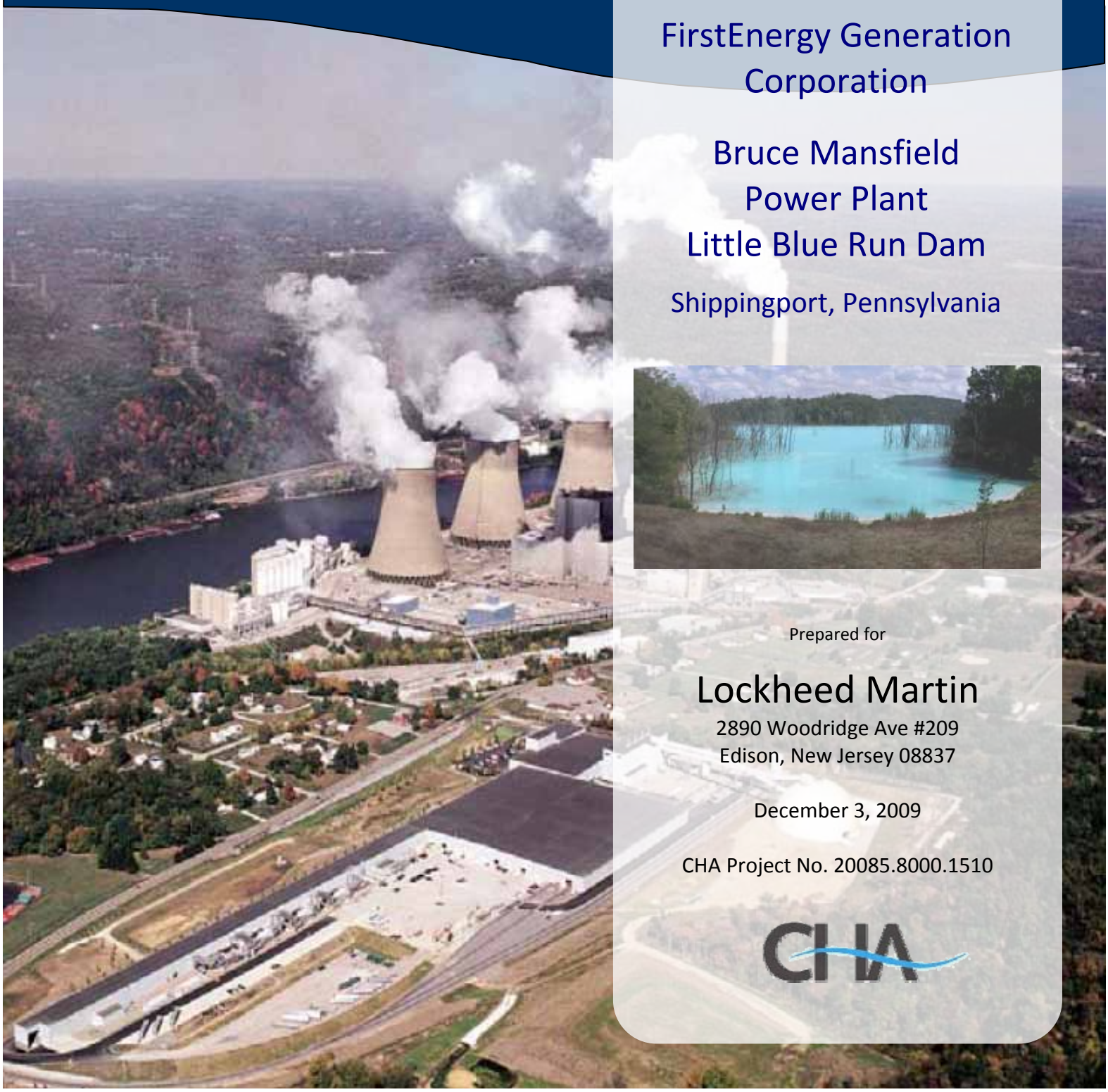
Assessment of Dam Safety
Coal Combustion Surface Impoundments (Task 3)
Draft Report



FirstEnergy Generation Corporation

Bruce Mansfield Power Plant
Little Blue Run Dam

Shippingport, Pennsylvania

Prepared for

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

December 3, 2009

CHA Project No. 20085.8000.1510

CHA

I acknowledge that the management unit referenced herein:

- Little Blue Run Dam

has been assessed on October 22, 2009.

Signature: _____

Katherine E. Adnams, P.E.
Senior Geotechnical Engineer

Reviewer: _____

Warren A. Harris, P.E.
Geotechnical Operations Manager

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Appendix A - Completed EPA Coal Combustion Dam Inspection Checklists and Coal Combustion Waste (CCW) Impoundment Inspection Forms

1.0 INTRODUCTION & PROJECT DESCRIPTION

1.1 Introduction

CHA was contracted by Lockheed Martin (a contractor to the United State Environmental Protection Agency) 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 FirstEnergy Generation Corporation's Little Blue Run Dam at the Bruce Mansfield Plant, which is located in Shippingport, Beaver County, Pennsylvania as shown on Figure 1 – Project Location Map.

CHA made a site visit on October 22, 2009 to inventory coal combustion surface impoundments at the facility, to perform visual observations of the Little Blue Run Dam, and to collect relevant information regarding the impoundment.

CHA engineers Katherine Adnams, P.E. and Warren Harris, P.E. were accompanied by the following individuals:

Company or Organization Name	Name
First Energy Generation Corporation	Robert W. Kish, Senior Consultant
First Energy Generation Corporation	Rick Sprecker, Environmental Manager
First Energy Generation Corporation	Ron Lonnett
GAI Consultants	Stanley R. Michalski, Senior Staff Geologist
GAI Consultants	Phillip E. Glogowski, P.E., Senior Staff Engineer
PA Department of Environmental Protection	Joseph W. Schultz, P.E., Geotechnical Engineer
PA Department of Environmental Protection	Roger P. Adams, P.E., Division of Dam Safety
PA Department of Environmental Protection	Diane D. McDaniel, PE, Engineering Manager
PA Department of Environmental Protection	Paul Minor, Solid Waste Specialist
US Environmental Protection Agency	Craig Dufficy, Environmental Engineer

1.2 Project Background

The Little Blue Run Dam (Dam Permit/I.D. No. D04-049) is under the jurisdiction of the Commonwealth of Pennsylvania Department of Environmental Protection (PA-DEP). According to the Pennsylvania Code Title 25, Chapter 105 - Dam Safety and Waterway Management the dam has a Size Classification of Class A (impoundment storage equal to or greater than 50,000 acre feet) and a Hazard Potential Classification of 1 (substantial loss of life and excessive economic loss).

1.2.1 State Issued Permits

FirstEnergy Generation Corporation (First Energy) has been issued a solid waste permit (No. 300558) by the Pennsylvania Department of Environmental Protection Bureau of Waste Management which allows for coal combustion solids to be stored to Elevation 1162 feet MSL.

1.2.2 Independent Engineering Review

Prior to our site visit to the Bruce Mansfield Power Plant CHA was tasked with performing an independent engineering review (Task 2) of the Little Blue Run Dam. PA-DEP and First Energy's engineer consultant, GAI Consultants, Inc. (GAI), provided CHA with copies of the documents listed in Section 1.7 – Bibliography. Table 1 identifies professional personnel who participated in the review of the state inspection reports, in preparation of this report and along with state and utility company representatives who were contacted by CHA to request documents. CHA prepared a draft report titled *Independent Engineering Review of Coal Combustion Surface Impoundments Draft Report* dated August 31, 2009.

Table 1 - Persons Involved in Coordination of the Task

Company or Agency	Name and Title
CHA	Jennifer Everleth, P.E., Geotechnical Engineer
CHA	Katherine Adnams, P.E., Senior Geotechnical Engineer
CHA	Warren Harris, P.E., Geotechnical Operations Manager
PA-DEP, Division of Dam Safety	Ryan Knarr, Project Specialist, OH Watershed Section
FirstEnergy Generation Corporation	Rick Sliper, Environmental Manager
GAI Consultants, Inc.	Stanley R. Michalski, P.G., Senior Staff Geologist

1.3 Location and Site Description

Figure 2 – Photo Plan shows the location of the Little Blue Run Dam and the Bruce Mansfield Power Plant. The dam is located approximately 0.6 miles south of the Ohio River and approximately 4 miles west of the Bruce Mansfield Plant.

As-Built design/construction drawings for the Little Blue Run Dam provided to CHA indicate that the impoundment was constructed between 1976 and 1977. Figure 3 shows a typical cross section of the dam. According to the PA-DEP Dam Inspection Reports the dam is a 400-foot high earth and rock dam with an impervious core. The storage volume is approximately 73,000 acre-feet and the drainage area approximately 2.93 square miles. The crest of the dam is curved with the vertex pointed upstream. The crest is reportedly 2,100 feet long by 50 feet wide at elevation 1,100 feet with a maximum elevation of 1,102 feet at the center of the dam. The dam crest is covered with a crushed stone access road. The upstream face of the dam is a uniform 2H:1V slope with a rock exterior. The downstream slope is 1H:1V slope with a large rock cover. In October and November 2001 work was performed to restore the design top of dam embankment elevation to compensate for normal settlement of the embankment materials over the 30-year period following construction. The work consisted of adding a two foot camber to account for additional future settlement.

There are weirs installed on the left and right abutments to collect and monitor seepage discharges. At the toe of the dam there is a 6-foot thick filter blanket with a perforated PVC drain pipe. A stilling basin is located at the toe that collects all of the seeps and the outlets for the secondary spillway.

There are three spillways at the Little Blue Lake Dam; a secondary spillway (which functions as the primary spillway), a service spillway and an emergency spillway. The secondary spillway is a 36-inch diameter pipe through the right abutment. There is a trash rack and treatment system at the entrance to the pipe. A valve at the inlet is used to vary the discharge elevation between 1,087.5 feet to 1,090 feet. The pipe discharges to the gabion lined ditch which runs down the

right abutment to the stilling basin at the toe of the dam. In 2005 work was performed to modify the secondary spillway discharge routing system and stilling basin discharge facilities, in order to fully utilize the discharge capability of the secondary spillway and to control the outflow from the dam within existing and proposed permit limits. These modifications allow dam operators to more easily maintain a normal operating pool at Elevation 1088 feet or lower.

The service spillway is located on the left side of the dam. The inlet has an invert at elevation 1,090.3 feet. There is a rock lined trapezoidal channel that leads to the inlet. The spillway discharges to a 48-inch concrete pipe 1,000 feet long that discharges to the stilling basin.

The emergency spillway is located along the left side of the dam (to the left of the secondary spillway). This spillway was modified between September 2006 and March 2007 to fully utilize the disposal facilities and remain within the permitted regulatory operational requirements. The work included widening the existing spillway from 25 feet to 160 feet by rock excavation and construction of a trapezoidal labyrinth weir. The invert of the weir is at elevation 1,095 feet. The channel discharges over the hillside into a wooded area.

On April 5, 2006 the PA-DEP issued a modification to the solid waste disposal permit for the dam which allowed for a multi-year demonstration project of the utilization of Geotube technology to allow for vertical expansion of the disposal impoundment without raising the elevation of the existing dam embankment. Since 2005 six Geotubes have been constructed; four in the WV Finger and two in the PA Finger. The two northern-most Geotubes in the WV and PA fingers are underlain with the greatest thickness of sludge, approximately 180 feet. First Energy requested and PA-DEP approved the use of Gutterbuddies to slightly increase the effective height of the Geotubes at locations where the tubes were not constructed to a consistent height due to variations in base grades and filled heights. The *Annual Operations Report and Annual Demonstration Project Progress Report for the Report Year April 2008 to April 2009 Permit No. 300558* prepared by Civil and Environmental Consultants, Inc. and dated June 2009 provides additional information on the project including settlement and horizontal movement data for the installed Geotubes.

CCW placed above the Service Spillway invert elevation 1,090.3 feet MSL is maintained upstream (south) of the north-south line for safe, storm water management. The approximate location of the line is shown on Figure 2.

There is a Saddle Dam located to the east of the main embankment, as shown on Figure 2. In the PA-DEP Dam Inspection Report dated January 21, 2009 for the Little Blue Run Dam the PA-DEP stated that they have become aware that the saddle dam "was not permitted for construction with the original authorization of the Little Blue Run Dam and has never been permitted by the PA-DEP Dam Safety Program". The PA-DEP performed a preliminary breach analysis and found "the dam to be most likely a C-2, High Hazard Dam". It was also noted that a failure of the saddle dam with the reservoir level at the PMF design storm pool would impact one home and a roadway. The PA-DEP stated that a Dam Permit is required for the continual operation and maintenance of the saddle dam. The PA-DEP assigned a Dam Number of D04-068 for the Little Blue Saddle Dam. It was recommended that a subsurface investigation be conducted and piezometers installed at the saddle dam as very little information is available about its original construction and inspections have indicated seepage through the embankment or its foundation.

A map of the region indicating the location of the Bruce Mansfield Power Plant, the Little Blue Run Dam and schools, hospitals, or other critical infrastructure located within approximately 5 miles down gradient of the ash pond is provided as Figure 4.

1.3.1 Other Impoundments

There are three other impoundments at the Bruce Mansfield Power Station; the North LDS Pond (N-LDS), the South LDS Pond (S-LDS) and the West HDS Pond (W-HPDS). Theses three dams are classified as C-2 dams (non-high hazard). It is our understanding that site assessments (Task 3) of these structures were performed by Paul C. Rizzo Associates, Inc.

1.4 Previously Identified Safety Issues

FirstEnergy reports that there are several seeps in the Little Blue Run Dam and in the surrounding hillsides. These seeps are reportedly well known to PA-DEP. Several of the seeps are permitted as NPDES outfalls, and FirstEnergy conducts a semi-annual seep survey and reports the results to PA-DEP. The seeps are also assessed and monitored by FirstEnergy's engineering consultants. In addition, the seeps and their management is the subject of a Consent Order and Agreement between FirstEnergy and PA-DEP.

1.5 Geology and Subsurface Conditions

The Little Blue Run Impoundment Dam and Related Facilities General Construction Specification No. 2375-S-4 dated April 1, 1974 and revised December 2, 1974 notes in Sections 4.1 to 4.3 that "the site is blanketed by a relatively thin (less than 10 feet) mantle of residual soil (in-place soil derived by weathering and decomposition of parent rock) on the hilltops and hillsides. Alluvial soils (stream deposited) and colluvial soils (soil of residual origin but transported down-slope by gravity) occur in considerable thickness in and near the valley bottom. Although the existing stream lies on or near rock throughout most of its length, alluvial and/or colluvial soils adjacent the channel were found to attain a thickness of 55 feet. These soils which consist primarily of a mixture of silt, sand, gravel and rock fragments are for the most part saturated due to the high ground water level within the valley bottom. The soils are underlain by shale, sandstone, siltstone, or claystone. The sandstones are usually massive and medium hard to hard. The siltstone and shales rarely exceed being medium hard and are often in a relatively broken state. The claystones range from soft to medium hard and are commonly in a medium soft state. The water pressure test data indicate, in general, that the rock strata along the valley walls below the valley bottom are relatively permeable to depths of the order of 80 to 90 feet below the top of rock". The As-Built drawings note the indication of slickensided surfaces in siltstone core recovery. The drawings also note strata at Elevation 680 feet consists of coal and carbonaceous shale. The *Foundation Treatment for Little Blue Run Dam* notes that there was a series of "county bank" coal mines which penetrated as far as 110 feet into the abutments.

Section 3.4 discusses how the coal mines were prepared prior to the construction of the dam. Figures 5A and 5B show generalized geologic sections of the dam in this area.

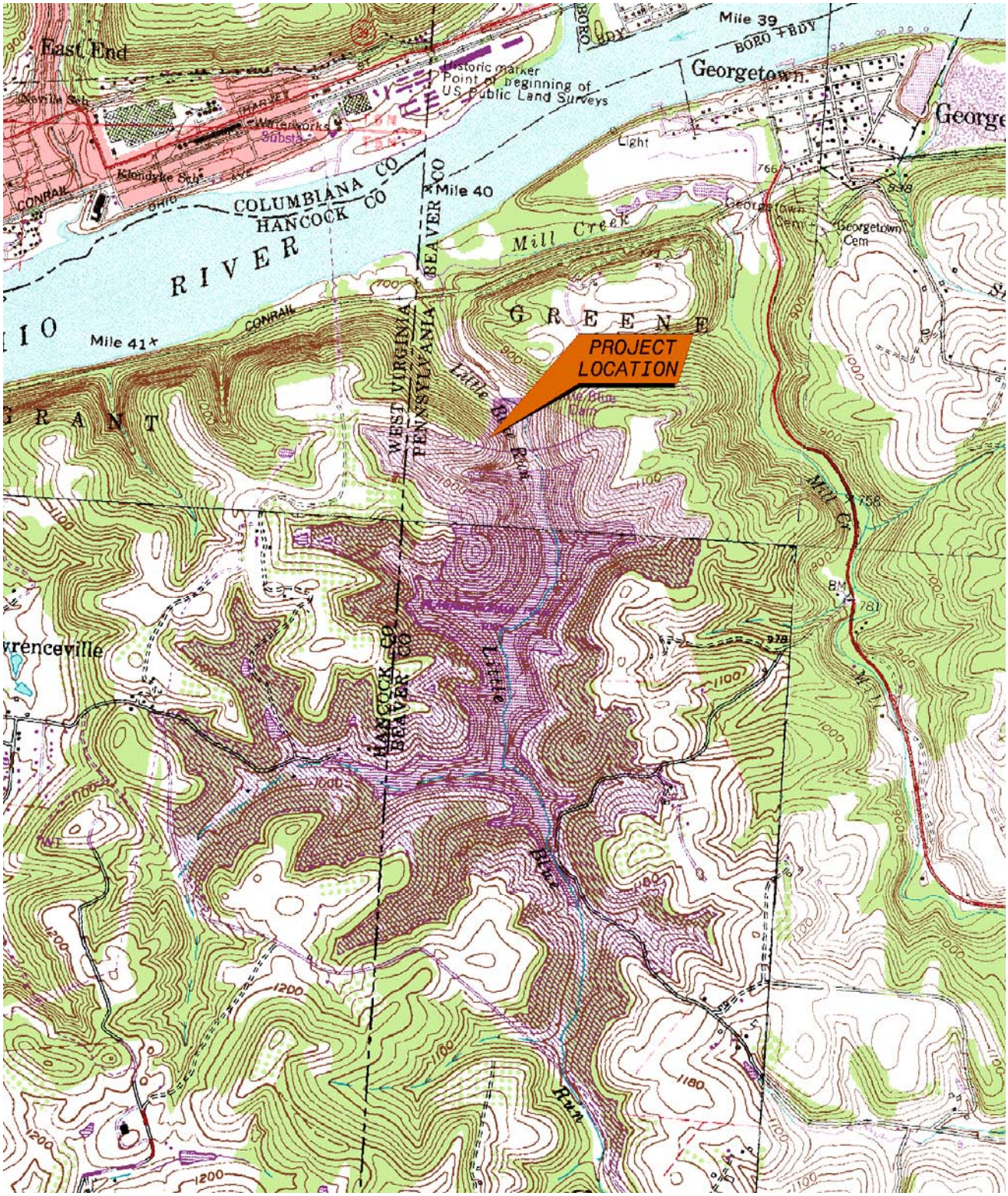
1.6 Bibliography

CHA reviewed the following documents provided by PA-DEP, First Energy and GAI in preparing this report:

- Pennsylvania Code Title 25 – Environmental Protection, Chapter 105 – Dam Safety and Waterway Management, Subchapter - General Provisions and Subchapter B – Dams and Reservoirs;
- Commonwealth of Pennsylvania Department of Environmental Protection Dam Safety and Encroachment Acts, 1978, Nov. 26, P.L. 1375, No. 325;
- Pennsylvania Department of Environmental Protection Division of Dam Safety, *The Inspection, Maintenance and Operation of Dams In Pennsylvania 2009 Edition*, Prepared by Karl H. Lewis, Ph.D., Daniel L. Bink, P.E., Lois M. Muller - Department of Civil Engineering University of Pittsburgh;
- *PA-DEP Dam Inspection Report for the Little Blue Run Dam (ID No. D04-049)*, January 21, 2009;
- *PA-DEP Dam Inspection Report for the Little Blue Run Dam (ID No. D04-049)*, August 19, 2008;
- *PA-DEP Dam Inspection Report for the Little Blue Run Dam (ID No. D04-049)*, September 21, 2006;
- *PA-DEP Dam Inspection Report* (Observation of construction activities only) *for the Little Blue Run Dam (ID No. D04-049*), November 20, 2006;
- *PA-DEP Dam Inspection Report for the Little Blue Run Dam (ID No. D04-049)*, August 29, 2005;
- *Inspection and Evaluation Report No. 89 Embankment Monitoring Program – April through September 2008, Little Blue Run Dam*, GAI Consultants, Inc., December 10, 2008;

- *Inspection and Evaluation Report No. 87 Embankment Monitoring Program - April 2007 through September 2007, Little Blue Run Dam,* GAI Consultants, Inc., January 3, 2008;
- *Inspection and Evaluation Report No. 86 Embankment Monitoring Program – October 2006 through March 2007, Little Blue Run Dam,* GAI Consultants, Inc., May 21, 2007;
- *Inspection and Evaluation Report No. 85 Embankment Monitoring Program – March 2006 through September 2006, Little Blue Run Dam,* GAI Consultants, Inc., February 13, 2007;
- *Inspection and Evaluation Report No. 84 Embankment Monitoring Program - October 2005 through March 2006, Little Blue Run Dam,* GAI Consultants, Inc., June 26, 2006;
- *Inspection and Evaluation Report No. 83 Embankment Monitoring Program – October 2004 through March 2005, Little Blue Run Dam,* GAI Consultants, Inc., January 24, 2006;
- *Inspection and Evaluation Report No. 82 Embankment Monitoring Program – October 2004 through March 2005, Little Blue Run Dam,* GAI Consultants, Inc., May 16, 2005;
- *Inspection and Evaluation Report No. 81 Embankment Monitoring Program, Little Blue Run Dam,* GAI Consultants, Inc., March 7, 2005;
- As-Built Drawings for Little Blue Run Dam Embankment, Appurtenant Structures, and Sludge Transport Pipeline (Plant-to-Dam), Bruce Mansfield Power Station, 1977;
- Little Blue Run Dam Impoundment Dam and Related Facilities General Construction Specification No. 2375-S-4, April 1, 1974 and revised December 2, 1974;
- *Little Blue Run Development Area Bruce Mansfield Power Generation Station Preliminary Information Data Addendum 1*, General Analytics, Inc., January 25, 1974;
- *Little Blue Run Development Area Bruce Mansfield Power Generation Station Preliminary Information Data, Section VIII – Embankment Material Properties*, General Analytics, Inc., April 1, 1974;
- *Foundation Treatment for Little Blue Run Dam*, Thiers; G.R., Lobdell, L.W.; Mihalcin, B.M.; Rock Engineering, 1976;
- *Final Report Emergency Spillway Modifications*, GAI Consultants, Inc., August 2007;
- *Emergency Spillway Modifications Technical Specifications*, GAI Consultants, Inc., May 2, 2006;

- *Design Report Restoration of the Design Top of Dam Embankment Elevation Plus Camber*, GAI Consultants, Inc., August 15, 2001;
- *Final Report Restoration of the Design Top of Dam Embankment Elevation Plus Camber*, GAI Consultants, Inc., December 2001;
- *Engineering Document for Little Blue Run Dam Jobsite for Secondary Spillway Outlet Box Modification Secondary Spillway – 24-Inch Outlet Pipe Installation, 24-Inch Ohio River Discharge Pipe Removal, Stilling Basin Modification and 36-Inch Ohio River Discharge Pipe Installation*, GAI Consultants, Inc.;
- *Geology of the Right Abutment Above Elevation 1037 Vicinity of the Secondary Spillway Little Blue Run Dam*, GAI Consultants, Inc., March 14, 2002;
- *Final Report Modifications to Secondary Spillway and Stilling Basin Outlet Works*, GAI Consultants, Inc., December 2005;
- *Slope Stability Requirements of Proposed Residual Waste Management Regulations Little Blue Rum Dam*, GAI Consultants, Inc., May 22, 1992; and
- *Annual Operations Report and Annual Demonstration Project Progress Report for the Report Year April 2008 to April 2009 Permit No. 300558*, Civil and Environmental Consultants, Inc., June 2009.



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CHA

Figure 1
Project Location Map

Scale 1" = 2000' Image Date: 07/01/1983	CHA File No: 20085.8000.1510	BRUCE MANSFIELD PLANT SHIPPINGPORT, PA EAST LIVERPOOL NORTH USGS QUAD

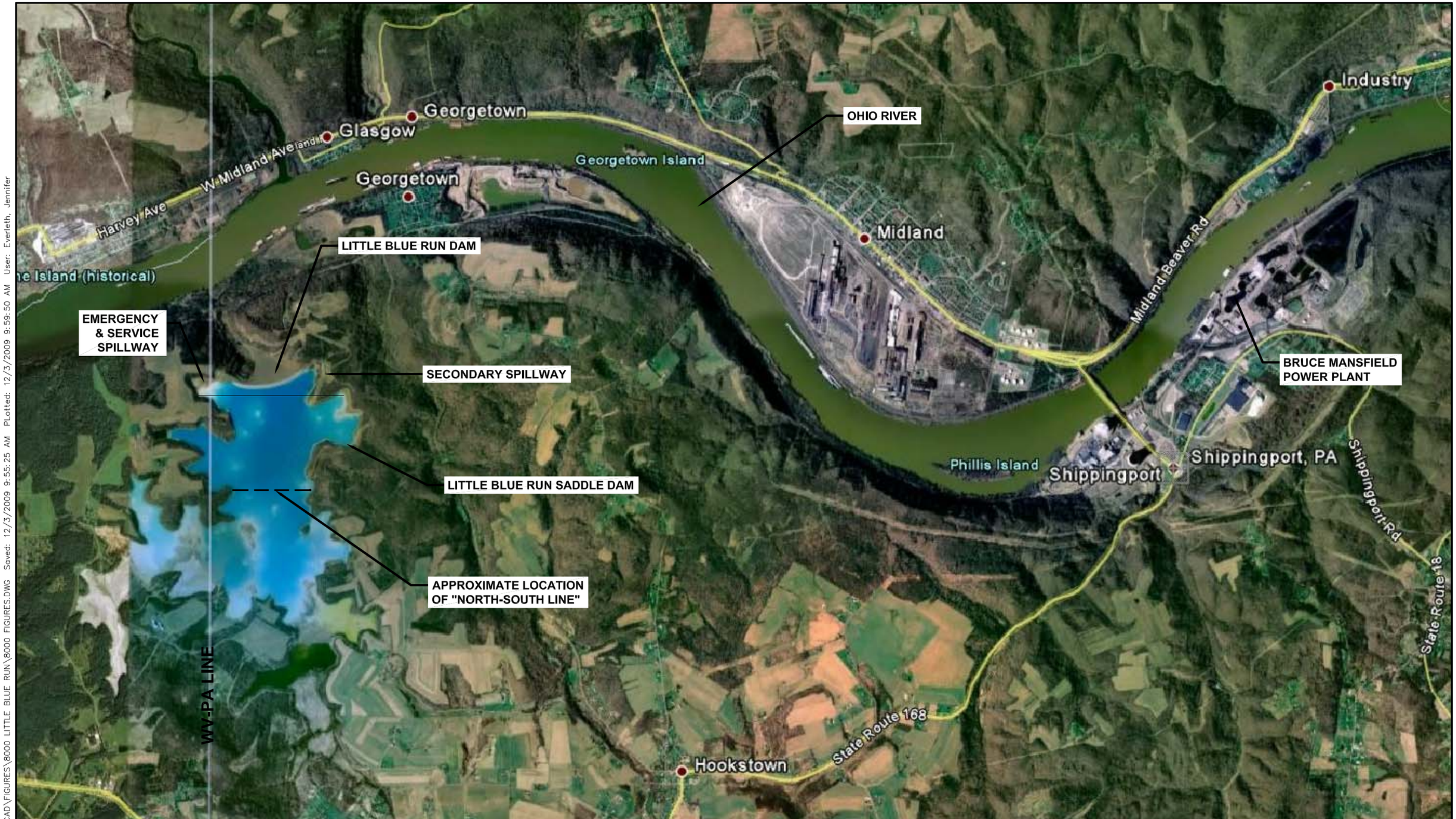

IMAGE REFERENCE: GOOGLE EARTH, IMAGE DATED APRIL 2005

0 2338 4676

Scale in feet

N

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SITE PHOTO PLAN

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 2

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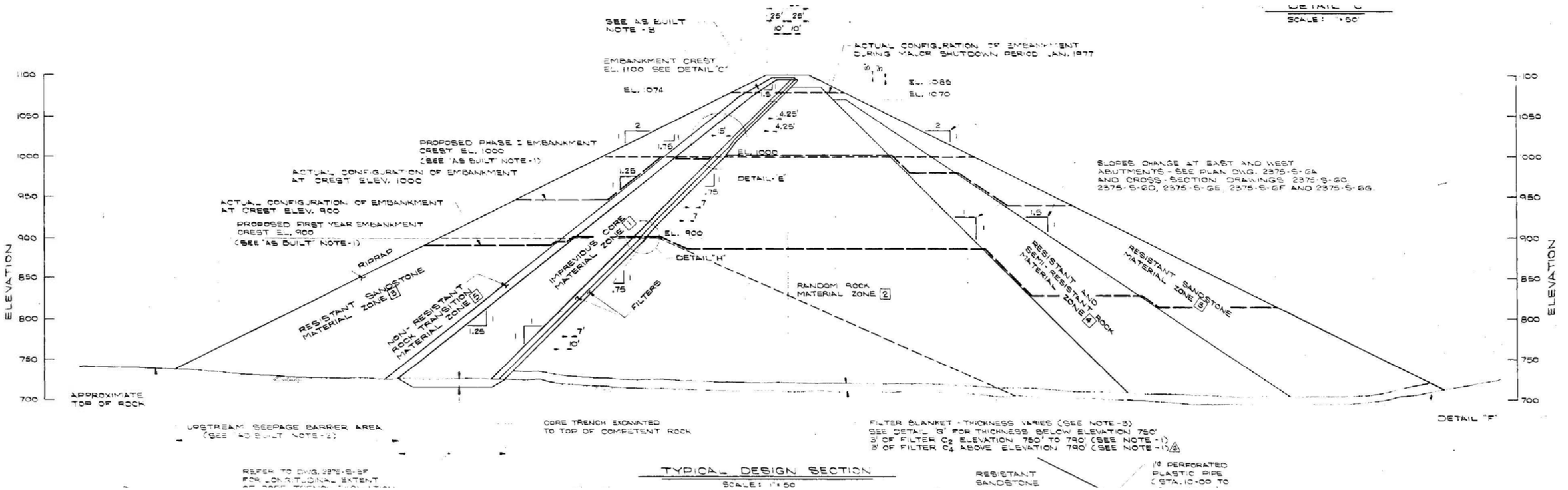

IMAGE REFERENCE: IMPOUNDMENT DAM TYPICAL DESIGN SECTION OF EMBANKMENT & DETAILS, APRIL 1, 1974, DWG NO. E-8399, REVISION 7.

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TYPICAL CROSS SECTION

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 3

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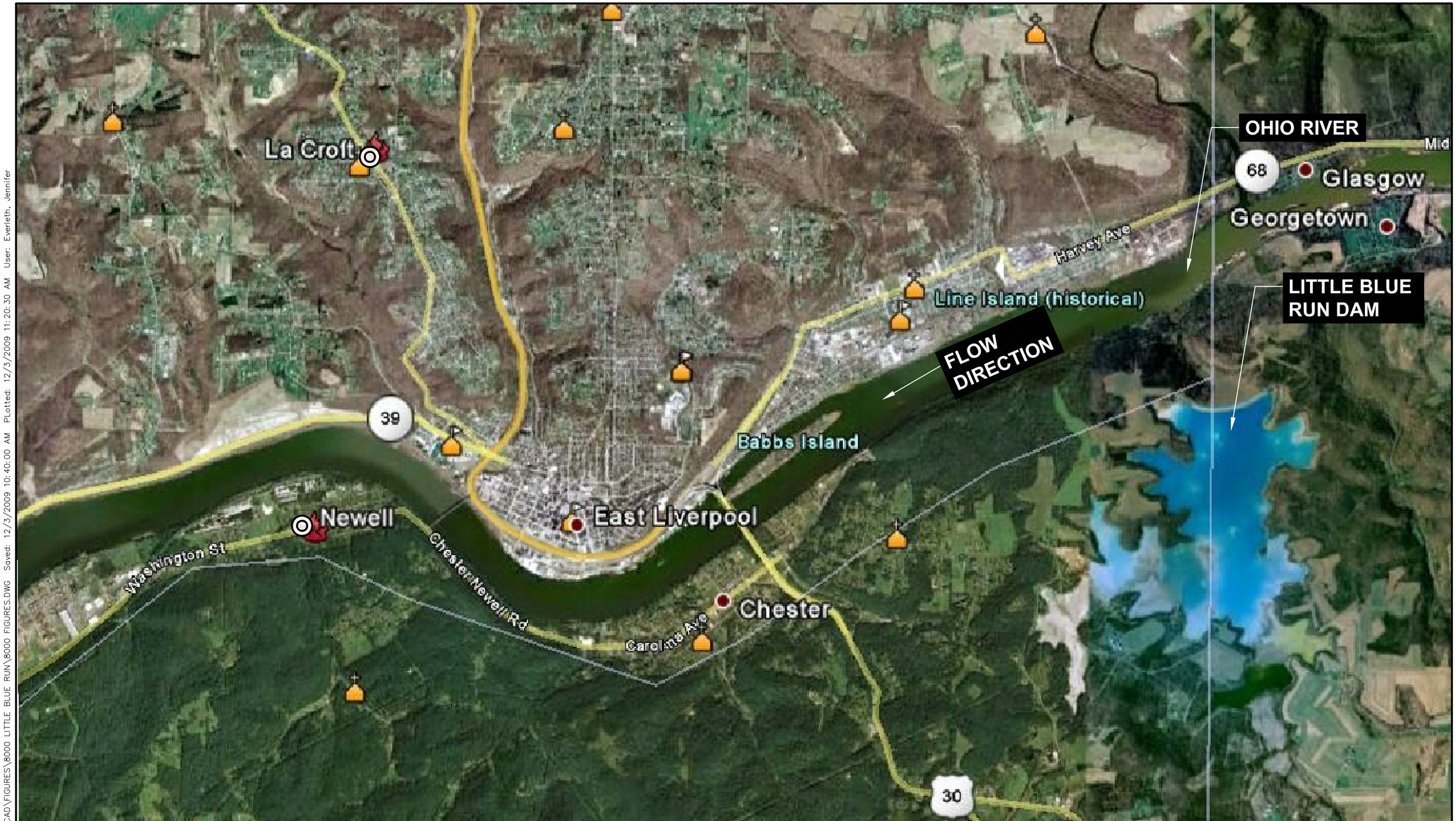

IMAGE REFERENCE: GOOGLE EARTH, IMAGE DATED APRIL 2005

0 1920 3840
Scale in feet

LEGEND

39 STREET, HIGHWAY

FIRE DEPARTMENT

SCHOOL

CHURCH

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CRITICAL INFRASTRUCTURE MAP

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 4

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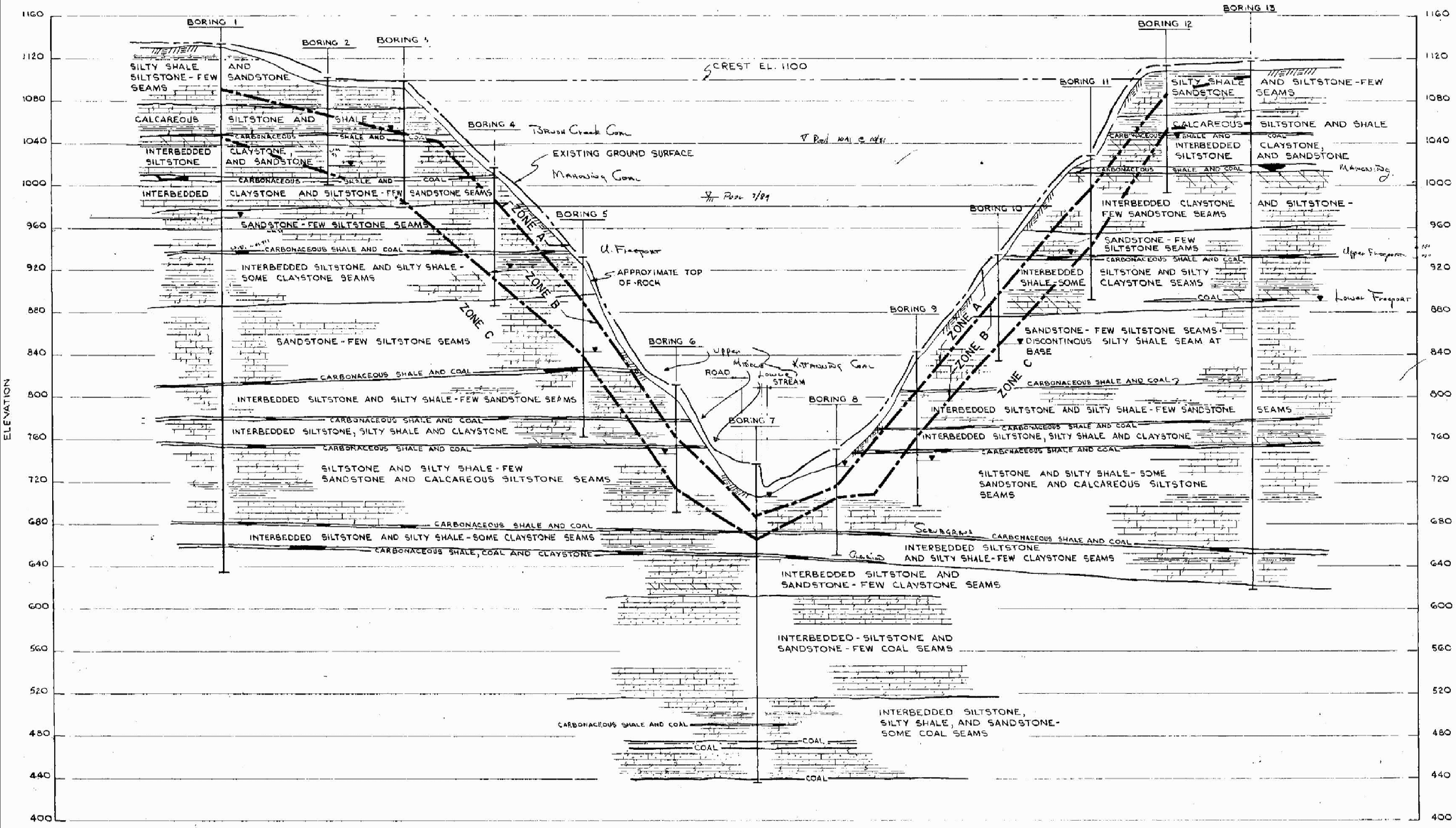

SECTION A-A

IMAGE REFERENCE: IMPOUNDMENT DAM GENERALIZED GEOLOGIC CROSS SECTION A–A', APRIL 1, 1974, DWG NO. E–8399, REVISION 3.

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GENERALIZED GEOLOGY CROSS SECTION
SECTION 'A–A'

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 5A

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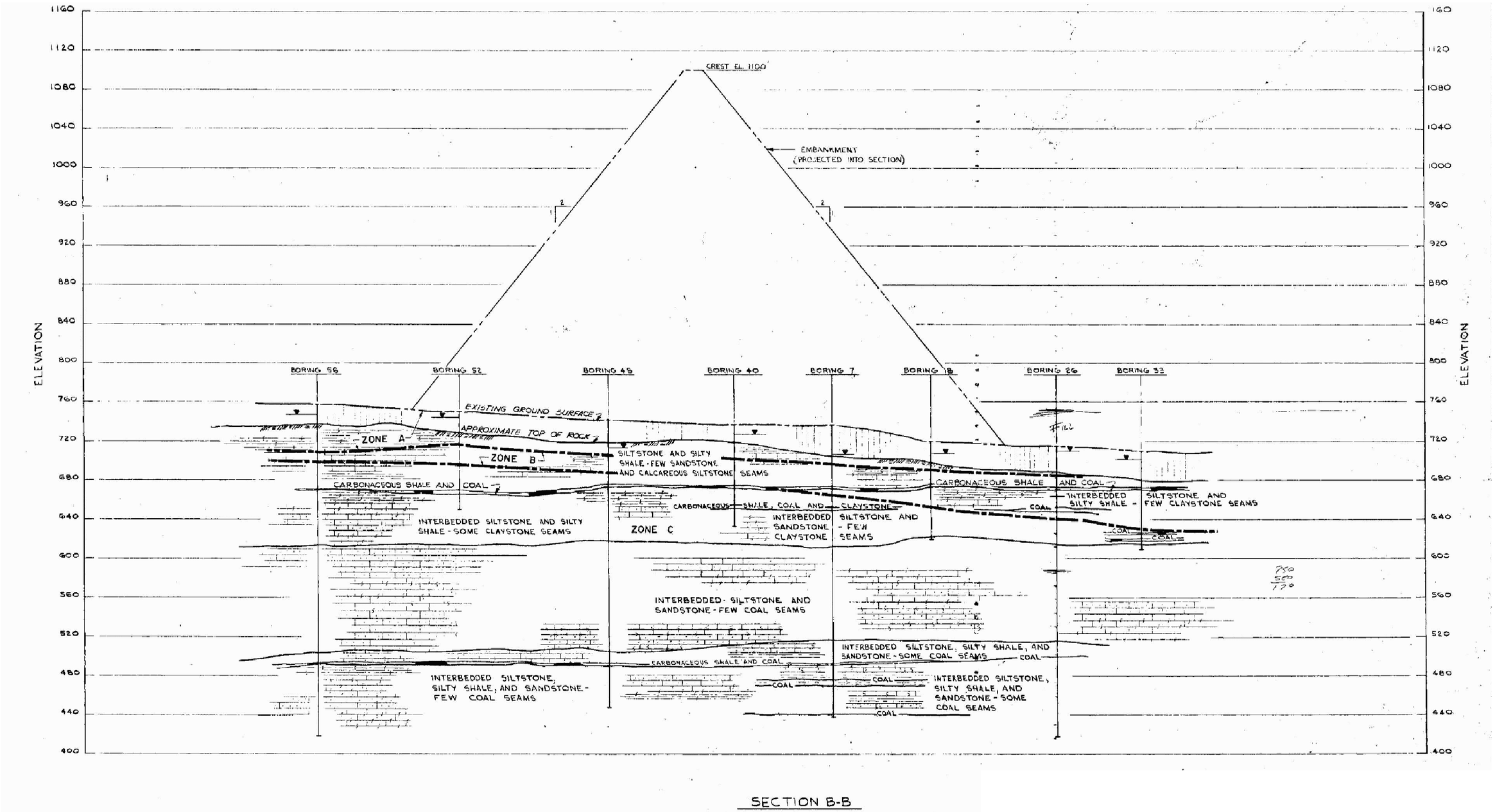

SECTION B-B

IMAGE REFERENCE: IMPOUNDMENT DAM GENERALIZED GEOLOGIC CROSS SECTION B–B', APRIL 1, 1974, DWG NO. E–8399, REVISION 3.

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GENERALIZED GEOLOGY CROSS SECTION
SECTION 'B–B'

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 5B

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2.0 FIELD ASSESSMENT

2.1 Visual Observations

CHA performed visual observations of the Little Blue Run Dam following the general procedures and considerations contained in Federal Emergency Management Agency's (FEMA's) *Federal Guidelines for Dam Safety* (April 2004), and Federal Energy Regulatory Commission (FERC) Part 12 Subpart D to make observations concerning settlement, movement, erosion, seepage, leakage, cracking, and deterioration. A Coal Combustion Dam Inspection Checklist and Coal Combustion Waste (CCW) Impoundment Inspection Form, prepared by the US Environmental Protection Agency, was completed on-site during the site visit. A copy of the completed form was submitted via email to Lockheed Martin representatives approximately three days following the site visit to the facility. Copies of these completed forms are included in Appendix A. A photo log and a Site Photo Location Maps (Figures 8A and 8B) are also located at the end of Section 2.3.

CHA's visual observations were made on October 22, 2009. The weather was mostly sunny with temperatures between 60 and 70 degrees Fahrenheit. Prior to the days we made our visual observations the following approximate rainfall amounts occurred (as reported by www.weather.com).

Table 2 - Approximate Precipitation Prior to Site Visit

Date of Site Visit – October 22, 2009		
Day	**Date**	**Precipitation (inches)**
Wednesday	10/14/09	0.00
Thursday	10/15/09	0.27
Friday	10/16/09	0.13
Saturday	10/17/09	0.03
Sunday	10/18/09	0.00
Monday	10/19/09	0.00
Tuesday	10/20/09	0.00
Wednesday	10/21/09	0.00
Thursday	10/22/09	0.00
Total	**Week Prior to Site Visit**	**0.43 inches**

2.2 Visual Observations – Little Blue Run Dam

CHA performed visual observations of the Little Blue Run Dam and the Little Blue Run Saddle Dam. The water in the reservoir north of the north/south line is approximately 20 feet deep. There are reportedly deeper pockets where ash has not been deposited and there is approximately 90 feet of water over deposited ash in these areas. In general, the dam embankments do not show signs of change in their horizontal alignments from their proposed alignments. No evidence of prior releases, failures or patchwork on the embankments was observed at the time of the site visit. Our field observations for this impoundment are provided in Sections 2.2.1, 2.2.2 and 2.2.3.

2.2.1 Little Blue Run Embankment and Crest

A gravel access road runs the entire length of the crest of the Little Blue Run Dam (Photo Nos. 2 through 5). The downstream embankment slope is covered with large rip rap which is reportedly sprayed for vegetation control every two years (Photo Nos. 7 and 8). Near the toe of the downstream slope there is a stilling basin (Photo No. 9). Slope protection above the reservoir pool elevation on the upstream embankment slope was observed to be rip rap (Photo Nos. 14 and 15).

During the site visit, First Energy and GAI representatives pointed out areas previously repaired on the west embankment-abutment contact where surface sloughing and sliding of surficial soils had occurred in the location of an access road some years ago (Photos 6, 12 and 13). Seepage that is directed to weirs for monitoring was observed on the west abutment (Photos No. 27 and 33). The east abutment was also observed (Photo Nos. 1, 10, and 11).

The weirs located on the left and right abutments to collect and monitor seepage discharges were observed. On the west abutment there are two weirs; the upper weir (ULA, Photo No. 30) and the lower weir (LLA, Photo No. 34) and on the right abutment there is one weir (RA, Photo No. 25). During the site visit it was observed that the culvert downstream of the west abutment upper

weir (ULA) was clogged causing back-flow in to the weir structure (Photo No. 30). The Parshall Flume toe drain (TD) which is a monitoring point for blanket drain seepage was also observed (Photo Nos. 28 and 29).

The Geotubes which were installed for vertical expansion of the impoundment without raising the elevation of the existing dam embankment were observed during the site visit (Photo No. 40).

2.2.2 Little Blue Run Outlet Control Structures

The three outlet structures at the Little Blue Run Dam were observed during the site visit. The service spillway is located on the left side of the dam and has an invert at elevation 1,090.3 feet (Photo No. 16). The spillway discharges to a 48-inch concrete pipe 1,000 feet long that discharges to the stilling basin (Photo 17).

The secondary spillway is a 36-inch diameter pipe through the right abutment. The intake was submerged at the time of the site visit (Photo Nos. 22 and 23). The pipe discharges to a gabion lined ditch which runs down the right abutment to the stilling basin at the toe of the dam (Photo No. 24). The ditch continues to a v-notch weir containing both secondary spillway discharge and seepage flow from the east abutment (Photo No. 25). Below the v-notch weir the flow continues in a rock lined channel to the stilling basin (Photo No. 26).

The emergency spillway is located to the left of the service spillway and consists of a trapezoidal labyrinth weir (Photo Nos. 16, 18 and 19). The channel discharges over the hillside into a wooded area (Photo Nos. 20 and 21).

A stilling basin is located at the toe that collects all of the seeps and the outlets for the secondary spillway. The water in the basin was clear at the time of the site visit (Photo Nos. 31 and 32). Outfall from the stilling basin is conveyed via a buried pipe to the Ohio River (Photo No. 35).

2.2.3 Little Blue Run Saddle Dam Embankment and Crest

At the time of the site visit the Little Blue Run Dam was not impounding water. A gravel access road runs the length of the crest of the Little Blue Run Saddle Dam (Photo No. 36). The upstream and downstream embankment slopes are grass covered (Photo Nos. 37 and 39). A small rodent hole was observed on the upstream slope (Photo No. 38).

2.3 Monitoring Instrumentation

Monitoring instrumentation at the Little Blue Run Dam includes v-notch weirs, piezometers and surface monuments.

2.3.1 V-Notch Weirs

Seepage from the dam embankment and the abutments is measured at four primary monitoring stations; the Upper Left Abutment (ULA) Weir, the Lower Left Abutment (LLA) Weir, the Right Abutment (RA) Weir and the Parshall Flume Toe Drain (TD). A secondary monitoring station, RA-Flume 1, drains through the RA weir. Discharge from the secondary spillway also drains through the RA Weir.

Discharge through these devices is measured daily. The data is reduced to obtain a monthly average for each device. The monthly average is combined and averaged for the current period to obtain the six-month average. Since weir data includes surface runoff, data collected on days where ½-inch of rainfall has been recorded is not tabulated for the six-month average calculation. The average base flow through the RA Weir is plotted for data collected only when the secondary spillway is not discharging. Plots of seepage from these weirs are shown on Figure 9A and Figure 9B.

Two underdrains on the right abutment collect seepage from above and below Elevation 925 feet between the dam access road and the dam embankment. Discharge from the underdrains occurs

at two locations, the RA-Flume 1 adjacent the dam access road at approximate Elevation 925 feet and from a pipe discharging into the basin above the RA Weir at the bottom of the right abutment. The flume is monitored daily and the pipe discharge is observed daily for changes.

The inspection and evaluation reports for the Little Blue Run Dam prepared by GAI Consultants summarized the average seepage measured from these monitoring stations during the previous six-month period. The December 10, 2008 report noted the following;

- Seepage from the TD has declined beginning in September 1995. Since that time flow has been relatively constant although additional declines at the TD began in May 2005 and continued through December 2008. Flow from the TD remains well below the average for the two years proceeding September 1995, a decline of nearly 50 percent.
- The record baseline flow from the RA Weir for a single month occurred in April 1999 and has been in decline since 2001.
- Seepage from the ULA Weir continues to show an overall decline which began in December 2001 despite a record high for a single month occurring in December 2007.
- Seepage from the LLA Weir remains fairly constant and continues to provide the base flow for Little Blue Run.

2.3.2 Piezometers

Twenty-two pneumatic piezometers were installed during construction of the dam embankment and two additional open-tube well points were installed at the embankment toe in 2004. The purpose of the original 22 piezometers was to monitor internal pore pressures within the embankment fill materials as the dam was raised and to monitor embankment performance during filling of the impoundment. The piezometers are read twice a year, in the spring and fall. The open-tube well points (UD-1 and UD-2) that were installed in 2004 monitor water levels in the filter blanket/underdrain system at the toe of the dam. Of the 22 piezometers and 2 well points installed, 16 have reportedly malfunctioned, three yield questionable data according to FirstEnergy's consultant and 5 are performing satisfactorily. Figure 10 shows the location of the

piezometers and Figures 11A through 11C shows the piezometer data from 2000 to December 2008.

The inspection and evaluation report dated December 10, 2008 for the Little Blue Run Dam prepared by GAI Consultants noted the following in regards to recently obtained piezometer data;

- Piezometers Nos. 11, 12, 13, 14, AL-3, AR-2, UD-1 and UD-2 were read during this period.
- Piezometers 11 and 12 monitor pore pressure in the embankment underdrain system. Piezometer 11 remained the same and Piezometer 12 declined slightly from the previous reading. These piezometers yield results well below specified limits, but the data is suspect for Piezometer 11.
- Piezometers 13 and 14 monitor pore pressures in the random rock fill of the dam embankment. Both piezometers declined slightly from the pervious readings and continue to yield results well below their specified limits.
- Piezometers AL-3 and AR-2 monitor pore pressures near claystone interfaces, which is considered to be relatively weak zones within the abutment foundation. Piezometer AL-3 showed a sharp increase in pore pressure from the previous reading. Piezometer AR-2 showed no change in pore pressure from the previous readings. It was noted that bother piezometers yield data below their specified limits but the piezometers continue to be suspect.
- Open-tube piezometers (well points) UD-1 and UD-2 monitor the hydrostatic water elevation in the embankment filter blanket/underdrain system. Both well points showed no change from the previous readings and the current data indicates normal conditions within the underdrain system.

2.3.3 Surface Monuments

Twenty-two surface monuments are currently being monitored for vertical and horizontal movement; 13 downstream monuments and 9 upstream monuments. Surface monument data is presented in Figures 12A through 12J from 2002 to March 2008. The surface monuments were surveyed on March 11, 2008. The inspection and evaluation report dated December 10, 2008 prepared by GAI Consultants notes that no evidence of embankment instability has been detected or observed. It should be noted that settlement values reported prior to 2001 for the Elevation 1100 series of monuments have been negated with respect to the dam crest elevation as a result of the dam embankment camber restoration in 2001.

IMAGE REFERENCE: GOOGLE EARTH, APRIL 2005

0 507 1,014
Scale in feet

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PHOTO LOCATION MAP

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SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 8A

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\8000_8_PHOTO LOCATION MAP.DWG Saved: 12/1/2009 3:36:19 PM PLotted: 12/3/2009 10:11:14 AM User: Everleth, Jennifer

IMAGE REFERENCE: MICROSOFT BING MAPS 2009, IMAGE COURTESY OF USGS

0 507 1,014
Scale in feet

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PHOTO LOCATION MAP

LITTLE BLUE RUN DAM
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PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 8B

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\8000_8_PHOTO LOCATION MAP.DWG Saved: 12/1/2009 3:36:19 PM PLotted: 12/3/2009 10:17:30 AM User: Everleth, Jennifer

1

East abutment, looking east.

2

Crest and east abutment, looking east.

3

Dam crest, looking southwest.

4

Dam crest, looking west.

5

Dam crest, looking west.

6

West abutment, looking west.

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CHA Project No.: 20085.8000.1510	October 22, 2009

7

Downstream slope, looking west.

8

Crest elevation re-establishment made with darker stone and gravel.

9

Downstream slope looking north at toe and stilling basin.

10

East abutment contact with downstream slope, looking east.

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CHA Project No.: 20085.8000.1510	October 22, 2009

11

East abutment contact with downstream slope, looking up from the toe.

12

West abutment contact with downstream slope, looking west.

13

West abutment contact with downstream slope, looking up from the toe.

14

Upstream slope, looking southwest.

15

Upstream slope, looking southeast.

16

Service spillway and emergency spillway.

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CHA Project No.: 20085.8000.1510	October 22, 2009

17

Terminus of service spillway at stilling basin.

18

Approach to emergency spillway in bedrock.

19

Downstream channel of emergency spillway.

20

Emergency spillway channel over natural slope, looking downstream from the labyrinth weir.

21

Emergency spillway channel over natural slope, looking upstream from the stilling basin.

22

Area of secondary spillway intake. Pipe was submerged during our sit visit.

23

Secondary spillway.

24

Gabion channel from secondary spillway.

25

V-notch monitoring weir containing secondary spillway and east abutment seepage flow.

26

Channel downstream of east abutment v-notch to stilling basin.

27

West abutment seepage.

28

Toe drain collection pipe terminating in Parshall Flume.

29

Parshall flume monitoring point for blanket drain seepage.

30

V-notch monitoring weir for west abutment seepage monitoring. Clogged culvert was causing back flow during our site visit.

31

Stilling basin sediment control.

32

Water in stilling basin was clear at the time of our site visit,

33

Lower left (west) abutment seepage. This natural seepage maintains flow in Little Blue Run per permit conditions.

34

V-notch monitoring weir for lower left abutment seepage.

35

Outfall from stilling basin conveyed by buried pipe to the Ohio River.

36

Crest of Little Blue Run Saddle Dike, looking south.

37

Upstream slope of Little Blue Run Saddle Dike, looking south.

38

Small rodent hole on upstream slope of Little Blue Run Saddle Dike.

39

Downstream slope of Little Blue Run Saddle Dike, looking north.
Vegetation near group of people on slope consists of material that the mower cannot traverse.

40

Geotubes and dry ash placement at south end of reservoir.

SEEPAGE COLLECTION SYSTEMS (1979 - 2008)
LITTLE BLUE RUN DAM

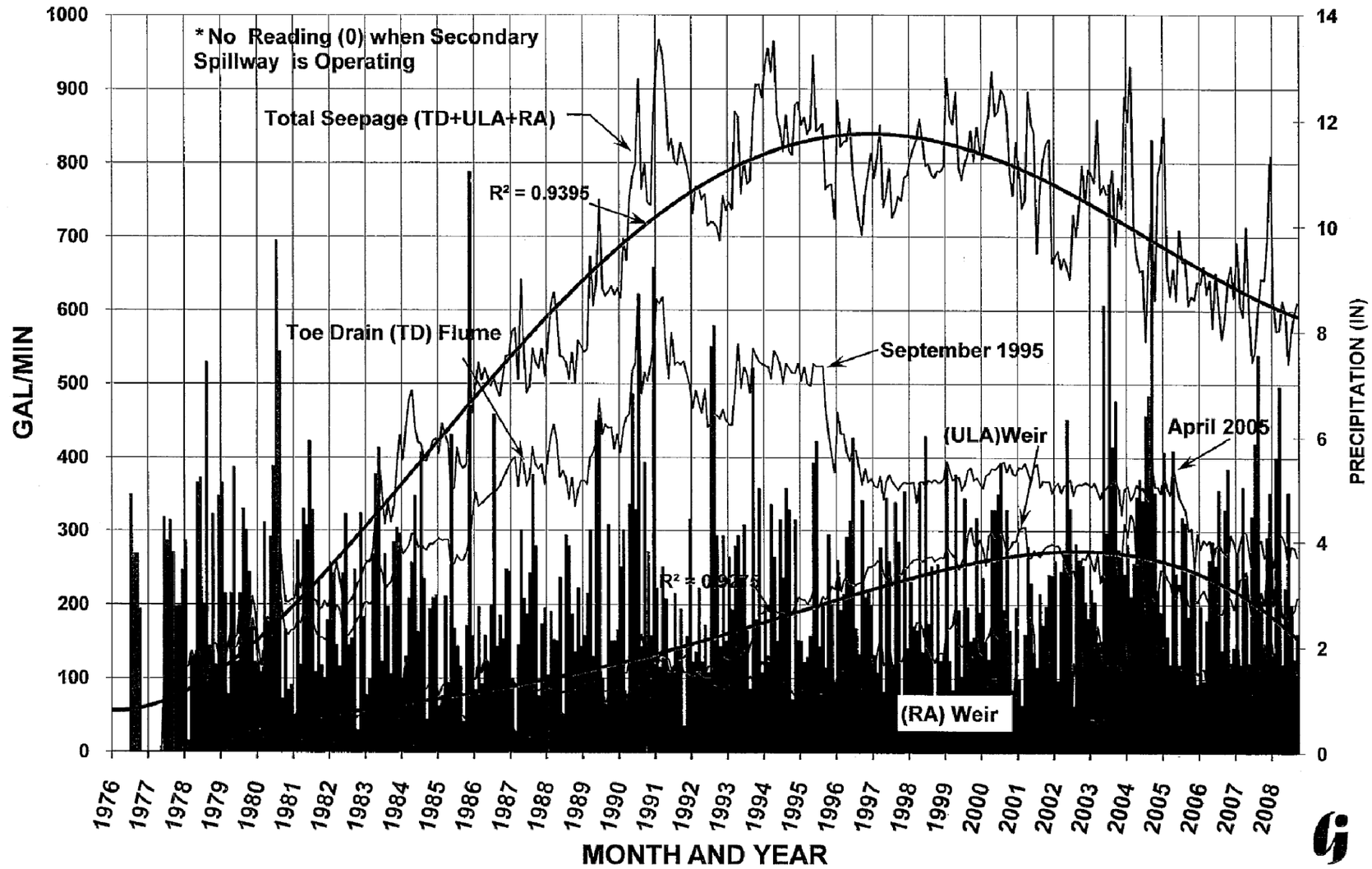

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IMAGE REFERENCE: XXXXXXXXXXXXXXX

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SEEPAGE COLLECTION SYSTEMS
(1979 – 2008)

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 9A

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\8000 FIGURES.DWG Saved: 12/3/2009 10:07:10 AM PLotted: 12/3/2009 10:19:35 AM User: Everleth, Jennifer

ULA SEEPAGE and PRECIPITATION (1979 - 2008)
LITTLE BLUE RUN DAM

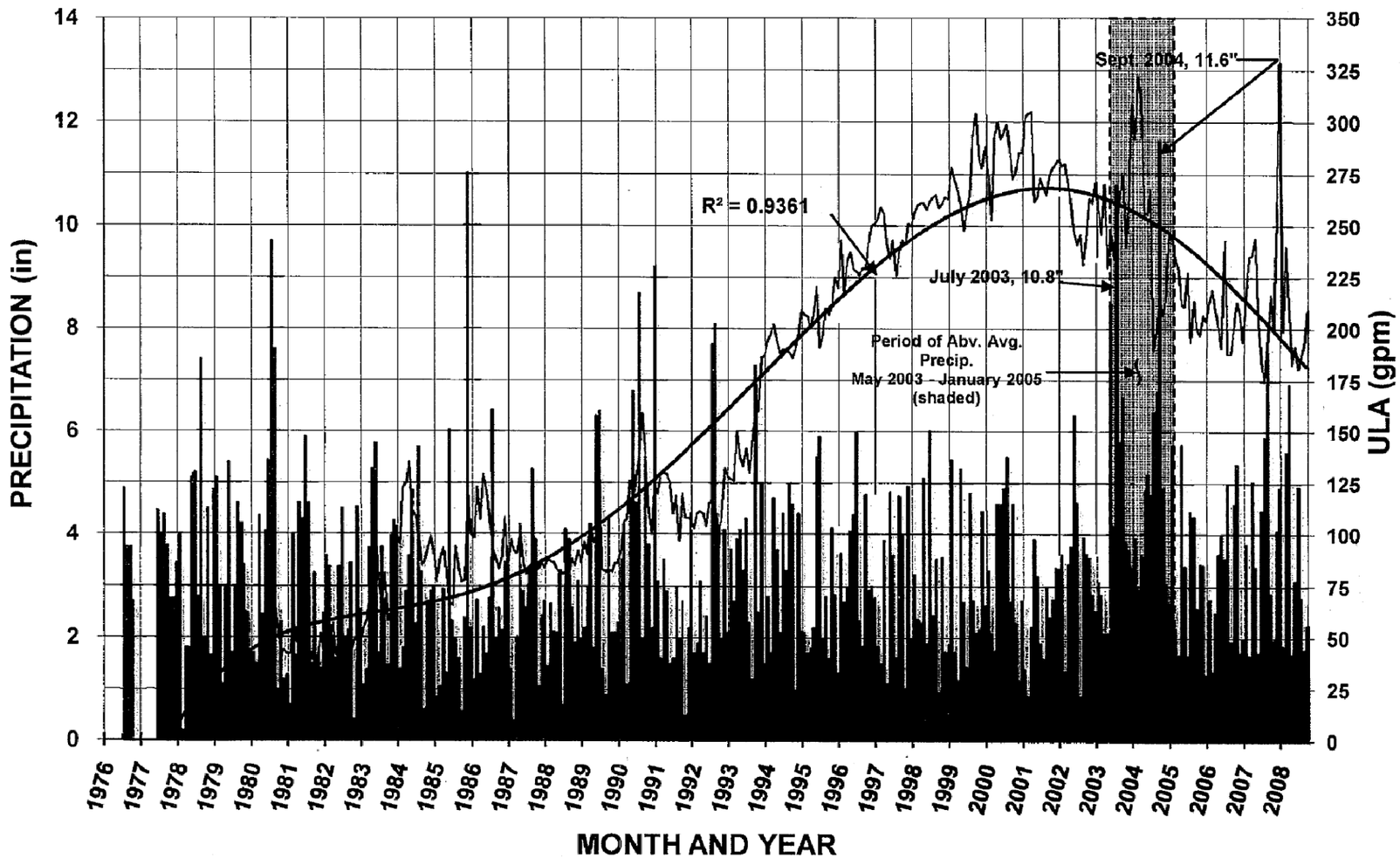

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IMAGE REFERENCE: XXXXXXXXXXXXXXX

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ULA SEEPAGE AND PRECIPITATION (1979 – 2008)

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DATE: 12/2009

FIGURE 9B

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\8000 FIGURES.DWG Saved: 12/3/2009 10:07:10 AM PLotted: 12/3/2009 10:20:42 AM User: Everleth, Jennifer

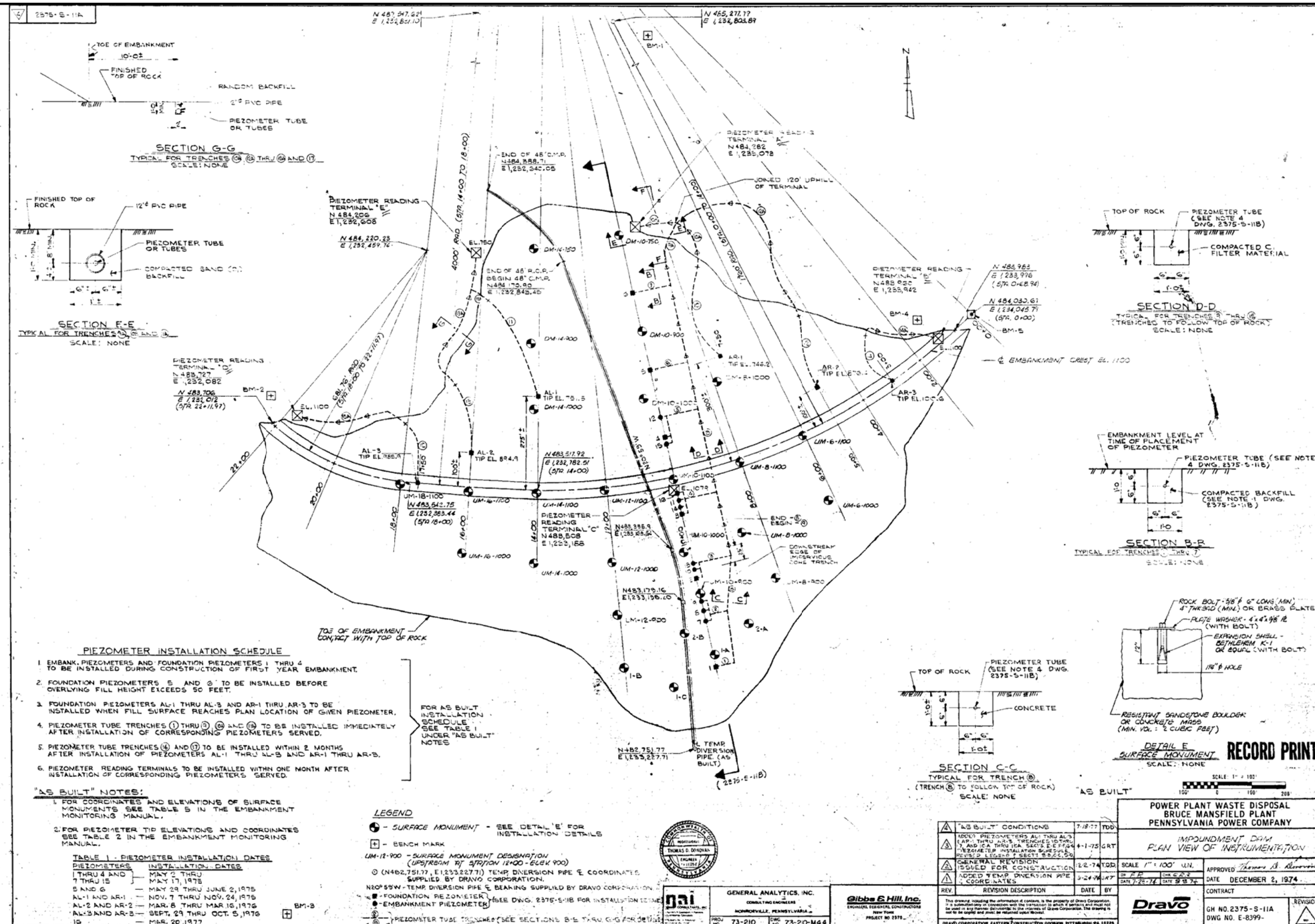

IMAGE REFERENCE: XXXXXXXXXXXXXXX

0 400 800
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PIEZOMETER LOCATIONS

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

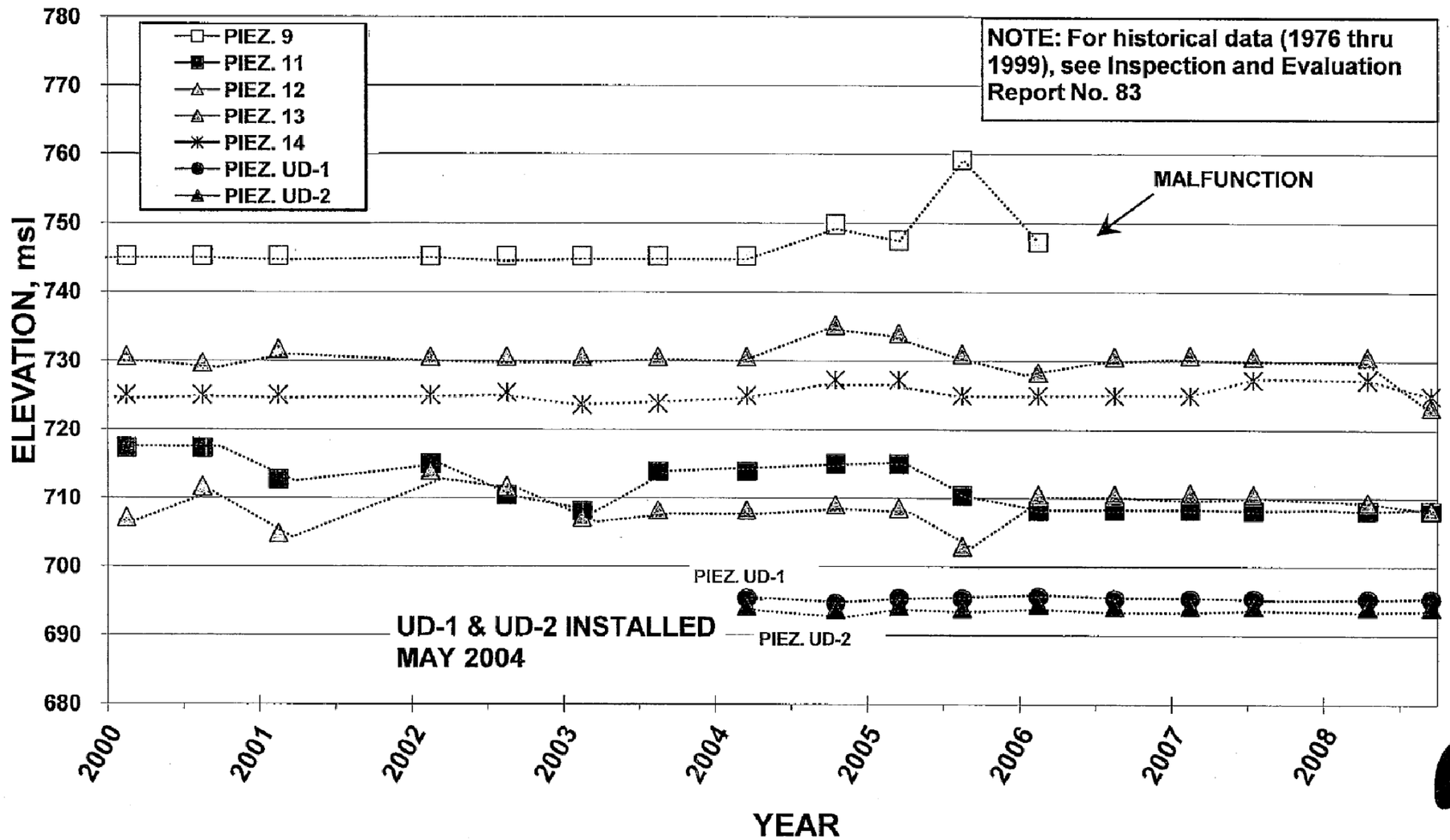
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 10

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\8000 FIGURES.DWG Saved: 12/3/2009 10:07:10 AM PLotted: 12/3/2009 10:21:21 AM User: Everleth, Jennifer

PIEZOMETERS 9, 11, 12, 13, 14, UD-1 and UD-2 LITTLE BLUE RUN DAM



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PIEZOMETER DATA
PIEZMOTERS 9 11 12 13 14 UD-1 AND UD-2

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

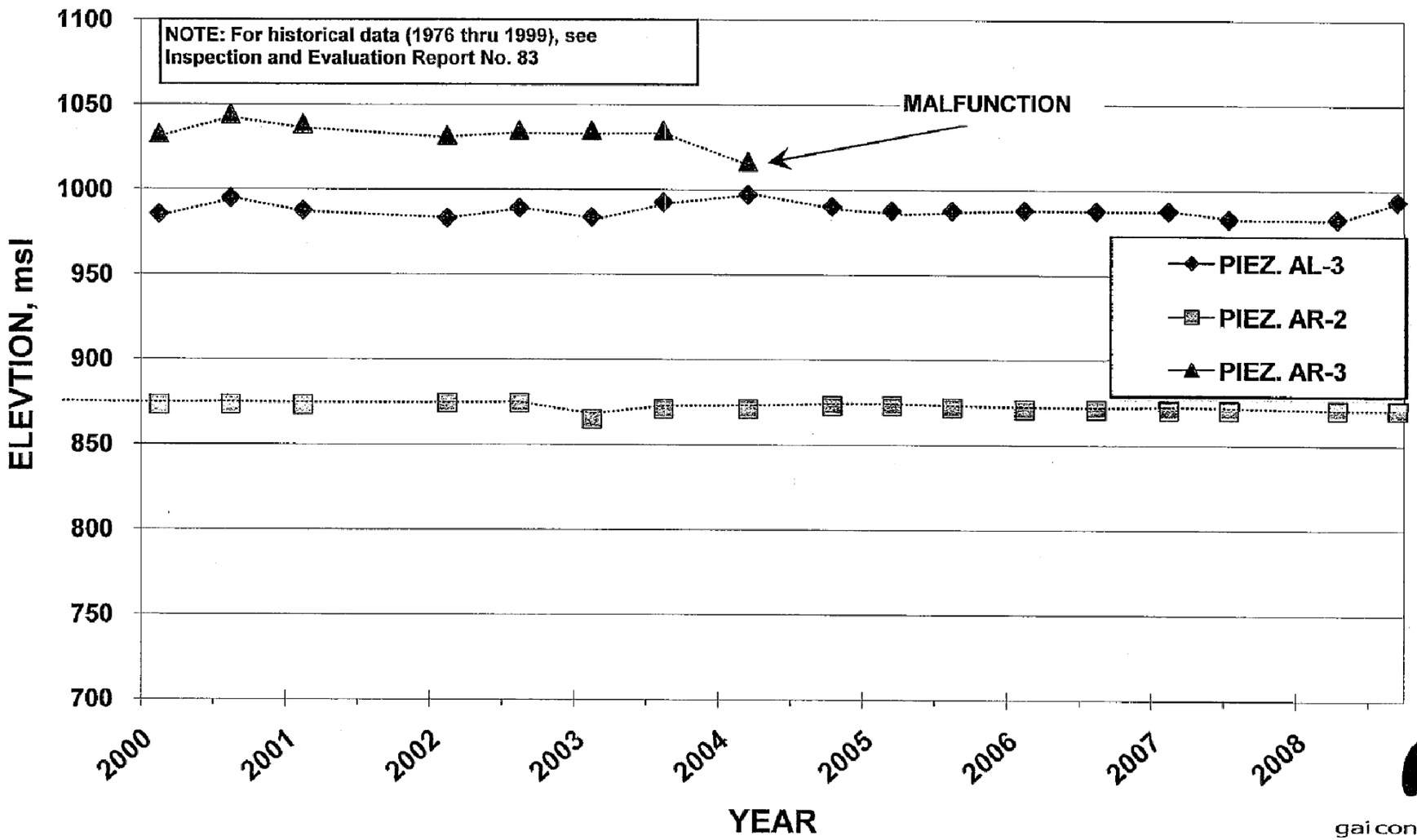
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 11A

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-8000-FIGS_10A-10C.DWG Saved: 12/1/2009 3:39:53 PM PLotted: 12/3/2009 10:22:34 AM User: Everleth, Jennifer

PIEZOMETERS AL-3, AR-2 AND AR-3
LITTLE BLUE RUN DAM



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PIEZOMETER DATA
PIEZOMETERS AL-3 AR-2 AND AR-3

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

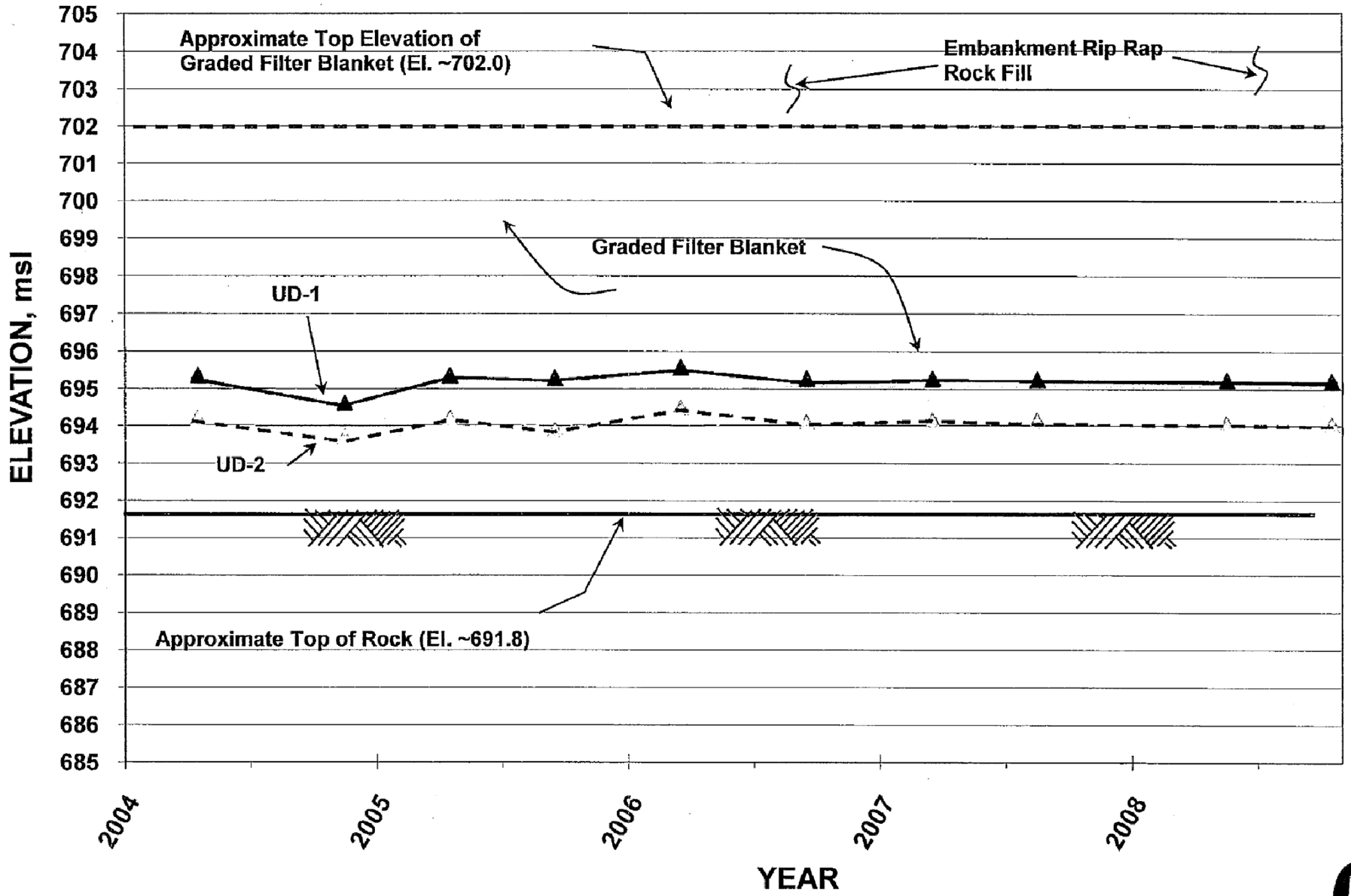
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 11B

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-8000-FIGS_10A-10C.DWG Saved: 12/1/2009 3:39:53 PM PLotted: 12/3/2009 10:23:33 AM User: Everleth, Jennifer

TOE DRAIN PIEZOMETERS UD-1 AND UD-2
LITTLE BLUE RUN DAM



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PIEZOMETER DATA
TOE DRAIN PIEZOMETERS UD-1 AND UD-2

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

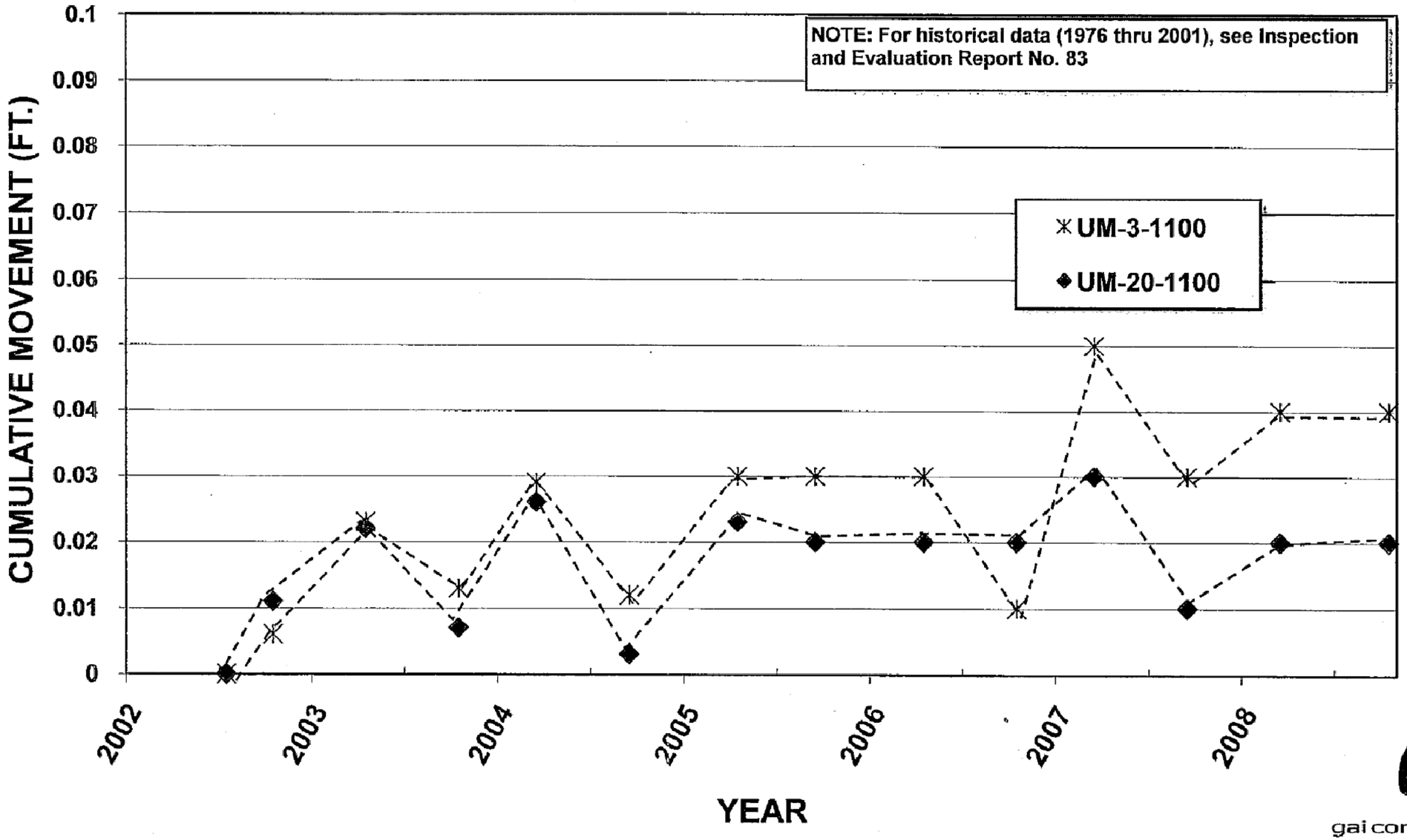
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 11C

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-8000-FIGS_10A-10C.DWG Saved: 12/1/2009 3:39:53 PM PLotted: 12/3/2009 10:24:00 AM User: Everleth, Jennifer

CUMULATIVE VERTICAL MOVEMENT
UPSTREAM MONUMENTS - EL. 1100
LITTLE BLUE RUN DAM



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CUMULATIVE VERTICAL MOVEMENT
UPSTREAM MONUMENTS – EL. 1100

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

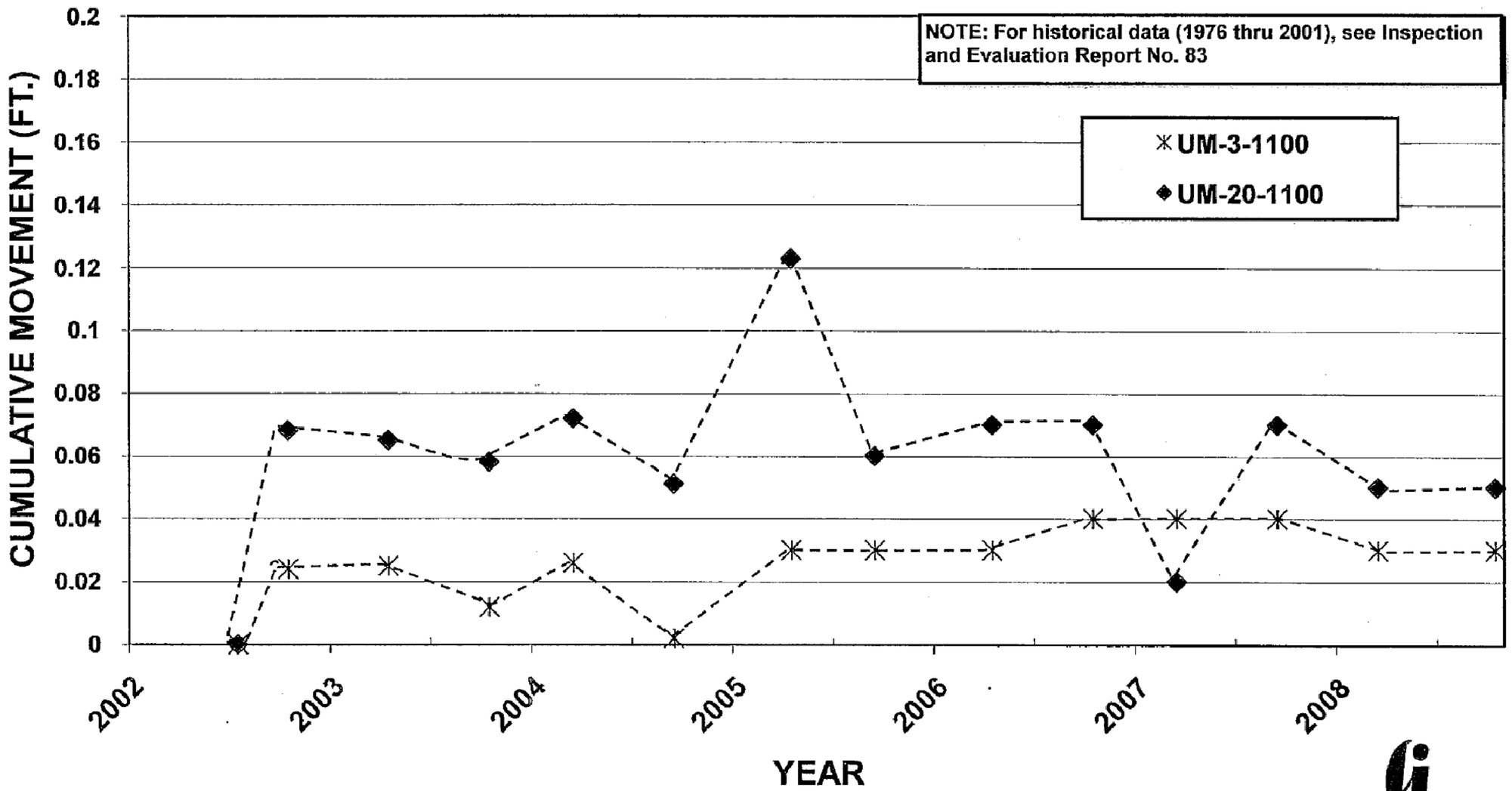
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12A

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:24:52 AM User: Everleth, Jennifer

CUMULATIVE HORIZONTAL MOVEMENT
UPSTREAM MONUMENTS - EL. 1100
LITTLE BLUE RUN DAM



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CUMULATIVE HORIZONTAL MOVEMENT
UPSTREAM MONUMENTS – EL. 1100

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

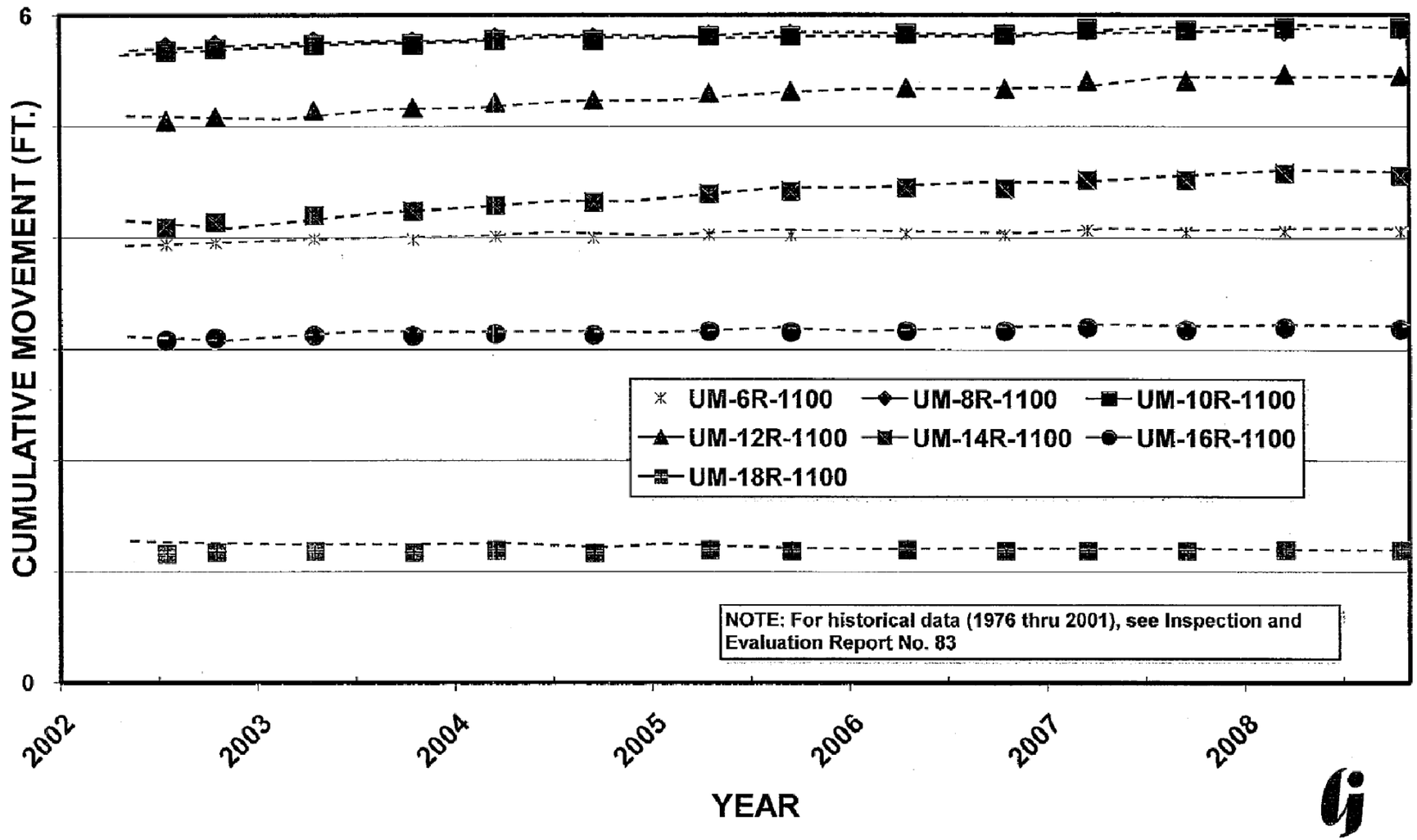
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12B

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:25:20 AM User: Everleth, Jennifer

CUMULATIVE VERTICAL MOVEMENT
UPSTREAM MONUMENTS - EL. 1100
LITTLE BLUE RUN DAM



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CUMULATIVE VERTICAL MOVEMENT
UPSTREAM MONUMENTS – EL. 1100

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

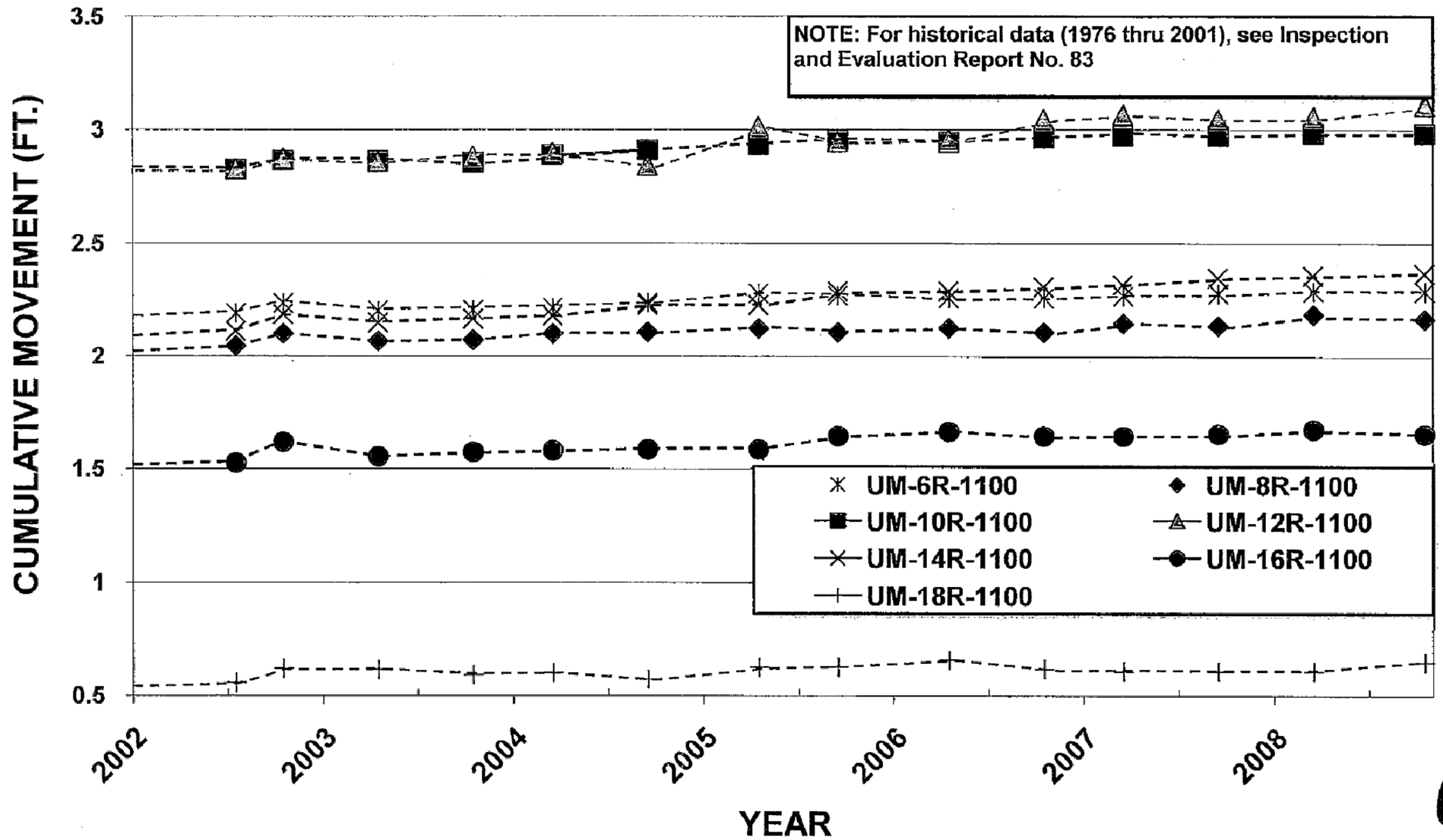
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12C

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:25:49 AM User: Everleth, Jennifer

CUMULATIVE HORIZONTAL MOVEMENT
UPSTREAM MONUMENTS - EL. 1100
LITTLE BLUE RUN DAM



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CUMULATIVE HORIZONTAL MOVEMENT
UPSTREAM MONUMENTS – EL. 1100

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

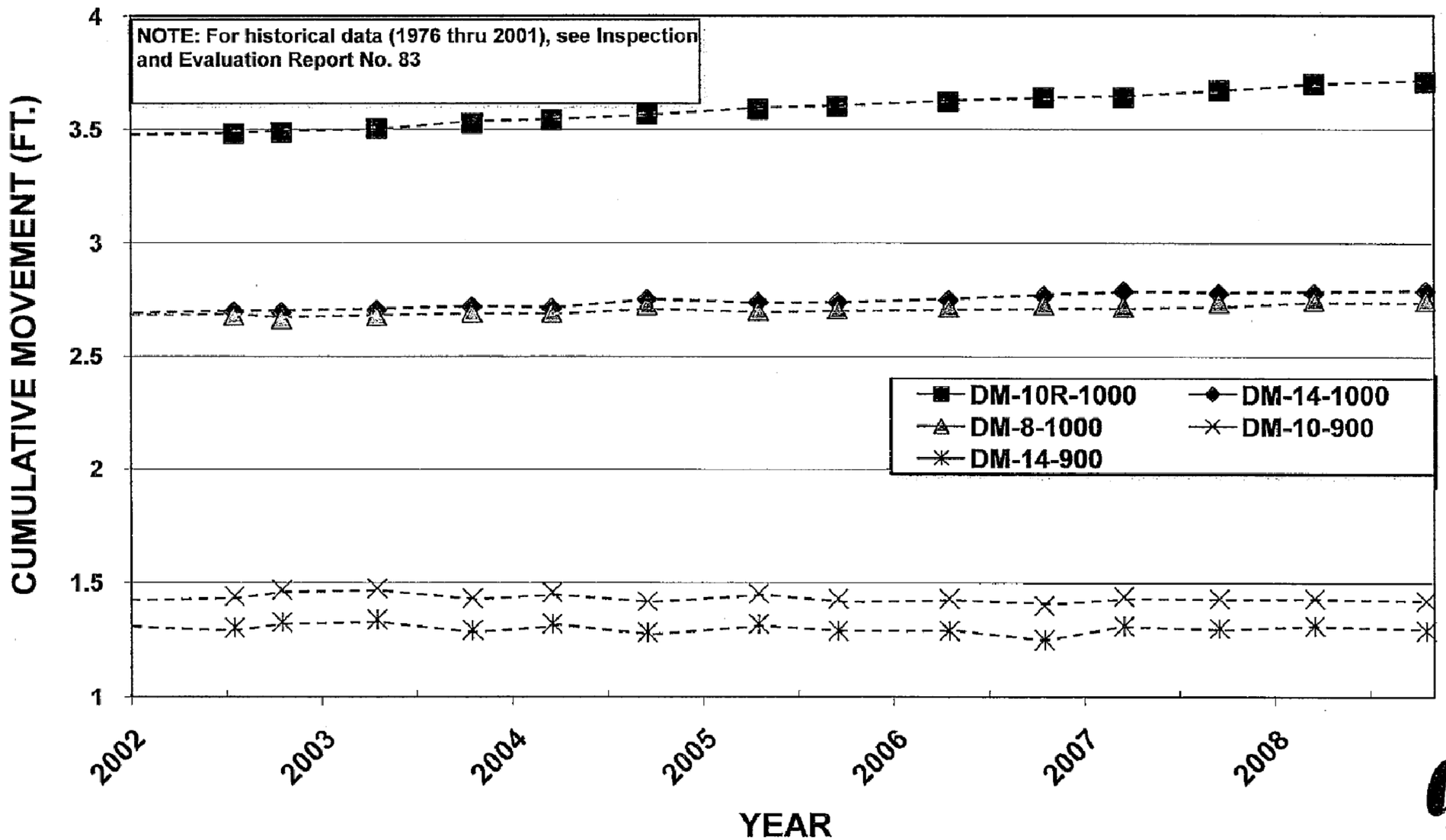
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12D

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:26:19 AM User: Everleth, Jennifer

CUMULATIVE VERTICAL MOVEMENT
DOWNSTREAM MONUMENTS - EL 1000 & 900
LITTLE BLUE RUN DAM



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CUMULATIVE VERTICAL MOVEMENT
DOWNSTREAM MONUMENTS – EL. 1000 & 900

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

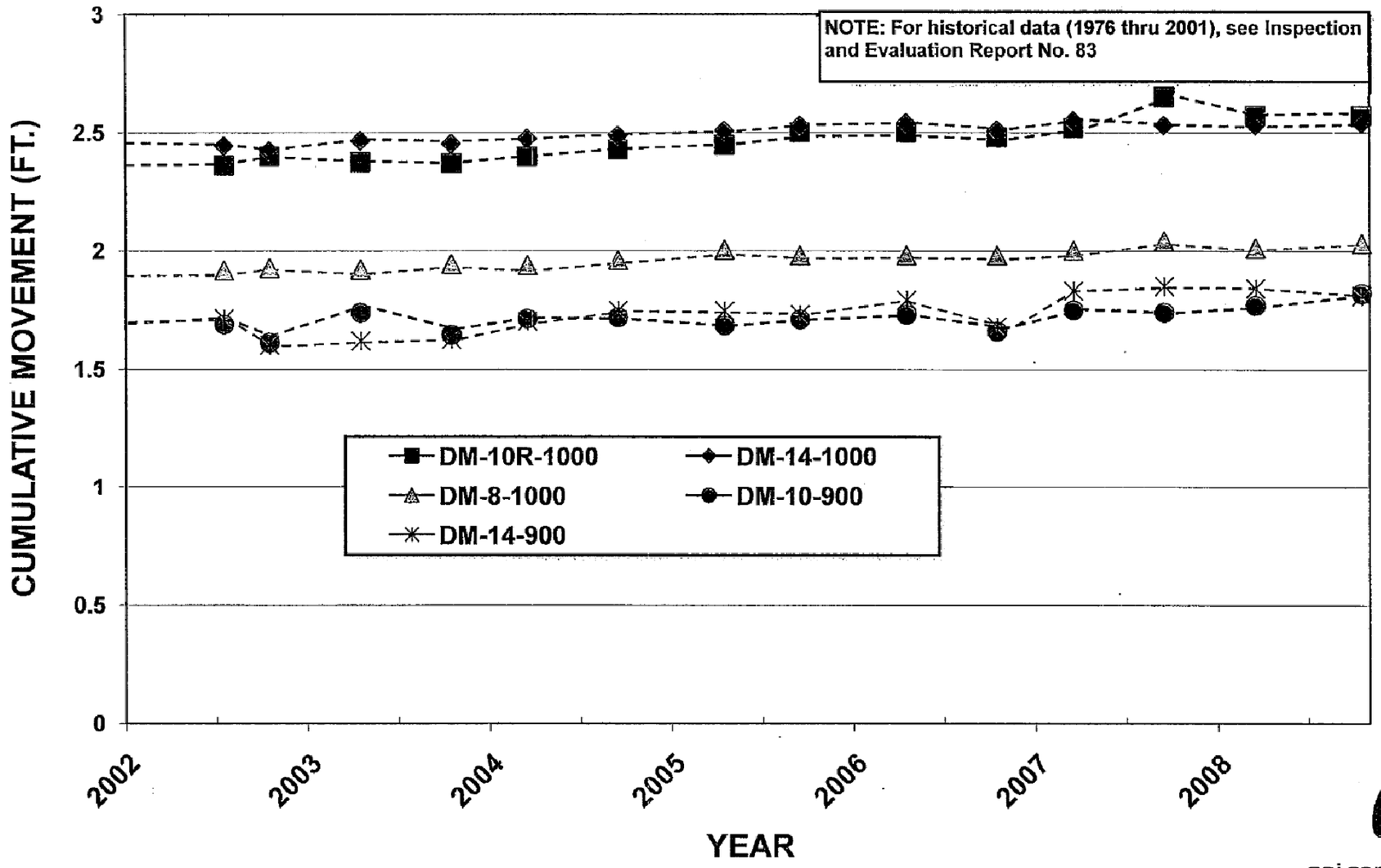
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12E

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:28:14 AM User: Everleth, Jennifer

CUMULATIVE HORIZONTAL MOVEMENT
DOWNSTREAM MONUMENTS - EL 1000 & 900
LITTLE BLUE RUN DAM



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CUMULATIVE HORIZONTAL MOVEMENT
DOWNSTREAM MONUMENTS – EL. 1000 & 900

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

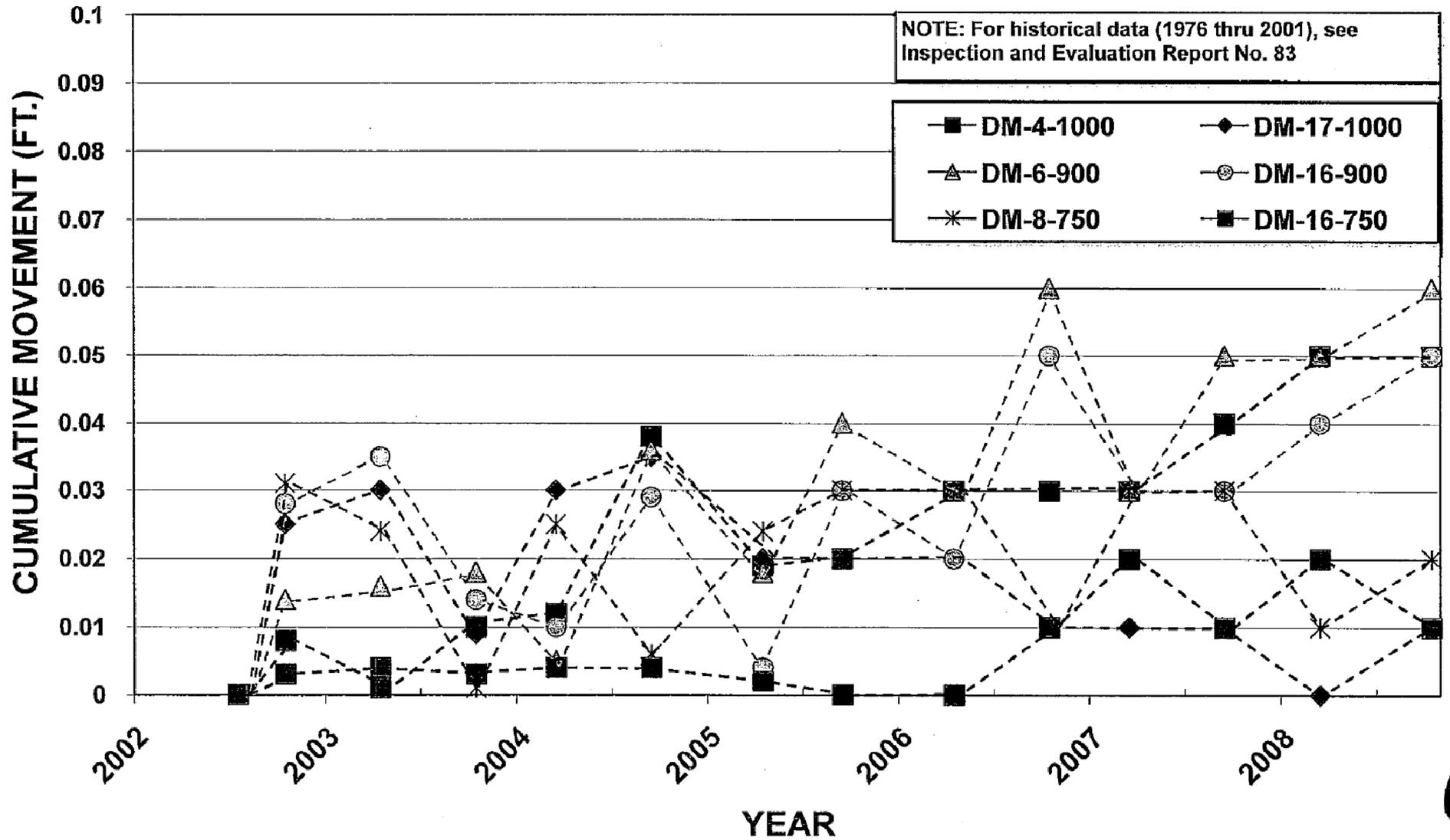
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12F

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:28:50 AM User: Everleth, Jennifer

CUMULATIVE VERTICAL MOVEMENT
DOWNSTREAM MONUMENTS - EL 1000, 900 & 750
LITTLE BLUE RUN DAM



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CUMULATIVE VERTICAL MOVEMENT
DOWNSTREAM MONUMENTS – EL. 1000 900 & 750

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

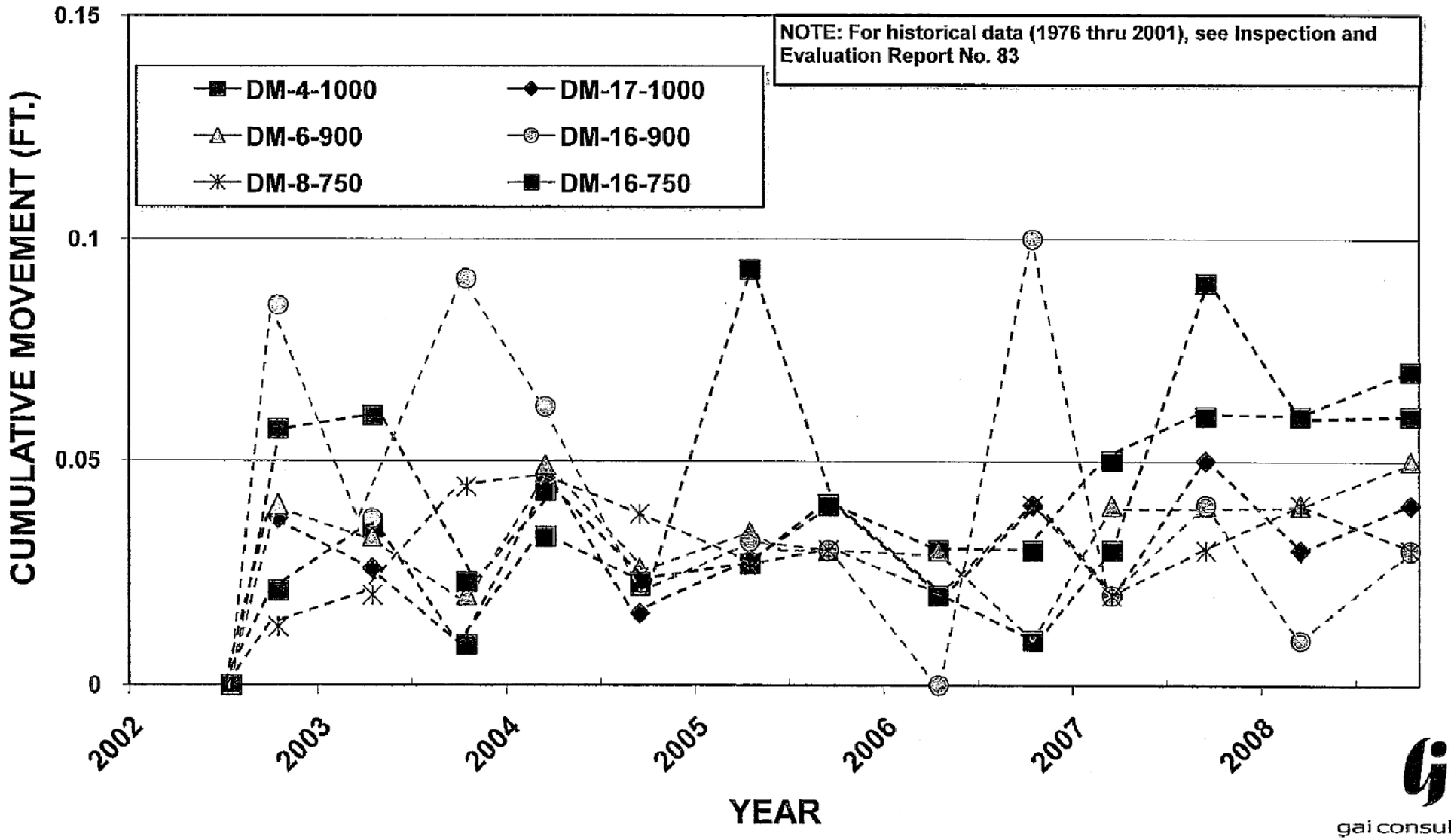
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12G

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:29:19 AM User: Everleth, Jennifer

CUMULATIVE HORIZONTAL MOVEMENT
DOWNSTREAM MONUMENTS - EL 1000, 900 & 750
LITTLE BLUE RUN DAM



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CUMULATIVE HORIZONTAL MOVEMENT
DOWNSTREAM MONUMENTS – EL. 1000 900 & 750

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12H

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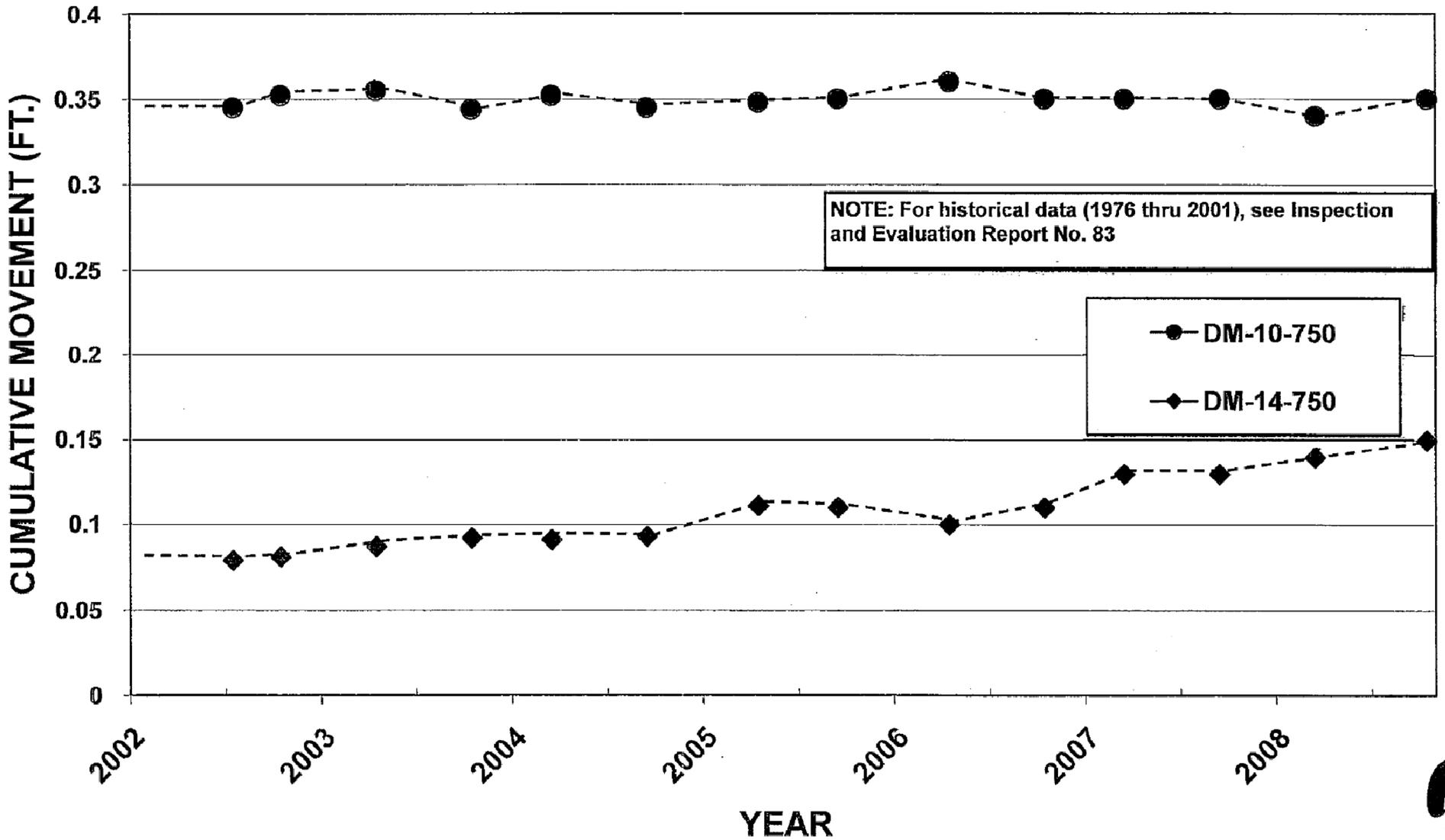
CUMULATIVE VERTICAL MOVEMENT
DOWNSTREAM MONUMENTS - EL. 750
LITTLE BLUE RUN DAM



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CUMULATIVE VERTICAL MOVEMENT
DOWNSTREAM MONUMENTS – EL. 750

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

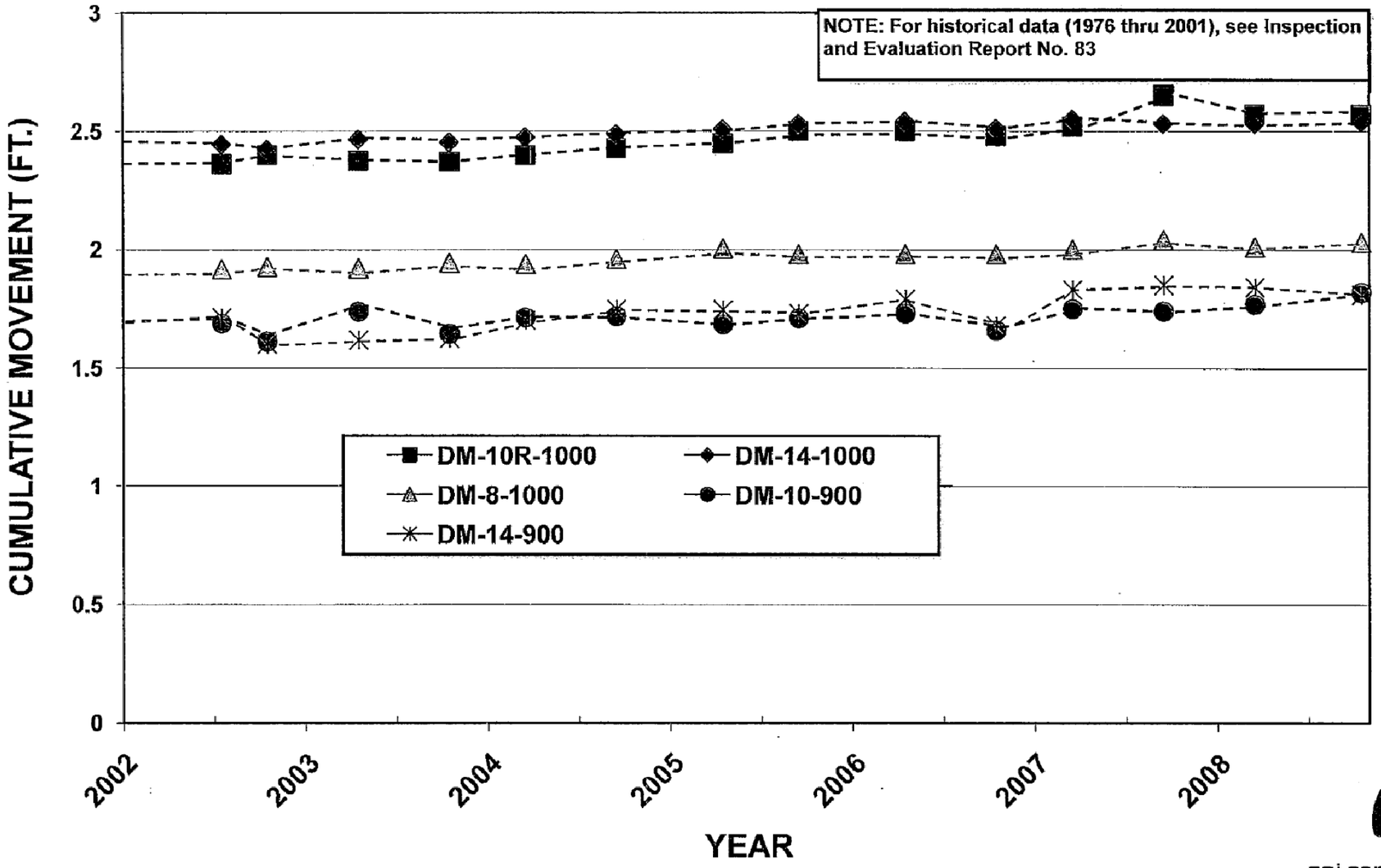
PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12I

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:30:24 AM User: Everleth, Jennifer

CUMULATIVE HORIZONTAL MOVEMENT
DOWNSTREAM MONUMENTS - EL 1000 & 900
LITTLE BLUE RUN DAM



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CUMULATIVE HORIZONTAL MOVEMENT
DOWNSTREAM MONUMENTS – EL. 750

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 12J

File: K:\20085\CADD\ACAD\FIGURES\8000 LITTLE BLUE RUN\20085-FIGS_11A-11J.DWG Saved: 12/2/2009 8:16:14 AM PLotted: 12/3/2009 10:30:47 AM User: Everleth, Jennifer

3.0 DATA EVALUATION

3.1 Design Assumptions

CHA has reviewed the design assumptions related to the design and analysis of the stability and hydraulic adequacy of the Little Blue Run Dam which were available at the time of our site visit and provided to us by FirstEnergy, GAI Consultants and the PA-DEP. The design assumptions are listed with the applicable summary of analysis in the following sections.

3.2 Hydrologic and Hydraulic Design

PA Code 105.98 – Design Flood Criteria requires that the discharge capacity or storage capacity, or both, shall be capable of safely accommodating the recommended design flood for the size and hazard potential classification of the dam. The Little Blue Run Dam is classified as an A-1 dam and is therefore required to safely discharge or accommodate the probable maximum flood (PMF).

Engineering analyses results data from Emergency Spillway Modification Reports from 2006 and 2007 prepared by GAI Consultants showed that a 10-cycle labyrinth spillway with invert elevation 1,092.85 feet and a width normal to the direction of flow of 161 feet would pass the routed PMP event through the reservoir and discharge structure while limiting the reservoir maximum pool elevation to 1,096.67 feet, yielding a freeboard of 3.33 feet. This is accomplished with discharges from the emergency (labyrinth) and service spillways reaching a peak discharge of 9,649 CFS. Discharge is anticipated to occur through the emergency spillway for approximately 16 hours before diminishing to the point where the service spillway would manage the final portion of the storm runoff.

3.3 Structural Adequacy & Stability

According to PA-DEP dam safety regulations allowable stresses shall conform to the current standards accepted by the engineering profession. Industry guidelines, such as those published in the US Army Corps of Engineers EM 1110-2-1902 Table 3-1, suggest the following guidance values for minimum factors of safety as shown in Table 3.

Table 3 - Minimum Safety Factors Recommended by US Army Corps of Engineers

Analysis Condition	Required Minimum Factor of Safety	Slope
Long-Term (Steady state seepage, maximum storage pool elevation)	1.5	Downstream
Maximum Surcharge Pool (Flood condition)	1.4	Downstream
Rapid Drawdown (From maximum storage pool elevation)	1.3	Upstream
Earthquake Loading (Maximum pool elevation)	1.0	Downstream
Liquefaction	Analyze potential and safeguard against if needed	NA

The regulations note that dams shall be structurally sound and shall be constructed of sound and durable materials. The completed structure shall be stable under all probable conditions of operation. In reviewing the stability of a structure, the PA-DEP may consider, without limitation, the following:

- The physical properties of the materials available for construction.
- The seismic and hydraulic forces affecting the structure.
- The methods of construction.

The 1977 As-Built Drawings for the Little Blue Run Dam show engineering analyses results for stability. Figure 6 and Figure 7 show the cross sections modeled and the corresponding results.

Table 4 shows a comparison of the minimum safety factors recommended to the analyses results shown on the 1977 As-Built Drawings.

Table 4 - Comparison of Engineering Analyses Results to Design Criteria

Minimum Safety Factors Recommended Based on USACOE Guidelines		**Engineering Analyses Results** Data from 1977 As-Built Drawings
Long-Term – Downstream Slope (Steady state seepage, maximum storage pool elevation)	1.5	1.6
Long-Term – Upstream Slope (Steady state seepage, maximum storage pool elevation)	1.5	1.5
Maximum Surcharge Pool (Flood condition)	1.4	Loading condition not analyzed
Rapid Drawdown (From maximum storage pool elevation)	1.3	1.1
Earthquake Loading – Downstream Slope (Maximum pool elevation)	1.0	1.3
Earthquake Loading – Upstream Slope (Maximum pool elevation)	1.0	1.0
Liquefaction (Analyze potential and safeguard against, if needed)		No conclusion provided to CHA. Subsurface information provided does not appear to suggest liquefaction susceptible soils are found at this site.

3.4 Foundation Conditions and Documentation of Foundation Preparations

The *Foundation Treatment for Little Blue Run Dam* notes that there was a series of "county bank" coal mines (small scale mines for domestic use of coal) which penetrated as far as 110 feet into the abutments. According to GAI Consultants the mines that were deeper were backfilled with grout and shallow mines were cleaned of loose material and filled with sand backs prior to backfill being placed. It has also been reported that coal and carbonaceous shale layers encountered were cleaned of loose material and "dental concrete" (a four-sack, sand-cement mixture delivered to the site by a local redi-mix facility) was placed.

Grouting work was performed at the Little Blue Run Dam and consisted of constructing a grout blanket and a single row grout curtain, except within a limited portion of the valley bottom in which an additional two rows of angled holes were incorporated into the grout curtain design. Reportedly grout work was also performed along the concrete diversion pipe when bedrock was

excavated for the pipe placement. In general the grouting scheme consisted of constructing a shallow grout blanket with an average depth of 25 feet into rock and a deeper single grout curtain approximately 50 to 70 feet into rock. In some areas where adverse cross-valley slopes were encountered, the grout blanket was constructed by drilling inclined holes roughly parallel to the rock face of the slope from a bench at the top of the slope. These inclined holes were not expected to exceed 125 feet in depth.

According to the Specifications for Plugging Abandoned Oil and/or Gas Wells in the Little Blue Run Development Area dated February 1974 prior to the construction of the impoundment abandoned oil and gas wells were plugged in the location of the dam (General Analytics, Inc. Drawing No. 73-210-M13, 1973).

3.5 Operations & Maintenance

In accordance with the Pennsylvania Environmental Quality Board (1980) Chapter 105 - Dam Safety and Waterway Management, Rules and Regulations dam owner are required to inspect their facility and appurtenant works as follows:

- At least once every 3 months; and
- For a Category 1 – High Hazard dam annual reports regarding the condition of the dam, certified by a registered professional engineer, are to be submitted to the PA-DEP on or before December 31 of each year. More frequent reports of dam conditions may be required by the PA-DEP.

First Energy plant personnel perform daily inspections at the Little Blue Run Dam. Section 3.5.1 outlines observations and measurements that are to be made during these inspections.

GAI performs semiannual inspections of Little Blue Run Dam. During these inspections the dam embankment is inspected and piezometer data is recorded. Around the same time surface monument movement data is obtained by a separate consultant. The First Energy daily

inspection data and surface monument movement data is then transmitted to GAI for review. GAI then analyzes and compiles the data in tabular and graphical form for inclusion in the semiannual inspection report for that time period. GAI has been First Energy's consultant with regard to the Little Blue Run Dam for over 30 years. Section 3.5.2 provides additional details on these inspections.

PA-DEP performs periodic inspections (generally every year) at the Little Blue Run Dam. Over the last 5 years, PA-DEP has performed inspections in 2005, 2006, 2008, and 2009 in response to the Tennessee Valley Authority (TVA) incident. Section 3.5.3 provides additional details on these inspections.

3.5.1 First Energy Generation Corporation Daily Inspections

First Energy performs routine inspections daily. The facility has an in-house document that outlines expectations for the operator doing the daily inspections. This document lists the overall inspections that are to be made including observations of the following; transport lines and road from pump house to the dam, impoundment area, and the river discharge pH control system. Plant personnel then complete a Daily Dam Inspection checklist to document their observations. Example copies of the inspections forms are provided at the end of this section. This daily inspection report includes the following questions and each of the questions has a yes or no box that is checked.

- Any scarps, crack, bulges on downstream face?
- Any damp areas, seeps on downstream face?
- Any boils, sandcones on valley floor/abutment?
- Any scarps, landslides, bulges in abutments?
- Any excessive erosion on abutments?
- Any subsidence above toe drain pipe?
- Any change of color or discharge of sediment from abutment weirs or toe drain pipe?
- Any change of color or discharge of sediment of existing springs?

- Any floating debris or ash in stilling basin?
- Any new springs?
- Service spillway blocked?
- Emergency spillway blocked?
- Any erosion on downstream/upstream face?
- Any scarps, cracks, subsidence on crest?
- Any scarps, cracks, bulges on upstream face?
- Any whirlpool or current in reservoir?
- Two feet or more rise in water level/day?
- One foot or more drop in water level/day?
- Any dusting at ponds cleaning deposit area of dam?
- Upper abutment pumps problem?
- Lower abutment pumps problems?
- River discharge pipe at Mill Creek obstructed?

Facility personnel make the following measurements as part of their daily inspections and this data is also recorded on the daily inspection reports;

- Lower abutment hour meter reading
- Rainfall reading (Inches/day)
- pH reading at gravity flow inlet structure
- Reservoir reading (Feet)
- Downstream springs and weirs
- Upper left abutment weir box (Feet)
- Lower left abutment weir box (Feet)
- Lower right abutment weir box (Feet)
- Upper right abutment weir box (Flume, Feet)
- Toe drain pipe (Flume, Feet)
- Stilling basin weir (Feet)
- Stilling basin flow recorder (Counter)

3.5.2 Semiannual Inspections

GAI performs semiannual inspections of the Little Blue Run Dam. The results of these inspections are summarized in letter reports which generally include the following items:

- Date the dam was inspected and piezometers readings were recorded by GAI;
- Date surface monument movement data was obtained by consultant (Michael Baker Jr., Inc.) and date that the data was received by GAI;
- Date that the daily inspection data recorded by First Energy personnel and rainfall data recorded at the dam (and at other gauging stations) tabulated by First Energy was received by GAI;
- Recent pool level elevation and a comparison between recent data and the design pool operating level;
- Summary of visual observations of the east marker of the 'north-south' line made to confirm that the impoundment is not being filled with CCW below the minimum area for safe, storm water management;
- Daily precipitation data collected and averaged to obtain a monthly average. The monthly data is totaled to obtain a six month total for the period. Data for this record has been recorded since 1976;
- Summary of piezometers readings (recorded twice a year in the spring and fall);
- Description of the conditions observed at the dam including the embankment (surface monuments), downstream abutments (runoff, seepage, stability), spillways (service, emergency and secondary), saddle dam, stilling basin, downstream weirs and abutment springs (seepage), and Ohio River discharge;
- Summary of findings which includes GAI's opinion as to the condition of the Little Blue Run Dam and a list of items that should be attended to. The list is broken down into two categories – Action Required and Continuing Activities.
- Dam inspection forms including Form CL-1 which is completed at the time of the inspection and the required PA-DEP Division of Dam Safety Dam Inspection Checklist which lists the names and titles of the persons present at the time of the inspection and is

stamped and signed by a registered professional engineer certifying that the dam has been inspected and the results of the inspection are provided in the checklist;

- Tables of data including six-month average precipitation and seepage monitoring summary, pneumatic piezometer reading changes, surface monument movements measurements,
- Plots of pool elevation, seepage, precipitation, vertical and horizontal movement, and piezometer data; and
- Photographs taken during the inspection.

The semiannual inspection and evaluation reports reviewed by CHA note that the on-site inspections have been performed by Mr. Stanley R. Michalski, P.G., a licensed professional geologist in the Commonwealth of Pennsylvania. The PA-DEP Division of Dam Safety Dam Inspection Checklists have been certified by Mr. Phillip E. Glogowski, P.E., a licensed professional engineer in the Commonwealth of Pennsylvania.

3.5.3 Inspections by PA-DEP Dam Safety

PA-DEP dam safety personnel make periodic inspections of Little Blue Run Dam. Over the last 5 years, PA-DEP Dam Safety personnel have made inspections in 2005, 2006, 2008 and 2009. The most recent inspection in January 2009 was performed in follow-up to the TVA incident, and was part of a PA-DEP Dam Safety effort to perform a comprehensive review of all dams that impound coal-ash across the state.

PA-DEP provides First Energy a copy of their inspection reports which includes the items listed below.

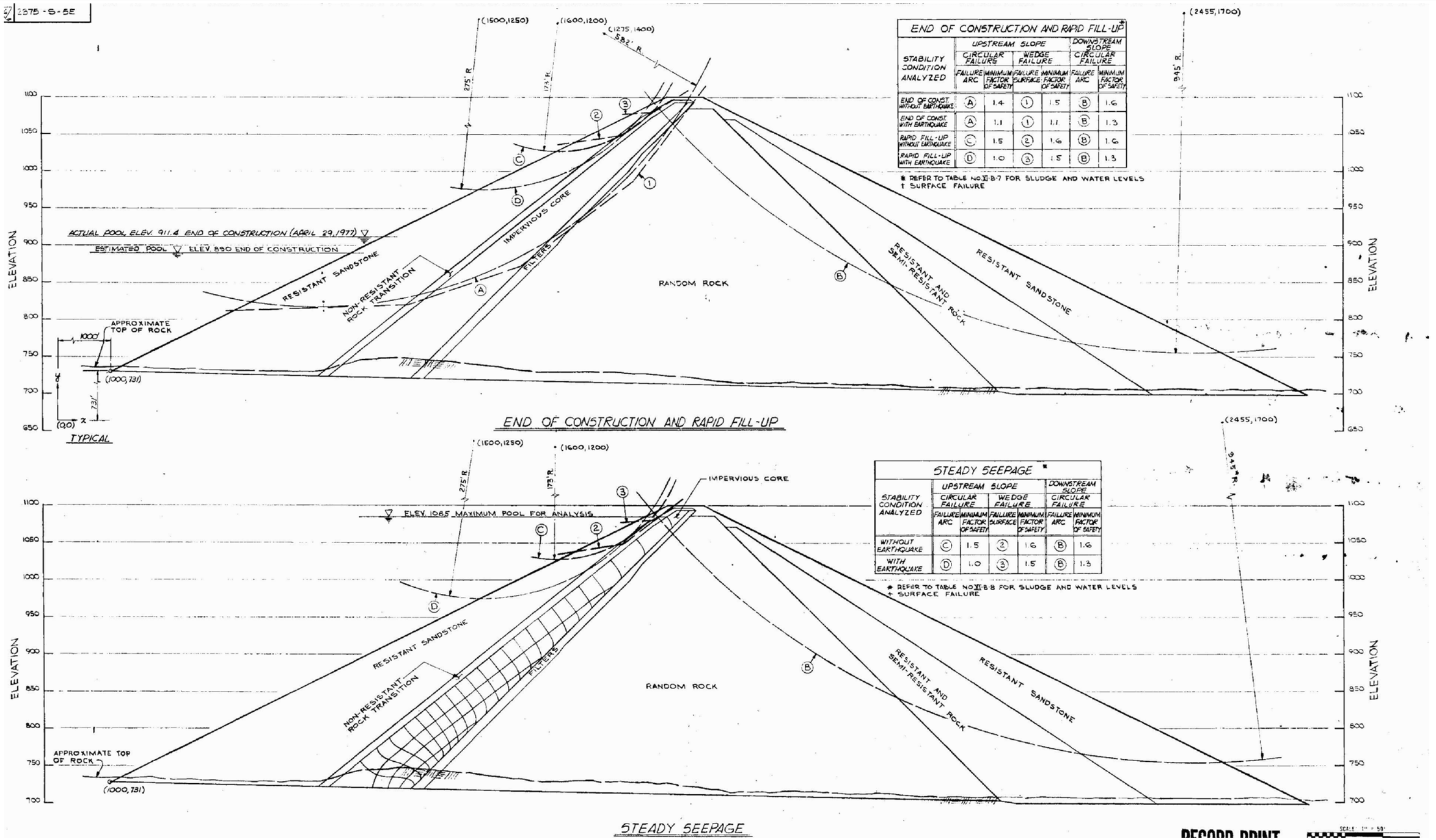
- A Dam Safety Inspection Notice – a form used to summarize the inspection and contains the following information;
    - Name and mailing address of the dam owner/permittee;

- The location of the dam (county, municipality, GPS coordinates taken at the center of the crest of the dam);
- The type of inspection performed (administrative, compliance evaluation, complaint inspection, construction progress, Category 1 or 2 dam and others);
- The location/appurtenance inspected (i.e. crest, upstream face, downstream face, outlet structure, outlet conduit, spillways) and the condition observed (OK or concern) along with corresponding comments/explanation of concern, violations and cited codes;
- The results of inspection (codes include No Significant Violations Noted, Outstanding Violations, Recurring Violations, Repairs or Upgrade Required and others);
- Remarks;
- Information on the PA-DEP representative(s) who performed the inspection, the facility representative(s) and owner's consultant's who accompanied the PA-DEP inspector during the on-site inspection;

- A Dam Inspection Report – This report contains information on the location of the dam, driving directions, detailed contact information for the dam owner and owner's consulting engineer, pertinent data (i.e. dam type, height, storage), observations of present conditions of the dam, action(s) on previous recommendations, and comments and recommendations based on present conditions observed by PA-DEP.
- Photographs taken by PA-DEP during the inspection.

3.5.4 Operation, Maintenance and Emergencies

The owner of a dam is required to prepare an operations plan for the facility to provide for maximum dam safety by formalizing a regular schedule of routine tasks. *The Inspection, Maintenance and Operation of Dam in Pennsylvania, 2009 Edition* provides principal elements which should be made part of an effective operation plan.



END OF CONSTRUCTION AND RAPID FILL-UP*	UPSTREAM SLOPE				DOWNSTREAM SLOPE	
STABILITY CONDITION ANALYZED	CIRCULAR FAILURE		WEDGE FAILURE		CIRCULAR FAILURE	
	FAILURE ARC	MINIMUM FACTOR OF SAFETY	FAILURE SURFACE	MINIMUM FACTOR OF SAFETY	FAILURE ARC	MINIMUM FACTOR OF SAFETY
END OF CONST. WITHOUT EARTHQUAKE	A	1.4	1	1.5	B	1.6
END OF CONST. WITH EARTHQUAKE	A	1.1	1	1.1	B	1.3
RAPID FILL-UP WITHOUT EARTHQUAKE	C	1.5	2	1.6	B	1.6
RAPID FILL-UP WITH EARTHQUAKE	D	1.0	3	1.5	B	1.3

* REFER TO TABLE NO. XI-B-7 FOR SLUDGE AND WATER LEVELS
† SURFACE FAILURE

STEADY SEEPAGE*	UPSTREAM SLOPE				DOWNSTREAM SLOPE	
STABILITY CONDITION ANALYZED	CIRCULAR FAILURE		WEDGE FAILURE		CIRCULAR FAILURE	
	FAILURE ARC	MINIMUM FACTOR OF SAFETY	FAILURE SURFACE	MINIMUM FACTOR OF SAFETY	FAILURE ARC	MINIMUM FACTOR OF SAFETY
WITHOUT EARTHQUAKE	C	1.5	2	1.6	B	1.6
WITH EARTHQUAKE	D	1.0	3	1.5	B	1.3

* REFER TO TABLE NO. XI-B-8 FOR SLUDGE AND WATER LEVELS
† SURFACE FAILURE

RECORD PRINT

IMAGE REFERENCE: IMPOUNDMENT DAM STABILITY ANALYSIS CREST ELEVATION 1100', APRIL 1, 1974, DWG NO. E-8399, REVISION 4.

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IMPOUNDMENT DAM
STABILITY ANAYLISIS

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 6

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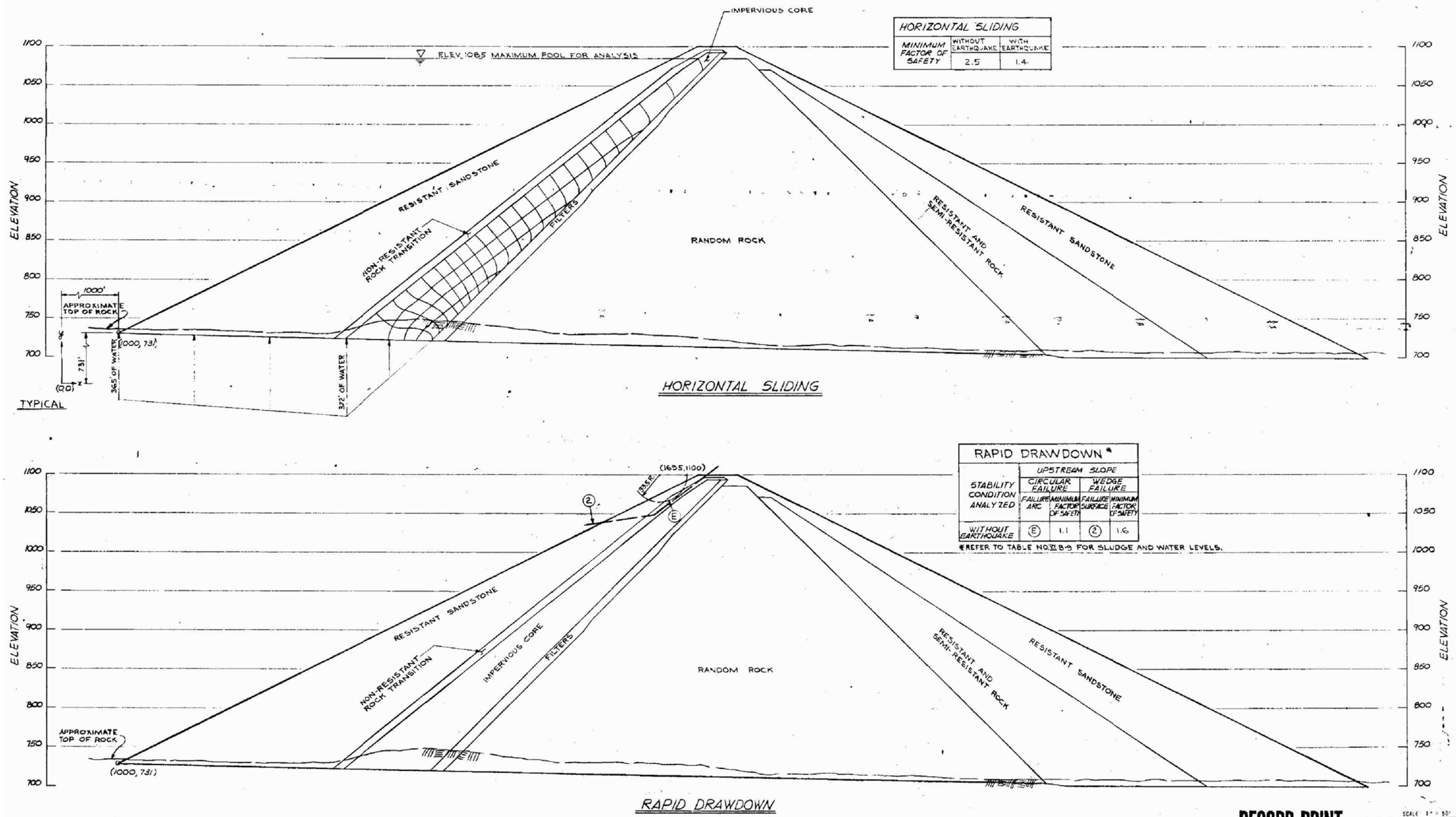

HORIZONTAL SLIDING		
MINIMUM FACTOR OF SAFETY	WITHOUT EARTHQUAKE	WITH EARTHQUAKE
	2.5	1.4

RAPID DRAWDOWN *				
STABILITY CONDITION ANALYZED	UPSTREAM SLOPE			
	CIRCULAR FAILURE		WEDGE FAILURE	
	FAILURE ARC	MINIMUM FACTOR OF SAFETY	FAILURE SURFACE	MINIMUM FACTOR OF SAFETY
WITHOUT EARTHQUAKE	E	1.1	2	1.6

*REFER TO TABLE NO. XIB-3 FOR SLUDGE AND WATER LEVELS.

IMAGE REFERENCE: IMPOUNDMENT DAM STABILITY ANALYSIS CREST ELEVATION 1100', APRIL 1, 1974, DWG NO. E-8399, REVISION 4.

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IMPOUNDMENT DAM STABILITY ANALYSIS

LITTLE BLUE RUN DAM
SHIPPINGPORT, PENNSYLVANIA

PROJECT NO. 20085.8000

DATE: 12/2009

FIGURE 7

4.0 CONCLUSIONS/RECOMMENDATIONS

4.1 Acknowledgement of Management Unit Condition

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

A management unit found to be in satisfactory condition is defined as one in which no existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions in accordance with the applicable criteria. Minor maintenance items may be required.

CHA's assessment of the Little Blue Run Dam indicates that it is in satisfactory condition. As described in the following sections, maintenance and monitoring will further enhance the condition of this dam.

4.2 Annual Report on Dam Condition

As part of our previously performed independent engineering review (Task 2) of the Little Blue Run Dam CHA was tasked with reviewing annual inspection reports submitted to PA-DEP by FirstEnergy's engineering consultant. The GAI semiannual inspection reports reviewed by CHA do not included information regarding the location, size or age of the management unit. CHA recommends that the formats of the semiannual inspection reports be expanded to include this information.

4.3 Left Abutment Seepage Investigation

The PA-DEP Dam Safety Inspection Notice dated January 26, 2009 noted that the flow of water from numerous seeps on the left abutment is quite high. The PA-DEP recommends that a subsurface investigation be performed on the left abutment that includes rock coring in

conjunction with pressure testing and the installation of piezometers. The results of the pressure testing could be compared to pressure testing conducted with the original foundation investigation prior to the dam's construction. This would also help to define the current permeability profile from the top of the embankment at about Elevation 1,100 feet through the toe of the dam at about Elevation 700 feet.

CHA recommends that FirstEnergy perform the subsurface investigation as outlined by PA-DEP. It is our understanding that FirstEnergy has recently submitted to PA-DEP a proposed subsurface investigation plan in response to the January 2009 comments and that is plan is currently being reviewed.

4.4 Installation of Piezometers

The PA-DEP recommended that additional piezometers be installed within the central portion of the embankment. It was recommended that at a minimum two borings with multiple tip piezometers be installed and screened at elevations from 800 to 900 feet within the central portion of the embankment. These additional piezometers will be used to detect the current pheratic surface within the dam and to monitor the embankment for any impacts from efforts to reduce seepage through the left abutment.

4.5 Installation of Inclinometers

The slope movements that have occurred since 2001 have been described as surficial and within the soil horizon. The PA-DEP recommended that inclinometers be installed to check for more deep-seated movement, possibly along soft clay seams inter-bedded with more durable rock that may be found during the subsurface investigation. CHA recommends that additional inclinometers be installed as outlined by the PA-DEP.

4.6 Stability Analysis

CHA was not provided with a maximum surcharge (flood condition) loading condition analysis, which while not specifically required under PA-DEP regulations, the US Army Corps of Engineers guidelines in EM-1110-2-1902 suggests a factor of safety under flood conditions of 1.4.

The calculated factor of safety for the rapid drawdown loading condition (1.1) is below the suggested US Army Corps of Engineers guidelines (1.3 for rapid drawdown from maximum storage pool) for as shown in Section 3.3. CHA understands that it is undesirable to rapidly evacuate water containing CCW from the impoundment. Reportedly rapid drawdown is only possible via pumping off supernatant water above the sludge level at high volume flow rates. CHA suggests that in the event of an emergency at the dam (the classic rapid drawdown scenario) it may be favorable to evacuate impounded water to reduce stresses on the dam to reduce the risk of an uncontrolled release in the event of failure.

The last reported stability analysis performed for the Little Blue Run Dam embankment was in 1977, with the results shown on the AS-Built Drawings. CHA recommends that an updated stability analysis be performed following the proposed subsurface investigation and installation of piezometers as outlined by the PA-DEP. Data from the new piezometer (and replacement piezometers) should be used to model the current pheratic surface in the embankment. Loading conditions which should be analyzed include those shown in Table 3 in Section 3.3, including the maximum surcharge loading condition which was not previously considered.

4.7 Settlement of Geotubes

The January 2009 PA-DEP inspection report noted that the valley below the saddle dam has been impacted by leachate and there is a pump return system for this water. It was recommended that the leakage in the valley and in the Mill Creek valley be evaluated. In addition, it was recommended that the settlement of the geotubes that are retaining waste in the upper part of the

valleys be monitored quantitatively. CHA recommends that the monitoring of the geotubes be performed at the same frequency as the surface monuments and the results be included in the semi-annual reports prepared and submitted to the PA-DEP.

4.8 Subsurface Investigation – Little Blue Run Saddle Dam

The PA-DEP recommends that a subsurface investigation be conducted on the saddle dam as very little information is available about its original construction and inspections indicate seepage through the embankment or its foundations. The investigation should include the installation of piezometers.

4.9 Animal Control and Filling of Existing Animal Burrows

Evidence of animal burrows was observed on the embankment slopes of the Little Blue Run Saddle Dam. CHA recommends that FirstEnergy keep notes of areas disturbed by animal activity, trapping of the animals, and repair to the areas.

4.10 Maintaining Vegetation Growth

Appropriate grasses covered most of the Little Blue Run Saddle Dam embankments. However, there was a patch of brambles extending from the downstream toe to the crest of the embankment requires cutting and/or removal in order to properly observe the embankment.

5.0 CLOSURE

The information presented in this report is based on visual field observations, review of reports by others and this limited knowledge of the history of the Bruce Mansfield Power Plant Little Blue Run Dam. 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.

APPENDIX A

Completed EPA Coal Combustion Dam Inspection Checklist Forms

&

Completed EPA Coal Combustion Waste (CCW) Impoundment Inspection Forms

APPENDIX A

Completed EPA Coal Combustion Dam Inspection Checklist Forms

&

Completed EPA Coal Combustion Waste (CCW) Impoundment Inspection Forms

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Bruce Mansfield Plant	Date:	10-22-09
Unit Name:	Little Blue Run Dam	Operator's Name:	First Energy
Unit I.D.:	Little Blue Run Dam	Hazard Potential Classification:	High Significant Low
Inspector's Name:	Katherine Adnams & Warren Harris, P.E.		

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?	Semiannually		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	1088		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	1087.5		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	See Note		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	1100		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	X		Is water exiting outlet flowing clear?	X	
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)?	NA		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?	X		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?		X
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 N/A = Not Applicable/Available

4. A 48-inch diameter "service spillway" has an invert elevation @ 1090.3 and an labyrinth weir Emergency Spillway @ Elev. 1095.

11. In 2001 the crest was regraded to return camber to the crest since settlement had exceeded the initial camber of about 4 feet.

21. Seepage is collected from the right abutment, left abutment in two control areas, and the dam blanket drain. Each of these seepage areas is diverted to v-notch weirs (abutments) or parshall flume (blanket drain) for monitoring purposes.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # PA0027481 INSPECTOR Adnams/Harris

Date October 22, 2009

Impoundment Name Little Blue Run Dam

Impoundment Company First Energy

EPA Region 3

State Agency (Field Office) Addresss 206 Municipal Building, 8th Avenue and 15th Street
Beaver Falls, PA 15010

Name of Impoundment Little Blue Run Dam

(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: Primarily Fly Ash disposal

Nearest Downstream Town : Name Chester, WV and East Liverpool, OH

Distance from the impoundment 2.5 and 0.7 miles, respectively

Impoundment Location:

Longitude 40 Degrees 37 Minutes 42 Seconds

Latitude 80 Degrees 30 Minutes 82 Seconds

State PA County Beaver

Does a state agency regulate this impoundment? YES X NO _____

If So Which State Agency? WV Department of Environmental Protection - Dam Safety

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.

_____ **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.

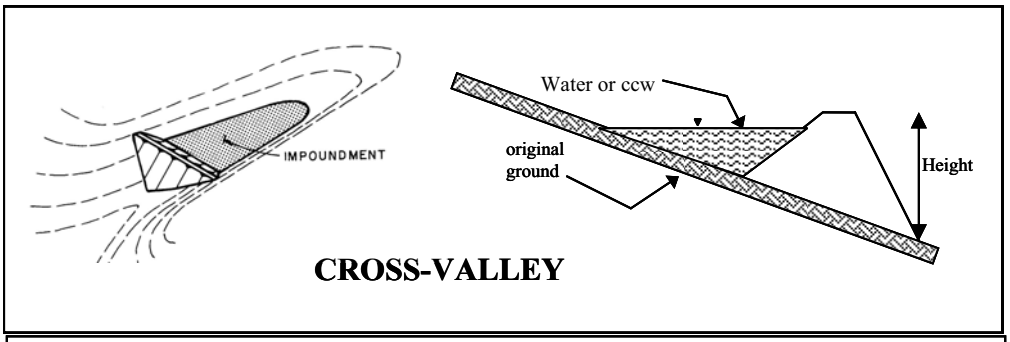
_____ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.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

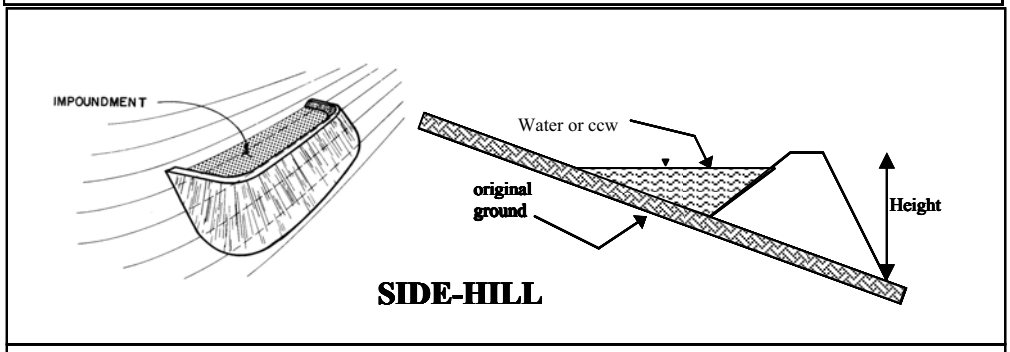
X_____ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

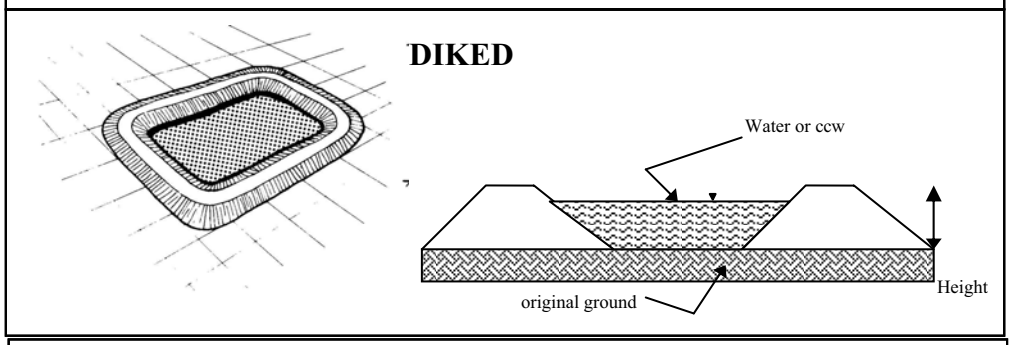
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

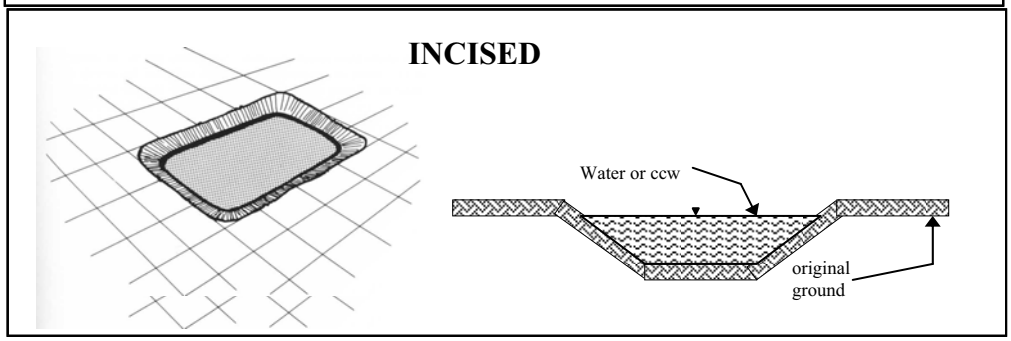
Homes downstream of Little Blue Run dam are at risk for inundation in the event of a failure.

CONFIGURATION:







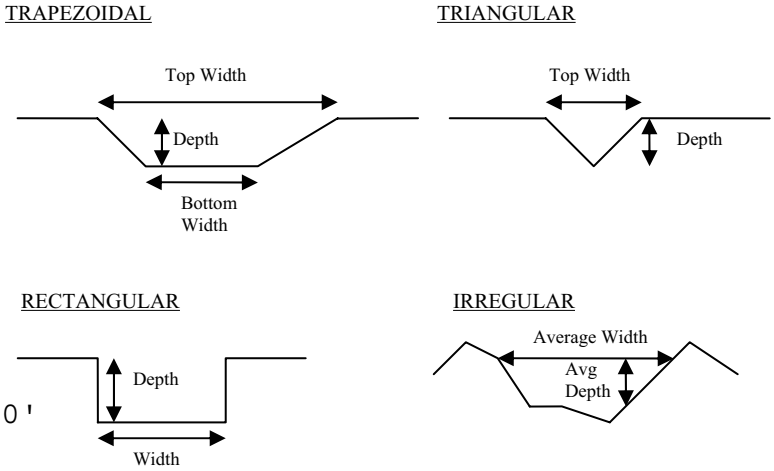


__X__ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

Embankment Height ____400____ feet Embankment Material Zoned Embankment
Pool Area ____770____ acres Liner None
Current Freeboard ____12____ feet Liner Permeability Not Applicable

TYPE OF OUTLET (Mark all that apply)

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

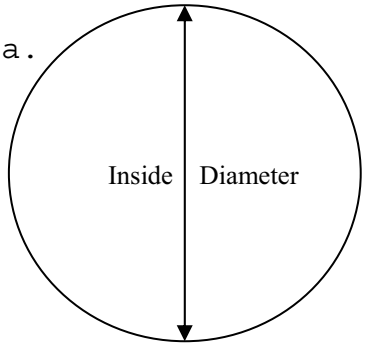


_____ depth
_____ bottom (or average) width
_____ top width
X Emergency Spillway - 160' wide TLW

X **Outlets**

Service 48" inside dia.
Secondary 36" inside dia.

_____ inside diameter



Material
_____ corrugated metal
_____ welded steel
X concrete Service Spillway
X plastic (hdpe, pvc, etc.) Secondary Spillway
_____ other (specify) _____

_____

Is water flowing through the outlet? YES X NO _____

_____ **No Outlet**

_____

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

The Impoundment was Designed By GAI Consultants

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 X NO _____

If So When? Ongoing

IF So Please Describe:

Seepage occurs through the blanket drain installed during construction of the dam and reportedly through coal/sandstone contacts in both abutments. Design estimates of the amount of seepage was about 1,200 gallons per minute (gpm). Seepage reached a peak in 1991 at just over 650 gpm, but has since receeded to about 300 gpm.

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,...)? Ongoing

If so Please Describe :

Many piezometers are installed on the dam although many of the pneumatic piezometers have malfunctions or do not provide reliable results due to their age. PADEP has recommended that additional piezometer be installed within the central portion of the embankment. It was recommended that at a minimum two borings be installed with multiple tip piezometers that are screened at elevations from 800 to 900 within the central portion of the embankment. All piezometers installed to date have been installed within or immediately above the foundation.