GZA
GeoEnvironmental, Inc.

Engineers and Scientists

September 15, 2009
GZA File No. 01.0170142.00

Lockheed Martin Services Inc.
REAC Program
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Attention: Dr. Dennis Miller

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Re: Task 3 Dam Assessment Report
Project #0-381
Marshall Steam Station Coal Ash Retention Dam
Catawba County, North Carolina

Dear Dr. Miller:

In accordance with our Purchase Order #7100051898, dated June 2009, GZA GeoEnvironmental, Inc. (GZA) has completed our inspection of the Marshall Steam Station Coal Ash Retention Dam, located in Catawba County, North Carolina. The site visit was conducted on May 28, 2009. The purpose of our efforts was to provide Lockheed Martin and the U.S. Environmental Protection Agency (EPA) with a site specific inspection of the dam to assist EPA in assessing the structural stability of the dam under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). We will submit one CD-ROM copy of this report directly to Lockheed Martin and EPA.

Based on our visual inspection, the dam is currently in **FAIR** condition, in our opinion. A further discussion of our evaluation and recommended actions are presented in the Task 3 Dam Assessment Report. The report includes a: (a) completed Coal Combustion Dam Inspection Checklist Form; (b) field sketch; and (c) selected photographs with captions. Our services and report are subject to the Limitations found in **Appendix A.**

We are happy to have been able to assist you with this inspection and appreciate the opportunity to continue to provide you with dam engineering consulting services. Please contact the undersigned if you have any questions or comments regarding the content of this Task 3 Dam Assessment Report.

Sincerely,

GZA GEOENVIRONMENTAL, INC.

Frank S. Vetere, P.E.
Senior Project Manager

Anders. B. Bjarngard
Consultant/Reviewer

Peter H. Baril
Principal-In-Charge

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Final Report

EXECUTIVE SUMMARY

This Phase I Inspection/Evaluation Report details the results of a visual dam inspection of the Marshall Steam Station Coal Ash Retention Dam (MA01161) located on State Route 150 in Catawba County, North Carolina. The inspection was performed on May 28, 2009 by GZA GeoEnvironmental, Inc (GZA).

The Marshall Steam Station Coal Ash Retention Dam has a maximum structural height of dam of approximately 90 feet. In accordance with the U.S. Army Corps of Engineers (COE) guidelines, this dam is an **Intermediate** size structure. However, under criteria listed in the North Carolina Dam Safety Regulations, the dam would be classified as a **Large** size structure.

The original Hazard Potential Classification for the Marshall Steam Station Coal Ash Retention Dam was **Low** under the COE and State of North Carolina criteria. Damage to North Carolina Highway 150 could possibly occur should there be a failure, and loss of life was not expected. However, the State of North Carolina revised the Hazard Potential Classification to **High** in 1984 due to the probable environmental damage to the adjacent waters of Lake Norman, the public financial loss, and the interruption of services from a dam failure. Per the EPA criteria the hazard classification would be considered **Significant.**

The dam was judged to be in **FAIR** condition in GZA's opinion. At the time of the inspection water was flowing over the Discharge Tower Structure stoplogs, and the outlet in the discharge canal to Lake Norman was submerged.

The deficiencies at the dam that were noted during the current visual inspection include:

- The downstream slope of the upper embankment (i.e. above the berm) appears to be steeper than the design slope of 2H:1V, especially near the top. Moderate sloughing of the upper portion of this downstream slope has occurred in at least five locations near the crest
- Flowing water and wet areas at the toe of the upper downstream slope and erosion of dam soils in one location, forming a deltaic deposit on the berm surface. The erosion appears to be a result of the uncontrolled flow of surface water runoff from the crest to the toe of the upper embankment through a scarped area. The surface water management system appears to require improvement.
- Heavy brush, tress and associated vegetation were observed on the upstream and downstream embankment slopes. Trees and their root systems and undergrowth within approximately 10 feet of the toe of the downstream slope (north of the boat ramp adjacent to the outlet channel) and along the southern upstream slope should be removed. It is GZA's opinion that the vegetative growth on the downstream slope of the berm does not present a significant dam safety hazard due to the 200 to 300 foot width of the berm.

GZA recommends that the owner arrange for the following actions to be performed at the dam:

- An updated stability analysis of the dam should be performed. This analysis should include an analysis of shallow slope failure, especially for the as-built downstream slopes, which appear steeper than 2H:1V. The slope stability analysis should be conducted after and based on surveying the actual configuration of the slopes.

- Duke Energy has retained an outside consultant to provide an engineered repair of the scarps, but rather than approach this issue as an isolated repair, GZA recommends investigating the cause of the scarps more thoroughly, including but not necessarily limited to the slope stability analysis discussed above.

- Observations of the upper downstream toe (above the berm) should be made during periods of low rainfall to determine whether the wet and spongy conditions observed at the toe were due to surface water runoff or internal seepage. Further study should be conducted to correct the migration of dam embankment material that is being deposited on the berm.

- Surface grading and the extent and condition of the drainage system (including video camera survey of pipe interiors and related drainage infrastructure where appropriate) at and adjacent to the dam should be evaluated.

With respect to the Environmental Protection Agency's (EPA's) inquiry concerning whether any portion of the embankment was constructed upon coal ash slimes (known to GZA as TDF-5 and containing three specific questions), GZA provides the following response:

Question 1 "Concerning the embankment foundation, was the embankment construction built over wet ash, slag, or other unsuitable materials? - Available information reviewed by GZA indicates that the Marshall Steam Dam was constructed over natural granular soils and or saprolite. GZA did not find any indication that the Unit was constructed over wet ash, slag or other unsuitable material. Available borings performed through the Dam and into the foundation reviewed by GZA did not indicate the presence of such unsuitable foundation materials.

Question 2. "Did the dam assessor meet with, or have documentation from, the design Engineer-of-Record concerning the foundation preparation?" - Select Design and Record Drawings were reviewed by GZA. Drawing M-25 includes the following note regarding the foundation preparation: "Material with Penetration Resistance < 5 Blows/Ft to be removed to depth of 6' +/- below original ground. Before placing compacted fill, foundation shall be drained and dry as approved by Engineer."

Question 3. "From the site visit or from photographic documentation, was there evidence of prior releases, failures, or patchwork on the dikes? " - The only evidence of prior releases, failures, or patchwork observed by GZA was the repair of ongoing surficial slope instability on the downstream slope of the embankment. Our report discusses this instability in detail and it is GZA's understanding that Duke has engaged an engineer to evaluate and design repairs to address this deficiency.

PREFACE

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Prepared by:

GZA GeoEnvironmental, Inc.

NORTH CAROLINA PROFESSIONAL SEAL 021803 ENGINEER FRANK S. VETERE

Frank S. Vetere, P.E.
North Carolina License No.: 021803

MARSHALL STEAM STATION COAL ASH RETENTION DAM
CATAWBA COUNTY, NORTH CAROLINA

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MARSHALL STEAM STATION COAL ASH RETENTION DAM
CATAWBA COUNTY, NORTH CAROLINA

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1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The United States Environmental Protection Agency (EPA), through Lockheed Martin Corporation (LM), has retained GZA GeoEnvironmental, Inc. (GZA) to perform a visual inspection and develop a report of conditions for the Duke Energy Company (Owner) Marshall Steam Station Coal Ash Retention Dam on North Carolina Highway 150 in the unincorporated community of Terrell, North Carolina. This inspection and report were performed in accordance with Task 3 of Lockheed Martin Competitive RFP for Assessment of Dam Safety of Coal Combustion Surface Impoundments, EAC-0381, dated March 17, 2008. The inspection generally conformed to the requirements of the Federal Guidelines for Dam Safety[1], and this report is subject to the limitations contained in **Appendix A** and the Terms and Conditions of our Contract Agreement (P.O. # 7100051898).

1.1.2 Purpose of Work

The purpose of this investigation is to visually inspect and evaluate the present condition of the dam and appurtenant structures (the management unit) to identify conditions that may adversely affect their structural stability and functionality, to note the extent of any deterioration that may be observed, review the status of maintenance and needed repairs, and to evaluate the conformity with current design and construction standards of care.

The investigation was divided into four parts: 1) obtain and review available reports, investigations, and data previously submitted to the Owner pertaining to the dam and appurtenant structures; 2) perform an on site review with the Owner of available design, inspection, and maintenance data and procedures for the management unit 3) perform a visual inspection of the site; and 4) prepare and submit a final report presenting the evaluation of the structure, including recommendations and proposed remedial actions.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in **Appendix E**. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) general; and 4) condition rating.

1.2 Description of Project

1.2.1 Location

The Marshall Steam Station Coal Ash Retention Dam is located in the unincorporated community of Terrell in Catawba County, North Carolina. The site can be reached from Interstate 77 by taking exit 36 for North Carolina Highway 150 West. The entrance to the Marshall Steam Station is at Steam Station Road, approximately 6 miles west of I-77 on Highway 150.

[1] FEMA/ICODS, April 2004: http://www.ferc.gov/industries/hydropower/safety/guidelines/fema-93.pdf

Marshall Steam Station Coal Ash Retention Dam is located at latitude 35°36'21.4" North and longitude - 80°57'35.7" West (WGS 84 datum), as determined from Google Earth.

The Marshall Steam Station Coal Ash Retention Dam drainage area is located entirely within the community of Terrell. The dam impounds the former Holdsclaw Creek, an isolated finger of Lake Norman. The location of Marshall Steam Station Coal Ash Retention Dam is shown in **Figure 1**. An aerial photograph of the dam is provided as **Figure 2**.

1.2.2 Owner/Caretaker

The dam is owned by the Duke Energy Carolinas, LLC of Charlotte, North Carolina.

	Dam Owner	Dam Caretaker
Name	Duke Energy Company Fossil and Hydro Generation Dept.	Marshall Steam Station
Mailing Address	PO Box 1006	8320 NC Highway 150 East
Town	Charlotte, NC 28201-1006	Terrell, NC 28682-8708
Daytime Phone	(800) 777-9898	(828) 478-7700
Emergency Phone	911	911

1.2.3 Purpose of the Dam

The Marshall Steam Station Coal Ash Retention Dam was built in 1965 to provide a retention pond for the disposal of coal ash slurry, a by-product of the burning of coal for the generation of electricity. Until the mid-1980s, the coal ash was mixed with water and sluiced from the plant to the Coal Ash Retention Pond. Currently, the plant employs a dry ash handling system, in which the ash is conveyed via aboveground piping to silos, where it is temporarily stored before either being landfilled or recycled. The pond contains residual ash from historic sluicing operations and some wet disposal still employed on an occasional basis.

There are three embankments in addition to the Coal Ash Retention basin on the premises of the Marshall Steam Station that are used in the handling of the coal ash disposal from the power plant. These embankments were evaluated by GZA, who determined that they did not qualify as "management units" according to the definition presented in the LM RFP. These embankments include the concrete basin used for temporary storage of the bottom ash, the "intermediate dike" located west of the Coal Retention Pond that originally directed the coal ash slurry from the plant to the north side of the ash retention pond, and the "coal yard dike" that contains the main coal stockpile.

The concrete bottom ash storage basin acts as a settling basin for wet-sluiced bottom ash from the plant. Water is periodically decanted from the basin to a ditch that eventually flows into the Coal Ash Retention Pond. The upstream surface water in the Coal Ash Retention Pond is at the same elevation as the water level in the bottom ash storage basin; thus, there is no differential head acting on the basin dike. A similar hydraulic condition exists at the 1,500-foot long intermediate dike, where the water level is essentially equal on both sides of the dike. The 1,000 foot long coal yard dike retains no water, and therefore is also not subjected to hydraulic pressures differentials.

1.2.4 Description of the Dam and Appurtenances

The Marshall Steam Station Coal Ash Retention Dam consists of an approximately 90 foot high earth embankment with a total length of approximately 3,000 feet, a crest width of approximately 76 to 90 feet, and a downstream berm approximately 80 to 100 feet wide. The crest varies from elevation 798.5 to 803.5 feet, and the berm elevation is at 755 feet. The average head differential is approximately 45 feet. The dam runs in a straight line from southwest to northeast from the power plant to a point of land where the emergency spillway was constructed. Two to three railroad tracks for the storage of empty coal cars run along the crest. The upstream and downstream embankments are covered with heavy vegetation consisting mostly of field grasses, with the exception of a portion of the upstream embankment north of the Discharge Tower, that is covered with 6- to 12-inch-minus rip rap. Embankments slope at approximately two-foot horizontal to one-foot vertical (2H:1V), although the upper portions of the downstream slope, adjacent to the crest, visually appear to be steeper than 2H:1V.

The outlet/spillway structure is referred to as the Discharge Tower, and consists of a reinforced concrete intake tower that controls the pond water level with a removable stoplog weir structure. The stoplogs are constructed of 5-foot long precast concrete sections on two sides of the tower structure. Water entering the Discharge Tower is directed into a 30 inch diameter HDPE pipe that extends through the dam and discharges underwater in a small discharge canal directly to Lake Norman, whose normal water level is at approximately elevation 760 feet. The invert of this pipe at the bottom of the Discharge Tower is 755 feet, and at the outlet the invert elevation is 750.25 feet. According to Duke Energy, the pond level is changed to control the settling rate of the coal ash and to regulate the Total Suspended Solids of the pond water, and not generally for flood control. The pond level has been lowered when major hurricanes approach the site. There is no means of controlling flow other than by adjusting the stoplogs, the height of which were maintained at elevation 789.1 during the inspection. Based on record information provided by Duke Energy, the current 30-inch pipe was installed in 1986 as a slip-liner for the original 42-inch diameter corrugated steel pipe. The annular spacing between the two pipes was grouted, as was the soil in the dam under and around the pipeline from inlet to outlet.

The Emergency Spillway is located north of the main dam, and consists of a 275 foot wide channel excavated in the natural ground. There is no specific structure at the spillway; the control "structure" is the haul road extending from the dam to the former ash landfill located on the north end of the property, which is set at elevation 794.5 feet.

1.2.5 Operations and Maintenance

No written operations and maintenance plan for the dam was provided by Duke Energy. Operations and maintenance of the dam is performed by the Marshall Steam Station operating personnel, who perform regular monthly inspections and special inspections after a rain event exceeding 2 inches in 24 hours. A Duke Energy Company registered professional engineer or consultant performs a yearly inspection, and an independent consultant performs the 5 year inspection of the dam and appurtenant structures required by the North Carolina Utility Commission (NCUC).

1.2.6 Size Classification

The Marshall Steam Station Coal Ash Retention Dam has a maximum structural height of dam of approximately 90 feet. In accordance with the U.S. Army Corps of Engineers (COE) guidelines, this dam is an **Intermediate** size structure. However, under criteria listed in the North Carolina Dam Safety Regulations, the dam would be classified as a **Large** size structure.

1.2.7 Hazard Potential Classification

The original Hazard Potential Classification for the Marshall Steam Station Coal Ash Retention Dam was **Low** under the COE and State of North Carolina criteria. Damage to North Carolina Highway 150 could possibly occur should there be a failure, and loss of life was not expected. However, the State of North Carolina revised the Hazard Potential Classification to **High** in 1984 due to the probable environmental damage to the adjacent waters of Lake Norman, the public financial loss, and the interruption of services from a dam failure. Per the EPA criteria the hazard classification would be considered **Significant. Figure 3** shows the downstream area.

1.3 Pertinent Engineering Data

1.3.1 Drainage Area

According to a hydrologic and hydraulic evaluation of the dam performed in 1989 by Trigon Engineering, the drainage area for the Marshall Steam Station Coal Ash Retention Dam is approximately 1180 acres or 1.84 square miles, and is located entirely within Catawba County and mostly on Duke Energy property.[2] The watershed is a mix of wooded and industrial areas of the power plant property. The watershed boundaries for the dam are presented in **Figure 4**. The coal ash impoundment` has a current surface area of approximately 80 acres.

1.3.2 Reservoir

The reservoir has decreased in size and storage capacity significantly since original construction due to previous coal ash deposition. The reservoir currently has a somewhat rectangular shape with a maximum length of about 1,000 ft and a maximum width of about 1,000 feet. The normal operating pool ranges from elevation 789 to 790, but is typically closer to 789. The spillway design pool for the ¾ PMP is 796.5 based on analysis performed by Trigon Engineering during their 1989 NCUC five-year inspection.

1.3.3 Discharges at the Dam Site

No records of flow are kept at the dam.

1.3.4 General Elevations (feet – NGVD 1929)

All elevations are taken from design drawings and reports provided by Duke Energy. Elevations are based upon the USGS topographic map NGVD datum.

A.	Top of Dam	798.7 to 803.0±
B.	Emergency Spillway	794.5±

[2] Currently Duke Energy reports that they own 100% of the property within the watershed.

C.	Normal Pool	789.0 to 790.0±
D.	Typical Stoplog Elevation	788.8±
E.	Overflow weir at Discharge Tower	792.0±
F.	Upstream Water at Time of Inspection	789.1±
G.	Downstream Water at Time of Inspection	Coincident with Lake Norman, 760±

1.3.5 Main Spillway Data

A.	Type	Stoplog weir orifice
B.	Weir Length 10.0± ft	
C.	Stop logs typically set at	789 ± ft
D.	Fixed 10 foot overflow weir at	792 ± ft
C.	Upstream Outlet Invert	755 ft.
C.	Downstream Outlet Invert	750.25 ft.

1.3.6 Design and Construction Records and History

The dam was design by Law Engineering in 1962. Construction of the dam was completed prior to opening of the plant in 1965. The original 40-inch corrugated metal pipe (CMP) was slip-lined in 1985. Duke maintains design drawings as well as construction records and drawings which were made available to GZA during our site visit.

With respect to whether GZA's dam assessors met with, or have documentation from, the design Engineer-of-Record concerning the foundation preparation, we offer the following: Select Design and Record Drawings were reviewed by GZA. Drawing M-25 includes the following note regarding the foundation preparation: "Material with Penetration Resistance < 5 Blows/Ft to be removed to depth of 6' +/- below original ground. Before placing compacted fill, foundation shall be drained and dry as approved by Engineer."

Concerning the embankment foundation, and whether the embankment built over wet ash, slag, or other unsuitable materials, GZA offers the following: Available information reviewed by GZA indicates that the Marshall Steam Dam was constructed over natural granular soils and or saprolite. GZA did not find any indication that the Unit was constructed over wet ash, slag or other unsuitable material. Available borings performed through the Dam and into the foundation reviewed by GZA did not indicate the presence of such unsuitable foundation materials.

1.3.7 Operating Records

There are no operating records for the dam. Monitoring wells were recently installed at the downstream edge of the downstream berm. These wells are now read twice a year.

1.3.8 Previous Inspection Reports

Independent consultant Inspection Reports dating back to 1979 were reviewed. The most recent 5-year Inspection Report was prepared in November 2004 by Mactec Engineering and Consulting, Inc. of Charlotte, NC. Mactec concluded that "… the ash basin dikes and outlet

structures at the Marshall Steam Station are in good visual condition." Sloughed areas and erosion found on the upstream slope were observed to have been repaired since the 1999 report.

2.0 INSPECTION

2.1 Visual Inspection

The Marshall Steam Station Coal Ash Retention Dam was inspected on May 28, 2009 by Frank S. Vetere, P.E. and Anders B. Bjarngard of GZA GeoEnvironmental Inc who were accompanied by Mr. Craig Dufficy of the EPA and Messrs. Larry Frost and Scott Harrell of the North Carolina Department of Environment and Natural Resources (NCDENR). At the time of the inspection, the weather was mostly overcast with temperatures in the in the low 80's Fahrenheit. Heavy rain had fallen during the afternoon and early morning prior to the inspection. Flow over the stoplogs was estimated to be higher than normal as a result of the recent precipitation. Photographs to document the current conditions of the dam were taken during the inspection and are included in **Appendix B**. The water elevation in the impoundment was approximately 789.1 feet, approximately 3 inches above the top-most stoplog. Underwater areas were not inspected, including the inside of the submerged outfall culvert, as this level of investigation was beyond of GZA's scope of services. A copy of the inspection checklists is included in **Appendix C**.

The only evidence of prior releases, failures, or patchwork observed by GZA was the repair of ongoing surficial slope instability on the downstream slope of the embankment. Our report discusses this instability in detail and it is GZA's understanding that Duke has engaged an engineer to evaluate and design repairs to address this deficiency.

2.1.1 General Findings

In general, Marshall Steam Station Coal Ash Retention Dam was found to be in **FAIR** condition. The specific concerns are identified in more detail in the sections below. A sketch showing the dam in plan and noting areas of observed deficiencies is contained in **Figure 5**. Locations of photos are also shown in **Figure 5**.

2.1.2 Dam

- Upstream Slope (Photos 1,2, 4, and 5)

  The upstream slope has a design slope of 2H:1V. The first 2,000 feet of the upstream slope between the intermediate dike and the Discharge Tower is covered with tall grass from the crest to the toe of slope/water line. Trees ranging in height from 10 to 15 feet are evident beyond the toe of slope/water line for most of this distance. The trees do not appear to be growing on the upstream slope; rather, they appear to be rooted in residual ash that has settled along the base of the upstream slope. Several finger dikes, apparently used to redirect the coal slurry, extend perpendicular to the main dam. These dikes are also heavily vegetated, but the water level appears to be the same on either side of each dike. At Pole 38, the crest road narrows at the point where the upstream side transitions to open water. A band of heavy vegetation runs parallel to the dam in the open water section, but the trees appear to be rooted in a submerged layer of coal ash beyond the exposed upstream slope. The Discharge Tower is located beyond the upstream toe approximately 2,000 feet from the intermediate dike. A wooden footbridge provides access to the

structure. The upstream slope of the remaining 700 feet of the dam has 6 to 12 inch rip rap from crest to at least the water surface. The rip rap provides slope protection in the portion of the dam most susceptible to wave action across the impoundment. The rip rap slope appeared to be in good condition, although some grass has grown near the water surface on the northern end of the dam.

- Top of Dam (Photos 3 and 6)

  The top of the dam runs in a straight line from the intermediate dike to the haul road at the emergency spillway, and in general, the crest has good horizontal and vertical alignment. The crest is approximately 76 feet wide, with a gravel access road on the upstream side and rail tracks on the downstream side of the crest. There are three rail tracks on the southern (right) end of the crest. The track which is located the furthest upstream ends approximately 1,000 feet from the right abutment while the other two extend to the North (left) abutment. The rail tracks are used to store empty coal transport cars, which occupied approximately half the length of the downstream track at the time of the inspection. The upstream track was empty during the inspection. Except in the area where the crest was raised (2 feet ± above the rails) along the northern end of the dam, the tracks are 1 to 2 feet higher than the access road, and the change in grade appears to act as a drainage ditch to handle surface water runoff.

- Upper Downstream Slope [i.e. above the berm] (Photos 10, 11, 12, 13, 14, and 16)

  The downstream section of the dam consists of the slope from the crest to a 200- to 300-foot wide berm at elevation 770 feet used for storage and as a material laydown area for the plant. The design drawings for the downstream embankment indicate a slope of 2H:1V, but the top section of the slope appears steeper. The entire upper downstream slope is covered with a grass that is mowed three times per year. The grass was approximately 3 feet high at the time of our inspection and thus our ability to observe the downstream slope was limited.

  The slope was generally in good condition, except for at least five scarps that have formed near the crest. These scarps have formed at the crest, and appear to be due to localized slope failures due to the steep slope near the crest. The scarps vary in length from about 10 feet to 45 feet, and average about 3 feet in height. Duke Energy has retained Mactec to design and oversee a localized repair for the scarps. The repair plan was reviewed during the inspection, and the design appeared adequate in GZA's opinion. However, the historical problems with surficial slope stability and the current presence of five scarps in need of repair raises the issue of whether a localized repair will provide a permanent solution, or whether further investigations are needed to evaluate the cause and provide a more permanent solution.

  Water was observed flowing from the toe of the upper downstream slope approximately 500 feet south of the discharge canal. The flow is just below a scarp, but appears to be related to a drain that extends from the crest that exits near the toe. A deltaic deposit of red soil, similar to the embankment material had formed on the berm. It is possible that this deposition is a result of surficial erosion in a scarped area immediately upslope. A large part of the toe was wet and spongy, but because

of the heavy rainfall prior to the inspection, it is difficult to differentiate between seepage and surface water runoff. It appears that there are several local 6-8 inch CMP drain pipes embedded along the downstream face that transport runoff from the crest to the berm. Many of these drains were observed but it is believed that there are others which are buried.

Two drainage outlets were located at the toe of the northern (left) section of the downstream embankment. A relatively new precast concrete discharge structure was located downstream of the new riprap chute constructed between poles 45 and 46. There was no flow or debris in this structure. An older 36-inch diameter CMP drain was located at the toe of slope downstream of a hole exposing a 20-inch vertical CMP observed on the crest of the dam. This pipe was silted in to approximately 6 inches below the crown but still had roughly 2 gallons per minute (gpm) of clear flow discharging through it (Photo No. 19).

- Lower Downstream Slope [i.e. below the berm] (Photos 15 and 17)

  GZA attempted to inspect the lower downstream slope from the berm to Lake Norman however due to heavy vegetation and the steep slope our ability to do so was limited. In general the condition of this slope was found to be in poor condition. The vegetation on the slope is quite heavy with significant tree growth. There are several drainage swales cut into the berm that direct surface water to the lake. A large (approximately 8-foot) erosional hole was found near the scrap yard and several smaller ones were observed. Given the width of the berm and the distance from the lower downstream slope to the upper embankment, the poor condition of the lower slope is not considered to be a major dam safety issue.

2.1.3 Appurtenant Structures (Photos 7, 8, 9, and 15)

The water level in the pond is controlled by a square concrete drop inlet structure that has two 5-foot-long stoplog-controlled weirs and two 5-foot long fixed weirs. This structure, referred to as the Discharge Tower, was observed to be in good condition. The stoplog-controlled weirs are on the north and south (left and right) side of the drop inlet and have steel sleeves for precast concrete stop logs on two sides. The fixed weirs are on the upstream and downstream (west and east) sides of the drop inlet at approximately elevation 792 feet. The concrete appeared intact, and the stop logs had little signs of wear or spalling.

Water is discharged to Lake Norman though a polyethylene pipe that penetrates the dam and outlets under water in a small canal on the downstream slope. The pipe could not be inspected, but water was discharging during the inspection, as evidenced by the bubbling water at the discharge point.

2.1.4 Emergency Spillway (Photo 18)

The emergency spillway consists of the overland discharge of pond water across a wide vegetated area with the elevation set at 794.5 feet, which corresponds to the crest of a haul road traversing the emergency spillway. The area between the pond and the road appears to be underlain by shallow bedrock that extends to the surface in some areas, with marsh grasses on the ground surface. A grassy area extends north of the road for approximately 200 feet, where the emergency spillway discharges into heavily wooded forest sloping toward Lake Norman.

The trees do not appear as if they would impede the overland flow, although there might be significant tree damage if a large volume of water were released. Duke Energy personnel had no recollection of flow over the Emergency Spillway.

2.2 Caretaker Interview

Maintenance of the dam is the responsibility of the Duke Energy operating plant personnel. Regular maintenance activity at the dam consists of periodic adjustment of the stoplogs to control the water quality in the pond, and mowing is performed three times per year by a subcontractor. A Duke Energy Company registered professional engineer or independent consultant performs a yearly inspection, and an independent consultant performs the 5 year inspection of the dam and appurtenant structures required by the North Carolina Utilities Commission (NCUC).

2.3 Operation and Maintenance Procedures

There is no formal operation procedure or record keeping at the dam.

2.4 Emergency Warning System

There is no Emergency Action Plan (EAP) developed for the dam. Given the dam's size and potential for adverse environmental consequences in the event of a partial/full breach, GZA recommends that an EAP be developed.

2.5 Hydrologic/Hydraulic Data

GZA did not perform an assessment of the hydraulics and hydrology for the dam as this was beyond our scope of services. An analysis was performed by Trigon Engineering during their 1989 NCUC five-year inspection, which was summarized by Mactec in their 2004 five-year inspection report.

According to the 2004 Mactec report, "The drainage area to the main dike is approximately 1,180 acres or 1.84 square miles. Based on the HEC-1 flood routing, the peak inflow for the flood resulting from the ¾ PMP storm is approximately 8,796 cubic feet per second (cfs). The maximum discharge through both the concrete tower and the emergency spillway is approximately 2,142 cfs with a maximum stage of 796.65 feet. Since the minimum crest elevation of the main dike is 798.5 feet, a total of 1.85 feet of freeboard is provided against direct runoff from the ¾ PMP. Wind and wave action were not considered in these analyses." Mactec also stated that "The peak flow for the 100 year flood is estimated at 690 cfs. …based on the HEC-1 flood routing, peak outflow is 99 cfs at a maximum stage of 792.36 feet. Therefore, the 100-year flood will not activate the emergency spillway."

2.6 Structural and Seepage Stability

2.6.1 Structural Stability

- <u>Embankments</u>

  A structural slope stability analyses has been summarized in previous inspection reports made available for the dam from the Duke Energy files. The minimum

factor of safety during normal operating conditions was greater than 1.4 for a deep-seated failure plane. The downstream berm was not included in the original stability analysis, so these calculations were considered conservative. The factor of safety under rapid drawdown conditions was greater than 1.0. However, no calculation for shallow slope failure was provided to GZA. This is particularly critical because the upper downstream slope appears to be graded steeper than the design slope of 2H:1V, and several local failures have occurred. GZA did not observe any other indications of structural stability problems during the visual dam inspection.

2.6.2 Seepage Stability

During the visual inspection, potential seepage was observed on the upper downstream slope. Several soft, spongy wet areas were also observed. Four nests of monitoring wells were recently installed at the lower downstream toe, but no other instrumentation exists on the site.

2.6.3 Seismic Stability

According to the 2004 Mactec report, the Marshall Steam Station lies in a Seismic Zone 2, which is considered to present "no hazard from earthquakes, provided static stability conditions are satisfactory and conventional safety margins exist." However, liquefaction potential must be evaluated. A liquefaction analysis was performed by Devine Tarbell & Associates in December of 2003 based on a 5.4 to 5.7 magnitude earthquake with a peak ground acceleration of 0.145g. This report judged "that the Main Dike at the Marshall Steam Station meets currently accepted stability criteria for the seismic loading condition".

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

In general, the overall condition of Marshall Steam Station Coal Ash Retention Dam is judged to be **FAIR**. The dam was found to have the following deficiencies:

1. Several scarps have formed on the upper downstream slope near the crest. Vertical movement from scarps can indicate the initiation of a large slide plane, which could move rapidly at any time;

2. Flowing water and wet areas were observed in several locations along the toe of the upper downstream slope. In one location, a significant delta of dam embankment material has formed on the downstream berm south of the discharge canal, apparently from erosion of exposed soil in a scarped area. Because of recent heavy rainfall at the time of the inspection, it is difficult to determine whether the water at the toe was from uncontrolled seepage through the dam or surface water flowing down the dam slope or drains buried or obscured by vegetation.

3. The surface water drainage system at and adjacent to the Dam appears to be in need of repair.

4. Vegetation including trees are present upstream of the toe of the upstream slope and at the downstream toe of dam.

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies at the dam. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of environmental permits needs to be determined for activities that may occur within resource areas under the jurisdiction of the appropriate regulatory agencies.

3.2 Studies and Analyses

1. An updated stability analysis of the upstream and downstream embankment slopes including an analysis of shallow slope failure (especially for the as built upper downstream slopes, which appear steeper than 2H:1V) should be conducted after surveying the actual configuration of the slopes.

2. Duke Energy has retained an outside consultant to provide an engineered repair of the scarps, but rather than approach this issue as an isolated repair, GZA recommends investigating the cause of the scarps more thoroughly (including but not necessarily limited to item 1 above).

3. Observations of the upper downstream toe should be made during periods of low rainfall to determine whether the wet and spongy conditions observed at the toe were due to surface water runoff or internal seepage. Further study should be conducted to correct the migration of dam core material that is being deposited on the berm.

4. Surface grading and the extent and condition of the drainage system (including video camera survey of pipe interiors and related drainage infrastructure where appropriate) at and adjacent to the dam should be evaluated.

3.3 Recurrent Maintenance Recommendations

GZA recommends no additional recurrent maintenance level activities that should be undertaken by the dam owner at this time.

3.4 Repair Recommendations

GZA recommends the following minor repairs which may improve the overall condition of the dam, but do not alter the current design of the dam. The recommendations may require design by a professional engineer and construction contractor experienced in dam construction.

1. Repair of surface drainage system and grading including minor depressions found on the crest.

2. Investigate seeps at the downstream toe in dry weather, with repairs designed by a professional engineer and construction by a contractor experienced in dam repair.

3.5 Remedial Modifications Recommendations

These recommendations will require design by a professional engineer and construction by a contractor experienced in dam repair. A Dam Safety Permit will likely be required.

1. Investigation and repair of the scarps and potential improvements required to meet required factors of safety for embankment stability if found necessary by the analysis recommended above.
2. Trees and their root system and undergrowth within approximately 10 feet of the toe of the downstream slope (north of the boat ramp adjacent to the outlet channel) and along the southern upstream slope should be removed. The trees and root systems growing along the downstream slope of the berm are not considered to be a major dam safety issue given the 200 to 300 foot wide berm. However, erosion and vegetation along the downstream slope of the berm should be maintained.

3.6 Alternatives

There are no practical alternatives to the repairs itemized above.

4.0 ENGINEER'S CERTIFICATION

I acknowledge that the management unit(s) referenced herein was personally inspected by me and was found to be in the following condition - **FAIR**

Frank S. Vetere, P.E.
Senior Project Manager

Anders B. Bjarngard
Principal

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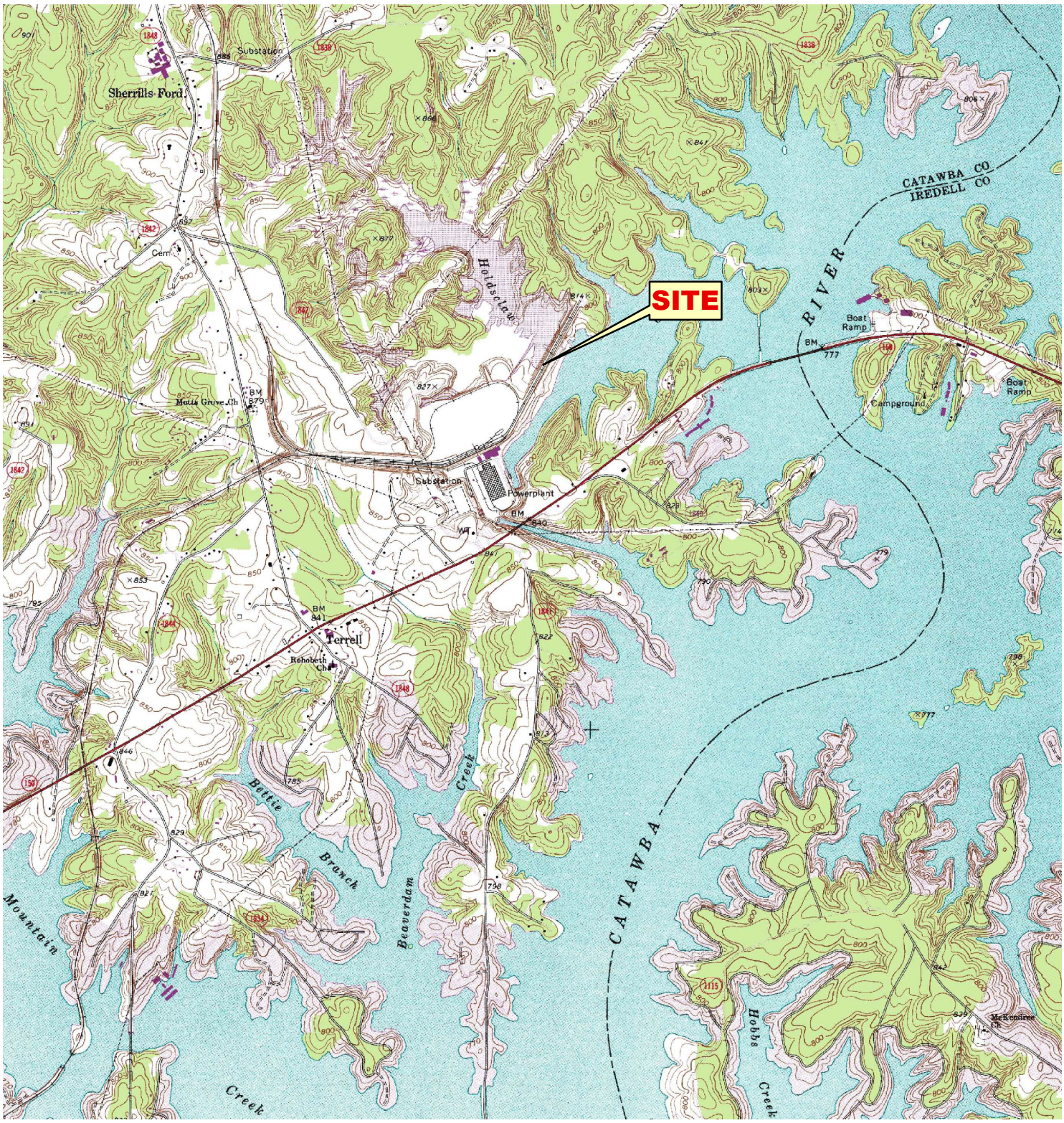
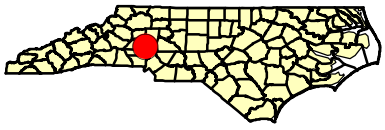
FIGURES





USGS QUADRANGLE LOCATION

SOURCE : SCANNED USGS TOPOGRAPHIC QUADRANGLES
SUPPLIED BY THE USGS.

NOT TO SCALE

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GZA	PROJ. MGR.: ABB DESIGNED BY: GAS REVIEWED BY: ABB OPERATOR: GAS DATE: 06-15-2009	SITE LOCATION MAP	JOB NO. 01.0170142.00
		MARSHALL STEAM STATION CATAWBA COUNTY, NORTH CAROLINA	FIGURE NO. **1**

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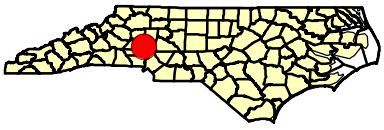

USGS QUADRANGLE LOCATION

SOURCE : SCANNED USGS TOPOGRAPHIC QUADRANGLES
SUPPLIED BY THE USGS.

0 500 1,000 2,000 Feet

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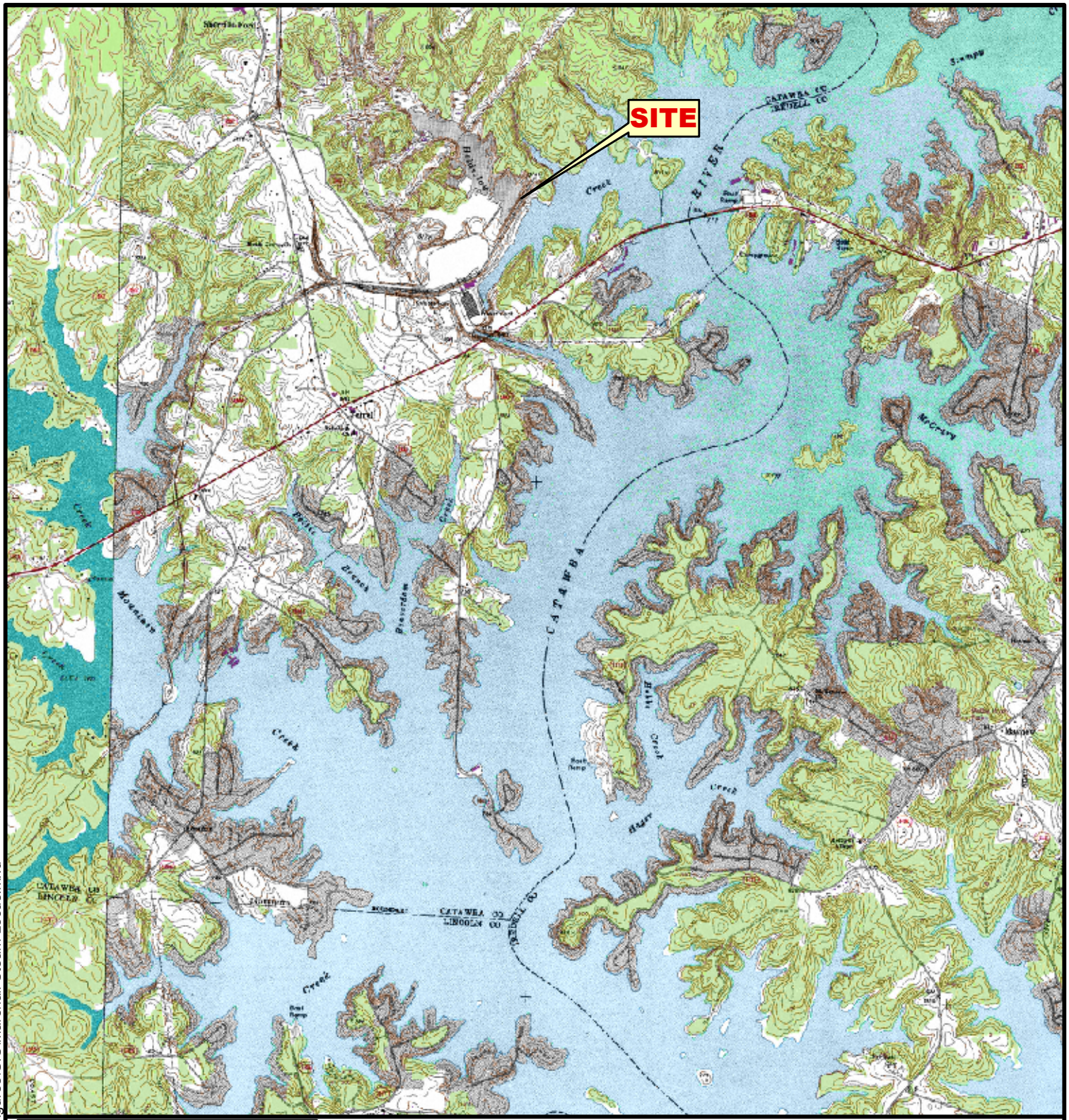
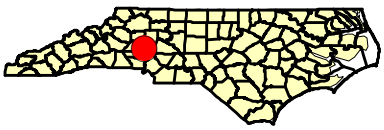
GZA	PROJ. MGR.: JPG DESIGNED BY: GAS REVIEWED BY: ABB OPERATOR: GWH DATE: 06-16-2009	ORTHOPHOTO LOCATION MAP	JOB NO. 01.0170142.00
		MARSHALL STEAM STATION CATAWBA COUNTY, NORTH CAROLINA	FIGURE NO. **2**





USGS QUADRANGLE LOCATION

SOURCE : SCANNED USGS TOPOGRAPHIC QUADRANGLES
SUPPLIED BY THE USGS.

0 2,000 4,000 8,000 Feet

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GZA	PROJ. MGR.: ABB DESIGNED BY: GAS REVIEWED BY: ABB OPERATOR: GAS DATE: 06-29-2009	DOWNSTREAM AREA MAP	JOB NO. 01.0170142.00
		MARSHALL STEAM STATION CATAWBA COUNTY, NORTH CAROLINA	FIGURE NO. **3**

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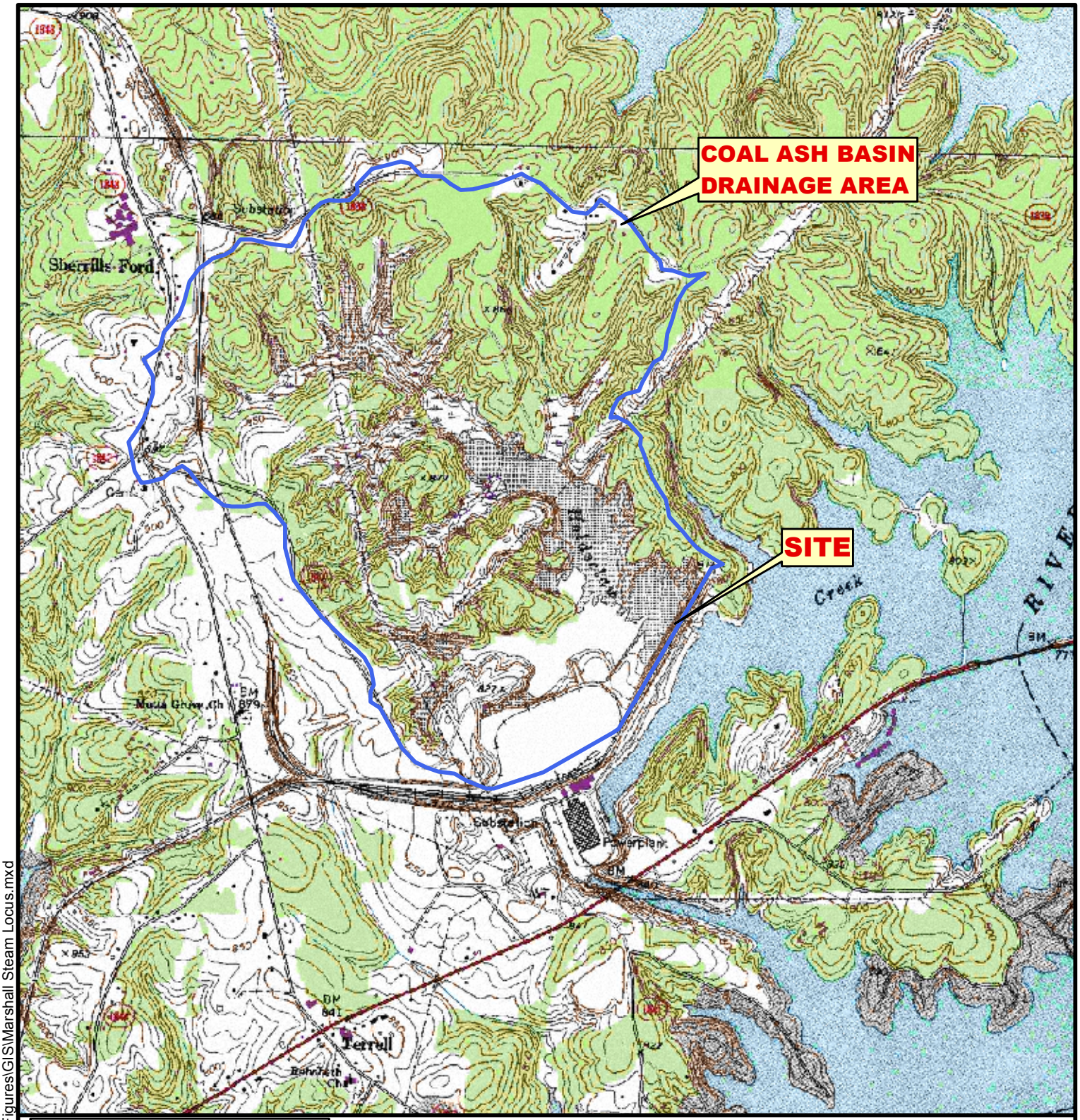

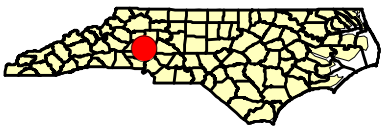

USGS QUADRANGLE LOCATION

SOURCE : SCANNED USGS TOPOGRAPHIC QUADRANGLES
SUPPLIED BY THE USGS.

0 1,000 2,000 4,000 Feet

N W E S

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GZA	PROJ. MGR.: ABB DESIGNED BY: GAS REVIEWED BY: ABB OPERATOR: GAS DATE: 06-29-2009	DRAINAGE AREA MAP	JOB NO. 01.0170142.00
		MARSHALL STEAM STATION CATAWBA COUNTY, NORTH CAROLINA	FIGURE NO. **4**

MARSHALL STEAM
COAL ASH RETENTION DAM
TERRELL, NORTH CAROLINA

FIELD SKETCH

UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR MODIFIED IN WHOLE OR IN PART FOR ANY OTHER PURPOSE OR PROJECT. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING SHALL BE AT THE USER'S OR SUCH OTHER PARTIES' SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
ONE EDGEWATER DRIVE
NORWOOD, MA 02062
781-278-3700

PREPARED FOR:

PROJ MGR: JPG	REVIEWED BY: ABB	CHECKED BY: FV	FIGURE
DESIGNED BY: ABB	DRAWN BY: GAS	SCALE: N.T.S.	5
DATE: 06-29-2009	PROJECT NO. 170142.00	REVISION NO.	

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APPENDIX A

LIMITATIONS

DAM ENGINEERING & VISUAL INSPECTION LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by Lockheed Martin.

2. In preparing this report, GZA GeoEnvironmental, Inc. (GZA) has relied on certain information provided by Lockheed Martin, Duke Energy Corporation (and their affiliates) as well as Federal, state, and local officials and other parties referenced therein. GZA has also relied on certain information contained on the State of North Carolina's Dam Safety Program website as well as Federal, state, and local officials and other parties which were available to GZA at the time of the inspection. Although there may have been some degree of overlap in the information provided by these various sources, GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this work.

3. In reviewing this Report, it should be realized that the reported condition of the dam is based on observations of field conditions during the course of this study along with data made available to GZA. The observations of conditions at the dam reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

4. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions may be detected.

5. Water level readings have been reviewed and interpretations have been made in the text of this report. Fluctuations in the level of the groundwater and surface water may occur due to variations in rainfall, temperature, and other factors different than at the time measurements were made.

6. GZA did not perform an assessment of the hydraulics and hydrology for the dam as this was outside our scope of services. Comments on this subject in the report are referenced from an analysis performed by Trigon Engineering during their 1989 NCUC five-year inspection as summarized by Mactec in their 2004 five-year inspection report.

7. This report has been prepared for the exclusive use of Lockheed Martin for specific application to the existing dam facilities, in accordance with generally accepted dam engineering practices. No other warranty, express or implied, is made.

8. This dam inspection verification report has been prepared for this project by GZA. This report is for broad evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

APPENDIX B

PHOTOGRAPHS

Photo 1: Upstream view of dam from south end of impoundment. Note heavy vegetation at upstream toe.

Photo 2: Finger dike extending from upstream slope near the south end of embankment. Note heavy vegetation.

Photo 3: South end of crest road, looking south towards the plant. Note the coal cars, the elevation of track w/r to the crest road, and the ponding of surface water.

Photo 4: Upstream face on southern end of dam. Note vegetation growth at toe and finger dike on right.

Photo 5: Upstream slope north of Discharge Tower. Note the rip rap slope.

Photo 6: View of crest road and rail tracks looking north

Photo 7: View of walkway to Discharge Tower, with stoplog structure at the end of the walkway.

Photo 8: View of water flowing over the stoplogs at the Discharge Tower. Pipes to left are used to add chemicals for pH correction.

Photo 9: Discharge Tower, looking north.

Photo 10: Scarp on downstream slope at crest road, near the Discharge Tower. Lower berm on left.

Photo 11: Frontal view of scarp on downstream slope near the Discharge Tower.

Photo 12: Seepage at base of upper downstream slope.

Photo 13: Water at base of upper downstream slope.

Photo 14: Deltaic deposits at base of scarp. Note the surface erosional path from the crest to the berm

Photo 15: Discharge canal. Note the water bubbling at the submerged discharge point.

Photo 16: Repaired scarp .

Photo 17: Downstream slope to Lake Norman. Note heavy vegetation near water line.

Photo 18: Emergency Spillway

Photo 19: Old 36-inch CMP drain outlet at Toe of the Downstream Slope of the Northern Embankment.

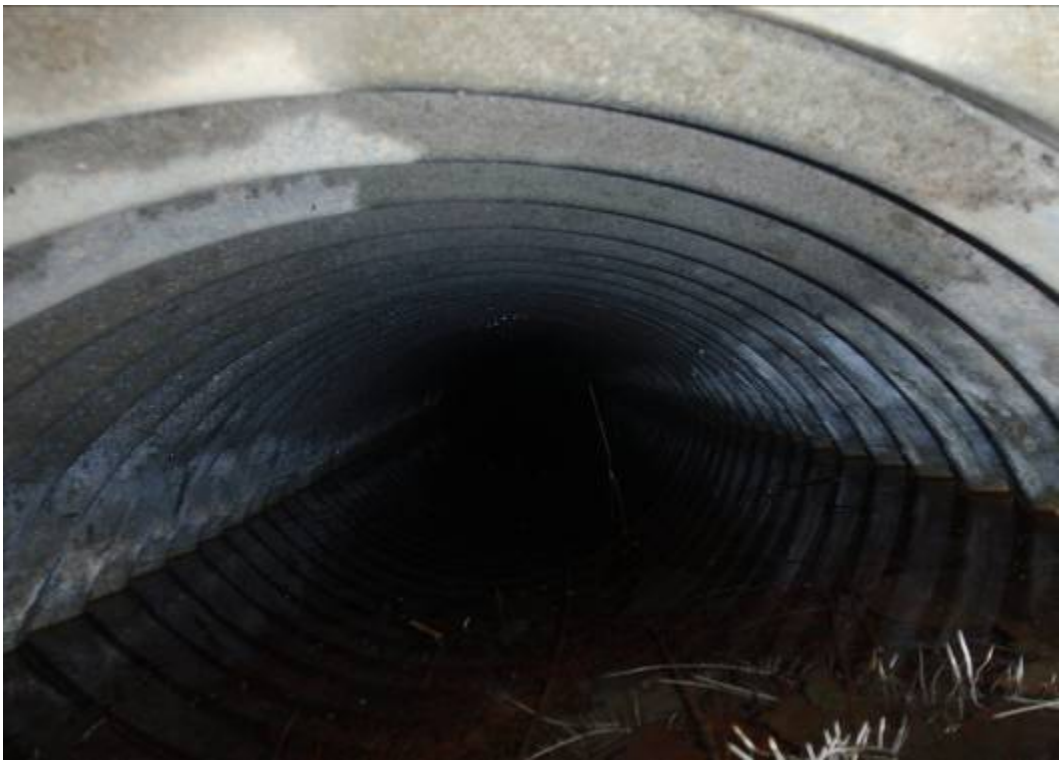


Photo 20: Interior of Old 36-Inch Diameter CMP Drain Located at the Toe of the Downstream Slope.

APPENDIX C

EPA & GZA INSPECTION CHECKLISTS

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Marshall Steam Station	Date:	May 28, 2009
Unit Name:	Coal Ash Retention Dam	Operator's Name:	Duke Power
Unit I.D.:		Hazard Potential Classification:	High ✔ Significant Low
Inspector's Name:	Frank Vetere, P.E., and Anders Bjarngard		

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?	Yes		18. Sloughing or bulging on slopes?	✔	
2. Pool elevation (operator records)?	Yes		19. Major erosion or slope deterioration? at scarp areas		✔
3. Decant inlet elevation (operator records)?	Yes		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	Yes		Is water entering inlet, but not exiting outlet?		✔
5. Lowest dam crest elevation (operator records)?	Yes		Is water exiting outlet, but not entering inlet?		✔
6. If instrumentation is present, are readings recorded (operator records)?	✔		Is water exiting outlet flowing clear? submerged, observation limited	✔	
7. Is the embankment currently under construction?		✔	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)? N/A			From underdrain?		✔
9. Trees growing on embankment? (If so, indicate largest diameter below)		✔	At isolated points on embankment slopes?	✔	
10. Cracks or scarps on crest?	✔		At natural hillside in the embankment area?		✔
11. Is there significant settlement along the crest?		✔	Over widespread areas?		✔
12. Are decant trashracks clear and in place?	✔		From downstream foundation area?		✔
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✔	"Boils" beneath stream or ponded water?		✔
14. Clogged spillways, groin or diversion ditches?		✔	Around the outside of the decant pipe? Submerged		✔
15. Are spillway or ditch linings deteriorated?		✔	22. Surface movements in valley bottom or on hillside?		✔
16. Are outlets of decant or underdrains blocked?	submerged		23. Water against downstream toe? at outlet	✔	
17. Cracks or scarps on slopes?	✔		24. Were Photos taken during the dam inspection?	✔	

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

Inspection Issue # Comments

1. Inspection by plant monthly and after 2"/24 hr. rainfall; by Duke or consultant P.E. yearly; by independent consultant @ 5 years.
2. Observed El. 789.1'. According to operator, fluctuates but typically El. 790'.
3. Decant inlet elev. set by stoplogs @ 789.1, with overflow weir @ El. 792'
4. Emergency spillway El. 794.5'
5. Dam crest El. 803' max to 798.7' min
6. Monitoring wells read twice per year
9. No trees on embankment, but significant growth just beyond upstream toe between intermediate dike & decant structure and on extreme downstream toe @ edge of bench. A significant dam safety hazard.
10., 17l, 19. Downstream slope has several scarps along crest road where slope appears greater than 2:1.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # NC 0004987 INSPECTOR F. Vetere, P.E. & A. Bjarngard (GZA)

Date May 28, 2009

Impoundment Name Marshall Steam Station Coal Ash Retention Dam

Impoundment Company Duke Power

EPA Region 4

State Agency (Field Office) Addresss N. C. Utilities Commission (NCUC)

Name of Impoundment Coal Ash Retention Dam

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

New _____ Update _____

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

IMPOUNDMENT FUNCTION: Retain coal ash from power plant

Nearest Downstream Town : Name Doolie, NC

Distance from the impoundment _____

Impoundment Location:

Longitude 80 Degrees 57 Minutes 35.7 Seconds

Latitude 35 Degrees 36 Minutes 21.4 Seconds

State NC County Catawba

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

If So Which State Agency? North Carolina Utilities Commission

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.

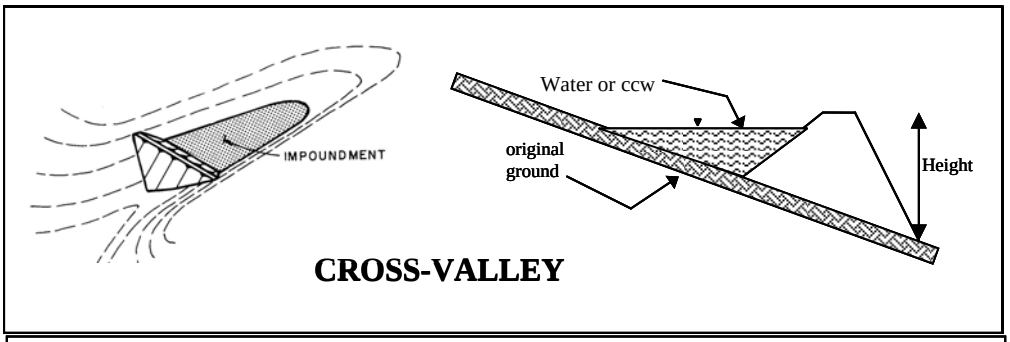
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

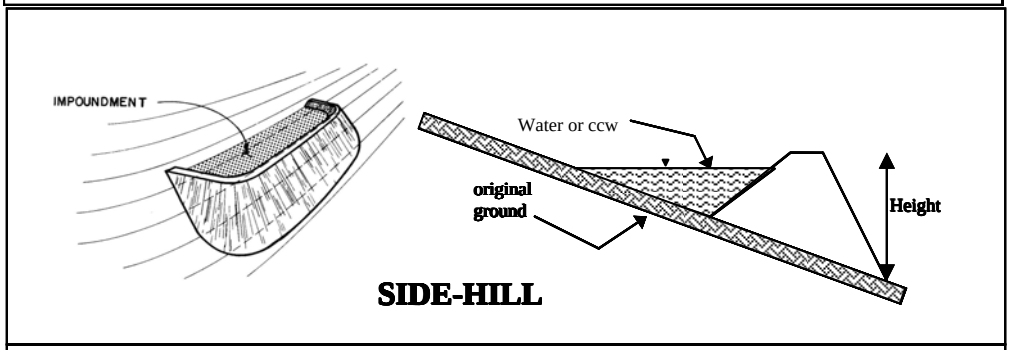
1984 High Hazard Classification by State of North Carolina based on environmental impacts to Lake Norman.

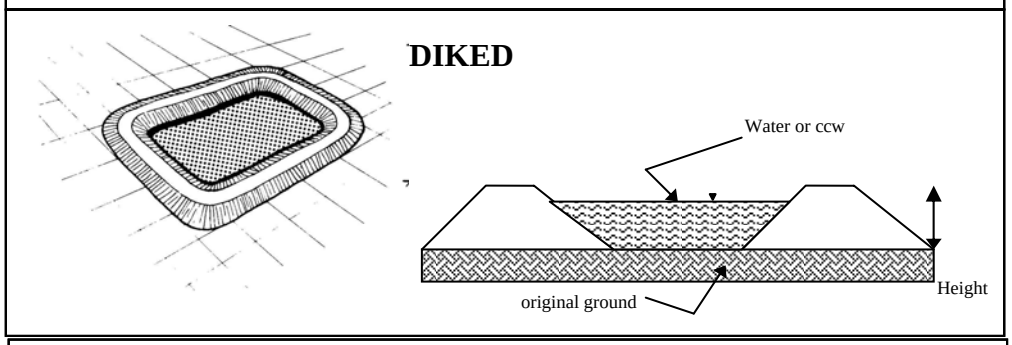
Per EPA criteria as defined above, the hazard would be Significant.

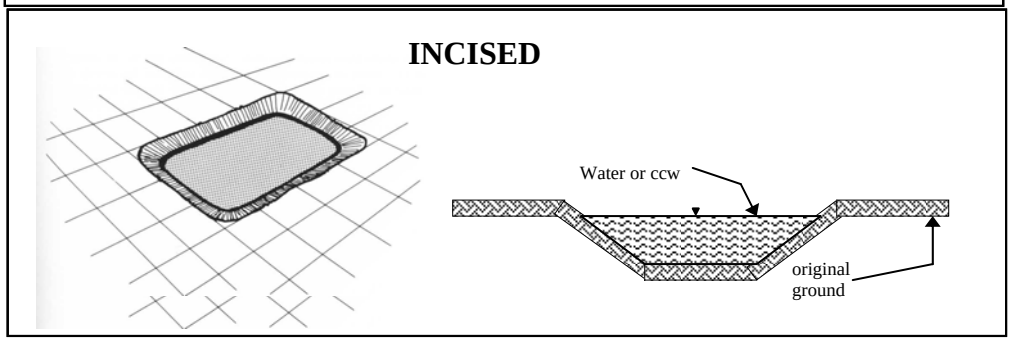
West Bottom Slag

CONFIGURATION:









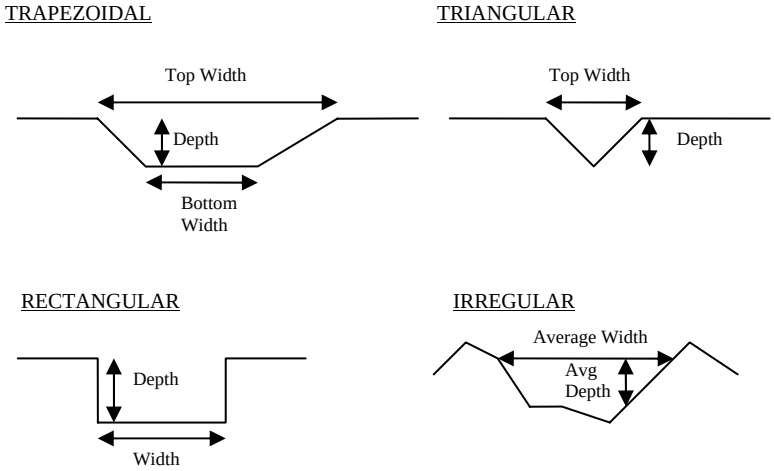
__x__ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

Embankment Height _____ feet Embankment Material Clayey Sand
Pool Area 1188 acres Liner None
Current Freeboard 9.6 feet Liner Permeability N/A

TYPE OF OUTLET (Mark all that apply)

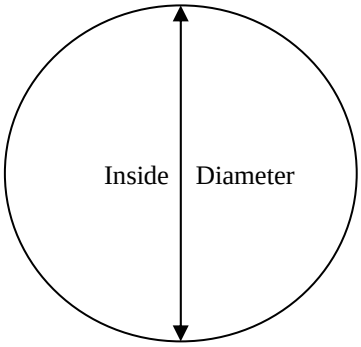
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular N/A
_____ Rectangular
_____ Irregular

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



__X__ **Outlet**

__30"__ inside diameter



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

__X__ 30" HDPE sliplined within original 42" CMP in 1986.

Is water flowing through the outlet? YES __X__ NO _____
Submerged discharge into Lake Norman

_____ **No Outlet**

_____

_____ **Other Type of Outlet** (specify) 275' wide emergency spillway at left abutment (Elev. 794.5')

The Impoundment was Designed By Law Engineering

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

If So When? _____

If So Please Describe : _____

Has there ever been significant seepages at this site? YES _____ NO __X__

If So When? _____

IF So Please Describe: _____

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

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

If so Please Describe : _____

DAM SAFETY INSPECTION CHECKLIST

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam

STATE ID #:

REGISTERED: ☐ YES ☐ NO

NID ID #:

STATE SIZE CLASSIFICATION: Large

STATE HAZARD CLASSIFICATION: High*

CHANGE IN HAZARD CLASSIFICATION REQUESTED?:

*Based on environmental damage

DAM LOCATION INFORMATION

CITY/TOWN: Terrell, North Carolina

COUNTY: Catawba

DAM LOCATION: Steam Station Road off Rt. 150
(street address if known)

ALTERNATE DAM NAME: -

USGS QUAD.:

LAT.: 35° 36' 21.4"

LONG.: 80° 57' 35.7"

DRAINAGE BASIN:

RIVER: Holdsclaw Creek

IMPOUNDMENT NAME(S): Marshall Steam Ash Basin

GENERAL DAM INFORMATION

TYPE OF DAM: Earth Embankment

OVERALL LENGTH (FT): 3,000 ±

PURPOSE OF DAM: Cal Ash Retention

NORMAL POOL STORAGE (ACRE-FT): ?

YEAR BUILT: 1965

MAXIMUM POOL STORAGE (ACRE-FT): ?

STRUCTURAL HEIGHT (FT): 90

EL. NORMAL POOL (FT): Elev. 789' - 790'

HYDRAULIC HEIGHT (FT): 40' ±

EL. MAXIMUM POOL (FT): 796.7 (3/4 PMP)

FOR INTERNAL MADCR USE ONLY

FOLLOW-UP INSPECTION REQUIRED: ☐ YES ☐ NO

CONDITIONAL LETTER: ☐ YES ☐ NO

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

INSPECTION SUMMARY

DATE OF INSPECTION: May 28, 2009 DATE OF PREVIOUS INSPECTION: November 2, 2004

TEMPERATURE/WEATHER: Overcast, 80's ARMY CORPS PHASE I: If YES, date

CONSULTANT: GZA GeoEnvironmental, Inc. PREVIOUS DCR PHASE I: If YES, date

BENCHMARK/DATUM: NGVD 1929

OVERALL PHYSICAL CONDITION OF DAM: FAIR DATE OF LAST REHABILITATION: 1986

SPILLWAY CAPACITY: #N/A

EL. POOL DURING INSP.: 789.1 EL. TAILWATER DURING INSP.: 760 ±

PERSONS PRESENT AT INSPECTION

NAME	TITLE/POSITION	REPRESENTING
See attached listing		

EVALUATION INFORMATION

	Click on box to select E-code		Click on box to select E-code
E1) TYPE OF DESIGN		E8) LOW-LEVEL OUTLET CONDITION	
E2) LEVEL OF MAINTENANCE		E9) SPILLWAY DESIGN FLOOD CAPACITY	
E3) EMERGENCY ACTION PLAN		E10) OVERALL PHYSICAL CONDITION	3
E4) EMBANKMENT SEEPAGE		E11) ESTIMATED REPAIR COST	
E5) EMBANKMENT CONDITION		ROADWAY OVER CREST	NO
E6) CONCRETE CONDITION		BRIDGE NEAR DAM	NO
E7) LOW-LEVEL OUTLET CAPACITY			

NAME OF INSPECTING ENGINEER: Frank Vetere SIGNATURE: Frank Vetere

PERSONS PRESENT AT INSPECTION

NAME	TITLE/POSITION	REPRESENTING
Frank S. Vetere. P.E.	LSP, Senior Project Manager	GZA GeoEnvironmental, Inc.
Anders Bjarngard	Principal	GZA GeoEnvironmental, Inc.
Jim Kohler, P.E.	Environmental Engineer	Environmental Protection Agency
Craig Duffy	Environmental Engineer	Environmental Protection Agency
Larry Frost	Regional Engineer	NC Dept of Environment & Natural Resources
A. Scott Harrell, P.E.	Assistant Regional Engineer	NC Dept of Environment & Natural Resources
B. Henry Taylor, P.E.	Senior Engineer	Duke Energy Corporation
James W. Reid III	Production Manager	Duke Energy Carolinas, LLC
Donna L. Burrell	Scientist	Duke Power
Carlton Allred	Bulk Material Coordinator	Duke Energy Corporation
Ed Sullivan		Duke Power

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam

STATE ID #: 0

INSPECTION DATE: May 28, 2009

NID ID #: 0

OWNER:		CARETAKER:	
ORGANIZATION		ORGANIZATION	
NAME/TITLE	Duke Power	NAME/TITLE	
STREET		STREET	
TOWN, STATE, ZIP		TOWN, STATE, ZIP	
PHONE		PHONE	
EMERGENCY PH. #		EMERGENCY PH. #	
FAX		FAX	
EMAIL		EMAIL	
OWNER TYPE			

PRIMARY SPILLWAY TYPE: Stop-log controlled drop inlet with overflow weirs at

SPILLWAY LENGTH (FT):

SPILLWAY CAPACITY (CFS):

AUXILIARY SPILLWAY TYPE: 275'-wide grassed channel

AUX. SPILLWAY CAPACITY (CFS):

NUMBER OF OUTLETS: 1

OUTLET(S) CAPACITY (CFS):

TYPE OF OUTLETS: Drop inlet

TOTAL DISCHARGE CAPACITY (CFS):

DRAINAGE AREA (SQ MI):

SPILLWAY DESIGN FLOOD (PERIOD/CFS):

HAS DAM BEEN BREACHED OR OVERTOPPED: ☐ YES ☑ NO IF YES, PROVIDE DATE(S):

FISH LADDER (LIST TYPE IF PRESENT): None

DOES CREST SUPPORT PUBLIC ROAD? ☐ YES ☑ NO IF YES, ROAD NAME: Tracks for storage of empty rail cars

PUBLIC BRIDGE WITHIN 50' OF DAM? ☐ YES ☑ NO IF YES, ROAD/BRIDGE NAME:

MHD BRIDGE NO. (IF APPLICABLE):

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

EMBANKMENT (CREST)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
CREST	1. SURFACE TYPE	Gravel on U.S. - Railroad tracks downstream			
	2. SURFACE CRACKING	None observed on crest			
	3. SINKHOLES, ANIMAL BURROWS	None observed on crest			
	4. VERTICAL ALIGNMENT (DEPRESSIONS	Fair alignment of tracks, puddles on gravel		X	
	5. HORIZONTAL ALIGNMENT	Good		X	
	6. RUTS AND/OR PUDDLES	Some depressions and puddles on crest		X	
	7. VEGETATION (PRESENCE/CONDITION)	Minimal			
	8. ABUTMENT CONTACT	Left, good - right, unclear where dam ends as it transitions into the power plant			
		Soft wet area on downstream crest at right alignment (reportedly due to recent			
		surficial construction)			

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

EMBANKMENT (D/S SLOPE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S SLOPE	1. WET AREAS (NO FLOW)	Localized wet areas at toe and sloughed sections		X	
	2. SEEPAGE	Localized areas of seepate at toe		X	
	3. SLIDE, SLOUGH, SCARP	Yes. Near crest - shallow slope instability			X
	4. EMB.-ABUTMENT CONTACT	Left, good; Right transitions into plant			
	5. SINKHOLE/ANIMAL BURROWS	See comment below.			X
	6. EROSION				
	7. UNUSUAL MOVEMENT	Shallow instability prevalent near crest			X
	8. VEGETATION (PRESENCE/CONDITION)	Thick grassed. Requires mowing, limited inspection			X

ADDITIONAL COMMENTS: 5) 12' diameter, 2'-3' deep sinkhole observed near right abutment upstream of CMP drain with flow along it. Also 6" ± burrow at pole at toe.

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

EMBANKMENT (U/S SLOPE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S SLOPE	1. SLIDE, SLOUGH, SCARP	None observed			
	2. SLOPE PROTECTION TYPE AND COND.	Right end vegetated; left end 6" ± riprap			
	3. SINKHOLE/ANIMAL BURROWS	One 2'-3' diameter hole near pole 41		X	
	4. EMB.-ABUTMENT CONTACT	See comment below.			
	5. EROSION	None observed			
	6. UNUSUAL MOVEMENT	None observed			
	7. VEGETATION (PRESENCE/CONDITION)	Right side thick grass - needs mowing			

ADDITIONAL COMMENTS: 3) Left good between emergency spillway; Right filled in and vegetated; water level on right side appeared few feet higher than impoundment.

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

INSTRUMENTATION

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
INSTR.	1. PIEZOMETERS	None observed			
	2. OBSERVATION WELLS	At toe		X	
	3. STAFF GAGE AND RECORDER	At intake to outlet			
	4. WEIRS	None observed			
	5. INCLINOMETERS	None observed			
	6. SURVEY MONUMENTS	None observed			
	7. DRAINS	Several 6"-8" CMP surface water drains - many buried			X
	8. FREQUENCY OF READINGS				
	9. LOCATION OF READINGS	Duke			

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

DOWNSTREAM MASONRY WALLS

AREA INSPECTED	CONDITION	OBSERVATIONS			NO ACTION	MONITOR	REPAIR
D/S WALLS	1. WALL TYPE						
	2. WALL ALIGNMENT						
	3. WALL CONDITION						
	4. HEIGHT: TOP OF WALL TO MUDLINE	min:	max:	avg:			
	5. SEEPAGE OR LEAKAGE						
	6. ABUTMENT CONTACT						
	7. EROSION/SINKHOLES BEHIND WALL						
	8. ANIMAL BURROWS						
	9. UNUSUAL MOVEMENT						
	10. WET AREAS AT TOE OF WALL						

N/A

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

UPSTREAM MASONRY WALLS

AREA INSPECTED	CONDITION	OBSERVATIONS			NO ACTION	MONITOR	REPAIR
U/S WALLS	1. WALL TYPE						
	2. WALL ALIGNMENT						
	3. WALL CONDITION						
	4. HEIGHT: TOP OF WALL TO MUDLINE	min:	max:	avg:			
	5. ABUTMENT CONTACT						
	6. EROSION/SINKHOLES BEHIND WALL						
	7. ANIMAL BURROWS						
	8. UNUSUAL MOVEMENT						

N/A

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

DOWNSTREAM AREA

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S AREA	1. ABUTMENT LEAKAGE	None observed			
	2. FOUNDATION SEEPAGE	None observed except minor seepage at boat ramp adjacent to outlet		X	
	3. SLIDE, SLOUGH, SCARP	Localized scarp/slough on toe of lower berm			X
	4. WEIRS	None observed			
	5. DRAINAGE SYSTEM	See comment below			
	6. INSTRUMENTATION	Monitoring wells at downstream edge of berm		X	
	7. VEGETATION	Trees and heavy undergrowth on toe of lower berm			X
	8. ACCESSIBILITY	Good access on lower berm, toe of lower berm inaccessible			
	9. DOWNSTREAM HAZARD DESCRIPTION	Lake Norman			
	10. DATE OF LAST EAP UPDATE	None			

ADDITIONAL COMMENTS: 5) 24" precast concrete outlet from riprap chute at toe downstream of Pole 46 (no flow). Old 36" CMP outlet downstream of Pole 44, silted in to 6" below crown (2 gmp ± clear flow). Riprap lined surface swales on berm of north side of dam.

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

MISCELLANEOUS

AREA INSPECTED	CONDITION	OBSERVATIONS
MISC.	1. RESERVOIR DEPTH (AVG)	Less than 40
	2. RESERVOIR SHORELINE	Generally vegetated
	3. RESERVOIR SLOPES	Shallow slopes (from sluicing in most areas)
	4. ACCESS ROADS	Access roads throughout facility
	5. SECURITY DEVICES	Locked gate to facility, surveillance
	6. VANDALISM OR TRESPASS	☐ YES ☑ NO WHAT:
	7. AVAILABILITY OF PLANS	☑ YES ☐ NO DATE: Design 1962, Sliplining & Grouting 1985
	8. AVAILABILITY OF DESIGN CALCS	☑ YES ☐ NO DATE: Liquefaction Analysis December 2003
	9. AVAILABILITY OF EAP/LAST UPDATE	☐ YES ☑ NO DATE: None
	10. AVAILABILITY OF O&M MANUAL	☐ YES ☑ NO DATE:
	11. CARETAKER/OWNER AVAILABLE	☑ YES ☐ NO DATE: May 27th and 28th, 2009
	12. CONFINED SPACE ENTRY REQUIRED	☐ YES ☑ NO PURPOSE:

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

PRIMARY SPILLWAY

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE	Concrete drop inlet tower			
	WEIR TYPE	Two (2) stop-log controlled 5-ft-long weirs, 2 fixed overflow weirs (5 feet long)			
	SPILLWAY CONDITION	Good			
	TRAINING WALLS	N/A			
	SPILLWAY CONTROLS AND CONDITION	Concrete stop logs - good condition			
	UNUSUAL MOVEMENT	None observed			
	APPROACH AREA	Clear			
	DISCHARGE AREA	Stilling basin channel in Lake Norman			
	DEBRIS	None observed		X	
	WATER LEVEL AT TIME OF INSPECTION	Elev. 789.1 (~ 3 inches above stop logs)		X	

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

AUXILIARY SPILLWAY

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE	275-foot-wide grassed spillway			
	WEIR TYPE	None - access road serves as weir			
	SPILLWAY CONDITION	Grassed			
	TRAINING WALLS	None			
	SPILLWAY CONTROLS AND CONDITION	None			
	UNUSUAL MOVEMENT	None observed			
	APPROACH AREA	10" HDPE pipe across approach area was removed during inspection			
	DISCHARGE AREA	Wooded natural slope			
	DEBRIS	None			
	WATER LEVEL AT TIME OF INSPECTION	Approximately 5 feet below control (Pool level 789.1, control of emergency			
		spillway 794.5)			

ADDITIONAL COMMENTS: Eroded channel observed near impoundment
Weathered bedrock observed

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

OUTLET WORKS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
OUTLET WORKS	TYPE	Concrete drop inlet structure (see Page 12)			
	INTAKE STRUCTURE	Two 5-foot-long stop-log controlled weirs and two 5-foot-long overflow weirs			
	TRASHRACK	None observed			
	PRIMARY CLOSURE	Stop logs			
	SECONDARY CLOSURE	None			
	CONDUIT	30-inch HDPE slip lining within 42" CMP			
	OUTLET STRUCTURE/HEADWALL	Submerged			
	EROSION ALONG TOE OF DAM	None observed			
	SEEPAGE/LEAKAGE	Submerged			
	DEBRIS/BLOCKAGE	None observed			
	UNUSUAL MOVEMENT	None observed			
	DOWNSTREAM AREA	Lake Norman			
	MISCELLANEOUS				

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

CONCRETE/MASONRY DAMS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
GENERAL	TYPE				
	AVAILABILITY OF PLANS				
	AVAILABILITY OF DESIGN CALCS				
	PIEZOMETERS				
	OBSERVATION WELLS				
	INCLINOMETERS				
	SEEPAGE GALLERY				
	UNUSUAL MOVEMENT				

N/A

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

CONCRETE/MASONRY DAMS (CREST)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
CREST	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	HORIZONTAL ALIGNMENT				
	VERTICAL ALIGNMENT				

N/A

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

CONCRETE/MASONRY DAMS (DOWNSTREAM FACE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S FACE	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	ABUTMENT CONTACT				
	LEAKAGE				

N/A

ADDITIONAL COMMENTS:

NAME OF DAM: Marshall Steam - Coal Ash Retention Dam STATE ID #: 0

INSPECTION DATE: May 28, 2009 NID ID #: 0

CONCRETE/MASONRY DAMS (UPSTREAM FACE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S FACE	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	ABUTMENT CONTACTS				

N/A

ADDITIONAL COMMENTS:

APPENDIX D

DEFINITIONS

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to references published by the U.S. Army Corps of Engineers, the Federal Energy Regulatory Commission, the Department of the Interior Bureau of Reclamation, or the Federal Emergency Management Agency.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate there from, including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Condition Rating

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

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

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

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

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.

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