recommended for grading CCP materials along the top of the facility.

2.2 Engineering Parameters

Golder has previously collected soil and material property information from CCS (Golder 2002). Material properties for each material used for the stability analysis of Ash Pond 92 and SW Section 16 are given in Table 1.

2.2.1 Existing Natural Soil

Existing Natural Soil properties were based on lab work performed by Golder on three Shelby tube samples taken from the SW Section 16 area. Seven samples were taken from the boreholes yielding an average dry unit weight of 99.1 pcf and an average moisture content of 25.7%. Values of 99 pcf for the dry unit weight and 26% for the moisture content were chosen resulting in a moist unit weight of approximately 125 pcf.

Two triaxial shear strength tests were performed from the Shelby tube samples. Test 1 has an effective cohesion of 590.4 psf and an effective friction angle of 24.3 degrees. Test 2 has an effective cohesion of 57.6 psf and an effective friction angle of 32.7 degrees. Based on these tests, a conservative strength envelope at or below the tested strength envelopes was developed with an effective cohesion of 57 psf and an effective friction angle of 30 degrees.

One hydraulic conductivity test was performed from a Shelby tube sample, and resulted in a saturated hydraulic conductivity of 3.9×10^{-7} cm/sec.

2.2.2 Clay Liner

Clay Liner inputs are based on field experience at the CCS CCP facilities, and published values for CL and CH type materials (NAVFAC 7.02).

Results of saturated hydraulic conductivity, dry unit weight, and moisture content from Shelby tube samples of clay liners constructed at CCS indicate a dry unit weight range between 91.9 and 103.8 pcf (99.5 pcf average), and a moisture content range between 18.6 and 27.7 % (22.8 % average). Using the average dry unit weight and moisture content, the moist unit weight is approximately 122 pcf.

Saturated hydraulic conductivity from site Shelby tube samples ranged between 1.8×10^{-8} and 8.3×10^{-8} cm/sec, with an average value of 3.8×10^{-8} cm/sec. Hydraulic conductivity for clay liner is specified in the North Dakota Department of Health regulations as 1×10^{-7} cm/sec or less. For analysis, the maximum allowable value of 1×10^{-7} cm/sec will be used.

Published values for effective cohesion of CH material suggest a value of 230 psf. Published values for effective cohesion of CL material suggest a value of 270 psf. Published values for effective friction angle of CH material suggest a value of 19 degrees. Published values for effective friction angle of CL material suggest a value of 28 degrees. For conservatism, the lower strength parameters for CH material were chosen for analyses.

2.2.3 Geosynthetics Interfaces

Geomembrane Interface inputs are based on lab work performed by Golder and published values. The interfaces of interest are a smooth HDPE against clay liner and smooth HDPE against sand for Ash Pond 92 and textured LLDPE against clay liner and textured LLDPE against bottom ash for SW Section 16.

A large direct shear interface friction test was performed between a 40 mil smooth HDPE liner and site specific clays representative of those used in liner construction. Results indicate a residual friction angle of 7.5 degrees and a residual adhesion intercept of approximately 190 psf for smooth HDPE against clay liner.

Golder lab experience for smooth HDPE against sand indicate a residual friction angle between 13.4 and 20 degrees (average of 16.7 degrees) and a residual adhesion intercept between 0 and 72 psf (average of 36 psf). Published values for interface friction between smooth HDPE and sand range between 17 and 28 degrees. A friction angle of 17 degrees with no adhesion intercept was chosen for use in engineering analysis.

Golder lab experience for textured LLDPE against clay/low permeability soil indicate a residual friction angle between 30.5 and 40 degrees (average of 35.4 degrees) and a residual adhesion intercept of approximately 0 psf. A friction angle of 35 degrees with no adhesion intercept was chosen for this interface.

Limited published values and lab experience for the textured LLDPE against sand (reflective of bottom ash) interface exists. Therefore, the interface friction angle of 35 degrees reflective of textured LLDPE against clay was chosen as a conservative estimate (interface friction is likely higher between bottom ash and textured LLDPE).

The hydraulic conductivities for HDPE and LLDPE liner were taken from the HELP program documentation as 2.0×10^{-13} cm/sec and 4.0×10^{-13} cm/sec, respectively (Schroeder et al. 1994).

2.2.4 Sand Layer

Sand Layer inputs were based on published values for SW and SP type materials (NAVFAC 7.02).

Published maximum dry unit weight values range between 100 and 130 pcf (115 pcf average) with optimum moisture contents between 9 and 21% (15% average). Assuming a construction specification of 95% maximum dry density and optimum moisture, the dry unit weight chosen is 109 pcf with a moisture content of 15%. This results in a moist unit weight value of approximately 125 pcf.

Published values for effective cohesion of SW and SP material suggest a value of 0 psf. Published values for effective friction angle of SW material suggest a value of 38 degrees. Published values for effective friction angle of SP material suggest a value of 37 degrees. For conservatism, the lower effective friction angle of the SP material was chosen for analyses.

The average hydraulic conductivity for SW/SP type material was taken from the HELP program documentation as 6.3×10^{-3} cm/sec (Schroeder et al. 1994).

2.2.5 Fly Ash

Fly Ash / Fly Ash Paste input parameters are based on lab work performed by Golder for a 75% solids paste mix.

Dry unit weights from lab strength testing ranged between 87.8 pcf and 94.5 pcf with an average value of 91.9 pcf; a value of 92 pcf was chosen. Moisture contents from the same testing ranged between 6.3% and 27.7% with an average value of 16%; a value of 16% was chosen. These values result in a moist unit weight of 107 pcf.

Consolidated undrained triaxial lab testing with pore pressure measurements were used to evaluate the strength of the fly ash. The effective cohesion at 28 days was 1613 psf and the effective friction angle was 32.9 degrees. The effective cohesion at 60 days was 1858 psf and the effective friction angle was 32.2 degrees. The more conservative 28 day strength envelope was chosen for use in the stability analysis.

Lab permeability testing on this material indicated an average hydraulic conductivity of 3.6×10^{-5} cm/sec.

2.2.6 Bottom Ash

Bottom Ash input parameters are based on lab and field work performed by Golder.

The dry unit weight for compacted bottom ash is based on 95% standard Proctor densities from lab testing which gives a value of approximately 81 pcf. The dry unit weight of sluiced bottom ash is 60 pcf. A value of 70 pcf was chosen for analysis. The moisture content from field sampling of drained and saturated bottom ash ranged between 12% and 61%. For unsaturated conditions, a moisture content of

18.5% was assumed. Using the lab measured specific gravity of bottom ash (2.60); the moisture content of bottom ash for saturated conditions was determined to be between 40% and 65% (average 52.5%). Bottom ash has average moist unit weight of 83 pcf and an average saturated unit weight of 107 pcf.

Lab direct shear strength testing of bottom ash indicated residual strength values of 463 psf and 40.3 degrees for effective cohesion and effective friction. Visual observations of the bottom ash material indicates little cohesion, therefore the effective cohesion was chosen as 50 psf and an effective friction value of 40 degrees was chosen for analysis.

Lab rigid wall permeability testing was performed on the bottom ash providing a hydraulic conductivity value range between 0.038 cm/sec (0 psi load) and 0.021 cm/sec (25 psi load). An average hydraulic conductivity value of 0.03 cm/sec was chosen.

2.2.7 FGD Sludge Waste

FGD sludge waste input parameters are based on published data, field testing, design calculations, and lab work performed by Golder between 2001 and 2010.

Six laboratory tests between 2002 and 2010 indicate an average specific gravity (G_s) of 2.7. Consolidation analyses indicate an average dry unit weight of 54 pcf at the end of FGD sludge deposition, and an average dry unit weight of approximately 60 pcf after closure. Field sampling of saturated FGD sludge deposits indicates dry unit weights between 27 and 49 pcf. Assuming the FGD sludge is fully saturated during the active life of the facility, the saturated unit weight ranges between approximately 80 pcf at initial deposition and during intermediate deposition and 100 pcf at final closure heights. Saturated unit weights are based on moisture contents as low as 65% after closure to more than 100% during deposition. A saturated unit weight of 80 pcf will be used for Scenario 3 (intermediate sludge level) and a saturated unit weight of 100 pcf will be used for all other scenarios.

Lab testing on this material indicates a hydraulic conductivity of 6.0×10^{-6} cm/sec after closure based on a void ratio of 2.0.

Consolidated undrained triaxial lab testing was used to evaluate the strength of FGD sludge. Testing was performed on two remolded samples and resulted in total stress friction angles of 11 and 16 degrees and cohesion intercepts between 360 and 480 psf, respectively for the two samples. For conservatism, a shear strength envelope was developed that approximates the lower strength sample results and has a maximum shear strength of 1,000 psf. The strength envelope chosen for use in stability analyses is also given in the following table.

Assumed Strength Envelope	
Normal Stress	Shear Strength
psf	psf
0	100
3,000	1,000
10,000	1,000

2.2.8 Mixed Waste

Mixed Waste is a combination of fly ash, bottom ash, FGD sludge, and soil in different ratios depending upon deposition and material availability. Inputs for this material are highly variable but have little effect on the facility slope stability.

For effective stress parameters, the natural soil has the lowest strength and its strength properties were chosen for modeling mixed waste in the stability analysis (cohesion of 57psf and friction angle of 30 degrees). The moist unit weight used for analysis was chosen to be 100 pcf. The hydraulic conductivity depends on how the waste was mixed and the direction of flow. The hydraulic conductivity used in analysis was 1.5×10^{-6} cm/sec.

2.2.9 Cover

Cover soil inputs are based on field experience at the Section 32 special waste landfill, and published values for CL, CH and OH type materials (NAVFAC 7.02). The cover consists of a 24-inch clay barrier layer, and a 28-inch clay protective layer overlain by 8 inches of topsoil.

Saturated hydraulic permeability, dry unit weight, and moisture content come from Shelby tube samples of the clay cover constructed at Section 32. The dry unit weight for clay used in analysis was 109 pcf, the moisture content was 17.5%, and the moist unit weight was 128 pcf. The protective clay will consist of the same materials used in the barrier layer but under a less stringent compaction and moisture specification. The dry unit weight for the barrier layer used in analysis was 89 pcf, the moisture content was 13%, and the moist unit weight was 100.5 pcf. The topsoil is likely to consist of organic clays which have published maximum dry unit weights of 65 to 100 pcf (82.5 pcf average) with optimum moisture contents between 21 and 45% (33% average). Assuming minimal compaction of 60% of maximum dry unit weight with moisture content around 21%, the moist unit weight is approximately 60 pcf.

Combining the three cover components, results in a moist unit weight of approximately 106 pcf, and a dry unit weight of approximately 96 pcf.

The hydraulic conductivity for the cover material will be controlled by the barrier layer and will be equated to the barrier layer permeability for analysis, which was chosen to be 1×10^{-7} cm/sec for analysis.

Published values for effective cohesion of CH material suggest a value of 230 psf. Published values for effective cohesion of CL material suggest a value of 270 psf. Published values for effective friction angle of CH material suggest a value of 19 degrees. Published values for effective friction angle of CL material suggest a value of 28 degrees. For conservatism, the lower strength parameters for CH material were chosen for analyses.

2.2.10 Pit Run

Pit Run is described as a silty sand and inputs were based on published values for SM type material (NAVFAC 7.02).

Published maximum dry unit weight values range between 110 and 125 pcf (117.5 pcf average), with optimum moisture contents between 11 and 16% (13.5% average). Assuming a construction specification of 95% maximum dry density and optimum moisture, the dry unit weight chosen is 112 pcf with a moisture content of 13.5%. This results in a moist unit weight value of approximately 127 pcf.

Strength parameters were based on the published values of 420 psf for effective cohesion and 34 degrees for effective friction angle.

The average hydraulic conductivity for SM type material was taken from the HELP program documentation as 9.9×10^{-4} cm/sec.

2.3 Groundwater Information

2.3.1 Ash Pond 92

SEEPW was used to model water in Ash Pond 92 (see Figure 3). The flow of water within the facility is controlled by the hydraulic conductivities of each of the materials, especially the conductivity of the bottom ash drainage layer. Water generally moves from the sludge in the center of the facility toward drainage pipes (approximate elevations between 1908 feet and 1918 feet) in the bottom ash above the liner, and is eventually transferred to Ash Pond 91. After modeling was performed in SEEPW, the water table was applied to the stability section constructed in SLIDE, a two-dimensional finite elements groundwater modeling and slope stability computer program developed by Rocscience Inc. (2010).

In addition to modeling, five piezometers were installed in 2004 to monitor the presence of water in the outer slopes of Ash Pond 92/SW Section 16 (see Appendix B for piezometer locations and water levels since 2006). The bottom of each of the five piezometers was installed into the bottom ash drainage layer to determine whether the drainage layer is effectively conveying water from Ash Pond 92 to Ash Pond 91. Piezometers 1 through 4 show nearly steady water levels at an elevation of approximately 1918 feet while the water level in the center of the facility has increased in height from 1927 feet to 1947 feet, an indication the drainage system appears to be functioning properly. Surrounding site groundwater wells were used to estimate the slope and elevation of the groundwater below Ash Pond 92. From the wells groundwater generally flows to the north and northeast below Ash Pond 92 and is at an approximate elevation of 1880 feet.

2.3.2 SW Section 16

The phreatic surface used in the analysis of SW Section 16 was based on the groundwater analysis of SW Section 16 using the modeling tools within SLIDE (Figure 9). The FGD material within the facility is assumed to remain saturated at facility closure. Therefore, the water table is assumed to follow the elevation of the top of the FGD material. The analysis also assumes water within the facility is controlled by the drainage system (bottom ash and piping) and is conveyed toward Ash Pond 92. As a result, the majority of the bottom ash is expected to remain unsaturated at closure, with water levels decreasing to an elevation near the top of the low permeability soil cutoff layer. The water table beneath the facility has an assumed elevation of approximately 1876 feet.

Piezometer 5 installed near the southwest corner of SW Section 16 has a water level that has fluctuated between an elevation of 1923 feet and 1928 feet over the past 4 years. This fluctuation is representative of the phased construction and sludge pool development over SW Section 16 as well as the variability in downstream pond elevations which are hydraulically connected to SW Section 16. The measured piezometers levels are well below the sludge pool elevation (1927 to 1947 feet) indicating the drainage system is functioning.

Surrounding site groundwater wells were used to estimate the slope and elevation of the groundwater below SW Section 16. From the wells groundwater generally flows north and northeast below SW Section 16 and is at an approximate elevation of 1875 feet.

2.3.3 Interior Slopes

Golder performed a groundwater analysis of the interior of the facility using the groundwater modeling tools within SLIDE (Figure 13). Water within the facility is controlled by the drainage system (bottom ash and piping) and water drains from the sludge in the center of the facility toward the bottom ash drainage layer and piping to the perimeter of the facility.

2.4 Stability Analysis

Golder performed stability analyses using SLIDE. Factors of safety were computed for circular and noncircular failure surfaces using Spencer's method for force and moment equilibrium. Scenarios 1 and 4 were analyzed using circular failure surfaces as the slip surface was assumed to cut through a homogeneous section of the exterior perimeter berm. Scenarios 6 and 7 were also analyzed with circular failure surfaces as there was no evidence of a preferentially weak layer. Scenarios 2, 3, and 5 were evaluated using noncircular failure surfaces to analyze the weak interface between the clay liner and geomembrane. A summary of factors of safety calculated for each scenario are provided in the following table:

FACTORS OF SAFETY FOR EACH SCENARIO

Scenario	Description		Factor of Safety	Figure - Stability Analysis Results
1	Ash Pond 92 – Perimeter Berm		**1.9**	4
2	Ash Pond 92 – Geomembrane Interface		**1.4**	5
3	Ash Pond 92 – Intermediate Sludge Level		**1.6**	7
4	SW Section 16 – Perimeter Berm		**1.9**	10
5	SW Section 16 – Global		**2.0**	11
6	SW Section 16 – Geomembrane Interface		**3.4**	12
7	Ash Pond 92 Interior Bottom Ash / Sludge	No Equipment	**1.7**	14
		Equipment Loading	**1.3**	15

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 except scenarios 2 and 7 have a factor of safety greater than or equal to 1.5 and are expected to remain stable under the anticipated loading conditions.

Scenario 2 combines both a long-term and temporary condition and is expected to remain stable under the anticipated loading conditions with the estimated factor of safety of 1.4. The full design height with final cover is reflective of long-term conditions, but the location of the piezometric surface within the facility and the density/strength of the FGD sludge are conservative temporary conditions. At the end of wet deposition (when FGD sludge extends to an elevation of 1968), the facility will be converted to a dry landfill through the pumping of water from the liner head reduction system, and the placement of a cap material to promote consolidation and drainage of the FGD sludge material. The net impact of these activities will be to lower the piezometric surface and increase the density/strength of the FGD sludge; increasing the factor of safety against slope movement.

For temporary conditions, a factor of safety greater than or equal to 1.3 is desired. Scenario 7 is a temporary condition with a factor of safety equal to 1.3 and is expected to remain stable under the anticipated loading conditions.

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 Ash Pond 92/SW Section 16 were performed on September 25, 2009 by Craig Schuettpelz and November 2, 2009 by Todd Stong. Golder observed the condition of inflow and outflow structures (if applicable), upstream berm slopes, the berm crest, downstream berm slopes, and the berm toe. Inspection checklist logs are included in Appendix C and photographs taken during the visual observations are included in Appendix D.

3.2.1 Inflow and Outflow Structures

Ash Pond 92/SW Section 16 has an inflow pipe for depositing FGD sludge. The HDPE pipe is 8-inches in diameter and is periodically moved to different areas of Ash Pond 92/SW Section 16 to achieve an even distribution of FGD sludge in the facility. Bottom ash and fly ash are transferred to Ash Pond 92 with large haul trucks where the materials are deposited and spread out over the perimeter of the facility.

The outflows from Ash Pond 92/SW Section 16 consist of a series of gravity drainage pipes that transfer water from Ash Pond 92 to Ash Pond 91. Over time, these pipes can become clogged with material and new pipes are installed to convey water between the facilities. The inflow and outflow systems appear to be in good condition with no sign of settlement, cracking, or corrosion.

3.2.2 Upstream Slope

The upstream slope of Ash Pond 92/SW Section 16 is constantly changing as bottom ash and FGD sludge are deposited. Therefore, the upstream slopes are temporary and dependent on the angle of repose of the bottom ash material. The vertical distance from the top of the upstream slope to the water/FGD sludge mixture in the center of Ash Pond 92 is approximately 7 to 10 feet in most locations. The upstream slopes are generally in good condition.

3.2.3 Crest

The crest of the perimeter berm surrounding the facility (elevation approximately 1920 feet) is a gravel paved road that was in generally good condition. The road was well-compacted and experiences frequent heavy traffic. The visual inspections did not reveal signs of cracking, erosion, or settlement.

SW Section 16 has an additional crest at about 1950 that marks the approximate elevation of the expansion berm surrounding the facility during historic CCP disposal. The crest at 1950 feet was in generally good condition and was covered with tall grass and cover soil at the time of the visual inspections.

The crest along the top of the facility is constructed mainly of bottom ash. The bottom ash crest is bordered on the outsides of the facility by a fly ash “shell.” Bottom ash on the crest of the facility is in good condition and is continually worked and compacted with heavy equipment. During both inspections, cracks were noted on the surface of the bottom ash along the west and north sides of Ash Pond 92. In each case, the cracks were approximately 1 to 2 inches wide and between 50 and 100 feet long. The cracks may be a result of consolidation of sludge on the interior of the facility or thawing of frozen bottom ash material placed below the current bottom ash layer. Minor settlement and cracking of the bottom ash layer is expected based on the facility geometry (bottom ash placed over FGD sludge), but should be monitored to evaluate the rate of progression and whether a different stability condition exists. In addition to monitoring of the cracks, careful trafficking of heavy equipment over these areas and monitoring of piezometers should be continued. The crest of the facility is in fair condition.

3.2.4 Downstream Slope

The downstream slopes of Ash Pond 92/SW Section 16 below the original and expansion berms are covered with tall grass. There is no noticeable significant erosion, cracks, or scarps on these grassy slopes and they appear to be in good condition.

The area above the original and expansion berms surrounding Ash Pond 92/SW Section 16 had an exposed fly ash "shell" at the time of the inspections. The fly ash exterior is in good condition and there was no noticeable seepage, cracks, or settlement during the inspections. Golder did not observe indications of seepage, sloughing, cracking, significant erosion, excessive settlement, or vegetation that seemed to be thriving abnormally. The downstream slopes are generally in good condition.

3.2.5 Toe

The toe of the slopes on the north and south sides of Ash Pond 92/SW Section 16 are mostly covered with tall grass. A few small animal burrows were noticed during the inspection, but there were no noticeable signs of seepage, cracks, or settlement. The toe of slope off of the southwest side of Ash Pond 92/SW Section 16 has some marshy vegetation; however, there was no standing water in this area at the time of observations and the drainage zones surrounding the facility appeared to be in good condition.

The east and west sides of Ash Pond 92/SW Section 16 do not have a "toe of slope." Ash Pond 91 is west of the facility and the plant dry CCP landfill lies east of the facility. These slopes did not appear to be experiencing cracking or settlement and appeared to be in good condition at the time of the inspections.

The fly ash "shell" has a ditch surrounding the sides of Ash Pond 92/SW Section 16 at the toe. The toe of slope was mainly wet and there were no noticeable signs of excessive seepage into this ditch. The toe of the fly ash slope surrounding the southwest side of Ash Pond 92 contained some standing water at the time of inspection, but there was no noticeable seepage. Water in this portion of the toe was approximately 1 or 2 inches deep at the time of inspection and is controlled by the drainage system (piping and bottom ash) in the interior of the facility. The toe of slope was generally in good condition at the time of inspection.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This report summarizes impoundment stability information for Ash Pond 92/SW Section 16 at Great River Energy's Coal Creek Station. The report presents background information of the facility, results of a slope stability analysis performed using the computer program SLIDE, and the outcomes of visual inspections of the facility conducted on September 25, 2009 and November 2, 2009.

Ash Pond 92/SW Section 16 is used for storage of fly ash, bottom ash, and FGD sludge. Historically, the facility had a maximum perimeter berm elevation of approximately 1920 feet. Since original construction, the facilities have been converted into a vertically expanding storage area for CCPs. The most critical exterior slope appeared to be the slope through CCPs in Ash Pond 92 where the factor of safety is 1.4 and the slip surface progresses along the geomembrane/clay liner interface. Results indicate the facility should remain stable for this temporary condition, but that continued monitoring of groundwater and operations in and around the facility are important for safe operations. In addition, Golder performed several other slope stability analyses to examine the different geometries of the facility. In each analysis, the facility was stable, although additional analyses are recommended if conditions change.

Golder observed generally good vegetation and site maintenance and did not identify significant deficiencies such as significant seepage, settlement, or cracking during visual observations of Ash Pond 92/SW Section 16. The crest of the facility is in fair condition due to cracks noticed in the bottom ash on the crest of the facility that were likely due to sludge consolidation and/or thawing of frozen placed bottom ash. Overall, Ash Pond 92/SW Section 16 is in good condition.

Golder recommends that CCS continue to perform monthly observations of Ash Pond 92/SW Section 16. In addition, CCS should pay particularly attention to the crest of the slopes when performing grading of the vertically expanding facility. The crest and slopes should be evaluated for deterioration and cracking on a periodic basis and the drainage system should be monitored to ensure proper conveyance of water during and after closure. Golder recommends that CCS continue to monitor the piezometers installed on the north and south sides of the facility as a way to monitor the drainage system. Additional conditions to watch include seepage, sloughing, cracking, excessive settlement, extensive animal burrowing, excessive erosion, and abnormally thriving of vegetation.

GOLDER ASSOCIATES INC.

Ron Jorgenson Principal	Todd Stong, P.E. Senior Project Engineer	Craig Schuettpelz Geological Engineer

5.0 REFERENCES

Barr Engineering Company. (February 1982). *Seepage and Stability Analysis*, Prepared for Cooperative Power Association.

Cooperative Power and United Power Association. (1989). *Application to Renew Permit to Operate a Special Use Disposal Site, Coal Creek Station, Permit Number SU-033*. Prepared for the North Dakota State Department of Health and Consolidated Laboratories.

Eugene A. Hickok & Associates. (July 1986). *Evaluation of Pond Bottom Conditions Southwest and West Portions of the East Ash Pond: Coal Creek Station*, Prepared for Cooperative Power Association.

Foth & Van Dyke. (March 1988). *Liner Evaluation South Ash Pond and East Ash Pond*, Prepared for Cooperative Power Association and United Power Association.

Foundations and Earth Structures, Design Manual 7.02, Naval Facilities Engineering Command, September 1996 (NAVFAC 7.02)

Golder Associates Inc. (2002). *Material Properties, Permit Number SP-033*, Job Ref. 023-2409. Prepared for Great River Energy.

Rocscience Inc. 2009. SLIDE Version 5.043.

Schroeder, P.R., Aziz, N.M., Lloyd, C.M., and Zappi, P.A. (1994). *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*, EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

TABLES

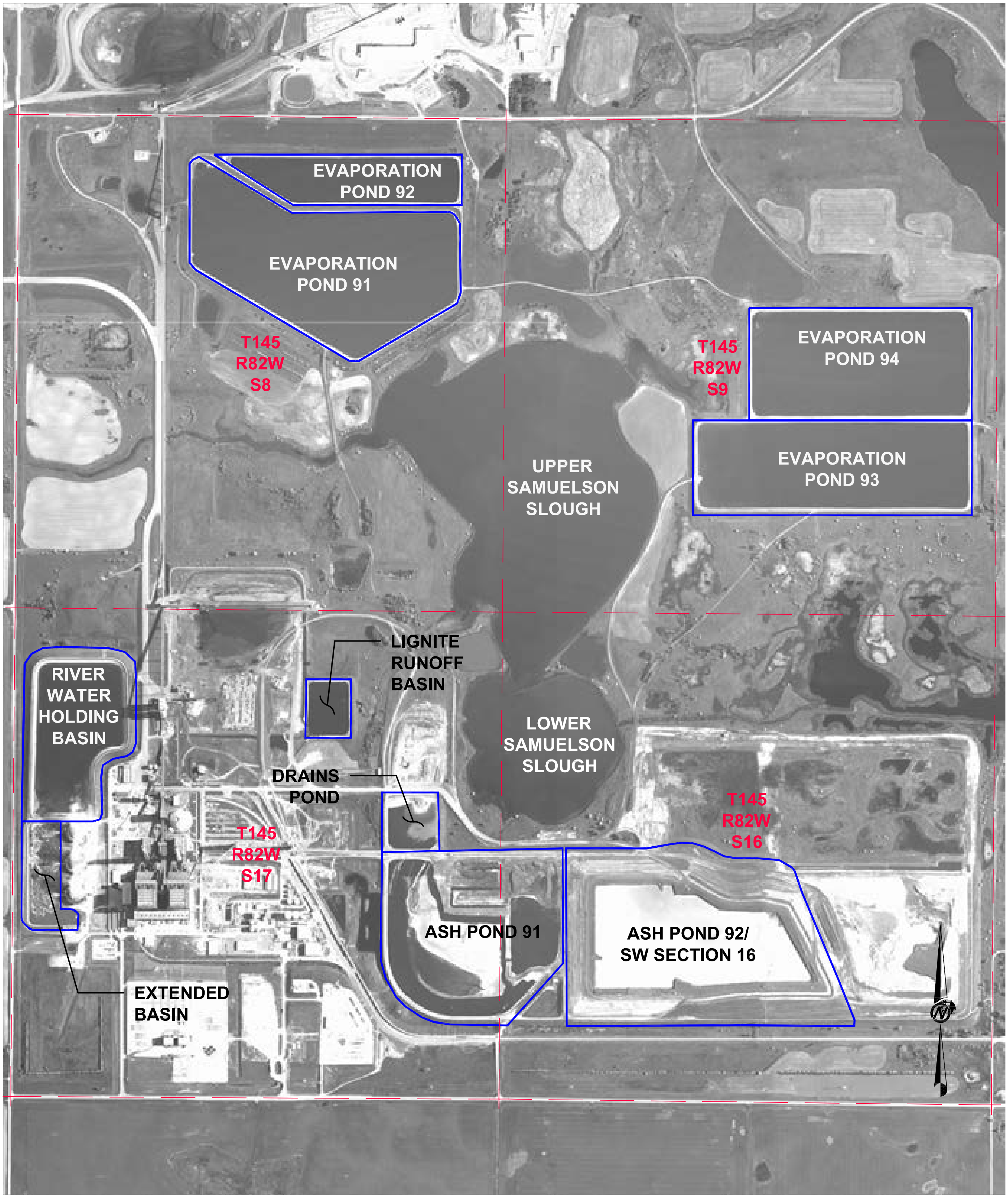
TABLE 1

MATERIAL PROPERTIES SUMMARY TABLE

	Hydraulic Conductivity		Moisture / Density					Shear Strength	
	k_{sat}		γ_{dry}	ω	γ_{wet}	ω (sat)	γ_{sat}	ϕ/δ	c/a
	cm/sec	ft/sec	pcf	%	pcf	%	pcf	degrees	psf
Existing Natural Soil	3.9E-07	1.3E-08	99	26.0	125	NA	NA	30	57
Clay Liner	1.0E-07	3.3E-09	99.5	22.8	122	NA	NA	19	230
Smooth HDPE / Clay	2.0E-13	6.6E-15	NA	NA	NA	NA	NA	7.5	190
Smooth HDPE / Sand	2.0E-13	6.6E-15	NA	NA	NA	NA	NA	17	0
Tex. LLDPE / Clay	4.0E-13	1.3E-14	NA	NA	NA	NA	NA	35	0
Tex. LLDPE / Sand	4.0E-13	1.3E-14	NA	NA	NA	NA	NA	35	0
Sand	6.3E-03	2.1E-04	109	15	125	NA	NA	37	0
Fly Ash	3.6E-05	1.2E-06	92	16	107	NA	NA	32.9	1613
Bottom Ash	3.0E-02	9.8E-04	70	18.5	83	52.5	107	40	50
FGD Sludge	6.0E-06	2.0E-07	NA	NA	NA	Varies	80 - 100	*	*
Mixed Waste	1.5E-06	4.9E-08	NA	NA	100	NA	NA	30	57
Cover Soil	1.0E-07	3.3E-09	96	NA	106	NA	NA	19	230
Pit Run	9.9E-04	3.3E-05	112	13.5	127	NA	NA	34	420

*See Section 2.2.7 (Sludge Waste)

FIGURES



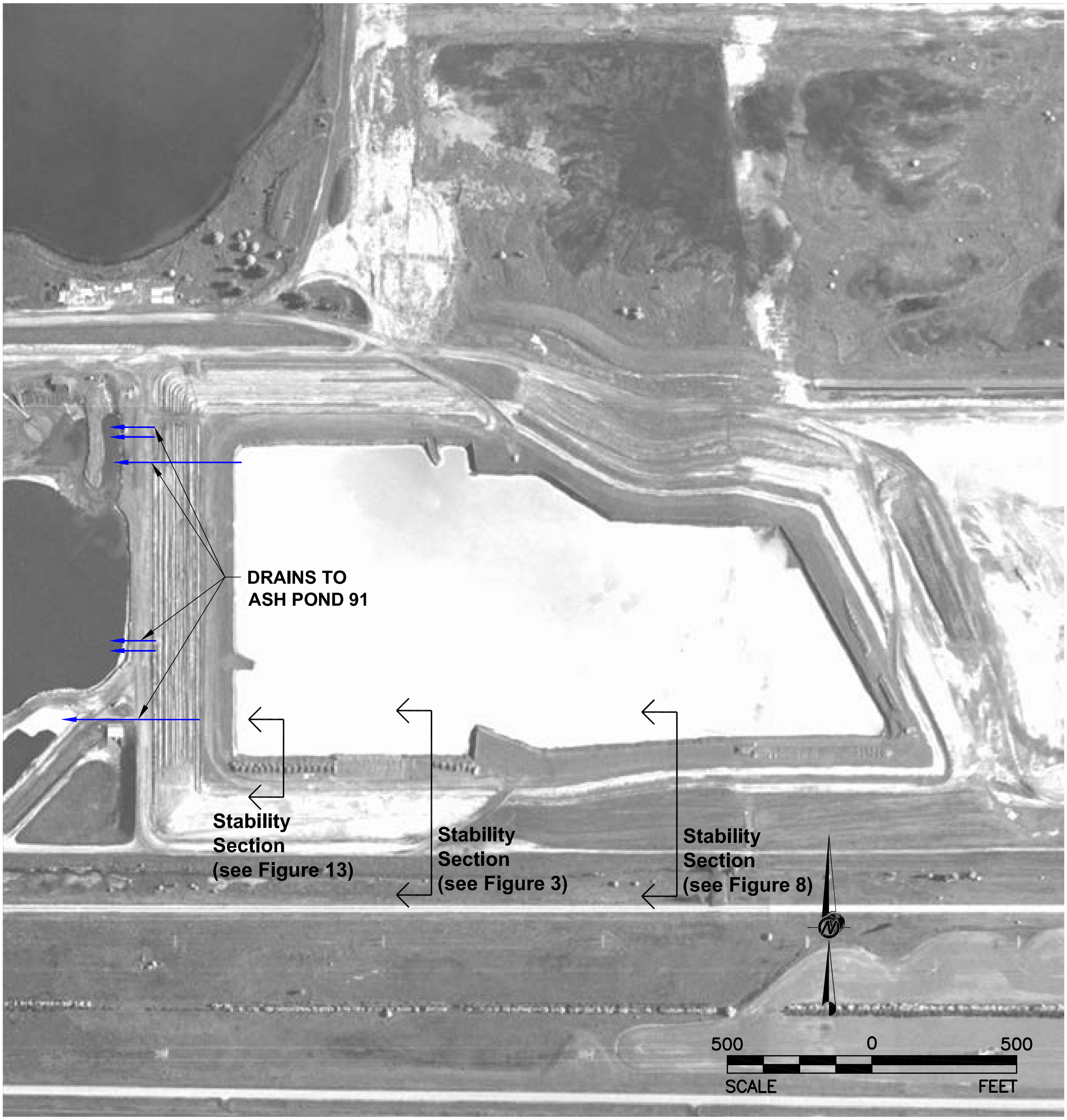
Aerial image from GRE taken June 24, 2010

COAL CREEK STATION POND LAYOUT

Golder Associates
DENVER, COLORADO

FIGURE 1

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg



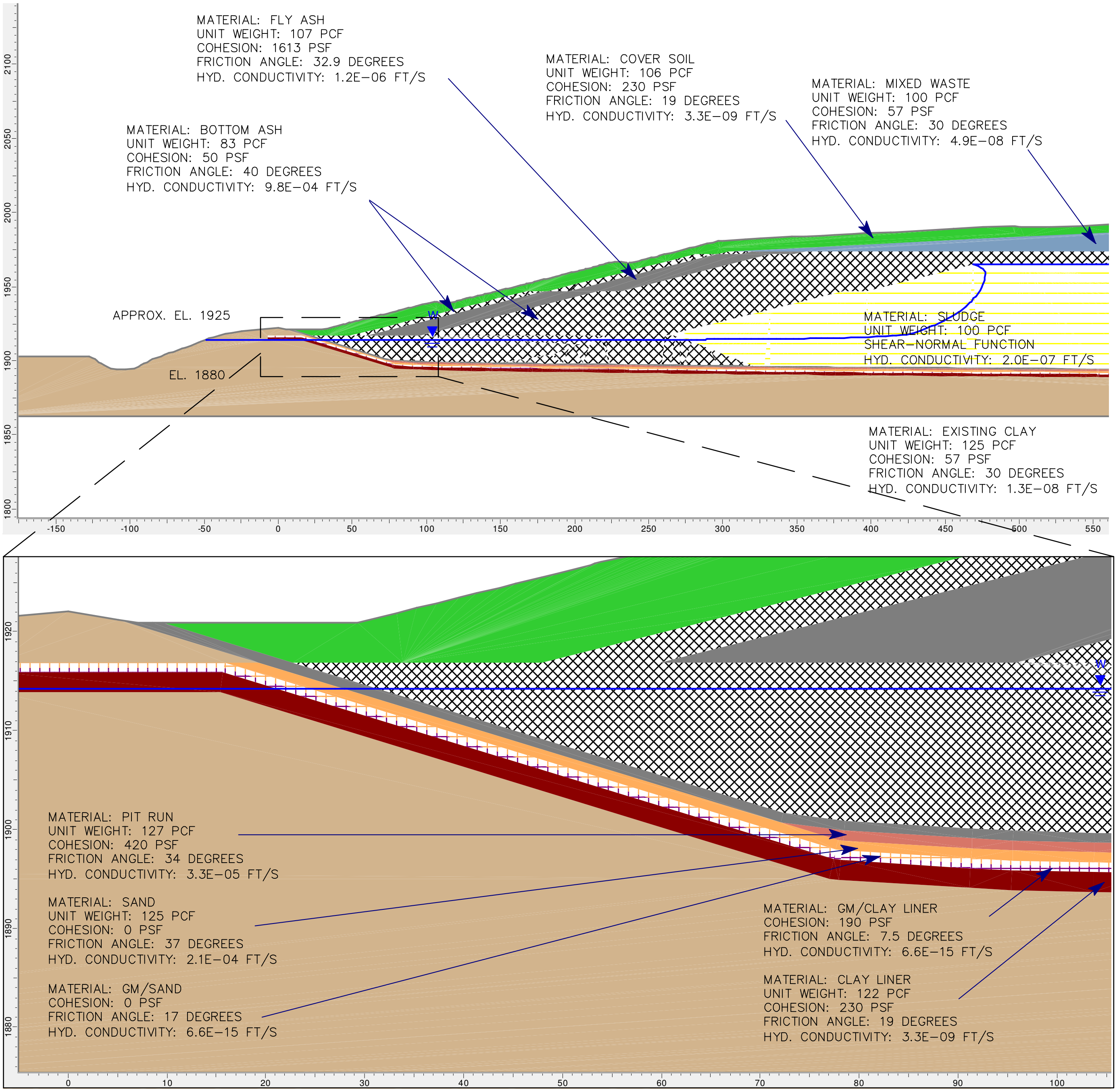
Aerial image from GRE taken June 24, 2010

Golder Associates
DENVER, COLORADO

ASH POND 92 / SW SECTION 16 LAYOUT

FIGURE 2

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg



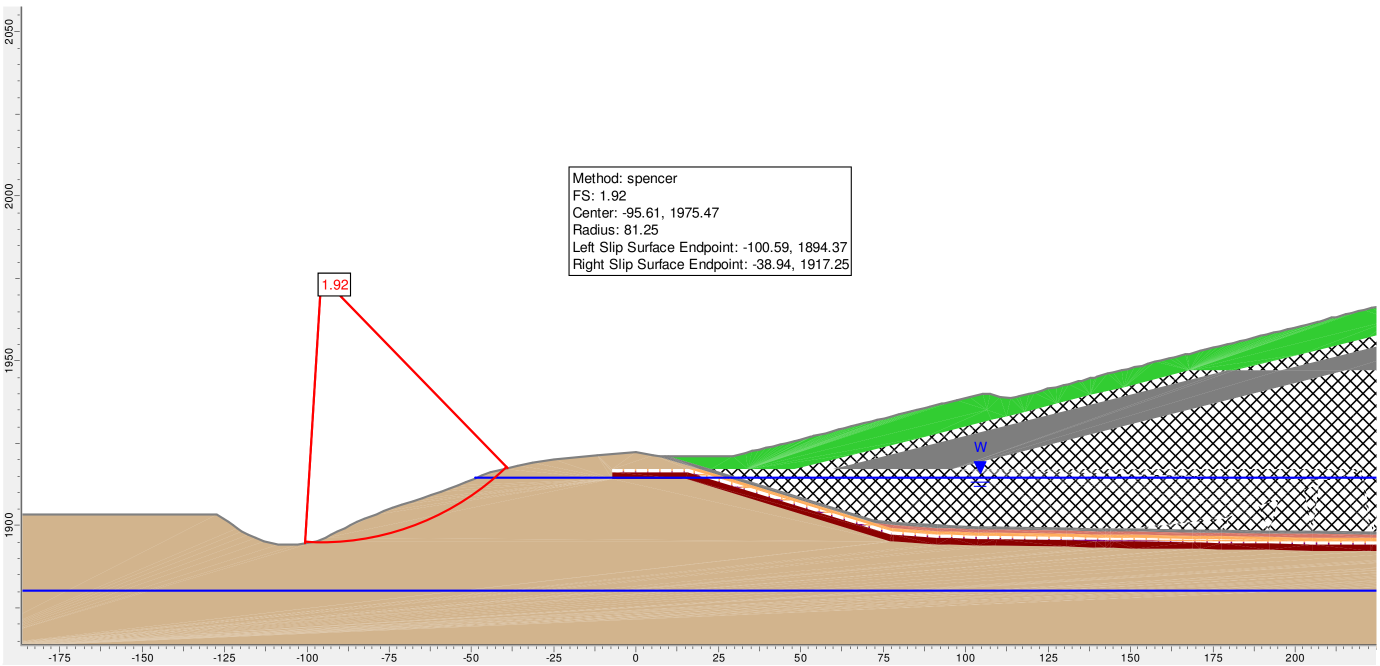
SCRUBBER MATERIAL SHEAR-NORMAL FUNCTION

Normal Stress (psf)	Shear Strength (psf)
0	100
3,000	1,000
10,000	1,000

ASH POND 92 CROSS SECTION

FIGURE 3

Golder Associates
DENVER, COLORADO

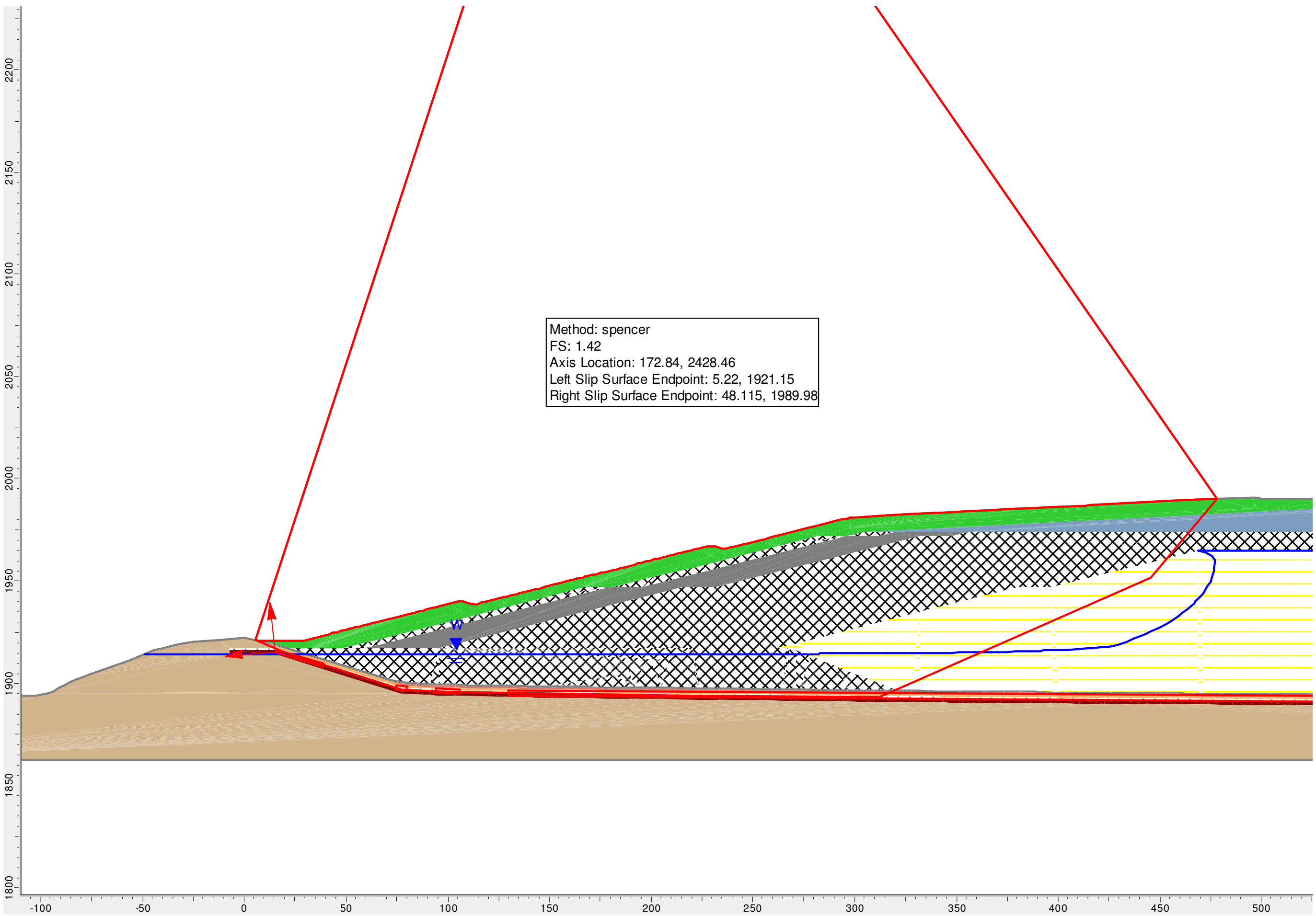


SCENARIO 1
ASH POND 92 - PERIMETER BERM STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 4

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

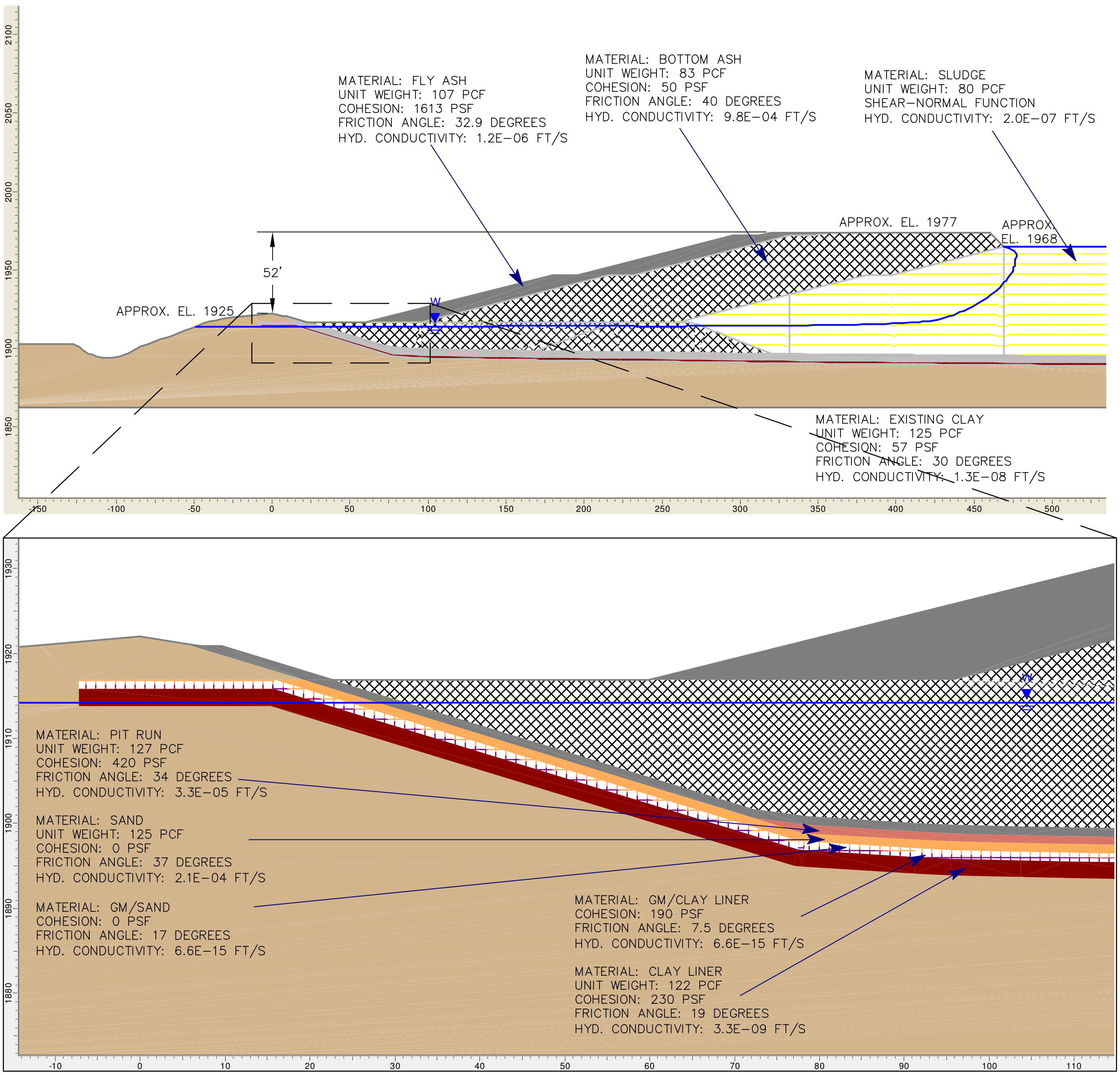


SCENARIO 2
ASH POND 92 - GEOMEMBRANE INTERFACE STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 5

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg



SCRUBBER MATERIAL SHEAR-NORMAL FUNCTION

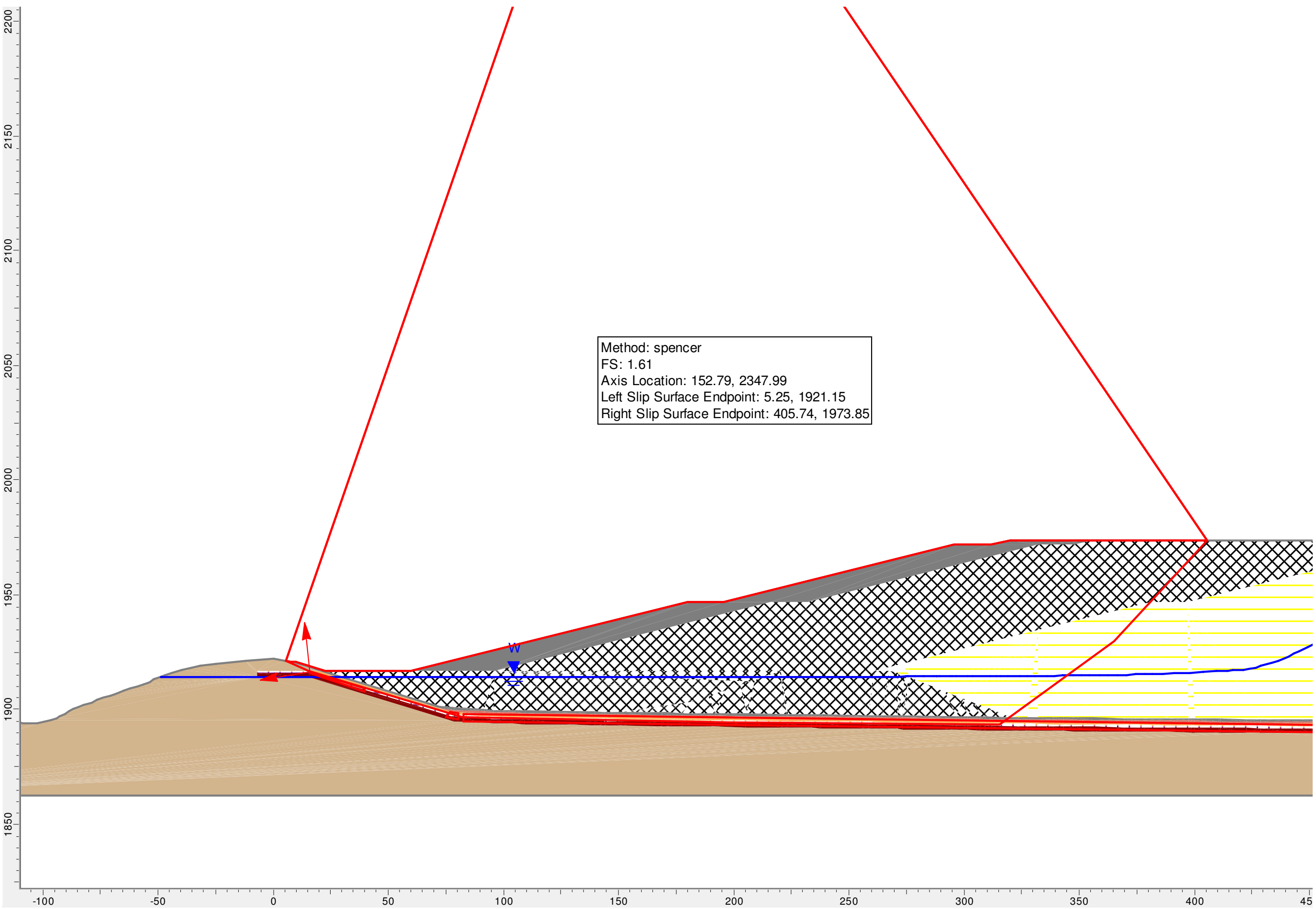
Normal Stress (psf)	Shear Strength (psf)
0	100
3,000	1,000
10,000	1,000

ASH POND 92 - INTERMEDIATE SLUDGE LEVEL CROSS SECTION

Golder Associates
DENVER, COLORADO

FIGURE 6

PROJECT No.103−81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

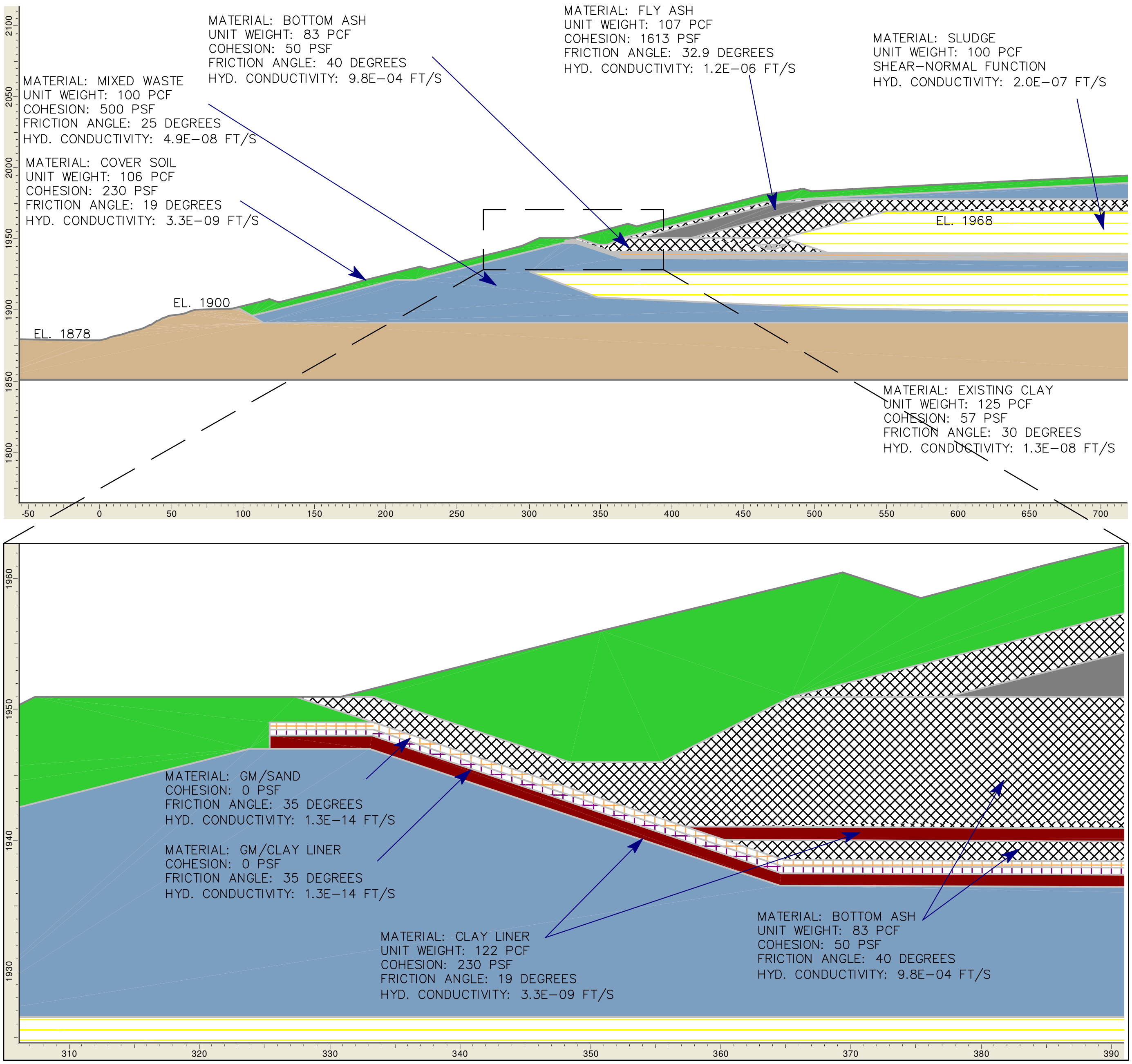


SCENARIO 3
ASH POND 92 - INTERMEDIATE SLUDGE LEVEL STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 7

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg



SCRUBBER MATERIAL SHEAR-NORMAL FUNCTION

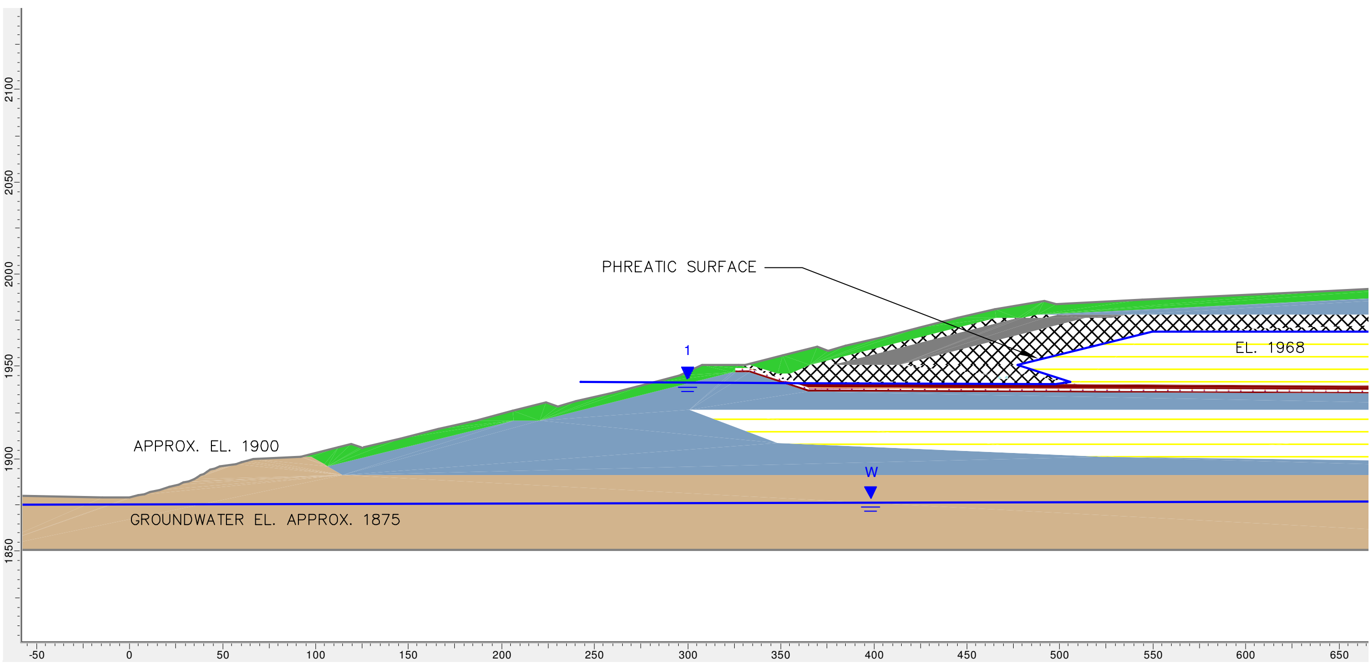
Normal Stress (psf)	Shear Strength (psf)
0	100
3,000	1,000
10,000	1,000

SW SECTION 16 CROSS SECTION

Golder Associates
DENVER, COLORADO

FIGURE 8

PROJECT No.103−81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

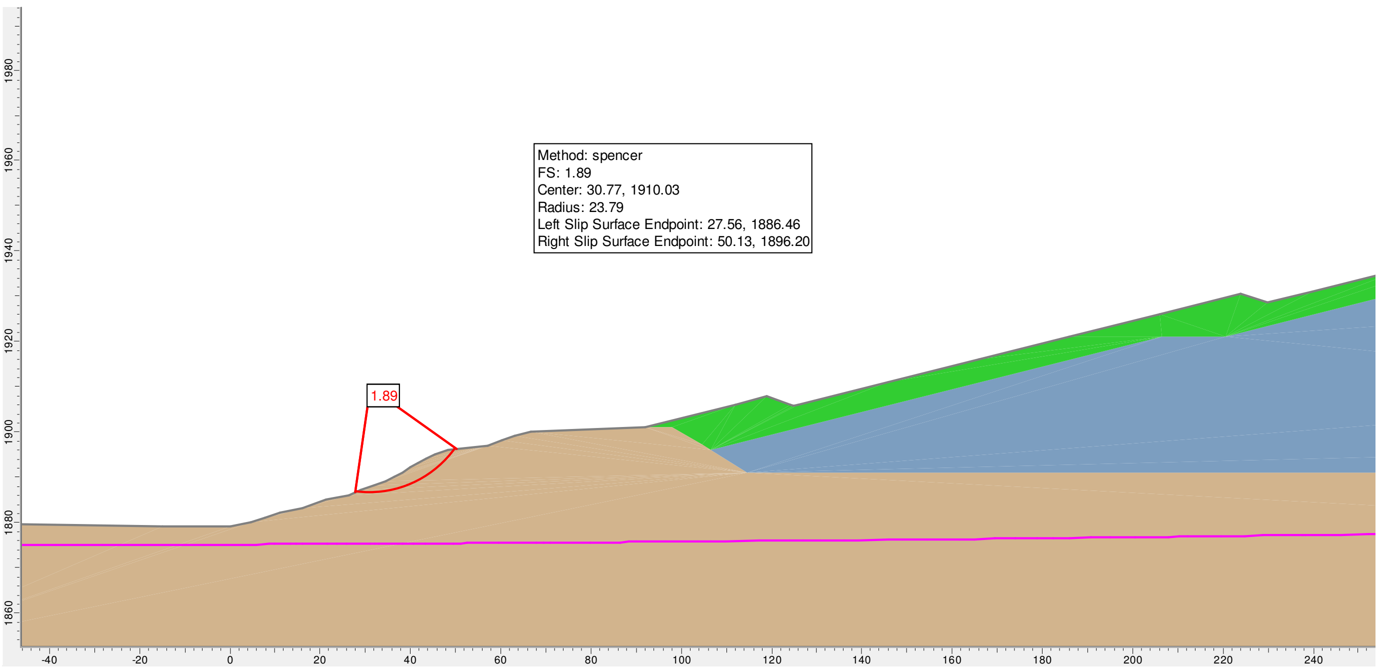


SW SECTION 16
GROUNDWATER ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 9

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

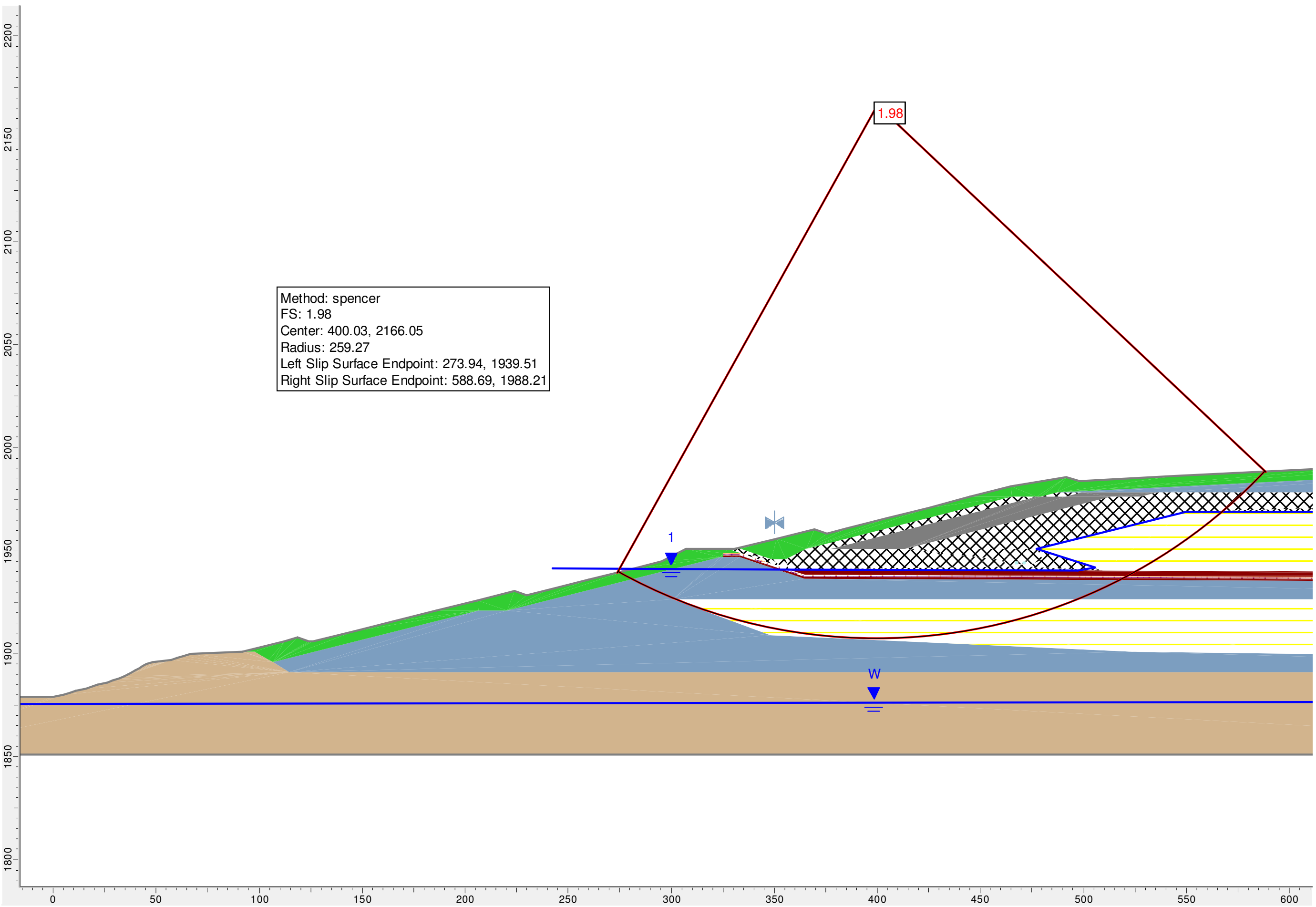


SCENARIO 4
SW SECTION 16 - PERIMETER BERM
STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 10

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

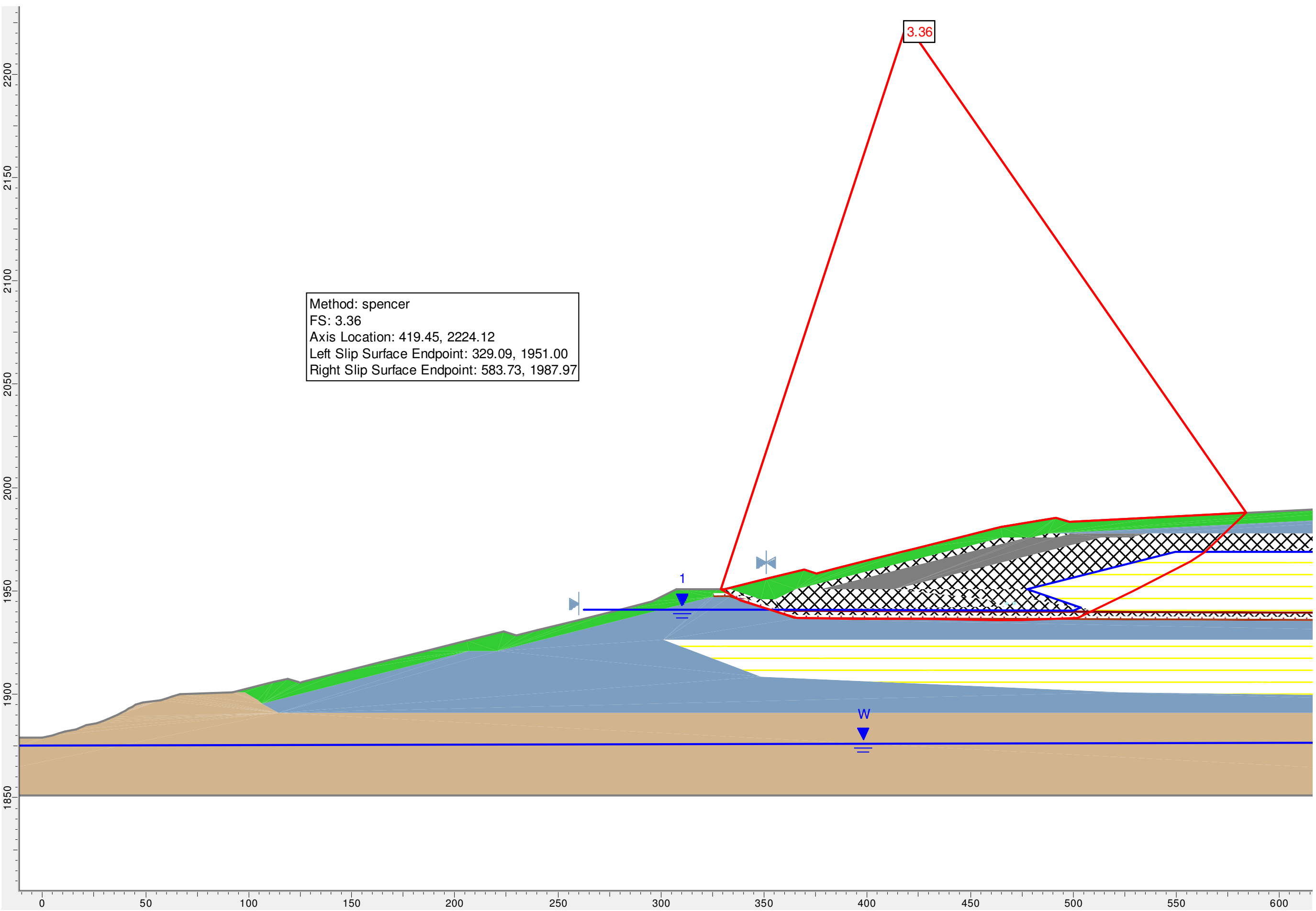


SCENARIO 5
SW SECTION 16 - GLOBAL STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 11

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

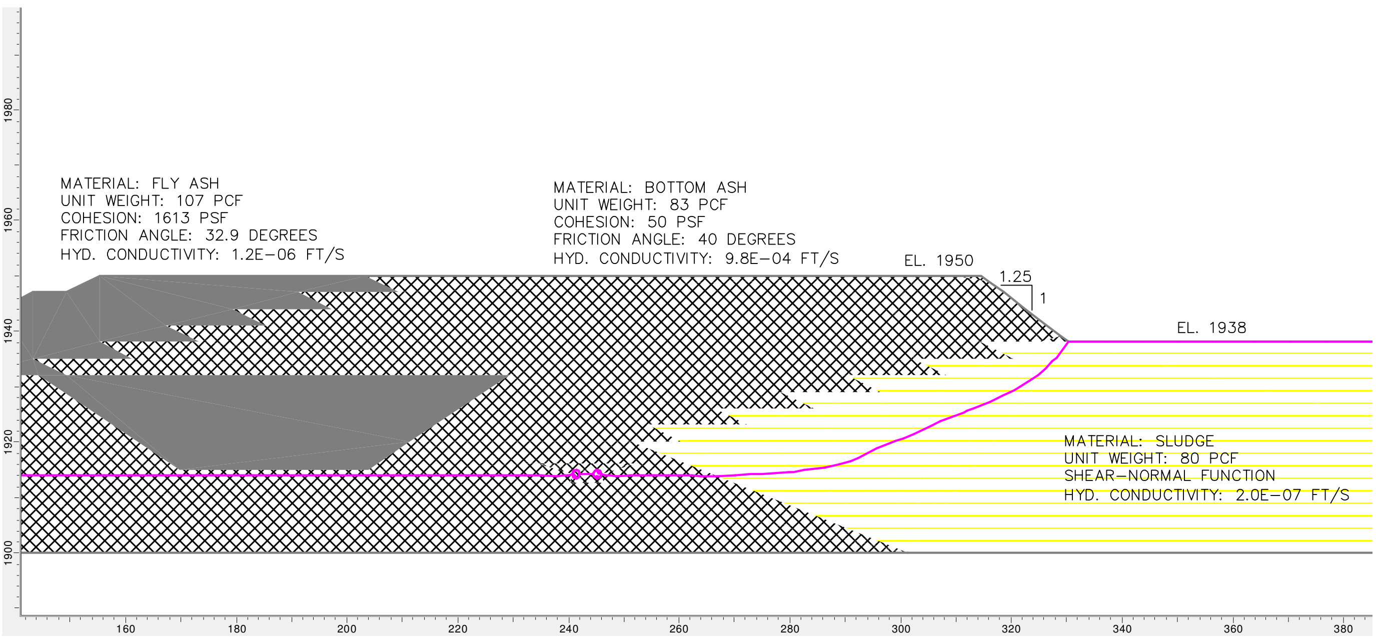


SCENARIO 6
SW SECTION 16 - GEOMEMBRANE INTERFACE STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 12

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg



SCRUBBER MATERIAL SHEAR-NORMAL FUNCTION

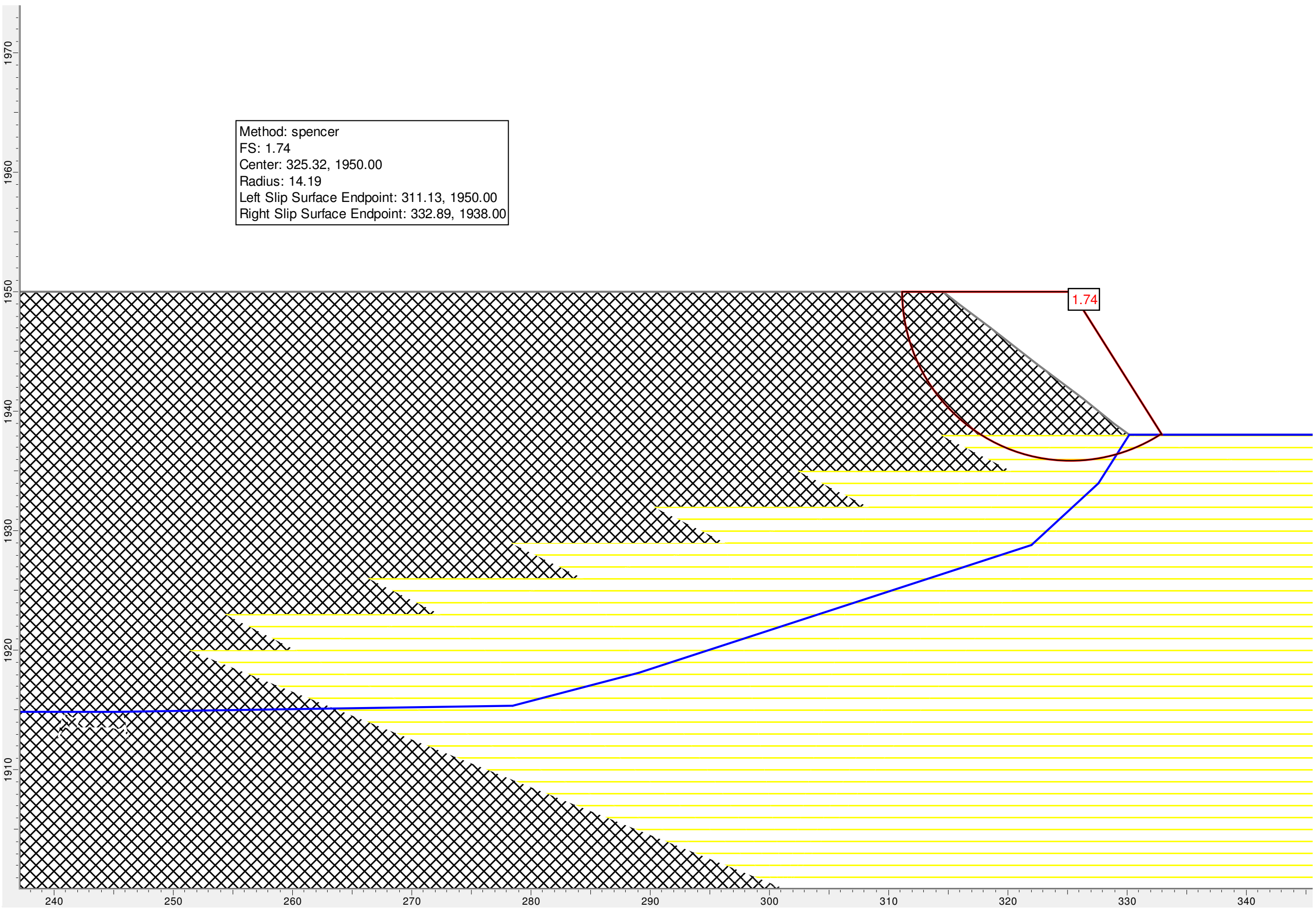
Normal Stress (psf)	Shear Strength (psf)
0	100
3,000	1,000
10,000	1,000

ASH POND 92 INTERIOR BOTTOM ASH / SLUDGE CROSS SECTION

Golder Associates
DENVER, COLORADO

FIGURE 13

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

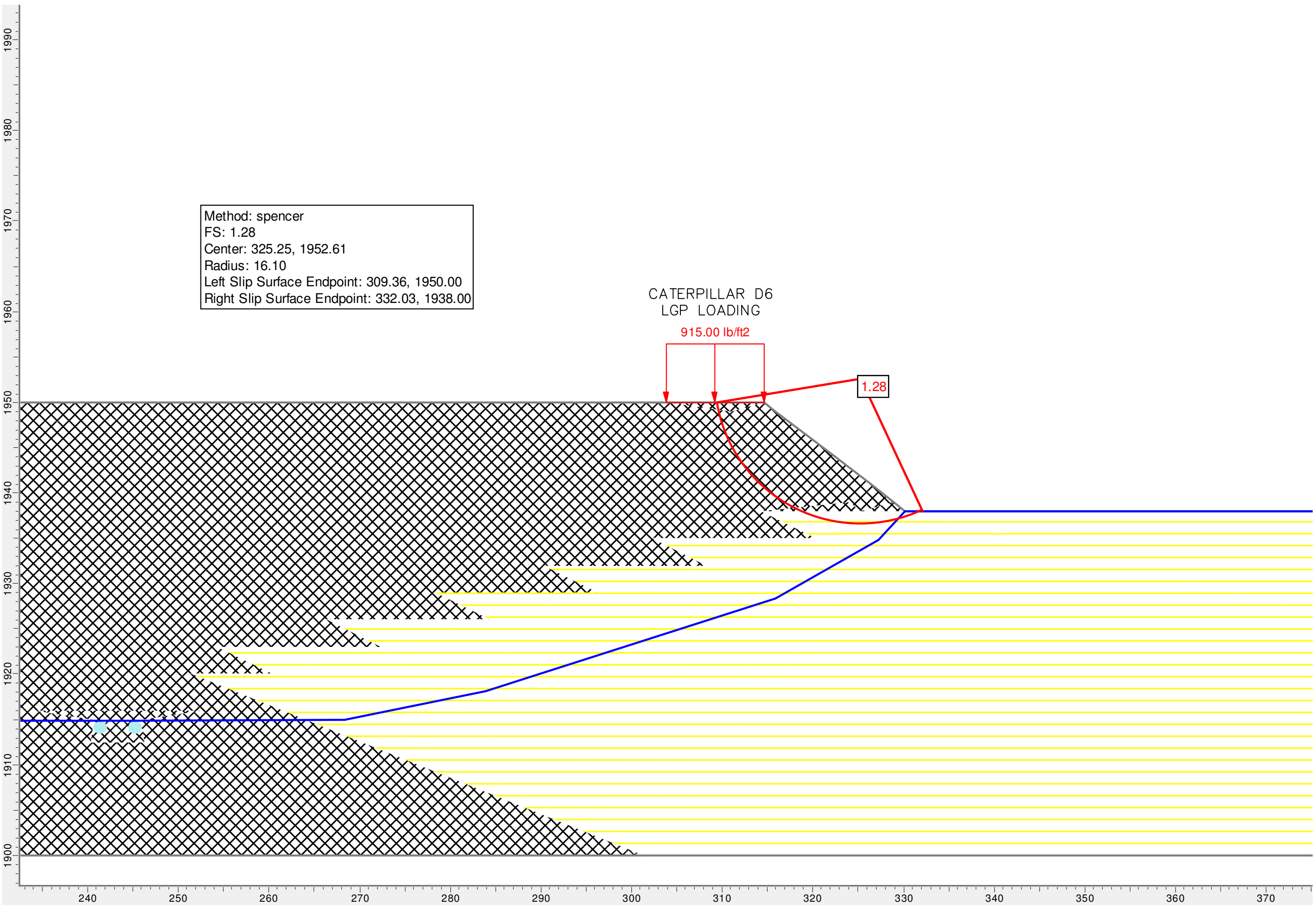


SCENARIO 7
ASH POND 92 INTERIOR BOTTOM ASH / SLUDGE STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 14

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg



SCENARIO 7
ASH POND 92 INTERIOR BOTTOM ASH / SLUDGE EQUIPMENT LOADING STABILITY ANALYSIS RESULTS

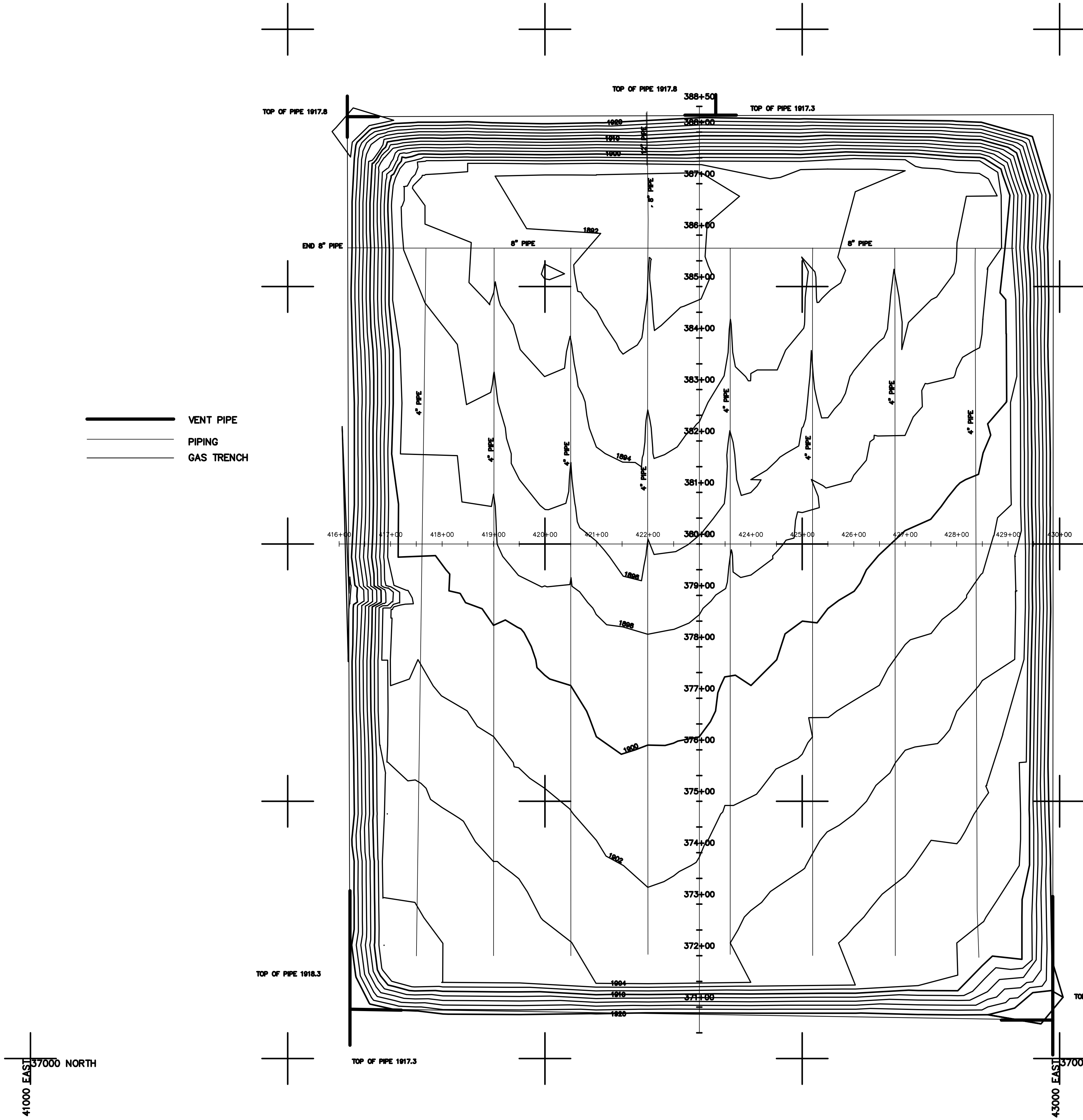
Golder Associates
DENVER, COLORADO

FIGURE 15

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figure ASH POND 92_December.dwg

APPENDIX A

ORIGINAL CONSTRUCTION DRAWINGS,
SITE TOPOGRAPHY,
AND
SW SECTION 16 REGRADE



COAL CREEK STATION

EAST HALF SOUTH ASH POND

FINISHED GRADES

AND PIPING

UNDERWOOD, NORTH DAKOTA

GRID

GRAPHIC SCALE

100 0 50 100 200 400

(IN FEET)
1 inch = 100 ft.

THIS DRAWING PREPARED JANUARY 26, 1990
FROM INFORMATION COMPLETED ON DECEMBER 20, 1989

NOTES
1. SITE LOCATION SW 1/4 SECTION 16
T. 145 N., R. 82 W., McLEAN COUNTY, NORTH DAKOTA.
2. TOPOGRAPHY IS BASED ON AN ACTUAL SURVEY OF THE GROUNDS.
3. ELEVATIONS ARE BASED ON SEA LEVEL DATUM.
4. HORIZONTAL DATUM IS BASED ON NORTH DAKOTA STATE PLANE COORDINATES SYSTEM AS FOLLOWS:
SITE GRID NORTH = NORTH STATE PLANE COORDINATES MINUS 1000,000.
SITE GRID EAST = EAST STATE PLANE COORDINATES MINUS 1,800,000.

SURVEYOR'S CERTIFICATE

I, LARRY J. SMITH, A REGISTERED LAND SURVEYOR IN THE STATE OF NORTH DAKOTA, HEREBY CERTIFY THAT THE ANNEXED PLAT IS A TRUE COPY OF THE NOTES OF SURVEY COMPLETED ON DECEMBER 20, 1989 AND IS A TRUE REPRESENTATION OF THE AS-BUILT CONDITION.

LARRY J. SMITH
NORTH DAKOTA REGISTRATION
NO. 2363

CIVIL ENGINEERING LAND PLANNING LAND SURVEYING
SWENSON, HAGEN & CO. P.C.
CONSULTING ENGINEERS
P.O. BOX 1135, 909 BASIN AVENUE
BISMARCK, NORTH DAKOTA 58502
701-223-2600

CADD PROJ CODE:	PRF NAME:	
DRAWN BY:	DATE:	
SURVEYED BY:	DATE:	
SURVEY DATA:		

NO	BY	DATE
1		
2		
3		
4		
5		
6		

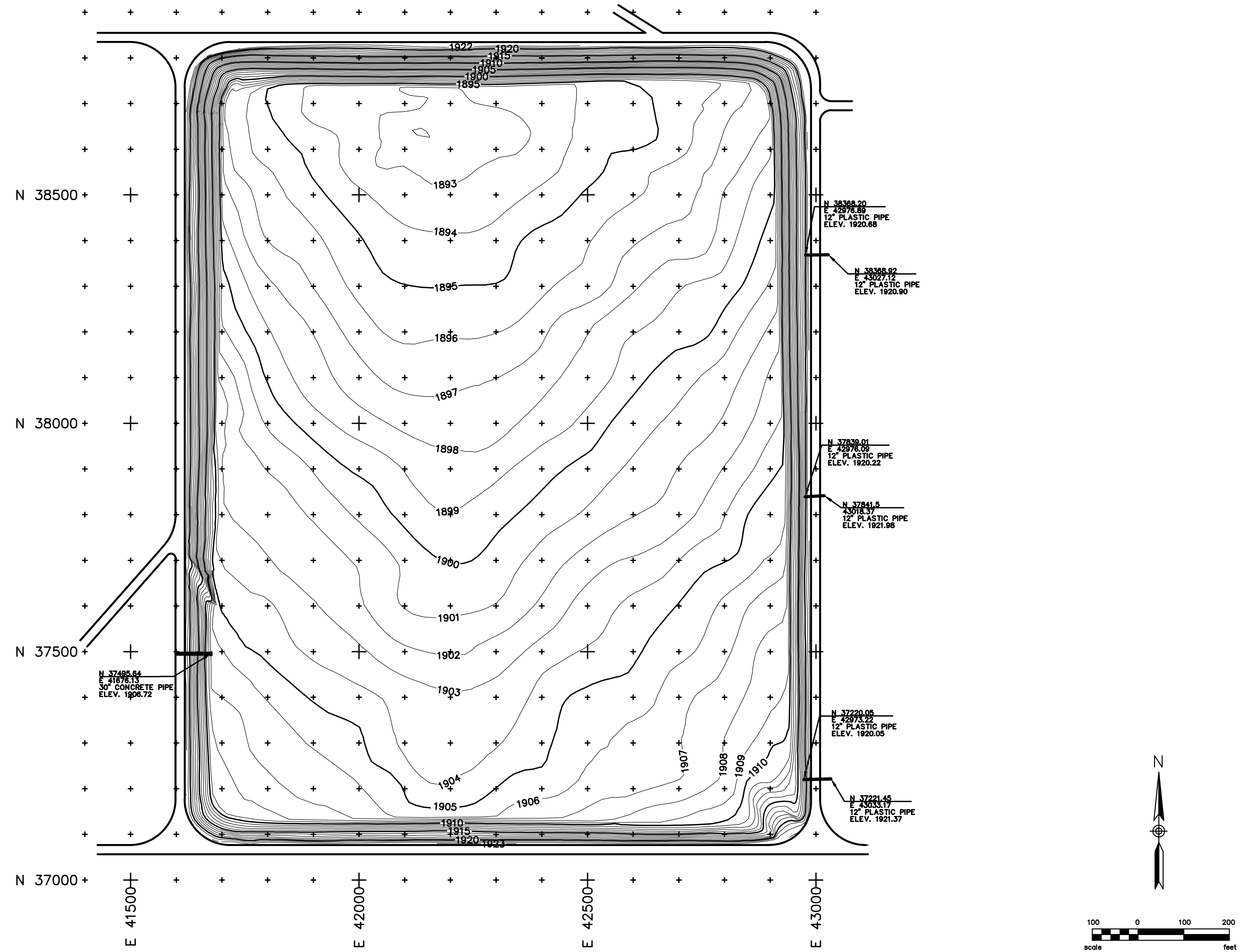
Foth & Van Dyke

SCALE

SCOPE ID.

DRAWING NO.

ASH POND 92



Revision No.	Date	By	Description

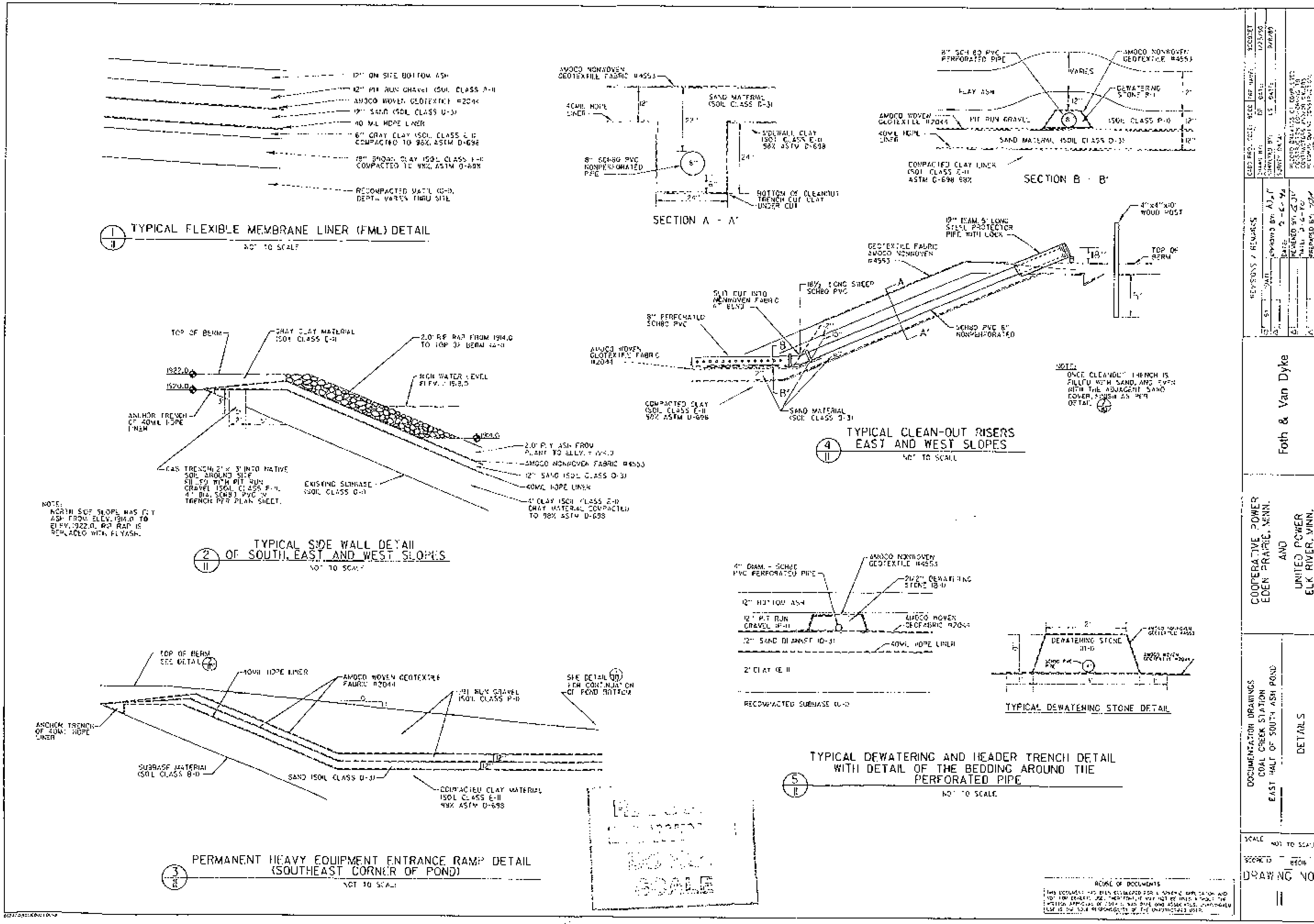
COOPERATIVE POWER ASSOCIATION
UNDERWOOD, NORTH DAKOTA

FINAL FLY ASH CONTOURS

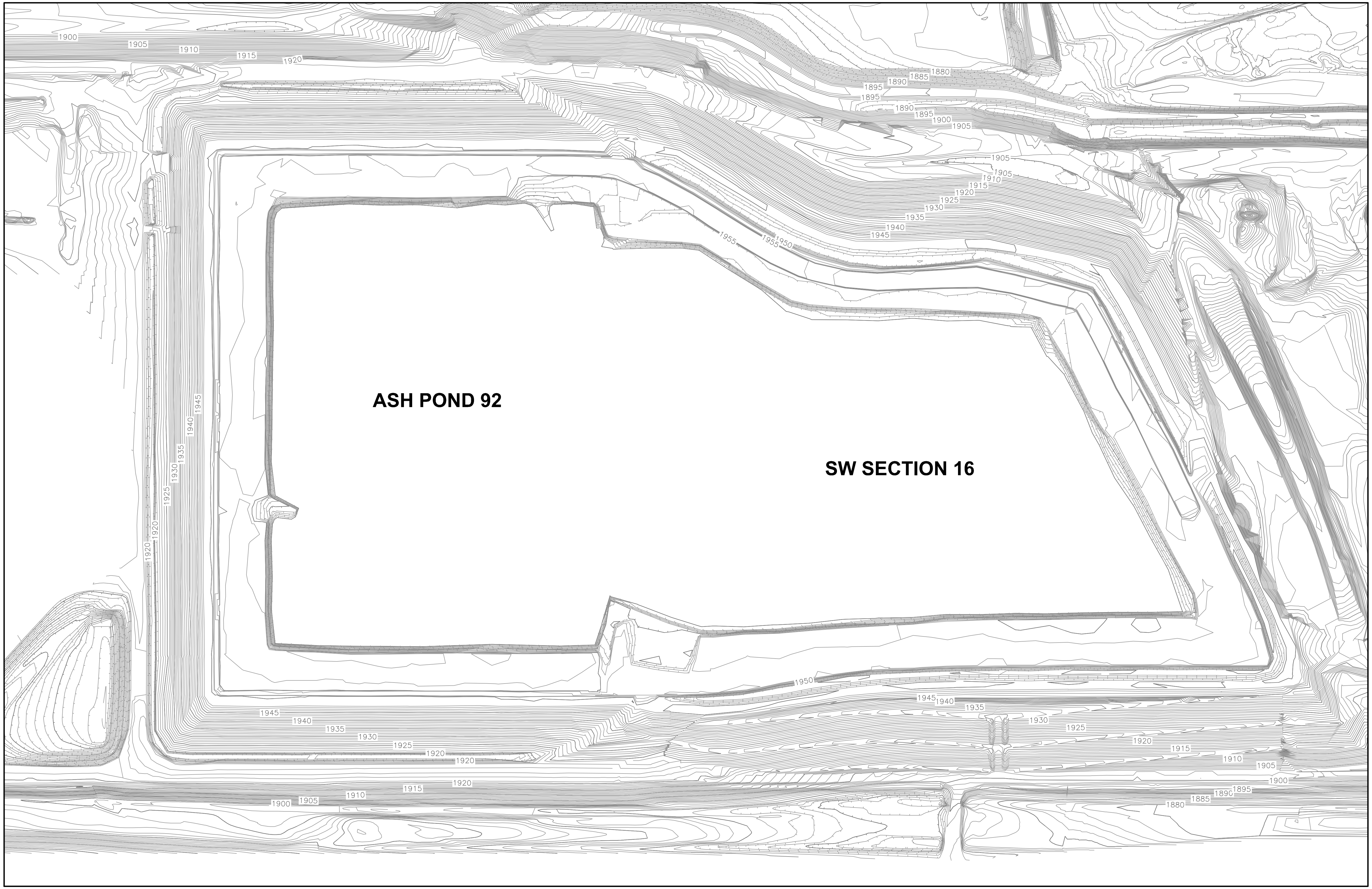
Drawn By D.B.J. Project No. B95-12-01
Checked By L.H.K Date 5/16/96

interstate engineering, inc.
Engineering – Surveying – Planning

SHEET NO. 1



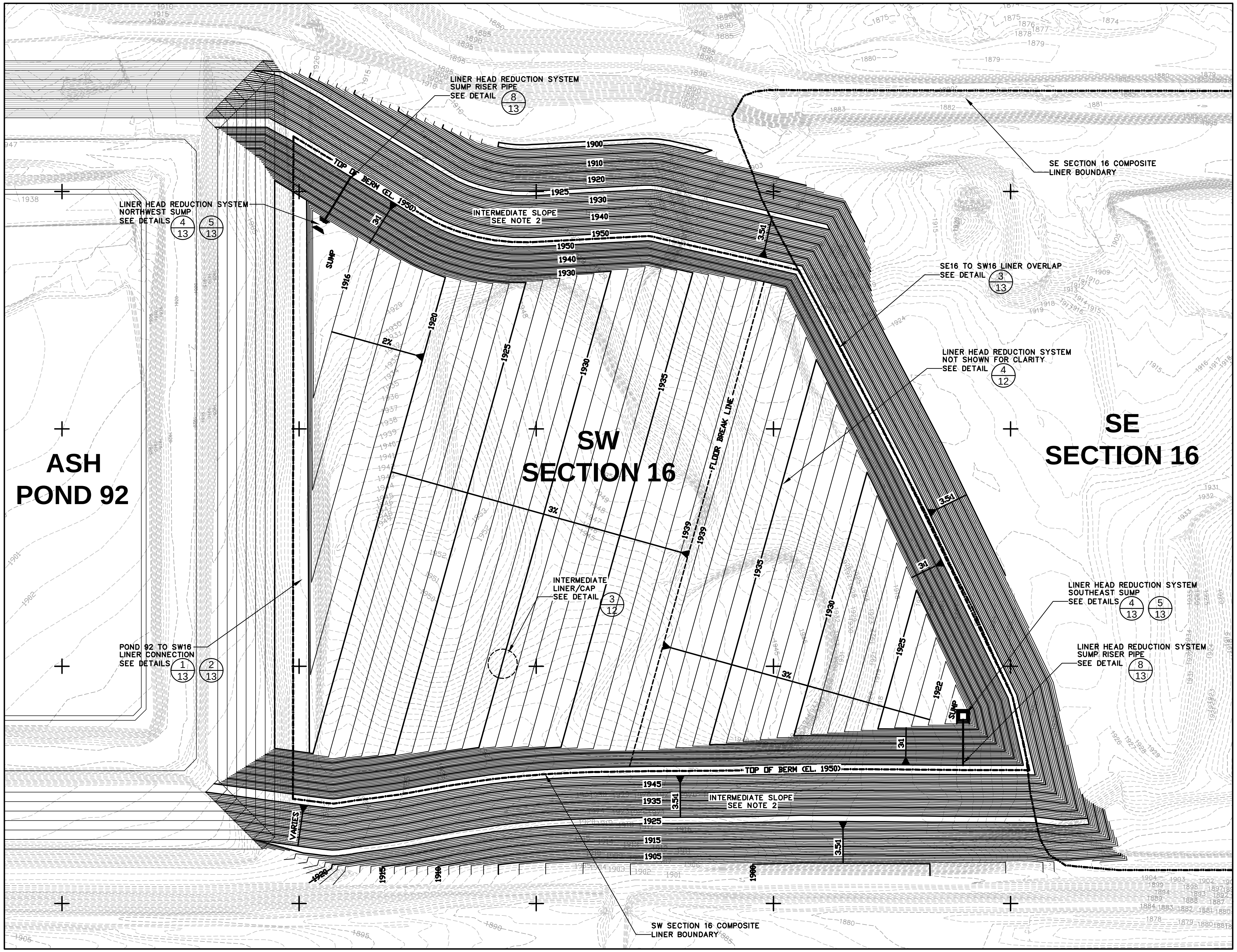
12" ON SITE BOTTOM ASH
12" PIT RUN GRAVEL (SOIL CLASS P-II)
AMOCO WOVEN GEOTEXTILE #2044
12" SAND (SOIL CLASS D-3)
40 MIL HDPE LINER
6" GRAY CLAY (SOIL CLASS E-II) COMPACTED TO 98% ASTM D-698
RECOMPACTED MAT'L (D-II) DEPTH VARIES THRU SITE
TYPICAL FLEXIBLE MEMBRANE LINER (FML) DETAIL
NOT TO SCALE
AMOCO NONWOVEN GEOTEXTILE FABRIC #4553
40MIL HDPE LINER
SAND MATERIAL (SOIL CLASS D-3)
SIDEWALL CLAY (SOIL CLASS E-II) 98% ASTM D-698
8" SCH80 PVC NONPERFORATED PIPE
BOTTOM OF CLEANOUT TRENCH CUT CLAY UNDER CUT
SECTION A - A'
8" SCH 80 PVC PERFORATED PIPE
AMOCO NONWOVEN GEOTEXTILE #4553
VARIES
FLAY ASH
DEWATERING STONE B-I
AMOCO WOVEN GEOTEXTILE #2044
PIT RUN GRAVEL
40MIL HDPE LINER
SAND MATERIAL (SOIL CLASS D-3)
COMPACTED CLAY LINER (SOIL CLASS E-II) ASTM D-698 98%
SECTION B - B'
TOP OF BERM
GRAY CLAY MATERIAL (SOIL CLASS E-II)
2.0' RIP RAP FROM 1914.0 TO TOP OF BERM
HIGH WATER LEVEL
1922.0
1920.0
ANCHOR TRENCH OF 40MIL HDPE LINER
2.0' FLY ASH FROM PLANT TO ELEV.
AMOCO NONWOVEN FABRIC #4553
12" SAND (SOIL CLASS D-3)
40MIL HDPE LINER
4' CLAY (SOIL CLASS E-II) GRAY MATERIAL COMPACTED TO 98% ASTM D-698
EXISTING SUBBASE (SOIL CLASS D-II)
NOTE: NORTH SIDE SLOPE HAS FLY ASH FROM ELEV. 1914.0 TO ELEV. 1922.0. RIP RAP IS REPLACED WITH FLYASH.
TYPICAL SIDE WALL DETAIL OF SOUTH, EAST AND WEST SLOPES
NOT TO SCALE
12" DIAM. 5' LONG STEEL PROTECTOR PIPE WITH LOCK
4"x4"x10' WOOD POST
TOP OF BERM
GEOTEXTILE FABRIC AMOCO NONWOVEN #4553
SCH80 PVC 6" NONPERFORATED
8" PERFORATED SCH80 PVC
AMOCO WOVEN GEOTEXTILE FABRIC #2044
COMPACTED CLAY (SOIL CLASS E-II) 98% ASTM D-698
SAND MATERIAL (SOIL CLASS D-3)
NOTE: ONCE CLEANOUT TRENCH IS FILLED WITH SAND, AND EVEN WITH THE ADJACENT SAND COVER, FINISH AS PER DETAIL
TYPICAL CLEAN-OUT RISERS EAST AND WEST SLOPES
NOT TO SCALE
TOP OF BERM SEE DETAIL
40MIL HDPE LINER
AMOCO WOVEN GEOTEXTILE FABRIC #2044
PIT RUN GRAVEL (SOIL CLASS P-II)
SEE DETAIL FOR CONTINUATION OF POND BOTTOM
ANCHOR TRENCH OF 40MIL HDPE LINER
SUBBASE MATERIAL (SOIL CLASS B-II)
SAND (SOIL CLASS D-3)
COMPACTED CLAY MATERIAL (SOIL CLASS E-II) 98% ASTM D-698
PERMANENT HEAVY EQUIPMENT ENTRANCE RAMP DETAIL (SOUTHEAST CORNER OF POND)
NOT TO SCALE
AMOCO NONWOVEN GEOTEXTILE #4553
4" DIAM. SCH80 PVC PERFORATED PIPE
12" BOTTOM ASH
12" PIT RUN GRAVEL (P-II)
AMOCO WOVEN GEOFABRIC #2044
12" SAND BLANKET (D-3)
40MIL HDPE LINER
2' CLAY (E-II)
RECOMPACTED SUBBASE (D-II)
DEWATERING STONE
TYPICAL DEWATERING STONE DETAIL
TYPICAL DEWATERING AND HEADER TRENCH DETAIL WITH DETAIL OF THE BEDDING AROUND THE PERFORATED PIPE
NOT TO SCALE
REVISIONS / REMARKS
Foth & Van Dyke
COOPERATIVE POWER EDEN PRAIRIE, MINN.
AND
UNITED POWER ELK RIVER, MINN.
DOCUMENTATION DRAWINGS COAL CREEK STATION EAST HALF OF SOUTH ASH POND
DETAILS
SCALE NOT TO SCALE
DRAWING NO. 11
REUSE OF DOCUMENTS



Golder Associates
DENVER, COLORADO

Dwg Name: J:\10JOBS\103-8160 ... References\0632227B010.dwg
Layout Name: Surrounding Topo   Machine: DEN1-L-CSCHUETT
Last Update: Sep 27, 2010 08:36   By: CSchuettpelz
Last Plot: Sep 27, 2010 15:26   By: CSchuettpelz

SURROUNDING TOPOGRAPHY
SPRING 2010



LEGEND

- EXISTING GROUND TOPOGRAPHY (SEE REFERENCES)
- PREVIOUS PHASE PROPOSED TOPOGRAPHY
- PROPOSED CONSTRUCTION TOPOGRAPHY
- SW SECTION 16 COMPOSITE LINER BOUNDARY
- SE SECTION 16 COMPOSITE LINER BOUNDARY

NOTES

1. SW SECTION 16 GRADES REPRESENT TOP OF CLAY LINER/SOIL DIKE.
2. SW SECTION 16 CONTAINMENT DIKE SLOPES ARE INTERMEDIATE SLOPES AT 3.5H:1V. FINAL CLOSURE SLOPES WILL BE GRADED TO 4H:1V.

REGULATORY DESIGN BASIS

1. CONTROL OF RUN-ON AND RUN-OFF DURING OPERATIONS FROM A TWENTY-FIVE-YEAR, TWENTY-FOUR-HOUR STORM EVENT (3.75"), PER SUBDIVISION A OF SUBSECTION 3 OF NDAC SECTION 33-20-04.1-09.
2. OPERATE THE UPSTREAM RAISE (SURFACE IMPOUNDMENT) TO HAVE A FREEBOARD OF AT LEAST TWO FEET, PER SUBDIVISION D OF SUBSECTION 2 OF NDAC SECTION 33-20-08.1-01.
3. MINIMIZE EROSION OF FINAL COVER, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
4. MAXIMUM FINAL SLOPES NOT LESS THAN THREE PERCENT, NOR MORE THAN TWENTY-FIVE PERCENT, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
5. EVALUATE SLOPES STEEPER THAN FIFTEEN PERCENT TO ENSURE STABILITY, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
6. CONTROL OF SURFACE WATER DRAINAGE FROM FINAL SLOPES, PER SUBDIVISIONS B2-B4 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
7. COMPOSITE LINER, PER SUBDIVISION B OF SUBSECTION 2 OF NDAC SECTION 33-20-08.1-01.
8. APPROPRIATE ENGINEERED FINAL COVER DESIGN, PER NDAC SECTION 33-20-07.1-02.
9. ALL OTHER APPLICABLE RULES FROM NDCC CHAPTER 23-29 AND NDAC ARTICLE 33-20.

REFERENCES

1. SITE LOCATION: SECTION 16, T145N, R82W, MCLEAN COUNTY, NORTH DAKOTA.
2. EXISTING GROUND TOPOGRAPHY PROVIDED BY GREAT RIVER ENERGY. PERFORMED BY INTERSTATE ENGINEERING AND KADRMAS, LEE & JACKSON BETWEEN 1996 AND 2003.
3. ELEVATIONS BASED ON MEAN SEA LEVEL DATUM, CONTOUR INTERVAL IS ONE FOOT.
4. HORIZONTAL DATUM BASED ON NORTH DAKOTA STATE PLANE COORDINATE SYSTEM AS FOLLOWS:

   SITE GRID N = N STATE PLANE COORDINATE MINUS 100,000
   SITE GRID E = E STATE PLANE COORDINATE MINUS 1,800,000

5. ALL PROPERTY SHOWN ON THIS MAP IS OPERATED BY GREAT RIVER ENERGY.

100 0 100
1" = 100 FEET

PROJECT
GREAT RIVER ENERGY
COAL CREEK STATION
PERMIT NO. SP-033 PERMIT MODIFICATION

TITLE
PHASE 2: SW SECTION 16 INTERMEDIATE LINER/CAP

ENGINEER'S STAMP

REFERENCE DRAWINGS

NO.	REVISION DESCRIPTION (THIS DRAWING IS NOT APPROVED UNLESS LAST REVISION IS HAND WRITTEN)	DATE	BY	CHKD	AP'VD
C	ISSUED FOR DRAFT REVISED PERMIT MODIFICATION	07/09/04			
B	ISSUED FOR PERMIT MODIFICATION	09/24/03	TJS	RRJ	RRJ
A	ISSUED FOR CLIENT REVIEW	06/04/03	TJS	–	RRJ

PRINT ISSUE RECORD

DATE	
FOR	
REVISED	
CLIENT	
FIELD	

Golder Associates
Denver, Colorado

PROJECT No.		023-2411	FILE No.	0232411A020
DESIGN	TJS	05/01/03	SCALE AS SHOWN	REV. C
CADD	TJS	05/01/03	5	
CHECK	RRJ	06/02/03		
REVIEW	RRJ	06/02/03		

LEGEND

EXISTING GROUND TOPOGRAPHY (SEE REFERENCES)

PREVIOUS PHASE PROPOSED TOPOGRAPHY

PROPOSED TOP OF CCP TOPOGRAPHY

NOTES

1. GRADES REPRESENT TOP OF WASTE/SOIL DIKE.
2. CONTACT WATER COLLECTED IN DITCH AROUND ASH POND 92 AND SW SECTION 16. WATER IS DIRECTED THROUGH CULVERT TO ASH POND 91 OR DOWNWARD INTO UPSTREAM RAISE.

REGULATORY DESIGN BASIS

1. CONTROL OF RUN-ON AND RUN-OFF DURING OPERATIONS FROM A TWENTY-FIVE-YEAR, TWENTY-FOUR-HOUR STORM EVENT (3.75"), PER SUBDIVISION A OF SUBSECTION 3 OF NDAC SECTION 33-20-04.1-09.
2. OPERATE THE UPSTREAM RAISE (SURFACE IMPOUNDMENT) TO HAVE A FREEBOARD OF AT LEAST TWO FEET, PER SUBDIVISION D OF SUBSECTION 2 OF NDAC SECTION 33-20-08.1-01.
3. MINIMIZE EROSION OF FINAL COVER, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
4. MAXIMUM FINAL SLOPES NOT LESS THAN THREE PERCENT, NOR MORE THAN TWENTY-FIVE PERCENT, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
5. EVALUATE SLOPES STEEPER THAN FIFTEEN PERCENT TO ENSURE STABILITY, PER SUBDIVISION B3 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
6. CONTROL OF SURFACE WATER DRAINAGE FROM FINAL SLOPES, PER SUBDIVISIONS B2-B4 OF SUBSECTION 4 OF NDAC SECTION 33-20-04.1-09.
7. COMPOSITE LINER, PER SUBDIVISION B OF SUBSECTION 2 OF NDAC SECTION 33-20-08.1-01.
8. APPROPRIATE ENGINEERED FINAL COVER DESIGN, PER NDAC SECTION 33-20-07.1-02.
9. ALL OTHER APPLICABLE RULES FROM NDCC CHAPTER 23-29 AND NDAC ARTICLE 33-20.

REFERENCES

1. SITE LOCATION: SECTION 16, T145N, R82W, MCLEAN COUNTY, NORTH DAKOTA.
2. EXISTING GROUND TOPOGRAPHY PROVIDED BY GREAT RIVER ENERGY. PERFORMED BY INTERSTATE ENGINEERING AND KADRMAS, LEE & JACKSON BETWEEN 1996 AND 2003.
3. ELEVATIONS BASED ON MEAN SEA LEVEL DATUM, CONTOUR INTERVAL IS ONE FOOT.
4. HORIZONTAL DATUM BASED ON NORTH DAKOTA STATE PLANE COORDINATE SYSTEM AS FOLLOWS:

   SITE GRID N = N STATE PLANE COORDINATE MINUS 100,000
   SITE GRID E = E STATE PLANE COORDINATE MINUS 1,800,000
5. ALL PROPERTY SHOWN ON THIS MAP IS OPERATED BY GREAT RIVER ENERGY.

150 0 150
1" = 150 FEET

PROJECT
GREAT RIVER ENERGY
COAL CREEK STATION
PERMIT NO. SP-033 PERMIT MODIFICATION

TITLE
PHASE 3: ASH POND 92 & SW SECTION 16 RAISE

NO.	REVISION DESCRIPTION (THIS DRAWING IS NOT APPROVED UNLESS LAST REVISION IS HAND WRITTEN)	DATE	BY	CHKD	AP'VD
C	ISSUED FOR DRAFT REVISED PERMIT MODIFICATION	07/09/04			
B	ISSUED FOR PERMIT MODIFICATION	09/24/03	TJS	RRJ	RRJ
A	ISSUED FOR CLIENT REVIEW	06/04/03	TJS	–	RRJ

ENGINEER'S STAMP

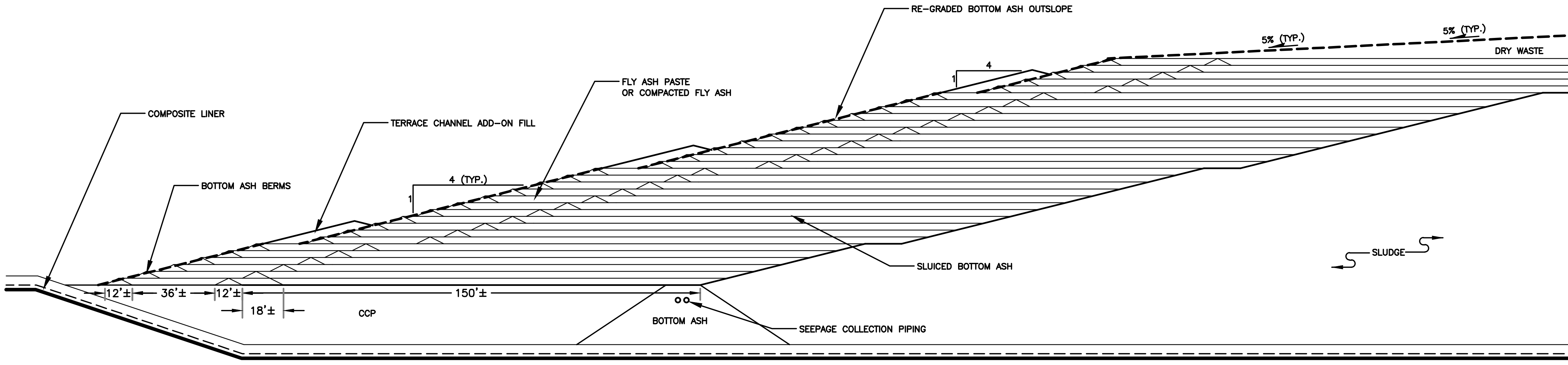
REFERENCE DRAWINGS

PRINT ISSUE RECORD: DATE / FOR / REVISED / CLIENT / FIELD

Golder Associates
Denver, Colorado

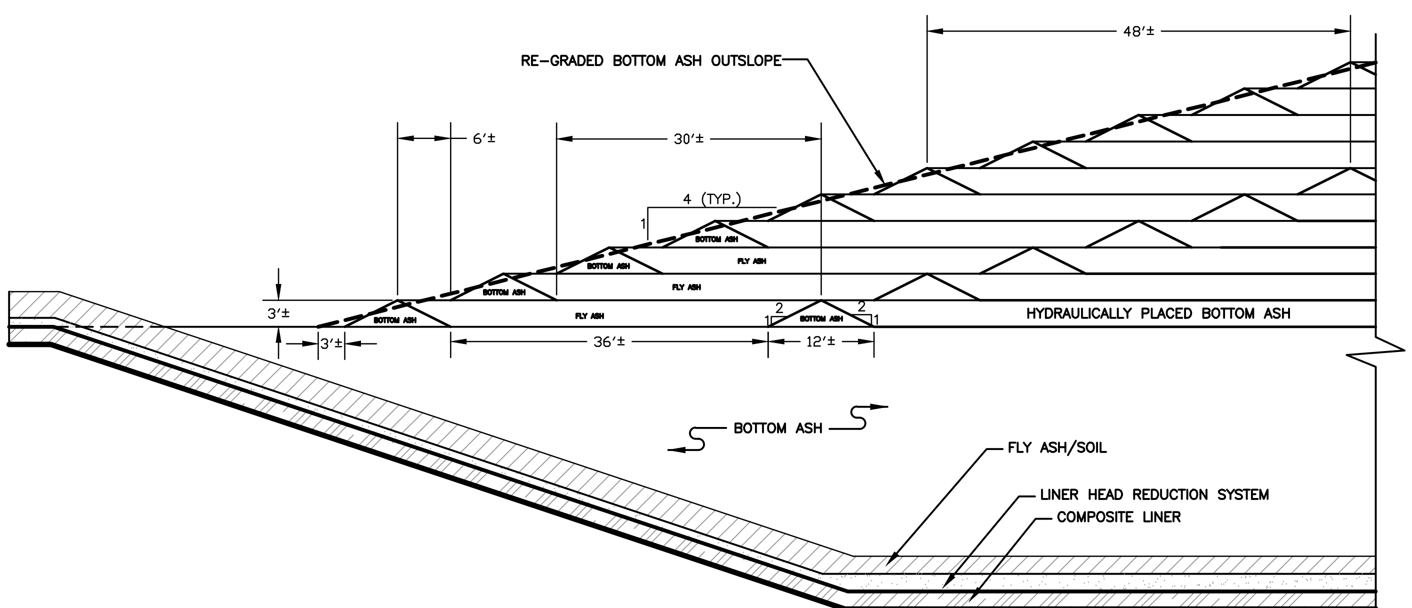
PROJECT No.		023-2411	FILE No.	0232411A021
DESIGN	TJS	05/01/03	SCALE AS SHOWN	REV. C
CADD	TJS	05/01/03		
CHECK	RRJ	06/02/03	6	
REVIEW	RRJ	06/02/03		

Dwg Name: J:\10JOBS\103-81601 ... References\0232411A021.dwg
Last Update: Jul 14, 2006 17:16 By: CSchuettpelz
Last Plot: Sep 27, 2010 15:28 By: CSchuettpelz
Machine: NOT SET



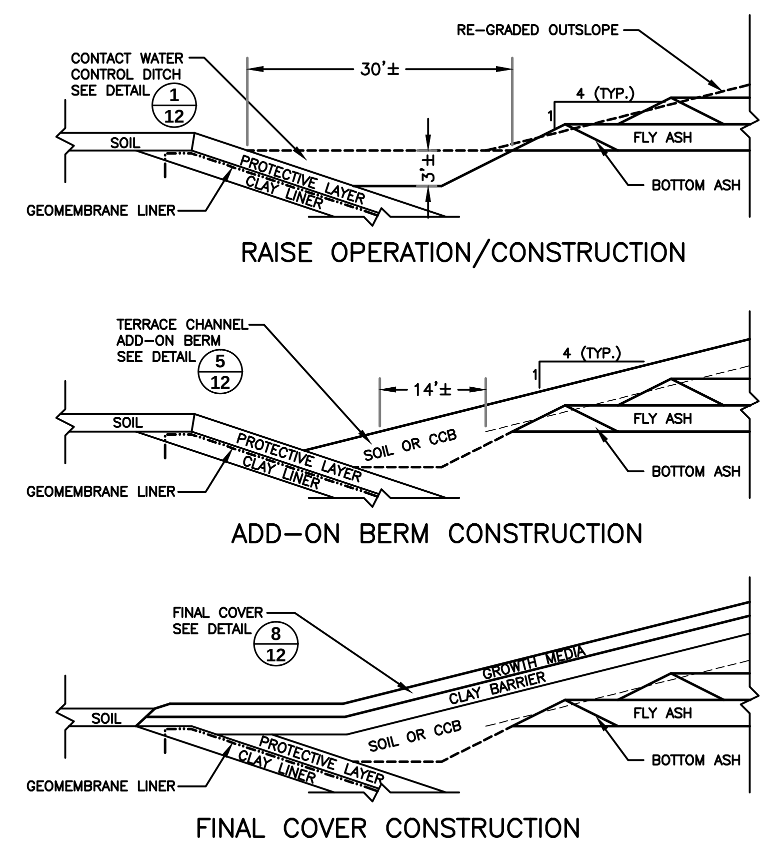
1/11 RAISE PROFILE

NOT TO SCALE



2/11 RAISE DETAIL

NOT TO SCALE



3/11 RAISE TOE TIE-IN

NOT TO SCALE

PROJECT: GREAT RIVER ENERGY
COAL CREEK STATION
PERMIT NO. SP-033 PERMIT MODIFICATION

TITLE: DETAIL SHEET 1

ENGINEER'S STAMP	REFERENCE DRAWINGS	NO.	REVISION DESCRIPTION (THIS DRAWING IS NOT APPROVED UNLESS LAST REVISION IS HAND WRITTEN)	DATE	BY	CHKD	AP'VD
		C	ISSUED FOR REVISED PERMIT MODIFICATION	07/09/04			
		B	ISSUED FOR PERMIT MODIFICATION	09/24/03	TJS	RRJ	RRJ
		A	ISSUED FOR CLIENT REVIEW	06/04/03	TJS	–	RRJ

PRINT ISSUE RECORD: DATE / FOR / REVISED / CLIENT / FIELD

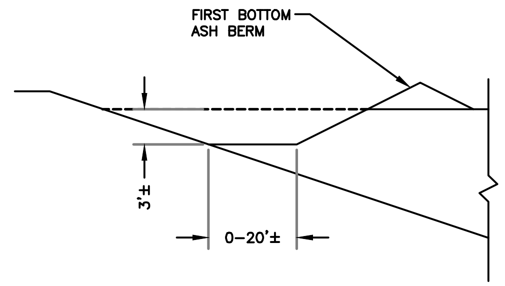
Golder Associates, Denver, Colorado

PROJECT No.		023-2411
DESIGN	TJS	06/02/03
CADD	TJS	06/02/03
CHECK	RRJ	06/02/03
REVIEW	RRJ	06/02/03

FILE No. 0232411A027
SCALE AS SHOWN REV. C

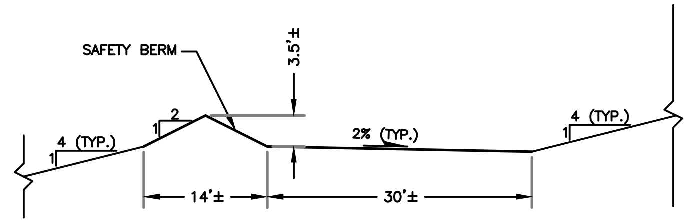
11

Dwg Name: J:\0JOBS\103-81601 ... References\0232411A027.dwg
Last Update: Jul 14, 2006 17:16 By: CSchuettpelz
Last Plot: Sep 27, 2010 15:27 By: CSchuettpelz
Machine: NOT SET



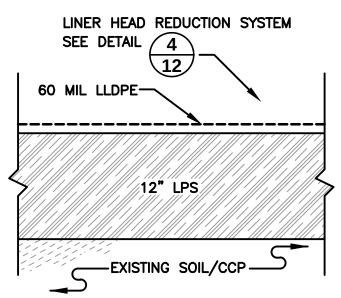
1/12 **CONTACT WATER CONTROL DITCH**

NOT TO SCALE



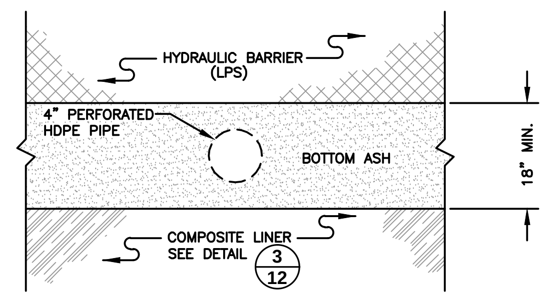
2/12 **ACCESS HAUL ROAD**

NOT TO SCALE



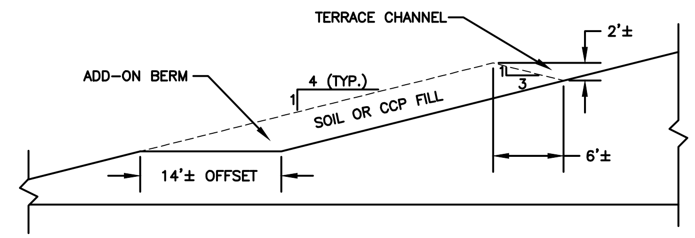
3/12 **INTERMEDIATE LINER/CAP DETAIL**

NOT TO SCALE



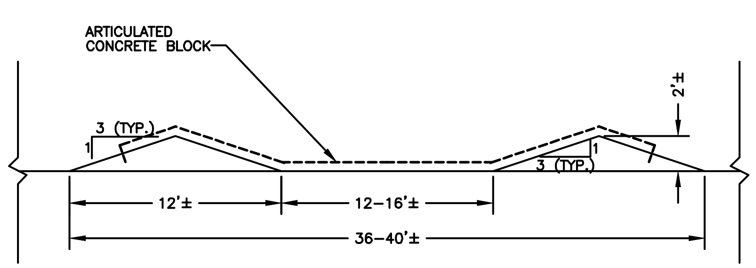
4/12 **LINER HEAD REDUCTION SYSTEM DETAIL**

NOT TO SCALE



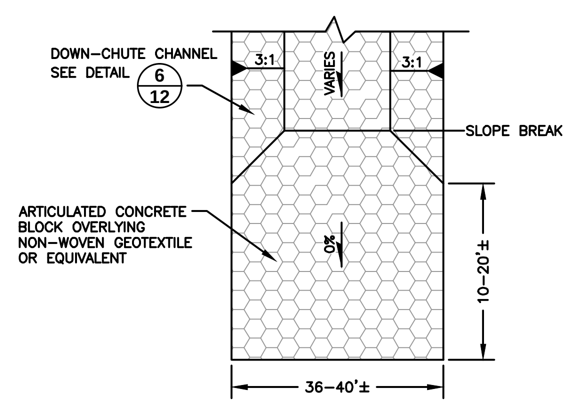
5/12 **TERRACE CHANNEL DETAIL**

NOT TO SCALE



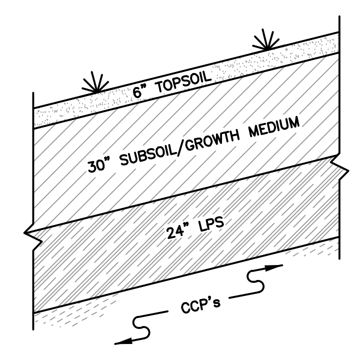
6/12 **TYPICAL DOWN-CHUTE CHANNEL**

NOT TO SCALE



7/12 **HYDRAULIC JUMP BASIN**

NOT TO SCALE



8/12 **PRESCRIPTIVE COVER DETAIL**

NOT TO SCALE

ENGINEER'S STAMP	REFERENCE DRAWINGS	NO.	REVISION DESCRIPTION (THIS DRAWING IS NOT APPROVED UNLESS LAST REVISION IS HAND WRITTEN)	DATE	BY	CHKD	AP'VD
		C	ISSUED FOR DRAFT REVISED PERMIT MODIFICATION	07/09/04			
		B	ISSUED FOR PERMIT MODIFICATION	09/24/03	TJS	RRJ	RRJ
		A	ISSUED FOR CLIENT REVIEW	06/04/03	TJS	–	RRJ

PRINT ISSUE RECORD: DATE / FOR / REVISED / CLIENT / FIELD

PROJECT

GREAT RIVER ENERGY
COAL CREEK STATION
PERMIT NO. SP-033 PERMIT MODIFICATION

TITLE

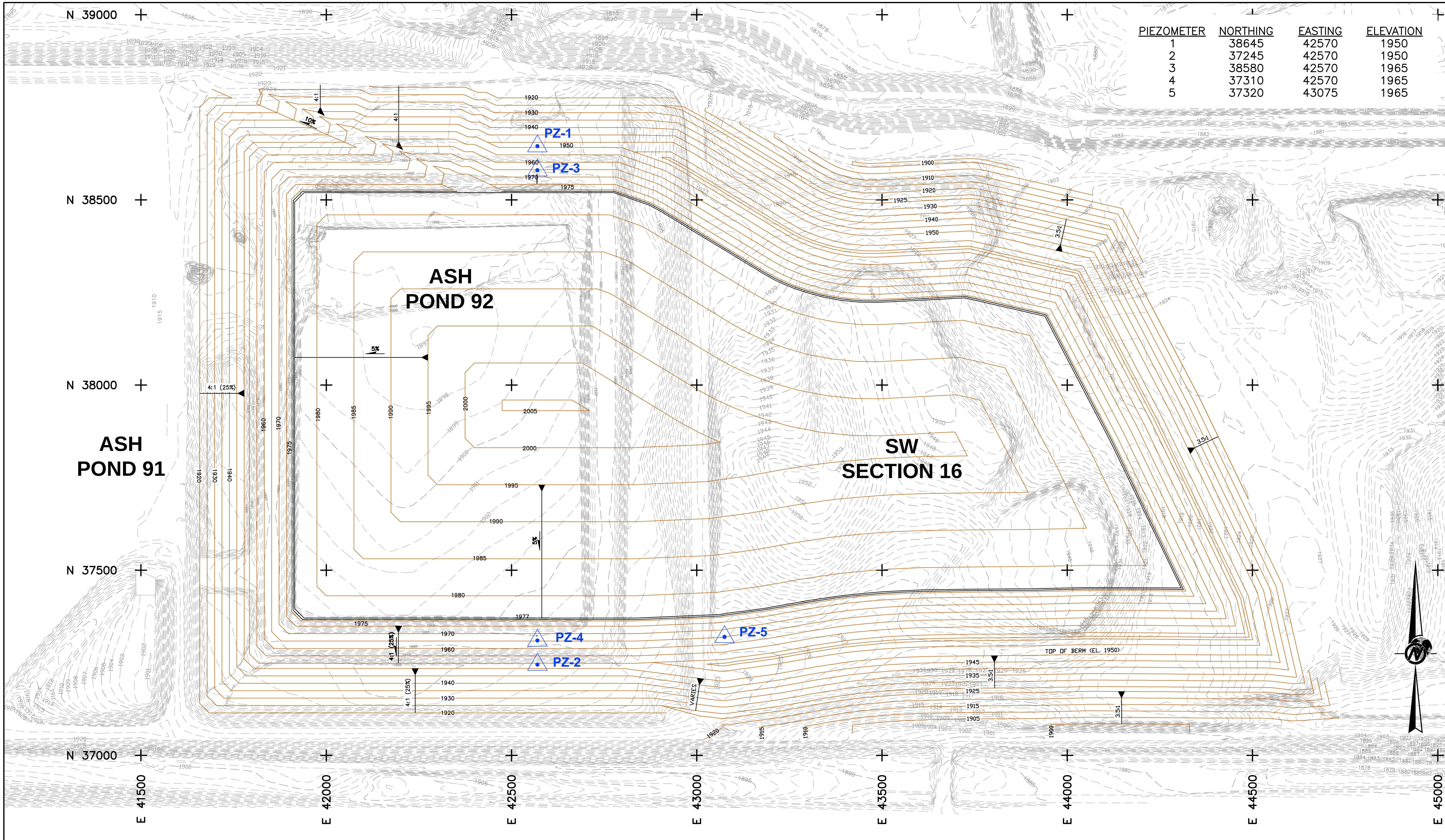
DETAIL SHEET 2

Golder Associates
Denver, Colorado

PROJECT No.		023-2411	FILE No. 0232411A028
DESIGN	TJS	05/01/03	SCALE AS SHOWN, REV. C
CADD	TJS	05/01/03	12
CHECK	RRJ	06/02/03	
REVIEW	RRJ	06/02/03	

Dwg Name: J:\TOJOBS\103-81601 ... References\0232411A028.dwg
Last Update: Jul 14, 2006 17:16 By: CSchuettpelz
Last Plot: Sep 27, 2010 15:27 By: CSchuettpelz
Machine: NOT SET

APPENDIX B
PIEZOMETER INFORMATION



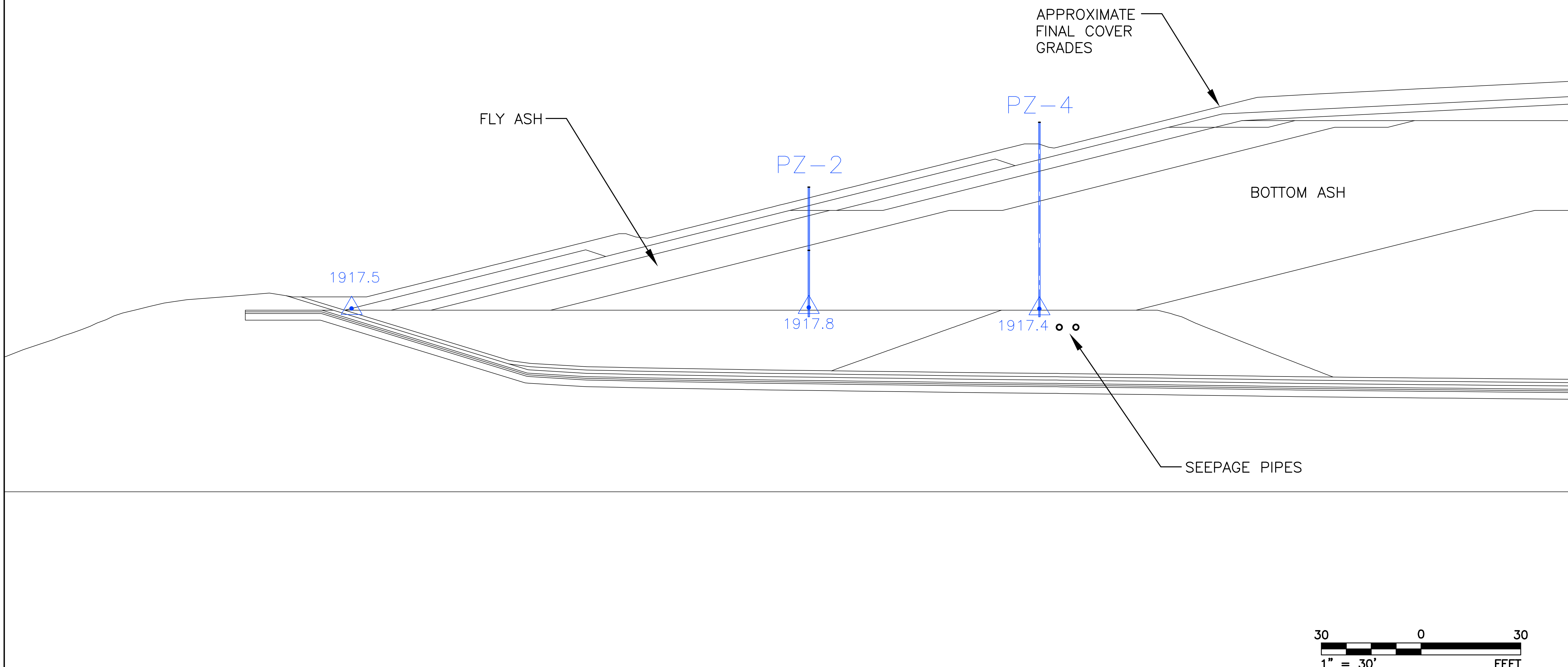
PIEZOMETER	NORTHING	EASTING	ELEVATION
1	38645	42570	1950
2	37245	42570	1950
3	38580	42570	1965
4	37310	42570	1965
5	37320	43075	1965

ASH POND 92 / SW SECTION 16 PIEZOMETER LOCATIONS

250 0 250
1"=250' FEET

Golder Associates
Denver, Colorado

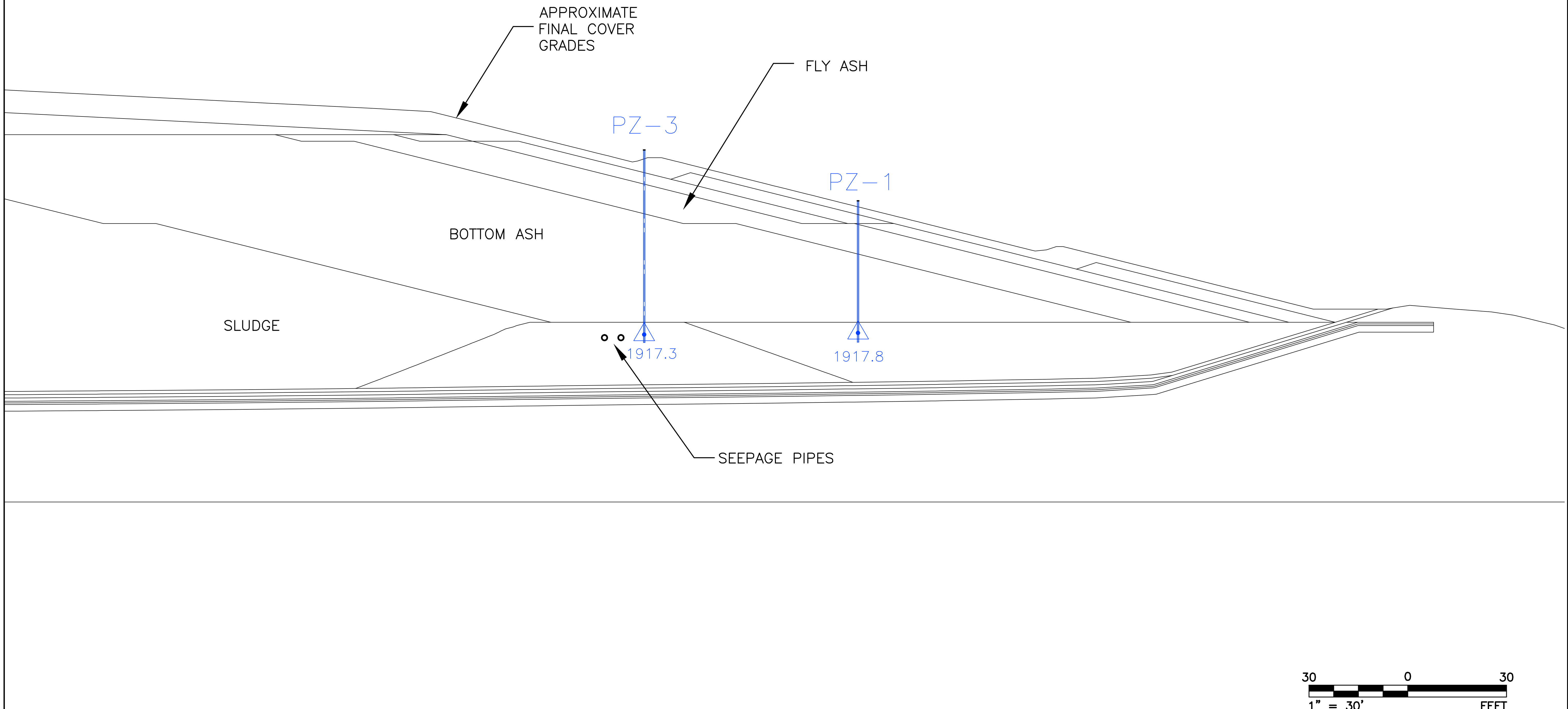
PROJECT No. 043-2226 FILE No.0432226A002.dwg CADD MRN DATE 06/04/04



ASH POND 92 / SW SECTION 16 PIEZOMETERS
SOUTH SECTION

Golder Associates
Denver, Colorado

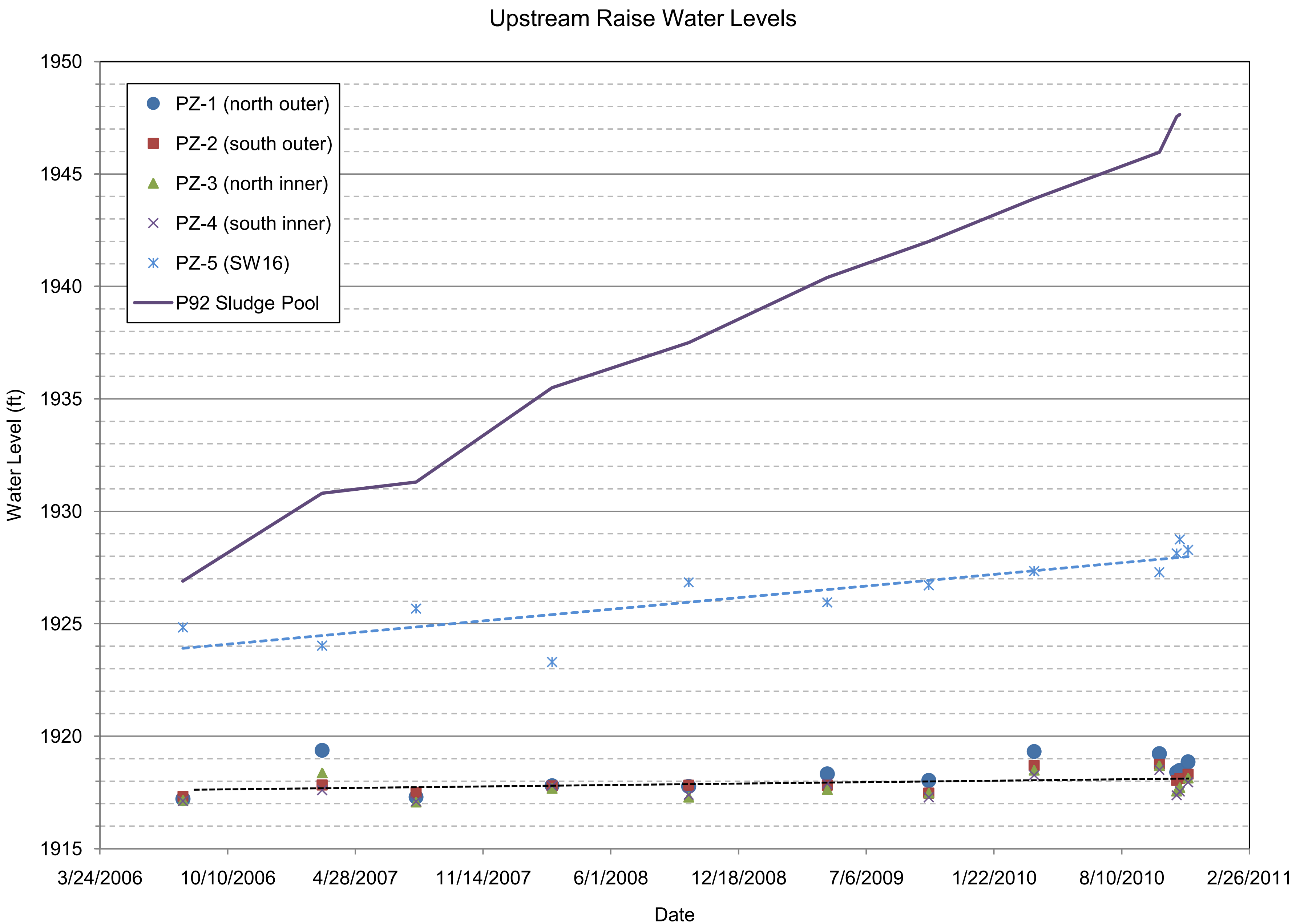
PROJECT No. 073-2227 FILE No. Raise Piezometers.dwg CADD TJS DATE 04/11/07



ASH POND 92 / SW SECTION 16 PIEZOMETERS
NORTH SECTION

Golder Associates
Denver, Colorado

PROJECT No. 073-2227 FILE No. Raise Piezometers.dwg CADD TJS DATE 04/11/07


Upstream Raise Water Levels
PZ-1 (north outer)
PZ-2 (south outer)
PZ-3 (north inner)
PZ-4 (south inner)
PZ-5 (SW16)
P92 Sludge Pool
Water Level (ft)
1950
1945
1940
1935
1930
1925
1920
1915
3/24/2006
10/10/2006
4/28/2007
11/14/2007
6/1/2008
12/18/2008
7/6/2009
1/22/2010
8/10/2010
2/26/2011
Date

APPENDIX C

VISUAL OBSERVATIONS

IMPOUNDMENT INSPECTION CHECKLIST

Facility Name: Ash Pond 92 / SW Section 16

Owner and Address: Great River Energy - Coal Creek Station
2875 Third St. SW, Underwood ND

Purpose of Facility: CCP Storage

Legal: Section: 16 Township: 145 Range: 82 W

County: McClean

Inspected By: Todd Stong **Inspection Date:** 11/2/09

Weather: Sunny, Clear 45° F

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations	X			Relined, vertical expansion
b. Development of downstream plain		X		
c. Grass cover	X			Perimeter berms
d. Settlement/misalignment/cracks				
e. High water mark			X	Elevation:
f. Current water level	X			Elevation: Perimeter at ~1917, sludge pool at 1944
g. Sudden drops in water level?		X		
2. Inflow Structure				FGD Pipe
a. Settlement		X		
b. Cracking		X		
c. Corrosion		X		HDPE
d. Obstacles in inlet		X		
e. Riprap/erosion control			X	
3. Outflow Structure				Gravity drain outlet, seepage drains working
a. Settlement		X		
b. Cracking		X		
c. Corrosion		X		HDPE
d. Obstacles in outlet		X		
e. Riprap/erosion control			X	Discharge to Pond 91
4. Upstream slope (inside)				
a. Erosion – liner exposed?		X		
b. Rodent burrows		X		
c. Vegetation		X		
d. Cracks/settlement	X			Cracks in bottom ash zone, settlement of bottom ash over sludge, over and settlement of snow/ice. (W. side of Ash Pond 92)
e. Riprap/other erosion protection		X		
5. Crest				
a. Soil condition	X			
b. Comparable to design width	X			
c. Vegetation		X		
d. Rodent burrows		X		
e. Exposed to heavy traffic	X			CAT 777, D8, other
f. Damage from vehicles/machinery		X		
6. Downstream slope (outside)				
a. Erosion	X			Some rills & minor erosion
b. Vegetation	X			Healthy grass
c. Rodent burrows	X			Along S. side of lower soil berm
d. Cracks/settlement/scarps		X		
e. Drain conditions	X			Channels & down-chutes in good condition
f. Seepage		X		
7. Toe				
a. Vegetation	X			
b. Rodent burrows	X			
c. Settlement		X		
d. Drainage conditions	X			Channel & ditch conveys water away
e. Seepage		X		

General Remarks: No significant issues identified. Cracking in bottom ash zone expected, to be monitored. In generally good condition

Name of Engineer: Todd Stong

Date: 11/2/09

Engineering Firm: Golder Associates

Signature: Todd Stong

REGISTERED PROFESSIONAL ENGINEER
TODD J. STONG
PE-6144
DATE 11/2/09
NORTH DAKOTA
PROFESSIONAL ENGINEER SEAL

IMPOUNDMENT INSPECTION CHECKLIST

Facility Name: ASH POND 92 / SW SECTION 16
Owner and Address: GREAT RIVER ENERGY - COAL CREEK STATION
2875 THIRD ST. SW, UNDERWOOD, ND
Purpose of Facility: CCP STORAGE
Legal: *Section:* 16 *Township:* 145 *Range:* 82 W
County: MCLEAN
Inspected By: CRAIG SCHUETTPELZ ***Inspection Date:*** 9/25/09
Weather: SUNNY, 80° F

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations	X			RELINED, DESIGN FOR VERTICAL
b. Development of downstream plain		X		CCP DISPOSAL
c. Grass cover	X			LOWER PERIMETER BERMS
d. Settlement/misalignment/cracks		X		
e. High water mark		X		Elevation:
f. Current water level	X			Elevation: 7'-10' BELOW BOTTOM ASH (TOP)
g. Sudden drops in water level?		X		
2. Inflow Structure				8" FGD PIPE IS IN GOOD
a. Settlement		X		CONDITION
b. Cracking		X		
c. Corrosion		X		
d. Obstacles in inlet		X		
e. Riprap/erosion control		X		
3. Outflow Structure				DRAINAGE PIPING IS
a. Settlement				NOT VISIBLE UNDER WATER
b. Cracking				AND CCPS
c. Corrosion				
d. Obstacles in outlet				
e. Riprap/erosion control				
4. Upstream slope				
a. Erosion – liner exposed?		X		
b. Rodent burrows		X		
c. Vegetation		X		
d. Cracks/settlement	X			SMALL CRACK IN BOTTOM ASH
e. Riprap/other erosion protection		X		LAYER (N. SIDE ASH POND 92)
5. Crest				
a. Soil condition	X			
b. Comparable to design width	X			CONTINUOUSLY UPDATED
c. Vegetation		X		
d. Rodent burrows		X		
e. Exposed to heavy traffic	X			CAT. DX, 777
f. Damage from vehicles/machinery		X		
6. Downstream slope				
a. Erosion		X		
b. Vegetation	X			TALL GRASS - PERIMETER BERMS
c. Rodent burrows		X		
d. Cracks/settlement/scarps		X		
e. Drain conditions	X			
f. Seepage		X		
7. Toe				
a. Vegetation	X			TALL GRASS, MARSHY IN DITCH
b. Rodent burrows	X			FEW ON S. SIDE OF
c. Settlement		X		FACILITIES
d. Drainage conditions	X			
e. Seepage		X		

General Remarks: ASH POND 92 / SW SECTION 16 ARE GENERALLY IN GOOD CONDITION WITH NO SIGNIFICANT STABILITY CONCERNS.

Name of Engineer: Todd Stong
Date: 11/20/09
Engineering Firm: Golder Associates
Signature: Todd Stong

REGISTERED PROFESSIONAL ENGINEER
TODD J. STONG
PE-6144
DATE 11/20/09
NORTH DAKOTA
PROFESSIONAL ENGINEER SEAL

APPENDIX D

PHOTOGRAPHS

Upstream Bottom Ash Slope and Sludge (1 of 4)

Upstream Bottom Ash Slope and Sludge (2 of 4)

Upstream Bottom Ash Slope and Sludge (3 of 4)

Upstream Bottom Ash Slope and Sludge (4 of 4)

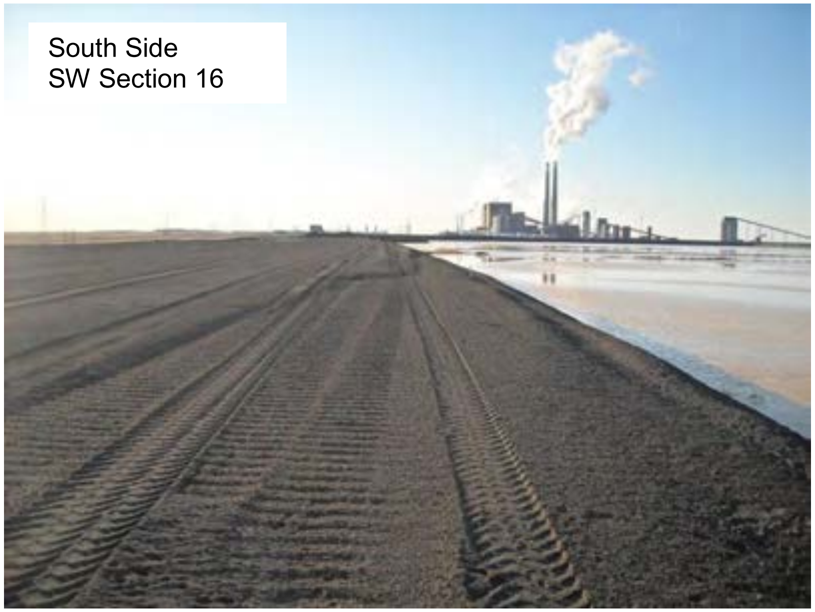
FGD Sludge (1 of 2)

FGD Sludge (2 of 2)

FGD Sludge Inflow (1 of 2)

FGD Sludge Inflow (2 of 2)

Crest of Facility – Southeast Corner (looking west)



Crest of Facility – South Side (looking west)

Crest of Facility – South Side (looking west)

Crack in Bottom Ash on Crest – North Side (looking west)

November 2, 2009

Crack in Bottom Ash on Crest – West Side

November 2, 2009

Crack in Bottom Ash on Crest – West Side

Fly Ash Exterior Slope 1 of 3– South Side (looking west)

Fly Ash Exterior Slope 2 of 3 – South Side (looking west)

Fly Ash Exterior Slope 3 of 3 – South Side (looking west)

West Side
Ash Pond 92

Fly Ash Exterior Slope – West Side (looking east)

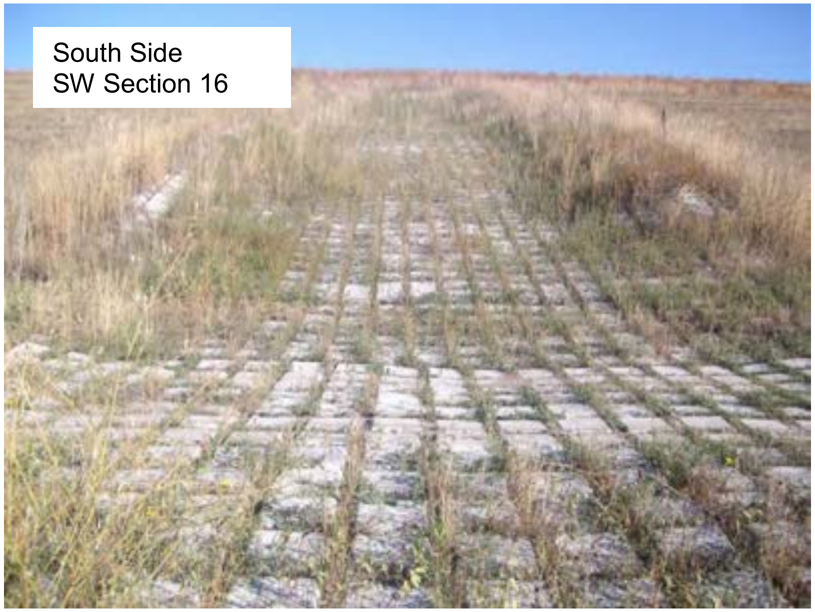
Downstream Slope Below Perimeter Road – South Side (looking west)

Downstream Slope – North Side (looking east)

Downstream Slope – Southeast Side (looking west)

Downstream Slope – East Side (looking north)

Outfall Drainage Tiles – South Side (looking downstream)



Outfall Drainage Tiles – South Side (looking upstream)

Toe of Slope Ditch Below Fly Ash Shell 1 of 2 – South Side (looking west)

Toe of Slope Ditch Below Fly Ash Shell 2 of 2 – South Side (looking west)

Toe of Slope – South Side SW Section 16 (looking west)

Toe of Slope – South Side Ash Pond 92 (looking west)

	
Toe of Slope – North Side SW Section 16 (looking west)	Animal Burrow
	
Animal Burrow	Outflow Pipes to Ash Pond 91 – West Side

	
Outflow Pipes to Ash Pond 91 – West Side	Outflow Pipes to Ash Pond 91 – North Side
	
Fly Ash Exterior (west side) and Drainage Pipes from Ash Pond 92	Drainage Pipe Outlets from Ash Pond 92 into Ash Pond 91

REPORT

EVALUATION OF ASH POND 91 BERM STABILITY

Submitted to: Great River Energy
Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

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

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

April 13, 2010 **103-81601**

A world of capabilities delivered locally

Golder Associates

Table of Contents

List of Tables

List of Figures

List of Appendices

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 Ash Pond 91 at Coal Creek Station (CCS). 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

CCS is located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. Various ponds and basins are utilized at CCS to manage the raw water, cooling water, process water, and coal combustion product (CCP) inventories (see Figure 1). This includes two ash storage/disposal ponds (Ash Pond 91 and Ash Pond 92/SW16), four evaporation ponds (Evaporation Ponds 91, 92, 93, and 94), a recycle pond (Drains Pond), a runoff/sewage collection pond (Lignite Runoff Basin), a cooling water basin (Extended Basin), and a raw water storage basin (River Water Holding Basin).

Ash Pond 91 (Figure 2) covers approximately 70 acres and is used as a dewatering/storage facility for CCPs including bottom ash, pulverizer rejects, economizer ash, and flue gas desulfurization (FGD) sludge as required. Ash Pond 91 is also part of the plant process water storage inventory and acts as a clarifier for the process water conveyed with the CCPs. Water and CCPs enter Ash Pond 91 through the 12" ash lines and through the cross-tie pipes with Ash Pond 92/SW16. A small amount of water may also enter through culverts draining the ash pipeline corridor into Ash Pond 91. Ash Pond 91 is bordered by Lower Samuelson Slough to the north, the plant area to the west, Ash Pond 92 to the east, and the entrance road and both lime and ash rail lines to the south.

Ash Pond 91 was originally part of the South Ash Pond. The South Ash Pond was constructed with a clay core dike and soil liner. A new clay liner was installed over the South Ash Pond in 1982 and the facility remained in operation until 1987 when ash was excavated from the South Ash Pond and transported to the Section 5 dry CCP landfill. The South Ash Pond was then divided into Ash Pond 91 and Ash Pond 92. Ash Pond 91 was deepened and a new composite liner consisting of a 2-foot thick clay and a 40-mil HDPE liner was completed in 1992. The liner is overlain with 1 foot of sand, 1 foot of gravel, and a drainage system. Selected construction drawings from the 1992 work are included under GRE job number 92G213 (Appendix A).

1.3 Pond Embankments

The design top of embankment surrounding Ash Pond 91 is at a constant elevation of 1922 feet with 3:1 upstream slopes to bottom of pond elevations between 1900 feet and 1914 feet, and approximately 3:1 downstream slopes to the surrounding grades. The bases of downstream slopes have minimum elevations of 1897 ft on the north side of the Pond and 1902 feet on the south and west sides of the Pond. The top of the HDPE liner is anchored at elevation 1920 feet and the typical pond water level is between 1917 and 1918 feet. The upstream slopes are protected with riprap between 1922 feet and 1918 feet, and then hardened fly ash to the bottom of the pond. The crest is a gravel paved roadway supporting light passenger vehicles to heavy construction equipment. The downstream slopes have grass vegetation.

1.4 Geological Conditions

Ash Pond 91 is generally constructed over a glacial till layer consisting of sandy and silty-clay soils. Glacial till varies in thickness from 20 feet to several hundred feet in the area of Coal Creek Station. Silty-sand and sand lenses are present throughout the glacial till formation, which is underlain by poorly consolidated siltstone/sandstone bedrock (Barr Engineering 1982; Cooperative Power and United Power Association 1989).

2.0 STABILITY EVALUATION

2.1 Slope Geometries

Golder developed a cross section through the south side of Ash Pond 91 (Figure 3) to evaluate the stability of the Ash Pond 91 embankments. This cross section was selected to represent the critical slope for stability analysis (tallest downstream slope with narrowest crest width). The cross section has 3:1 upstream slopes from 1910 feet to 1922 feet, a 25-foot wide crest, and then 3:1 downstream slopes from 1922 feet to 1902 feet. For conservatism, a freeboard of 0 feet was assumed (pond water to the top of embankment). A freeboard of 0 feet is assumed to be a short-term condition where the embankments surrounding the Pond would not become saturated.

2.2 Engineering Parameters

Golder has previously collected soil and material property information from CCS (Golder 2002). Material properties for each material used for the stability analysis of Ash Pond 91 are given in Table 1.

2.2.1 Existing Natural Soil

Existing Natural Soil properties were based on lab work performed by Golder on three Shelby tube samples taken from the SW16 area. Seven samples were taken from the boreholes yielding an average dry unit weight of 99.1 pcf and an average moisture content of 25.7%. Values of 99 pcf for the dry unit weight and 26% for the moisture content were chosen resulting in a moist unit weight of approximately 125 pcf.

Two triaxial shear strength tests were performed from the Shelby tube samples. Test 1 has an effective cohesion of 590.4 psf and an effective friction angle of 24.3 degrees. Test 2 has an effective cohesion of 57.6 psf and an effective friction angle of 32.7 degrees. Based on these tests, a conservative strength envelope at or below the tested strength envelopes was developed with an effective cohesion of 57 psf and an effective friction angle of 30 degrees.

One hydraulic conductivity test was performed from a Shelby tube sample, and resulted in a saturated hydraulic conductivity of 3.9×10^{-7} cm/sec.

2.2.2 Clay Liner

Clay Liner inputs are based on field experience at the CCS CCP facilities, and published values for CL and CH type materials (NAVFAC 7.02).

Results of saturated hydraulic conductivity, dry unit weight and moisture content from Shelby tube samples of clay liners constructed at CCS indicate a dry unit weight range between 91.9 and 103.8 pcf (99.5 pcf average), and a moisture content range between 18.6 and 27.7 % (22.8 % average). Using the average dry unit weight and moisture content, the moist unit weight is approximately 122 pcf.

Saturated hydraulic conductivity from site Shelby tube samples ranged between $1.8x10^{-8}$ and $8.3x10^{-8}$ cm/sec, with an average value of $3.8x10^{-8}$ cm/sec. Hydraulic conductivity for clay liner is specified in the North Dakota Department of Health regulations as $1x10^{-7}$ cm/sec or less. For analysis, the maximum allowable value of $1x10^{-7}$ cm/sec will be used.

Published values for effective cohesion of CH material suggest a value of 230 psf. Published values for effective cohesion of CL material suggest a value of 270 psf. Published values for effective friction angle of CH material suggest a value of 19 degrees. Published values for effective friction angle of CL material suggest a value of 28 degrees. For conservatism, the lower strength parameters for CH material were chosen for analyses.

2.2.3 Geosynthetics Interfaces

Geomembrane Interface inputs are based on lab work performed by Golder and published values. The interfaces of interest are a smooth HDPE against clay liner and smooth HDPE against sand. The geomembrane/clay interface is more critical than the geomembrane/sand interface; therefore, the geomembrane/sand interface will not be included in analyses. A large direct shear interface friction test was performed between a 40 mil smooth HDPE liner and site specific clays representative of those used in liner construction. Results indicate a residual friction angle of 7.5 degrees and a residual adhesion intercept of approximately 190 psf.

The hydraulic conductivity for HDPE liner was taken from the HELP program documentation as $2.0x10^{-13}$ cm/sec (Schroeder 1994).

Geotextile Interface inputs are based on historical lab information compiled by Golder. Based on interface shear testing between geotextiles and granular soils, friction angles are typically between 25 and 30 degrees. A value of 25 degrees was chosen for this analysis.

2.2.4 Sand Layer

Sand Layer inputs were based on published values for SW and SP type material (NAVFAC 7.02).

Published maximum dry unit weight values range between 100 and 130 pcf (115 pcf average) with optimum moisture contents between 9 and 21% (15% average). Assuming a construction specification of 95% maximum dry density and optimum moisture, the dry unit weight chosen is 109 pcf with a moisture content of 15%. This results in a moist unit weight value of approximately 125 pcf.

Published values for effective cohesion of SW and SP material suggest a value of 0 psf. Published values for effective friction angle of SW material suggest a value of 38 degrees. Published values for effective friction angle of SP material suggest a value of 37 degrees. For conservatism, the lower effective friction angle of the SP material was chosen for analyses.

The average hydraulic conductivity for SW/SP type material was taken from the HELP program documentation as $6.3x10^{-3}$ cm/sec (Schroeder 1994).

2.2.5 Fly Ash

Fly Ash / Fly Ash Paste input parameters are based on lab work performed by Golder for a 75% solids paste mix.

Dry unit weights from lab strength testing ranged between 87.8 pcf and 94.5 pcf with an average value of 91.9 pcf; a value of 92 pcf was chosen. Moisture contents from the same testing ranged between 6.3% and 27.7% with an average value of 16%; a value of 16% was chosen. These values result in a moist unit weight of 107 pcf.

Consolidated undrained triaxial lab testing with pore pressure measurements were used to evaluate the strength of the fly ash. The effective cohesion at 28 days was 1613 psf and the effective friction angle was 32.9 degrees. The effective cohesion at 60 days was 1858 psf and the effective friction angle was 32.2 degrees. The more conservative 28 day strength envelope was chosen for use in the stability analysis.

Lab permeability testing on this material indicated an average hydraulic conductivity of $3.6x10^{-5}$ cm/sec.

2.2.6 Bottom Ash

Bottom Ash input parameters are based on lab and field work performed by Golder.

The dry unit weight for compacted bottom ash is based on 95% standard Proctor densities from lab testing which gives a value of approximately 81 pcf. The dry unit weight of sluiced bottom ash is 60 pcf. A value of 70 pcf was chosen for analysis. The moisture content from field sampling of drained and saturated bottom ash ranged between 12% and 61%. For unsaturated conditions, a moisture content of 18.5% was assumed. Using the lab measured specific gravity of bottom ash (2.60); the moisture content of bottom ash for saturated conditions was determined to be between 40% and 65% (average 52.5%). Bottom ash has average moist unit weight of 83 pcf and an average saturated unit weight of 107 pcf.

Lab direct shear strength testing of bottom ash indicated residual strength values of 463 psf and 40.3 degrees for effective cohesion and effective friction. Visual observations of the bottom ash material indicates little cohesion, therefore the effective cohesion was chosen as 0 psf (lab intercept ignored) and an effective friction value of 40 degrees was chosen for analysis.

Lab rigid wall permeability testing was performed on the bottom ash providing a hydraulic conductivity value range between 0.038 cm/sec (0 psi load) and 0.021 cm/sec (25 psi load). An average hydraulic conductivity value of 0.03 cm/sec was chosen (average of two tests).

2.2.7 Riprap

Riprap input parameters are based on published values for GP materials (Design of Small Dams 1987). The average unit weight for placed materials is 127.5 pcf. The published values for the effective friction angle suggest an angle of 38 degrees. Published values for effective cohesion suggest a value of 5.9 psf. A cohesion value of 0 psf was chosen for analysis.

2.3 Groundwater Information

Groundwater generally moves northeast under Ash Pond 91 toward Samuelson Slough. Groundwater is typically between 5 and 10 feet below the final construction grades of the Pond and is at an approximate elevation between 1880 and 1900 feet amsl (site groundwater monitoring wells). Since the Pond is lined, the flux of water from the Pond to the groundwater is expected to be minimal.

2.4 Stability Analysis

Golder performed a stability analysis using SLIDE, a two-dimensional slope stability computer program developed by Rocscience Inc. (2009). Factors of safety were computed for circular failure surfaces using Spencer method for force and moment equilibrium. The resulting factor of safety against slope movement is 2.3, which exceeds the typical minimum acceptable factor of safety of 1.5 for permanent civil engineering structures. The failure surface calculated by SLIDE is shown in Figure 4. Based on the factor of safety computed using SLIDE, Ash Pond 91 is expected to remain stable under anticipated loading conditions.

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 Ash Pond 91 were performed on October 2, 2009 by Craig Schuettpelz and November 2, 2009 by Todd Stong. Golder observed the condition of inflow and outflow structures (if applicable), upstream berm slopes, the berm crest, downstream berm slopes, and the berm toe. Inspection checklist logs are included in Appendix B and photographs taken during the visual observations are included in Appendix C.

3.2.1 Inflow and Outflow Structures

Inflow structures to Ash Pond 91 consist of drainage pipes from Ash Pond 92/SW16 (Upstream Raise), culverts from the ash pipeline ditch, and the ash lines conveying bottom ash, pulverizer rejects and economizer ash. Some of these pipes are buried or below water and could not be observed. The pipes observed appeared to be in good condition with no noticeable settlement, cracking, significant corrosion, or significant erosion. The inflow structures were in fair condition. The outflow structures from Ash

Pond 91 consist of cross-over pipes directing water to the Drains Pond. These pipes were below water and could not be observed.

3.2.2 Upstream Slope

The slopes appeared to match the design slopes of 3:1 with no observed sections of significant slope difference. Slopes are being protected from erosion with a cemented fly ash layer from the floor up to near the embankment crest with riprap placed along the top 4 feet of the west and south sides. The fly ash layer and riprap appeared to be competent with no signs of significant distress. The water level is typically managed between Elevation 1916 and 1918 (4 to 6 feet freeboard). At the time of observations, the water level was approximately five feet below the embankment crest. Ash is placed along the north and east sides and these upstream slopes are mostly covered. The upstream slopes of Ash Pond 91 appear to be in good condition.

3.2.3 Crest

The berm crest around Ash Pond 91 is paved with gravel and used for both light vehicle and heavy construction equipment traffic. The crest roads on the west and south sides experience little heavy traffic and are mostly exposed to light vehicle traffic (cars, pickups, etc.). The crest road on the north and east sides of the Pond experience frequent heavy traffic from large haul trucks. The road on the crest of Ash Pond 91 appears to be in good condition, with no noticeable cracking or settlement, and appears to be well maintained.

3.2.4 Downstream Slope

The downstream slopes range from 0 to 20 feet in height and are heavily vegetated with native grasses. Golder did not observe indications of seepage, sloughing, cracking, significant erosion, excessive settlement, or vegetation that seemed to be thriving abnormally. Ground conditions were firm, with the exception of small areas of animal burrowing along the north and south downstream slopes. The downstream slope is generally in good condition.

3.2.5 Toe

There was no toe drain in the design of the Ash Pond 91 embankments. The environment at the toe of slope varies substantially surrounding the Pond. Ash Pond 92 is directly east of Ash Pond 91 and there is no downstream slope on the toe. North of the pond, the toe of the slope is covered with tall grass with no noticeable wet areas. There is a small drainage pond west of Ash Pond 91 that has some cat tails and appears to be full of water year round. The toe of the slope south of the Pond is in a site stormwater drainage channel with mostly tall grass, with some woody and marshy vegetation in the ditch between the rail lines and the crest of the Pond. There was little standing water in the ditch at the time of observation. The embankment toe is generally in good condition.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This report summarizes the results of Golder's stability analysis and visual observations to evaluate the stability of Ash Pond 91 at Great River Energy's Coal Creek Station. The report presents background information for the facility, results of a slope stability analysis, and the outcomes of visual observations of the facility conducted October 2, 2009 and November 2, 2009.

Ash Pond 91 is a storage facility for CCPs and process water. The Pond is contained with an engineered embankment with a composite liner installed in the early 1990s. Golder analyzed the stability of a cross section through the south side of the Pond. The factor of safety resulting from the stability analysis is 2.3, indicating the facility should remain stable for the anticipated loading conditions. Golder observed good vegetation and site maintenance and did not identify significant deficiencies such as seepage, excessive erosion or settlement, or cracking during visual observations of Ash Pond 91. The overall condition of Ash Pond 91 is good.

Golder recommends that CCS continue to perform monthly observations of Ash Pond 91, particularly the berm crest and downstream berm slopes, to identify undesirable or changing conditions. Such conditions may include, but are not limited to: seepage, sloughing, cracking, excessive settlement, extensive animal burrowing, excessive erosion, and abnormal thriving of vegetation.

GOLDER ASSOCIATES INC.

Ron Jorgenson	Todd Stong, P.E.	Craig Schuettpelz
Principal	Senior Project Engineer	Geological Engineer

5.0 REFERENCES

Barr Engineering Company. (February 1982). *Seepage and Stability Analysis*, Prepared for Cooperative Power Association.

Cooperative Power and United Power Association. (1989). *Application to Renew Permit to Operate a Special Use Disposal Site, Coal Creek Station, Permit Number SU-033*. Prepared for the North Dakota State Department of Health and Consolidated Laboratories.

Design of Small Dams, Department of the Interior – Bureau of Reclamation, 1987.

Foundations and Earth Structures, Design Manual 7.02, Naval Facilities Engineering Command, September 1996 (NAVFAC 7.02)

Golder Associates Inc. (2002). *Material Properties, Permit Number SP-033*, Job Ref. 023-2409. Prepared for Great River Energy.

Rocscience Inc. 2009. SLIDE Version 5.043.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M., and Zappi, P. A. (1994). *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*, EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

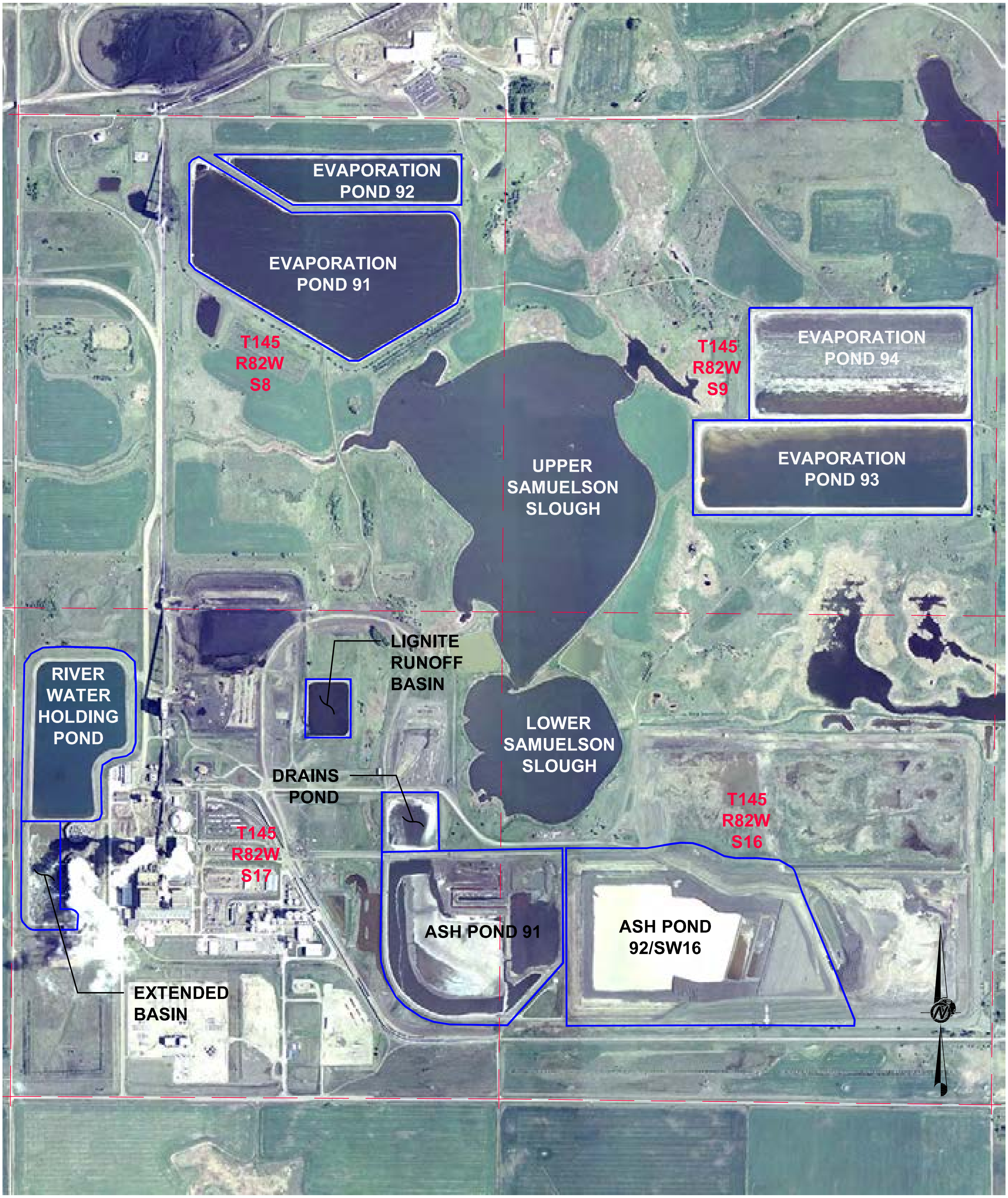
TABLES

TABLE 1

MATERIAL PROPERTIES SUMMARY TABLE

	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	Su psf
Natural/Existing Soil	3.9E-07	99	26.0	125	NA	NA	30	57	NA
Clay Liner	1.0E-07	99.5	22.8	122	NA	NA	19	230	NA
Smooth HDPE / Clay	2.0E-13	NA	NA	NA	NA	NA	7.5	190	NA
Sand Layer	6.3E-03	109	15	125	NA	NA	37	0	NA
Average Bottom Ash	3.0E-02	70	18.5	83	52.5	107	40	0	NA
Riprap	-	127.5	0	127.5	NA	NA	38	0	NA
Geotextile / Sand	-	NA	NA	NA	NA	NA	25	0	NA
Fly Ash / Paste	3.6E-05	92	16	107	NA	NA	32.9	1613	NA

FIGURES



Aerial image from GRE taken June 19, 2008

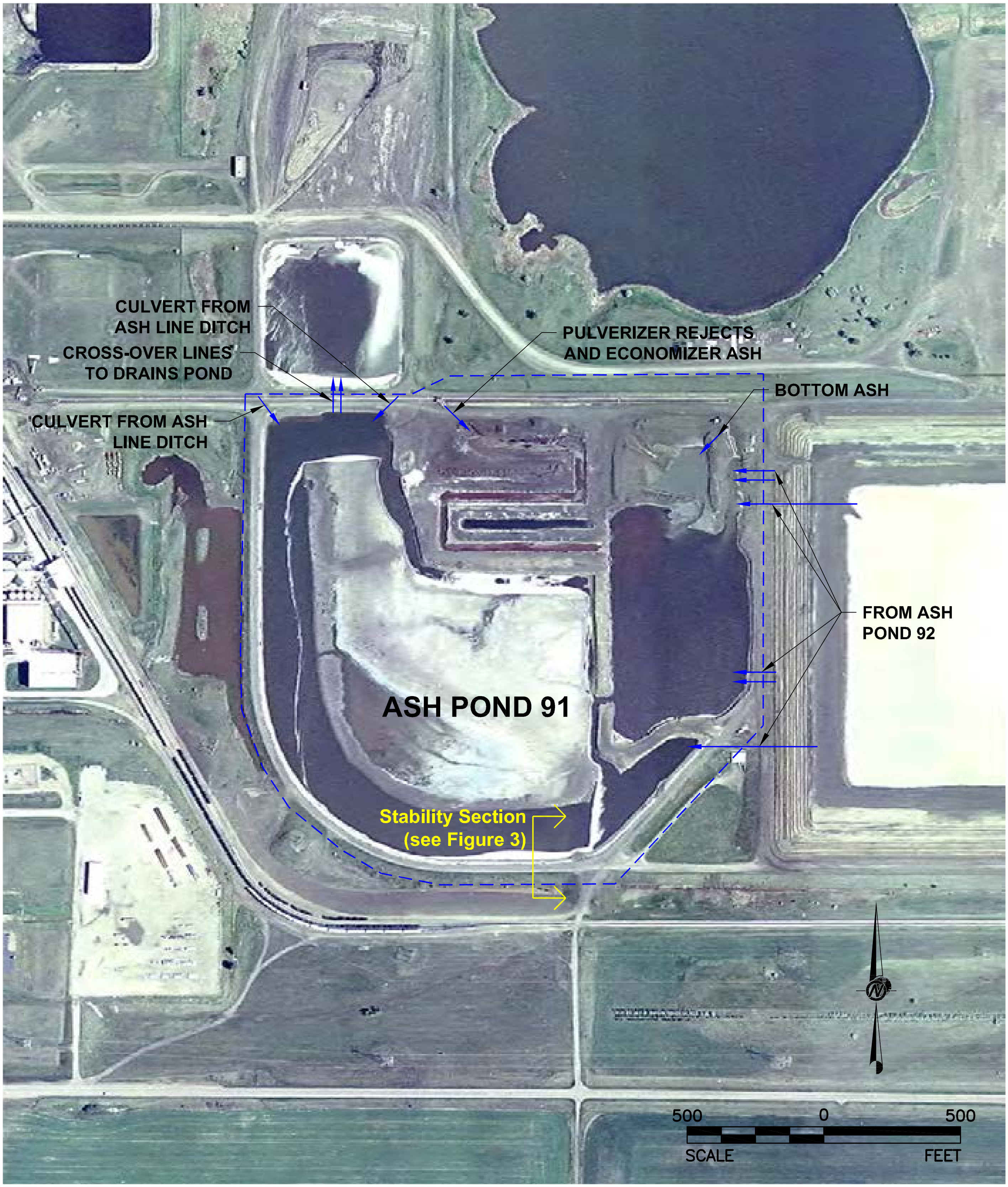
COAL CREEK STATION POND LAYOUT

Golder Associates
DENVER, COLORADO

FIGURE 1

PROJECT No.093-81601 CADD CCS DATE 04/02/10 FILE No. Figure ASH POND 91.dwg

Plot Time: 04/14/10 16:00



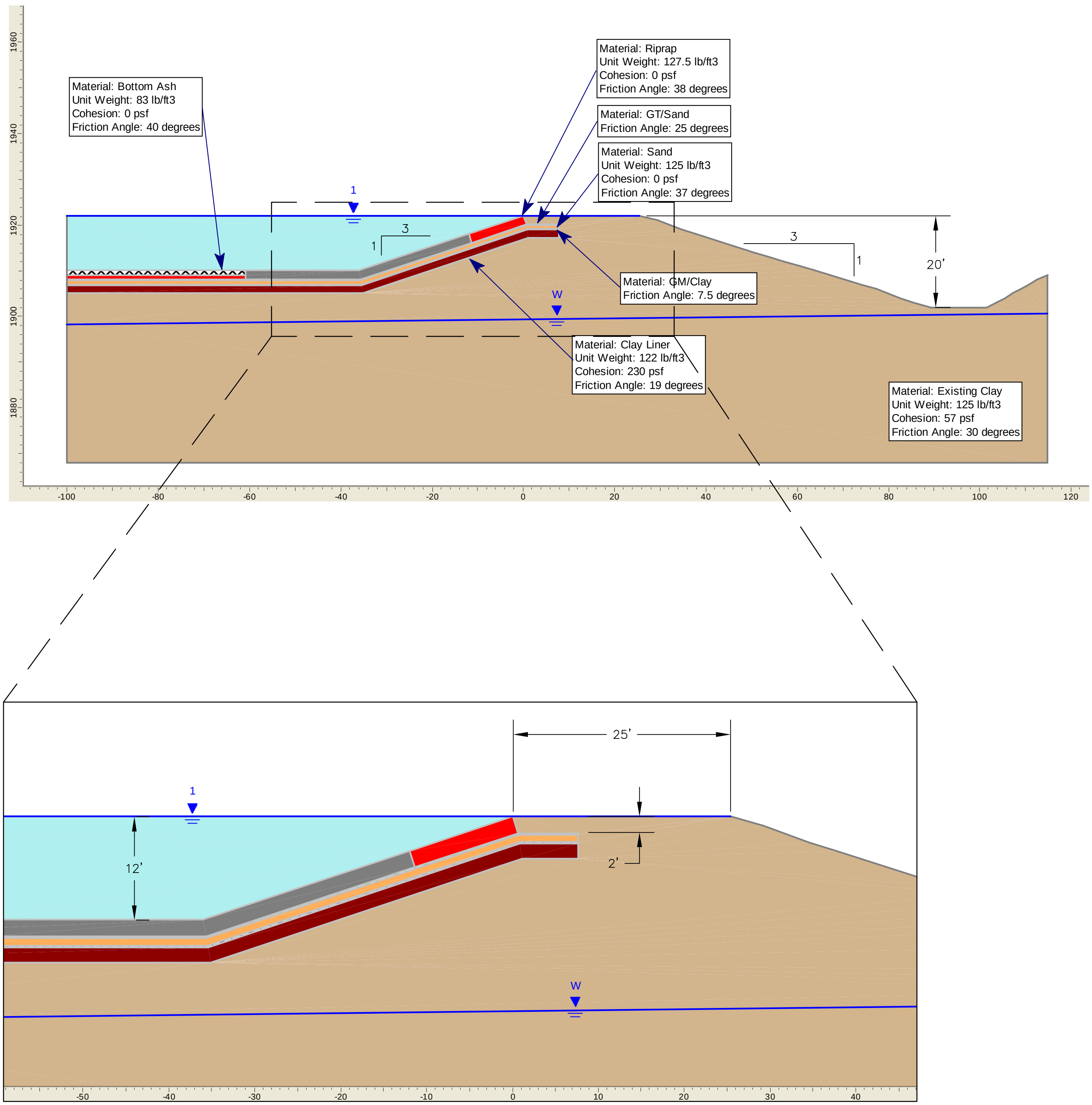
Aerial image from GRE taken June 19, 2008

ASH POND 91 LAYOUT

FIGURE 2

Golder Associates
DENVER, COLORADO

PROJECT No.093-81601 CADD CCS DATE 04/02/10 FILE No. Figure ASH POND 91.dwg

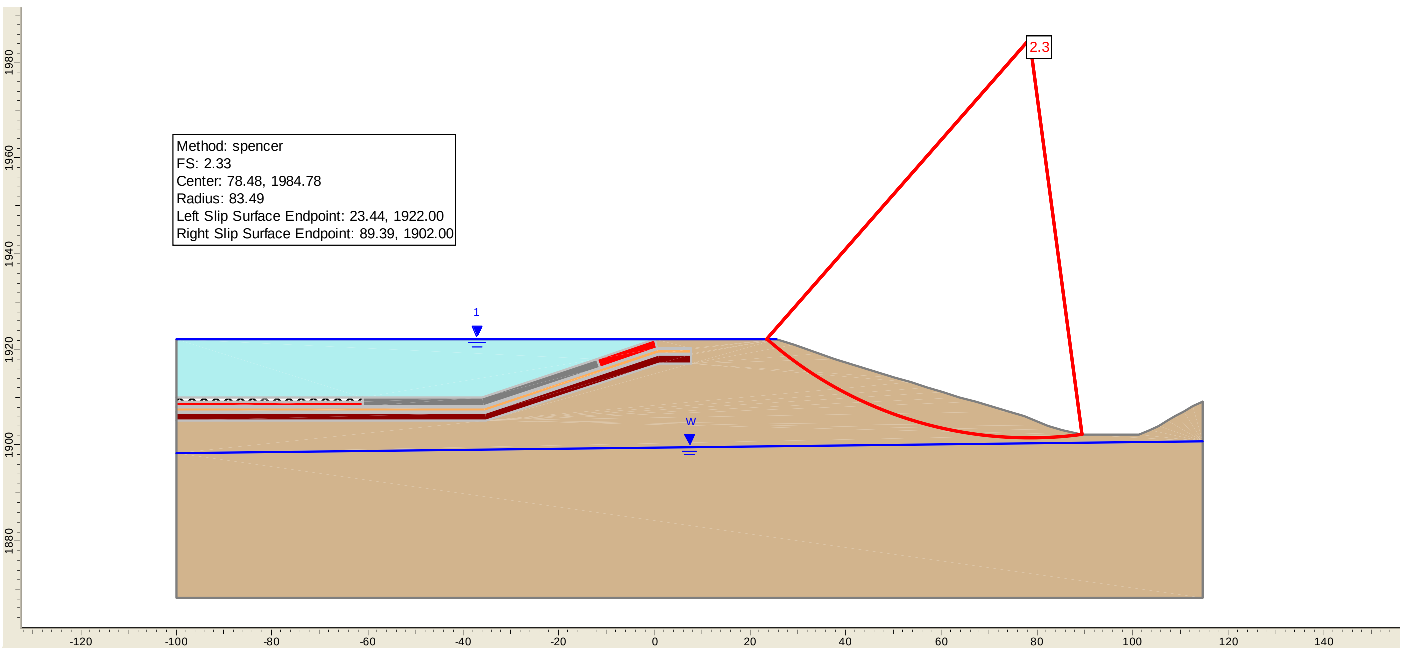


Golder Associates
DENVER, COLORADO

CROSS SECTION

FIGURE 3

PROJECT No.093-81601 CADD CCS DATE 04/02/10 FILE No. Figure ASH POND 91.dwg



Golder Associates
DENVER, COLORADO

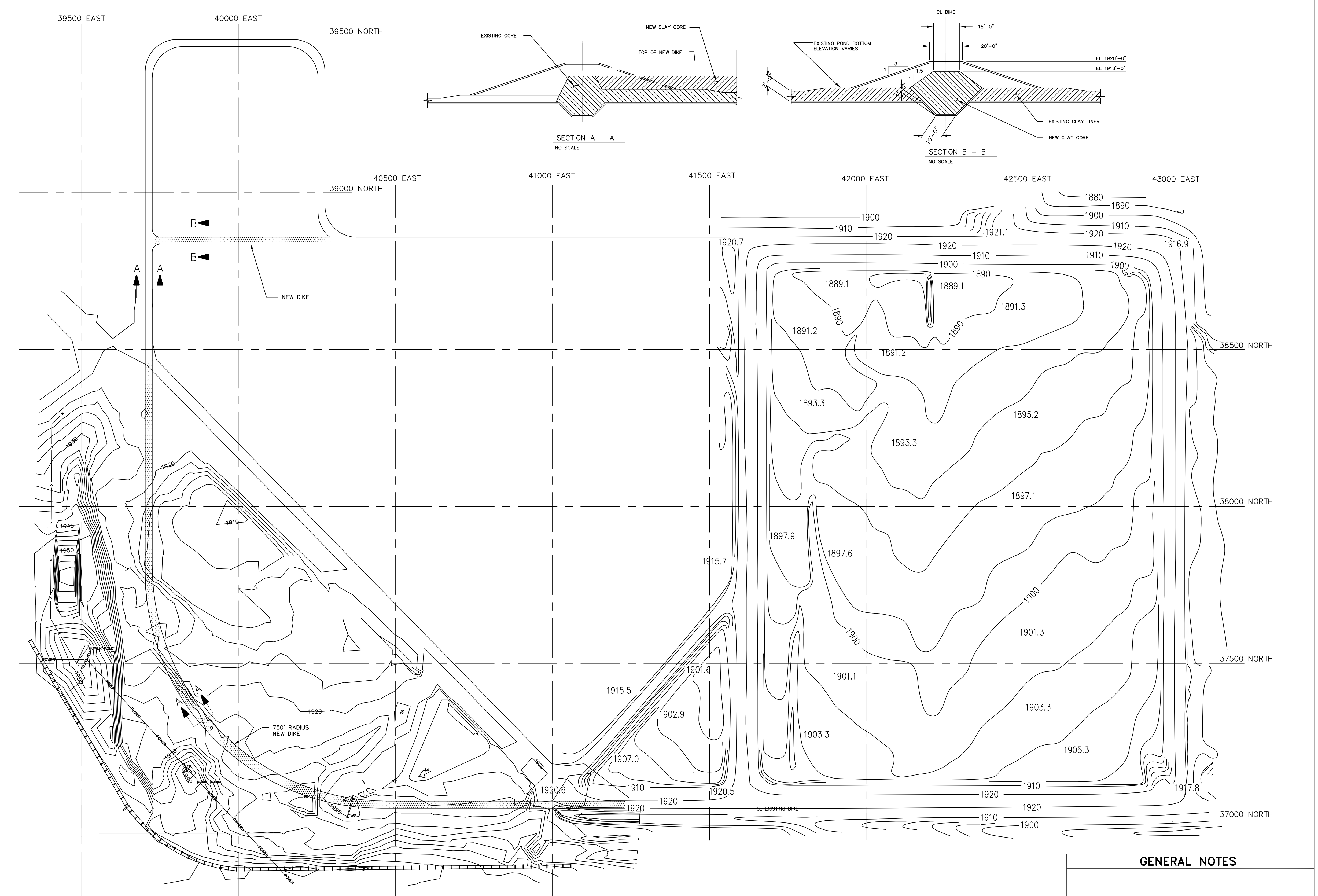
STABILITY ANALYSIS RESULTS

FIGURE 4

PROJECT No.093–81601 CADD CCS DATE 04/02/10 FILE No. Figure ASH POND 91.dwg

APPENDIX A

ORIGINAL CONSTRUCTION DRAWINGS



GENERAL NOTES

DRAWING NO.	REVISION	REFERENCE DRAWINGS

DWN. JJ | CHK.
DATE 01/07/91
W/O 91G105

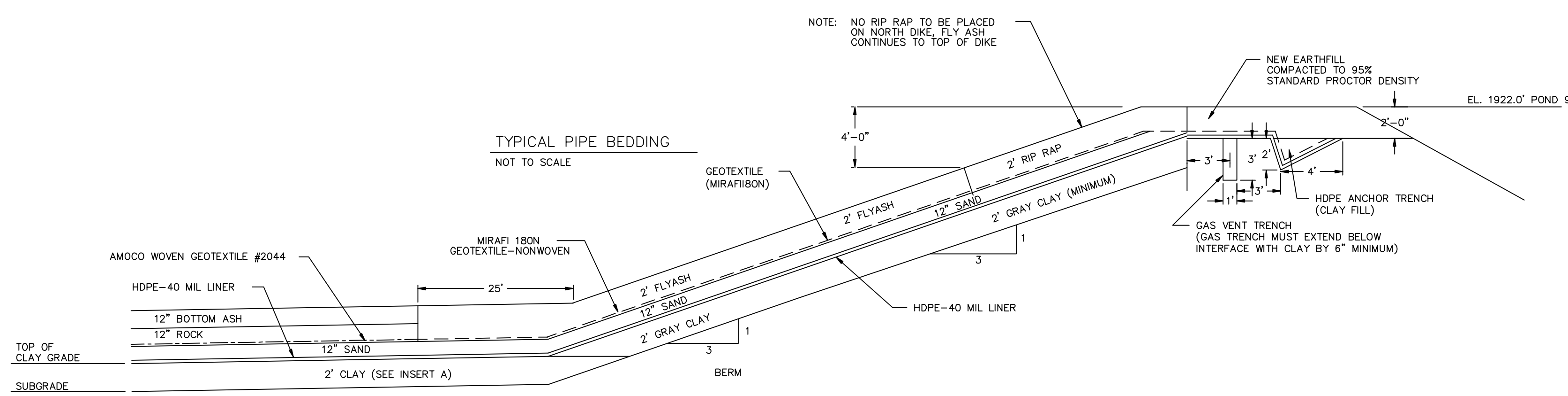
COOPERATIVE POWER Association

SOUTH ASH POND– SECTIONS AND ELEVS

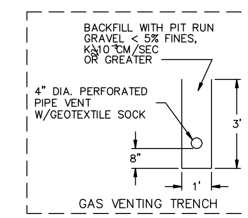
1991 ASH DISPOSAL

DRAWING NO. 91G105–26

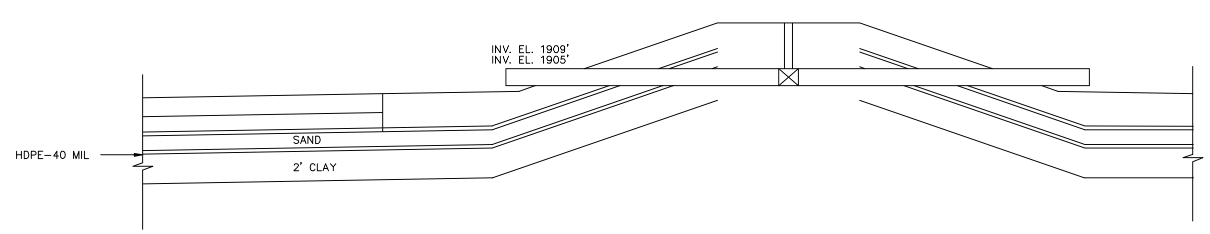
DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK.	APP
02/27/91	ISSUED FOR CONSTRUCTION	1	RR	AS	
01/18/91	ISSUED FOR BID	0	JJ	AS	



BERM & BOTTOM SECTION
ASH POND 91
(1/17) NOT TO SCALE



NOTE:
1. PROVIDE PERFORATED PIPE VENTS (PVC-SHED40), EACH APPROX. 120' LONG AND 4" DIA. IN THE GAS VENTING TRENCHES. THE EXACT LENGTHES TO BE DETERMINED BY SITE REPRESENTATIVE.
2. THE EXPOSED ENDS OF 4" DIA. GAS VENTING PIPE SHALL BE PROTECTED WITH BOTH A 1/2" STAINLESS STEEL SCREEN AND REGULAR SCREENING MATERIALS.



PIPE PENETRATION – BERM
ASH POND 91 AND DRAIN POND 91
(2/17) NOT TO SCALE

VALVE LIST

ITEM NO.	SYSTEM TAG	DESCRIPTION	B & V FILE NO.	SIZE IN.	PRESS TEMP	PRESS CLASS	TYPE	BODY MAT	END PREP	MFGR NO.	SHOP NO.	REMARKS
	WC08-VL9168	ASH POND 91-PLANT DRAIN POND		18	100	150	GA	CI				UNDERGROUND VALVE WITH VALVE BOX
	WC08-VL9169	PLANT DRAIN POND DISCHARGE		18	100	150	GA	CI				UNDERGROUND VALVE WITH VALVE BOX

DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK.	APP
03-16-92	ISSUED FOR CONSTRUCTION	1	BK	AS	AS
01/09/92	ISSUED FOR BID	0	BK	AS	AS

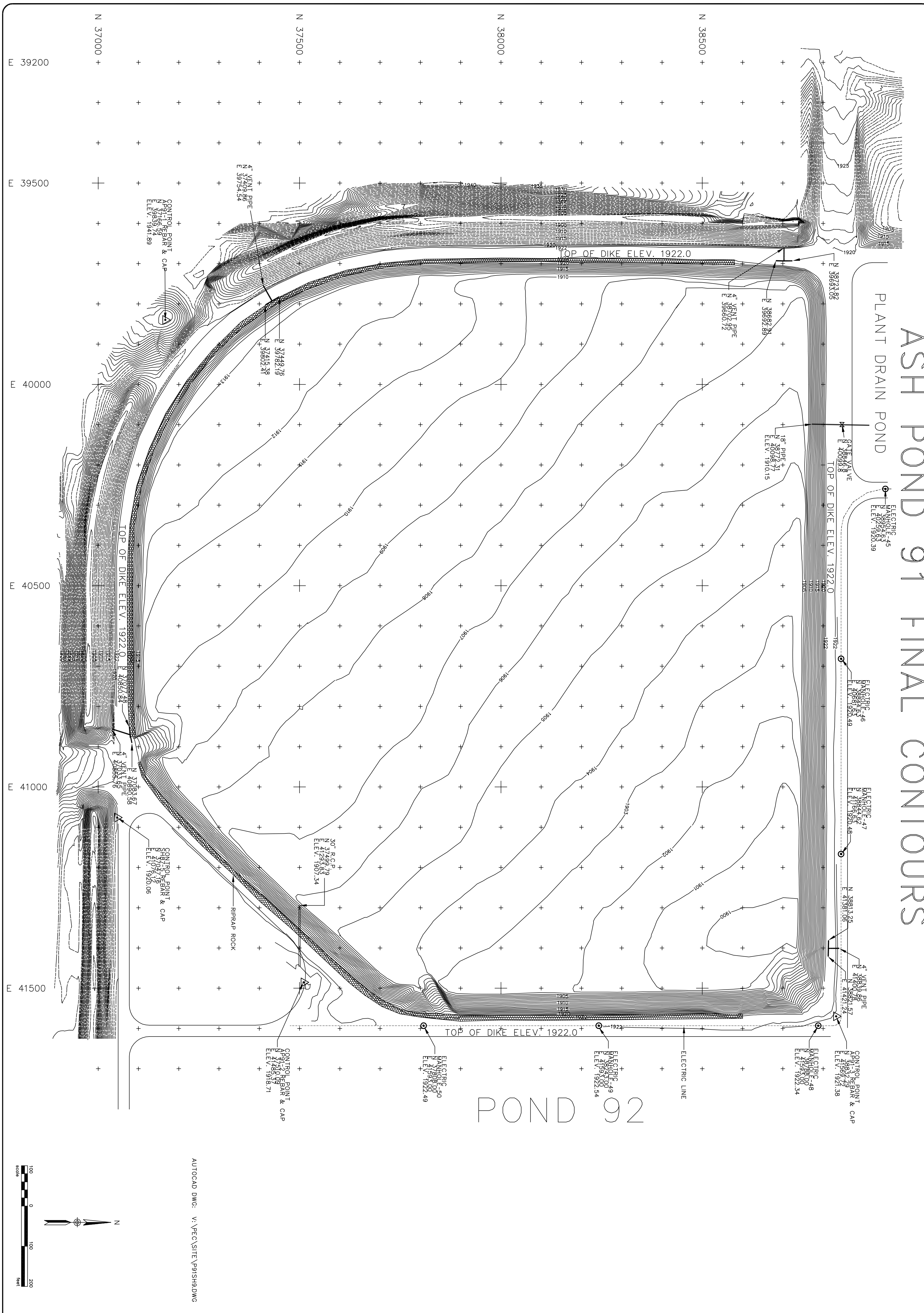
GENERAL NOTES

DRAWING NO.	REVISION	REFERENCE DRAWINGS

DWN. BAK CHK.
DATE 12/26/91
W/O 920213

COOPERATIVE POWER Association

TYPICAL SECTIONS AND DETAILS
1992 ASH DISPOSAL
DRAWING NO. 92G213-17



SHEET NO. 9

interstate engineering, inc.

Engineering – Surveying – Planning

COOPERATIVE POWER ASSOCIATION
UNDERWOOD, NORTH DAKOTA

ASH POND 91 FINAL CONTOURS

Drawn By D.B.J. Project No. B92-17-02
Checked By L.H.K Date 1/25/94

Revision No.	Date	By	Description

APPENDIX B

VISUAL OBSERVATIONS

IMPOUNDMENT INSPECTION CHECKLIST

Facility Name: Ash Pond 91
Owner and Address: Great River Energy - Coal Creek Station
2875 Third street SW, Underwood, ND
Purpose of Facility: Water and CCP storage
Legal: Section: 16 + 17 **Township:** 145 N **Range:** 82W
County: McLean
Inspected By: Todd Stong **Inspection Date:** November 2, 2009 (1:30 pm)
Weather: Sunny, clear, ~45°F

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations	X			HDPE Liner, cross-over pipes to drains pond & Ash Pond 92
b. Development of downstream plain			—	
c. Grass cover	X			
d. Settlement/misalignment/cracks		X		
e. High water mark	X			Elevation:
f. Current water level	X			Elevation: 4-6' below high mark
g. Sudden drops in water level?		X		
2. Inflow Structure				BA line, PREA lines, Ash Pond 92 flows
a. Settlement			—	
b. Cracking			—	* lines come in sub-aqueous or
c. Corrosion		X		into ash. Inflow structures
d. Obstacles in inlet		X		are pipes.
e. Riprap/erosion control			—	
3. Outflow Structure				Pipes to Drains pond
a. Settlement			—	
b. Cracking			—	* Sub-aqueous pipes, could not
c. Corrosion			—	be inspected
d. Obstacles in outlet			—	
e. Riprap/erosion control			—	
4. Upstream slope (inside)				
a. Erosion – liner exposed?		X		
b. Rodent burrows		X		
c. Vegetation		X		
d. Cracks/settlement		X		
e. Riprap/other erosion protection	X			Riprap on upper portion, hardpan FA below
5. Crest				
a. Soil condition	X			BA/Gravel roadway
b. Comparable to design width		X		Much wider on north side
c. Vegetation		X		
d. Rodent burrows		X		
e. Exposed to heavy traffic	X			Particularly North & East side (CAT-777)
f. Damage from vehicles/machinery		X		
6. Downstream slope (outside)				
a. Erosion		X		
b. Vegetation	X			Healthy native grass
c. Rodent burrows	X			
d. Cracks/settlement/scarps		X		
e. Drain conditions			—	No drain
f. Seepage		X		
7. Toe				
a. Vegetation	X			
b. Rodent burrows	X			
c. Settlement		X		
d. Drainage conditions			—	No drain (toe often into pond or SW drainage)
e. Seepage		X		

General Remarks: No significant stability/structural concerns observed.

Name of Engineer: Todd Stong
Date: Nov 2, 2009
Engineering Firm: Golder Associates Inc.
Signature: Todd Stong

REGISTERED PROFESSIONAL ENGINEER
TODD J. STONG
PE-6[illegible]
Todd Stong
DATE 11/2/09
NORTH DAKOTA
PROFESSIONAL ENGINEER SEAL

IMPOUNDMENT INSPECTION CHECKLIST

Facility Name: ASH POND 91
Owner and Address: GREAT RIVER ENERGY - COAL CREEK STATION
2875 THIRD ST SW, UNDERWOOD ND
Purpose of Facility: WATER & CCP STORAGE
Legal: Section: 16 + 17 **Township:** 145N **Range:** 82W
County: MCLEAN
Inspected By: CRAIG SCHUETTPELZ **Inspection Date:** 10/2/09
Weather: RAIN, 40°F

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations	X			HDPE LINER
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: ~3-4' BELOW RIPRAP
g. Sudden drops in water level?		X		
2. Inflow Structure				
a. Settlement			—	BA LINES, CULVERTS
b. Cracking			—	
c. Corrosion		X		
d. Obstacles in inlet		X		
e. Riprap/erosion control			—	
3. Outflow Structure				NOT VISIBLE
a. Settlement			—	
b. Cracking			—	
c. Corrosion			—	
d. Obstacles in outlet			—	
e. Riprap/erosion control			—	
4. Upstream slope				
a. Erosion – liner exposed?		X		
b. Rodent burrows		X		
c. Vegetation		X		
d. Cracks/settlement		X		
e. Riprap/other erosion protection	X			FLY ASH ALL AROUND, RIPRAP ON E, S, W SIDES
5. Crest				
a. Soil condition	X			
b. Comparable to design width	X			WIDER ON NORTH SIDE
c. Vegetation		X		
d. Rodent burrows		X		
e. Exposed to heavy traffic	X			HEAVY EQUIP. ON N. SIDE
f. Damage from vehicles/machinery		X		
6. Downstream slope				
a. Erosion		X		
b. Vegetation	X			GRASS, MARSHY IN DITCHES ON S. AND W. SIDES
c. Rodent burrows	X			
d. Cracks/settlement/scarps		X		
e. Drain conditions			—	DRAINAGE DITCHES GOOD
f. Seepage		X		
7. Toe				
a. Vegetation	X			GRASS
b. Rodent burrows		X		
c. Settlement		X		
d. Drainage conditions			—	
e. Seepage		X		

General Remarks: NO SIGNIFICANT STABILITY CONCERNS FOR ASH POND 91

Name of Engineer: Todd Stong
Date: Nov 20, 2009
Engineering Firm: Golder Associates Inc.
Signature: Todd Stong

REGISTERED PROFESSIONAL ENGINEER
TODD J. STONG
PE-6144
DATE: 11/20/09
NORTH DAKOTA
PROFESSIONAL ENGINEER SEAL

APPENDIX C

PHOTOGRAPHS

Ash Pond 91 from NW Corner

Ash Pond 91 from SW Corner

Gas Vent Pipe

Riprap and Fly Ash Upstream Slope Protection

Downstream Slope – North Side (looking east)

Downstream Slope – West Side (looking north)

	
Ash Pond 92 Drain Lines	Pulverizer Rejects and Economizer Ash Discharge
	
Surface Water Culvert from Ash Line Ditch (North side)	Surface Water Culvert from Ash Line Ditch (NW corner)

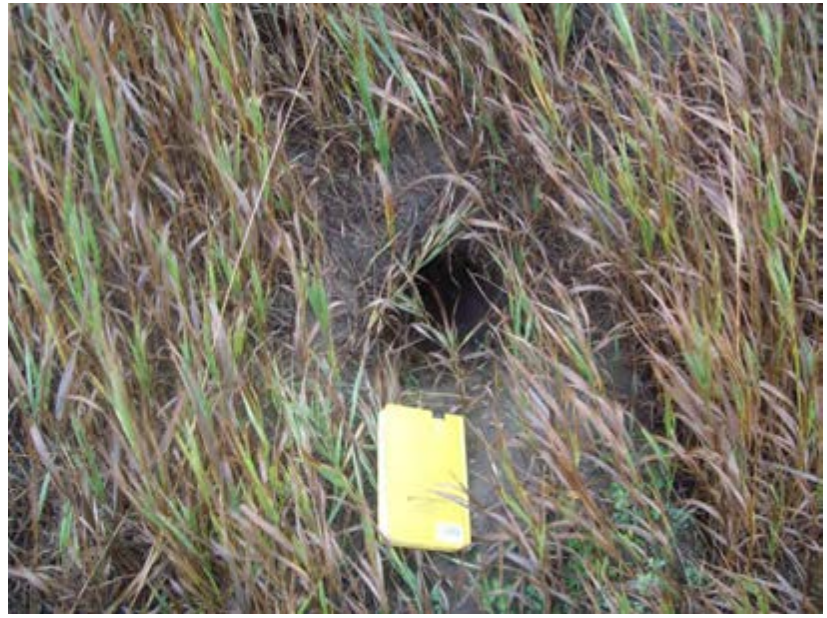
Downstream Slope – North Side Crest (looking west)

Crest Road – SW Corner (looking east)

Upstream Slope – North Side (looking west)

Riprap and Cemented Fly Ash on Upstream Slope (west side)

Stormwater Drains from Ash Pond 92



Small Animal Burrow

Pulverizer Rejects and Economizer Ash Discharge

Bottom Ash – Northeast Side (looking southwest)

OBJECTIVE:

Evaluate the seismic (pseudo-static) stability of the Ash Pond 91 and Ash Pond 92/SW Section 16 coal combustion product storage facilities at Great River Energy's (GRE) Coal Creek Station (CCS).

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 and noncircular slip surfaces using Spencer's method for force and moment equilibrium to determine limiting conditions.

ASSUMPTIONS:

Site

Coal Creek 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 Attachment C).

Underlying CCP Materials

Both Ash Pond 91 and Ash Pond 92/SW Section 16 (upstream raise) are constructed over historic coal combustion product (CCP) disposal/storage facilities.

Ash Pond 91 and the Ash Pond 92 portion of the upstream raise are constructed over the original South Ash Pond. Prior to construction of the composite liner systems for Ash Pond 91 and the Ash Pond 92 portion of the upstream raise (constructed in 1992 and 1989 respectively), CCPs and unsuitable material in the south ash pond were removed and disposed of in the Section 5 dry ash landfill. Based on our review of this site history and experience on site, neither Ash Pond 91 or the Ash Pond 92 portion of the upstream raise are built over wet ash or other unsuitable materials.

The Southwest Section 16 portion of the upstream raise is constructed over the southwest corner of the original East Ash Pond. This part of the East Ash Pond was converted into a dry disposal facility in 1989 and received CCPs from the northwest corner of the East Ash Pond including soil, fly ash, bottom ash, and flue gas desulfurization sludge (FGD). A temporary cover was placed over the CCPs with no activity until construction of the upstream raise. The Southwest Section 16 portion of the upstream raise was constructed over this dry disposal area between 2003 and 2008 and included regrading of CCPs, construction of containment berms, and the installation of a composite liner system. Based on our review of this site history and experience on site, some of the CCPs below the Southwest Section 16 portion of the upstream raise may include wet CCPs. Due to this possibility, the slope stability evaluation cross sections for the Southwest Section 16 portion of the upstream raise conservatively model the slope with a large zone of wet FGD below the composite liner.

Geometry

Golder developed several cross sections through Ash Pond 92/SW Section 16 to analyze interior and exterior slope stability of the facility at full design height and representing intermediate stages of development. Seismic slope stability scenarios mirror static slope stability analyses presented in Golder's Evaluation of Ash Pond 92/SW Section 16 Stability Report (dated August 6, 2010, revised December 21 2010).

- Scenario 1: Ash Pond 92 – Perimeter Berm
- Scenario 2: Ash Pond 92 – Geomembrane Interface
- Scenario 3: Ash Pond 92 – Intermediate Sludge Level
- Scenario 4: SW Section 16 – Perimeter Berm
- Scenario 5: SW Section 16 – Global
- Scenario 6: SW Section 16 – Geomembrane Interface
- Scenario 7: Interior Bottom Ash / Sludge

Golder also developed a cross section through Ash Pond 91 to analyze exterior seismic slope stability. The cross section is the same as the section used for the static analysis presented in Golder's Evaluation of Ash Pond 91 Stability Report (dated April 13, 2010).

Groundwater Information

Groundwater information used in seismic slope stability analyses is provided in Golder's Evaluation of Ash Pond 92/SW Section 16 Stability Report (dated August 6, 2010, rev. December 21 2010) and Golder's Evaluation of Ash Pond 91 Stability Report (dated April 13, 2010).

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 Attachment C). 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 are provided in Golder's Evaluation of Ash Pond 92/SW Section 16 Stability Report (dated August 6, 2010, rev. December 21 2010) and Golder's Evaluation of Ash Pond 91 Stability Report (dated April 13, 2010). Per the seismic stability method (EPA 1995), fine grained soils (natural soil, mixed waste, cover soil, FGD sludge, and clay liner), were assigned strength parameters corresponding to 80 percent of the total stress strength parameters:

- Existing soil and mixed waste were assigned a cohesion of 165 psf and a friction angle of 14 degrees (210 psf and 17.5 degrees static).
- Clay liner and cover soil were assigned an undrained shear strength of 1,600 psf (2,000 psf static) based on literature values for CH material (NAVFAC 7.02).
- FGD sludge was assigned a shear normal function following the table below, based on 80% of the shear-normal function for static conditions:

Assumed Dynamic Shear Strength Envelope	
Normal Stress	Shear Strength
psf	psf
0	80
3,000	800
10,000	800

Granular materials (bottom ash, Pit Run, and sand) are modeled with static shear strengths with no seismic reduction. These materials are well compacted within the facility and the majority of the bottom ash is unsaturated.

The geomembrane interface strength parameters were not modified for pseudo-static stability conditions based on recommendations in documentation provided by the EPA (1995). A summary of the static and pseudo-static material properties is provided in Attachment A.

RESULTS:

Golder performed seismic stability analyses using SLIDE. Factors of safety were computed for circular and noncircular slip surfaces using Spencer's method for force and moment equilibrium. Results of stability analyses are presented in figures 1-9 in Attachment B.

For Ash Pond 92/SW Section 16, scenarios 1 and 4 were analyzed using circular slip surfaces as surfaces were assumed to cut through a homogeneous section of the exterior perimeter berm. Scenario 7 was also analyzed with circular slip surfaces as there was no evidence of a distinct weak layer. Scenario 5 was evaluated using a noncircular slip surface, analyzing historically deposited and potentially weak CCP layers in SW Section 16. Scenarios 2, 3, and 6 were evaluated using noncircular slip surfaces to analyze the potentially weak interface between the clay liner and geomembrane. A summary of factors of safety calculated for each scenario are provided in the following table:

Scenario	Description		Static Factor of Safety	Seismic Factor of Safety
1	Ash Pond 92 – Perimeter Berm		**1.9**	**1.2**
2	Ash Pond 92 – Geomembrane Interface		**1.4**	**1.2**
3	Ash Pond 92 – Intermediate Sludge Level		**1.6**	**1.3**
4	SW Section 16 – Perimeter Berm		**1.9**	**1.4**
5	SW Section 16 – Global		**2.0**	**1.6**
6	SW Section 16 – Geomembrane Interface		**3.4**	**3.1**
7	Ash Pond 92 Interior Bottom Ash / Sludge	No Equipment	**1.7**	**1.4**
		Equipment Loading	**1.3**	**1.1**

For Ash Pond 91, stability was analyzed using circular slip surfaces as there was no evidence of a distinct weak layer through the exterior of the facility. Factors of safety for Ash Pond 91 are summarized in the following table:

Description	Static Factor of Safety	Seismic Factor of Safety
Ash Pond 91	**2.3**	**1.5**

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. No rigid structures are constructed on the facility that could be affected by expected deformations.

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/

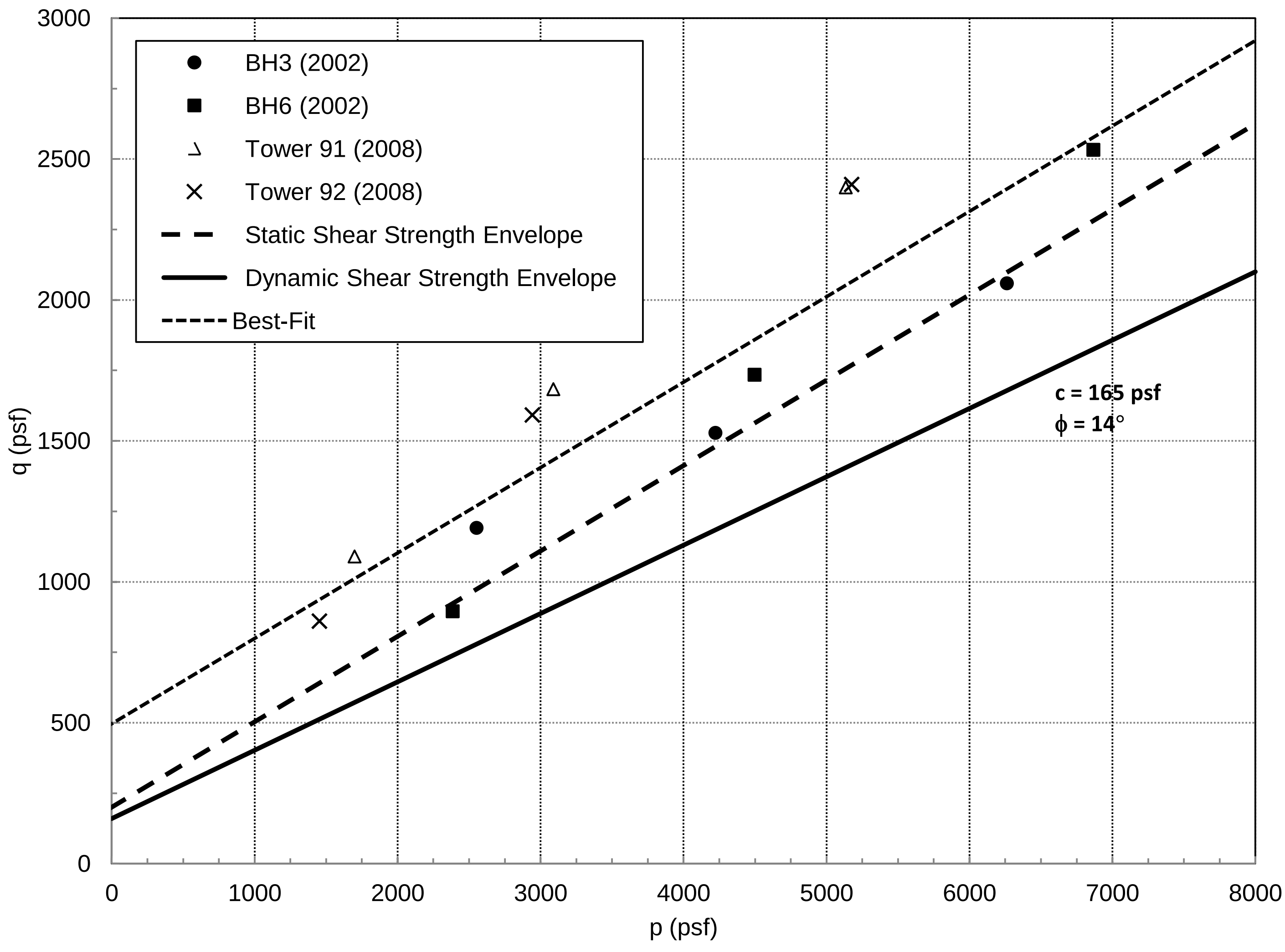
ATTACHMENT A

SHEAR STRENGTH

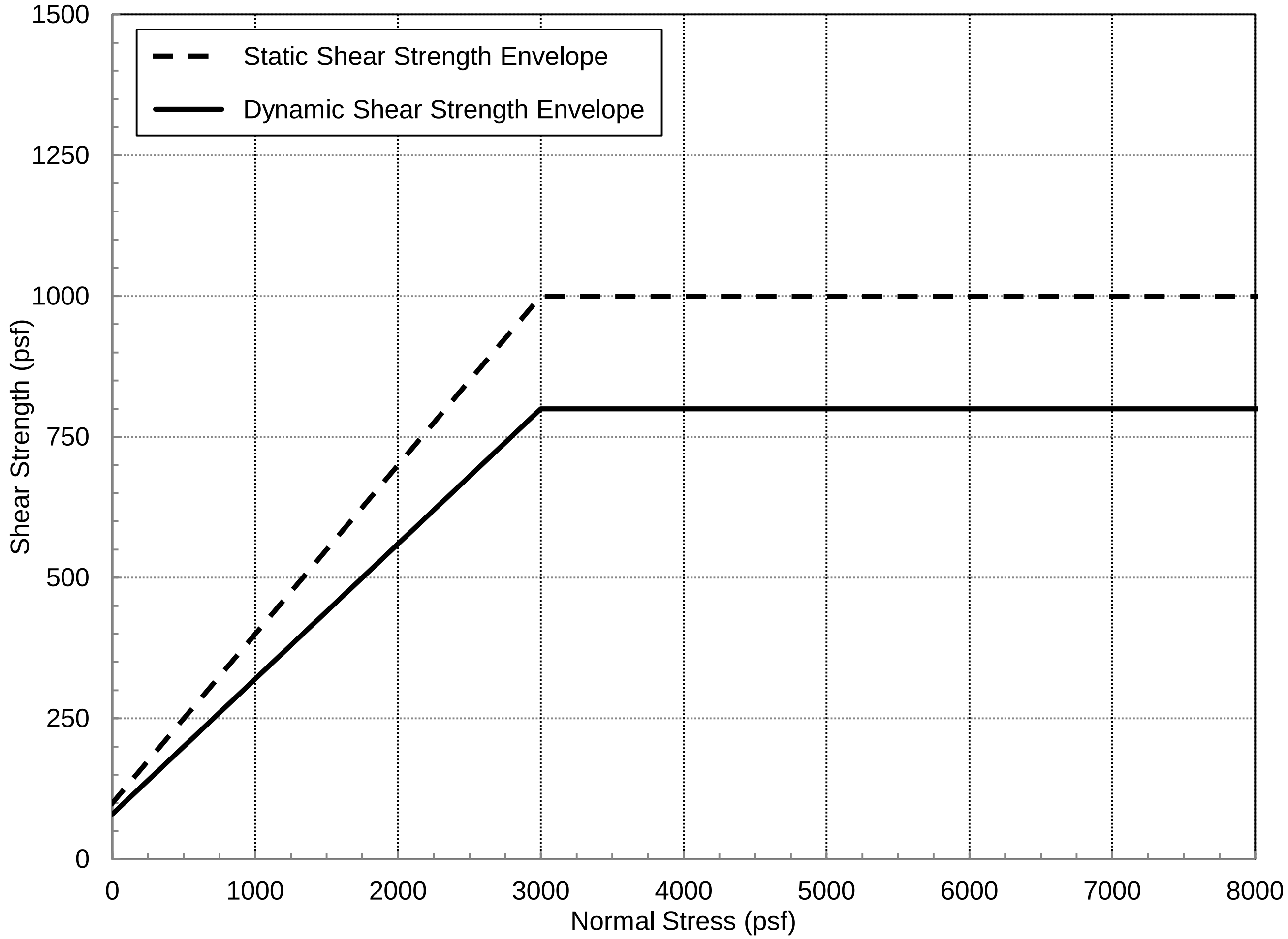
Shear Strength Parameters

	Static Shear Strength Parameters		Dynamic Shear Strength Parameters		
	ϕ/δ degrees	c/a psf	ϕ/δ degrees	c/a psf	S_u psf
Existing Natural Soil	30	57	**14**	**165**	**NA**
Clay Liner	19	230	**NA**	**NA**	**1,600**
Smooth HDPE / Clay	7.5	190	7.5	190	NA
Smooth HDPE / Sand	17	0	17	0	NA
Tex. LLDPE / Clay	35	0	35	0	NA
Tex. LLDPE / Sand	35	0	35	0	NA
Sand	37	0	37	0	NA
Fly Ash	32.9	1613	32.9	1613	NA
Bottom Ash	40	50	40	50	NA
FGD Sludge	Shear Normal Fx	Shear Normal Fx	**Shear Normal Fx**	**Shear Normal Fx**	**NA**
Mixed Waste	30	57	**14**	**165**	**NA**
Cover Soil	19	230	**NA**	**NA**	**1,600**
Pit Run	34	420	34	420	NA

Shear Strength Envelope (Existing Soil and Mixed Waste)



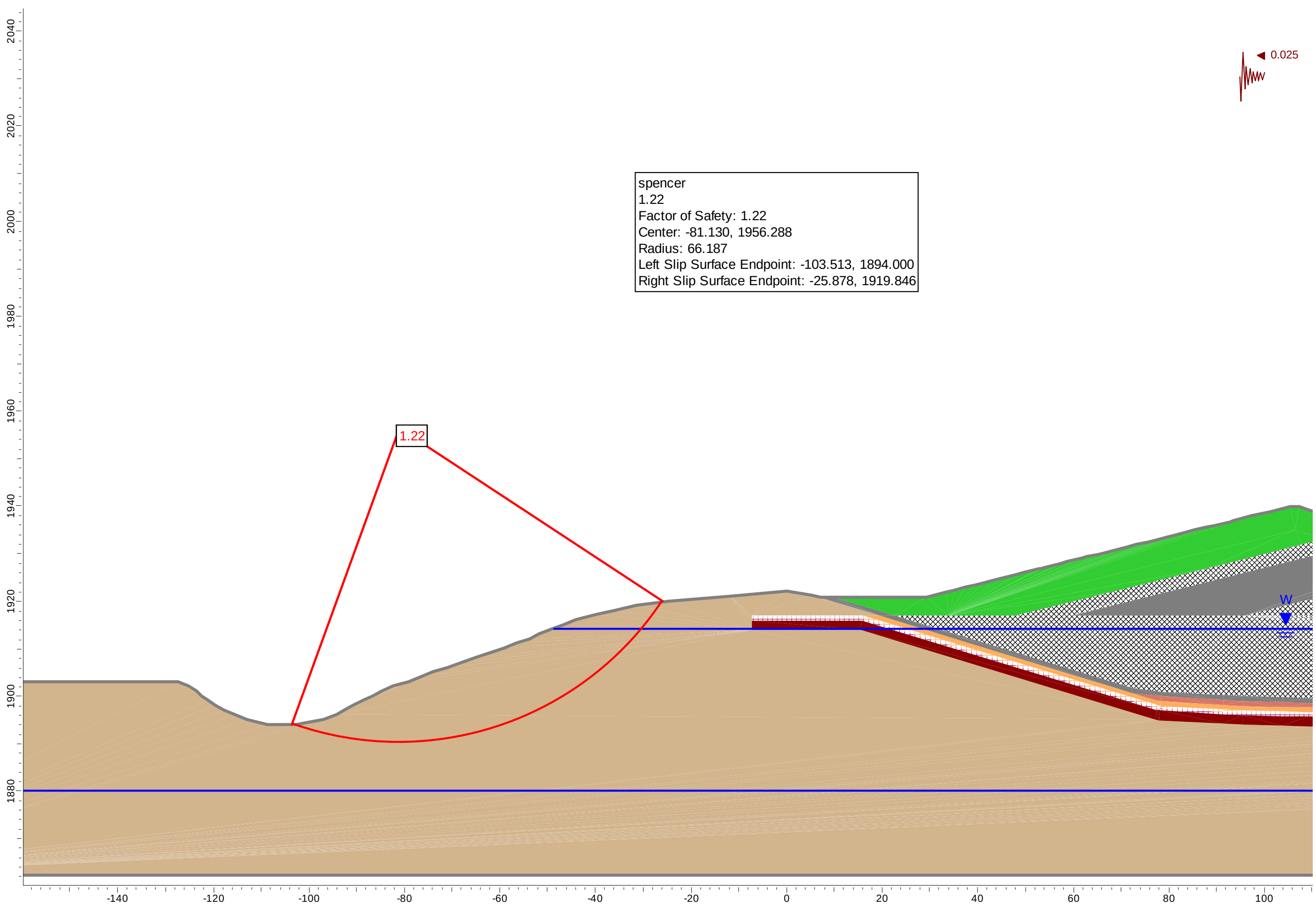
Shear Strength Envelope (FGD Sludge)



Golder Associates

ATTACHMENT B

FIGURES



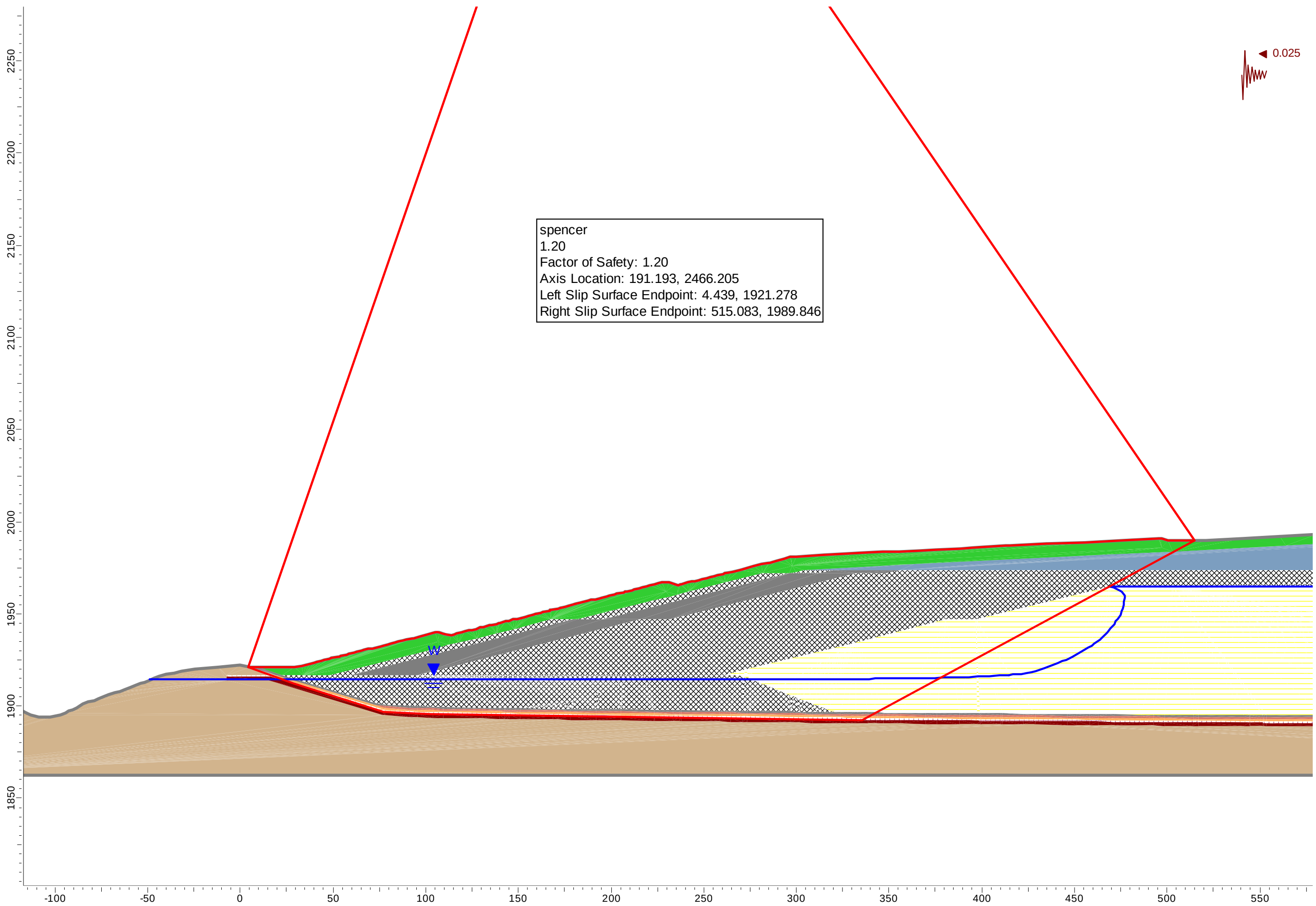
SCENARIO 1
ASH POND 92 - PERIMETER BERM
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 1

PROJECT No.123-81519 CADD CCS DATE 02/23/12 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:40



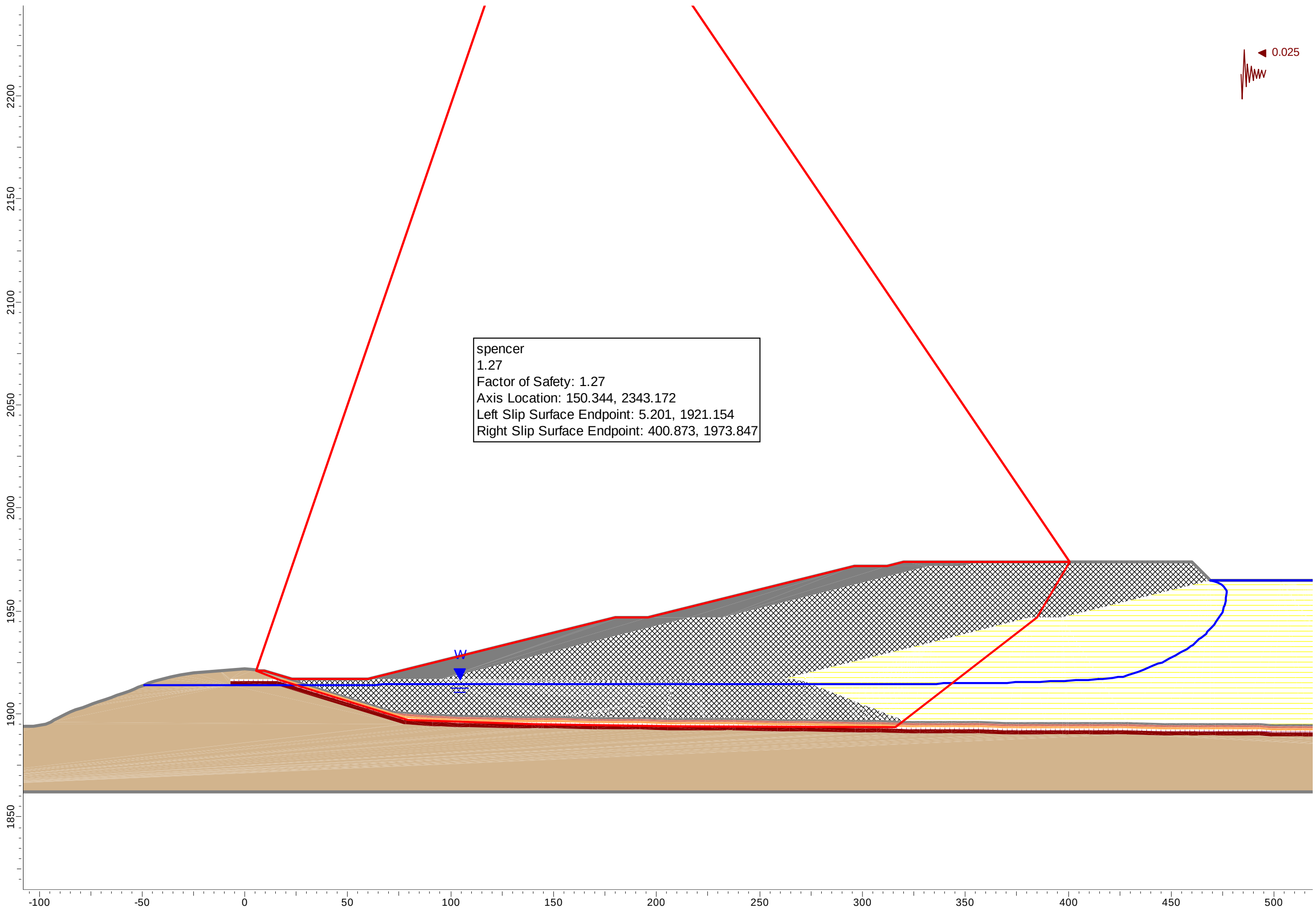
SCENARIO 2
ASH POND 92 - GEOMEMBRANE INTERFACE
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 2

PROJECT No.123-81519 CADD CCS DATE 02/23/12 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:40



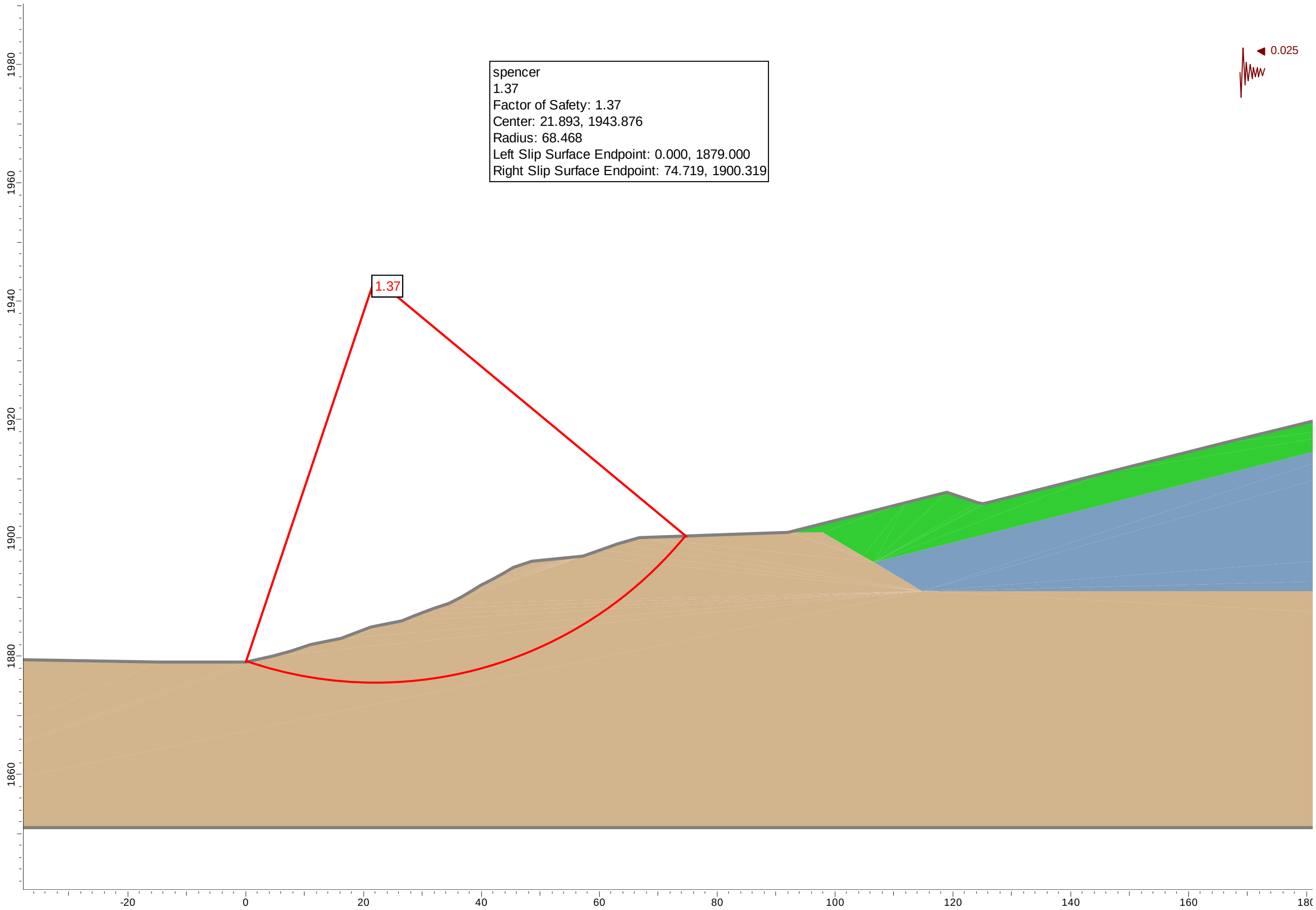
SCENARIO 3
ASH POND 92 - INTERMEDIATE SLUDGE LEVEL
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 3

PROJECT No.123-81519 CADD CCS DATE 02/23/12 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:41



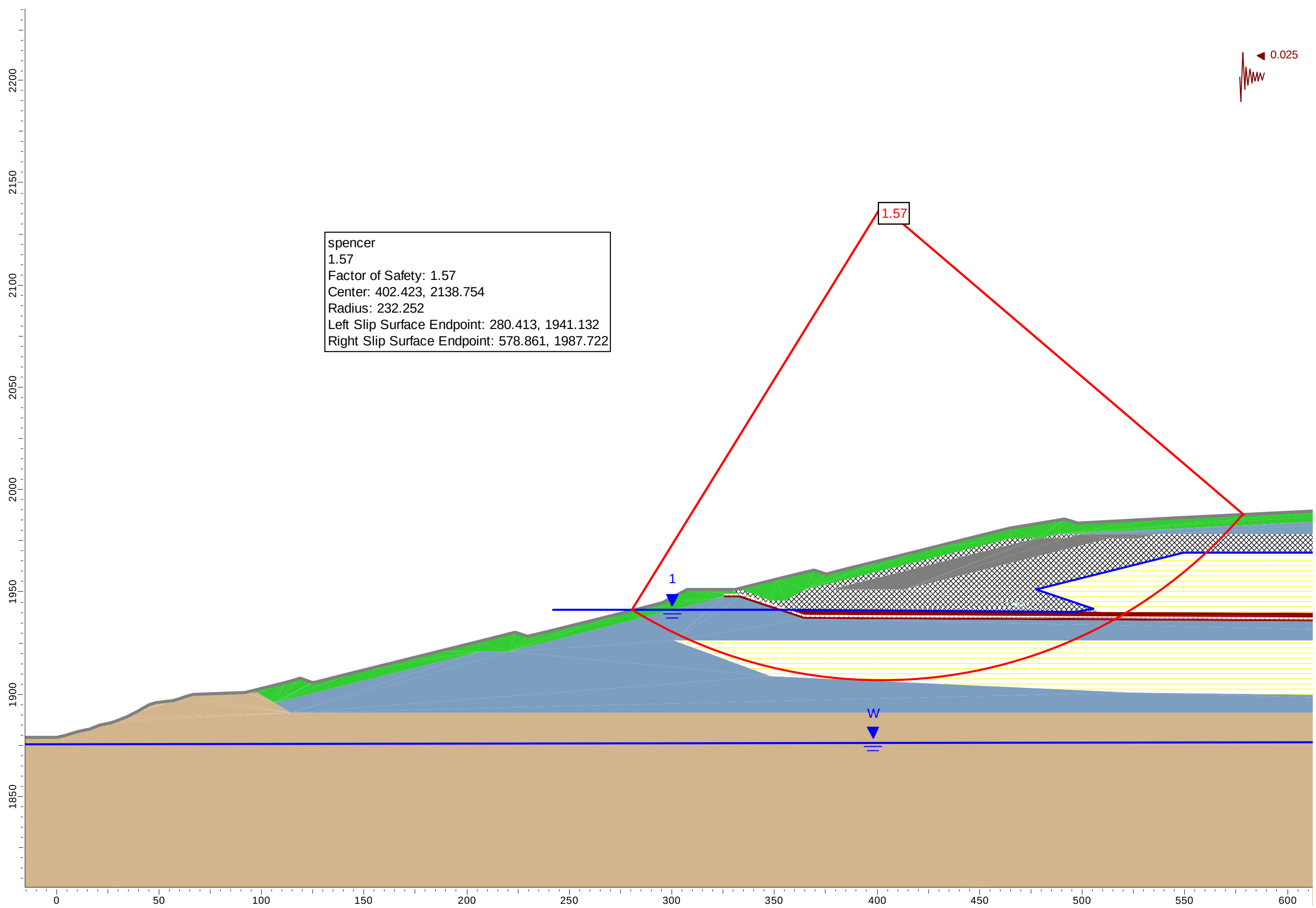
SCENARIO 4
SW SECTION 16 - PERIMETER BERM
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 4

PROJECT No.123-81519 CADD CCS DATE 02/23/12 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:41



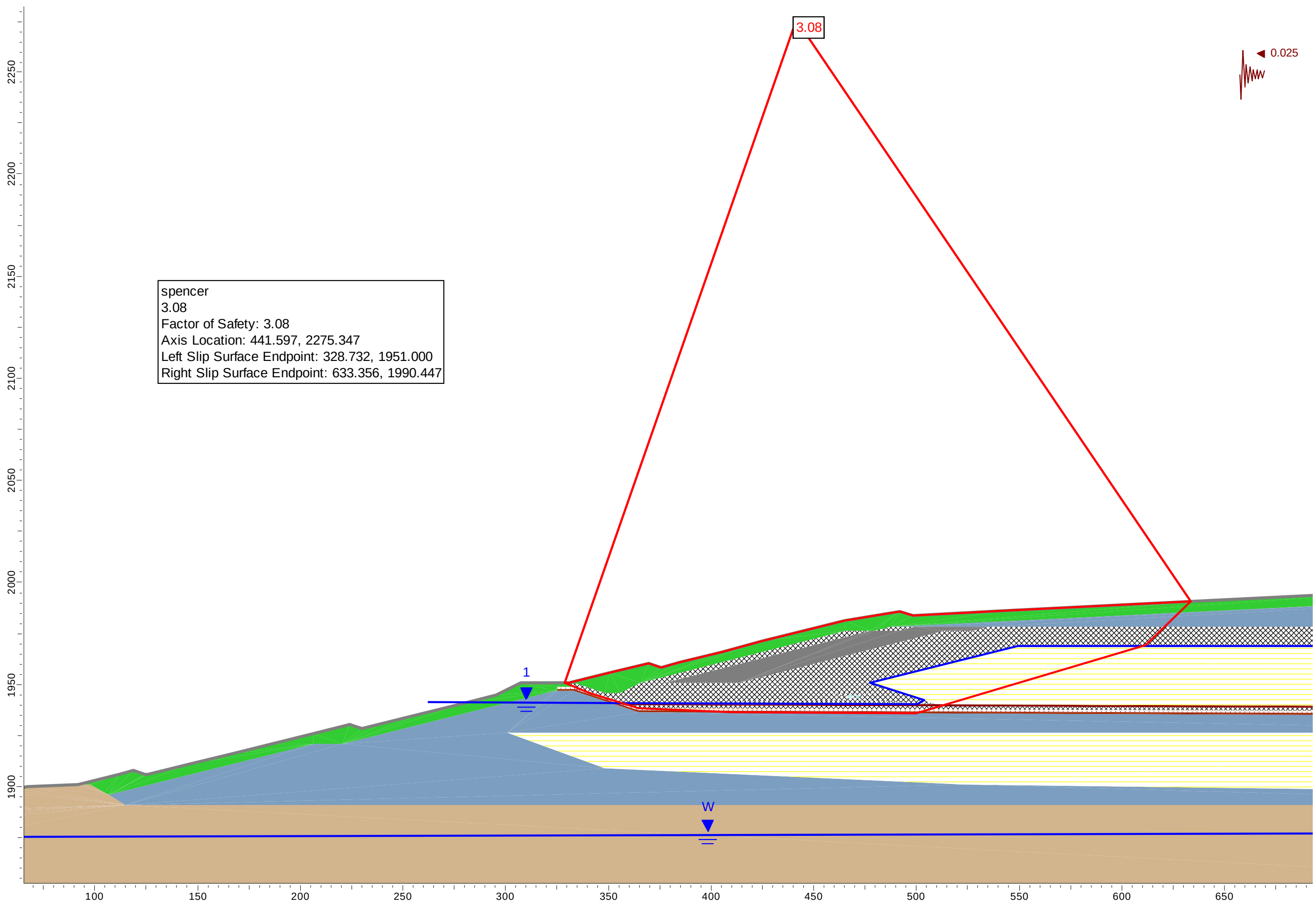
SCENARIO 5
SW SECTION 16 - GLOBAL
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 5

PROJECT No.123-81519 CADD CCS DATE 02/23/12 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 17:18



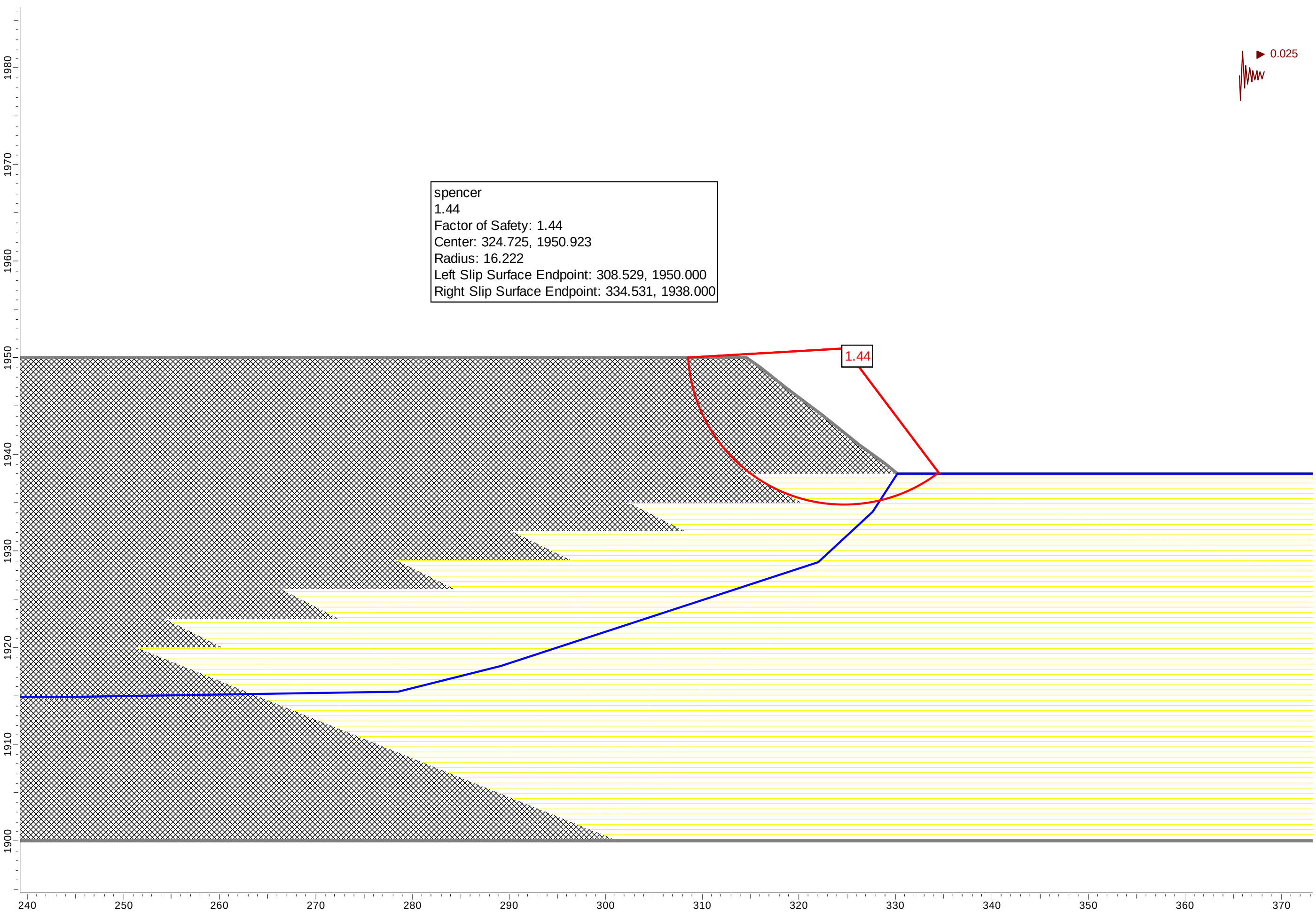
SCENARIO 6
SW SECTION 16 - GEOMEMBRANE INTERFACE
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 6

PROJECT No.123-81519 CADD CCS DATE 02/23/12 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:41



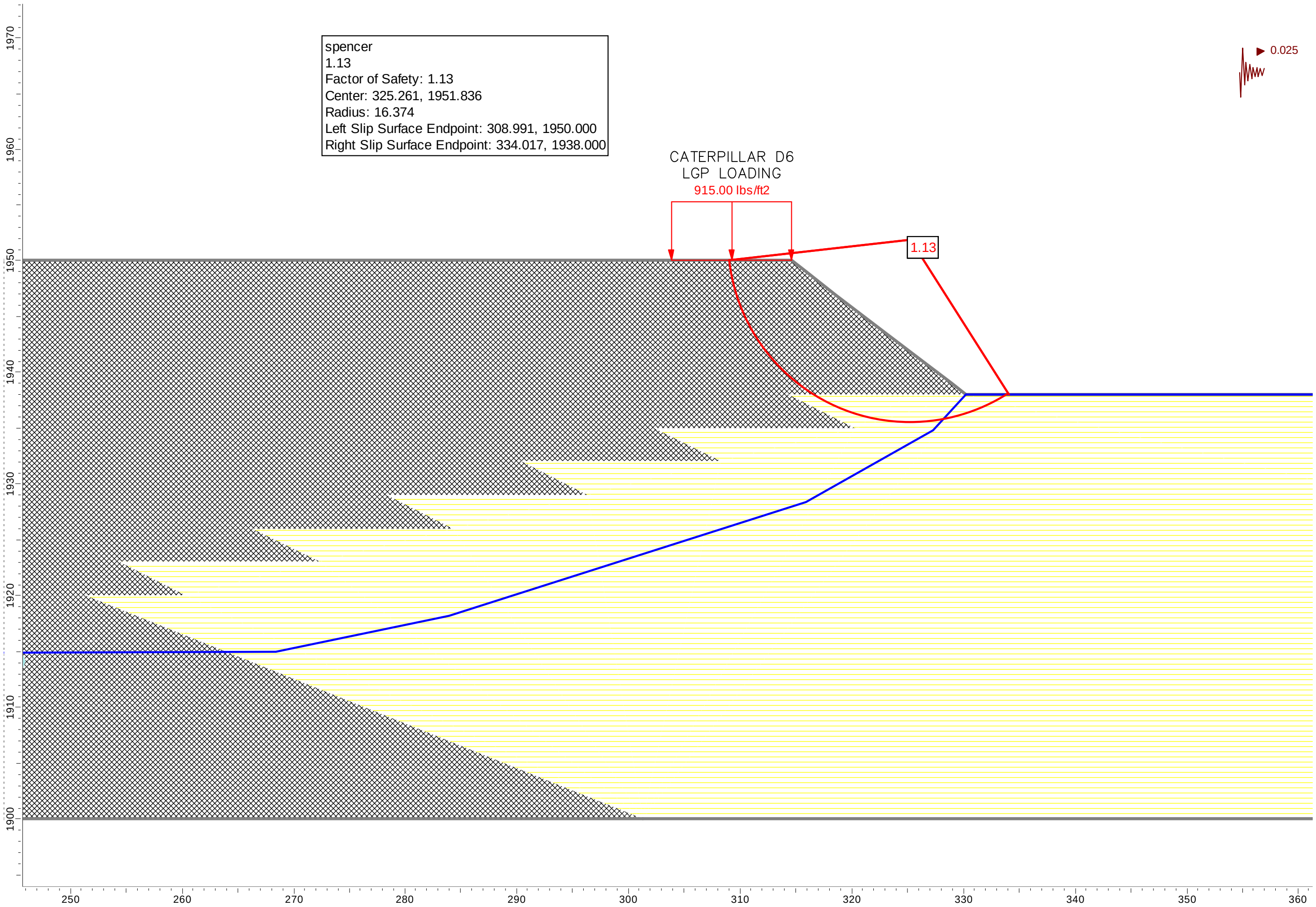
SCENARIO 7
ASH POND 92 INTERIOR BOTTOM ASH / SLUDGE
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 7

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:41



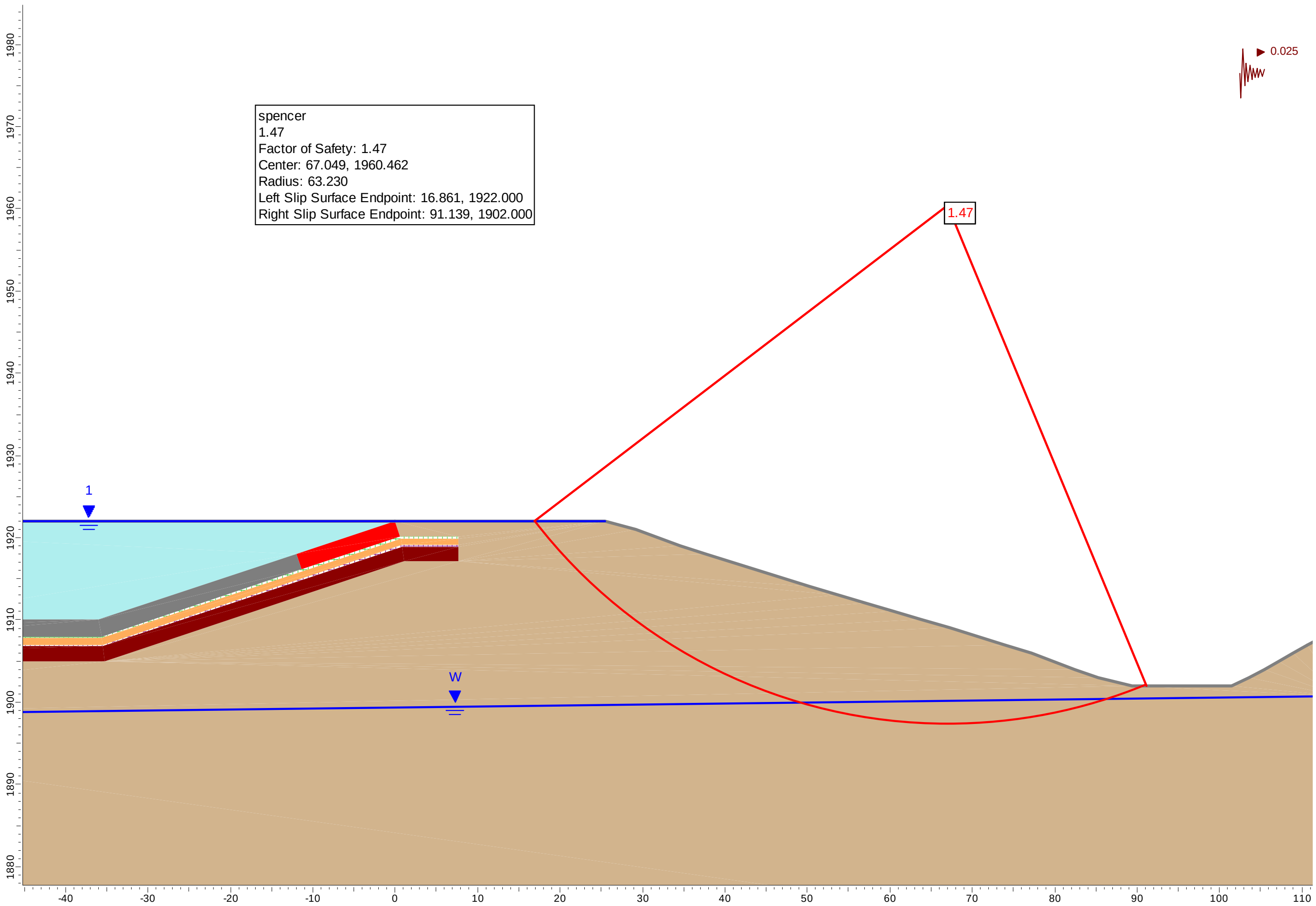
SCENARIO 7
ASH POND 92 INTERIOR BOTTOM ASH / SLUDGE EQUIPMENT LOADING STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 8

PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:42



ASH POND 91
SEISMIC STABILITY ANALYSIS RESULTS

Golder Associates
DENVER, COLORADO

FIGURE 9

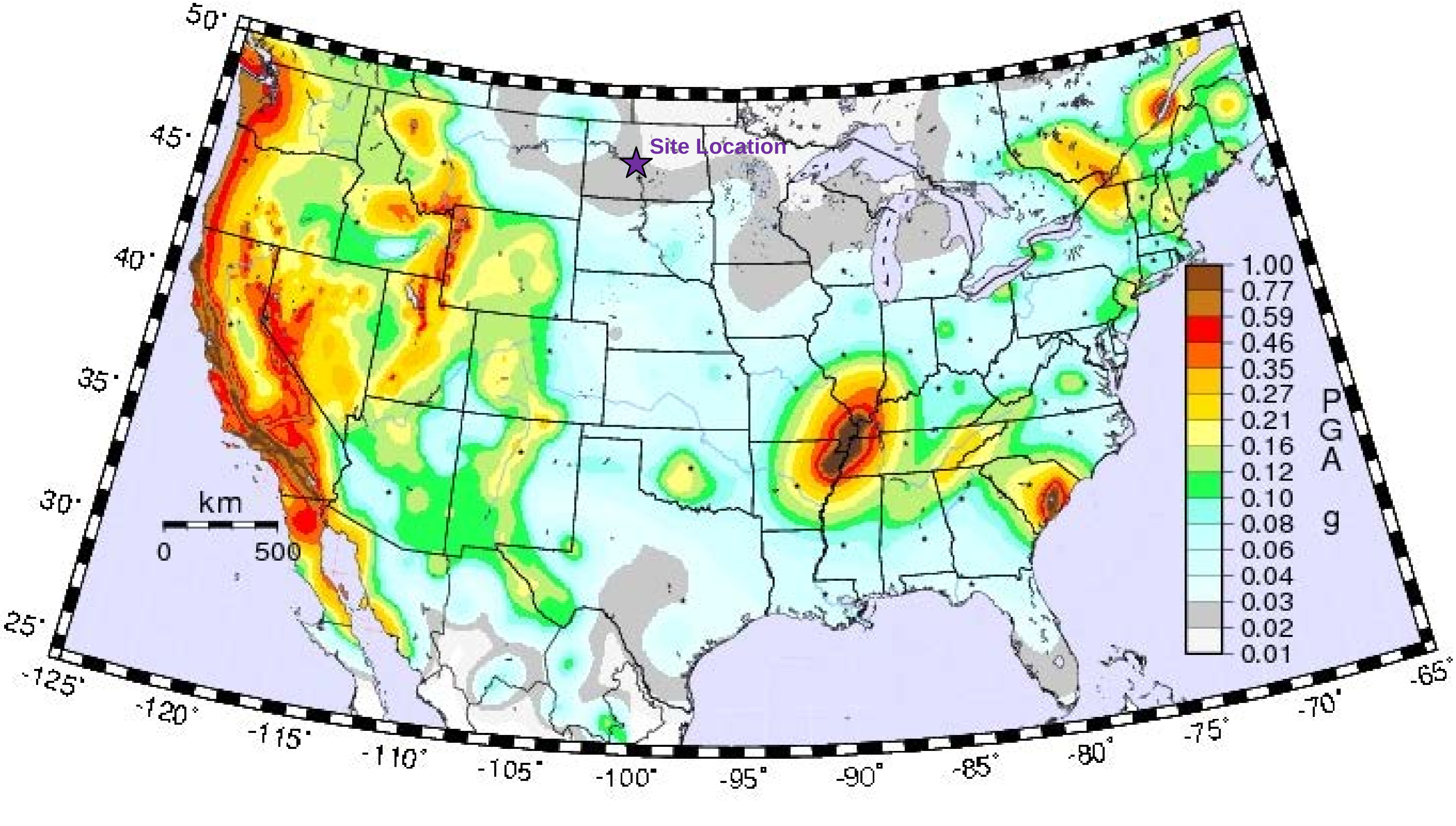
PROJECT No.103-81601 CADD CCS DATE 05/05/10 FILE No. Figures_Seismic.dwg

Plot Time: 02/27/12 15:42

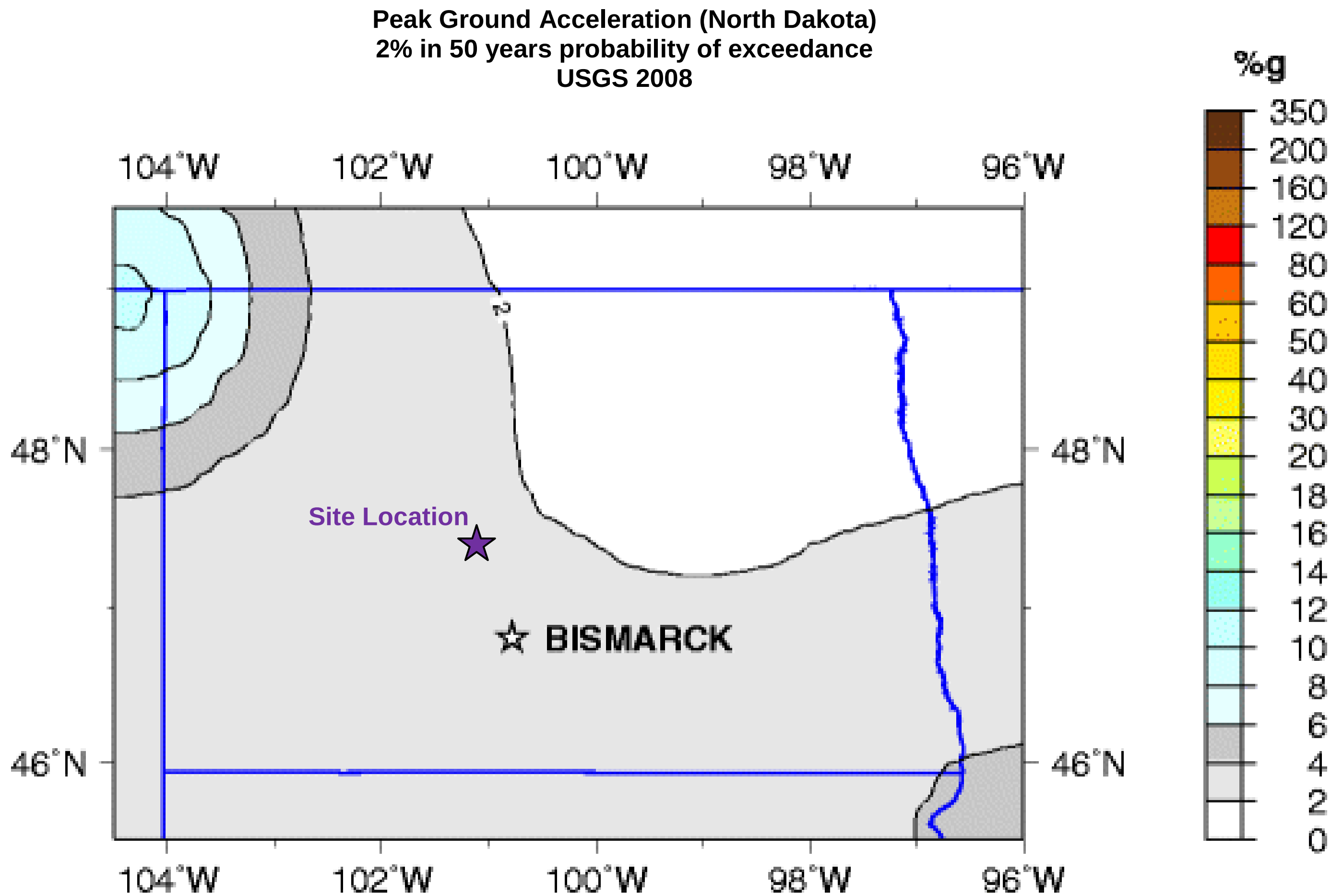
ATTACHMENT C

REFERENCES

Peak Ground Acceleration (Conterminous U.S.)
2% in 50 years probability of exceedance
USGS 2008



Golder Associates


Peak Ground Acceleration (North Dakota)
2% in 50 years probability of exceedance
USGS 2008
104°W
102°W
100°W
98°W
96°W
48°N
46°N
2
Site Location
BISMARCK
%g
350
200
160
120
80
60
50
40
30
20
18
16
14
12
10
8
6
4
2
0

May 14, 2012 Project No. 103-81601

Charlie Larson, PE
Principal Professional
Kleinfelder
611 Corporate Circle, Suite C
Golden, CO 80401

RE: RESPONSE TO YOUR EMAIL DATED MAY 11[TH] CONCERNING SLOPE STABILITY FACTORS OF SAFETY

Dear Mr. Charlie Larson, PE

Thank you for your email dated May 11, 2012. In response, we have prepared this letter to help address, and provide supporting information, for our rational in accepting the 1.4 factor of safety (FOS) of Scenario 2 from the December 2010 revised Evaluation of Ash Pond 92/SW Section 16 Stability.

In our report, Scenario 2 examined the stability of the geomembrane interface within the CCP facility using final design cover grades and the resulting FOS was calculated to be 1.4. We deemed this FOS acceptable because this scenario was considered a temporary condition with respect to phreatic surface, FGD sludge strength and density, and due to the conservative analysis with respect to the geomembrane liner interface.

Per your request, the information below describes our basis for temporary factors of safety, and some additional information on the particular stability scenario in question.

Acceptable Factors of Safety

As you are aware, factors of safety should be based on a combination of the consequence of failure, the confidence in input parameters (slope, material properties, phreatic surface), and the conservatism of the evaluation. We use professional judgment in combining these variables and assigning an acceptable factor of safety based on industry best practices.

To assist us, industry experience has developed guidelines for acceptable factors of safety for different scenarios. One resource for these recommendations is the Naval Facilities Engineering Command Soil Mechanics Design Manual (NAVFAC DM7.01, 1986). This manual is now Appendix A in the Unified Facilities Criteria Soil Mechanics manual (UFC, 2005). Chapter 7, Section 3, Part 5 of this manual reads:

> *5. REQUIRED SAFETY FACTORS. The following values should be provided for reasonable assurance of stability:*
>
> *(1) Safety factor no less than 1.5 for permanent or sustained loading conditions.*
>
> *(2) For foundations of structures, a safety factor no less than 2.0 is desirable to limit critical movements at foundation edge. See DM-7.2,Chapter 4 for detailed requirements for safety factors in bearing capacity analysis.*
>
> *(3) For temporary loading conditions or where stability reaches a minimum during construction, safety factors may be reduced to 1.3 or 1.25 if controls are maintained on load application.*
>
> *(4) For transient loads, such as earthquake, safety factors as low as 1.2 or 1.15 may be tolerated.*

Golder Associates Inc.
44 Union Boulevard, Suite 300
Lakewood, CO 80228 USA
Tel: (303) 980-0540 Fax: (303) 985-2080 www.golder.com

Temporary Conditions

In reviewing these required safety factors guidelines, the applicable range for temporary loading conditions is 1.25 to 1.3 or higher. In describing temporary loading conditions, the manual indicates that these factors of safety also apply to “where stability reaches a minimum during construction.”

As we described in our December 2010 evaluation, Scenario 2 was deemed a “temporary condition” since the phreatic surface and FGD sludge material properties are temporary. Sludge deposition, which brings water into the system, will finish years before unsaturated materials of the CCP crown and final cover are placed. During this time, the phreatic surface will decrease in elevation, and consolidation of the FGD sludge will increase the material’s density and strength. Both of these changes with time will increase the overall stability of the facility as the facility reaches a steady state condition. Such changes after the scenario analyzed indicate that this scenario is reflective of “where stability reaches a minimum during construction.” Because this scenario is reflective of a construction phase and stability is expected to increase with time, the estimated 1.4 factor of safety was deemed adequate.

Conservative Analysis

In addition to the temporary condition rationale provided in our December 2010 evaluation report, the 1.4 estimated factor of safety was also accepted based on the overall conservative approach to the stability evaluation. In addition to the location of the phreatic surface, and FGD material properties, the analysis was conservative with respect to the critical geomembrane interface (geomembrane against underlying clays).

First, rather than use peak shear strengths for this interface; residual shear strengths were chosen (Table 1). Second, full pore pressures were applied to this interface based on the phreatic surface within the facility, despite the interface lying on the underside of the geomembrane liner. Significant drainage would have to occur to have pore pressures from the interior of the facility be applied to the underside of the liner and is not reflective of the installation oversight that was done during liner construction. This assumption was included in the scenario to represent a worst-case condition and may be overly conservative.

Table 1: Geomembrane/Clay Interface Strengths

	Peak Strength	Residual Strength
Friction Angle (degrees)	8.0	7.5
Adhesion (psf)	360	190

The combination of the temporary/conservative assumptions for the phreatic surface (pore water pressure) and FGD material properties along with conservative interface shear strength allowed us to accept a 1.4 factor of safety. Removing some of this conservatism in the design would be justified and would increase the factor of safety above 1.5.

Please give me a call at your convenience to discuss the information provided in this letter and any other support you may need for your response to the EPA.

GOLDER ASSOCIATES INC.

Todd J. Stong, PE
Associate and Senior Engineer

cc: Jennifer Charles, Great River Energy

TJS/kcs