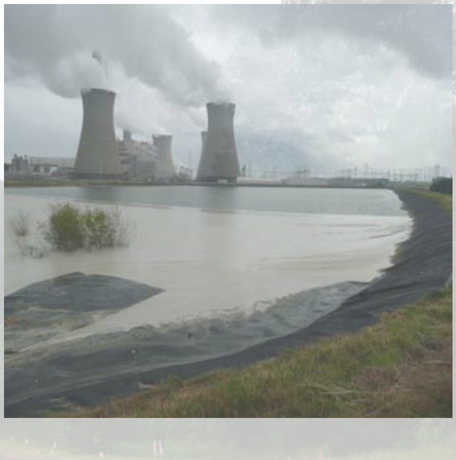
Assessment of Dam Safety
Coal Combustion Surface Impoundments
Draft Report

Georgia Power Company
Plant Bowen

Cartersville, Georgia



Prepared for

Lockheed Martin
2890 Woodridge Ave #209
Edison, New Jersey 08837

July 6, 2009

CHA Project No. 20085.1000.1510

I acknowledge that the management units referenced herein:

- Plant Bowen Ash Pond

Has been assessed on May 26, 2009 and May 27, 2009.

Signature: ____
Malcolm D. Hargraves, P.E.
Senior Geotechnical Engineer
Registered in the State of Georgia

Signature: ____
Katherine E. Adnams, P.E.
Senior Geotechnical Engineer

Reviewer: ____
Warren A. Harris, P.E.
Geotechnical Operating Manager
Registered in the State of Georgia

TABLE OF CONTENTS

TABLES

1.0 INTRODUCTION & PROJECT DESCRIPTION

1.1 Introduction

CHA was contracted by Lockheed Martin to perform site assessments of selected coal combustion surface impoundments (Project #0-381 Coal Combustion Surface Impoundments/Dam Safety Inspections). As part of this contract, CHA was assigned to perform a site assessment of Georgia Power Company Plant Bowen, which is located in Cartersville, Georgia as shown on Figure 1 – Project Location Map.

CHA made a site visit on May 26 and 27, 2009 to perform visual observations and to inventory coal combustion surface impoundments at the facility, inspect the containment dikes, and to collect relevant information regarding the site assessment.

CHA engineers, Malcolm Hargraves, P.E. and Katherine Adnams, P.E., were accompanied during the site visit by the following individuals:

Company or Organization	**Name and Title**
Environmental Protection Agency	Javier Garcia
Georgia Power	Tanya Blalock, Environmental Affairs Manager
Georgia Power Company	Kenneth Duquette, Compliance Team Manager
Georgia Power Company	Nik Budney, Bowen Plant Compliance Manager
Georgia Safe Dams	Carey Anderson, Environmental Engineer
Southern Company	Gary McWhorter, P.E., Environmental Engineering
Southern Company	Hollister Hill
Southern Company	Ron Wood, P.G., Hydro Services
Southern Company	Will McIntyre

1.2 Project Background

The Plant Bowen ash pond is under the jurisdiction of the Georgia Department of Natural Recourses Environmental Protection Division (EPD) Safe Dams Program. According to the Natural Inventory of Dams (NID) the Georgia State ID No. for the ash pond is 008-031-04136. According to the Georgia Safe Dams program, the ash pond has been categorized as a "Category II" dam, meaning improper operation or dam failure would not be expected to result in probable loss of human life. Category II facilities are exempt from much of the Georgia dam safety regulations thereby leaving the design, operation, and maintenance standards up to the owner's discretion for best management practices. According to Georgia Safe Dams personnel, as a Category II dam the facility is not held to any state recognized design standards.

The State of Georgia issued Permit No. GA0001449 to the Georgia Power Company authorizing discharge under the National Pollutant Discharge Elimination System to the Euharlee Creek and Etowah River (Coosa River Basin) in accordance with effluent limitations, monitoring requirements and other conditions set forth in the permit. The permit became effective on November 9, 2009 and will expire on June 30, 2012.

On August 1, 2002 Georgia Power provided a written report to the Georgia Department of Natural Resources Environmental Protection Division (EPD) of an ash pond sink hole and unpermitted ash discharge to the Euharlee Creek on July 28, 2002. As a result of the incident the EPD pursued enforcement action and a consent order was issued. The order required Georgia Power Company to perform the following tasks as summarized below:

1. Pay a fine to the Georgia Department of Natural Resources;
2. Conduct a study of the ecological impact of the discharge into Euharlee Creek and recommend remedial action;
3. Submit a dredging plan if proposed as part of the recommended redial actions;
4. Submit a report on the actions taken to fill the existing sinkhole and to grout fissures under the dike;

5. Conduct a geological engineering assessment of the ash pond stability and recommend corrective actions to prevent future sinkhole development;
6. Submit a revised ash water management plan which covers measures to reduce hydraulic loading in the northern section of the pond, including compacted clay lined ash sedimentation cells, lined runoff ditches, and dry handling of the stacked ash in the northern cell;
7. Comply with any corrective action plans approved by EPD;
8. Submit an interim progress on the completion of the corrective action plans; and
9. Submit a final report on the completion of the corrective action plans.

On September 16, 2008 Georgia Power provided a written report to the EPD of an ash release to Euharlee Creek on September 9, 2008 during a significant rain event. A consent order was issued by the EPD, requiring that Georgia Power Company perform the following tasks as summarized below:

1. Pay a fine to the Georgia Department of Natural Resources;
2. Submit a revised ash stack management plan to include, at a minimum, a description of the Best Management Practices that will be implemented in order to ensure the integrity of the ash stack piles, with particular focus given to the maintenance and management of the runoff ditches and perimeter of the ash stack piles. The plan was to include a description of the inspection and records keeping procedures to be implemented, as they relate to the operation and maintenance of the ash stack piles.

Georgia Power has provided CHA with copies of correspondences, reports and plans pertaining to the tasks outlined above. A list of these items is provided in Section 1.6 – Bibliography. As part of our assessment, information and data from these reports and plans were compared with existing site conditions observed during our site visit.

1.3 Site Description and Location

The Plant Bowen management units are shown on Figure 2 – Plant Bowen Site Plan. The main impoundment was created by construction of the main dike, which bounds the impoundment on the south and west sides, and the north dike, which bounds the impoundment on about two thirds of the north side. The remaining portions of the impoundment are contained by natural ground. The main and north dikes were originally constructed in 1968 creating a storage area of about 258 acres. In 1992 and again in 2001 Georgia Power developed Ash Stacking Plans to expand the capacity of the facility and transition from wet process disposal to dry disposal. These stacking plans were approved by Georgia Environmental Protection Division (GA EPD). Figures 3 and 4 show cross sections of the main and north dikes, respectively.

This transition to dry disposal was an engineered plan to reduce the impacts of fluctuating water levels in the impoundment from impacting the underlying karst topography, which is more thoroughly discussed in Section 1.5 below. The result of this change in operations is an impoundment with only about 60 acres containing liquid and these areas have been lined with geosynthetic clay liners (GCL) or HDPE liners, and/or clay soil liners. The remaining 198 acres of the main impoundment contains the dry-stacked ash. The areas where liquid is contained is comprised of two ash dewatering cells, two gypsum settling ponds, and a water recycle pond. Figures 5, 6, and 7 show cross sections of the dikes at the water recycle pond, ash dewatering cells, and gypsum settling ponds, respectively.

The Bowen Power Plant's recycle water portion of the unit, which contains the largest volume of liquid, is about 2 miles upstream of Euharlee, Georgia by the stream channel. The perimeter ditch drains to the Euharlee Creek, which subsequently discharges into the Etowah River.

A map of the region indicating the location of the Plant Bowen ash pond identifying schools, hospitals, or other critical infrastructure located within approximately 5 miles down gradient of the ash pond is provided as Figure 8.

1.3.1 Other Impoundments

In addition to the coal combustion waste (CCW) disposal area, CHA also observed and/or was made aware of other impoundments at the Plant Bowen site. The largest of these impoundments occupies roughly 62 acres and contains water pumped from the Etowah River for use as cooling water in the Plant. Other much smaller impoundments capture and control storm water runoff in the coal pile area and the waste gypsum coal combustion by-product storage facility located to the east of the steam plant and cooling water pond. These impoundments store water intermittently, do not contain CCW and therefore, were not inspected as part of this project. The locations of these areas are shown on Figure 2 – Plant Bowen Site Plan.

1.4 Previously Identified Safety Issues

There have been three previously identified dam safety issues at Plant Bowen. Two of the three incidents resulted in release of CCW from the main impoundment in the last 7 years. In July 2002 a release of ash occurred due to the opening of karst features beneath the impoundment, and in September 2008 a release of ash occurred due to rainfall triggered sloughing of the dry stacked ash which flowed over the main dike. In December 2008 a sinkhole developed at the north dike however no CCW was released. These incidents are discussed in more detail in Sections 1.4.1, 1.4.2 and 1.4.3.

1.4.1 2002 Release and Karst Topography

In July 2002 a sinkhole developed in the main impoundment. Groundwater and CCW/water mixtures emerged downstream of the main dike through groundwater monitoring piezometers. As reported by Georgia Power, about 11 cubic yards of ash reached the Euharlee Creek. The Georgia EPD executed a Consent Order to which Georgia Power complied and completed requirements of the Consent Order with a final report issued June 1, 2004. This Consent Order report contains the results of subsurface explorations, and stability analyses of the main and north dikes.

One of the primary conclusions of the Consent Order report was that the sinkhole and subsequent ash release was related to a geologic feature of the site called karst topography, rather than a failure of the constructed dike. In this case, impounded waste ash and water was conveyed beneath the dike through solution cavities in the weathered bedrock regime. A more complete discussion on the local geology and karst topography is contained in Section 1.5.

1.4.2 2008 Release and Revised Stacking Plan

On September 9, 2008 the Bowen Plant received about 1.25 inches of rain in 45 minutes. This heavy rainfall resulted in a portion of the ash stack to erode and flow over the north end of the main dike. Although this event resulted in a release of ash from the site, this event was not related to the safety of the dike system creating the impoundment.

1.4.3 2008 Sinkhole at North Dike

In December 2008 a sinkhole developed in the drainage swale between the ash stack and the north dike, and two sinkholes (presumably connected) developed about 50 feet downstream of the north dike as a result of the karst underlying the site. Several days prior to the development of the sinkholes, piezometer readings in this area showed a rise in the groundwater elevation.

When the sinkholes developed, reportedly some cracks and settlement occurred in the north dike. Therefore, in addition to sealing the sinkholes, a portion of the north dike was excavated and reconstructed. The north dike did not impound water beyond what may have been present in the drainage swale at the time of this incident (nor is it expected to impound water based on current site operating procedures). The sinkholes were excavated to the surface of the bedrock and a graded filter was placed to backfill the depressions.

1.5 Site Geology

A summary of the regional geology was prepared by Southern Company Services, Inc. as part of the *Report Prepared in Response to Consent Order No. EPD-WQ-4075* dated December 2002. Section 3.3 – Regional Geology of the report states that “The Plant Bowen ash pond lies within the Valley and Ridge physiographic providence about three to four miles north of the Cartersville Fault. The Cartersville Fault separates the late Precambrian-aged metamorphic rocks to the east and south from the Cambrian-aged sedimentary rocks to the north and west. The ash pond lies within an area mapped primarily as Knox Group undifferentiated. The Knox Group produces a characteristic orange to red clayey residuum, often cherty, that ranges in thickness from ten to a hundred feet or more.”

The report summarizes several site-specific subsurface explorations programs that have been conducted in the vicinity of the ash pond since the 1967 plant siting work, including investigations that were performed after the sinkhole development in July 2002. The investigations described in the report include;

- Literature Review (Regional Geology)
- Arial Photography (Lineament) Studies
- Geophysical Surveys (Resistivity, Self Potential and Electromagnetic)
- Drilling, Sampling, Cone Penetrometer Testing, and Related Laboratory Analysis

Based on the investigations the report provides a description of the soil and rock (Section 3.7). The soils underlying the ash pond and embankment are residual, formed from the in-place weathering of the underlying dolomite and limestone. The soils were noted as varying from a fine, sandy clayey silt to silty clay. Permeability of the material was reported as varying from about 1×10^{-6} to 1×10^{-8} cm/sec. Thickness was also found to vary from about 19 feet to 127 feet at the Plant Bowen site.

The report states that the carbonate rocks beneath the ash pond are typical of the Knox Group and that as part of various Plant Bowen studies, karst-controlling features such as lineaments and sinkholes were mapped across the site.

1.6 Bibliography

CHA reviewed the following documents provided by Georgia Power in preparing this report.

- Hill, Heather and Franke, Richard M. *Plant Bowen Ash Pond Dike Slope Stability Analysis Report*, Southern Company Services, Inc., December 2003.
- McWhorter, Gary H., Franke, Richard M. et.al. *Georgia Power Company Plant Bowen Final Consent Order EPD-WQ-4075*, Southern Company Services, Inc., May 28, 2004.
- Galt, Joel. *Plant Bowen Dam Safety Surveillance Quarterly Reports*, Southern Company Services, Inc (5/2004 to 4/2009).
- Various *Quarterly Reports on Dam Safety Surveillance* from 2004 to 2009, Southern Company Services, Inc.
- Engineering and Construction Services Calculation - Ash Dewatering Cells Stability, June 25, 2009, Southern Company Services, Inc.
- Gypsum Dewatering Cells Typical Dike Sections, Drawing E23847, October 1, 2007, Southern Company Services, Inc.
- Engineering and Construction Services Calculation - Ash Pond Flood Evaluation, June 30, 2009, Southern Company Services, Inc.

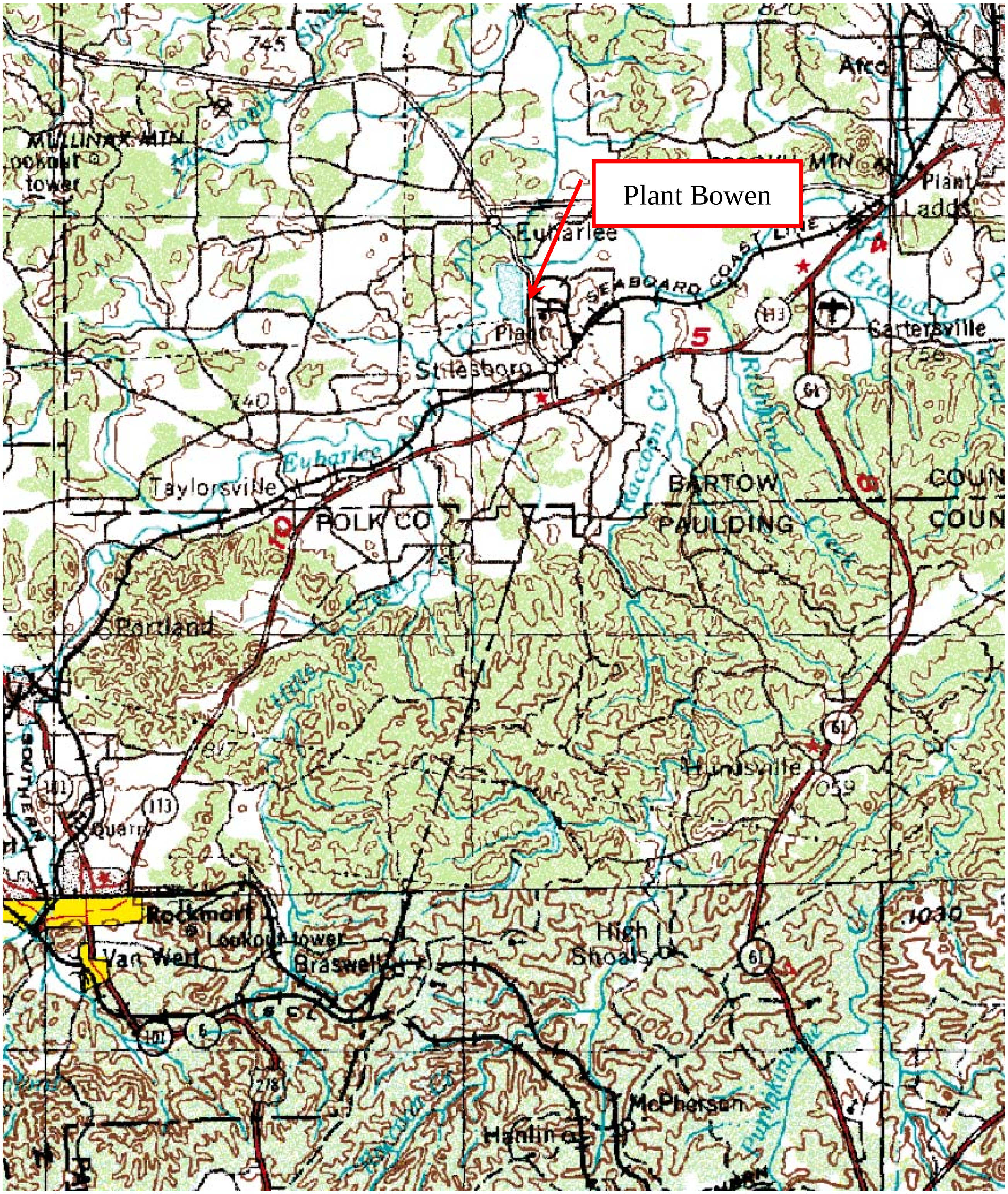


Figure 1
Project Location Map

N

Scale: 1" = 2 miles

Project No.:
20085.1000.1510

Georgia Power Company
Plant Bowen
Cartersville, Bartow County, Georgia

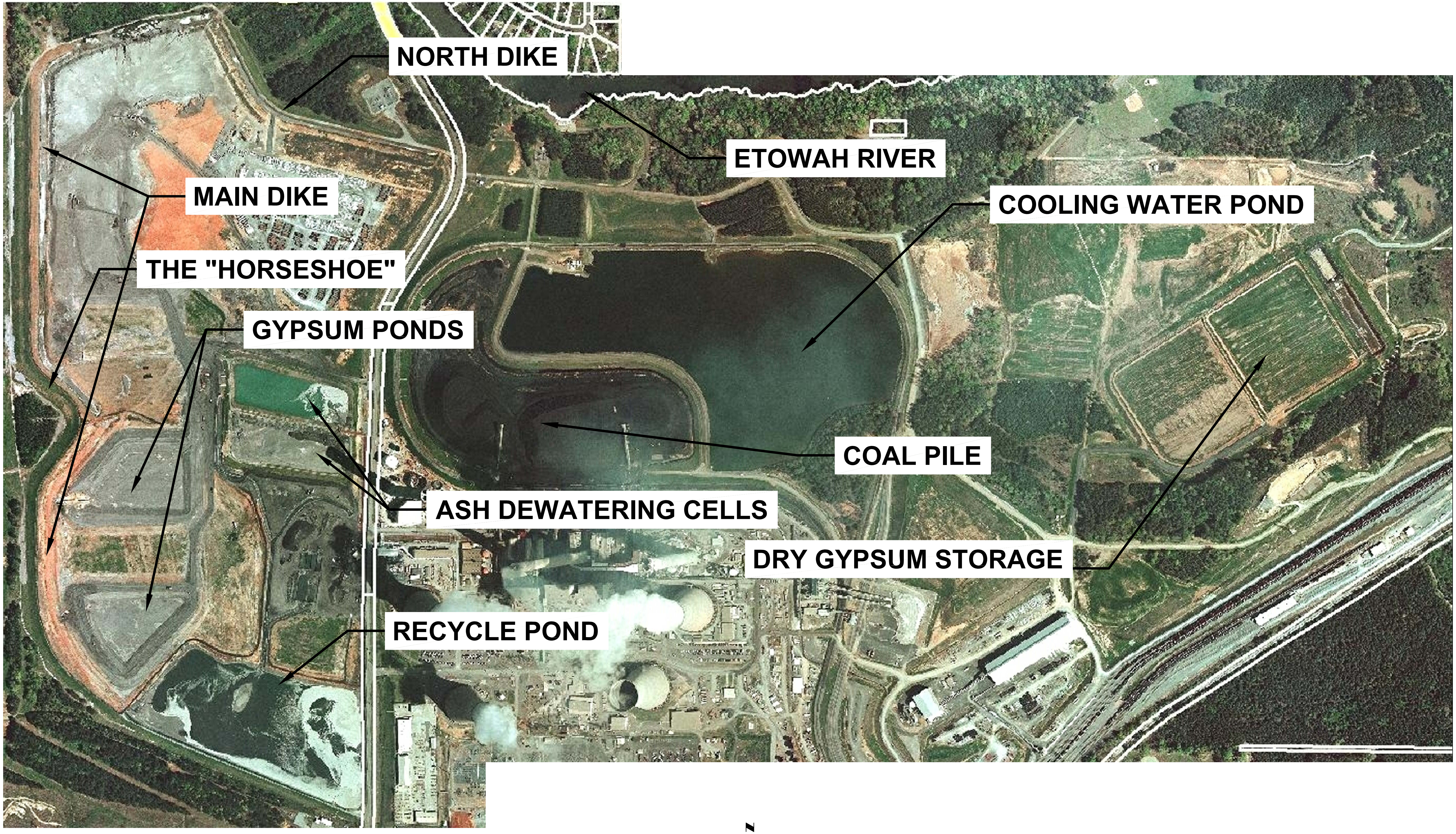


IMAGE REFERENCE: PLANT BOWEN BOW–API 0036

N

CHA

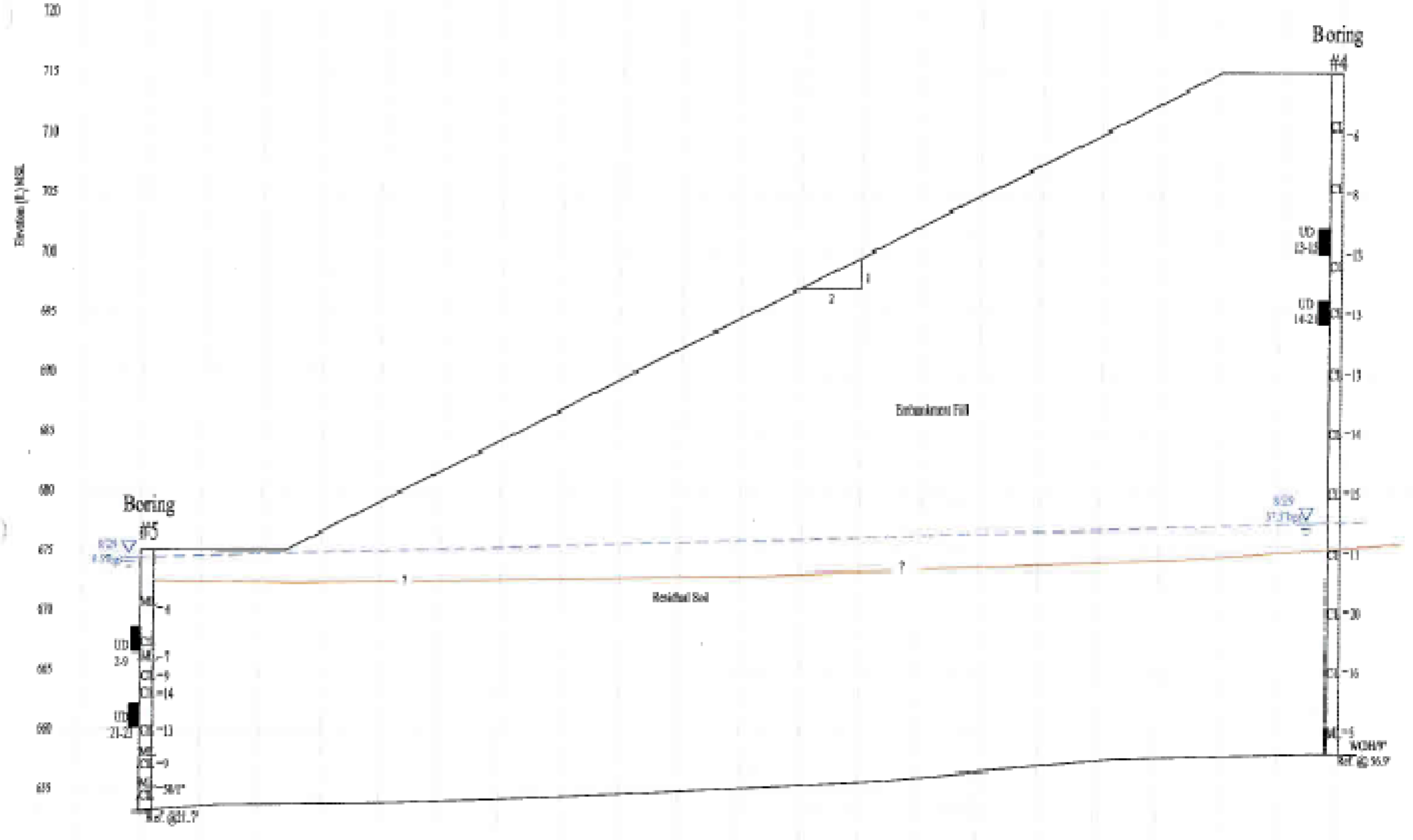
PLANT SITE PLAN
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 2

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN PLANS–MAPS.DWG Saved: 7/6/2009 2:35:49 PM Plotted: 7/6/2009 2:44:23 PM User: Filkins, Rebecca



LEGEND:

UD = Undisturbed Sample
▽ Water Table
CL Uniform Soil Class Symbol
-12 N - value resulting from SPT test (ASTM 1586) with Automatic Hammer
WOR = Wt. of Rod as SPT result
WOH = Wt. of Hammer as SPT result

BT No RK = Boring Terminated No Rock

HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 10'

Southern Company Services, Inc.

Figure 5
Plant Bowen
Dike Stability Study
SECTION D-D'
South Horseshoe

CONFIDENTIAL BUSINESS INFORMATION

IMAGE REFERENCE: STABILITY ANALYSIS, FIGURE 5,
PLANT BOWEN DIKE STABILITY STUDY, SECTION D-D'
SOUTH HORSESHOE

CHA

CROSS SECTION OF MAIN DIKE
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000
DATE: JULY 2009
FIGURE 3

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS1.DWG Saved: 6/26/2009 1:03:52 PM Plotted: 7/6/2009 12:11:17 PM User: Filkins, Rebecca

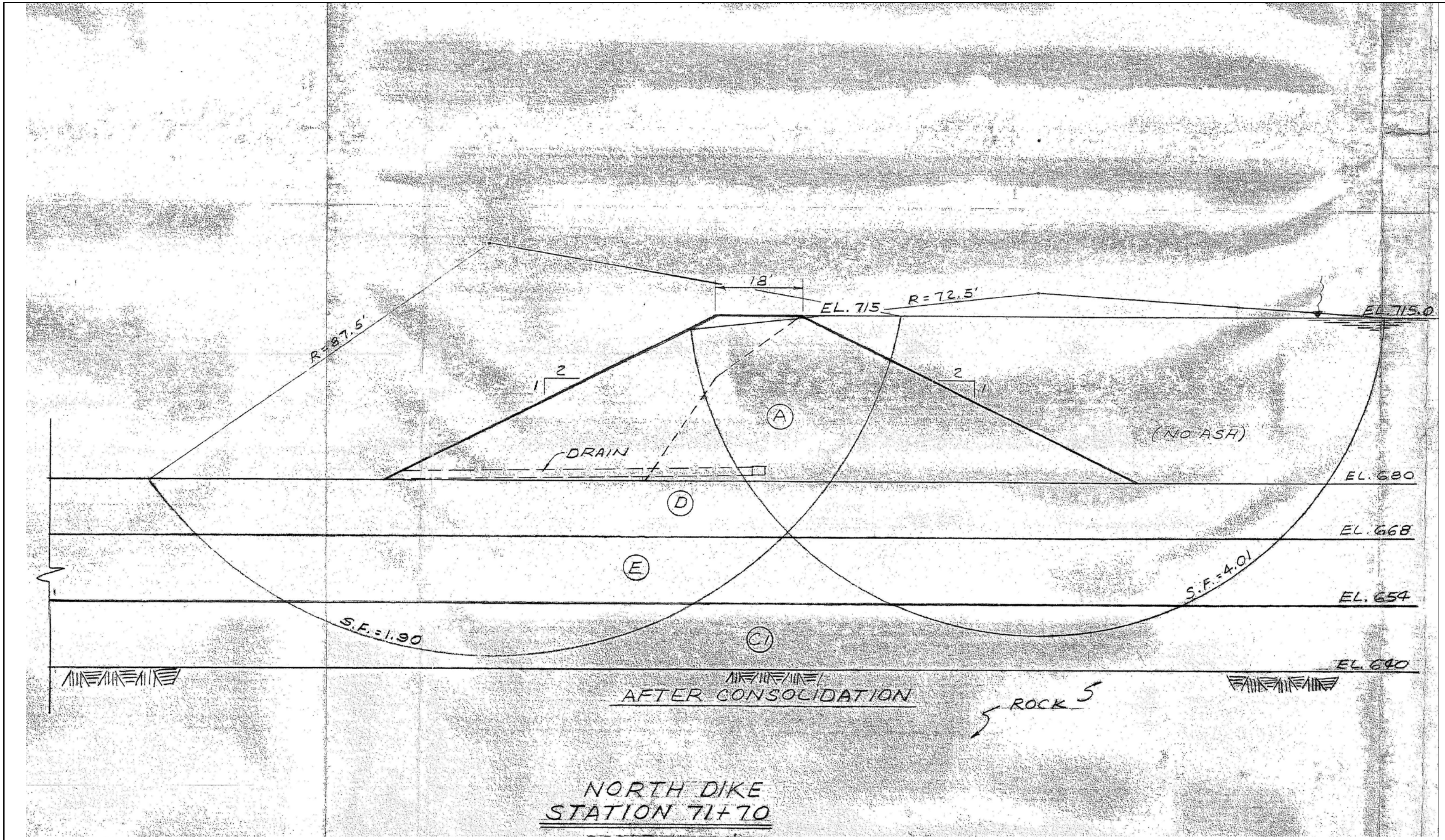


IMAGE REFERENCE: SHEET H-1163 STABILITY ANALYSIS ASH POND DIKES 1969

CHA

CROSS SECTION OF NORTH DIKE
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

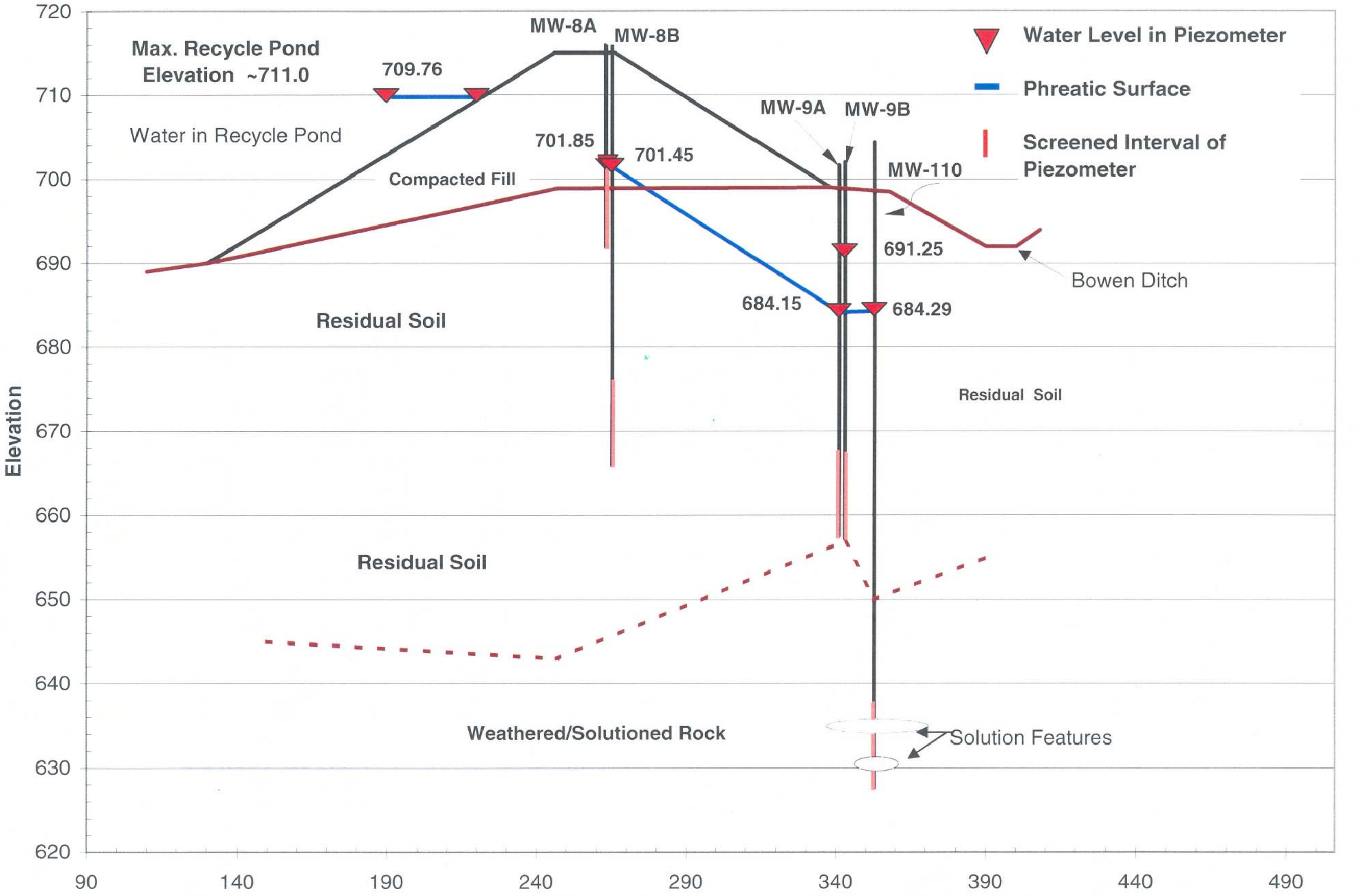
FIGURE 4

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS1.DWG Saved: 7/6/2009 3:29:04 PM PLotted: 7/6/2009 3:30:39 PM User: Filkins, Rebecca

Plant Bowen

TYPICAL SECTION

Date: 05/18/2009



C:\Documents and Settings\ghmcwhor\Local Settings\Temporary Internet Files\Bowen Ash Pond Dike Sections (2).xls Page **1**

NOTE: THE SLOPE TO THE EAST IS BERM CONSTRUCTED ON NATURAL SLOPE WITHOUT A BENCH

IMAGE REFERENCE: BOW-API 0065

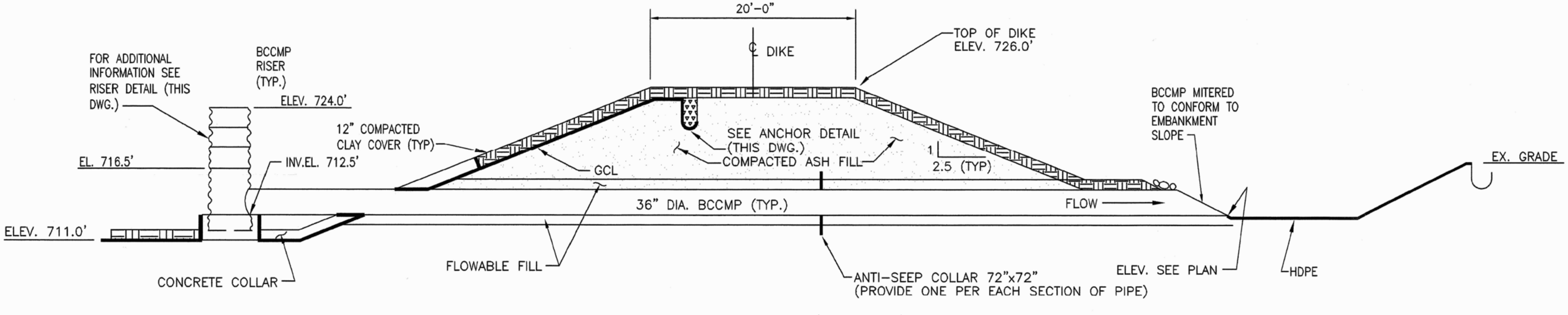
CHA

CROSS SECTION OF WATER RECYCLE POND
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 5



SECTION A-A (CELL A)

IMAGE REFERENCE: PLANT BOWEN UNITS 1-4 ASH POND DEWATERING CELLS GRADING AND DRAINAGE PLAN, SHEET 2, JUNE 2003

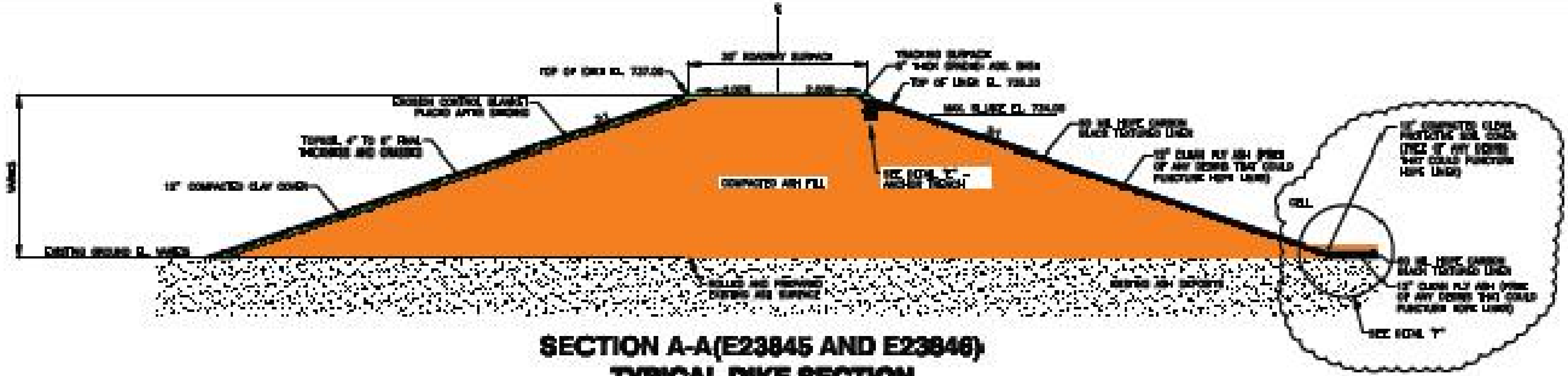
CHA

CROSS SECTION OF ASH POND
DEWATERING CELLS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

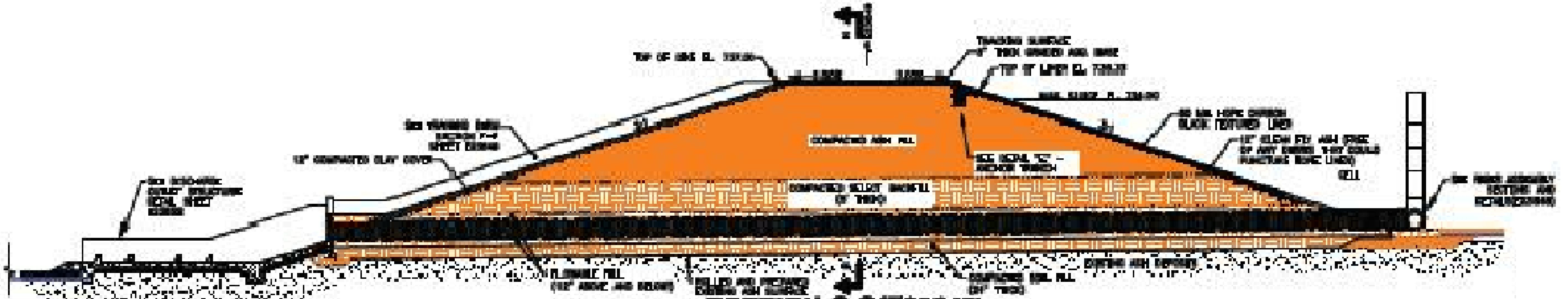
PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 6



SECTION A-A(E23845 AND E23846)
TYPICAL DIKE SECTION



SECTION C-C(E23845)
TYPICAL DIKE SECTION

IMAGE REFERENCE: PLANT BOWEN UNITS 1-4, FGD PROJECT, GYPSUM DEWATERING CELLS, TYPICAL DIKE SECTIONS, SHEET 1

CHA

GYPSUM DEWATERING CELLS
TYPICAL DIKE SECTIONS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 7

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS2.DWG Saved: 7/6/2009 9:51:29 AM PLotted: 7/6/2009 11:27:52 AM User: Filkins, Rebecca

IMAGE REFERENCE: GOOGLE EARTH

CHA

CRITICAL INFRASTRUCTURE MAP
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 8

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN PLANS-MAPS.DWG Saved: 7/6/2009 2:35:49 PM Plotted: 7/6/2009 3:00:45 PM User: Filkins, Rebecca

2.0 FIELD ASSESSMENT

2.1 Visual Observations

CHA performed visual observations of the main and north dikes following the general procedures and considerations contained in FEMA's Federal Guidelines for Dam Safety (April 2004), and FERC Part 12 Subpart D to make observations concerning settlement, movement, erosion, seepage, leakage, cracking, and deterioration. A Coal Combustion Dam Inspection Checklist Form, prepared by the US Environmental Protection Agency, was completed on-site during the site visit for the ash pond. A copy of the completed form was submitted via email to a Lockheed Martin representative approximately three days following the site visit to Plant Bowen. A copy of this completed form is included at the end of Section 2.5. A photo log of photos taken during the site visit and a Site Photo Location Map, Figure 9, are also located at the end of Section 2.5.

CHA's visual observations were made on May 26 and 27, 2009. The weather was cloudy with severe afternoon thunderstorms and temperatures between 64 and 82 degrees Fahrenheit. Prior to and during the days we made our visual observations, the following approximate rainfall amounts occurred (as reported by www.weather.com).

Table 1 - Approximate Precipitation Prior to Site Visit

Date of Site Visit - May 26, 2009 & May 27, 2009		
Day	**Date**	**Precipitation (inches)**
Tuesday	5/19/09	0.00
Wednesday	5/20/09	0.00
Thursday	5/21/09	0.05
Friday	5/22/09	0.00
Saturday	5/23/09	0.05
Sunday	5/24/09	0.00
Monday	5/25/09	0.03
Tuesday	5/26/09	0.94
Wednesday	5/27/09	0.06
Total	**Week Prior to Site Visit**	**1.13**
Total	**Month of May**	**7.71**

It should also be noted that localized, isolated thunderstorm activity was evident at the plant Monday mid-afternoon after the initial field walkthrough.

2.2 Embankments and Crest

The main dike is approximately 7,725 feet long, and the north dike is approximately 1,650 feet long. Two wet ash disposal ponds are contained within the main impoundment and consist of an exterior berm approximately 3,050 feet long, and a separator dike between the two ponds approximately 850 feet long. Also included in the main impoundment are two gypsum settling ponds with berms about 2,300 to 2,500 feet long each. The wet ash and gypsum ponds are lined with geosynthetic liners, and if a breach of one of those were to occur, the release would be contained within the main impoundment. Therefore, CHA performed only a cursory review of these structures.

2.2.1 Main Dike

In general, the main dike does not show signs of changes in horizontal alignment from the proposed alignment. According to Georgia Power personnel, the crest is regraded as needed to fill in tire ruts thereby reducing ponding of storm water on the crest. The embankment is uniform and well covered with appropriate grass cover, which was freshly mowed during our site visit. The main dike was constructed with a downstream slope of 2H:1V.

The southern portion of the main dike along the recycle pond consists of a 5- to 10-foot high dike constructed on top of a 15 to 20 foot high natural cut slope. The natural slope throughout this area has several locations where surficial slides have occurred as shown in Photos 1, 2, 5 and 6. Southern Company personnel who perform quarterly inspections at the dam indicated these features have been there for at least 6 to 10 years during which time the current staff responsible for quarterly inspections have been assigned to this project, and during this time the features have remained unchanged. One feature, as shown in Photo 7, appeared more recent because of relatively new erosion control matting. Southern Company personnel indicated this area had been reseeded several times without adequate vegetation growth, so the erosion matting was placed as an additional attempt to establish good grass growth.

In the area where the recycle pond ends and the main dike curves to the north, formerly sluiced or placed ash is level with the crest of the dam as shown in Photos 15, 16, 18, and 20. The design width of the crest was 15 feet. This condition continues along the entire length of the main dike from the southwest curve to the north abutment. Although obscuring the upstream slope of the constructed dike and the upstream edge of the main dike crest, CHA did not observe conditions of concern along the crest of the main dike.

2.2.2 North Dike

In general, the north dike does not show signs of changes in horizontal alignment. According to Georgia Power personnel, the crest is re-graded as needed to fill in tire ruts thereby reducing ponding of storm water on the crest. The embankment is uniform and well covered with appropriate grass cover, which was freshly mowed during our site visit. The north dike was constructed with a downstream slope of 2H:1V.

The western portion of the north dike is adjacent to the active dry stack area as shown in Photos 24 and 25. These photos also show the configuration of the drainage swale between the north dike and the ash stack. Georgia Power personnel indicated the drainage swale in this area is one of the last areas of water conveying portions of the impoundment to be regraded and lined as part of the work to reduce the facility's impact on the karst topography below. This swale is expected to be lined in 2009 or 2010.

2.3 Outlet Control Structure and Discharge Channel

The only outlet control structure in the main impoundment is in the southeast portion of the impoundment, which is used as a recycle pond. The outlet in this area discharges through a sampling flume into a discharge channel in natural ground (photo 1). The discharge channel flows west until it intersects the Euharlee Creek. This channel is relatively clear, although portions of the channel are being choked by soil previously sloughed from the adjacent natural slope as shown in photos 4 through 7.

2.4 Monitoring Instrumentation

There are 68 piezometers installed along the main impoundment dikes, recycle pond, and dewatering cell dikes at Plant Bowen. These piezometers are located in the embankments, existing ash, and in the bedrock underlying the site. Because of the karst at the site, selected piezometers are read by plant personnel on a daily basis, and all piezometers are read by plant personnel at least weekly. A new remote reading system is being installed to allow reading of all piezometers on a daily basis.

Figure 10 shows the piezometer layout at the site. Summaries and a review of this data are included in Section 3.4.1.

Coal Combustion Dam Inspection Checklist Form

US Environmental
Protection Agency

Site Name: Bowen Steam Plant

Date: May 26, 2009

Unit Name: Ash Disposal Pond

Operator's Name: Georgia Power

Unit I.D.:

Hazard Potential Classification: High [✓ Significant] Low

Inspector's Name: Katherine Adnams/Malcolm D. Hargraves

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?	quarterly		18. Sloughing or bulging on slopes?	x	
2. Pool elevation (operator records)?	709		19. Major erosion or slope deterioration?		x
3. Decant inlet elevation (operator records)?	n/a		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	n/a		Is water entering inlet, but not exiting outlet?	n/a	
5. Lowest dam crest elevation (operator records)?	715		Is water exiting outlet, but not entering inlet?	n/a	
6. If instrumentation is present, are readings recorded (operator records)?	x		Is water exiting outlet flowing clear?	n/a	
7. Is the embankment currently under construction?		x	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)?	n/a		From underdrain?		x
9. Trees growing on embankment? (If so, indicate largest diameter below)		x	At isolated points on embankment slopes?		x
10. Cracks or scarps on crest?		x	At natural hillside in the embankment area?		x
11. Is there significant settlement along the crest?		x	Over widespread areas?		x
12. Are decant trashracks clear and in place?	n/a		From downstream foundation area?		x
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		x	"Boils" beneath stream or ponded water?		x
14. Clogged spillways, groin or diversion ditches?		x	Around the outside of the decant pipe?	n/a	
15. Are spillway or ditch linings deteriorated?		x	22. Surface movements in valley bottom or on hillside?		x
16. Are outlets of decant or underdrains blocked?		x	23. Water against downstream toe?		x
17. Cracks or scarps on slopes?	x		24. Were Photos taken during the dam inspection?	x	

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

Note that the Hazard Potential Classification is based on the EPA classification prior to the site visit.

1 Georgia Power makes quarterly inspections of the embankments; daily to weekly measurements of monitoring wells and piezometers.

17,18 Scarps and sloughing, now healed, are noted in natural creek slopes below the berm at the south-east end. These are reportedly unchanged in at least the last 10 years.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # GA 0001449 INSPECTOR Adnams/Hargraves
Date May 26, 2009

Impoundment Name Bowen Power Plant Ash Pond
Impoundment Company Georgia Power
EPA Region 4
State Agency (Field Office) Addresss ______

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

New ________ Update x

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

IMPOUNDMENT FUNCTION: Dry Ash Stacked Storage, Gypsum Dewatering, Water Recycle

Nearest Downstream Town : Name Euharlee, Georgia
Distance from the impoundment 2 miles
Impoundment
Location: Longitude ______ Degrees ______ Minutes ______ Seconds
Latitude ______ Degrees ______ Minutes ______ Seconds
State ______ County ______

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

If So Which State Agency?______

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.

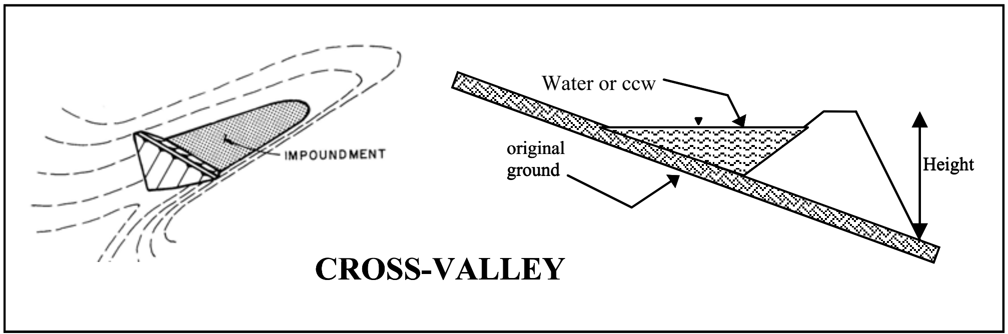
______ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. 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.

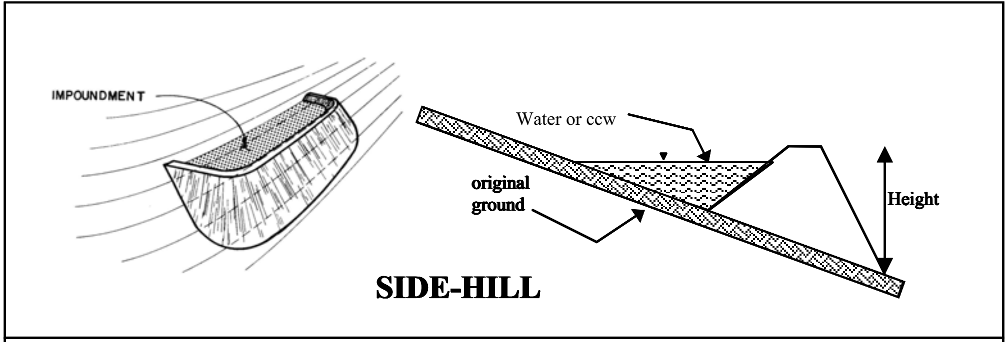
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

There is essentially little to no water-borne waste being retained in the ash "Pond". Essentially, the term "disposal pond" is misleading with respect to the function of the disposal operations. The hazard potential is primarily related to the karst topography evident below the disposal pond, the feature that eventually led to the change in operation from wet to dry storage/disposal. Any unpermitted releases would primarily be through the bottom of the disposal basin site, via karst solution features that can develop, most probably with notable fluctuations in groundwater table elevations in the bedrock and weathered bedrock formation. As such, any such damage would be environmental, associated with the coal combustion waste chemistry.

CONFIGURATION:

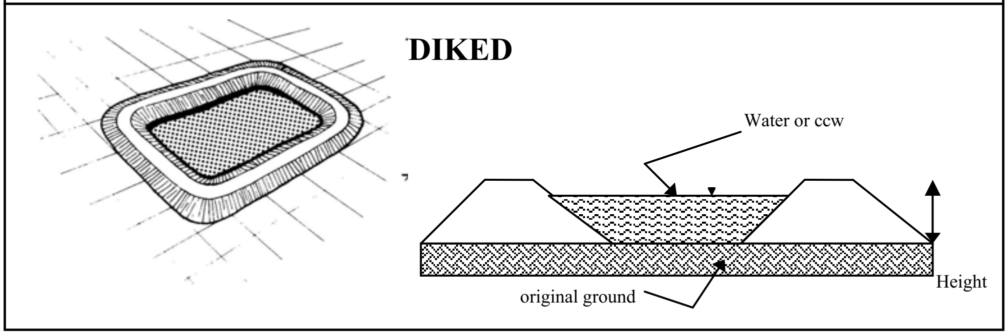


CROSS-VALLEY

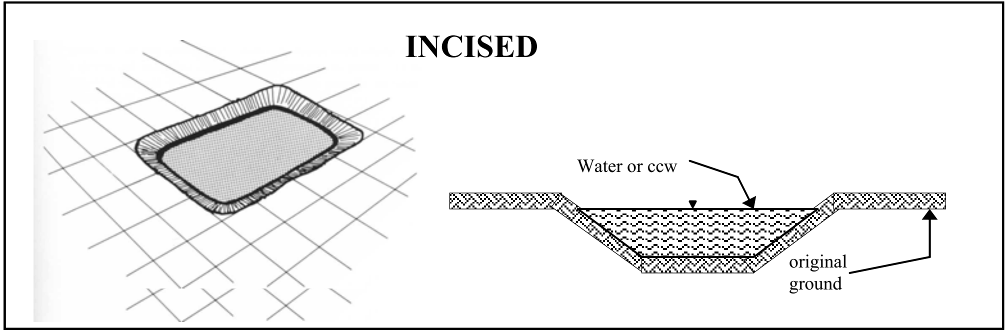


SIDE-HILL

DIKED



INCISED



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

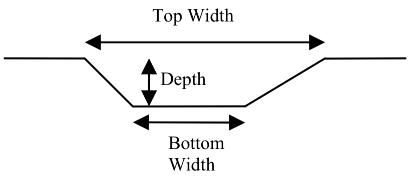
Embankment Height 45________ feet
Embankment Material Native Borrow______
Pool Area ____________________ acres
Liner HDPE (Recycle Pond), GCL, clay/silt
Current Freeboard n/a__________ feet
Liner Permeability ____________________

TYPE OF OUTLET (Mark all that apply)

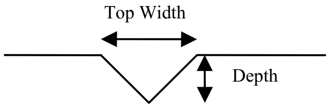
n/a **Open Channel Spillway**
______ Trapezoidal
______ Triangular
______ Rectangular
______ Irregular

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

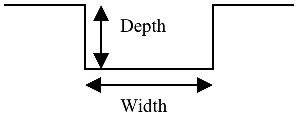
TRAPEZOIDAL



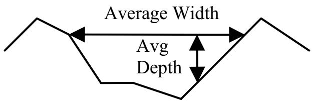
TRIANGULAR



RECTANGULAR

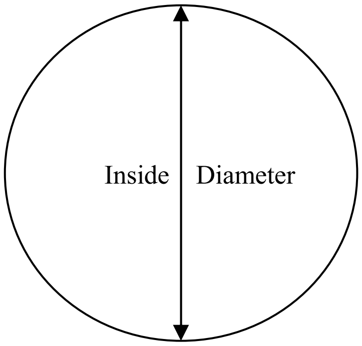


IRREGULAR



n/a **Outlet**

______ inside diameter



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

Is water flowing through the outlet? YES _______ NO _______

n/a **No Outlet**

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

The Impoundment was Designed By Southern Companies/Georgia Power

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

If So When? 2002, 2008

If So Please Describe :

In 2002, a sinkhole developed because of known karst topography underlying the site. During this event, ash laden water was conveyed below the dike via sinkhole activity and conduits in the karst topography. This event resulted in a significant evaluation of the dike stability, a compaction grouting program, and increased groundwater elevation monitoring frequency with all monitoring points read at least weekly and selected points read on a daily basis.

Additional measures were also undertaken to change the ash management process to a dry stack system with drainage swales. What remains of the wet process, a water recycling pond, two gypsum dewatering basins, and two ash dewatering/drying basins, have been lined with geosynthetic clay liners, HDPE liners, and/or native clay liners. This program was implemented to reduce the risk of fluctuation water levels from the plant operations having an impact on the underlying limestone formations.

In 2008 a surface water erosion event occurred in which a heavy rainstorm saturated and subsequently washed a portion of the dry stacked ash flowing over the dike. This event was not related to the stability of the impoundment dike, and a revised stacking plan has been developed with the Georgia EPD.

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

If So When? piezometers/dry stacking

IF So Please Describe:

See description of 2002 failure. Water-borne ash flowed beneath the dike structure through karst topography after sinkhole activity opened a conduit below the basin.

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,...)? piezometers/dry stacking

If so Please Describe :

The Bowen Power Plant has lined the recycle pond and the gypsum dewatering basins, and dewaters the CCW before stacking it in a dry state within the disposal area. A remote, automatic piezometer monitoring system is currently being installed and reconfigured as construction and dry stack disposal activities continue in the facility.

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN PLANS-MAPS.DWG Saved: 7/6/2009 2:35:49 PM Plotted: 7/6/2009 2:40:45 PM User: Filkins, Rebecca

IMAGE REFERENCE:
ASH POND AERIAL
OCTOBER 2008
DRAWING BOW-API 0044

Drawing Copyright © 2007 CHA

CHA

SITE PHOTO LOCATION MAP
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 9

1

South end of main dike at NPDES Sampling flume, looking west. The majority of the slope shown is a natural cut slope, 5 to 10 foot high embankment constructed to blend into slope in this area.

2

South end of main dike at NPDES sampling flume, looking east. Scarp in natural cut slope, reportedly unchanged in 6 to 10 years per Georgia Power Engineer responsible for inspections.

3

South end of the main dike, looking west. Note transition between natural cut slope and raised dike.

4

Perimeter ditch at south end of main dike, looking east. Another area of slough in natural cut slope has choked the channel and has reportedly remained unchanged in 6 to 10 years per Georgia Power Engineer responsible for inspections.

5

Perimeter ditch at south end of main dike looking west, 180 degree view of previous photo.

6

Continuing west on south end of main dike, another slough area in the natural cut slope, reportedly unchanged in 6 to 10 years per Georgia Power engineer responsible for inspections.

7

Continuing west on south end of main dike, another slough area in the natural slope reportedly unchanged in 6 to 10 years per Georgia Power engineer responsible for inspections. This area reportedly has had a difficult time re-establishing grass growth so more recent efforts included placing erosion matting.

8

South portion of the embankment near the end of the reclaimed water portion of the impoundment (looking west). Reclaim Pond is lined. Note set up for remote monitoring of piezometers (not operational as of our visit).

9

South end of the west portion of the Dike.

10

South end of the west portion of the Dike. Toe drain outlets are marked with concrete posts. Toe drain outlets located about every 200 feet. No flow noticed, and Georgia Power indicates they have not seen water flowing in the toe drain.

11

Embankment at the “Horseshoe” (looking south). Note the gravel at the toe which was placed during the grouting program to seal karst features below the embankment.

12

North end of main embankment (looking north). Note the gravel at the toe which was placed during the grouting program to seal karst features below the embankment.

13

Stone cover at North end of main embankment placed during the grouting program to seal karst features below the embankment. The white numbered concrete posts mark toe drain locations.

14

North end of main embankment (looking south).

15

Main Embankment Crest looking south. Note dry ash stack area in the left of the photo, original embankment crest width 15 feet. Drainage swale is located between the dam and the dry stacked ash pile.

16

Drainage swale between dam and dry stacked ash piles.

17

Surficial drainage system draining storm water runoff from ash stacks to the drainage swale.

18

Embankment at the "Horseshoe" looking north. Note original embankment crest width was 15 feet. Dry stacked ash placed uniform to dam crest.

19

Embankment at the "Horseshoe" looking north. Gray coloring at toe of embankment is gravel placed during the grouting program to seal karst features below the embankment.

20

Embankment looking from the "Horseshoe" looking south.

21

Reclaim Pond and south end of the embankment crest looking east. Note the Reclaim Pond is lined with and HDPE liner.

22

Drainage Swale noted in Photos 15, 16, and 17 discharges into the Reclaim Pond. Note the drainage swale is also HDPE lined. Behind the swale in this photo is one of two gypsum ponds.

23

Crest of south end of main embankment looking east.

24

Upstream side of North Dike looking east. Dry Stack ash piles in the right of the photo. Drainage swale in this area is unlined, but lining is planned for the 2009 construction season.

25

Overview of north dike, looking east.

26

West end of north dike, looking east.

27

Within the main impoundment looking north toward the dry stack area.

28

Within the main impoundment looking south. To the left of photo are the wet ash ponds (2) and to the right of the photo are the gypsum ponds (2).

29

The west embankment of the wet ash ponds. Note short height and 3H:1V slope.

30

North wet ash pond looking east.

31

North embankment of wet ash ponds.

32

North embankment of wet ash ponds, looking east.

33

Separator dike between two wet ash ponds.

34

South wet ash pond looking east.

35

West embankment of south wet ash pond, looking south.

36

South embankment of wet ash ponds, looking East. Note the lined drainage swale in right of photo discharges into the reclaim pond.

37

Upstream slope of south embankment of wet ash ponds, looking east. Note the red clay liner which overlays a liner.

38

East slope of wet ash ponds, looking south.

39

Sluiceway into the north wet ash pond.

40

East slope of wet ash ponds looking south.

41

Lined gypsum pond.

42

Emergency overflow and outlet sluice (via buried outlet pipe) from
the gypsum pond into the drainage swale running to the reclaim pond.

3.0 DATA EVALUATION

3.1 Design Assumptions

Design drawings from 1969 show that the dikes were generally homogenous structures comprising low permeability compacted fill supported above the natural soil, with a height ranging from 35 feet for the north dike to 45 feet for the west dike. The upstream and downstream slopes had 2:1 grades, which was fairly typical of that time period. Most critically, relative to the current condition in the pond, the dikes were to impound liquid borne, completely saturated, coal combustion waste (CCW). The required free board on the dikes would have been based on hydraulic and hydrology analyses for the impoundment. This historical information was not available at the time this report was written and current operating procedures at the site include only a small area of liquid borne CCW and the remaining portions of the site contain ash placed under hydraulic conditions, and stacks of dry ash.

3.2 Hydrology and Hydraulics

Georgia EPD classifies the Bowen Ash Pond as a Category II dam based on their criteria that a failure at this impoundment would not be likely to result in a loss of life. As a Category II facility, Georgia regulations exempt the dam from the dam safety regulations.

Despite being exempt from the dam safety regulations, Southern Company provided CHA with an evaluation of the drainage from the Ash Pond site (including the dry stack area, wet process ponds, and gypsum ponds) during a 10-year, 24-hour storm event. The volume of runoff from this storm can be completely stored in the Recycle Pond. This storage ability was based on the normal operating pool elevation of the Recycle Pond.

In addition, the there are two methods of discharge from the Recycle Pond. The first discharges to the Etowah River through the NPDES permitted outlet. The second is a former discharge point that is still in place, and discharges to the Euharlee Creek. According to Southern Company this outlet requires manual operation.

In comparison, the same facility in a Category I condition would be required to safely pass or store 50% of the probable maximum flood (PMF).

3.3 Structural Adequacy & Stability

The Georgia Department of Natural Resources Environmental Protection Division outlines rules and regulations for dam safety in Standards for the Design and Evaluation of Dams (391-3-8-.09). The regulations state that all dams must be stable under all conditions of construction and/or operation of the impoundment. Analyses using the methods, guidelines and procedures of the agencies listed in the regulations yielding the minimum safety factors shown in Table 2 for earthen embankments can be considered as acceptable stability.

Table 2 - Minimum Safety Factors Required

Load Case	Required Minimum Factor of Safety
End of Construction	1.3
Steady State Seepage	1.5
Steady State Seepage with Seismic Loading	1.1
Rapid Drawdown (Upstream)	1.3
Submerged Toe with Rapid Drawdown	1.3

CHA reviewed the available 1969 design documents, 2003 slope study documents for the main and north dikes, and June 2009 stability analyses for the ash dewatering cell and gypsum settling pond dikes to ascertain how the dike structures were modeled and the apparent factor of safety against a global failure that would cause a breach and allow a release of liquid borne waste.

3.3.1 Main and North Dikes

In both the 1969 and 2003 analyses the main and north dikes were modeled as a homogenous clay embankment on a layered soil foundation. The 1969 design modeled the dike foundations with four separate soil strata, one of which exhibited fairly weak strength characteristics in an undrained or short term loading condition. Laboratory testing of this weak stratum indicated that a strength gain would likely be realized when allowed to consolidate, resulting in more favorable strength characteristics in a steady state condition. The following table summarizes the soil parameters used during the original design to examine global stability.

Table 3 - 1969 Soil Strength Parameters

Soil Stratum	**Unit Weight (pcf)**	**Friction Angle (φ)**	**Cohesion (psf)**	**Description**
A	122	10°	1,000	Embankment
B	128	23°	500	Natural Subgrade
C	115	6°	250	Natural Subgrade
C_1	115	18°	500	Natural Subgrade (consolidated)
D	120	18°	1,500	Natural Subgrade
E	120	7°	1,000	Natural Subgrade

Two of the four strata were modeled below the west dike location while three of the four strata were modeled beneath the north dike. A stability cross-section of the north dike structure (Sta. 71+70) assuming steady-state conditions and a full hydrostatic head at Elevation 715 is shown in Figure 4.

Following the July 2002 sinkhole event, a slope stability study was undertaken, focusing primarily on the west dike structure. That study examined five load cases that included steady state, hydrostatic uplift from within karst solution cavities, earthquake, hydrostatic uplift a short time after an earthquake with earthquake reduced soil strengths, and post-remediation that involved compaction grouting. In a manner similar to the original 1969 design, the 2003 slope stability study modeled the dike sections with a homogeneous clay embankment over a soil foundation, but modeled the soil foundation with two layers, one of which reflected a weak soil stratum, and modeled the impounded ash. After an extensive soil exploration program utilizing soil borings, in-situ cone pentrometer testing and laboratory testing, the following parameters were used for a steady state analysis as summarized in the following table.

Table 4 - 2003 Soil Strength Parameters (Steady State)

Description	Unit Weight (pcf)	Friction Angle (φ)	Cohesion (psf)
Embankment		31°	350
Firm Residual Soil	128	30°	218
Weak Residual Soil	115	20°	100
Ash	85	0°	0

The earthquake analysis in the 2003 study examined two seismic events, one with a 10% probability of exceedance (PE) in 50 years which would result in a peak ground acceleration (PGA) of 0.06 g, and another with a 2% PE in 50 years resulting in a PGA of 0.15g. Half of the PGA was assumed to manifest itself as a horizontal acceleration in the dikes, so a value of 0.075g was used in the pseudo-static analysis. In addition to the seismic forces, the 2003 study also modeled the dikes under two strength cases. One case used all of the available soil strength and the other case used a soil strength degradation as result of dynamic cyclical loading to 80 percent of the ultimate strength in the embankment fill and residual soil. Due to the saturated condition of the ash, it was given no shear strength value, a conservative assumption. The worst case scenario involving the maximum force and strength degradation is highlighted in this report. Soil strength parameters used for the earthquake analysis are summarized in the following table:

Table 5 - 2003 Soil Strength Parameters (Earthquake)

Description	Unit Weight (pcf.)	Friction Angle (φ)	Cohesion (psf)
Embankment	122	2.5°	280
Firm Residual Soil	124	24°	175
Weak Residual Soil	117	20°	100
Ash	85	15°	0

Figures 11 and 12 show the typical geometry of the stability models analyzed in the 2003 stability report and Figure 13-1 through 13-3 and Figures 14-1 through 14-3 highlight the results of the analyses. Computed steady state safety factors in these locations ranged from 1.4 to 1.5

and the seismic safety factors ranged from 0.99 to 1.1. Table 6 summarizes the results of stability analyses performed on the main and north dikes.

Table 6- Safety Factors – Ash Pond

Load Case	USACOE Minimum Factor of Safety Guidelines	1969 Design Documents		2003 Slope Study (min. of sections analyzed)
		North Dike	Main Dike	
Steady State Seepage ▪ Downstream Slope ▪ Upstream Slope	1.5	1.9 2.7	1.7 4.0	1.4
Steady State Seepage with Seismic Loading	1.0	NP	NP	0.99 (2% in 50yr) 1.1 (10% in 50yr)
Rapid Drawdown (Upstream)	1.3	NP	NP	NP
Under Wash/Uplift from Karst Feature	--	NP	NP	0.97
Post Seismic Condition with Development of Karst Feature	--	NP	NP	0.95

NP: Not performed

3.3.2 Wet Ash and Gypsum Dikes

Since the 2003 slope stability report was completed, Plant Bowen has completed its change to a dry stack operation, greatly reducing the wet CCW processing area to two small dewatering cells and two gypsum settling ponds. These are diked, GCL or HDPE lined basins constructed from compacted bottom ash and capped with natural soil. The ash dewatering cells are constructed with a 20-foot wide crest, 2.5:1 slopes, and are about 14 feet in height.

Southern Company provided CHA with analyses for the dewatering cells, and the resulting factors of safety for steady state and seismic conditions are summarized in Table 7. Rapid drawdown is not required for these because the dikes are lined with geosynthetic liners. Therefore, there are not hydrostatic pressures within the embankment.

CHA performed a sensitivity analysis of these structures with slightly lower embankment and immediately underlying ash strength properties based on our review of properties used at multiple ash ponds under steady state and seismic conditions. The results of CHA's analyses are also listed in Table 7 and show factors of safety meeting industry accepted standards.

Table 7- Safety Factors – Dewatering Cells

Load Case	USACOE Minimum Factor of Safety Guidelines	Southern Company Analysis		CHA Stability Analysis	
		Downstream Slope	Upstream Slope	Downstream Slope	Upstream Slope
End of Construction	1.3				
Steady State Seepage	1.5	1.8 (shallow) 2.7 (deep)	2.5 (deep)	1.9	4.6 (shallow)
Steady State Seepage with Seismic Loading	1.0	1.1 (shallow) 1.6 (deep)	1.1 (shallow) 1.4 (deep)	1.5	
Rapid Drawdown (Upstream)	1.3	N/A	N/A	N/A	N/A

Figures 15-1 through 15-3 illustrate the construction and stability cross sections for the dewatering cells. Although the gypsum cells are slightly higher (about 23 feet), their side slopes are 3H:1V. Based on CHA analyses, the factors of safety for the gypsum cells is similar to that of the ash dewatering cells.

Based upon a review of the 2003 slope stability analysis data, the completed compaction grouting program under the west dike to strengthen foundation soils, the change from a wet to dry process disposal operation that continues to lower the overall piezometric levels in the pond, and a slope stability analysis of the present liquid CCW basins, the dikes appear structurally adequate.

3.4 Operations & Maintenance

Southern Company has performed engineering analyses on the main and north dikes since the 2002 release of CCW through karst below the site. Although the karst below the site was known about during original design and construction, and minor, non-release developing sinkholes as a result of the karst have occurred throughout the life of the site, the 2002 event resulted in continued efforts to isolate water associated with the Power Plant operations from impacting the groundwater and the karst.

Georgia Power began transitioning to dry ash stacking instead of sluicing wet ash into the main impoundment in 1992. Between 1992 and 2002, about 6 to 12 inches of water was maintained on the surface of the ash for dust control purposes. Following the 2002 release of ash through karst below the main dike, Georgia Power changed their process of dust control to include placing moist (but not saturated) CCW, limiting the exposed area of ash, using temporary cover soil, and temporarily sealing exposed areas with a smooth drum roller. This was part of a stacking plan prepared in coordination with GA EPD.

The ash stacking plan was further modified in 2008 following an erosion triggered event in which heavy rain fall cause erosion and sloughing of an ash slope to inundate the drainage swale and flow over the top of the embankment.

In addition to the day to day CCW disposal operations, plant personnel have been informed of the underlying karst condition that continues to result in periodic maintenance needs and to be on the look out for developing sinkholes. Daily piezometer readings are reviewed by Southern Company personnel assigned to this project. In December 2008, a new sinkhole developed in which several piezometers in the area of the site showed an increase in water levels a few days prior to the expression of the sinkholes at the ground surface.

3.4.1 Piezometers

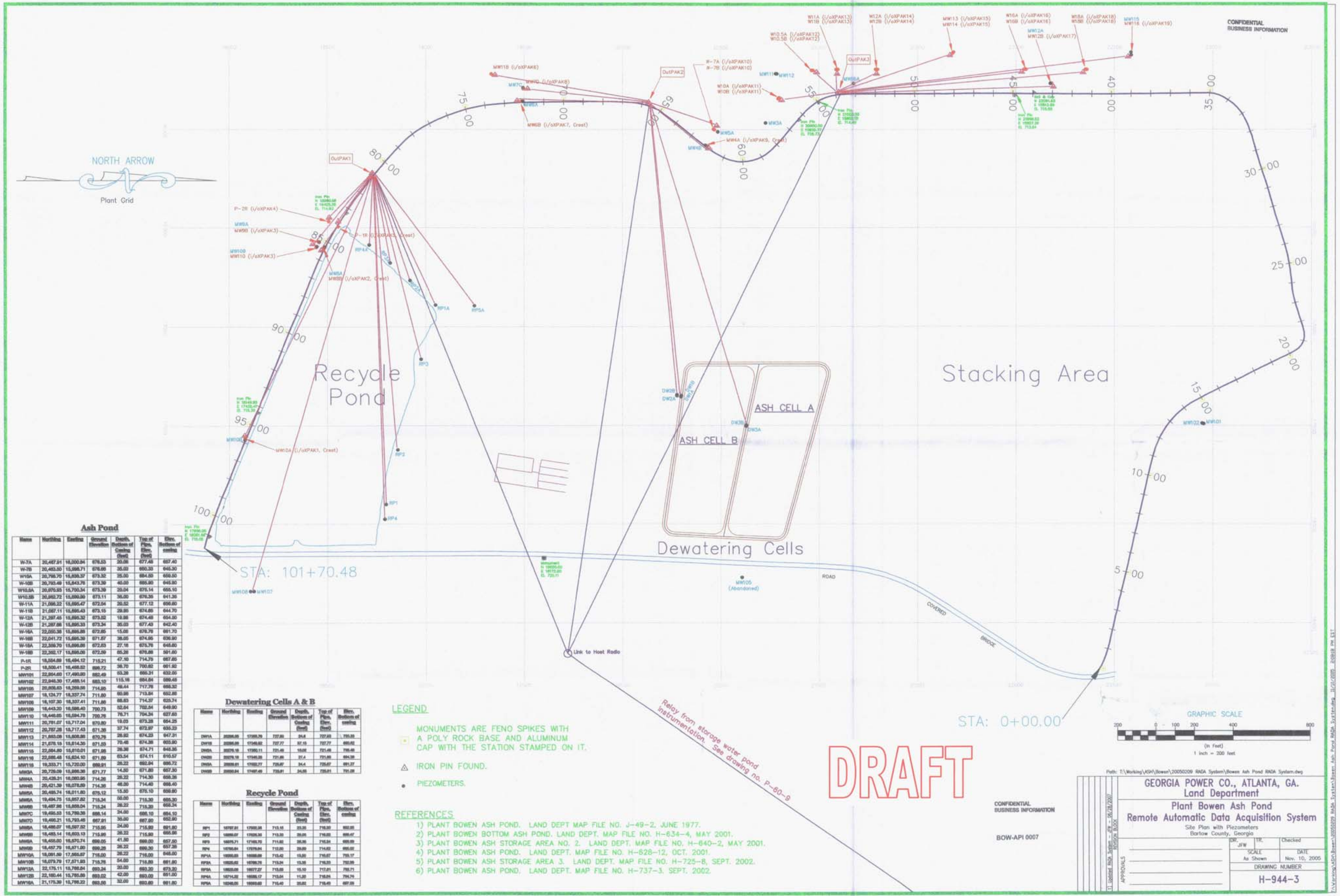
Plant Bowen personnel read selected piezometers around the impoundment on a daily basis and read all piezometers at least weekly. The data is transmitted to Southern Company for interpretation. Georgia Power is working on installing a new remote reading system so all piezometers will be able to be read daily.

Figures 16A-1 through 16-9 shows the piezometer readings for approximately the last ten years. Southern Engineering personnel indicated that prior to the December 2008 sinkhole, piezometric levels at MW-101 and MW-102 increased about three days before the sinkholes became visible at the ground surface.

3.4.2 Inspections

Plant Bowen personnel make daily to weekly inspections of the embankment. Southern Company personnel make quarterly inspections. Quarterly inspection reports from 2004 through 2009 were shared with CHA.

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN PLANS-MAPS.DWG Saved: 7/6/2009 2:35:49 PM Plotted: 7/6/2009 2:39:11 PM User: Filkins, Rebecca



LEGEND

- MONUMENTS ARE FENO SPIKES WITH A POLY ROCK BASE AND ALUMINUM CAP WITH THE STATION STAMPED ON IT.
- △ IRON PIN FOUND.
- ● PIEZOMETERS.

REFERENCES

1) PLANT BOWEN ASH POND. LAND DEPT MAP FILE NO. J-49-2, JUNE 1977.
2) PLANT BOWEN BOTTOM ASH POND. LAND DEPT. MAP FILE NO. H-634-4, MAY 2001.
3) PLANT BOWEN ASH STORAGE AREA NO. 2. LAND DEPT. MAP FILE NO. H-640-2, MAY 2001.
4) PLANT BOWEN ASH POND. LAND DEPT. MAP FILE NO. H-628-12, OCT. 2001.
5) PLANT BOWEN ASH STORAGE AREA 3. LAND DEPT. MAP FILE NO. H-725-8, SEPT. 2002.
6) PLANT BOWEN ASH POND. LAND DEPT. MAP FILE NO. H-737-3, SEPT. 2002.

IMAGE REFERENCE: PLANT BOWEN ASH POND REMOTE
AUTOMATIC DATA ACQUISITION SYSTEM
SITE PLAN WITH PIEZOMETERS
DRAWING NUMBER H-944-3
NOVEMBER 10, 2005

CHA

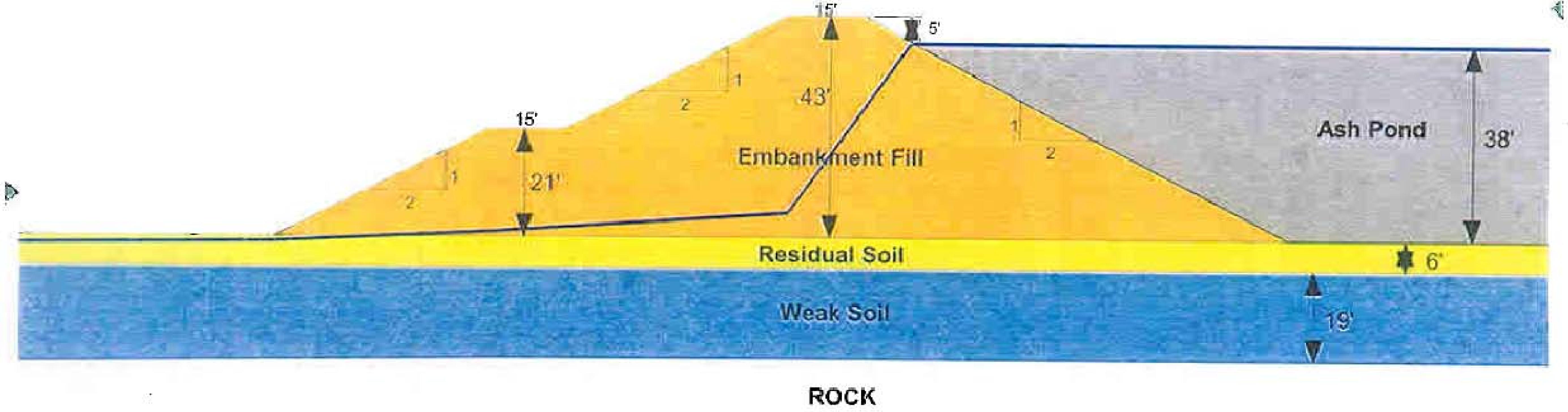
PIEZOMETER LAYOUT PLAN
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 10

Bowen Ash Pond Dike Stability Analysis
Section 1-2-3



Embankment Fill	Residual	Weak Residual	Ash
Unit Weight:122	Unit Weight:124	Unit Weight:117	Unit Weight:85
Cohesion:350	Cohesion:218	Cohesion:100	Cohesion:0
Phi:31	Phi:30	Phi:20	Phi:15

File Name: B-1,2,3 Case A.slz
Analysis Method: Bishop (with Ordinary & Janbu)
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

CONFIDENTIAL BUSINESS INFO

IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 3, PAGE 1

CROSS SECTION OF MAIN DIKE
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

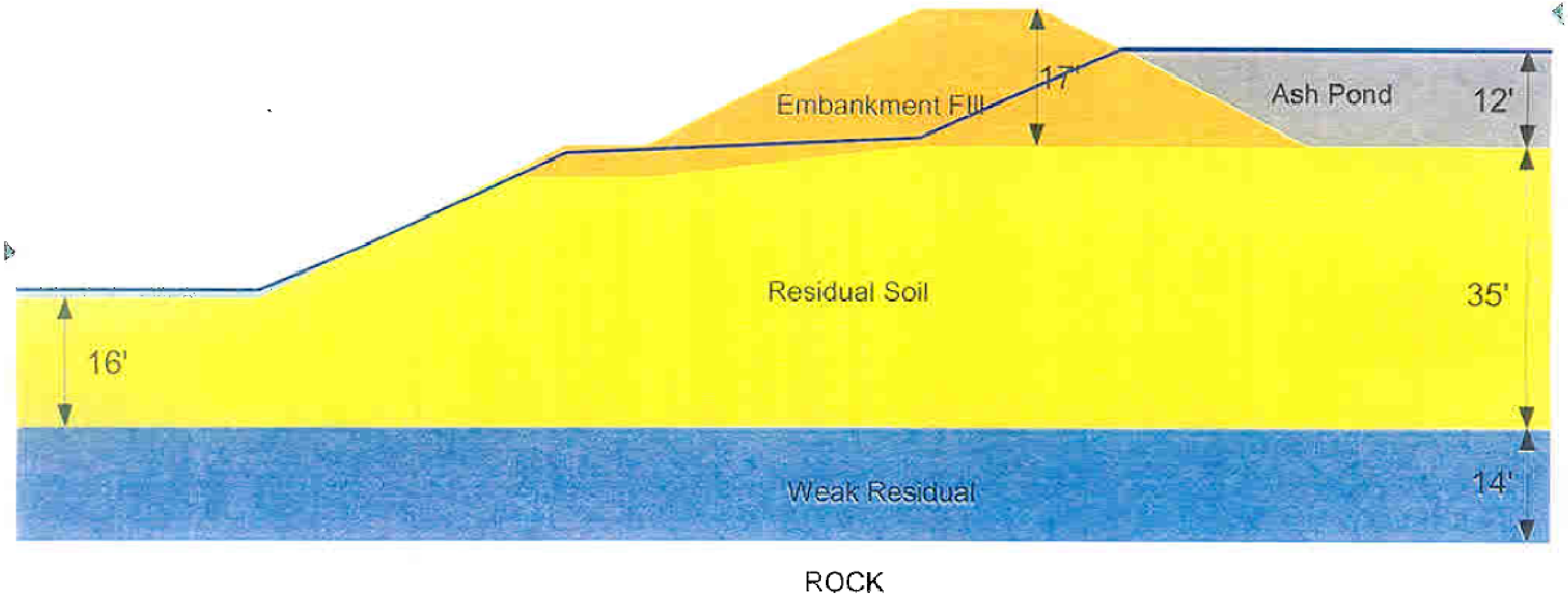
DATE: JULY 2009

FIGURE 11

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS1.DWG Saved: 7/6/2009 3:33:47 PM PLotted: 7/6/2009 4:58:25 PM User: Filkins, Rebecca

Bowen Ash Pond Dike Stability Analysis

Section 8-9



CONFIDENTIAL BUSINESS INFORMATION

Embankment Fill
Unit Weight:122
Cohesion:350
Phi:31

Residual
Unit Weight:124
Cohesion:218
Phi:30

Weak Residual
Unit Weight:117
Cohesion:100
Phi:20

Ash
Unit Weight:85
Cohesion:0
Phi:15

File Name: B-8,9 Case A.slz
Analysis Method: Bishop (with Ordinary & Janbu)
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 3,
PAGE 29

CHA

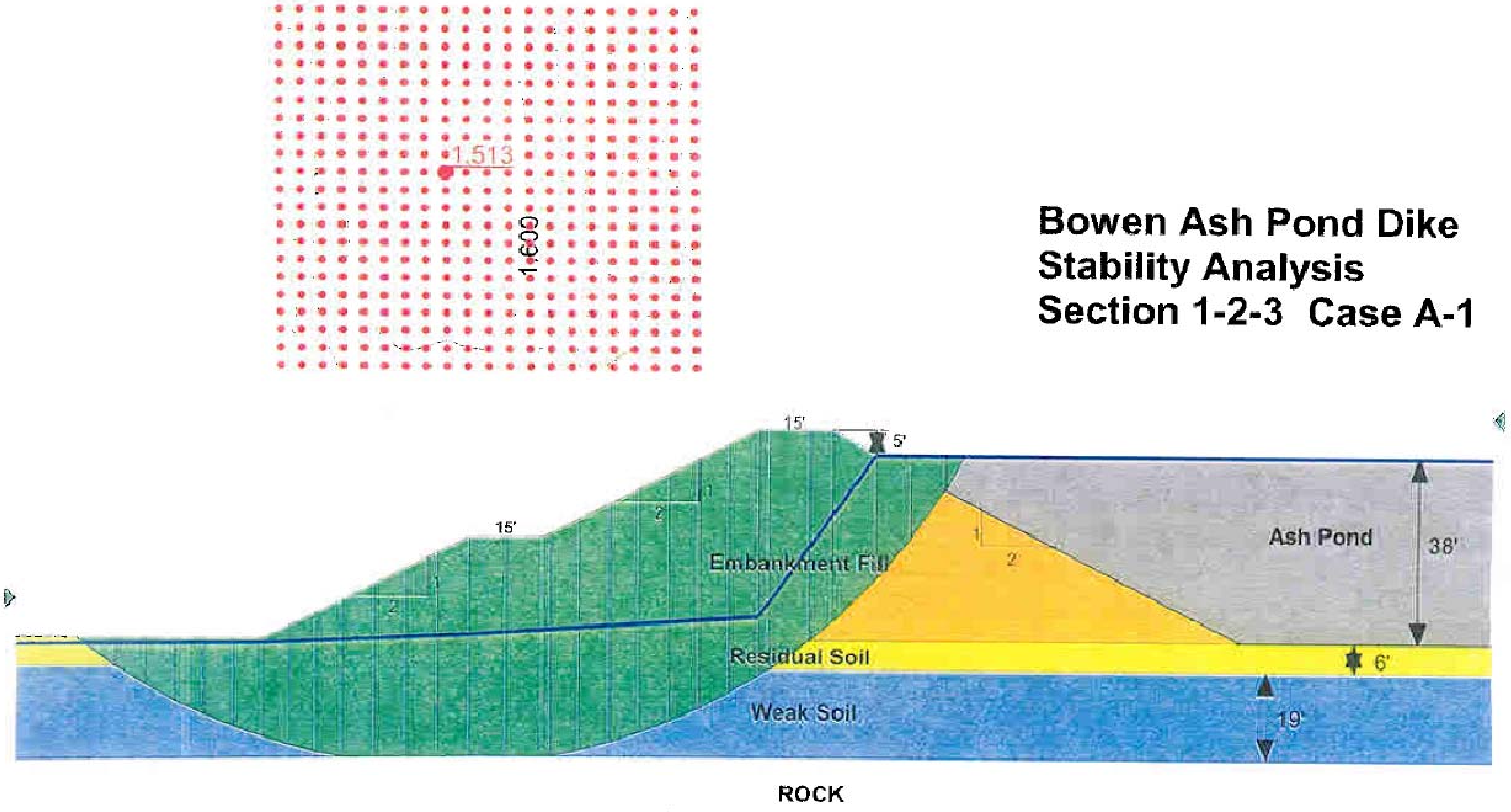
CROSS SECTION OF MAIN DIKE AT
RECYCLE POND
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 12

Bowen Ash Pond Dike Stability Analysis Section 1-2-3 Case A-1



Embankment Fill
Unit Weight:122
Cohesion:350
Phi:31

Residual
Unit Weight:124
Cohesion:218
Phi:30

Weak Residual
Unit Weight:117
Cohesion:100
Phi:20

Ash
Unit Weight:85
Cohesion:0
Phi:15

File Name: B-1,2,3 Case A-1.slz
Analysis Method: Bishop
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 3, PAGE 2

CHA

CROSS SECTION OF MAIN DIKE
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

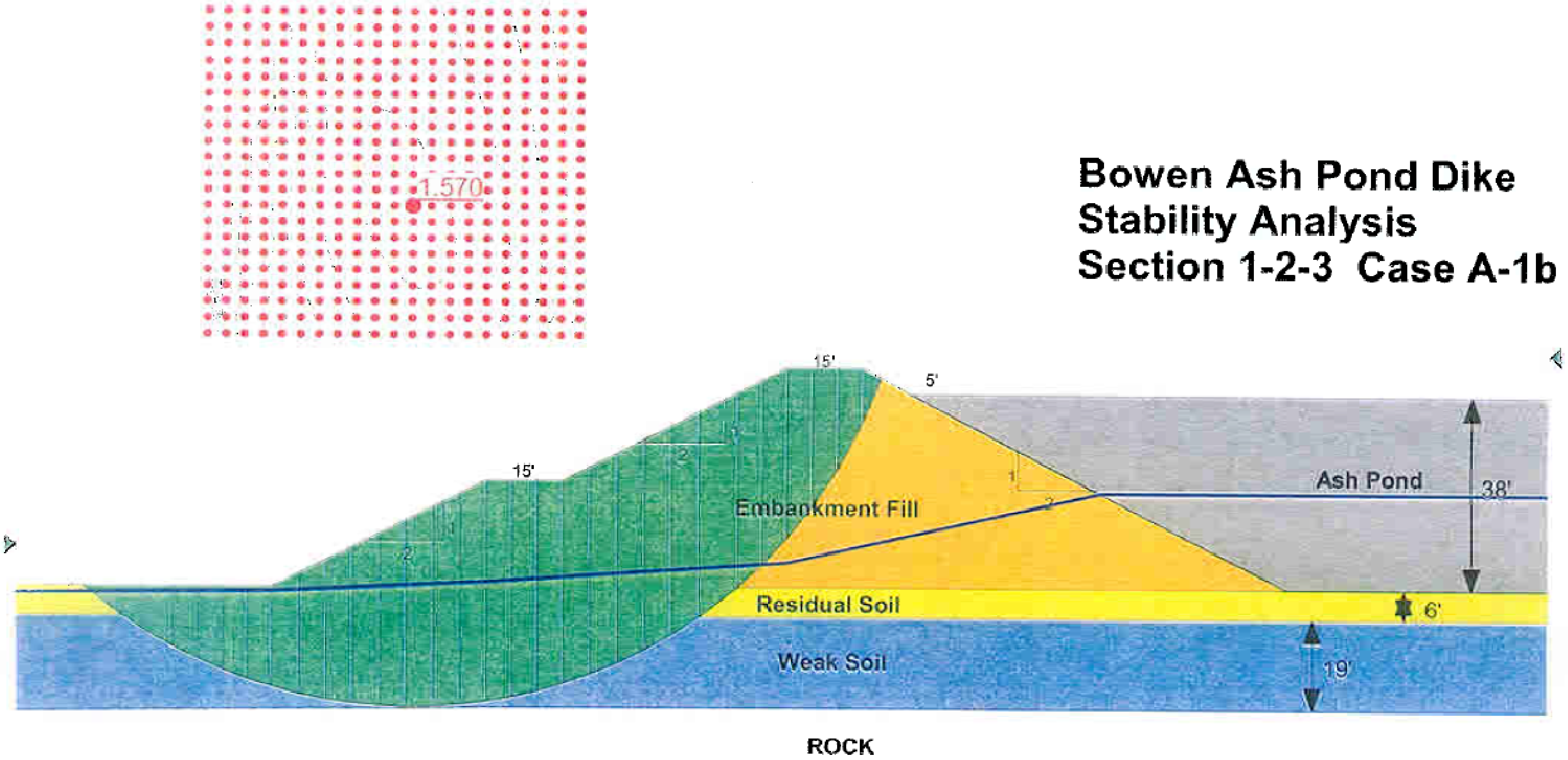
PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 13–1

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS1.DWG Saved: 7/6/2009 3:33:47 PM Plotted: 7/6/2009 5:07:56 PM User: Filkins, Rebecca

Bowen Ash Pond Dike
Stability Analysis
Section 1-2-3 Case A-1b



Embankment Fill
Unit Weight:122
Cohesion:350
Phi:31

Residual
Unit Weight:124
Cohesion:218
Phi:30

Weak Residual
Unit Weight:117
Cohesion:100
Phi:20

Ash
Unit Weight:85
Cohesion:0
Phi:15

File Name: B-1,2,3 Case A-1b.slz
Analysis Method: Bishop
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 3,
PAGE 4

CHA

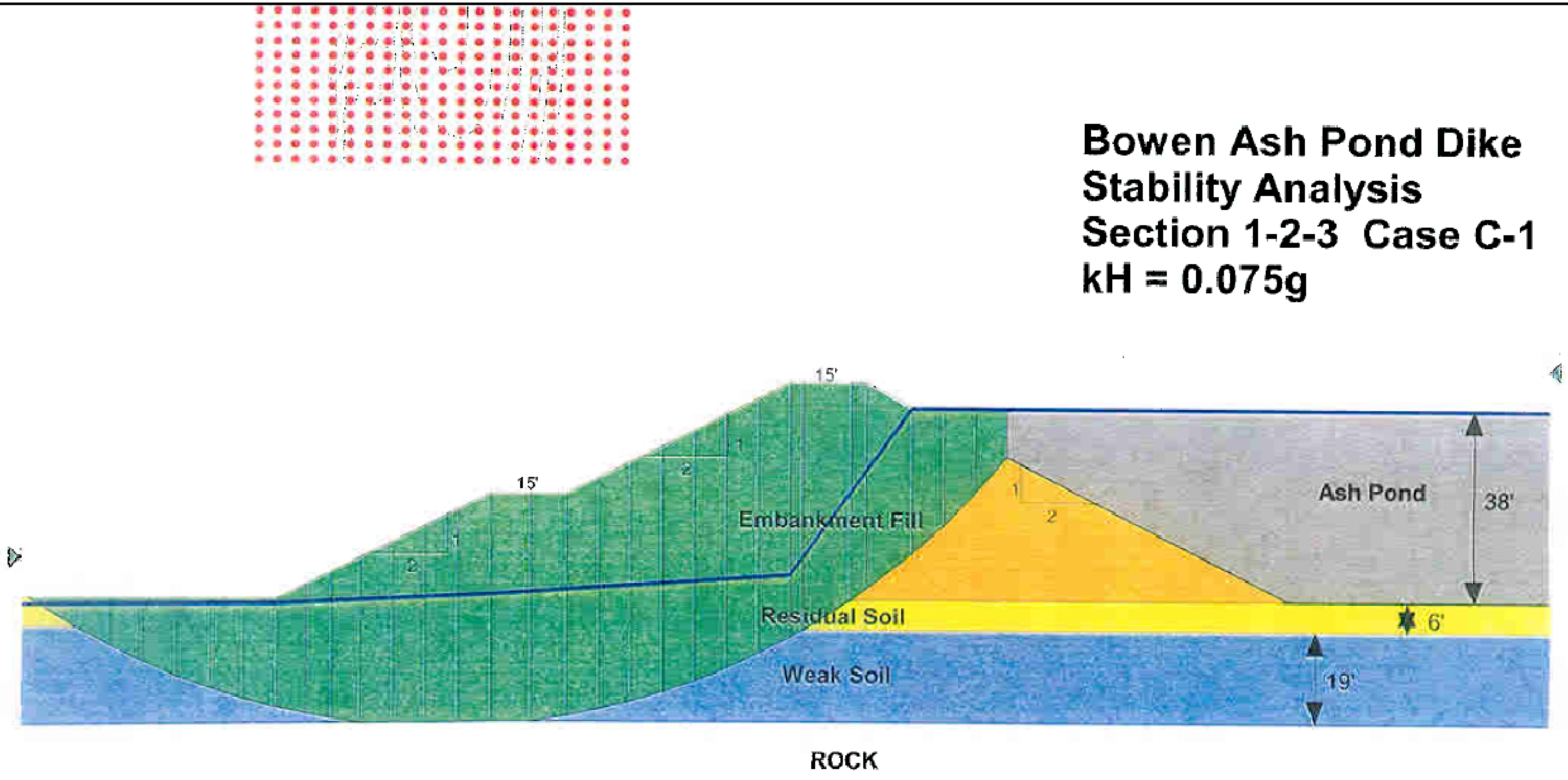
CROSS SECTION OF MAIN DIKE
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 13–2

Bowen Ash Pond Dike Stability Analysis Section 1-2-3 Case C-1 kH = 0.075g



Embankment Fill
Unit Weight:122
Cohesion:280
Phi:25

Residual
Unit Weight:124
Cohesion:175
Phi:24

Weak Residual
Unit Weight:117
Cohesion:100
Phi:20

Ash
Unit Weight:85
Cohesion:0
Phi:0

File Name: B-1,2,3 Case C-1.slz
Analysis Method: Bishop
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: Horizontal

CONFIDENTIAL BUSINESS INFORMATION

IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 3, PAGE 8

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS1.DWG Saved: 7/6/2009 3:33:47 PM Plotted: 7/6/2009 5:09:41 PM User: Filkins, Rebecca

CHA

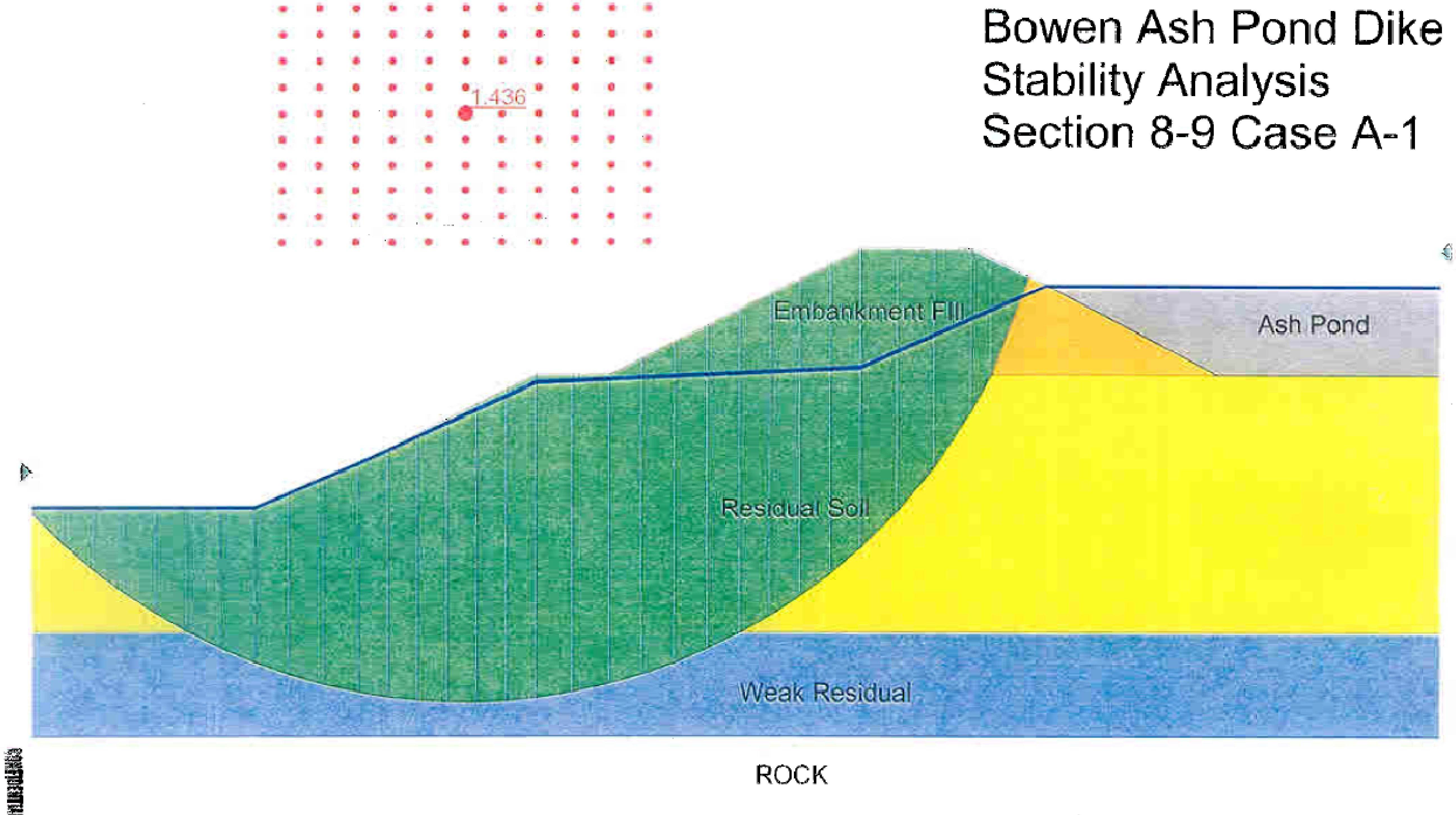
CROSS SECTION OF MAIN DIKE
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 13–3

Bowen Ash Pond Dike Stability Analysis Section 8-9 Case A-1



Embankment Fill
Unit Weight:122
Cohesion:350
Phi:31

Residual
Unit Weight:124
Cohesion:218
Phi:30

Weak Residual
Unit Weight:117
Cohesion:100
Phi:20

Ash
Unit Weight:85
Cohesion:0
Phi:15

File Name: B-8,9 Case A-1.slz
Analysis Method: Bishop
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

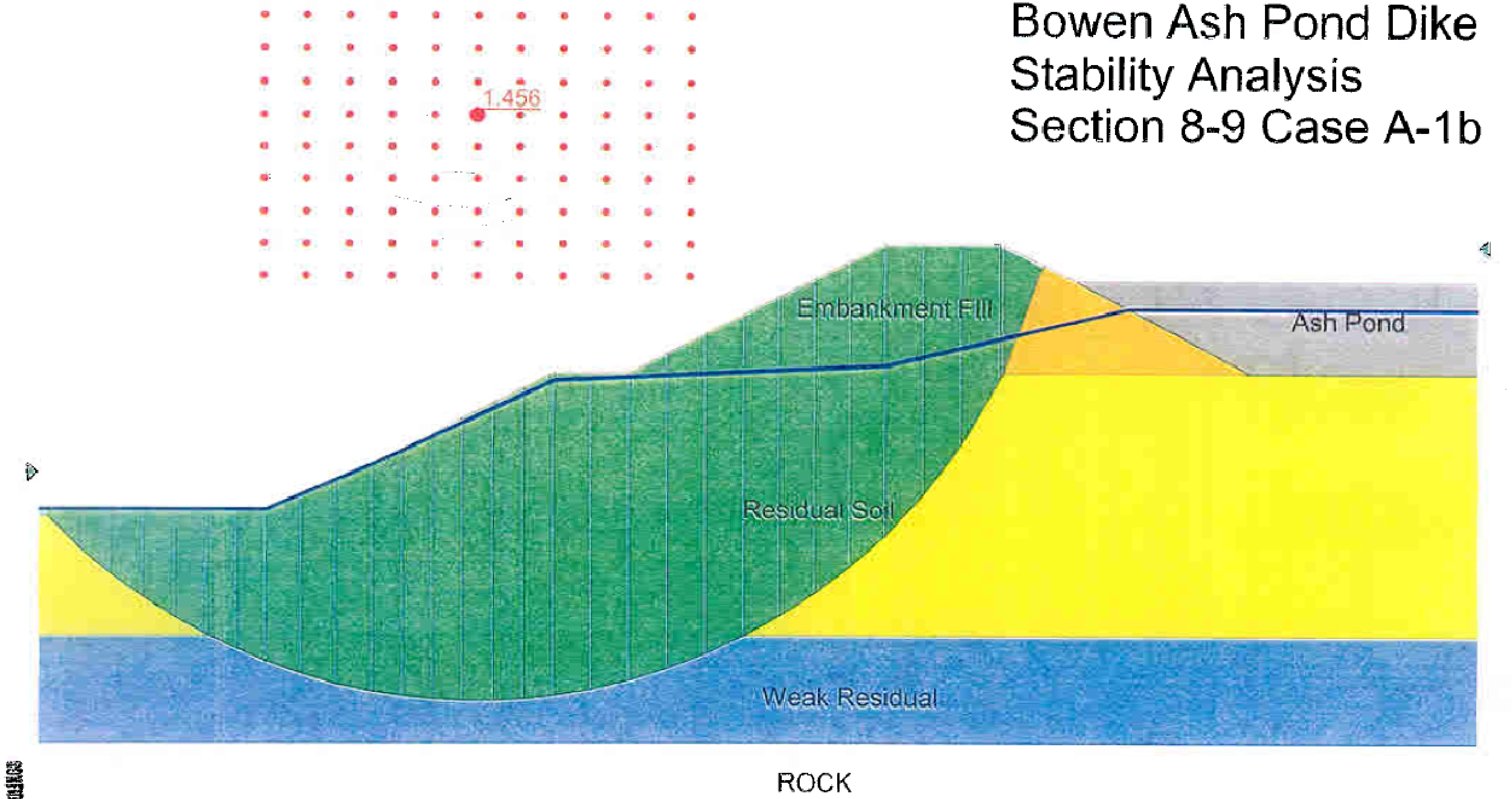
IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 3, PAGE 30

CHA

CROSS SECTION OF MAIN DIKE AT RECYCLE POND
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO. 20085.1000
DATE: JULY 2009
FIGURE 14–1

Bowen Ash Pond Dike
Stability Analysis
Section 8-9 Case A-1b



Embankment Fill
Unit Weight:122
Cohesion:350
Phi:31

Residual
Unit Weight:124
Cohesion:218
Phi:30

Weak Residual
Unit Weight:117
Cohesion:100
Phi:20

Ash
Unit Weight:85
Cohesion:0
Phi:15

File Name: B-8,9 Case A-1b.slz
Analysis Method: Bishop
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 3, PAGE 34

CHA

CROSS SECTION OF MAIN DIKE AT
RECYCLE POND
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

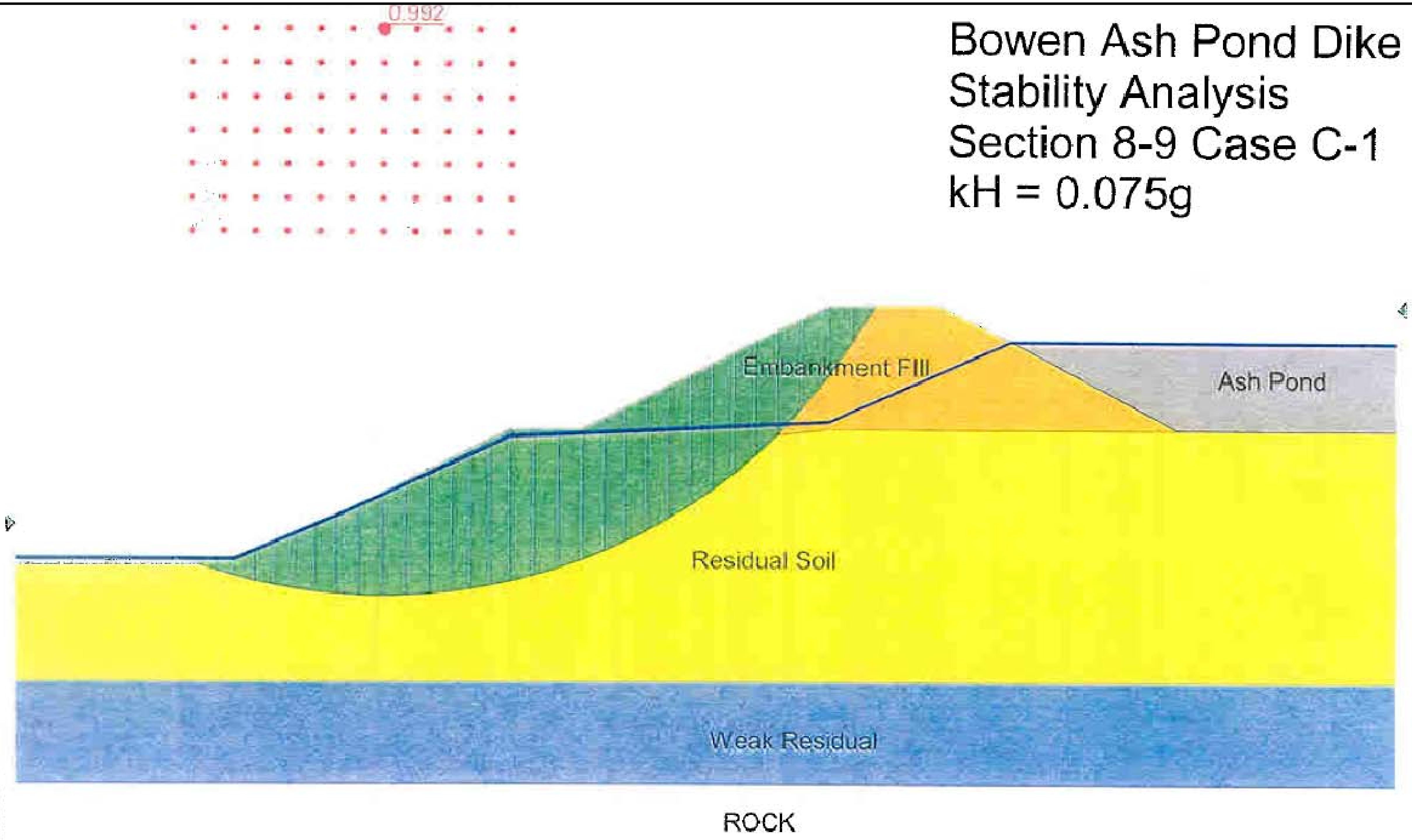
PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 14–2

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS2.DWG Saved: 7/6/2009 11:29:20 AM PLotted: 7/6/2009 5:23:05 PM User: Filkins, Rebecca

Bowen Ash Pond Dike
Stability Analysis
Section 8-9 Case C-1
kH = 0.075g



Embankment Fill
Unit Weight:122
Cohesion:280
Phi:25

Residual
Unit Weight:124
Cohesion:175
Phi:24

Weak Residual
Unit Weight:117
Cohesion:100
Phi:20

Ash
Unit Weight:85
Cohesion:0
Phi:0

File Name: B-8,9 Case C-1 shallow.slz
Analysis Method: Bishop
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: Horizontal

CONFIDENTIAL BUSINESS INFORMATION

IMAGE REFERENCE: STABILITY ANALYSIS OUTPUTS 2, PAGE 1

CHA

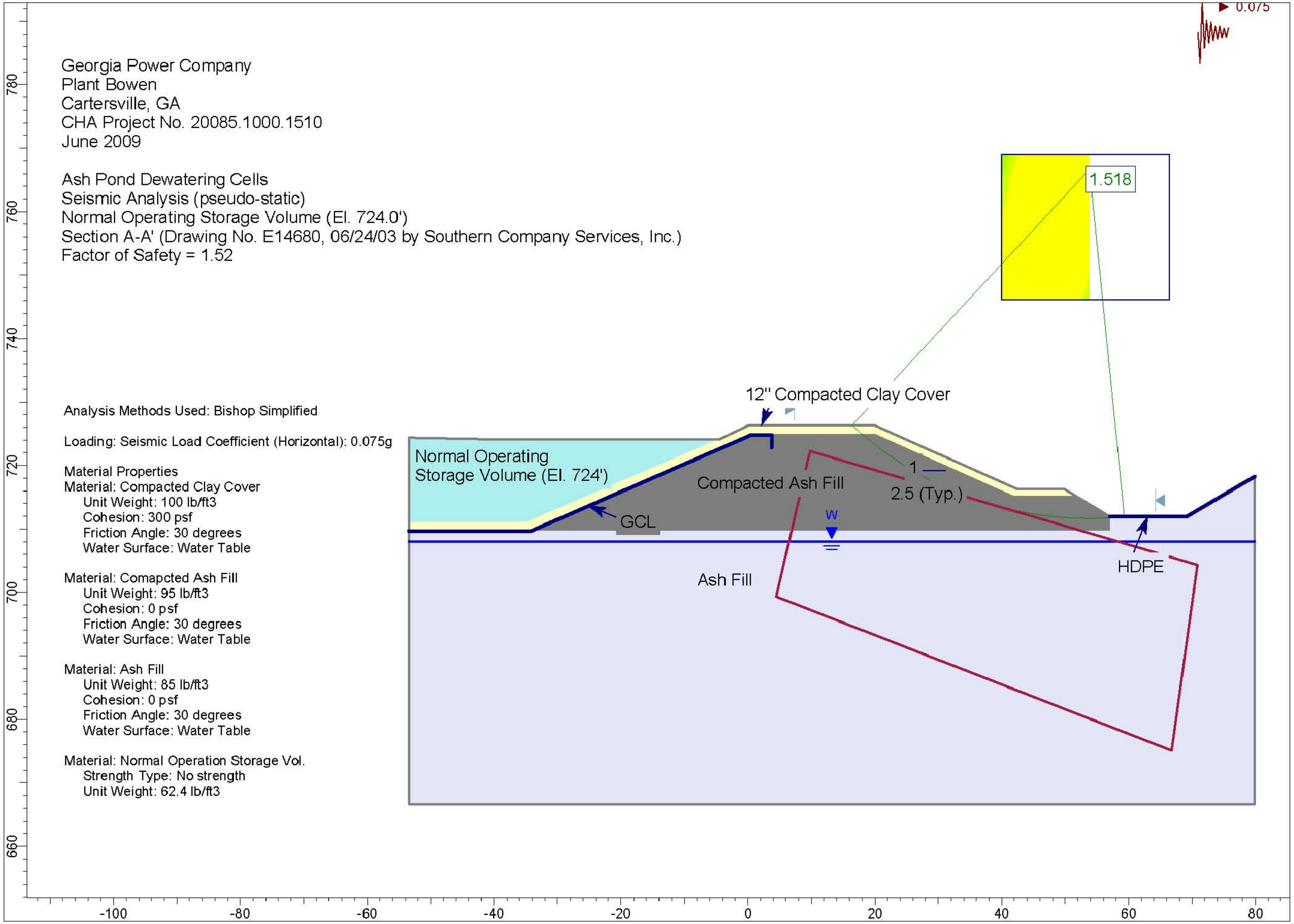
CROSS SECTION OF MAIN DIKE AT RECYCLE POND
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 14–3

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS2.DWG Saved: 7/6/2009 11:29:20 AM PLotted: 7/6/2009 5:25:11 PM User: Filkins, Rebecca


Georgia Power Company
Plant Bowen
Cartersville, GA
CHA Project No. 20085.1000.1510
June 2009

Ash Pond Dewatering Cells
Seismic Analysis (pseudo-static)
Normal Operating Storage Volume (El. 724.0')
Section A-A' (Drawing No. E14680, 06/24/03 by Southern Company Services, Inc.)
Factor of Safety = 1.52

Analysis Methods Used: Bishop Simplified

Loading: Seismic Load Coefficient (Horizontal): 0.075g

Material Properties
Material: Compacted Clay Cover
Unit Weight: 100 lb/ft3
Cohesion: 300 psf
Friction Angle: 30 degrees
Water Surface: Water Table

Material: Comapcted Ash Fill
Unit Weight: 95 lb/ft3
Cohesion: 0 psf
Friction Angle: 30 degrees
Water Surface: Water Table

Material: Ash Fill
Unit Weight: 85 lb/ft3
Cohesion: 0 psf
Friction Angle: 30 degrees
Water Surface: Water Table

Material: Normal Operation Storage Vol.
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

CHA

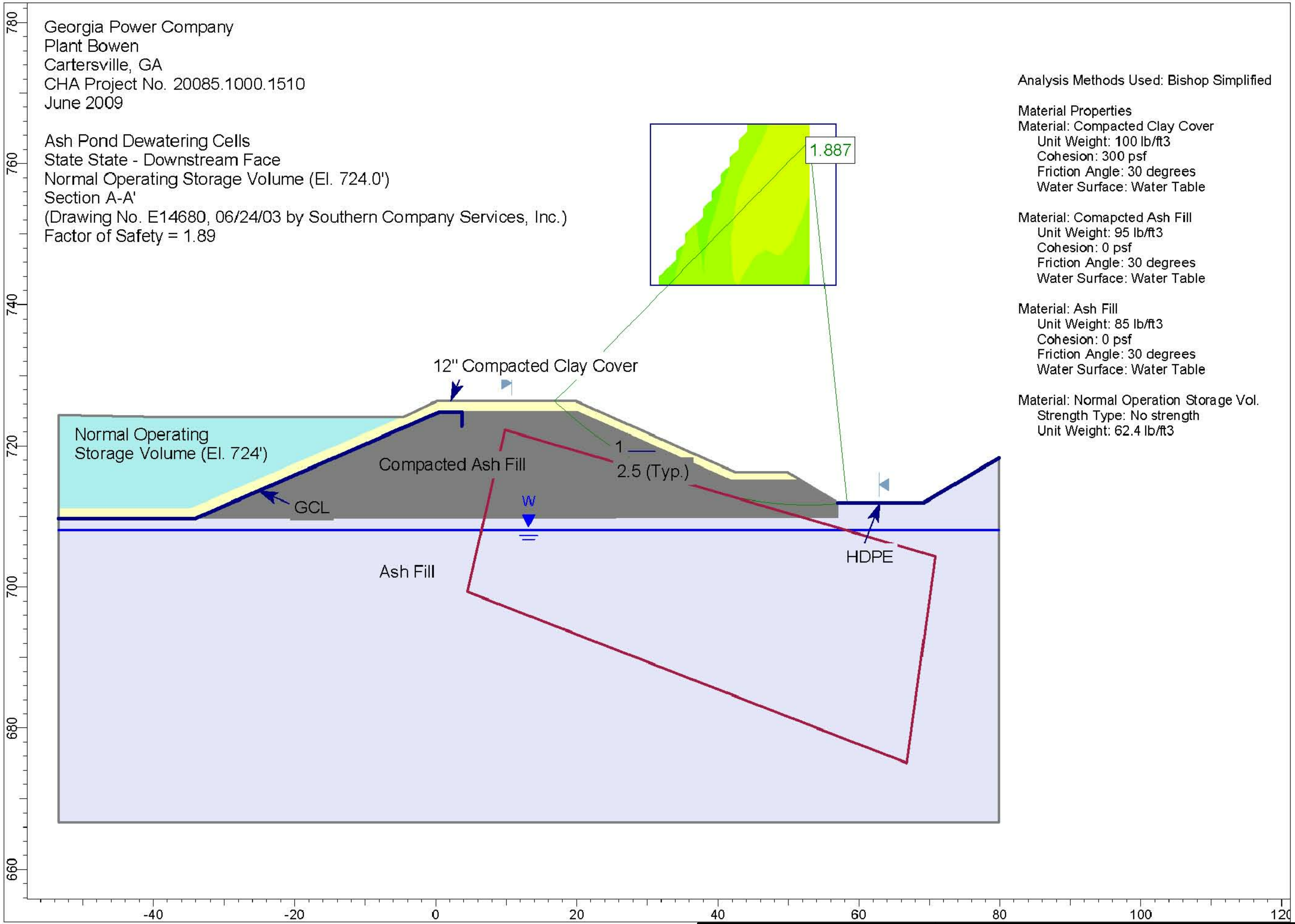
STABILITY ANALYSIS
ASH POND DEWATERING CELLS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 15-1

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS2.DWG Saved: 7/6/2009 9:51:29 AM PLotted: 7/6/2009 10:58:00 AM User: Filkins, Rebecca



Georgia Power Company
Plant Bowen
Cartersville, GA
CHA Project No. 20085.1000.1510
June 2009

Ash Pond Dewatering Cells
State State - Downstream Face
Normal Operating Storage Volume (El. 724.0')
Section A-A'
(Drawing No. E14680, 06/24/03 by Southern Company Services, Inc.)
Factor of Safety = 1.89

Analysis Methods Used: Bishop Simplified

Material Properties
Material: Compacted Clay Cover
  Unit Weight: 100 lb/ft3
  Cohesion: 300 psf
  Friction Angle: 30 degrees
  Water Surface: Water Table

Material: Comapcted Ash Fill
  Unit Weight: 95 lb/ft3
  Cohesion: 0 psf
  Friction Angle: 30 degrees
  Water Surface: Water Table

Material: Ash Fill
  Unit Weight: 85 lb/ft3
  Cohesion: 0 psf
  Friction Angle: 30 degrees
  Water Surface: Water Table

Material: Normal Operation Storage Vol.
  Strength Type: No strength
  Unit Weight: 62.4 lb/ft3

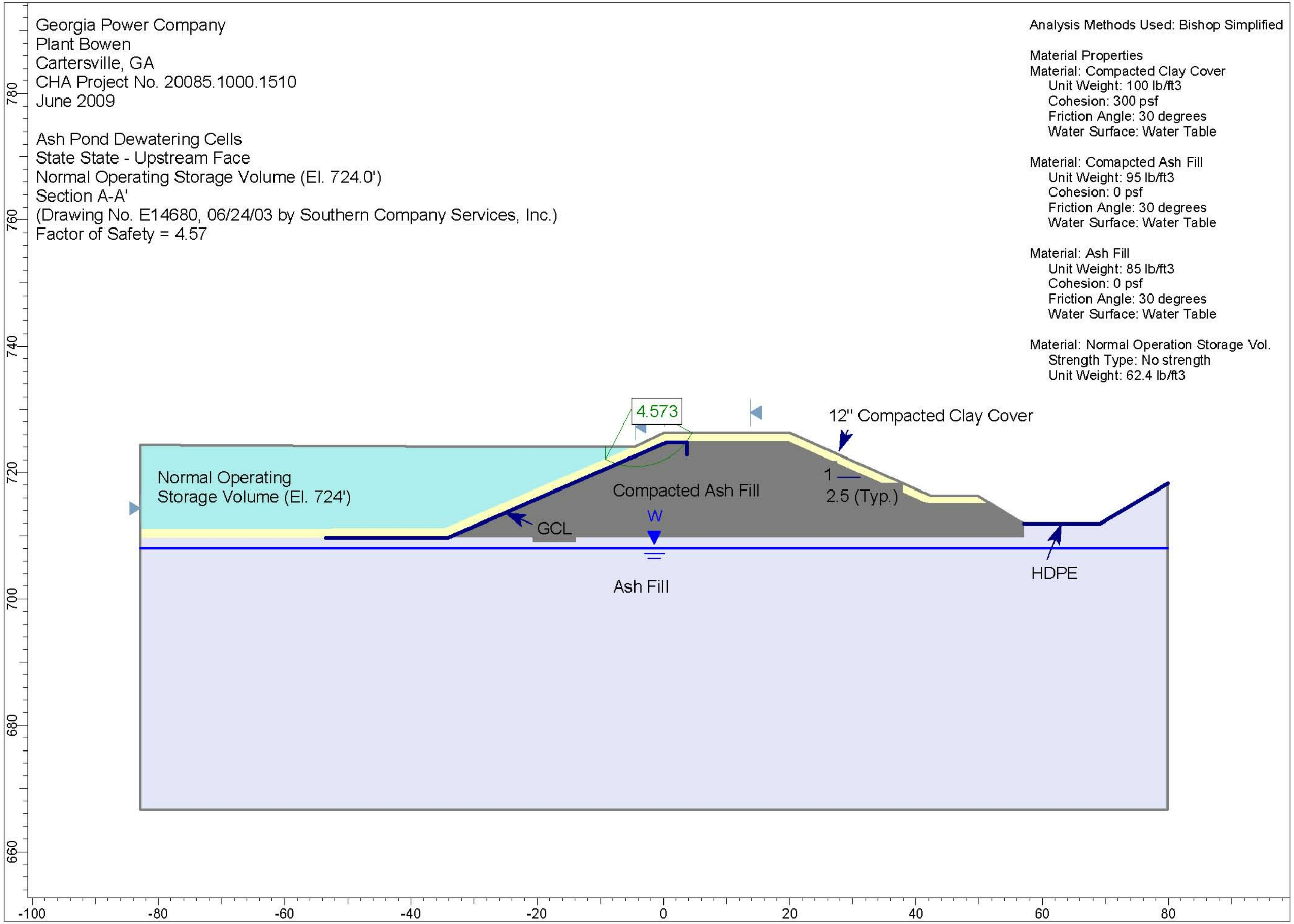
STABILITY ANALYSIS
ASH POND DEWATERING CELLS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 15–2

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS2.DWG Saved: 7/6/2009 9:51:29 AM PLotted: 7/6/2009 11:00:14 AM User: Filkins, Rebecca



Georgia Power Company
Plant Bowen
Cartersville, GA
CHA Project No. 20085.1000.1510
June 2009

Ash Pond Dewatering Cells
State State - Upstream Face
Normal Operating Storage Volume (El. 724.0')
Section A-A'
(Drawing No. E14680, 06/24/03 by Southern Company Services, Inc.)
Factor of Safety = 4.57

Analysis Methods Used: Bishop Simplified

Material Properties
Material: Compacted Clay Cover
Unit Weight: 100 lb/ft3
Cohesion: 300 psf
Friction Angle: 30 degrees
Water Surface: Water Table

Material: Comapcted Ash Fill
Unit Weight: 95 lb/ft3
Cohesion: 0 psf
Friction Angle: 30 degrees
Water Surface: Water Table

Material: Ash Fill
Unit Weight: 85 lb/ft3
Cohesion: 0 psf
Friction Angle: 30 degrees
Water Surface: Water Table

Material: Normal Operation Storage Vol.
Strength Type: No strength
Unit Weight: 62.4 lb/ft3

CHA

STABILITY ANALYSIS
ASH POND DEWATERING CELLS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

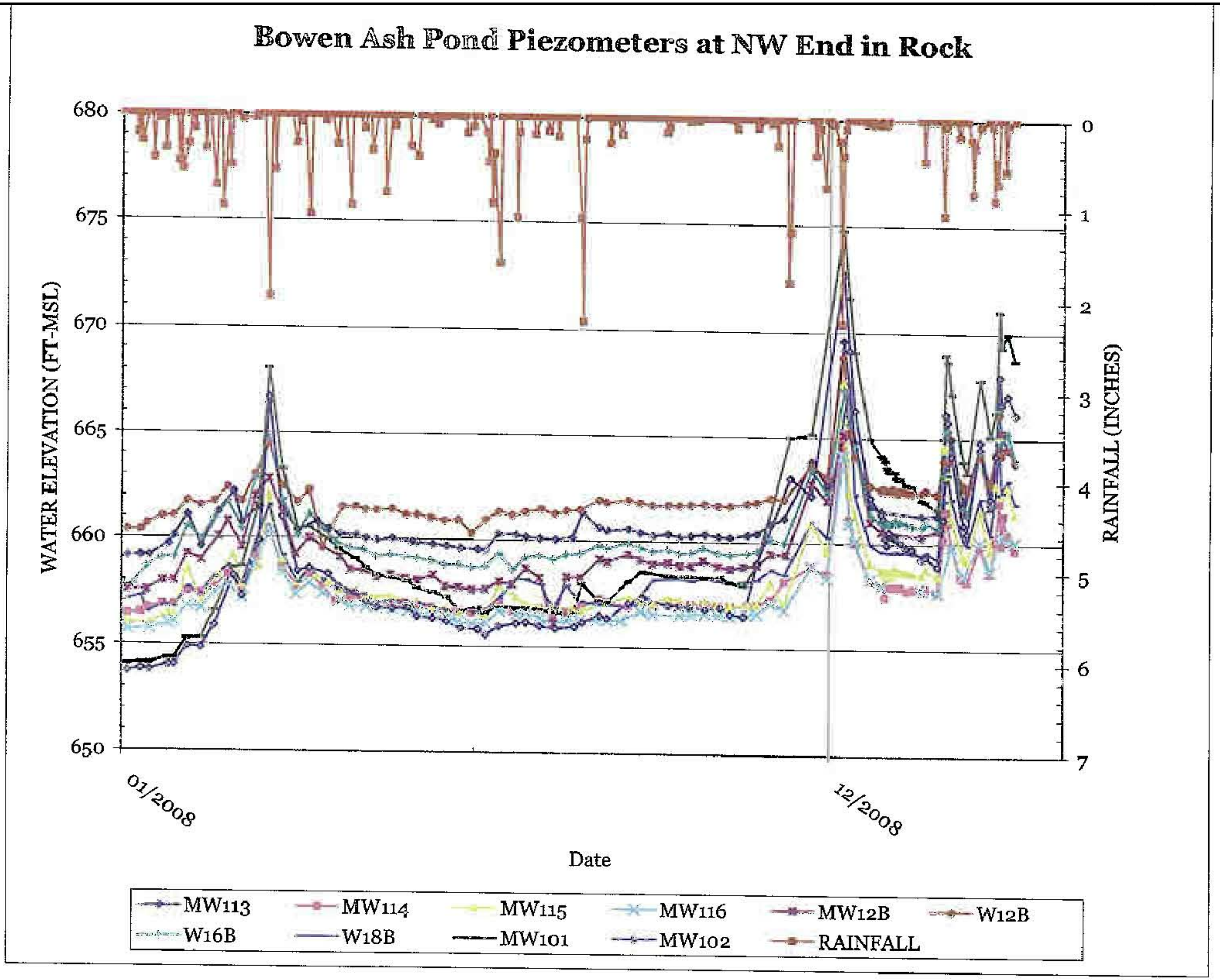
PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 15–3

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN XSECTS2.DWG Saved: 7/6/2009 9:51:29 AM PLotted: 7/6/2009 11:02:29 AM User: Filkins, Rebecca

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 12:55:25 PM User: Filkins, Rebecca



Z:\BOWEN\APNWPZB.XLS

4/17/2009

Drawing Copyright © 2007 CHA

CHA

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

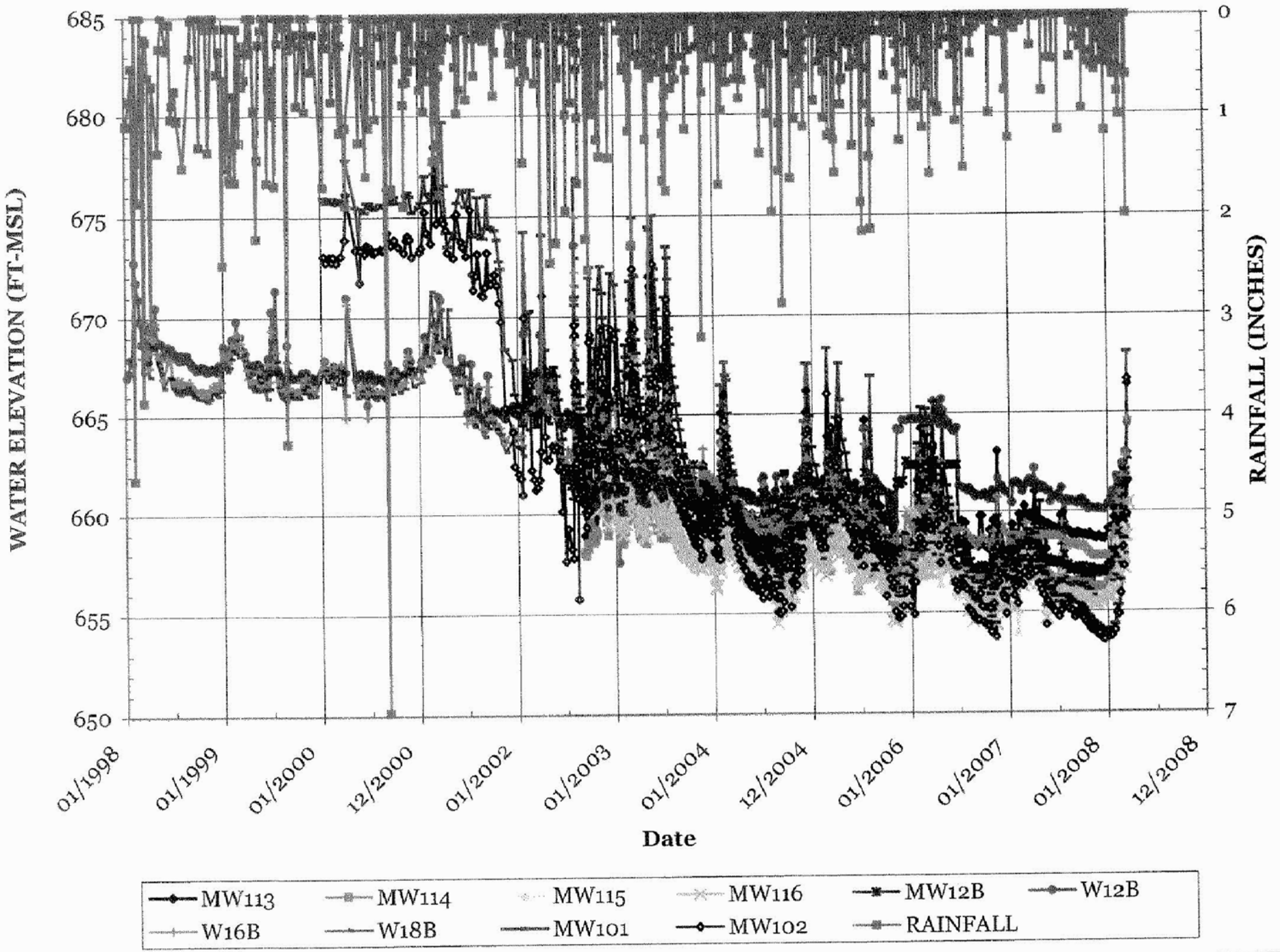
PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–1A

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 1:00:50 PM User: Filkins, Rebecca

Bowen Ash Pond Piezometers/OW at NW End in Rock



Z:\BOWEN\APNWPZB.XLS

5/5/2008

Drawing Copyright © 2007 CHA

CHA

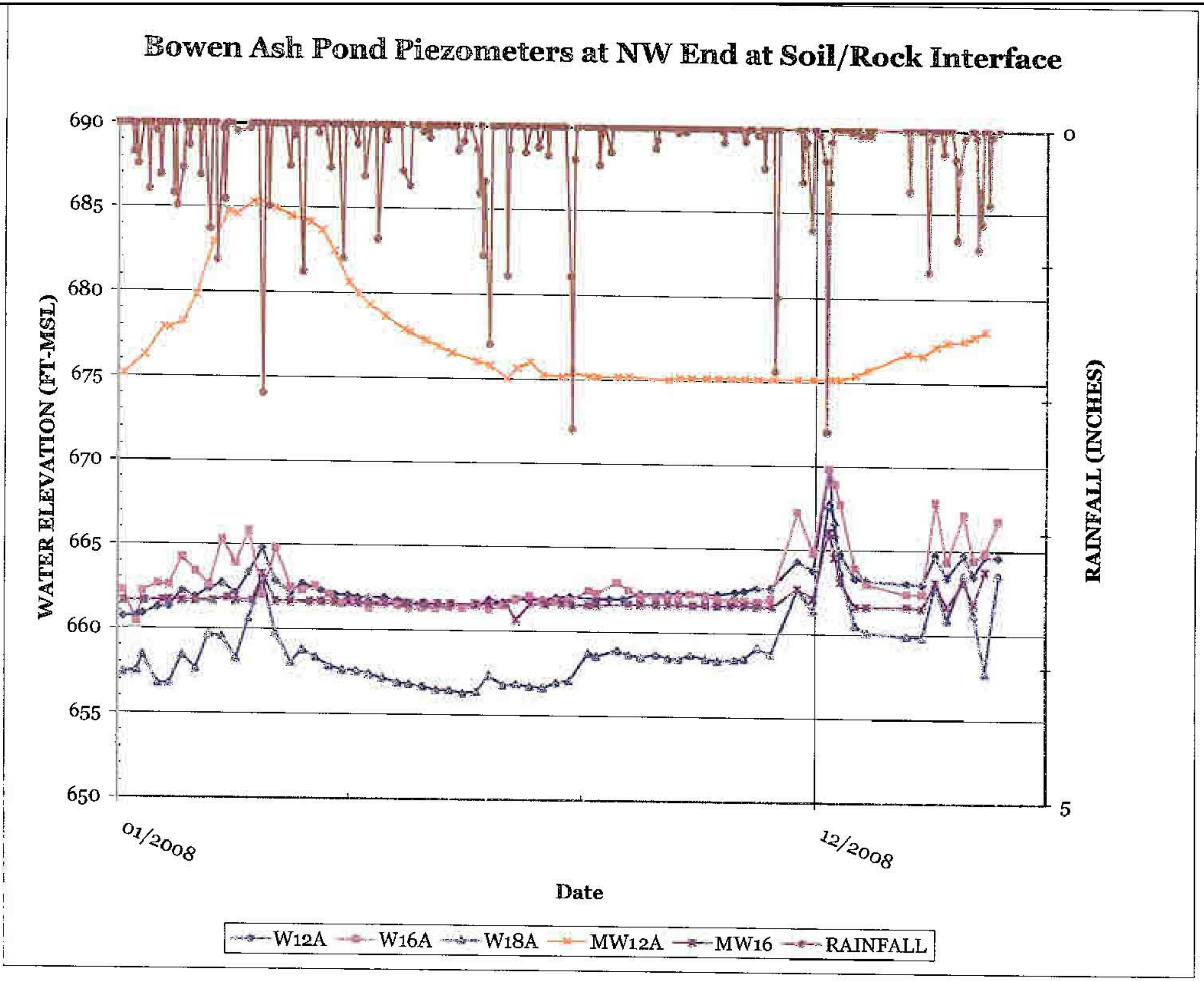
PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16-1B

CONFIDENTIAL BUSINESS INFORMATION



Z:\BOWEN\APNWPZA.XLS

4/17/2009

CHA

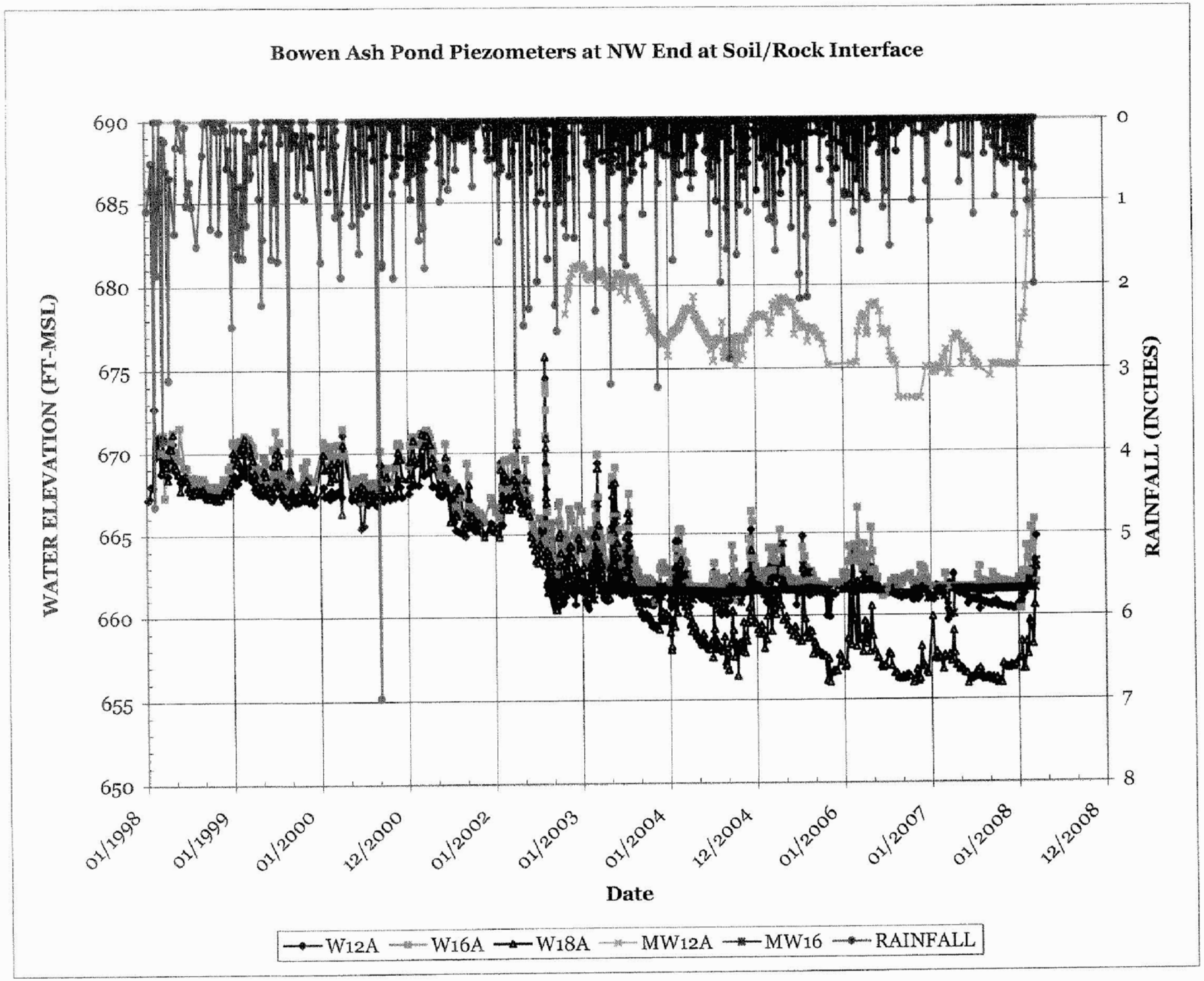
PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–2A

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 1:09:08 PM User: Filkins, Rebecca



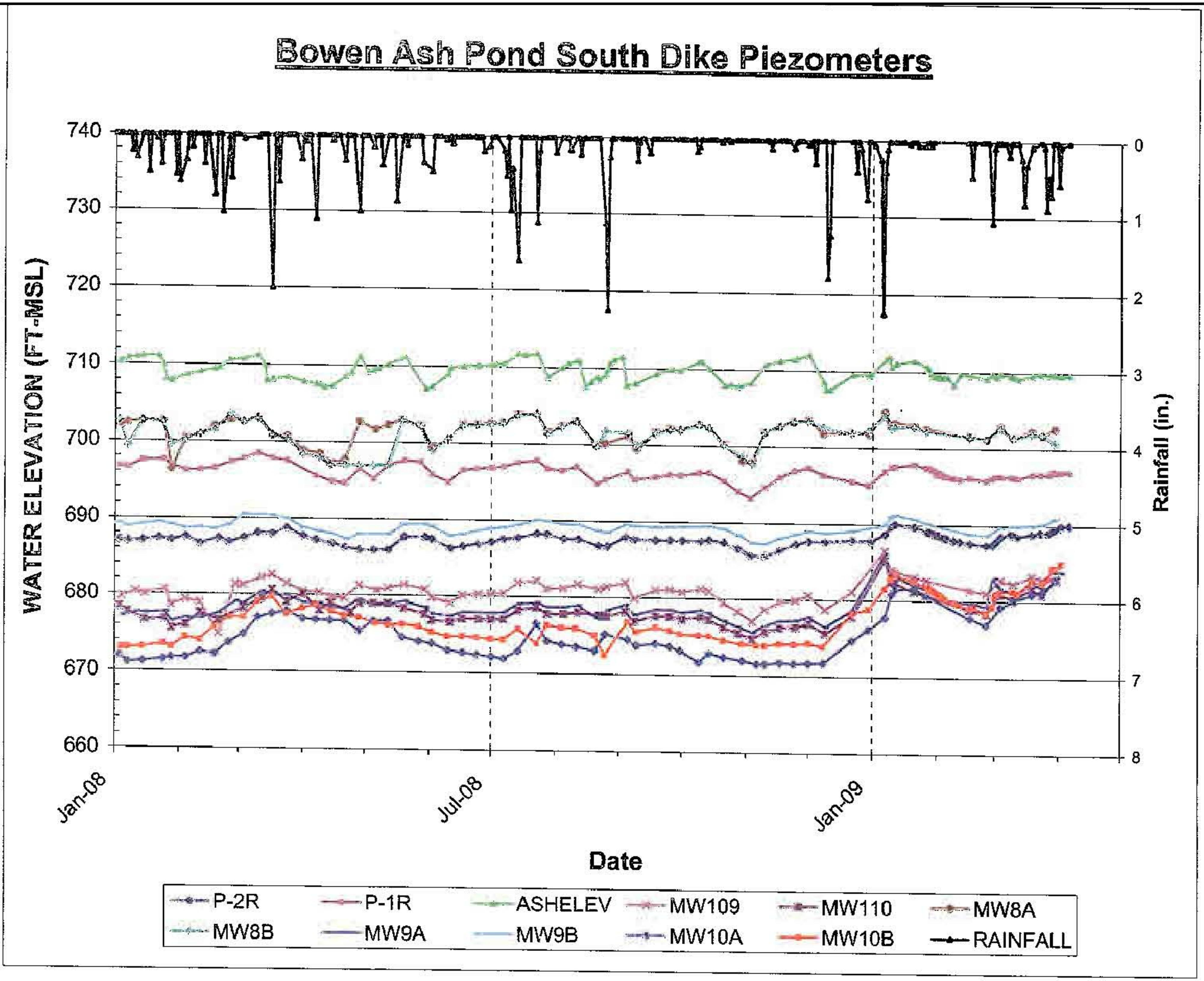
5/5/2008

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–2B



Z:\BOWEN\APPZ1.XLS

4/17/2009

Drawing Copyright © 2007 CHA

CHA

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

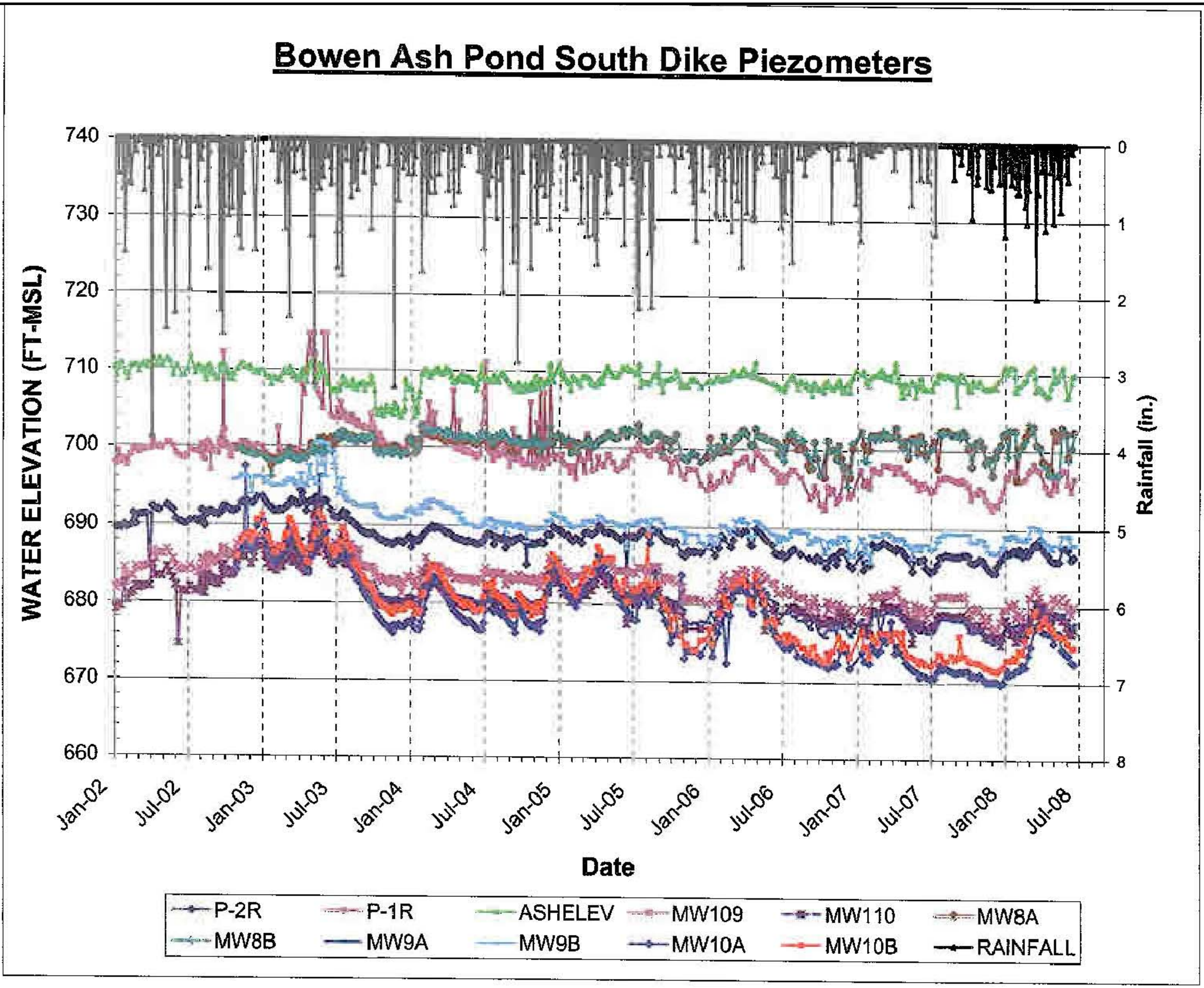
PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16-3A

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 1:11:00 PM User: Filkins, Rebecca

CONFIDENTIAL BUSINESS INFORMATION



Z:\BOWEN\APPZ1.XLS

1/16/2009

Drawing Copyright © 2007 CHA

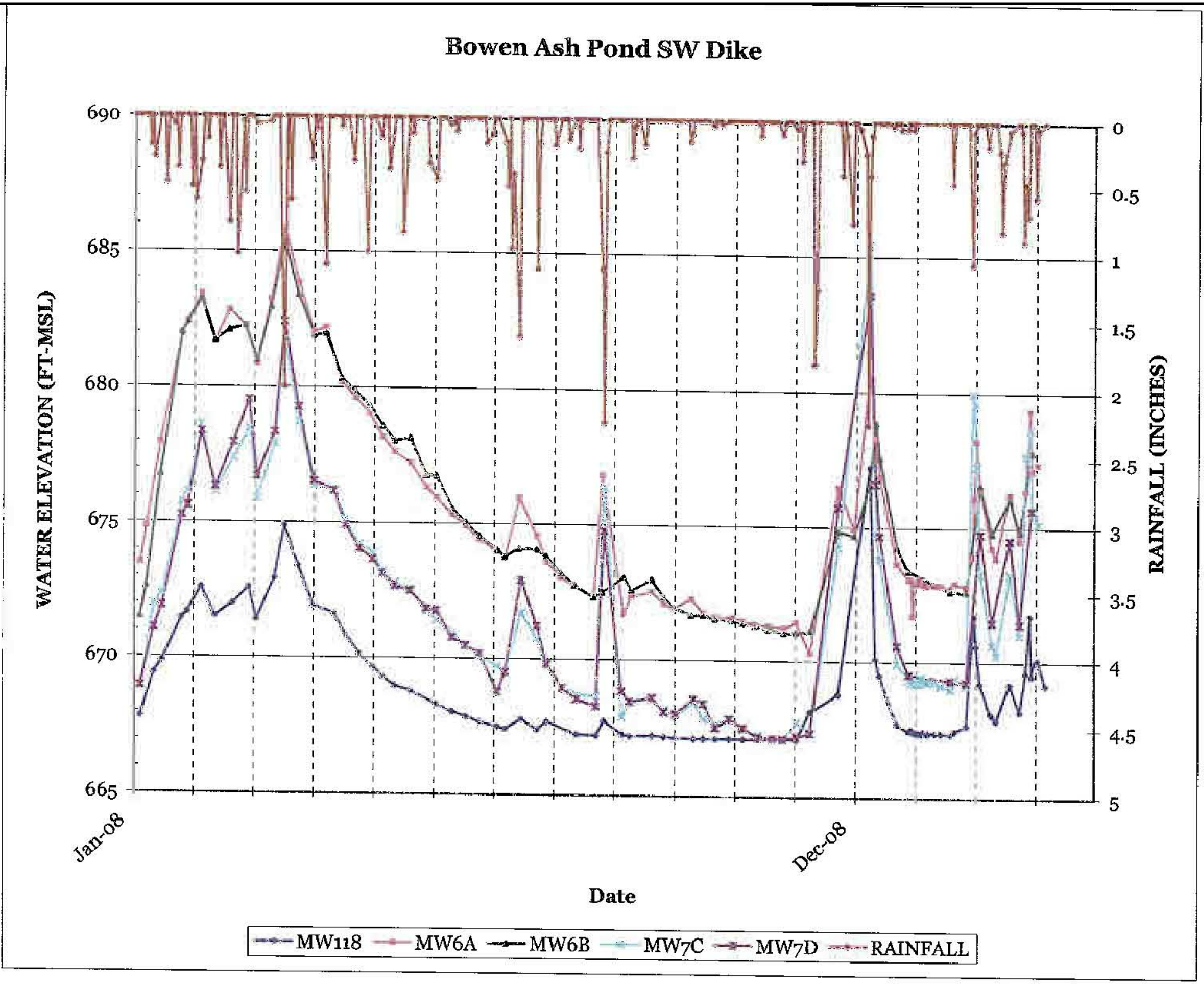
CHA

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–3B



Z:\BOWEN\WASHPIEZ.XLS

4/17/2009

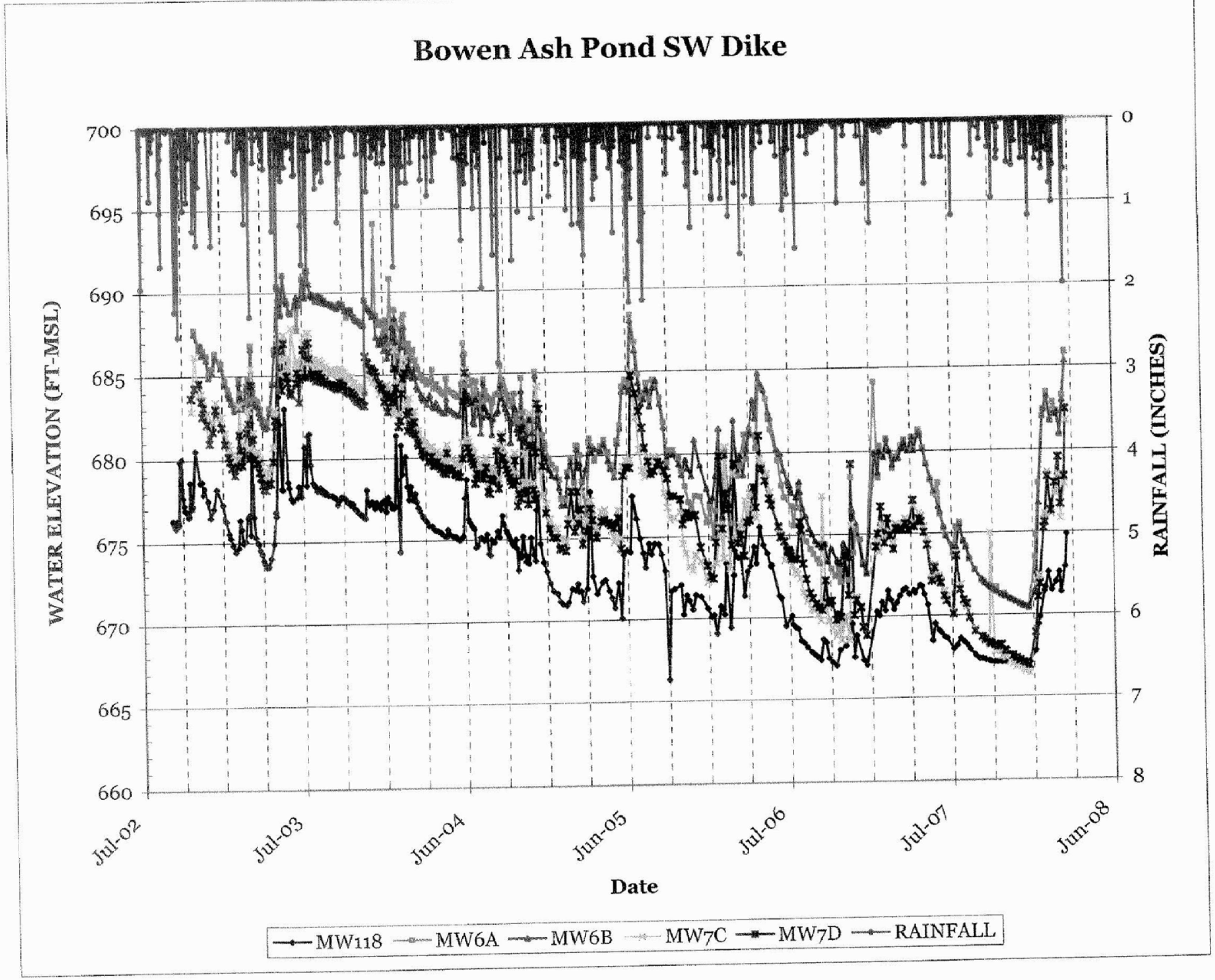
CHA

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–4A



5/5/2008

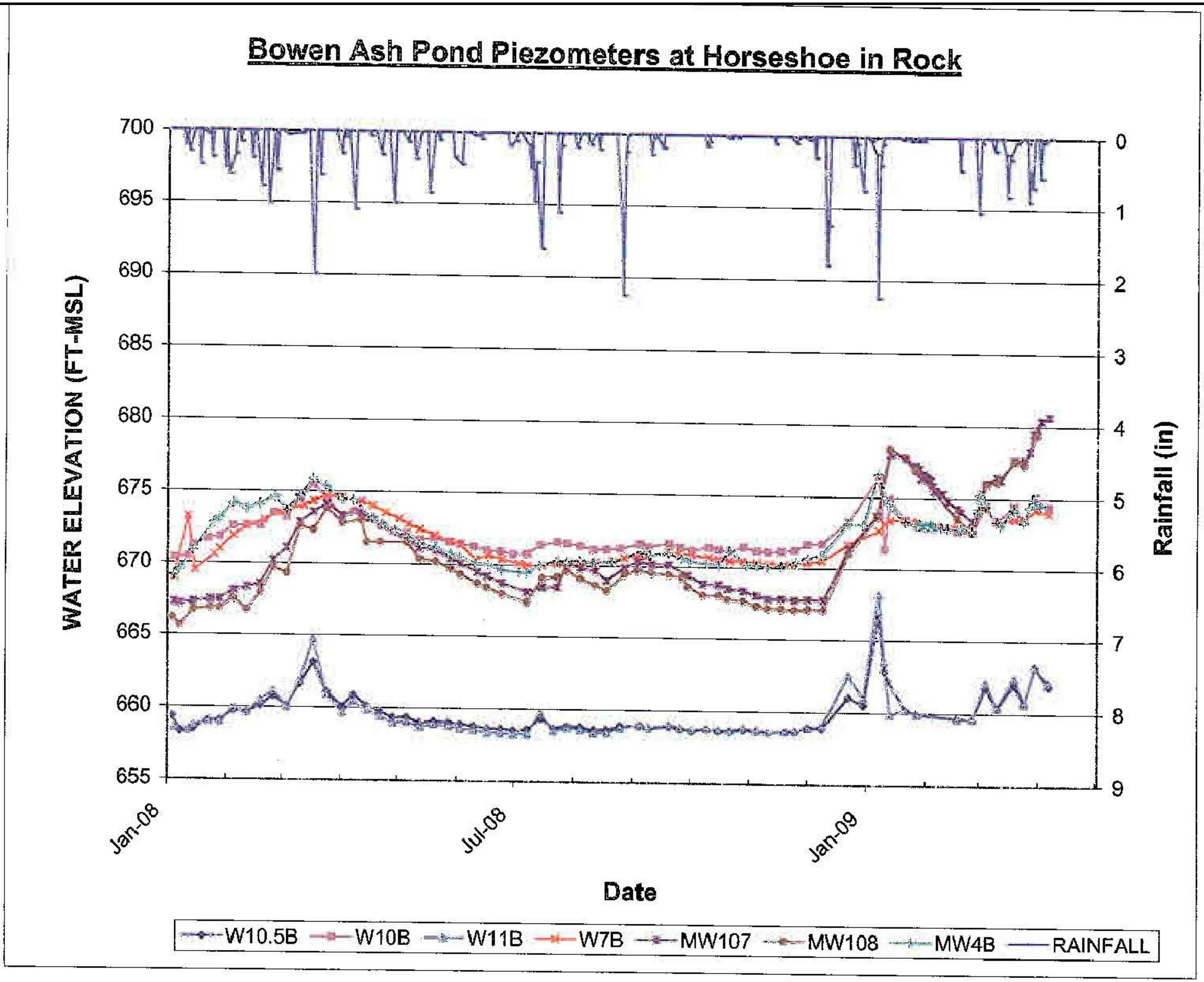
CHA

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–4B



Z:\BOWEN\NEWAPB.XLS

CHA

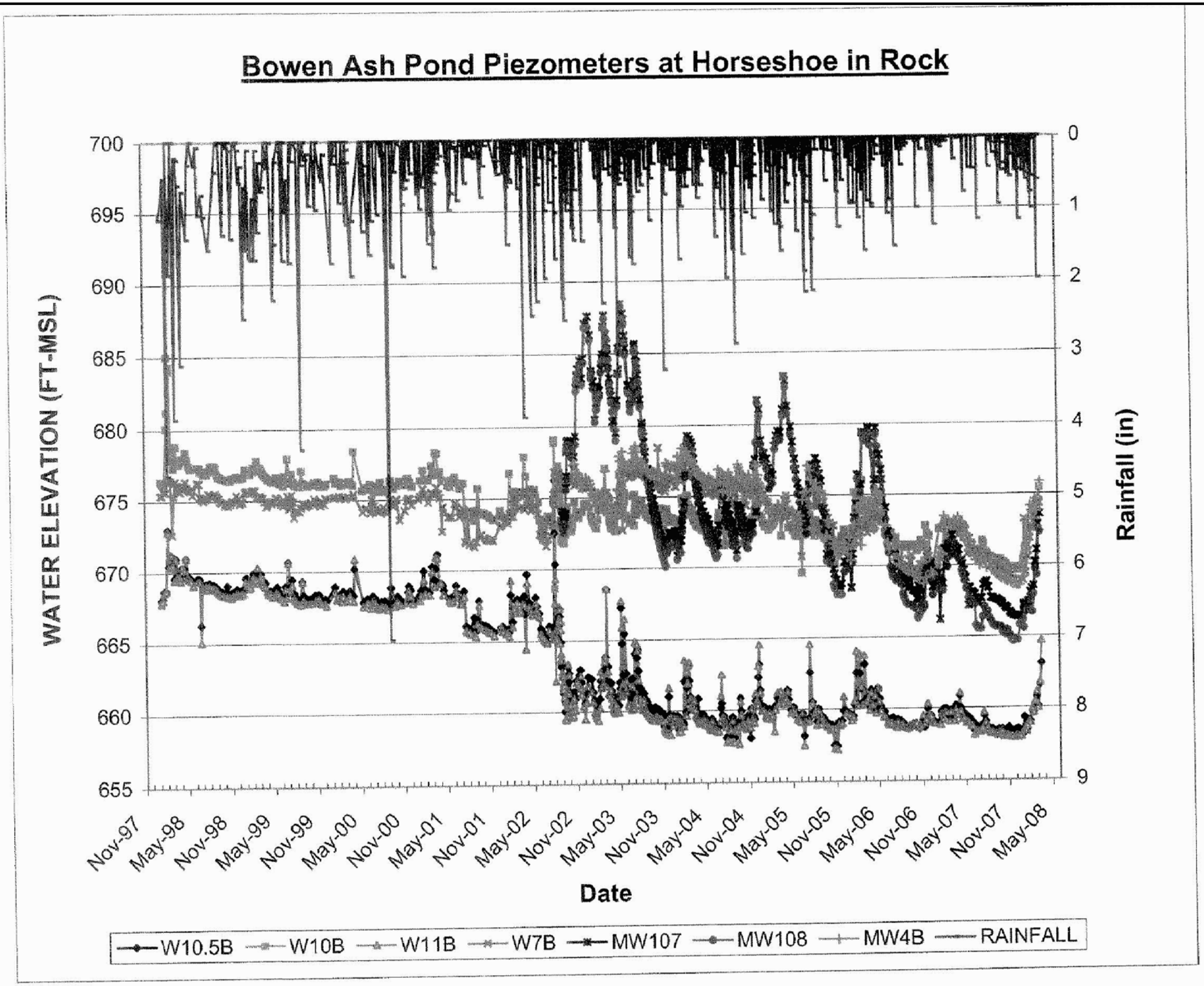
PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–5A

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM Plotted: 7/6/2009 1:22:00 PM User: Filkins, Rebecca



5/5/2008

CHA

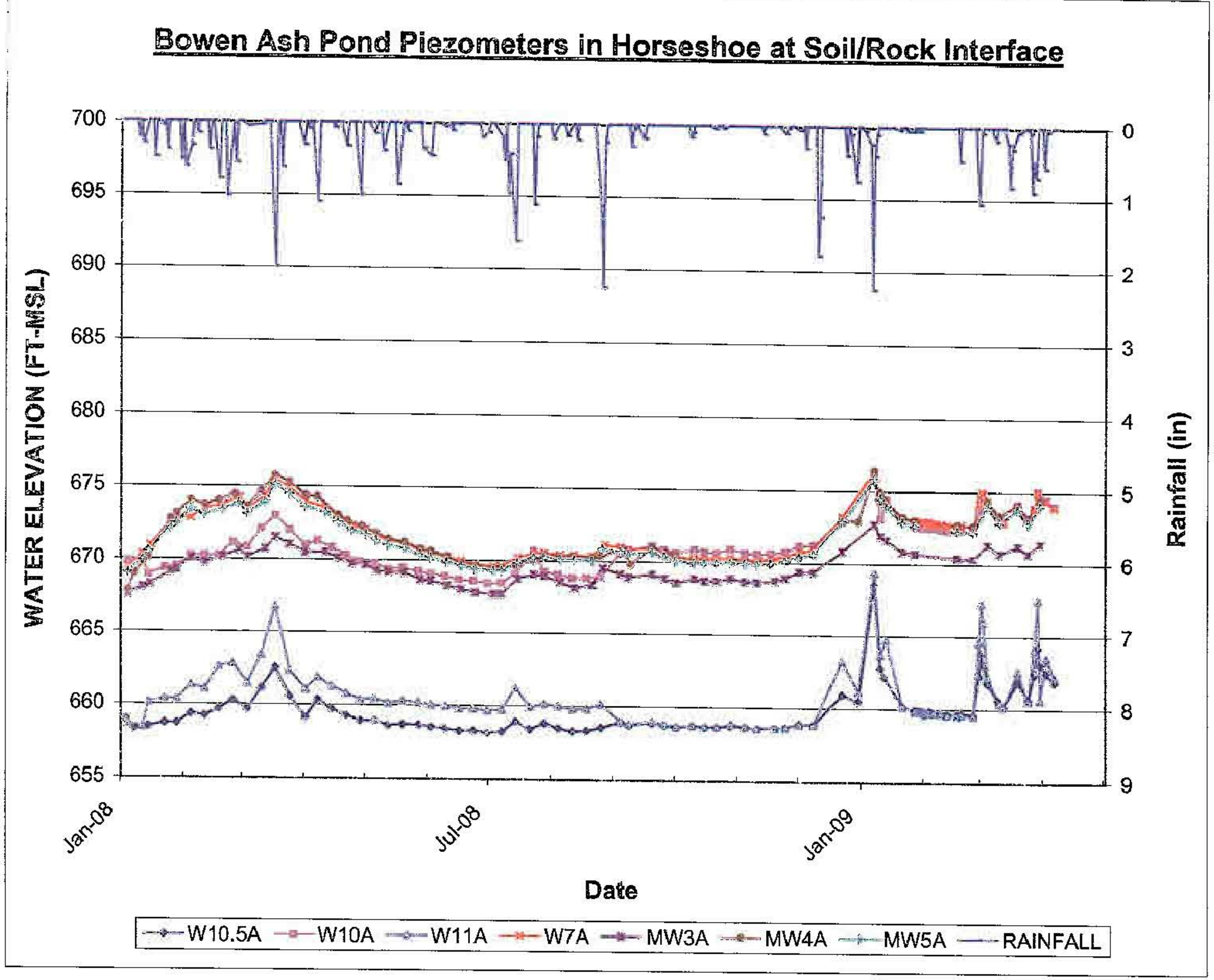
PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16-5B

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 1:24:06 PM User: Filkins, Rebecca



Z:\BOWEN\NEWAPA.XLS

4/17/2009

Drawing Copyright © 2007 CHA

CHA

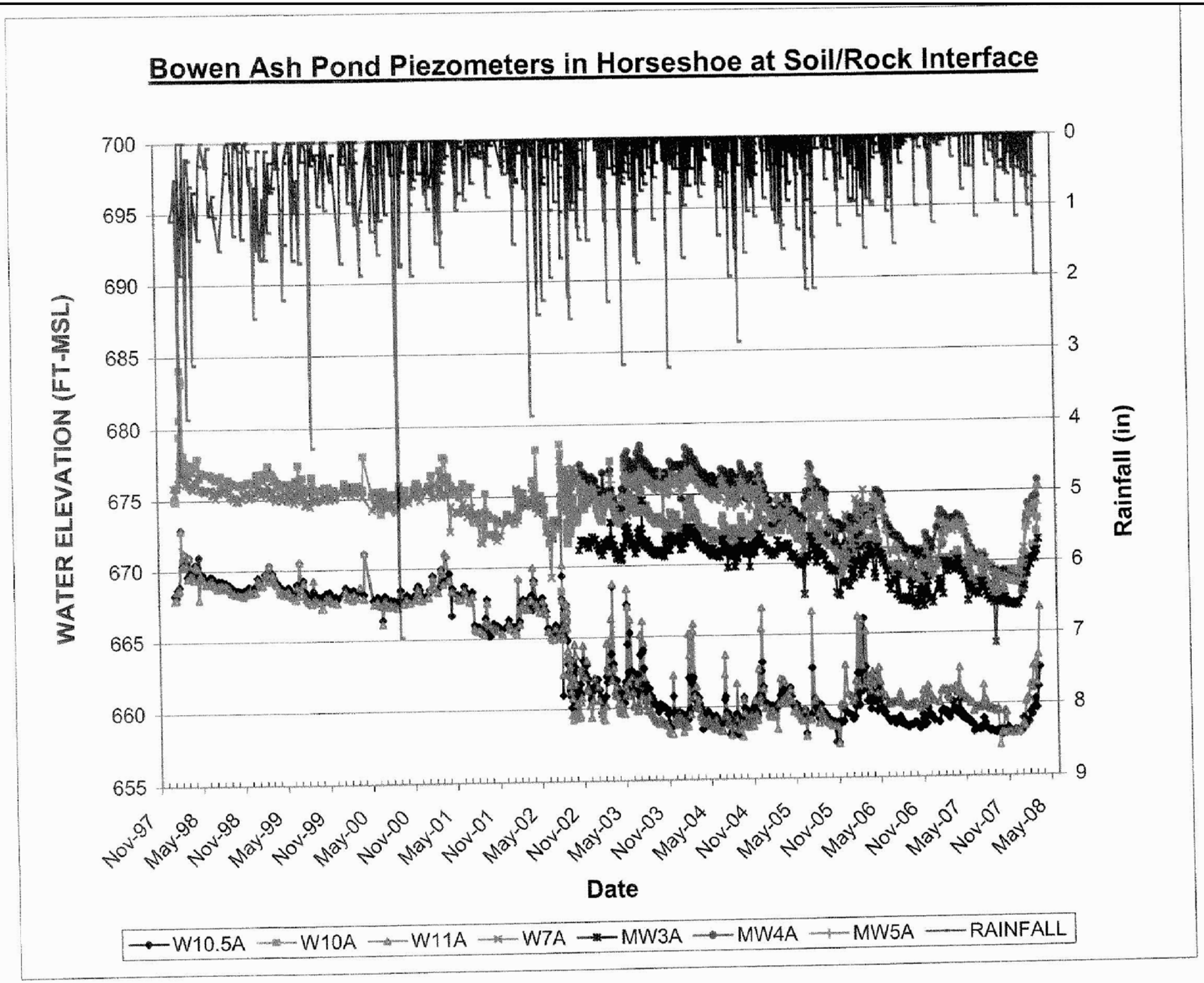
PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16-6A

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 1:26:30 PM User: Filkins, Rebecca


Bowen Ash Pond Piezometers in Horseshoe at Soil/Rock Interface

5/5/2008

Drawing Copyright © 2007 CHA

CHA

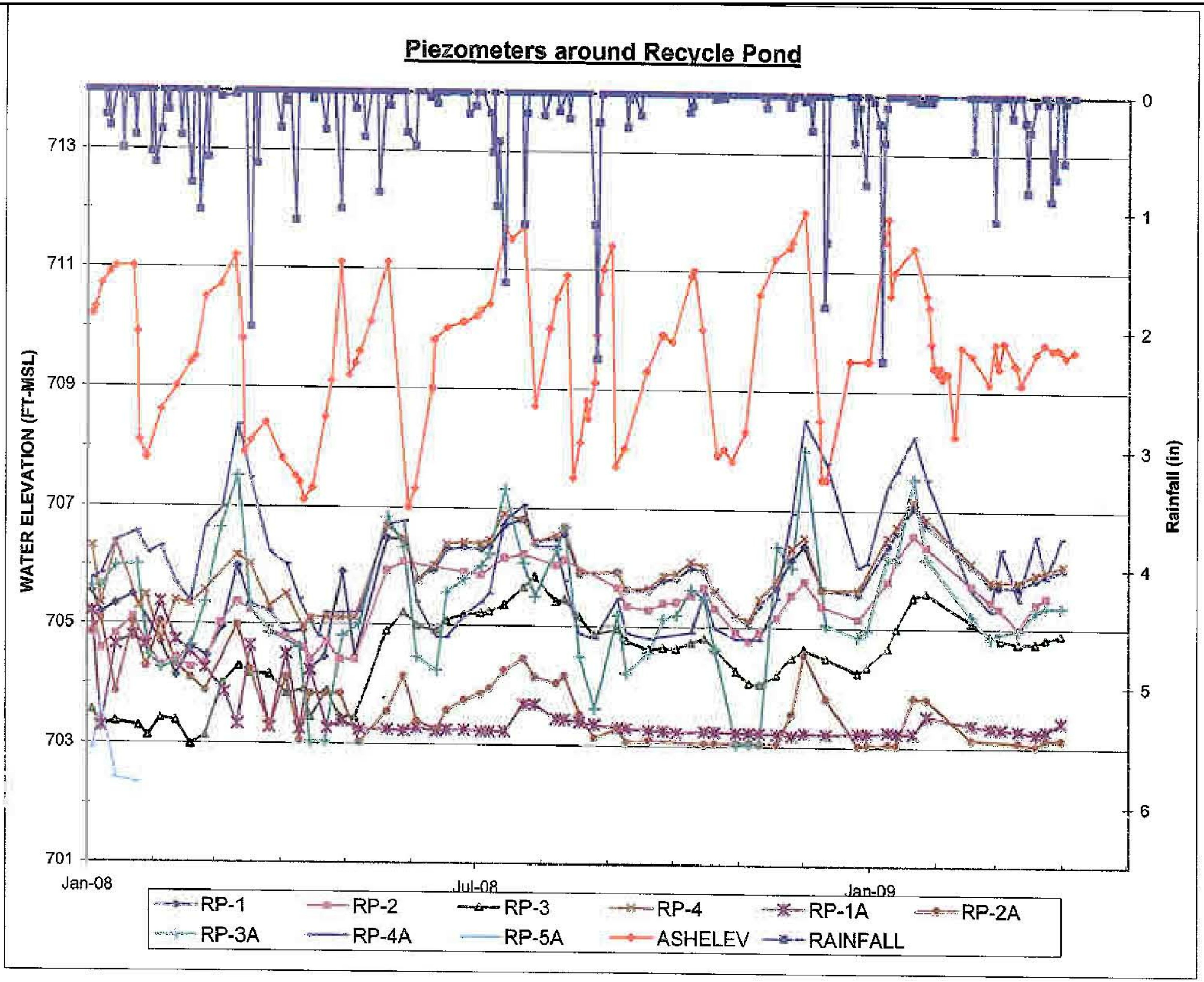
PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–6B

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 1:28:46 PM User: Filkins, Rebecca



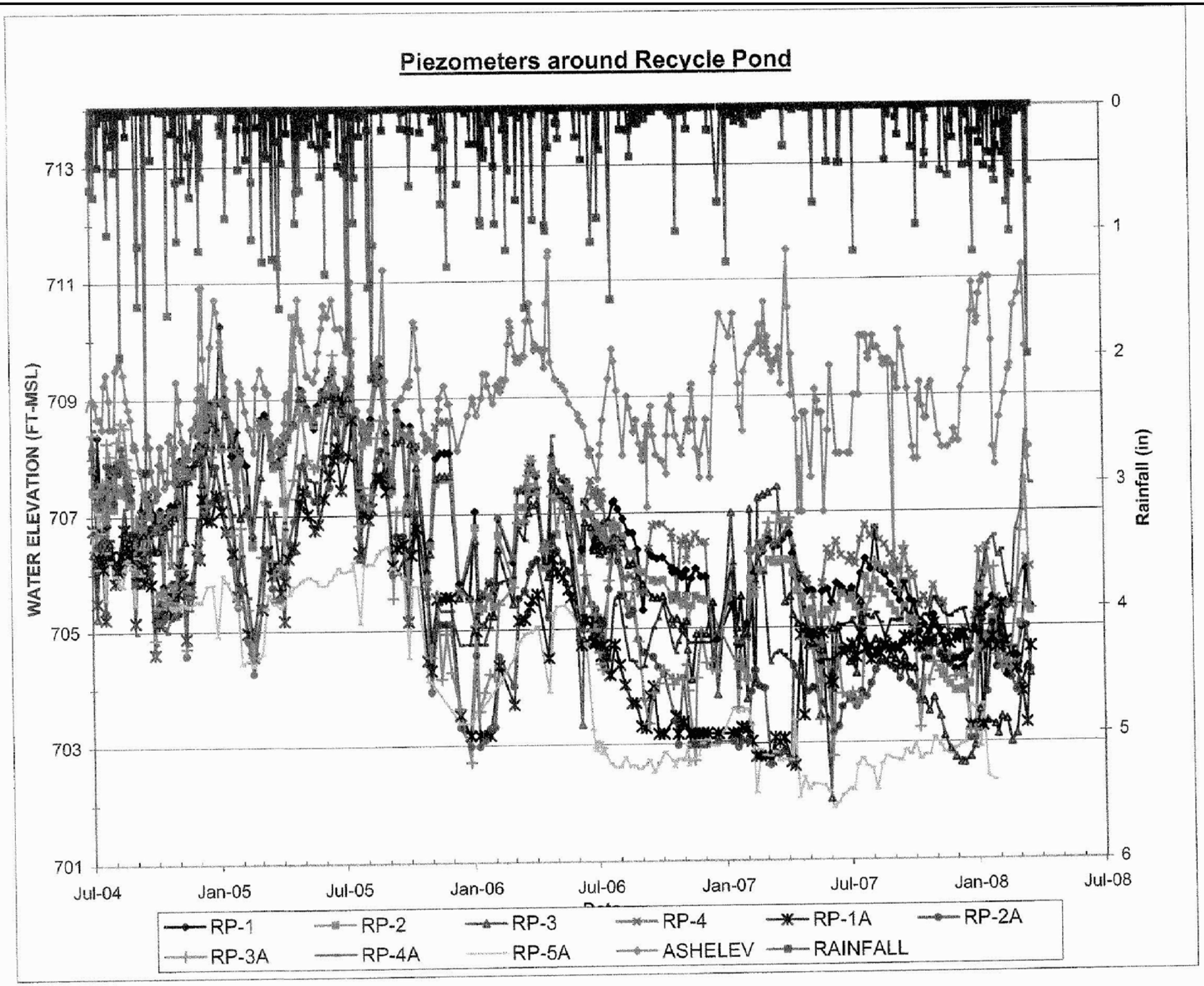
Z:\BOWEN\RECYPOND.XLS

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–7A



5/5/2008

CHA

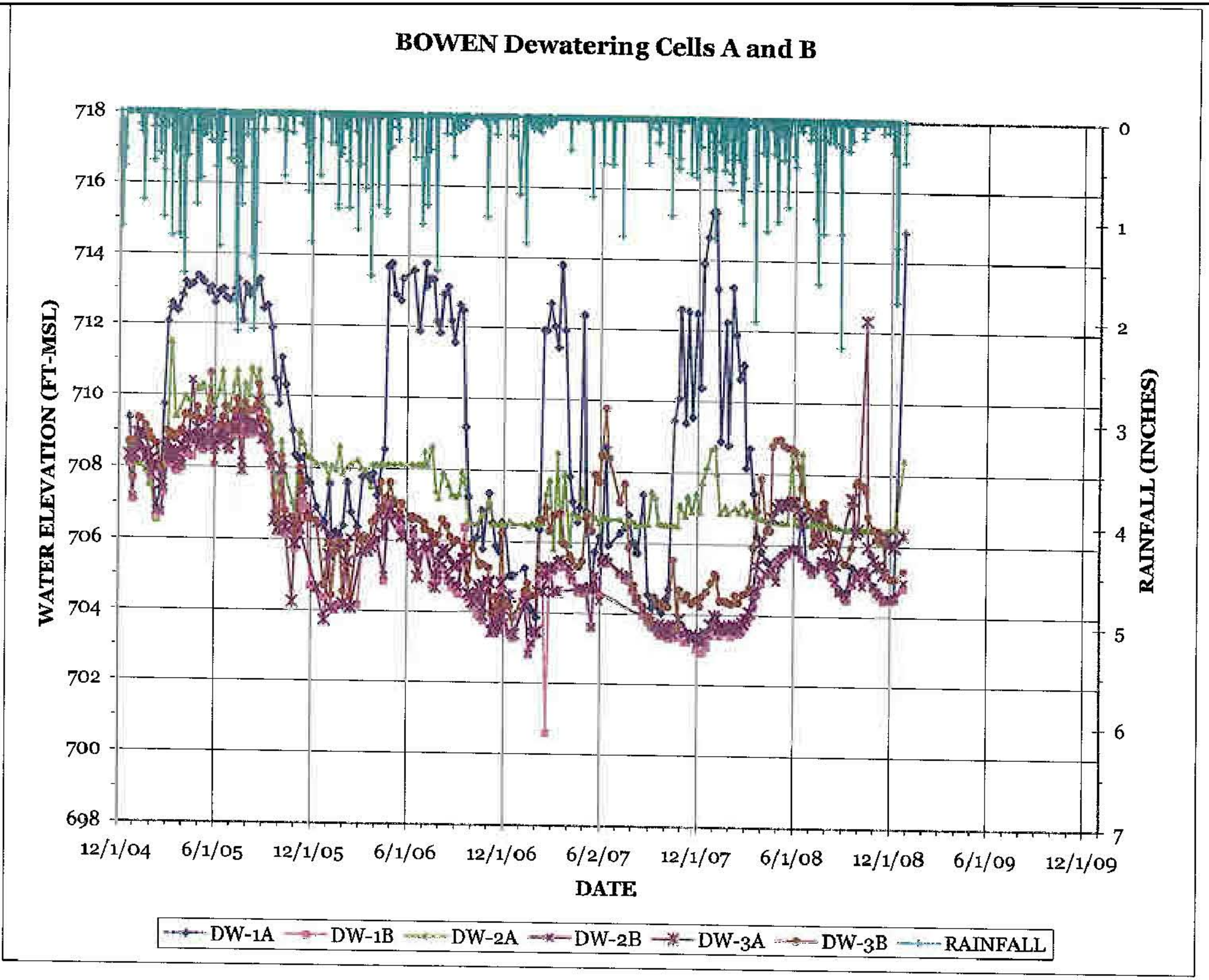
PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16-7B

CONFIDENTIAL BUSINESS INFORMATION



Z:\BOWEN\DEWATER.XLS

1/12/2009

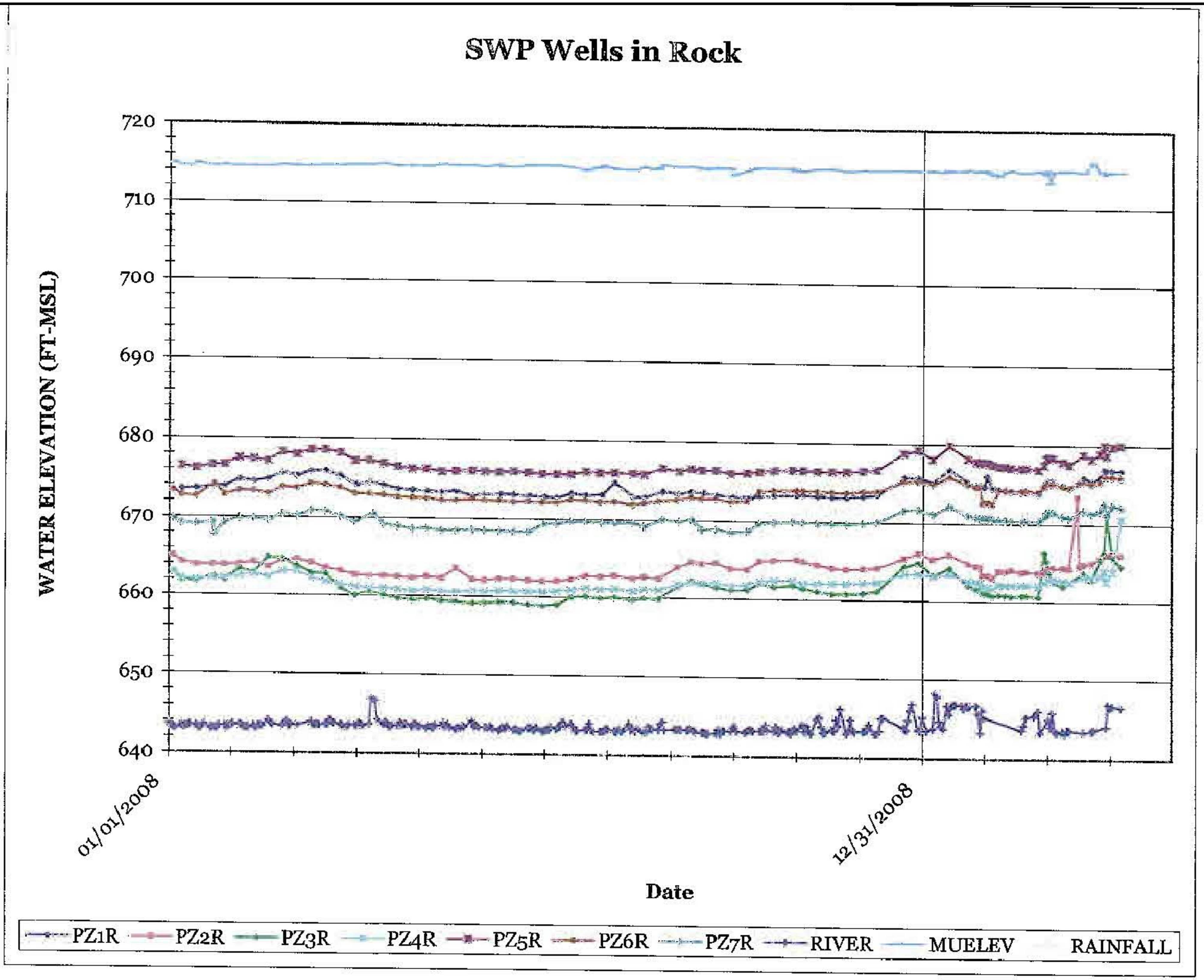
CHA

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–8



SWP Wells in Rock

Z:\BOWEN\ROCKWELL.XLS

4/17/2009

Drawing Copyright © 2007 CHA

CHA

PIEZOMETER READINGS
PLANT BOWEN
GEORGIA POWER COMPANY
CARTERSVILLE, GEORGIA

PROJECT NO.
20085.1000

DATE: JULY 2009

FIGURE 16–9

File: K:\20085\CADD\ACAD\FIGURES\GEO\1000 BOWEN PLANT\BOWEN DATA.DWG Saved: 7/6/2009 12:24:27 PM PLotted: 7/6/2009 1:40:14 PM User: Filkins, Rebecca

4.0 CONCLUSIONS/RECOMMENDATIONS

4.1 Acknowledgement of Management Unit Condition

I acknowledge that the management unit reference herein was personally inspected by me and was found to be in the following condition: **Satisfactory.**

The proactive measures taken after the 2002 and 2008 releases appear to have been effective with respect to improving and maintaining dike stability and addressing the karst features at the site below the ash basin and dike structures. Based upon the information obtained during this investigation, the Bowen Steam Plant has an effective monitoring and inspection program for this unit.

4.2 Hydrologic and Hydraulic Recommendations

CHA recommends that the hydrology of the site be evaluated and operating procedures developed for a larger storm than the 10-year storm, which can be stored with no discharge in the Recycle Pond. Even though the basin is no longer used for wet ash storage, inundation from storm water runoff and/or breach of wet ash or gypsum ponds is contained within the original impoundment could result in overtopping of the main dikes resulting in embankment failure and a subsequent release of ash. Best Management Practice should be used to consider a reasonable design storm in combination with Georgia Power's tolerance for risk of this type of event occurring. Based on the size of this facility, if development downstream put human life in jeopardy, the Georgia EPD Safe Dam regulations would require the impoundment to contain 33% to 50% (depending on total storage volume and height) of the Probable Maximum Flood (PMF). We suggest that because of potential environmental impacts that could result from an overtopping failure, that this criteria be considered for in storm event planning for the facility.

4.3 Stability Recommendations

Two stability conditions evaluated by Southern Company produce lower bound factors of safety. The first is under seismic loading, the factor of safety for the main embankment ranges from 0.99 to 1.1 for events ranging from 2% to 10% chance for exceedance in 50 years. The other condition is a Southern Company defined condition of uplift and reduced strength from a seismic event occurring at about the same time, which is a reasonable consideration for the site specific conditions.

CHA recommends that immediately following seismic events resulting in 25% of the peak ground acceleration for a 500-year earthquake (i.e., 10% chance for exceedance in 50 years), Southern Company perform a site inspection and thorough review of instrumentation data in anticipation of changing conditions within the karst terrain.

4.4 Inspection Recommendations

CHA recommends that Georgia Power and Southern Company continue the piezometer monitoring and inspections that have been implemented for the ash pond. This type of inspection allows for proactive responses to developing situations, which can reduce the risk of damaging releases or failures from occurring.

5.0 CLOSING

The information presented in this report is based on visual field observations, review of reports prepared by Southern Company Services, Inc. and this limited knowledge of the history of the Plant Bowen ash pond. The recommendations presented are based, in part, on project information available at the time of this report. No other warranty, expressed or implied is made. Should additional information or changes in field conditions occur the conclusions and recommendations provided in this report should be re-evaluated by an experienced engineer.