Tennessee Valley Authority
Office of the Inspector General

Inspection Report

REVIEW OF THE KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

2008-12283-02
July 23, 2009

Memorandum from the Inspector General, ET 4C-K

July 23, 2009

Tom D. Kilgore, WT 7B-K

FINAL REPORT – INSPECTION 2008-12283-02 – REVIEW OF KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

Attached is the subject final report for your review and action. Your written comments, which addressed your management decision and actions planned or taken, have been included in the report. Please notify us when final action is complete.

This report will not be released to the public before 10 a.m. July 28, 2009. Therefore, please do not distribute this report without prior approval of the Inspector General.

If you have any questions, please contact Robert E. Martin, Assistant Inspector General, Audits and Inspections, at (865) 633-7450. We appreciate the courtesy and cooperation received from your staff during the inspection.

Richard W. Moore

JAL:SDB
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TVA Office of the Inspector General

July 2009

REVIEW OF KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

On January 8, 2009, after the Kingston Spill on December 22, 2008, the Environment and Public Works Committee held a hearing where Tennessee Valley Authority (TVA) Chief Executive Officer Tom Kilgore testified. The Senators were clear that they wanted answers to what caused the spill and what decisions of TVA contributed to the spill. TVA created the expectation that the root cause analysis that was to be performed would answer those questions.

On June 25, 2009, TVA presented the findings of AECOM through its spokesman Bill Walton and TVA Chief Operating Officer Bill McCollum at a press conference. The report and the presentation by Walton and McCollum produced more questions than answers.

We find that TVA made no effort to publicly disclose what management practices may have contributed to the Kingston Spill.[i] The very tightly scoped AECOM report minimizes TVA management's liability and provides no "lessons learned." TVA has urged everyone just to "move forward" without further examination of what responsibility TVA management may have had for the disaster that occurred on December 22, 2008.

Given the lack of transparency and accountability demonstrated by TVA in failing to properly address the root cause of the Kingston Spill, we believe that limiting the scope of AECOM's work raises questions about TVA's intent. The TVA OIG hired an engineering consultant, Marshall Miller & Associates (Marshall Miller), to perform a peer review of the root cause analysis. In addition the OIG, reviewed prior stability analysis performed both by TVA personnel and by consultants hired by TVA. Based upon our review, we find that: (1) AECOM's focus on the "slimes" layer is misplaced; (2) TVA could have possibly prevented the Kingston Spill by implementing recommended corrective measures; (3) "red flags" existed for years that raised risks that were not captured by TVA's Enterprise Risk Management Program; and (4) the culture within TVA's fossil fuel plants resulted in coal ash being treated like garbage at a landfill rather than treating it as a potential hazard to the public and the environment.

TVA's silence on management practices that contributed to the Kingston Spill is compounded by the failure to report after seven months the stability analysis of TVA's ash ponds that was to have been performed by Stantec. Given Bill Walton of AECOM's statements about the potential vulnerability of TVA's ash ponds, that analysis is critical.

FAILURE TO REVIEW MANAGEMENT PRACTICES

TVA management handled the root cause analysis in a manner that avoided transparency and accountability in favor of preserving a litigation strategy. TVA elected not to publicly disclose management practices that may have contributed to the Kingston Spill. TVA management did not identify any "lessons learned" from the root cause analysis which does not bode well for the future. The emphasis by TVA via AECOM that the unique "slimes layer" was the triggering factor that led to the Kingston Spill is fortuitous for TVA in that TVA can claim: (1) the "slimes layer" was too difficult for TVA to have found, and therefore, TVA's responsibility is lessened; (2) TVA does not have to do anything differently in regard to their ash pond management; (3) TVA management has no culpability, and therefore, no legal liability; (4) there are no adverse implications for the utility industry since Kingston was a "one-off" event caused by a condition not believed to be present anywhere else in the world; and (5) since there are no "slime layers" at any other TVA facility, there is no cause for concern about those other ash ponds.

RECOMMENDED SAFETY MODIFICATIONS NOT MADE

TVA could have possibly prevented the Kingston Spill if it had taken recommended corrective actions. TVA was aware of "red flags" that were raised over a long period of time signaling the need for safety modifications to TVA ash ponds. These "red flags" were raised both by TVA employees and by consultants hired by TVA. Specifically, a 1985 internal memorandum written by a TVA engineer and two 2004 reports by external engineering consultants raised concerns about the stability of the Kingston ash storage facilities. For reasons that are still not entirely clear, appropriate safety modifications were not made. Marshall Miller holds that TVA could have possibly prevented the Kingston Spill if it had implemented the recommended safety modifications.

AECOM OVEREMPHASIZED SLIMES LAYER

Marshall Miller concluded that AECOM's root cause study focused disproportionately on the significance of a thin, discontinuous, soft silt and "slimes" foundation layer as one of the most probable factors/root causes. While Marshall Miller agrees that the four most probable root causes contributing to the Kingston ash pond failure identified by AECOM are technically plausible, reasonably supported by the study data, and that all four contributed significantly to the failure, Marshall Miller concluded that factors other than the "slimes" layer may have been of equal or greater significance . Moreover, Marshall Miller suggested that in assessing the stability of its ash storage facilities, TVA should determine whether any of the four factors contributing to the failure at Kingston exist sufficiently to pose a significant risk of failure. Marshall Miller concluded that TVA's assessment should not be limited to just looking for the existence of the combination of all four contributing factors found at Kingston.

ASH MANAGEMENT NOT SEEN AS A RISK BY TVA

Despite internal knowledge of risks associated with ash ponds, TVA's formal Enterprise Risk Management process, which began in 1999, had not identified ash management as a risk. In 1987, an internal memorandum stated that, "Greater amounts of ash have resulted in expansions of ash ponds. In some instances the dikes that contain this water have become quite high with increasing risk and consequences of a breech. Because of the potential for harm to both surface and groundwater from the failure of a dike, greater attention and establishment of more specific inspection standards for these dikes should be examined." This memorandum triggered internal discussion about whether the ash ponds should have been managed under TVA's Dam Safety Program, which would have required substantially more rigorous inspections and engineering. Ultimately, TVA did not place the ash ponds under its Dam Safety Program.

LEGACY CULTURE IMPACTED ASH MANAGEMENT

Attitudes and conditions at TVA's fossil fuel plant that emanate from a legacy culture impacted the way TVA handled coal ash. Ash was relegated to the status of garbage at a landfill rather than treating it as a potential hazard to the public and the environment. Subsequent to the Kingston ash spill, TVA management began trying to change the way TVA handles coal ash. History, however, suggests that the very best policies and procedures can be successfully resisted by a strong legacy culture. For TVA to be successful in avoiding another Kingston Spill, the culture must be accurately assessed, compliance with new policies and procedures must be faithfully measured with appropriate metrics, and employees must be educated to think differently about ash management than they have over several generations. To do this we believe TVA needs to hire a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout the organization.

[i] This OIG report is the report that was presented to the TVA Board on July 14, 2009. After the OIG briefed the Board on its findings, a specially called Board meeting was held on July 21, 2009, with a press conference that followed. The McKenna Long and Aldridge report that had been commissioned by the Audit Committee of the Board in February of 2009 was released. TVA management acknowledged at the July 21, 2009, meeting many of the management failures that we identify in this report. These admissions reflect the type of transparency and accountability for TVA that the OIG has pressed for some time. We applaud the TVA Board's leadership in this matter and TVA management's acknowledgement of TVA's role in the Kingston Spill.

INTRODUCTION

On December 22, 2008, a major dike failure occurred on the north slopes of the ash pond at the Tennessee Valley Authority's (TVA) Kingston Fossil Plant (KIF). This failure resulted in the release of approximately 5.4 million cubic yards of coal ash spilling onto adjacent land and into the Emory River. While there was no loss of life, 26 homes were either destroyed or damaged. Since the Kingston Spill, TVA has been (1) assessing the geotechnical cause of the spill, (2) developing and implementing a plan to clean up the spill and dispose of the ash, and (3) developing long-term solutions to the issue of ash disposal at all TVA fossil plants. TVA estimates the cost of this spill to be between $675 million and $975 million, not including potential litigation and claims, community recovery support, environmental remediation and long term monitoring, final closure of the failed cell, fines and regulatory costs, and implementation of an alternative to wet stacked fly ash storage at Kingston.

TVA's Chief Executive Officer (CEO), Tom Kilgore, directed the TVA Office of General Counsel (OGC) to contract with a firm to conduct a root cause analysis. He left the selection of the firm to the TVA OGC but did direct that the firm was to be "one of the best." OGC through one of their attorneys arranged for a contract to be drawn between TVA and with AECOM Technology Corporation (AECOM) after AECOM's selection. They also contracted with another consultant, Dr. Gonzalo Castro, P.E., to review AECOM's work. The OGC by contract and verbal instruction severely limited the scope the work of AECOM which we address in some detail in this report. The essence of the direction given to Bill Walton,[1] the chief consultant for AECOM, precluded AECOM from reviewing the (1) standard of practice used by TVA or their consultants for the design and construction of the ash ponds and dredge cells; (2) fate and transport of potential ash and possible contaminates from the cells into the environment; (3) design of remedial construction measures to clean and restore the Kingston site; (4) designs and operations at other TVA wet dredge cell disposal sites. (It should be noted that AECOM provided limited services at a gypsum dredge cell water release at the TVA's Widows Creek facility on January 9, 2009.)

[1] Any opinions attributed to Bill Walton which are outside the scope of AECOM's engagement with TVA do not reflect the opinion of AECOM.

TVA held a press conference on June 25, 2009, at which Bill Walton from AECOM and Bill McCollum, Chief Operating Officer for TVA, briefed the press on AECOM's determination of the root cause of the Kingston Spill. The AECOM report and the statements of Walton and McCollum avoided any comment on any culpability of TVA for the Kingston Spill.

TVA hired Stantec Consulting (Stantec) to assess the condition of its ash ponds and help restructure ash management at TVA. According to TVA management, Stantec is assessing ash ponds under stricter engineering and construction standards than had been applied to TVA's ash ponds in the past (i.e., dam safety standards, as discussed more fully later in this report.)[2] However, as of July 1, 2009, more than 6 months after the spill at Kingston, Stantec has not completed a stability analysis of the remaining dikes at Kingston. In fact, on July 7, 2009, we were informed by a Stantec official that certain procedures required to finalize the stability analysis of the Kingston dikes were not undertaken until approximately mid-June 2009.

The OIG hired an engineering consultant, Marshall Miller and Associates, Inc. (Marshall Miller), to perform an independent peer review of the TVA commissioned root cause analysis by AECOM and provide observations about ash storage facility management at TVA. This report addresses: (1) TVA's failure to address its culpability for the Kingston Spill,[3] (2) TVA's opportunities to implement recommended corrective measures that possibly could have avoided the Kingston Spill, (3) the results of Marshall Miller's peer review, (4) TVA's failure to adequately mitigate known risks for ash ponds at the Kingston site, (5) TVA culture which impacted ash management, and (6) TVA's recent actions to address ash management weaknesses.[4]

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[2] Stantec provides professional consulting services in planning, engineering, architecture, landscape architecture, surveying, environmental sciences, project management, and project economics for infrastructure and facilities projects.

[3] This OIG report is the report that was presented to the TVA Board on July 14, 2009. After the OIG briefed the Board on its findings, a specially called Board meeting was held on July 21, 2009, with a press conference that followed. The McKenna Long and Aldridge report that had been commissioned by the Audit Committee of the Board in February of 2009 was released. TVA management acknowledged at the July 21, 2009, meeting many of the management failures that we identify in this report. These admissions reflect the type of transparency and accountability for TVA that the OIG has pressed for some time. We applaud the TVA Board's leadership in this matter and TVA management's acknowledgement of TVA's role in the Kingston Spill.

[4] The OIG previously reported the results of its assessment of TVA's: (1) emergency response to the spill, (2) communications with the community and media, and (3) reparations to the victims and the community. See Inspection 2008-12283-01, Kingston Fossil Plant Ash Slide Interim Report, dated June 12, 2009.

TVA's CEO provided comments on a draft to this report. The CEO generally agreed with our recommendations and, in addition to identifying actions already taken, stated that actions in-process or planned include:

- Implementing a cultural focusing initiative across the agency, incorporating lesson learns from Kingston.

- Using the detailed, technical explanation of what and how the Kingston dike failure occurred, "to make more specific inquiries as to how the failure could have been prevented in fact and, more importantly, what steps we can take to ensure that it never happens again and to safely close the failed cell."

- Developing and implementing (1) more detailed and rigorous policies and procedures for storing, handling, and maintaining ash and ash disposal facilities and (2) a comprehensive program for future Coal Combustion Product remediation and conversion.

- Implementing enterprise risk management improvements to better achieve the goals of the program.

SUMMARY OF FINDINGS

The Kingston Spill is one of the most significant and costly events in TVA history. The immediate consequence of this disaster includes public doubts created about TVA's commitment to environmental stewardship. As we have pointed out in a previous report on the ash spill, TVA has made great strides in its efforts to make whole the individual victims of this spill, and it has demonstrated a genuine commitment to restore the surrounding area in Roane County, Tennessee, and to make it better than before. Unfortunately, as we discuss in this report, a critical part of remediation is missing. Any restoration for individual victims or the community of necessity involves an acknowledgement of TVA's role in what happened in the early morning hours on December 22, 2008.

- **TVA FAILED TO INVESTIGATE AND REPORT MANAGEMENT PRACTICES THAT CONTRIBUTED TO THE KINGSTON SPILL** TVA pledged early on to find out what caused the Kingston Spill. The reasonable expectation created for TVA stakeholders was that TVA would address not only the technical details of the ash pond failure but also what acts of TVA contributed to the spill. We find that the root cause analysis commissioned by TVA did not investigate what management practices or policies and procedures allowed conditions

to advance to the critical stage that precipitated the spill. TVA's CEO delegated the scoping of the root cause analysis to the OGC, which resulted in a scope that severely limited the value of AECOM's work. Litigation strategy seems to have prevailed over transparency and accountability. Bill Walton of AECOM was discouraged from disclosing information to the public that was relevant and necessary for the analysis of the safety of the remaining Kingston ash ponds and other TVA ash ponds.

- **TVA COULD HAVE POSSIBLY PREVENTED THE KINGSTON SPILL IF IT HAD TAKEN RECOMMENDED CORRECTIVE ACTIONS**
  TVA was aware of "red flags" that were raised over a long period of time signaling the need for safety modifications to TVA ash ponds.[5] These "red flags" were raised both by TVA employees and by consultants hired by TVA. Specifically, a 1985 internal memorandum written by a TVA engineer and two 2004 reports by external engineering consultants raised concerns about the stability of the Kingston ash storage facilities. For reasons that are still not entirely clear, appropriate safety modifications and additional analyses were not made. Marshall Miller holds that TVA could have possibly prevented the Kingston Spill if it had implemented the recommended safety modifications.

- **AECOM OVEREMPHASIZED THE "SLIMES" LAYER AS A TRIGGER FOR THE KINGSTON SPILL, WHICH COULD LIMIT CORRECTIVE ACTIONS**
  In Marshall Miller's opinion, AECOM's root cause study focused disproportionately on the significance of a thin, discontinuous, soft foundation layer (i.e., a sensitive silt and "slimes" foundation layer) as one of the most probable factors/root causes.[6] While Marshall Miller agrees that the fundamental conclusions by AECOM with regard to the four most probable root causes or factors[7] contributing to the Kingston ash pond failure are technically plausible and reasonably supported by the study data, and that all four contributed significantly to the failure,

[5] This report is the work solely of the TVA OIG and its consultant and the findings, conclusions, and recommendations do not represent the views of TVA. The TVA OGC is the arbiter of how rules and regulations, statutory law, and common law apply to TVA. This report should not be interpreted in any way so as to represent or bind TVA in any litigation concerning the Kingston Spill.

[6] Marshall Miller determined that the scope of the root cause study, as presented by AECOM, was sufficient, the methodologies applied reasonable, and the findings technically plausible. However, as discussed in this report, Marshall Miller concluded that the AECOM study results focused disproportionately on the slime layer.

[7] The four most probably root causes identified by AECOM were fill geometry, increased fill rates, soft foundation soils, and loose, wet ash. The upstream-constructed dike configuration on sluiced ash foundation is one of the significant, inherent components of the "fill geometry" factor.

Marshall Miller concluded that factors other than the "slimes" layer may have been of equal or greater significance. Specifically, Marshall Miller concluded that (1) the "fill geometry" is of equal or greater significance and is a condition that may exist in other ash disposal facilities, and (2) the characteristics of the loose, wet ash pose the wet ash as a probable root cause of equal or greater significance to the soft foundation soils.

In addition to independently reviewing the root cause analysis performed by AECOM, the OIG asked Marshall Miller to provide input regarding how to address ash management at TVA. Marshall Miller concluded that in assessing the stability of its wet ash storage facilities, TVA should determine whether any of the four factors contributing to the failure at Kingston exist elsewhere and might pose a substantive risk of failure. Marshall Miller concluded that TVA's assessment should not be limited to just looking for the existence of the combination of all four contributing factors found at Kingston. The goal of the stability assessment, according to Marshall Miller, is for TVA to develop and then implement (where found necessary) appropriate corrective actions to raise the standards of its wet ash storage facilities, targeting engineering and regulatory standards applicable to dams with similar hazard classification. Marshall Miller indicates that there is an unqualified risk of other dike failures if changes are not made in the design and operation of the wet ash disposal operations throughout TVA. Moreover, in Marshall Miller's opinion, had TVA included ash ponds in the Dam Safety Program, the probability of identifying some or all of the conditions that led to the Kingston failure would have increased significantly.

As noted above, TVA precluded AECOM from making these types of recommendations, thus limiting the value of the root cause study. The AECOM lead engineer on the root cause study spent several months examining in detail the conditions at Kingston and thus, in our opinion, would be well positioned to offer recommendations for improving TVA's ash management. Instead of soliciting recommendations from AECOM, TVA hired Stantec to assess the condition of its ash ponds and help restructure ash management.

See Appendix B for Marshall Miller's peer review report on AECOM's root cause analysis and Appendix C for observations and comments on TVA's past ash management practices, and opinions and input regarding how to address ash management at TVA.

- **TVA'S ENTERPRISE RISK MANAGEMENT PROGRAM DID NOT ADEQUATELY ADDRESS KNOWN RISKS ASSOCIATED WITH ASH PONDS**

  Despite internal knowledge of the risks associated with ash ponds, we found no evidence that TVA's formal Enterprise Risk Management process, which began in 1999, had identified ash management as a risk. An Enterprise Risk Management system is designed to identify and mitigate risks that could adversely affect the organizations ability to achieve their mission and objectives. Risks associated with ash management that were known internally as early as 1987 were not adequately mitigated.

  In 1987, an internal memorandum from the TVA Director of Environmental Quality to the TVA Manager of Policy, Planning, and Budget stated that, "Greater amounts of ash have resulted in expansions of ash ponds. In some instances the dikes that contain this water have become quite high with increasing risk and consequences of a breech. Because of the potential for harm to both surface and groundwater from the failure of a dike, greater attention and establishment of more specific inspection standards for these dikes should be examined." This triggered discussion among some in TVA about whether the ash ponds should have been managed under TVA's Dam Safety Program,[8] which would have required substantially more rigorous inspections and engineering. Some managers and executives within TVA took the position that doing so was unnecessary for safety, and TVA was not technically required to do so; ultimately, TVA did not place the ash ponds under its Dam Safety Program.

- **THE CULTURE AT TVA'S FOSSIL FUEL PLANTS IMPACTED ASH MANAGEMENT**

  Our review disclosed attitudes and conditions at TVA's fossil fuel plants that emanate from a culture that impacted the way TVA handled coal ash. Over the last nine months the OIG has conferred with the TVA Board and TVA management about what we perceive to be systemic problems that have their genesis in the culture. While we recognize that there is no one culture at TVA and instead there are subcultures that vary from one organization to another within TVA, there are common themes we find antithetical to the level of transparency and accountability expected of a public utility. While the

[8] TVA's Dam Safety Program seeks to ensure the structural integrity and safe operation of TVA's 49 dams and appurtenant structures, instrumentation to monitor dam performance, periodic inspections, maintenance and repairs, and emergency preparedness. The Dam Safety Program is also responsible for saddle dams and dikes in the TVA system. The TVA Dam Safety Officer is responsible for ensuring that TVA's Dam Safety Program meets federal guidelines for dam safety.

culture at TVA's fossil fuel plants is not the cause of the Kingston Spill, the culture, in our view, contributed to the spill, and it is likely to be resistant to the kinds of reforms necessary to avoid other safety failures.

TVA culture at fossil fuel facilities relegated ash to the status of garbage at a landfill rather than treating it as a potential hazard to the public and the environment. We believe this resulted in significant weaknesses in ash management practices across TVA, including: (1) a failure to implement recommended corrective actions that could have possibly prevented the Kingston Spill; (2) the lack of policies and procedures; (3) poor maintenance; (4) the lack of specialized training; (5) multiple organizational structure changes; (6) inadequate communication; and (7) a failure to follow engineering best practices.

TVA management is now implementing new policies and procedures to change the way TVA handles coal ash. History, however, suggests that the very best policies and procedures can be successfully resisted by a strong legacy culture. For TVA to be successful in avoiding another Kingston Spill, the culture must be accurately assessed, compliance with new policies and procedures must be faithfully measured with appropriate metrics, and employees must be educated to think differently about ash management than they have over several generations. We believe TVA needs a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA.

- **TVA HAS RECENTLY ACTED TO ADDRESS CERTAIN ASH MANAGEMENT WEAKNESSES**
  Since the Kingston ash spill, TVA management has begun to reassess its ash management program and has taken several actions to improve ash management across the agency. These actions include (1) organizational changes to address management and accountability issues, (2) changes designed to change the corporate culture which had de-emphasized the importance of ash management, and (3) steps to assess ash storage facilities against dam safety guidelines with the goal of complying with dam safety guidelines where possible.

FACTUAL BACKGROUND

ASH PONDS

Coal ash is what is left after coal is burned in power generating plants. Fly ash, captured by electrostatic precipitators, and bottom ash, taken from the boilers, are mixed with water and pumped to the ash containment ponds. KIF produced 1,000 tons, or 1,200 cubic yards, of coal fly ash daily when operating at full capacity.

Since the 1950's, TVA's KIF has been storing its coal ash in containment ponds at the plant site, which is adjacent to the Emory River. The initial KIF ash pond was built over the former Swan Pond Creek flood plain, which is illustrated by Picture 1 on page 9. By 1965, the initial ash pond was filled. Picture 2 on page 9 illustrates the configuration of the initial ash pond. After the initial ash pond was full, a settling pond and ash storage (i.e., dredge) cells were constructed. The ash storage area was subdivided into smaller dredge cells. The dredge cells consisted of perimeter dikes that were stacked on top of each other and upon previously sluiced ash materials. At KIF, the specific process for moving ash from the plant to the dredge cells included:

- Mixing ash with water in the plant and pumping it to a settling pond.
- Dredging the ash after it settled to the bottom of the pond.
- Pumping the dredged wet ash into the storage cells.

Picture 1 -- Swan Pond in Year 1949

Picture 2 -- KIF Ash Pond in 1962

TVA plant personnel visually inspected the dikes daily. TVA's engineers performed a more comprehensive inspection annually. The Tennessee Department of Environment and Conservation (TDEC) also inspected the ash pond dikes quarterly. In 2003 and 2006, small localized slope failures occurred on the dikes of the ash pond which were addressed by TVA with the assistance of a consulting engineering firm. The last TDEC inspection was in August 2008, and no deficiencies were found. The last KIF ash pond daily visual inspection was Sunday afternoon, December 21, 2008. No problems were noted.

On December 22, 2008, the north and central portions of the ash disposal site failed shortly before 1 a.m. EST, an estimated 5.4 million cubic yards of ash were released in a progressive sequence of flow slides over a period of one to two hours. The release extended over approximately 300 acres outside the ash storage area, causing damage to 26 homes, disrupting electrical power, rupturing a natural gas line in a neighborhood located adjacent to the plant, and covering a railway and road in the area. The flow slide extended northward approximately 3,200 feet beyond the limits of the original ash pond over the Swan Pond Creek flood plain, a back water slough of the Emory River and into the former Emory River channel of Watts Bar Reservoir. The ash disposal cell which failed had been permitted by TDEC as a Class II Solid Waste Landfill under state regulations.

ASSESSING THE ROOT CAUSE

As we have noted earlier, TVA's CEO Tom Kilgore tasked the OGC with contracting with an expert to do a root cause analysis. OGC retained AECOM in early January 2009 to conduct an independent analysis to determine the root cause of the KIF dike failure. AECOM is a global provider of professional technical and management support services to a broad range of markets, including transportation, industrial facilities, environmental, and energy. TVA's OGC also retained Dr. Gonzalo Castro to provide advice and assistance and peer review the root cause analysis. Dr. Castro is a civil engineer with more than 35 years of experience in geotechnical engineering. He is a recognized expert in seismic analysis and earthquake engineering. As part of the root cause analysis, AECOM (1) drilled 147 sampling borings; (2) located, surveyed, and logged identifiable relics; (3) conducted interviews to establish timelines; (4) reviewed existing TVA records to establish filling and flooding history; and (5) performed seepage and stability analyses. As noted above, the root cause analysis was limited to determining the more probable factors contributing to the Kingston failure.

The OIG retained Marshall Miller to perform an independent peer review of the TVA commissioned root cause analysis by AECOM. Marshall Miller has expertise in coal ash and other waste materials, containment design for hydraulically placed or sluiced ash and mine tailings, earthen and mine waste dams and, more generally, materials science and geotechnical engineering. Marshall Miller's peer review of AECOM's root cause analysis is presented in the attached Appendix B. A summary of Marshall Miller's conclusions and observations is presented in the following section.

FINDINGS

TVA FAILED TO INVESTIGATE AND REPORT MANAGEMENT PRACTICES THAT CONTRIBUTED TO THE KINGSTON SPILL

Great Expectations

In the aftermath of December 22, 2008, when asked about TVA decision making prior to the Kingston Spill, TVA officials repeatedly pointed to the root cause analysis report to come. For example, at the hearing before the Senate Environment and Public Works Committee on January 8, 2009, Senator Barbara Boxer's query to CEO Tom Kilgore as to what steps TVA would have done differently, Kilgore replied that he "…..would like to get the failure investigation complete and know exactly what the cause was."[9] Senator Boxer was clear in questioning Kilgore at the hearing that answers were expected not just about the technical physical failure of the ash pond at Kingston, but that answers were expected from TVA as to TVA's culpability in managing the ash ponds.[10] Kilgore's written testimony included a statement that, "We are beginning an independent, in-depth root cause analysis to determine why the ash pond dike failed."[11]

Clearly, a reasonable expectation was created for Congress and TVA's other stakeholders that since January of 2009, TVA has been working diligently to explain why the Kingston ash spill occurred. It was not foreseeable that, in fact, TVA would not review what management practices may have contributed to the failure, but would instead tightly circumscribe the scope of review to intentionally avoid revealing any

[9] U.S. Senate Committee on Environment & Public Works, Full Committee hearing entitled, "Oversight Hearing on the Tennessee Valley Authority and the Recent Major Coal Ash Spill," Thursday, January 8, 2009.

[10] "A lot of questions surrounding your decision making prior to the failure." *(Emphasis added*), [U.S. Senate Committee on Environment & Public Works, Full Committee hearing entitled, "Oversight Hearing on the Tennessee Valley Authority and the Recent Major Coal Ash Spill," Thursday, January 8, 2009.

[11] Written testimony of Tom Kilgore, President and Chief Executive Officer, Tennessee Valley Authority, before the Environment and Public Works Committee, January 8, 2009.

evidence that would suggest culpability on the part of TVA. In fact, it appears that TVA management made a conscious decision to present to the public only facts that supported an absence of liability for TVA for the Kingston Spill.

No "Could Have, Would Have, Should Have" For TVA: Let's Just All Move Forward

On June 25, 2009, TVA held a press conference to deliver AECOM's root cause analysis report. Bill Walton of AECOM appeared for his company and COO Bill McCollum represented TVA at the press conference. The presentation was tightly scripted to avoid any discussion of management errors at TVA. This is best captured by the following exchange by a member of the media and COO Bill McCollum:

> **Question**: "Well, should it have been, should TVA or TDEC have been more observant before that permit was issued to have discovered it? I mean it said it was a stable facility and apparently it wasn't."
>
> **McCollum**: "Well, I think that if you take what's been learned from the root cause analysis and from what Mr. Walton said about the depth of inquiry and investigation that it took to find some of the things that are reported here in the analysis, it's pretty hard for me to go back and say could have, would have, should have about things that you might have found at some point in the past."
>
> Repeated efforts by the media to learn anything about TVA's culpability were met with artful dodges. Clearly, both McCollum and Walton had been schooled in how to deflect any question that would elicit an answer that would suggest legal liability for TVA. The apparent agreed upon program was to avoid going back and second guessing TVA decisions and to counsel the media to focus only on the future. An example of the delicate tap dance required is shown in the following exchange between the media and Bill Walton.
>
> **Question**: "Not that you would have, but had you done your analysis prior to the event and noticed the slime layer and noticed sort of all of this coming together as one, what would you have recommended at the time? Would there have been a way to stop it, fix it, or would you have to shut it

down? What would you do had you discovered all of these factors prior?"

Walton: "I think that's the challenge of coming to this and doing this study. It presents the position of going forward on lessons learned. Hindsight is 20/20. Let's take the lessons learned and move forward."

Not once during the press conference was even a begrudging acknowledgement made that TVA could have done anything differently. On the contrary, as seen above, the emphasis was on how difficult it was for AECOM to discover the cause of the Kingston Spill (mostly the "slime" layer) and by inference TVA could not be expected in the exercise of due diligence to have discovered a problem. Even the building of the ash pond over the lake in the '50's was forgiven by Walton as demonstrated by this exchange with the media.

Question: "If you were building it now, would you say that's probably not a good site?"

Walton: "It would be different criteria. Not that it couldn't be built, but perhaps in '51 or '54 you would have to know the ultimate fate of the structure. And I don't know that anyone then knew what the geometry would be with the Clean Air and Clean Water Act. So there are circumstances of policy there, that affect that answer."

Most telling perhaps was the defense put forward by Walton that TVA could not have discovered the "slimes" layer which was the focus as the triggering mechanism for the spill. This defense was articulated in response to another question by the media:

Question: "Dr. Walton, was there anything in your review of the previous stability analysis and other historic documents from TVA that would have or <u>should have raised a red flag</u> for anyone reviewing those documents, say in the immediate aftermath of their creation? I mean if there was a stability analysis in 1981 was there anything in that one or any of the others that would have said oh we should investigate this site further before the stack height or take any other measures?" *(Emphasis added)*

> **Walton**: "Yes, we did look at earlier stability analyses as part of the root cause analysis. And in that root cause analysis, we had to look at the facts that were in front of us. And those signs simply were not identified in those, and it took us two-and-a-half months to find that. So I guess it's lessons learned to move forward." *(Emphasis added)*

While both Walton and McCollum cautioned that the focus should be on "lessons learned" and moving forward, it is not entirely clear what lessons TVA has learned. Since, according to TVA via its representatives, there were no "red flags" that TVA could have spotted to take corrective actions, and since TVA cannot say that even building the ash pond out on a lake bed was a bad site, what exactly were the "lessons learned going forward?" If as it appears TVA is saying that the "slimes" layer is a unique phenomenon appearing only if TVA builds an ash pond out on a lake bed and TVA does not intend to build an ash pond on a lake bed, what structural defects or management practices need to be avoided "going forward"? We have examined the press conference presentation on June 25, 2009, with some care. We have yet to discover one "lesson" TVA says that it learned. This does not bode well for the future.

We know that TVA has, in fact, learned from the December 2008 spill, and we know that because of the management changes that we report in the final section of this report. We believe that TVA should state publicly those lessons learned and that list would include, among others:

1. Building the original ash pond over a lake bed was a faulty design;

2. Corrective actions recommended both by TVA employees and by consultants should have been implemented;

3. Stacking ash to the heights contemplated at Kingston was a bad idea;

4. Not having policies and procedures for ash management contributed to the spill;

5. A culture that minimized the importance of ash management needs to be changed; and

6. Wet ash ponds should comply with dam safety standards rather than with landfill standards.

TVA's Dilemma: Accountability or Litigation Strategy?
TVA had a clear but difficult choice to make in the aftermath of the Kingston Spill. One choice was to conduct a diligent review of TVA management practices as well as to conduct a technical physical examination of the failed structure and then to publish whatever was discovered to the world. The second choice was to "circle the wagons," carefully craft press releases to project TVA in the most favorable light,[12] and to tightly control any reports done by TVA of the failure to minimize legal liability. The first choice required a value judgment that a government agency causing a major disaster affecting the lives and property of citizens around the Kingston Fossil Fuel Plant should err on the side of transparency and accountability. The downside to this choice is providing fodder for plaintiffs in litigation against TVA and bringing perhaps additional scrutiny on the agency.

The second choice also required a value judgment. That choice placed a premium on the preservation of TVA assets and the protection of an image of environmental stewardship. The advantage of this choice was limiting legal liability which arguably inures to the benefit of ratepayers and avoiding scrutiny of TVA management practices that might have contributed to the Kingston Spill.

We are not privy to the calculation made by TVA as to the relative merits of these two difficult choices. We are, however, privy to facts that suggest a predictable outcome from TVA electing to go with the second choice. First, we have found no evidence of any intention on the part of TVA to require AECOM to conduct a review of management practices that might have contributed to the Kingston Spill. During the course of the root cause study, TVA never claimed that a review of their management practices, policies, and procedures or consultants' reports would be publicly disclosed.[13] Second, the decision to delegate from the CEO to the OGC the responsibility of managing the root cause study predetermined the choice that would be made between accountability and litigation strategy. The OGC did what good lawyers do; they defend their client. TVA's lawyers do not make TVA policy and do not determine the degree of

[12] See OIG report, Inspection 2008-12283-01, Kingston Fossil Plant Ash Slide Interim Report, dated June 12, 2009, where we examined TVA's response to media inquiries immediately after the Kingston Spill.

[13] TVA has shown a belated interest in this in response to the Inspector General's probing about whether such a review was being conducted by TVA. Six months after the Kingston Spill, however, no review by TVA of management practices has commenced. We conclude that TVA did not intend to conduct such a review.

transparency or accountability for TVA. Third, the power to write the scope of the root cause study carried with it the inherent power to prevent disclosures that could potentially be damaging to TVA's defense against litigation from plaintiffs claiming damages from the Kingston Spill. Obviously, the more narrow the scope, the better for those entrusted with defending TVA in court.

Finally, the relationship created here was not with TVA generally and the Office of Legal Counsel but was instead between the OGC and AECOM. It was the lawyers who controlled the engagement whether they were the actual lawyers going to court to defend TVA or merely lawyers in the same office.

We should make clear that we are not suggesting that the facts recited above indicate any lack of independence of AECOM or more particularly any lack of independence of Bill Walton. On the contrary, our observation is that Bill Walton is the consummate professional not susceptible to any undue influence. Nor did we find any evidence of any effort to influence Walton's work. His conclusions as to the root cause appear to be based entirely upon his forensic work as a respected expert in his field.

The OIG interviewed Walton on two occasions. He stated AECOM was retained by TVA OGC to perform a root cause analysis of the December 22, 2008, dredge cell failure to determine the most probable cause(s) and location of the failure at the site. AECOM was also retained to provide peer review of remedial containment designs by Stantec and Geosyntec at Kingston and to check if the designs are consistent with post-failure geotechnical conditions encountered in AECOM investigations and to peer review ash handling, restoration and containment designs by Stantec and Geosyntec at the Kingston site to check if designs were/are consistent with the post-failure geotechnical conditions in AECOM investigations. He made it clear that he had been specifically directed not to, among other things, review the: (1) standard of practice used by TVA or their consultants for the design and construction of the ash ponds and dredge cells; (2) fate and transport of potential ash and possible contaminates from the cells into the environment; (3) design of remedial construction measures to clean and restore the Kingston site; (4) designs and operations at other TVA wet dredge cell disposal sites. (It should be noted that AECOM provided limited services at a gypsum dredge cell water release at the TVA's Widows Creek facility on January 9, 2009.) In our opinion, the defined limitations in scope precluded AECOM from (1) reviewing or judging the management practices of TVA in conjunction with the design, construction, or operation of TVA ash ponds; (2) determining fault for the Kingston Spill; and (3) judging TVA employees

or contractors. These restrictions placed on AECOM are consistent with a sound litigation strategy but are inimical to transparency and accountability for TVA. This is particularly true since TVA has evidenced no intention to address the areas listed above through either TVA management or anyone else.

We conclude that TVA defaulted to a preference for litigation strategy over transparency and accountability once the root cause study was turned over to the lawyers. Our conclusion is buttressed by TVA's obvious decision not to conduct a review of its management practices either as part of the root cause analysis or by a separate review. As far as the root cause analysis, the constraints placed on Bill Walton appear to have been intended to avoid any such review. While it would have increased the delay in announcing a root cause, having Walton review TVA's management practices would have allowed a recognized expert to provide a measure of transparency and accountability that is sorely lacking.

When the OIG interviewed Bill Walton he offered opinions that were not made a part of his written report or stated at the June 25, 2009, press conference. First, based on Walton's root cause analysis report and information presented to Walton by Stantec early in May 2009, and conditioned on Walton fully investigating such issues, Walton believes there may be an issue with other TVA ash ponds built on soft clay that may be particularly vulnerable to static and seismic loading or disturbance. That, according to Walton, is particularly true for those ash ponds in West Tennessee closer to the New Madrid Seismic Zone. Secondly, Walton expressed the belief that it might be more appropriate to treat wet ash ponds, like the one at Kingston, as a tailings dam designed to contain wet ash and hold water as opposed to treating such ash ponds as a landfill. Finally, conditioned on Walton fully investigating hypothetical failures, Walton believed that continually stacking the ash, like TVA was doing before the spill, might lead to an eventual breach. None of these positions has been reported by TVA. Given the expertise Walton has and the substantial fee paid to AECOM, TVA and TVA stakeholders would have been better served by TVA eliciting and sharing this information with the public.

Finally, we note that the conclusion reached by AECOM that the slime layer was a triggering device for the Kingston Spill enhances TVA's litigation efforts against claimants. The point was repeatedly made at the June 25 press conference that the slime layer was unique to Kingston and not found at any other TVA ash pond. AECOM did not attribute the failure to TVA's design of the ash pond or to TVA's operation of the ash pond. Walton, as noted earlier, even declined to say that building an ash dike out

on a lake bed was not a good idea. Does TVA know that building an ash pond over a lake bed is a bad idea? This is apparently not a "lesson learned" based on what TVA and its consultants are willing to say publicly.

Tagging the "slime layer" as the triggering mechanism for the Kingston Spill is fortuitous. The outcome for TVA results in TVA being able to claim that: (1) the "slimes layer" was too difficult for TVA to have found, and therefore, TVA management's liability is minimized; (2) TVA does not have to do anything differently since no fault was found in either the design of the ash pond or in the operation of the ash pond; (3) TVA management has no culpability because they couldn't have found the cause of the spill, and therefore, no legal liability; (4) there are no adverse implications for the utility industry since Kingston was a "one-off" event caused by a condition not believed to be present anywhere else in the world; and (5) since there are no "slime layers" at any other TVA facility, there is no cause for concern about those other ash ponds. As Marshall Miller points out later in this report, AECOM's emphasis on the "slime layer" is misplaced and inappropriately diminishes the role that the design and operation of the Kingston ash pond played in the spill. For all of these reasons, we conclude that TVA's explanation of the root cause of the Kingston Spill is suspect.

Perhaps some would say that it is unrealistic that a government agency would choose to disclose information that could be either embarrassing or that could create legal liability. It is certainly true that there are at times legitimate reasons for a government agency to withhold information from the public. We fail to see where that is the case here.

TVA COULD HAVE POSSIBLY PREVENTED THE KINGSTON SPILL IF IT HAD TAKEN RECOMMENDED CORRECTIVE ACTIONS

TVA had been made aware of certain "red flags" that were raised over a long period of time signaling the need for safety modifications to TVA ash ponds. These "red flags" were raised both by TVA employees and by consultants hired by TVA. Specifically, a 1985 internal memorandum written by a TVA engineer and two 2004 reports by external engineering consultants raised concerns about the stability of the Kingston ash storage facilities. For reasons that are still not entirely clear, appropriate safety modifications were not made. Marshall Miller holds that TVA could have possibly prevented the Kingston Spill if it had implemented the recommended safety modifications.

In April 1985, an internal memorandum written by a TVA engineer raised serious concerns about the stability of Dike C of the Kingston ash storage facility.[14] This memorandum states that Dike C had not been built according to design drawings. It further states that the dike's "as built" factor of safety was less than desirable and therefore recommended that plant personnel inspect Dike C daily. When asked by the OIG to review this memorandum, Marshall Miller stated that the memorandum:

> *which indicate that the calculated factor of safety was less than the minimum acceptable value of 1.5 and close monitoring was recommended to detect any potential signs of failure in lieu of changing TVA policies and procedures that would require that the ash pond would be designed to the higher "dam safety" standard.[15] The construction of successive upstream stages to elevations 820 (approximate crest elevation of Dredge Cell No. 2 at the time of failure) above the original containment dike system ("Perimeter Dike C" – approximate crest elevation of 748 feet) may have contributed to an additional decrease in the factor of safety of the containment dike system. In essence, at the time of failure on December 22, 2008, this increase in constructed height equated to an approximate 70-foot increase in the height of the ash pond above the crest elevation of the original Perimeter Dike C.*

In June 2004, Worley Parsons (Parsons) reported on the results of a slope stability analysis it performed at TVA's request related to the design of an upward expansion of the Kingston coal pond. At the time of the spill, the expansion design had been approved by TVA and some of the work completed. This upward expansion would have resulted in more of the ash being piled into the cell that later spilled. In its report, Parsons noted the existence of an approximately 7- to 10-foot thick layer of loose ash immediately overlaying the clay soil beneath the ash pond. Parsons further noted that this layer of loose ash may undergo liquefaction[16] under certain circumstances, including a seismic event. Parsons stated that the probability of this occurring was "extremely low." However, they then

[14] This memorandum, dated April 3, 1985, was from TVA's Director of Engineering projects to TVA's Director of Fossil and Hydro power. The memorandum subject was: *"Kingston Steam Plant – Dike C Soils Investigation and Engineering Study Results."*

[15] As discussed later in this report, designing to dam standards would have required a significantly higher level of engineering, inspection, stability analyses, and the like.

[16] Dictionary.reference.com defines liquefaction as the process by which sediment that is very wet starts to behave like a liquid. Liquefaction occurs because of the increased pore pressure and reduced effective stress between solid particles generated by the presence of liquid. It is often caused by severe shaking, especially that associated with earthquakes.

stated that methods of predicting liquefaction have proven to be "insufficient" and, therefore, recommended that TVA take measures to improve drainage in the ash pond. When we inquired with TVA officials as to whether this recommended drainage system had been installed, we learned that it had not.

We also found that TVA contracted with a second consulting firm, Geosyntec, to conduct an engineering peer review of coal byproduct (gypsum and ash) plans for the Kingston plant, including the stability analyses completed by Parsons pertaining to the ash pond expansion design. According to a TVA manager, TVA hired Geosyntec to perform the peer review because of questions about the quality of the Parsons' study. Geosyntec reported the results of its work to TVA in November 2004. With regard to the proposed drainage system and liquefaction, Geosyntec found that (1) an analysis estimating the liquefaction potential of the ash layer was not performed and therefore the need for the drains was not determined, and (2) the effect the drains would have had was not calculated and, therefore, it is unclear whether the drains would have been effective at mitigating liquefaction. In its report to TVA, Geosyntec concluded that the "potential for liquefaction should be estimated and, depending on the results of this estimate, a liquefaction analysis may be required. If the site is expected to liquefy then ground improvement techniques need to be implemented." *(Emphasis added)* In addition, Geosyntec questioned certain aspects of the stability analysis performed by Parsons and made recommendations pertaining to stratigraphy,[17] design material/soil property, slope stability evaluation, and veneer stability analyses.

When asked whether the Geosyntec recommendations had been followed, TVA officials responded that they had not. The TVA CEO remarked that he had noted the significance of the Geosyntec study and inquired internally why the recommendations had not been implemented; according to the CEO, he was unable to ascertain why.

When asked to review the 2004 Parsons and Geosyntec reports for the OIG, Marshall Miller concluded that the Geosyntec report should have served as a clear warning to TVA regarding the stability of the Kingston ash storage facilities. Marshall Miller stated that it was evident from the findings and recommendations in the Geosyntec report that the expansion design should have been modified to conform to a more stringent design configuration. Upon completion of the proposed expansion, which had not occurred at the time of the failure, more height and weight would have

[17] Per PhysicalGeography.net, stratigraphy refers to the subdiscipline of geology that studies sequence, spacing, composition, and spatial distribution of sedimentary deposits and rocks.

been added to what is now the failed ash pond. Marshall Miller told us that TVA's implementing the Geosyntec recommendations would have resulted in additional extensive analyses and modeling. Marshall Miller concluded that the recommendations made by Geosyntec were appropriate and the failure of the TVA to respond to such warnings and complete necessary revisions to the design shows that conservative engineering design principles were not being followed within the TVA. Furthermore, had corrective measures been taken in a timely fashion, it is possible that TVA could have potentially prevented the occurrence of the failure. *(Emphasis added)*

On June 1, 2004, TVA submitted an application to TDEC for the upward expansion of the Kingston ash pond facility. This application was approved by TDEC on September 12, 2006. TVA provided the Parsons' study to TDEC as part of the permit application. However, TDEC was unable to find documentation that the Geosyntec study was provided to them. The TDEC permit requires TVA to submit any relevant facts it becomes aware were not submitted. Specifically, the permit says, "Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Commissioner, it shall promptly submit such facts or information."

We conclude that Marshall Miller's review of these various engineering reports demonstrates that TVA was on notice about safety issues and that those safety issues were not addressed by TVA. TVA does not appear to have an answer as to why these issues were not properly addressed. Contrary to the position seemingly taken by AECOM at the June 25, 2009, press conference, the prior engineering reports were "red flags," and TVA could have taken corrective action that could have possibly avoided the Kingston Spill.

AECOM OVEREMPHASIZED THE "SLIMES" LAYER AS A TRIGGER FOR THE KINGSTON SPILL, WHICH COULD LIMIT CORRECTIVE ACTIONS

In Marshall Miller's opinion, AECOM's root cause study focused disproportionately on the significance of one factor -- the thin, discontinuous, soft foundation layer (i.e., a sensitive silt and "slimes"

foundation layer) as one of the most probable factors/root causes.[18] While Marshall Miller agrees that the fundamental conclusions by AECOM with regard to the four most probable root causes or factors[19] contributing to the Kingston ash pond failure are technically plausible and reasonably supported by the study data, the AECOM study suggests that the failure of December 22, 2008, depended on all four factors working in combination. In Marshall Miller's professional opinion, only some of the four factors could have acted together to cause the failure. In addition, Marshall Miller concluded that factors other than the "slimes" layer may have been of equal or greater significance. Specifically, Marshall Miller summarized that (1) the "fill geometry" is of equal or greater significance to the "soft foundation soils" and might be similarly critical at other upstream-constructed wet ash disposal facilities, and (2) the characteristics of the "loose, wet ash" pose the wet ash as a probable root cause of equal or greater significance to the "soft foundation soils."

A discussion of (1) AECOM's scope and methodology and technical determination of what caused the Kingston Spill, and (2) Marshall Miller's conclusions regarding the AECOM root cause analysis and other observations follows.

AECOM's Scope and Methodology

AECOM executed a consulting agreement with TVA's OGC on January 16, 2009, and commenced a data review phase shortly thereafter. AECOM's scope of work was limited to the identification of the likely initiator(s) ("root cause(s)") of the failure, which inherently encompasses consideration of potential failure modes, possible "initiators" or "triggers" of the onset of failure, and factors that contributed to its progression.

As field samples and observations became available, AECOM started the laboratory testing and analytical phases of the project, which was completed in June 2009. The purpose of the laboratory testing program was to characterize the native soils and non-native site materials and determine their geotechnical and mechanical properties to allow AECOM to analyze their behavior under the conditions prevailing on-site at the time of the failure. AECOM also performed multiple engineering analyses of

[18] The OIG contracted with Marshall Miller to perform an independent peer review of the root cause analysis conducted by AECOM. Marshall Miller's work included a review of site investigations, evaluations, analyses, and findings and conclusions prepared by AECOM relating to the ash pond failure. The final root cause analysis report was published by AECOM on June 25, 2009. Notably, Marshall Miller did not conduct a parallel investigation to AECOM's. Marshall Miller's professional opinions are based principally on review of various documents, briefings provided by AECOM, and a review of their root cause analysis report.

[19] The four most probable root causes identified by AECOM were fill geometry, increased fill rates, soft foundation soils, and loose, wet ash. The upstream-constructed dike configuration on sluiced ash foundation is one of the significant, inherent components of the "fill geometry" factor.

the data obtained from site surveys and laboratory test results, as well as undertaking an extensive compilation and review of documents from TVA's archives.

AECOM's Determination of Cause
AECOM determined that the four probable root causes of the Kingston ash pond failure were:

1. Fill geometry (upstream-constructed dike configuration on sluiced ash foundation)
2. Increased fill rates (increased loads and loading rates due to higher fill levels and shrinking footprint)
3. Soft foundation soils (weak, sensitive silt and slimes foundation layer prone to creep)
4. Loose, wet ash (very loose hydraulically placed/sluiced ash is susceptible to collapse if subjected to rapid loading or rapid displacement)

AECOM specifically characterized the root cause of the failure as a complex set of conditions, including a long-evolving combination of the high-water content of the wet ash, the increasing height of the ash, the construction of the sloping dikes over the wet ash, and the existence of an unusual foundation layer consisting of sensitive slimes and silts. AECOM concluded that the failure on December 22, 2008, depended on all four factors, without them working in combination, the failure would have not likely occurred on this date. AECOM's root cause analysis discussed in detail the thin layer of slimes beneath the dikes and identified the thin, discontinuous, soft foundation layer (sensitive silt and slimes) as one of the most probable factors/root causes.

Marshall Miller's Conclusions
It is Marshall Miller's opinion that the scope of investigation, as presented by AECOM was sufficiently thorough for the root cause analysis and applied appropriate investigated methods, in-situ testing techniques, and sampling practices. Also, the fundamental conclusions of AECOM with regard to the four most probable root causes or factors contributing to the Kingston ash pond failure were technically plausible and reasonably supported by the study data. Marshall Miller concurs with AECOM that some or all of the four factors contributed significantly to the failure. However, Marshall Miller also notes that:

- Because the failure was not strictly associated with the "thin, weak slimes" layer, and more associated with the ash dike ("or fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

- AECOM was not able to recover and extrude undisturbed samples of the hydraulically placed ash for laboratory testing which adds uncertainty to AECOM's characterization of the hydraulically placed ash; and thus, the role of the loose, wet ash as a root cause of the failure cannot be discounted.

- Although the properties of the slime layer suggest it as a potential slippage surface based on mathematical modeling, it is not the only possible slippage surface. In fact, AECOM documented that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.

- The characteristics of the loose, wet ash (hydraulically placed/sluiced ash) pose the wet ash as a probable root cause of equal or greater significance to the soft foundation soils (weak, sensitive silt and slimes foundation layer).

Other Marshall Miller Observations

As noted earlier in the report, AECOM's scope of work was limited to the identification of the likely initiator(s) ("root cause(s)") of the failure, which inherently encompasses consideration of potential failure modes, possible "initiators" or "triggers" of the onset of failure, and factors that contributed to its progression. This scope limitation resulted in Marshall Miller noting that the stated objectives of the AECOM root-cause analysis do not encompass the task of identifying necessary changes in design philosophy, design standards, construction documentation, inspection and instrumentation to prevent another Kingston-type failure. In addition, the root cause study and culminating report by AECOM defines the problem, but does not provide clear direction to TVA in the form of technical guidance for evaluating, designing, and constructing reliable containments for "wet" ash disposal now or in the future. Marshall Miller also concluded:

- Given what is known now about the ash material and the geologic conditions within the Kingston ash disposal facility before December 22, 2008, there was an unquantified probability of failure. Consequently, the sensitivity of the upstream-constructed containment dike system to changes to loading, loading rate, seepage regime,

sluiced ash behavior, and other circumstances must be appreciated to preclude another catastrophic failue as occurred on December 22, 2008.

- As discussed more thoroughly later in this report, as early as 1985, intrinsic problems related to the stability of the Kingston Dike C were mentioned, specifically in a TVA memorandum. This memorandum indicated that the calculated factor of safety was less than the minimum acceptable value and close monitoring was recommended to detect any potential signs of failure in lieu of changing TVA policies and procedures that would require that the ash pond be designed to the higher "dam safety" standard. No specific action by TVA appears to have been taken as per the reviewed documents.

- Had TVA included its ash ponds in the Dam Safety Program, discussed in December 1988 when TVA decided against this policy, protocol would have been established for performing customary geotechnical exploration, in-situ and laboratory testing, dike seepage and stability analyses, and adherence to the higher "dam" design standards, and the probability of identifying some or all of the conditions that led to the Kingston failure would have increased significantly.

- The design of the Kingston coal ash dredge cells should have included a thorough engineering evaluation of all potential failure modes.

- AECOM's study focused disproportionately on the significance of the thin, discontinuous, soft foundation layer (sensitive silts and slimes) as one of the most probable factors/root causes. Marshall Miller stated the significance of the "Fill Geometry" factor/root cause should be equally emphasized. This fill geometry refers to upstream-constructed dike configuration on sluiced ash foundation. In Marshall Miller's professional opinion, "Fill Geometry" is of equal or greater significance relative to the "Soft Foundation Soils" factor.

- AECOM's root cause study concludes, "*The failure on December 22, 2008 depended on all four factors [root causes], without them working in combination, the failure of Dredge Cell 2 would have not likely occurred on this date.*" In Marshall Miller's professional opinion, the suggestion that all four factors had to work in combination to cause the failure diminishes and disregards the risks that were posed by the upstream-constructed dike configuration and disposal procedures and the ever increasing height of Dredge Cell 2.

- Other factors evaluated by AECOM as probable root causes should be strongly considered by TVA and the power generation industry as a whole in evaluating the condition and structural integrity of ash disposal facilities. Each one of these factors is critical and should be closely evaluated for all of the existing TVA ash handling and disposal facilities. These concerns and findings could have a significant effect on the requirements and standards of care for facilities throughout the Fossil Plant industry.

- It would not be prudent to assume that, if the slimes layer observed in the failed section at Kingston does not exist at other plant sites, there is adequate stability of these structures. On the contrary, the information developed from the extensive studies conducted by both Stantec and AECOM indicates that there is a reasonable risk of other dike failures if changes are not made in the design construction, oversight, and operation of the wet ash disposal sites throughout TVA.

- If the ash ponds had been included in the Dam Safety Program, closer evaluation and a more sound "engineered" solution probably would have occurred pertaining to the 2003 leak at the Swan Pond road dike.

- TVA "designs" provide very little "room for error" which was evident at Kingston. It is considered solid engineering practice to design such facilities with features that provide a reasonable degree of redundancy or "second line of defense" in the event that one or more of the systems becomes inoperable. In Marshall Miller's opinion, it is important this design philosophy be applied to all of TVA's ash disposal facilities.

TVA'S ENTERPRISE RISK MANAGEMENT PROGRAM DID NOT ADEQUATELY ADDRESS KNOWN RISKS ASSOCIATED WITH ASH PONDS

Risk management underpins an agency's approach to achieving its objectives and provides crucial mechanisms for staff to identify and report key risks to senior management. An Enterprise Risk Management process is designed to identify and mitigate risks such as those associated with ash management. Successful implementation of a risk management program occurs when:

- Risk management is embedded in how the organization conducts business;

- The value of risk management is clearly understood by executive and line managers;
- The firm's risk tolerance is clearly articulated;
- Risks are systematically identified, assessed, and communicated;
- Decisions are made with due consideration to risk/return tradeoffs; and
- Risk adjusted performance metrics are specified and monitored.

Modern corporations operate to a certain extent based on their assessment of risks. The better the risk assessments of the company the better the company performs. Risks tolerance differs in every industry and in every company. Some companies have a very low risk tolerance, for example, for activities that could result in breeches of environmental compliance or public safety. A company's Enterprise Risk Management Program ideally identifies risks on what is commonly referred to as a "heat map" according to the likelihood of a risk occurring and then the severity of consequences if the risk event occurs. If the likelihood is high and the severity is high, the corporation typically devotes more resources to risk avoidance in that particular area. TVA's Enterprise Risk Management Program began in 1999, when TVA's Board of Directors issued a risk policy authorizing the creation of a Risk Management Committee, appointment of a Chief Risk Officer, and adoption of an enterprise-wide risk management approach.

The OIG reviewed the Enterprise Risk Management Program in both 2003 and 2008 and recommended various improvements to it. The 2008 review, done with the assistance of an external consultant with broad knowledge of risk management practices, found that TVA had made progress in risk identification and assessment since 2003 and that the commitment to risk management at the top of the agency was strong. However, the OIG assessment, published in September 2008, also found that the program needed to be driven further down into the organization.

We determined that risks associated with ash management were known internally as early as 1987. Despite this internal knowledge, we found no evidence that TVA's Enterprise Risk Management Program had identified ash management as a significant risk.[20] While TVA did not have a formal Enterprise Risk Management process during the 1987 through 1996

[20] The only risk related to ash identified by the Enterprise Risk Management Program, in March 2008, was the financial risk that ash ponds would be designated as hazardous waste facilities requiring liners and other remediation actions.

timeframe, it did have one at the time of the Kingston Spill and for several years prior.

In reviewing documentation, we found numerous memorandums dating from 1987 through 1996 where TVA internally discussed whether ash ponds should fall under the Dam Safety Program. TVA recognized that if dam safety guidelines were implemented, additional steps would need to be taken, such as closely reviewing the existing inspection procedures for compliance with dam safety requirements, performing additional stability analyses, adding monitoring instrumentation, and instigating a drilling and testing program. Some TVA managers and executives took the position that managing ash ponds under the Dam Safety Program was unnecessary for safety, and TVA was not technically required to do so. TVA ultimately did not place the ash ponds under the Dam Safety Program.

Below are some highlights from the memorandums we reviewed where placing TVA's ash ponds under its Dam Safety Program was discussed:

- In June 1987, the Manager of Policy, Planning, and Budget stated that, "Greater amounts of ash have resulted in expansions of ash ponds. In some instances the dikes that contain this water have become quite high with increasing risk and consequences of a breech. Because of the potential for harm to both surface and groundwater from the failure of a dike, greater attention and establishment of more specific inspection standards for these dikes should be examined."

- In response to the June 1987 memorandum, the Safety Office Coordinator prepared a memorandum stating: "(1) Many of these dikes should be classified as dam safety (possibly safety deficient) and inventoried into TVA's inventory as Ash Pond Dikes, and (2) TVA should bite the bullet and place them under the Dam Safety Office and begin a program similar to the present dam safety program."

- In 1988, the Manager of Dam Safety Program wrote, "It is my understanding that there may be as many as 17 ash ponds contained by earthen filled "dams" in the TVA system that may meet or exceed the technical definition provided by the guidelines." Yet in 1989, the Vice President of Power Engineering and Construction stated, "The potential for loss of life or significant property damage as a result of a failure at one of these facilities is minimal…Therefore, we can see no advantage to TVA in reassigning management control to the Dam Safety Program."

- In a 1988 draft memorandum, the Vice President of Power Engineering and Construction wrote, "Because of concerns about groundwater contamination, TVA is moving away from wet ash disposal techniques to dry stacking."

- In an undated memorandum, the Vice President of Fossil and Hydro Projects said for those dikes redefined as dams, "TVA will have to (1) perform additional stability analysis, (2) add instrumentation, ….., (3) calculate and document flooding criteria, (4) perform inspections at intervals no greater than 2 ½ years, and (5) prepare emergency notification procedures for each plant."

- In 1996, the TVA Manager of Fossil Engineering stated, "A previous internal agreement established that TVA does not consider the waste disposal area dikes hazardous as defined by this act. Therefore, we continue to manage them as pollution control facilities, not 'dams.'…In general, we would expect these inspections to meet dam safety inspection requirements; however, should these dikes be reclassified as 'dams,' we would need to closely review our inspection procedures for compliance. Also, should these dikes be reclassified to 'dams,' we would probably need to reanalyze our dike stability and in many cases, need to instigate a drilling and testing program before performing this analysis…We believe it would be in TVA's best interest to continue to treat the waste area dikes as pollution control facilities rather than as 'dams.'"

Since the September 2008 OIG assessment of TVA's Enterprise Risk Management Program, TVA has hired additional risk management personnel and restructured its program to, among other things, drive the program further down into the organization by starting the risk assessment process in the strategic business units. If TVA is able to do this effectively, it will increase the likelihood that it will surface and deal with issues such as the ash ponds that were known to various parties in TVA but not identified as part of the Enterprise Risk Management process.

THE CULTURE AT TVA'S FOSSIL FUEL PLANTS IMPACTED ASH MANAGEMENT

It's the Culture

Our review disclosed attitudes and conditions at TVA's fossil fuel plant that emanate from a culture that impacted the way TVA handled coal ash. We give some examples of that in this section that may seem anecdotal, but they are consistent with our observations about the culture in other parts of TVA as well. Over the last nine months, the OIG has conferred with the

TVA Board and TVA management about what we perceive to be systemic problems that have their genesis in the culture. While we recognize that there is no one culture at TVA and instead there are subcultures that vary from one organization to another within TVA, there are common themes we find antithetical to a high performance organization. While the culture at TVA's fossil fuel plants is not the cause of the Kingston Spill, the culture, in our view, is likely to be resistant to the kinds of reforms necessary to avoid other safety failures.

Corporate culture is defined as the combined beliefs, values, ethics, procedures, and atmosphere of an organization. The culture of an organization is often expressed as "the way we do things around here" and consists of largely unspoken values, norms and behaviors that become the natural way of doing things.[21] Over TVA's 75-year history, cultural traits have developed that if not identified and addressed can undermine the best policies and procedures. The importance of recognizing cultural limitations cannot be overemphasized.

This discussion of culture could be perceived to suggest that TVA employees are guilty of bad behavior. Culture, however, is more a product of management and leadership over successive generations than a product of a bottom up phenomenon. Changing or renewing corporate culture in order to achieve the organization's strategy is considered one of the major tasks of organization leadership and such change doesn't happen without focused leadership. We believe that TVA employees come to work every day to do a job, a good job. If their culture ("how we do things around here") harms the organization, that is a leadership problem.

TVA management is now implementing new policies and procedures to change the way TVA has handled coal ash. History suggests that the very best policies and procedures can be successfully resisted by a strong legacy culture. For TVA to be successful in avoiding another Kingston Spill, the culture must be accurately assessed, compliance with new policies and procedures must be faithfully measured with appropriate metrics, and employees must be educated to think differently about ash management than they have over several generations.

[21] This definition of corporate culture came from the BNET.com Business Dictionary, Corporate Culture: Definition and additional sources from BNET. BNET's Web site notes its Business Library provides unlimited access to one of the largest databases of white papers, Web casts, and case studies on the Web.

Corporate-wide safety programs fail when policies and procedures are not driven from the top of the organization to the bottom of the organization. That requires clear communication from leaders and crisp "zero-tolerance" from managers below them. The audits and investigations conducted by the OIG over the last ten years indicate repeat findings of noncompliance with policies and procedures. The challenge to drive compliance consistently through the organization is a difficult one that requires a new approach.

As we state in our recommendations section of this report, we believe TVA needs a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA. This group should be tasked with identifying and addressing directly any underlying resistance not just to the new policies and procedures for coal ash management but resistance to TVA's policies and procedures across the enterprise. A change management task force of sorts should also: (1) devise a comprehensive plan to drive compliance; (2) establish appropriate metrics to measure accountability; and (3) review policies and procedures for consistency and relevancy.

History suggests that if TVA merely creates new policies and procedures to be implemented in the same fashion as before but within a new organizational box, the culture will eventually erode the effort. While a task force approach to compliance may seem drastic, the Kingston Spill demonstrates how ineffective programs can be if a legacy culture is not addressed.

Culture and Ash Management

During our review, we found that ash management at TVA reflected a culture that ash was unimportant. This resulted in significant weaknesses in ash management practices across TVA including: (1) a failure to implement recommended corrective actions that could have possibly prevented the Kingston Spill; (2) the lack of policies and procedures; (3) poor maintenance; (4) the lack of specialized training; (5) multiple organizational structure changes; (6) inadequate communication; and (7) a failure to follow engineering best practices.

While the weaknesses we identified clearly demonstrate cultural issues, interviews with current and former TVA employees lend further support to our view that ash was seen as unimportant. We interviewed plant personnel, engineering personnel, and management and heard several comments indicative of a culture resistant to treating ash management as much more than taking out the garbage. For example:

- One member of management stated, “Ponds have always been the back end of the plant. It is the same way at other utilities,” indicating that ponds are not an area of primary focus for utilities.

- A former member of management believed, “Being sent to Yard Operations is like being sent to Siberia,” suggesting the yards were not considered a place of high importance.

- Another employee said, “The further away from the plant you got the less management seemed to care,” conveying the ponds got little attention because they were away from the plant and not directly related to power production.

- A TVA engineer said TVA had always stacked ash higher at KIF so it must be okay. He went on to say that if something worked in the past, TVA will keep on doing it and that TVA had a cheap solution to ash storage by stacking higher so that is what they did.

- After being questioned about a current ash disposal project by Marshall Miller, a TVA engineer was critical of Marshall Miller consultants and stated they were trying to turn a landfill into “rocket science.” This is clearly reflective of a culture resistant to a professional engineering standard of care.

TVA Lacked Policies and Procedures for Ash Management

When asked by the OIG, TVA personnel were unable to provide any policies and procedures dealing with the storing, handling, and maintaining of ash and ash facilities. TVA personnel said they follow the state approved operations permit for each plant, but had no policies and procedures regarding how to do so. Without policies and procedures, it is unclear who is responsible for specific tasks, how to address certain problems when they arise, and how to ensure proper communication occurs. When discussed with the CEO, he agreed that without policies and procedures needed actions often do not occur.

Ash Storage Facilities were Poorly Maintained

Through review of inspection results and visits to seven sites[22] by Marshall Miller, we found that reported maintenance issues were often not addressed. TVA Engineering conducts annual inspections of each of TVA’s ash storage areas. These inspections are documented in the annual inspection report for each fossil plant. Our review of all such

[22] Marshall Miller visited and assessed conditions at the following seven sites: Bull Run Fossil Plant, Cumberland Fossil Plant, Johnsonville Fossil Plant, John Sevier Fossil Plant, Kingston Fossil Plant, Paradise Fossil Plant, and Widows Creek Fossil Plant.

available reports for the last five years for each of TVA's plants found that legacy problems existed at all of TVA's fossil plants. Legacy problems are problems documented in consecutive reports without being addressed by TVA. We found the following legacy problems in reviewing the inspection reports:

- Erosion – which can cause dike instability because of loss of structural cover;
- Seepage – which can cause internal dike erosion and dike instability;
- Overgrown vegetation – which can make it difficult to conduct a thorough inspection and to identify suspect dike changes, such as cracks, bulging, and seepage outbreaks;
- Sparse vegetation – which can allow erosion to occur and expand more rapidly;
- Tree growth on dikes – which can mask seepage issues and weaken the structural integrity of the dike;
- Standing water – which can cause the soil and ash to become saturated and weaken the dike; and
- Piping issues – joint and seepage failures and displaced materials at outlet piping.

TVA Engineering reported these issues repeatedly, but few corrective actions were taken. There were certain instances where corrective actions created additional problems. For example, in one instance TVA cut down trees to address a vegetation issue, but did not remove the roots; as a result, depressions developed on the dikes.

In addition, Marshall Miller's work at seven sites confirmed what we found in reviewing the annual inspection reports. They noted general maintenance issues at each facility visited. Legacy maintenance issues identified by Marshall Miller include:

- Heavily overgrown vegetation.
- Trees on dikes.
- Indications of six shallow depressions of varying size and depth in the western slope of the embankment at Johnsonville Fossil Plant (JOF).

Some of these depressions have been documented by TVA during its yearly inspections; however, it appears they were not addressed until very recently. Specifically, TVA's inspection reports for the previous three-year period stated that initially one, then four, and finally six depressions were observed to be re-occurring on the western side of the embankment. While the condition worsened from year to year, no actions were taken to address the problem (Stantec has performed an investigation of the depressions and determined that no additional actions are needed at this time).

- The presence of multiple uncontrolled seepage points or seepage outbreaks is one of the main problems at the JOF Active Ash Impoundment Area. These apparently have existed for many years. They have been documented by TVA representatives and/or their consultants in various inspection reports; however, no actions have been taken to resolve the conditions.

In our discussions with the Senior Vice President, Fossil Operations Support, he concurred that maintenance has been a big problem in the past. For example, he noted that it had been a common practice to mow the facilities only twice a year, which made visual inspections difficult if not impossible. He further noted that TVA is working to address this issue by increasing the frequency of mowings, removing trees from dikes, improving drainage, and other steps as needed to improve maintenance.

Ash Storage Inspectors at TVA Lacked Training

Through interviews conducted at fossil plants, we found that there is no formalized training for the personnel who inspect the dikes. The daily visual inspections are generally conducted by plant personnel and annual inspections are conducted by engineering personnel with no specialized training for dike inspections. Management concurred that no specialized training for inspectors of ash pond dikes had been provided. In our opinion, standardized training would result in several significant benefits, such as equipping inspectors to:

- Recognize maintenance issues early;
- Properly assess the significance of issues identified;
- Identify changing conditions; and
- Properly communicate issues identified.

Organizational Changes Hampered Accountability

Through the years the management of the ash ponds has undergone significant changes. In 1999, Yard Operations, which had responsibility for the ash ponds, was moved from the plants' control to the Heavy

Equipment Division (HED). The plants had numerous efficiency issues, and management did not believe the plants could address those issues as well as the problems that existed with Yard Operations and the ash ponds.

In 2006, TVA's CEO made the decision to move the ash pond management back under the control of the plants. However, the CEO said that he had concerns about accountability because of all the organizational changes that occurred in this area over the years. According to the COO, TVA recognized this problem and has reorganized the ash management function to, among other things, promote accountability. Prior to the spill in 2008, Combustion By-Products moved from the Fossil Operations Region 2 group to the Operations Support group.

Communication Among Organizations was Inadequate

Through interviews and document reviews, we found that fragmented organizational responsibilities for ash management created silos that contributed to inadequate communication. One individual stated plant management was not informed of problems with the ash ponds. The problem was further demonstrated by a TDEC representative who stated, "It seemed the plant management, the environment group, and other groups at TVA were not always communicating." The TDEC representative stated that his questions often had to be directed to different groups. He heard from TVA personnel that they could not get management to recognize the urgency of ash management at the plants. Another communication issue was found in a plant's summary of the FY 2008 Inspection Report. An engineer stated, "An internal dredge cell was constructed inside of the bottom ash pond without consultation or input from Engineering. It was in such poor condition that Engineering recommended against its use until modifications were made. (Subsequent to the inspection, modifications were made and the dredge cell was used successfully.)" The fact that modifications were made to an ash facility without obtaining input from engineering demonstrates a lack of communication, as well as a lack of appreciation of the importance of having professional engineering input into dike modifications.

During a site visit to one of the plants, Marshall Miller identified uncompacted and/or poorly compacted gravel that had been placed around the perimeter of the fly ash impoundment. In Marshall Miller's opinion, the condition of the stone layer indicated there had not been any engineering or field oversight/quality control to ensure it was properly placed and compacted. Since the proper base was not established and the gravel was poorly compacted, it would not achieve its intended purpose and was a waste of TVA money. TVA management

acknowledged that they acted quickly to address complaints about ruts and holes due to increased traffic in the area and did not obtain engineering input.

TVA Did Not Follow Engineering Best Practices

We found that TVA did not follow engineering best practices with respect to ash ponds. According to Marshall Miller, dikes such as the failed one at Kingston that contain hydraulically placed materials with the potential to impound water should be treated as dams. Compared to a dam constructed across a valley or hollow, expansive dike systems for coal ash storage can present greater uncertainties relative to the native foundation, hydraulically placed materials, and dike/embankment materials. Marshall Miller observed that treating ash storage facilities as dams would have significant implications to TVA's (1) standards for designing the facilities, (2) construction documentation and inspection, and (3) instrumentation and monitoring activities (for more detailed information see Appendix C).

Moreover, during the course of our review, we discovered a TVA design guide for performing static slope stability analyses that was last updated in June of 1981. The design guide covered key areas such as: (1) field and laboratory testing, (2) evaluating soil characteristics, (3) facility loading characteristics and required factors of safety, (4) methods of analysis, and (5) slope stabilization techniques. Our consultant, Marshall Miller, reviewed this design guide and commented that it represented good engineering and design standard as of 1981. Unfortunately, TVA has not updated the design guide to reflect engineering and design standards as they evolved since 1981.

In practice, we saw this failure to follow engineering best practices manifest itself in several ways. For example:

- TVA did not create "as-built" or "record" drawings, which would document construction of the facilities as they were built including any deviations that might occur between actual construction and the engineered design, permit, or construction drawings. According to TVA engineers, this has been a problem but recent improvements have been made in regards to placing "as-built" drawings on the TVA drawing system.

- TVA did not always have an engineer on-site to perform Construction Quality Assurance/Construction Quality Control (CQA/CQC) while modifications or construction of ash storage facilities occurred. The CQA/CQC function helps to ensure that the facilities are designed to current engineering, agency, and regulatory standards and remain in accordance with good engineering practice. Furthermore, this practice

ensures that these facilities are constructed in accordance with approved engineering design plans, and that the as-constructed conditions are properly documented for future reference.

- TVA did not require construction drawings to be stamped by the Professional Engineer (P.E.) of record. A P.E. stamped drawing would identify the design engineer-of-record and their firm, which would reduce the risk of using an incorrect version of a drawing, provide an appropriate technical contact for resolving ambiguities in design and construction documents, performance issues, and other problems that might arise, and define the primary entities that are accountable for the design. Management stated they will evaluate the need to have construction drawings stamped in the future.

As we point out above, these conditions indicate a pervasive legacy culture that impacted coal ash management. A new approach as suggested in our recommendations section is warranted.

TVA HAS RECENTLY ACTED TO ADDRESS CERTAIN ASH MANAGEMENT WEAKNESSES

As we have previously noted, since the Kingston Spill TVA management has begun to reassess its ash management program and has taken several actions to improve ash management across the agency. These actions include (1) organizational changes to address management and accountability issues, (2) changes designed to change the corporate culture which had deemphasized the importance of ash management, and (3) steps to assess ash storage facilities against dam safety guidelines with the goal of complying with dam safety guidelines where possible. Actions taken to-date include:

- TVA recognized there are too many business units involved in ash pond design, maintenance, modification, and operations and has taken steps to improve the organizational structure. On April 24, 2009, the COO announced that TVA will be establishing a new Coal Combustion Products Management Division (CCPMD). According to the COO, "This will allow us to bundle all coal-combustion products, gypsum-management activities and other ponds into one group to develop and implement a consistent fleet strategy for these operations." The Senior Vice President (SVP) of Fossil Operations Support said TVA has reorganized the fossil division for better management. He said one person has been designated Vice President of Engineering and will be responsible for the contractor assessing and designing changes for all TVA ash facilities, all the capital projects to convert the wet ponds to

dry stacks (including gypsum and ash), closure of the ponds, new bottom ash ponds, and issues identified during inspections. He further explained that another position has been given responsibility for the day-to-day operations, by-product sales, maintenance, and assigning dedicated supervisors for the daily operation of the ponds. The maintenance program will also include any ponds which have the potential for an environmental release. The COO stated the organizational changes were made to enhance accountability, transparency, and communication.

- TVA also recognized that the mindset and culture regarding ash ponds needed changing and more emphasis needs to be placed on ash management. For example, the SVP of Fossil Operations Support was recently given the authority to shut a plant down if he finds significant issues with ash management. In addition, the organizational changes to enhance the authority and accountability of those responsible for ash management described above, along with the memory of the KIF spill, underscores the importance of the proper management of ash at TVA.

- In addition, TVA has moved toward managing the ash ponds under dam safety engineering, construction, and operation, inspection and maintenance guidelines. According to the COO, TVA is now taking steps to implement a program for ash facility management that is in compliance with dam safety guidelines. He went on to say while TVA plans for ash storage facilities to meet dam safety requirements, they acknowledge that some facilities may not be able to meet all the requirements because of their original designs and construction. TVA hired Stantec to assess the condition of its ash ponds and to help restructure ash management. For example, TVA does not believe it can meet the recent seismic requirements for the dam safety standards at certain facilities. In addition, the Stantec assessments may reveal that certain other dam safety standards are unachievable. Stantec stated that TVA had not previously followed the dam safety guidelines for their ash ponds because Tennessee regulators exempted TVA, Alabama does not have clear dam safety guidelines, and it was unclear to Stantec if TVA was granted an exception to the Kentucky dam safety guidelines.

RECOMMENDATIONS

In addition to the management actions noted above, we recommend the CEO, in consultation with the Board of Directors, where appropriate:

- Commission a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA and measuring positive changes in the culture that effects ash management and other TVA programs.

- Assess the culture of the fossil fuels group to determine what changes need to be made, if any, to ensure the support for sound policies and procedures related to ash management.

- Assess the management practices of TVA for ash management to determine whether those practices contributed to the failure of the dike at Kingston.

- Complete the assessments of TVA ash storage facilities and determine which ones are at risk of failure. The determination should be, as suggested by Marshall Miller, based on whether any of the four conditions contributing to the failure at Kingston exist sufficiently to pose a significant risk of failure. The determination should not be limited to just looking for the existence of the combination of all four contributing conditions found at Kingston.

- Develop policies and procedures for the storing, handling, and maintaining of ash and ash disposal facilities.

- Continue the efforts to drive the Enterprise Risk Management Program further down into the organization to increase the future likelihood that known risks will be identified and addressed.

OBJECTIVE, SCOPE, AND METHODOLOGY

The objectives of our overall review are to determine (1) the causes of the spill, (2) the adequacy of TVA's response to the spill, and (3) what TVA can do to assure the public that a similar spill will not occur again at this or any other TVA plant. The purpose of this inspection is to (1) provide an independent peer review of AECOM's root cause analysis and (2) review TVA's ash management for weaknesses. To achieve the objectives of this report, we:

- Hired Marshall Miller & Associates (Marshall Miller) to perform an independent peer review of TVA's root cause analysis and provide other observations about coal ash management at TVA. Marshall Miller has expertise in coal ash and other waste materials, containment design for hydraulically placed or sluiced ash and mine tailings, earthen and mine waste dams and, more generally, materials science and geotechnical engineering. Marshall Miller's peer review of AECOM's root cause analysis is presented in the attached Appendix B, and its other observations on coal ash management at TVA are in Appendix C.

- Conducted interviews with selected TVA management, engineering personnel, plant personnel, and consultants.

- Obtained and reviewed the last five years of available annual inspection reports of TVA waste disposal facilities to identify legacy issues at the fossil plants.

- Performed walkdowns, along with Marshall Miller, of seven fossil sites.

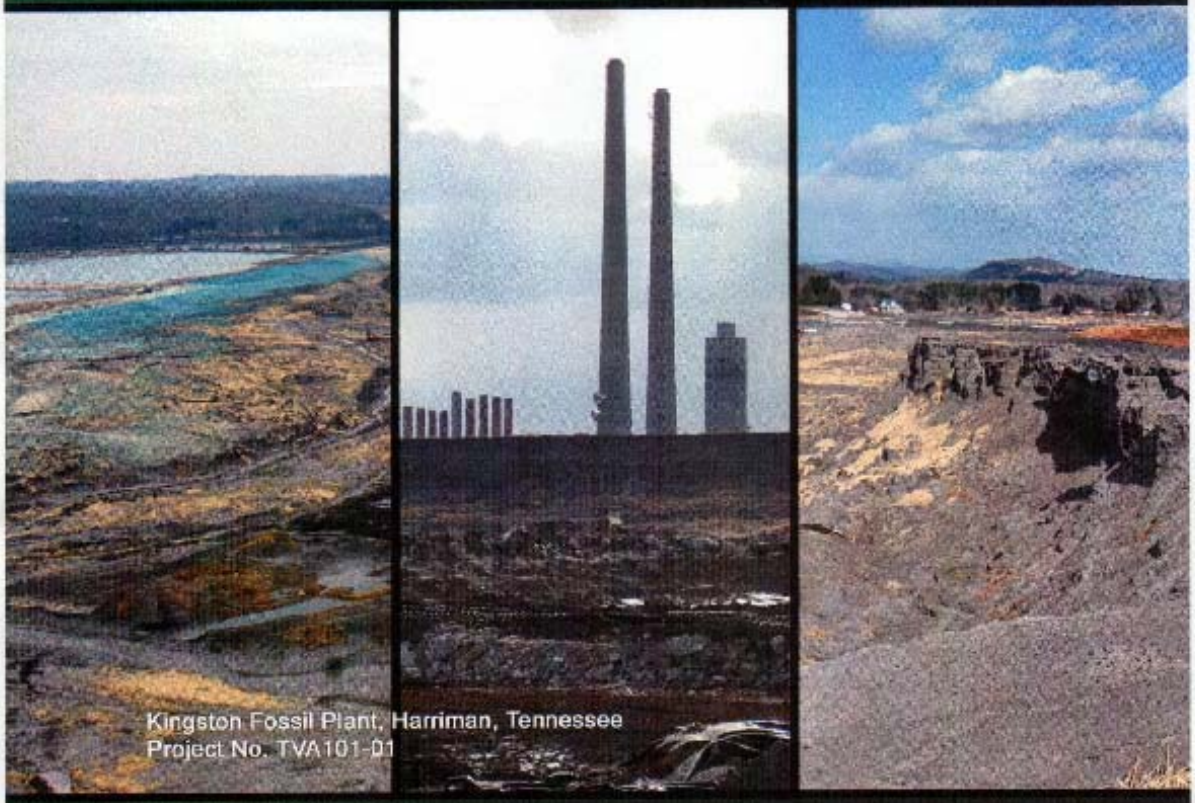
- Obtained and reviewed documentation pertaining to the ash storage at TVA (e.g., memorandums, quarterly inspection reports, etc.)

- Attended key TVA meetings, which included amongst others TVA's consultants.

This review was conducted in accordance with the Quality Standards for Inspections.

Report

Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008



Kingston Fossil Plant, Harriman, Tennessee
Project No. TVA101-01

Prepared for:

July 2009

TVA Office of the Inspector General
Knoxville, Tennessee

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MARSHALL MILLER & ASSOCIATES

Item 1: TITLE PAGE

Title of Report

Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008

Project Location

The project site is located in Harriman, Roane County, Tennessee, and is situated on a peninsula formed by the confluence of the Emory River and the Clinch River.

Qualified Persons

William S. Almes, P.E.
Project Manager
Senior Engineer & Director of Geotechnical Services
Marshall Miller & Associates, Inc.

Edmundo Laporte, P.E.
Senior Project Engineer
Marshall Miller & Associates, Inc.

Christopher J. Lewis, P.E.
Principal Engineer
D'Appolonia, Engineering Division of Ground Technology, Inc.

Effective Date of Report

July 9, 2009

MARSHALL MILLER & ASSOCIATES

Item 2: TABLE OF CONTENTS

LIST OF FIGURES

Note: Figures 1 through 5 have been included within this report for reference only. All figures were obtained from the AECOM report entitled "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" dated June 25, 2009.

Item 3: INTRODUCTION AND BACKGROUND

The **Tennessee Valley Authority (*TVA*) Office of Inspector General (*OIG*)** engaged **Marshall Miller & Associates, Inc. (*MM&A*)** to conduct a peer review of the Root Cause Analysis (*RCA*) prepared by **AECOM Technologies Corporation (*AECOM*)** relating to the ash dredge cell failure which occurred at the TVA Kingston Fossil Plant (*Kingston*) near Harriman, Tennessee, on December 22, 2008. On June 25, 2009, AECOM publicized the results of its comprehensive six-month study entitled "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008." According to AECOM, the root cause of the failure was a complex set of conditions, including a long-evolving combination of the high water content of the wet ash, the increasing height of ash, the construction of the sloping dikes over the wet ash, and the existence of an unusual foundation layer consisting of sensitive slimes and silts.

It is MM&A's understanding that shortly after 12:00 a.m. Eastern Standard Time (*EST*) on December 22, 2008, the north and central portions of Dredge Cell 2 of the ash disposal site failed, and an estimated 5.4 million cubic yards of ash were released in a progressive sequence of flow slides over a period of one to two hours. The ash spill extended outside of the Dredge Cell 2, covering approximately 300 acres of the Swan Creek flood plain and surrounding acreage. While there was no loss of life, 3 homes were destroyed and 23 homes were damaged, electrical power was disrupted, a natural gas line in a neighborhood located adjacent to the plant was ruptured, and the ash covered a railway and road in the area. The flow slide extended beyond the limits of the original ash pond, referred to as Dike C. AECOM described the uneven limits of the flow slide as extending (1) northward approximately 3,200 feet up Slough No. 2 and against the flow of the Emory River Channel; (2) more than 1,600 feet southward toward the Emory River; and (3) nearly 1,000 feet up Slough No. 3, a side channel to the reservoir. The ash disposal Cell 2 had been permitted by the **Tennessee Department of Environment and Conservation (*TDEC*)** as a Class II Solid Waste Landfill under State regulations.

MM&A initially visited the Kingston facility on February 4, 2009, and met with various representatives of the OIG, TVA, and AECOM, among others, during the course of the engagement. Subsequently, MM&A was provided access to various documents including

engineering design drawings, photographs, aerial maps and other documents which were reviewed in the context of the engagement.

Item 4: MM&A PROJECT TEAM

MM&A, an employee-owned Engineering News-Record Magazine (*ENR*) Top 500 company, began offering geologic services to the mining industry in 1975 and for 33 years has provided a full range of related services to the mining, utility, financial, governmental, and legal industries. Today, MM&A employs nearly 200 engineers, geologists, scientists and other professionals working from regional offices in ten states.

It is noteworthy that members of MM&A's Project Team have been intimately involved with the development of the two engineering design manuals prepared by the **Mine Safety and Health Administration (*MSHA*)**, which specifically address the procedures that should be followed for designing and operating coal refuse impoundments and embankments. The first manual was published in 1975, and an updated version is scheduled to be released in 2009. Although these manuals were written to address the design and operation of coal refuse disposal facilities, the key chapters, which include material characterization, hazard classification, planning, staging, foundation considerations, surface drainage and storm water control, instrumentation monitoring, geotechnical engineering and design, seismic hazard assessment, seismic stability and deformation, environmental considerations, and emergency action plans, are directly applicable to the disposal of fly ash and bottom ash materials

MM&A has also been involved with forensic studies of major waste impoundments that have experienced uncontrolled releases of fine slurry, as well as slope instability within the embankment portions of both coal ash embankments and impoundments and coarse coal refuse dams.

The MM&A Project Team is comprised of the following professionals:

- Mr. Peter Lawson – Executive Vice President & Principal-in-Charge
- Mr. William S. Almes, P.E. – Director of Geotechnical Services & Project Manager for TVA OIG
- Mr. Edmundo Laporte, P.E. – Senior Engineer
- Mr. William M. Lupi, P.E. – Project Engineer

- Mr. John E. Feddock, P.E. – Senior Vice President & Senior Peer Review Team Member
- Mr. Richard G. Almes, P.E. – Principal Geotechnical Engineer & Senior Peer Review Team Member
- Mr. Christopher J. Lewis P. E. – Principal Geotechnical Engineer & Senior Peer Review Team Member[1]

[1] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

Item 5: SCOPE OF WORK & BACKGROUND

5.1. SCOPE OF WORK

MM&A was engaged to provide technical support and independent opinion to the TVA OIG in its review and documentation of the failure of Dredge Cell 2. Specifically, MM&A was to perform an independent peer review of AECOM's RCA report as contracted by TVA.

MM&A has completed a peer review of the final version of the AECOM RCA. Notably, MM&A did not conduct a parallel investigation to AECOM's. MM&A's professional opinions are based principally on the review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, Illinois, office location on June 2, 2009, briefings provided by AECOM during presentation and conference call meetings, and a review of the final RCA report dated June 25, 2009.

5.2. BACKGROUND

AECOM was retained by the TVA **Office of General Counsel (*OGC*)** to perform an RCA investigation of the ash Dredge Cell 2 failure, after AECOM conducted its initial visit to the site on January 8, 2009. According to AECOM, its scope of work was limited to the identification of the likely initiator(s) ("root cause(s)") of the failure, which, according to AECOM, inherently encompasses consideration of potential failure modes, possible "initiators" or "triggers" of the onset of failure, and factors that contributed to its progression or propagation.

AECOM executed a consulting agreement with the OGC on January 16, 2009, and commenced a data review phase shortly thereafter. Simultaneously, AECOM started a field exploration campaign, which ended on April 3, 2009. The field exploration program included the following activities:

- Completed 147 sampling borings
- Performed 59 standard penetration test borings
    - 8 of the 59 borings included rock coring and 25 of the 59 borings included slope inclinometer installations
- Prepared 21 piezometer locations and installed 54 piezometers
- Completed 48 vane shear/2" Shelby tube test borings

- Completed 40 Osterberg/Shelby tube sampling holes
- Completed 87 cone penetrometer CPTu tests
- Drilled and installed cross-hole geophysical test borings for **Stantec Inc. (*Stantec*)**, a subcontractor for TVA
- Located, surveyed, and logged identifiable relics
- Surveyed monuments, spillway, cell tower, outlet piping, etc.
- Observed two test trenches for location of outfall piping

As field samples and observations became available, AECOM started the laboratory testing and analytical phases of the project, which MM&A understands were completed during the first week of June 2009. AECOM performed multiple engineering analyses of the data obtained from site surveys and laboratory test results, while also undertaking an extensive compilation and review of documents from TVA's archives. The purpose of the laboratory testing program was to characterize the native soils and non-native site materials and to determine the geotechnical and mechanical properties of the soils and materials. In this manner, AECOM could analyze the soils' respective behavior and postulate the conditions prevailing in and below Dredge Cell 2 and Dike C prior to the failure on December 22, 2008.

It is MM&A's opinion that the scope of the investigation, as presented by AECOM, was sufficiently thorough for the RCA and applied appropriate investigative methods, in-situ testing techniques, and sampling practices. MM&A also believes that the laboratory geotechnical testing program was sufficiently thorough and applied appropriate and complementary suites of tests to characterize the native soils and non-native site materials (e.g., ash and slimes) in the primary areas of interest for the RCA.

Item 6: GENERAL BACKGROUND ON HISTORICAL ASH DISPOSAL PRACTICES

AECOM documented the history of development of fly ash disposal at Kingston, including the depositional and construction history of Dredge Cell 2 and of Dike C surrounding Dredge Cell 2 (See *Section 1.2* of the AECOM's RCA report dated June 25, 2009). Several important factors are observed from this history:

- The ash storage facility was built over portions of the former Swan Pond Creek flood plain. Clayey sediments found below Dike C and Dredge Cell 2 are "lacustrine," a term which refers to sediments deposited in lake environments. The type of sediment deposited in lakes can vary widely and locally depends upon the size of the lake, the climate, and the nature of the surrounding soils and environment.

- Prior to the construction of the initial ash containment dike, fly ash from the plant was sluiced directly into the Watts Bar Reservoir.

- In 1958, Dike C was completed creating the Ash Pond.

- Since the passage of the Clean Water Act in 1972, many industries in the United States, including the power industry, implemented new waste handling and disposal practices in an effort to prevent pollution of surface water and groundwater features. As a result of the operational changes, containment dikes for the ash disposal ponds were required. The upstream construction method, as depicted in **Figure 1**, consists of raising the crest of the impounding dike by constructing each successive dike, or stage, above previously placed/sluiced ash, which then becomes the foundation material.

- While employing the upstream construction method during the vertical expansion of the existing dredge pond, TVA's use of this practice at the site resulted in the Dredge Cell 2 having a series of ash dikes built with 3H:1V slopes and 15-foot wide benches founded on 35 to 40 feet of hydraulically placed or sluiced ash, with a 200-foot setback from the original Perimeter Dike C. The ash used for dike construction was

dredged from an adjacent ash collection / settling pond which was allowed to dewater over time.

- As the height of the dikes was increased, the dredge cell footprint area decreased as new lifts of material were placed. Consequently, more height was necessary to provide adequate storage for the same annual production of ash at the fossil plant. This process increased the total load and rate of loading imposed on the sluiced ash.

- Samples of the sluiced ash indicate that it has a high void ratio and does not show signs of consolidation or densification under the weight of new ash placed over older ash. As a result, the wet ash remains very loose and susceptible to liquefaction under rapid loading or rapid displacement.

- Laboratory test results also indicate that the wet ash is prone to experience static liquefaction due to its highly sensitive structure, which shows a rapid decrease in its shear strength when it changes from a drained to an undrained behavior.

The conclusion from these observations, and from the testing performed by AECOM, is that the depositional sequence and construction methods employed by TVA were confirmed by the exploration and testing program.

Item 7: Field Observations to Understand Direction of Movement and Failure Sequence

MM&A reviewed results of the analyses performed by AECOM to determine the direction of movement and inferred failure sequence. This was partly based on correlation of the final resting place of various relics observed on-site with their estimated position in the original dike configuration. It is MM&A's opinion that the methodology used by AECOM to determine the direction of movement is sound and, according to the information presented in AECOM's final RCA report, gives reasonable support to AECOM's generalized potential failure sequence.

7.1. Assessment of Key As-Built Condition Versus Design Configuration

7.1.1. Test Trench Exploration

As part of its RCA, AECOM excavated a test trench in one of the unfailed dikes in order to achieve the following goals:

1. Confirm the upstream dike construction geometry.
2. Compare the as-built conditions to TVA design drawings.
3. Determine whether the slip-film woven geotextile fabric indicated in the design documents was present under the base of the dikes.
4. Confirm the configuration of the dike drainage system.
5. Check the degree of compaction in the dikes.
6. Estimate fly ash and bottom ash proportions in the dike.

7.1.2. Findings

The main findings of the test trench exploration were:

1. There was no presence of a slip-film woven geotextile fabric layer beneath Dikes C1 through D2, as specified in the original TVA design drawings[2].

2 In accordance with the original design specifications prepared by TVA, a slip-film woven geotextile layer was required to be installed at these locations. The intent of adding this layer of geosynthetic material is unknown at this time. If the intended function of the material was to promote horizontal drainage between upper and lower dikes, other nonwoven materials should have been considered by TVA. Improper specification and use of geosynthetic materials can also promote weaker interface friction scenarios (since some woven geotextiles tend to exhibit a more "slick" surface than non-woven geotextiles) additional slope stability issues could occur.

2. The dike heel drains were located, and it was confirmed that they were functional and built in accordance with the original plans. The drain pipes were oval but were not crushed.
3. No evidence of piping[3], plugging of pipes, or drainage gravel enveloped in filter fabric (nonwoven geotextile) was observed in the trench.
4. The majority of the dikes were constructed of fly ash, with occasional layers of bottom ash evident.
5. The construction of the dikes generally matched the design cross-section established by TVA.
6. It was found that mechanically placed ash, generally denser than sluiced ash, was disposed in the dikes.

[3] Internal erosion of the dike materials

Item 8: POTENTIAL FAILURE MODES, "TRIGGERS," AND MOST PROBABLE FACTORS/ROOT CAUSES OF FAILURE

In simplistic terms, the failure of Dredge Cell 2 and Dike C was the result of the hydraulically placed/sluiced ash assuming undrained behavior resembling a liquid and flowing into the Swan Creek flood plain and surrounding acreage. A technical review of the fly ash material identified several factors that indicate the conversion from a stable to unstable condition, which occurs rapidly as a result of the material's placement into undrained shear failure. In a technical letter report dated June 25, 2009, prepared for Mr. Ralph E. Rodgers, Assistant General Counsel for TVA, Dr. Gonzalo Castro, a Geotechnical Consultant from Lexington, Massachusetts, presented his conclusions regarding AECOM's analyses of the failure at Kingston. Castro succinctly explains the physical conversion from stable (drained) strength to the substantially lower undrained strength of the ash material[4]. The physical process involved in the liquefaction conversion is well documented in the literature for soils or materials with properties similar to the ash analyzed and tested by AECOM. Castro further observes that "Liquefaction caused by non-seismic triggering is referred to as static liquefaction... and caused by a) slippage elsewhere in the soil [ash] mass... b) an increase in the rate of loading... and c) local relatively rapid erosion at the toe of slopes..."[5] AECOM concludes that increases in the rate of loading and localized failure at the toe of slopes or other surface/outslope areas are lesser possibilities of triggering the failure that occurred.

In the course of its analysis, AECOM identified the following probable root causes of the Kingston ash pond failure:

1. Fill geometry (upstream-constructed dike configuration on sluiced ash foundation);
2. Increased fill rates (increased loads and loading rates due to higher fill levels and shrinking footprint);
3. Soft foundation soils (weak, sensitive silt and slimes foundation layer); and
4. Loose, wet ash (hydraulically placed/sluiced ash).

[4] Dr. Gonzalo Castro, Geotechnical Consultant, to Mr. Ralph E. Rodgers, TVA, June 25, 2009, Page 3.
[5] Ibid, Page 4

AECOM discussed the thin layer of slimes beneath the dikes of Dredge Cell 2, per item 3 above, which was discovered during its subsurface investigation (see **Figure 2**). Slimes do not exist beneath Dike C. Although the properties of this slime layer suggest it as a potential slippage surface based upon mathematical modeling, it is MM&A's opinion that it is not the only possible slippage surface. AECOM documented that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.

The characteristics of the loose, wet ash, such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, pose the wet ash as a probable root cause in the failure of Dredge Cell 2. AECOM demonstrated three stages of the progressive failure, and these are included as **Figures 3, 4,** and **5**.

AECOM described the high sensitivity of the sluiced ash in very specific terms when it stated in *Section 1.8* of its RCA report: "Undrained behavior in the metastable ash requires less than 0.5% shear strain to reach peak strengths in both triaxial compression and extension tests. If cell loading exceeds the peak drained shear strength the available strength decreases rapidly towards an undrained steady state shear strength which may be as low as 100 psf."

It is MM&A's professional opinion that AECOM correctly identified the more probable root causes of the Kingston failure. MM&A concurs with AECOM that some or all of these four factors discussed contributed significantly to the failure. MM&A concludes that because the failure was not strictly associated with the "thin, weak slimes" layer, and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

Item 9: CONCLUSION AND OBSERVATIONS

The following outlines MM&A's conclusions and observations based on its review of AECOM's June 25, 2009 RCA report, as well as its review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, IL office location on June 2, 2009, and briefings provided by AECOM during presentation and conference call meetings. In summary, MM&A found the following with regard to the RCA performed by AECOM:

1. The scope of the RCA, as presented by AECOM, was sufficiently thorough for the RCA, and AECOM applied appropriate methodologies, investigative methods, in-situ testing techniques, and sampling practices.
2. The laboratory geotechnical testing program was sufficiently thorough and applied appropriate and complementary suites of tests to characterize the native soils and non-native site materials (e.g., ash and slimes) in the primary areas of interest for the RCA. However, MM&A understands that AECOM was not able to recover and extrude undisturbed samples of the hydraulically placed ash for laboratory testing. This situation adds uncertainty to AECOM's characterization of the hydraulically placed ash at Kingston; thus, the role of the loose, wet ash as a root cause of the failure can not be discounted.
3. AECOM discussed the thin layer of slimes beneath the dikes of Dredge Cell 2, which was discovered during its subsurface investigation. Slimes do not exist beneath Dike C. Although the properties of this slime layer suggest it as a potential slippage surface based upon mathematical modeling, it is not the only possible slippage surface. AECOM documented (*Sections 1.3.4.2* and *1.7.11* of the RCA report dated June 25, 2009) that slimes were not found in some locations, were not of consistent thickness, and had properties very close to those of the ash material itself.
4. The characteristics of the loose, wet ash (hydraulically placed/sluiced ash), such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, pose the wet ash as a probable root cause of equal or greater significance to the soft foundation soils (weak, sensitive silt and slimes foundation layer).
5. The fundamental conclusions of AECOM's RCA with regard to the four most probable root causes or factors contributing to the Kingston ash pond failure are technically plausible and reasonably supported by the study data. MM&A concurs with AECOM that some or all of these four factors discussed contributed significantly to the failure.

6. MM&A concludes that, because the failure was not strictly associated with the "thin, weak slimes" layer and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

Item 10: CLOSING

In preparing this report, the professional services of MM&A have been utilized, findings obtained, and conclusions made in accordance with generally accepted engineering principles and practices. MM&A reserves the right to amend and supplement this report based on new or additional information that might be obtained or become known. If OIG, TVA, TVA's consultants, or others discover additional information pertinent to the Kingston ash pond failure or related studies, MM&A requests the opportunity to review the information for significance relative to MM&A's findings and conclusions as presented herein.

ITEM 11: DATE AND SIGNATURE PAGE

The effective date of this Summary Report is July 9, 2009.

Signature of Qualified Person — July 9, 2009 (Date of Signing)

William S. Almes, P.E.
Print Name of Qualified Person

Signature of Qualified Person — July 9, 2009 (Date of Signing)

Edmundo Laporte, P.E.
Print Name of Qualified Person

Signature of Qualified Person — July 9, 2009 (Date of Signing)

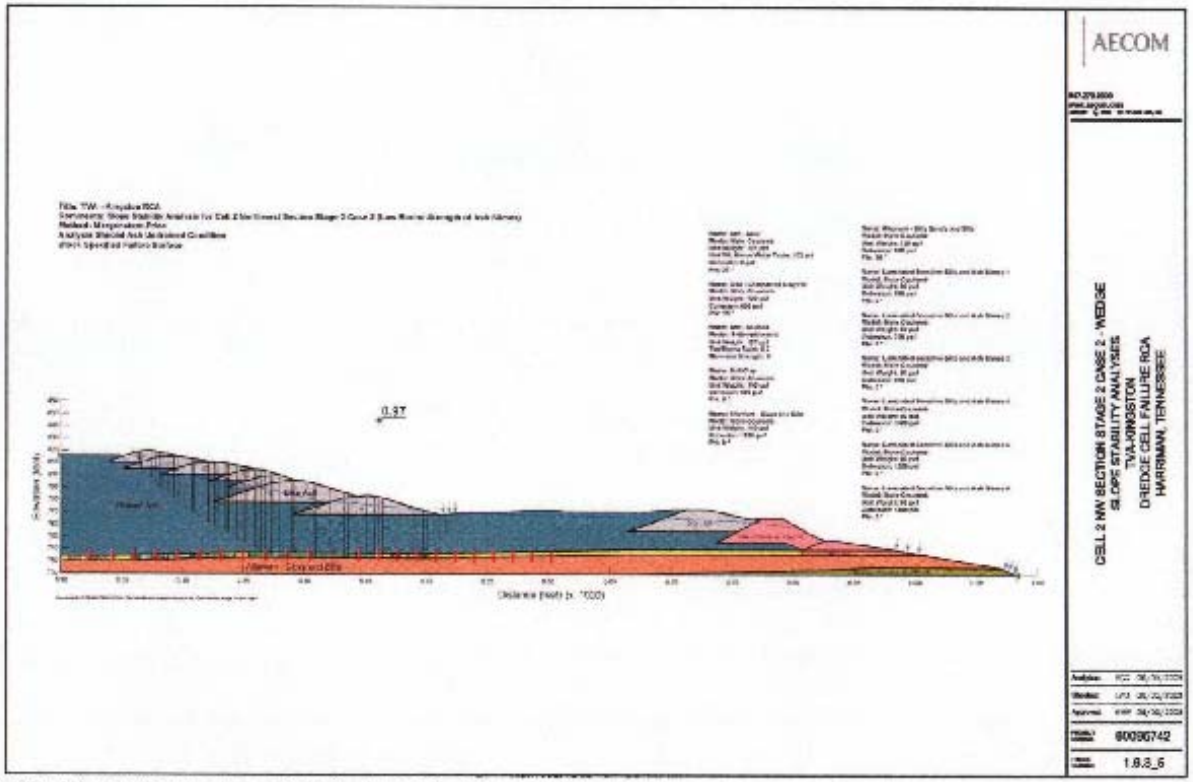
Christopher J. Lewis, P.E.[6]
Print Name of Qualified Person

[6] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

FIGURES

MARSHALL MILLER & ASSOCIATES

Figure 1

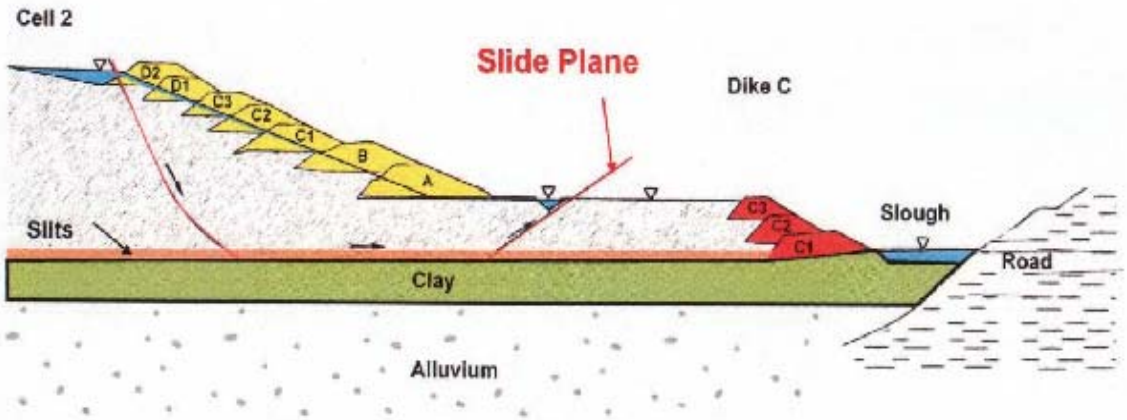


Source:
Figure 1.6.3_5 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Source:
Figure 1.7.11_1 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Figure 3

Stage 1 - Initiation of Failure at North Side of Dredge Cell 2

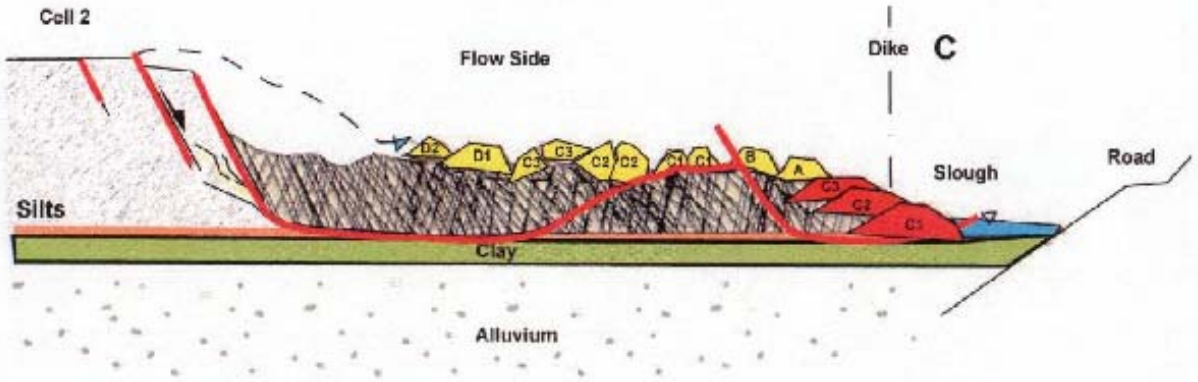


Looking West

Source:
Figure 1.8 3 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Figure 4

Stage 2 – Ash & Dikes A thru D2 Pile Up Against Dike C. This Surcharge and increased Ash Pressure Causes Dike C to Fail

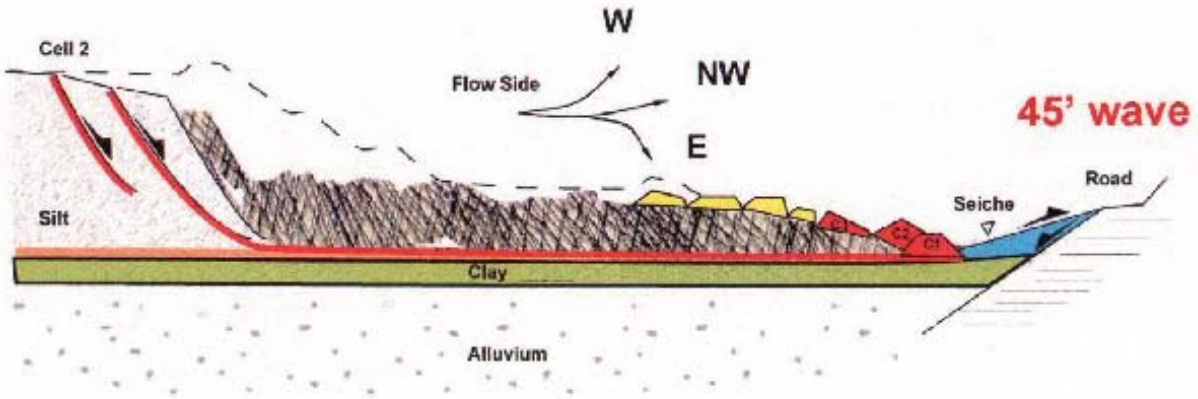


Looking West

Source:
Figure 1.8_5 from Volume 1 of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Figure 5

Stage 3 – Progressive Failure Southward that Fails North Dikes A thru D2 Back to Cell 1 Divider Dike. 5.4 Million CY Fill Sloughs and Reservoir

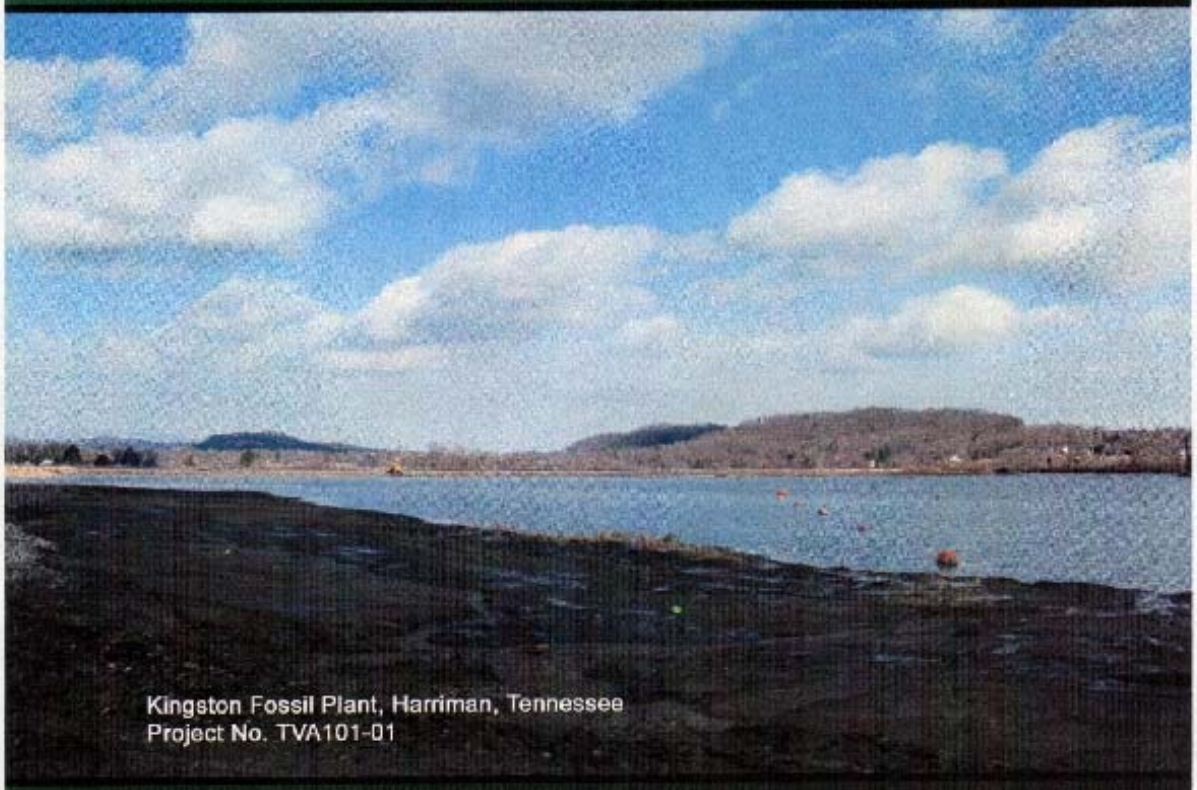


Looking West

Source:
Figure 1.8_5 from Volume I of "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008" by AECOM dated June 25, 2009.

Report

Historical TVA Documentation Review Summary, Opinions and Recommendations Related to the TVA Kingston Dredge Pond Failure on December 22, 2008



Kingston Fossil Plant, Harriman, Tennessee
Project No. TVA101-01

Prepared for:

July 2009

TVA Office of the Inspector General
Knoxville, Tennessee

Prepared by:
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Item 1: TITLE PAGE

Title of Report

Historical TVA Documentation Review Summary, Opinions and Recommendations
Related to the TVA Kingston Dredge Pond Failure on December 22, 2008

Project Location

The project site is located in Harriman, Roane County, Tennessee, and is situated on a peninsula formed by the confluence of the Emory River and the Clinch River.

Qualified Persons

William S. Almes, P.E.
Project Manager
Senior Engineer & Director of Geotechnical Services
Marshall Miller & Associates, Inc.

Edmundo Laporte, P.E.
Senior Project Engineer
Marshall Miller & Associates, Inc.

Christopher J. Lewis, P.E.
Principal Engineer
D'Appolonia, Engineering Division of Ground Technology, Inc.

Effective Date of Report

July 12, 2009

MARSHALL MILLER & ASSOCIATES

Item 2: TABLE OF CONTENTS

LIST OF EXHIBITS

Note: Exhibits 1 and 2 have been included within this report for reference only. All Exhibits were obtained from TVA OIG during its investigation of TVA archived documents.

Item 3: INTRODUCTION AND BACKGROUND

The **Tennessee Valley Authority (*TVA*) Office of the Inspector General (*OIG*)** engaged **Marshall Miller & Associates, Inc. (*MM&A*)** to conduct a peer review of the Root Cause Analysis (*RCA*) prepared by **AECOM Technologies Corporation (*AECOM*)** relating to the ash dredge cell failure which occurred at the TVA Kingston Fossil Plant (*Kingston*) near Harriman, Tennessee, on December 22, 2008. On June 25, 2009, AECOM publicized the results of its comprehensive six-month study entitled "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008." According to AECOM, the root cause of the failure was a complex set of conditions, including a long-evolving combination of the high water content of the wet ash, the increasing height of ash, the construction of the sloping dikes over the wet ash, and the existence of an unusual foundation layer consisting of sensitive slimes and silts.

MM&A prepared a report entitled "Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008", in which it concluded that the characteristics of the loose, wet ash indicate the wet ash as a probable root cause of equal or greater significance to the soft foundation soils. It also concluded that because the failure was not strictly associated with the "thin, weak slimes" layer and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

MM&A met with various representatives of the OIG, TVA, and AECOM, among others, during the course of its engagement, and was provided access to various documents including engineering design drawings, photographs, aerial maps, internal TVA memoranda and various reports produced by TVA's consultants, as well as other documents which were reviewed in the course of the engagement.

This report presents the following sections:

- A summary of the MM&A Project Team
- A description of the MM&A's scope of work

- A discussion of coal ash facility design practices and standards
- A summary of MM&A's review of TVA's historical documentation
- A timeline of events relative to the Kingston Dredge Pond / Disposal Facility
- Conclusions and observations

Item 4: MM&A PROJECT TEAM

MM&A, an employee-owned Engineering News-Record Magazine (*ENR*) Top 500 company, began offering geologic services to the mining industry in 1975 and has provided a full range of related services to the mining, utility, financial, governmental, and legal industries for 33 years. Today, MM&A employs nearly 200 engineers, geologists, scientists and other professionals working from regional offices in ten states.

It is noteworthy that members of MM&A's Project Team have been intimately involved with the development of the two engineering design manuals prepared by the **Mine Safety and Health Administration (*MSHA*)**, which specifically address the procedures that should be followed for designing and operating coal refuse impoundments and embankments. The first manual was published in 1975, and an updated version is scheduled to be released in 2009. Although these manuals were written to address the design and operation of coal refuse disposal facilities, the key chapters, which include material characterization, hazard classification, planning, staging, foundation considerations, surface drainage and storm water control, instrumentation monitoring, geotechnical engineering and design, seismic hazard assessment, seismic stability and deformation, environmental considerations, and emergency action plans, are directly applicable to the disposal of fly ash and bottom ash materials

MM&A has also been involved with forensic studies of major waste impoundments that have experienced uncontrolled releases of fine slurry, as well as slope instability within portions of both coal ash embankments and impoundments, and coarse coal refuse dams.

The MM&A Project Team is comprised of the following professionals:

- Mr. Peter Lawson – Executive Vice President & Principal-in-Charge
- Mr. William S. Almes, P.E. – Director of Geotechnical Services & Project Manager for TVA OIG
- Mr. Edmundo Laporte, P.E. – Senior Engineer
- Mr. William M. Lupi, P.E. – Project Engineer
- Mr. John E. Feddock, P.E. – Senior Vice President & Senior Peer Review Team Member

- Mr. Richard G. Almes, P.E. – Principal Geotechnical Engineer & Senior Peer Review Team Member
- Mr. Christopher J. Lewis P. E. – Principal Geotechnical Engineer & Senior Peer Review Team Member[1]

[1] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

Item 5: SCOPE OF WORK

In addition to the peer review presented in MM&A's July 9, 2009 report entitled "Peer Review of the AECOM Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008," MM&A was also engaged to discuss its understanding of the historical development of the disposal facility as it relates to the siting, design and construction of the containment dikes at Kingston up to the time of failure on December 22, 2008. This report is intended to summarize MM&A's opinions concerning appropriate design philosophy, design standards, and construction and operations procedures that are applicable to ash disposal facilities. MM&A's opinions are based on extensive experience with a variety of mine waste embankments and impoundments that have been operating throughout the United States for several decades. MM&A will also comment on salient aspects of the evolution of the facility.

Understanding and acting on these findings are important to the prevention of a similar occurrence at other TVA wet disposal facilities that have active ash embankments and impoundments or similar structures planned for future use.

Item 6: Discussion of Coal Ash Facility Design Practices and Standards

6.1. Design Philosophy

Technically, dikes/embankments containing hydraulically placed or sluiced materials with the potential to impound water should be treated as dams. Compared to a dam constructed across a valley or hollow, expansive dike/embankment systems for coal ash storage can present greater uncertainties relative to the native foundation, hydraulically placed or sluiced materials, and dike/embankment materials.

Usually, dikes for wet ash storage and disposal facilities, as in the case of Kingston and other TVA fossil plants, are designed and built as upstream-constructed, staged embankments. This technique consists of constructing the first stage of the dike, or starter embankment, using soil, bottom ash or a similar competent material, while fly ash is used for the subsequent stages. The upstream construction method is the most economical construction method because it minimizes the quantity of earthwork and demand for earthen fill, relying largely on the ash materials (bottom ash and fly ash) for containment construction, and spreading the costs over a longer period of time compared to the development of a large starter containment dike/embankment. One of the limitations of the upstream construction method is that the individual dike stages must be relatively broad and the overall side slope of the staged dike system must be relatively flat (3H:1V to 4H:1V) to provide a safe, stable construction of a vertical succession of dike stages over hydraulically placed or sluiced wet ash. Also, the adequate design of the seepage collection and control system is particularly important, since the phreatic surface (groundwater pressures) may tend to advance close to the external face of the containment dike given the unique geometry of an upstream-constructed, staged dike system.

Upstream embankment construction designs are dependent upon the cross-sectional geometry that can be practically attained based on the rates of ash generation, projected maximum embankment height, shear strength of the embankment and sluiced materials, and the adequacy and long-term efficacy of seepage control features within the embankment and its foundation. Typically, the embankment geometry for the final proposed configuration, with all stages defined, will have a maximum height that will provide the required slope stability factor

of safety for the estimated material shear strengths and conservatively designed seepage control system (internal drains and seepage cutoffs/barriers). In most cases, once the designed maximum height has been reached for the particular embankment geometry, material shear strengths, and internal drain configuration, the only way to further increase the embankment height is to install downstream buttresses unless special construction or ground improvement methods are implemented to enhance the stability of the existing containment system and permit vertical expansion. Therefore, it is advisable that the facility's layout for an upstream-staged coal ash embankment allow for future downstream buttress zones when planning locations for access roads, drainage structures, and other fixed site features should vertical expansion be contemplated in the future.

Because permitting, design, engineering and construction requirements vary from state to state, the time period in which each disposal facility was designed and constructed may differ. Significant differences in subsurface conditons and/or operational practices might exist at any given site and between sites, overall stability of each individual disposal unit should be evaluated individually to identify the most critical sections and designed to preclude failure of these "weak links."

An additional factor to be considered in the design of a coal ash embankment is the potential for a seismically-induced slope failure due to earthquake effects acting on the embankment and possible significant strength loss (liquefaction) within any sluiced ash zones behind or under the staged embankments. Also, embankment stages founded over sluiced ash materials have the potential to settle differentially if an earthquake were to occur due to contraction of the sluiced ash. Settlement of the sluiced ash may cause the formation of cracks in the embankment, which can result in the settlement of the crest or prompt sloughs, all of which could aggravate seepage, create an overtopping potential, and reduce the stability of the embankment.

Upstream embankment configurations are more complex from an investigation, testing, design and construction standpoint and require closer scrutiny.

Because of the high sensitivity of hydraulically placed or sluiced coal ash, which is prone to significant deformations if caused to behave under undrained conditions, the design should not be predicated on its drained behavior of impounded ash. Moreover, some coal ash may be thixotropic material, that is, it may appear as a solid but will liquefy when vibrated or agitated. Furthermore, studies performed on fly ash in ponds have documented the fact that wet coal ash does not consolidate.[2] Instead, it maintains its relatively high void ratio notwithstanding the fact that it may have been stored for decades and that a considerable load may have been placed on top of it. This was also observed and reported by AECOM during the RCA investigation and mentioned as one of the characteristics of the sluiced ash that may have contributed to the failure.

6.2. DESIGN STANDARDS

The stability analyses of coal ash embankments are typically performed for static and dynamic conditions. A minimum factor of safety of 1.5 under normal static/steady-state seepage conditions is widely considered as the minimum acceptable value in the design of dams, landfills, and containment dikes/embankments.

Additionally, where the consequences of containment failure are significant with respect to potential property damage, environmental impacts, and/or loss of life, seismic stability and deformation potential also warrant evaluation.

MSHA is nearing completion of the publication of an updated "*Engineering and Design Manual, Coal Refuse Disposal Facilities*" which provides relevant guidance for the evaluation and design of earthen, mine waste, and similar containment structures for seismic loading. Per the MSHA manual, a minimum acceptable factor of safety during a seismic event under normal seepage conditions, using pseudo-static slope stability analysis, would be 1.2. If this limit cannot be met, a more rigorous dynamic analysis and evaluation is required.

6.3. CONSTRUCTION DOCUMENTATION AND INSPECTION

Ash disposal facilities, like other waste disposal facilities, are under constant construction, alteration, and expansion. Therefore, such facilities should be subject to regular

[2] Ground/Water Technology, Inc., "Dewatering to Stabilize Fly Ash Disposal Ponds", May 1985.

intervals of inspection; field/laboratory testing, reviews of internal drain and seepage barrier materials (as applicable) and installation procedures; as-built documentation/surveying; and technical review (e.g., annual dam safety inspection and periodic assessment of compliance with the approved design plan by the professional engineer of record). The frequency of these oversight aspects should in part be related to the rate at which the facility changes (expands, rises, and/or enters a new stage or phase of construction) and the timing of critical construction tasks (e.g., internal drain construction and principal spillway/outfall pipe installation).

6.4. INSTRUMENTATION AND MONITORING

A well-designed instrumentation plan and monitoring program provides insight into a structure's performance that cannot be ascertained from visual inspections. Also, the scheduled installation of instruments provides an ideal opportunity to explore the prevailing as-built subsurface conditions and to retrieve and test material samples for comparison with the design-phase findings, parameters, and inferences/assumptions.

Seepage development through a hydraulic containment dike/embankment system and its foundation is typically monitored via a network of piezometers, and regular measurement and recording of internal drain, relief well, and seep discharges. The phreatic surface within the embankment should be monitored over time to determine if internal drains have become significantly less effective because of clogging or other factors. This can be accomplished by monitoring multiple piezometers at critical sections of the coal ash embankment slopes. Seepage from internal drains should be recorded on regular intervals, and rainfall logs should be maintained to record the precipitation associated with each rainfall event and to track the cumulative precipitation over time. If necessary, a data logging, tipping-bucket rain gauge might be considered to automate this monitoring activity. The seepage rates, rainfall data and pool level in the ash pond should be recorded for comparison.

Deformation monitoring with automated instruments and/or other resources such as settlement monuments, extensometers or inclinometers would also be advisable to track the dike/embankment response throughout initial construction and thereafter. The frequency of instrumentation monitoring should be based on the hazard classification of the containment structure, its past performance, the rate of change in the facility's configuration, the regularity of

visual inspections, and governing state and federal regulatory agency requirements. The accumulated monitoring data should be reviewed regularly by a qualified geologist or engineer—monthly, quarterly, or annually, depending on the required or warranted frequency of instrumentation monitoring. Every year, the reviewing geologist/engineer should verify that the current constructed conditions are in reasonable conformance with the design and, if questionable, re-evaluate the stability of the constructed embankment using the highest recorded phreatic levels.

Item 7: HISTORICAL TVA DOCUMENTATION REVIEW & TIMELINE OF EVENTS RELATIVE TO THE KINGSTON DREDGE POND / DISPOSAL FACILITY

In a 1924 topographic survey, the Emory River elevation was below 710 feet (per *Figure 1.2.2_1* of the AECOM RCA report). In December 1941, the Watts Bar dam gates were closed and the reservoir began filling. The Watts Bar Reservoir normal pool elevation had been maintained at 745 feet in the summer and was typically lowered to 735 feet during the winter and spring months.

The Kingston Fossil Plant construction began in 1951. The first unit at Kingston was brought online in February 1954. Ash was initially discharged to slack waters in the Watts Bar Reservoir. In 1958, the northern 275-acre ash pond containment dike construction was completed. The approximate elevations of the base and crest of the Dike C berm were at 736 feet and 748 feet, respectively. The portion of the earthen Dike C that was installed below water level was reported to have consisted of a firm shale fill. The perimeter Dike C was installed with approximately 6 Horizontal to 1 Vertical (6H:1V) exterior slopes. The drawings did not specify any drainage filter zones or underdrains to control the phreatic surface within the Dike C perimeter embankment.

The initial ash disposal cell boundary dike was filled in 1965 to an elevation of approximately 746 feet. A second earthen dike fill was placed up to a top elevation of 765 feet with a top width of approximately 20 feet and 2H:1V interior and exterior slopes. In 1980, Cell 1 was constructed under the supervision of Fossil Power's Technical Services Branch. In 1986, Cell 2 and Cell 3 were added to the dredge cell complex. The stability analysis was checked by Fossil Engineering for a maximum elevation of 785 feet.

On April 3, 1985, Memorandum No. 850408C0373 was authored by R.G. Domer and presented attachments detailing a slope stability analysis of Dike C. The memo (also provided as **Exhibit 1**) stated the following: "*The minimum 'as built' factor of safety against dike slide failure is 1.2± ... Since a factor of safety of 1.5 is desirable, we recommend continued daily*

inspections of this dike by plant personnel."[3] The attachments to the memo presented the slope stability analysis results for the case of the existing two stages of the earthen Dike C embankments and a third compacted bottom coal ash embankment stage that was shifted 20 feet upstream and built with 4H:1V downstream slopes and a 60-foot wide top. It is noteworthy that the top width had been modified to only have a 12-foot top width, per the as-built section presented in *Figure 1.2.5_4 o*f AECOM's RCA report.

TVA had reviewed its coal ash disposal facilities and, in December 1988, W.M. Bivens, Vice President of Power Engineering and Construction, determined the following: "*[W]e believe ash disposal facilities, even those that contain significant amounts of ash sluice water, are not appropriate for inclusion in the TVA Dam Safety Program. Our position is based on the following: (1) ...It is clear that the intent of the guidelines is to regulate those facilities, including tailings or waste disposal ponds, which block natural streamflow. An ash pond, essentially a basin on flat ground, does not meet that definition. (2)... The basis for this position was both that the facilities were not dams per se as well as TVA is not strictly subject to the Federal guidelines (we do conform to them as a matter of policy), and (4)...Because of concerns about groundwater contamination, TVA is moving away from wet ash disposal techniques to dry stacking.*"[4] This memorandum is provided as **Exhibit 2**.

In 1995, the dredge cell complex was permitted to expand from an elevation of 785 feet to an elevation of 844 feet as a dredge cell and up to 868 feet as a landfill. The design was analyzed for stability by Fossil Engineering, and a landfill permit was obtained based on the design.

In 2003 a shallow slope failure occurred along Swan Pond Road. Two consulting firms retained by TVA, **Geosyntec Consultants, Inc. (*Geosyntec*)** and **Parsons Corporation (*Parsons*)**, analyzed the dike for stability and produced a repair design. A third firm, **MACTEC Engineering and Consulting, Inc. *(MACTEC)***, an engineering consulting firm based in Atlanta, Georgia, was hired by TVA to provide consulting engineering services in support of the

[3] R.G. Doner, Director of Engineering Project, to C.C. Schonhoff, Director of Fossil and Hydro Power, 3 April 1985. Archived TVA files, Tennessee.
[4] W.M. Bivens, Vice President of Power Engineering and Construction, to Morris G. Herndon, Manager of Dam Safety Program, 29 December 1988. Archived TVA files, Tennessee.

Kingston dredge cell facility. MACTEC installed monitoring wells and performed laboratory testing. In 2006, a second shallow slope failure occurred along Swan Pond Road. Geosyntec investigated and recommended the reconstruction of the slope, modification of the interior dimensions of the exiting riprap toe buttress, and addition of groundwater spring collection boxes. Geosyntec prepared monitoring criteria for the failed slopes and turned over the responsibility of monitoring to TVA. In accordance with correspondence between TVA OIG and MM&A, a member of the emergency response team who responded to the 2003 leak at the Swan Pond Road dike stated that one of the immediate responses was to put weight on the leak. TVA engineers recommended using 200 feet of riprap (rock). A contracted engineer recommended 250 feet of riprap. Reportedly, after installing 50 feet of riprap, the now-retired manager of Coal Combustion Byproducts stopped further installation of the material having said that it looked fine and that he wanted to wait to see what happened.

The aforementioned emergency response team member expressed grave concern that only 50 feet of the rock had been applied, but the former Coal Combustion Byproducts manager was considered the overriding expert at the time. The fix turned out to be fine, but the emergency team member was concerned that only 50 feet had been used when the other engineers recommended 200 to 250 feet. The manager of Coal Combustion Byproducts stated that when he arrived at the site, the area was very saturated. He was concerned about adding the additional weight of the stone and the weight of the trucks dumping the stone, so he stopped the riprap installation at a point where the riprap width was approximately 50 feet.

MM&A performed a review of the following sections contained within the 2004 TVA document entitled: "*Operations Manual–Dredge Cell Lateral Expansion*" dated June 1, 2004 (Revised March 27, 2006):

- *Appendix G: Stability and Seismic Impact Analysis* (a 32-page calculation brief prepared by Parsons and dated May 26, 2004)
- *Sheet 5: Dredge Cell Existing Conditions & Drainage Layer* (TVA Drawing No. 10W425-30)
- *Dredge Cell Lateral Expansion Phase 2/3 – Typical Cross Section & Details* (TVA Drawing No. 10W425-65)

Parsons reported on the results of a slope stability and seepage analysis it performed at TVA's request related to a proposed ash pond expansion design in support of the evaluation of the proposed Phase 2 and 3 Lateral Dredge Cell expansions. In that report, Parsons noted the existence of an approximately 7- to 10-foot thick layer of loose ash immediately overlying the clayey soil beneath the ash pond. Parsons further noted that this layer of loose ash may undergo liquefaction under certain circumstances, including a seismic event. Parsons stated that the probability of this occurring was "extremely low." However, Parsons then stated that methods of predicting liquefaction have proven to be "insufficient," and therefore recommended that TVA take measures to improve drainage in the ash pond. The seepage analysis recommended the installation of three additional shallow underdrains to reduce the seepage forces and exit gradient near the toe of the dredge cell slopes. The slope stability analysis was performed for the static case, and the corresponding yield acceleration was determined for the static stability models that would cause the slope to fail. However, the Parsons evaluation did not consider that the hydraulically placed/sluiced ash is especially prone to abrupt strength loss down to the steady-state strength under seismic loading, as well as under other relatively sudden changes in loading or loading rate that activate undrained response. Given this behavior and sensitivity of the loose, wet ash, minimal undrained shear strength should have been assumed for the loose, wet ash zone(s) when evaluating the post-earthquake/seismic stability and other conceivable load cases under which undrained ash behavior might govern stability.

The Parsons calculations and TVA's design drawings were evaluated by Geosyntec during a peer review. The peer review concluded that the seismic yield acceleration was below recommended values from two guidance documents and that justification should be provided for values presented in the calculations.

With regard to the proposed drainage system and liquefaction, Geosyntec also found that "[t]he potential for liquefaction should be estimated. Depending on the results of this estimate, a liquefaction analysis may be required. If the site is expected to liquefy then ground improvement techniques need to be implemented."[5]

[5] GeoSyntec Consultants, "Engineering Peer Review of Coal Byproducts Disposal Plans, Kingston Fossil Plant, Kingston, Tennessee", prepared for Tennessee Valley Authority, November 2004.

The influence of the drains was not calculated, therefore it is unclear if the drains would be effective at mitigating liquefaction. Upon review of correspondence between TVA-OIG and TVA, it is MM&A's understanding that the improvements had not been completed by TVA since the base area of the expansion had not been completed to the point where the proposed drainage blanket could be installed. Evidently, the drainage blanket needed to be constructed before the column drains could be inserted.

In 2005 Parsons performed seepage and slope stability calculations for the western slope of the dredge cells. The analysis recommended that three additional underdrains be installed at bench elevations 795±, 781± and 775± feet above mean sea level within portions of the embankment that did not contain underdrains. The three proposed drains were to be installed at a depth of approximately 5 to 6 feet. MM&A is not certain why existing underdrains were not installed at elevation 768± feet as part of the Stage A dike construction (i.e., the first shifted stage at the north side of the Dredge Cells). The slope stability analysis showed a factor of safety of 1.37± using the modeled phreatic surface that included the three proposed underdrains.

In April 2005, TVA requested a minor modification to Permit IDL 73-0094 from **Tennessee Department of Environment and Conservation (*TDEC*)** to repair a blowout that occurred in November 2003. This modification included the installation of three trench drains at existing benches at elevations 795±, 781± and 775± feet. Additionally, well points were installed to reduce the hydrostatic pressure within the riprap-lined drain. A reconfigured riprap buttress was installed at the toe of the embankment. The buttress included a toe underdrain consisting of a geosynthetic drainage composite to collect seepage and direct it to new drainage structures.

During the October 20, 2008, annual inspection of the Kingston dredge cell dikes, "redwater" seepage was reported at one of the well points (KWP-8) that had a closed valve.[6] The report stated that "[d]rain lines with valves were installed on the old dewatering wells to allow personnel to relieve some of the water in these wells."[7] The well points were installed in

[6] Chris Butram, "Kingston Fossil Plant, Annual Ash Pond Dike Stability Inspection, 2009" (Executive Summary, 2009 Kingston Ash Pond Annual Dike Stability Inspection), 12 January 2009, Page 8.
[7] Ibid, Page 7.

the western slope during repairs conducted in 2006. It is not clear if the drain lines were gravity lines or required pumping to control the water in the well points. No specific recommendations were made in the report addressing the elevated phreatic surface observed at well point KWP-8 or the other well points. The comment in the report that states "[t]he valves of the other monitoring wells were open and were flowing clear water to the drainage ditch" [8] is not clear as to whether the water flowing from these wells is an elevated condition relative to the ground surface or if an elevated or artesian condition is present at these locations."

Shortly after 12:00 a.m. Eastern Standard Time (*EST*) on December 22, 2008, the northern and central portions of Dredge Cell 2 of the ash disposal site failed, and an estimated 5.4 million cubic yards of ash were released in a progressive sequence of flow slides over a period of one to two hours. The ash spill extended outside of the Dredge Cell 2, covering approximately 300 acres of the Swan Creek flood plain and surrounding acreage.

[8] Ibid, Page 7.

Item 8: CONCLUSIONS AND OBSERVATIONS

The following outlines MM&A's conclusions and observations based on its review of AECOM's June 25, 2009, RCA report, as well as its review of various documents regarding Dredge Cell 2, a meeting with AECOM personnel at their Vernon Hills, Illinois, office on June 2, 2009, and briefings provided by AECOM during presentation and conference call meetings.

8.1. AECOM RCA

In summary, MM&A found the following with regard to AECOM's root cause study and culminating RCA report dated June 25, 2009:

- AECOM's RCA concludes in *Section 1.8*: "The failure on December 22, 2008 depended on all four factors [root causes], without them working in combination, the failure of Dredge Cell 2 would have not likely occurred on this date." In MM&A's professional opinion, the suggestion that all four factors had to work in combination to cause the failure diminishes and disregards the risks that were posed by the upstream-constructed dike configuration and disposal procedures and the ever increasing height of Dredge Cell 2. Given what was known about the ash material and the geologic conditions within the Kingston ash disposal facility before December 22, 2008, there was an unquantified probability of failure. Consequently, the sensitivity of the upstream-constructed containment dike system to changes in loading, loading rate, seepage regime, sluiced ash behavior, and other circumstances must be appreciated to preclude another catastrophic failure as occurred on December 22, 2008.

- Moreover, the stated objectives of the AECOM RCA do not encompass the task of identifying necessary changes in design philosophy, design standards, construction documentation, inspection and instrumentation to prevent another Kingston-type failure.

- Consequently, the root cause study and culminating report by AECOM defines the problem but does not provide clear direction to TVA in the form of technical

guidance for evaluating, designing, and constructing reliable containments for "wet" ash disposal now or in the future.

- MM&A believes that the AECOM RCA focused disproportionately on the significance of the thin, discontinuous, soft foundation layer (sensitive silt and slimes) as one of the most probable factors/root causes. The significance of the "Fill Geometry" factor/root cause should be equally emphasized. In the Kingston case, the specific complexities and uncertainties associated with the ash dikes/embankments constructed over the hydraulically placed or sluiced ash deposits (i.e., upstream-constructed containment) is an important component of the "Fill Geometry" factor and, in MM&A's professional opinion, is of equal or greater significance relative to the "Soft Foundation Soils" factor.

- The characteristics of the loose, wet ash (hydraulically placed/sluiced ash), such as the rounded particle shape, weakly fused and loose particle structure, sensitivity, consistently high void ratios with increasing depth (lack of consolidation behavior), along with the contractive undrained behavior and very low undrained steady-state shear strength evidenced in the laboratory tests, suggest it (wet ash) as a probable root cause of equal or greater significance to the soft foundation soils (weak, sensitive silt and slimes foundation layer).

- Other factors evaluated by AECOM as probable root causes should be strongly considered by TVA and the power generation industry as a whole in evaluating the condition and structural integrity of wet ash disposal facilities. Each one of these factors is critical and should be closely evaluated for all of the existing TVA ash handling and disposal facilities. These concerns and findings could have a significant effect on the requirements and standards of care for facilities throughout the Fossil Plant industry.

- MM&A concludes that, because the Kingston failure was not strictly associated with the "thin, weak slimes" layer, and more associated with the ash dike (or "fill") geometry and relatively low strength of the sluiced ash foundation and

impounded material, other similarly constructed ash (or gypsum and/or other byproducts) impoundments could be at risk of failure and should be properly investigated.

8.2. GENERAL

During its historical record review, meetings and observations, MM&A determined the following:

- As early as 1985, intrinsic problems related to the stability of Dike C were mentioned, specifically in R.G. Domer's memorandum (**Exhibit 1**), which indicate that the calculated factor of safety was less than the minimum acceptable value of 1.5 and close monitoring was recommended to detect any potential signs of failure in lieu of changing TVA policies and procedures that would require that the ash pond be designed to the higher "dam safety" standard. No specific action by TVA appears to have been taken as per the reviewed documents.

- The construction of successive upstream stages to elevation 820 (approximate crest elevation of Dredge Cell No. 2 at the time of failure) above the original containment dike system ("Perimeter Dike C" - approximate crest elevation of 748 feet) may have contributed to an additional decrease in the factor of safety of the containment dike system. In essence, at the time of failure on December 22, 2008, this increase in constructed height equated to an approximate 70-foot increase in the height of the ash pond above the crest elevation of the original Perimeter Dike C.

- In MM&A's opinion, if TVA had included its ash ponds in the Dam Safety Program as discussed in December, 1988 when TVA decided against this policy, protocol would have been established for performing customary geotechnical exploration, in-situ and laboratory testing, dike seepage and stability analyses, and adherance to the higher "dam" design standards, and the probability of identifying some or all of the conditions that led to the KIF failure would have increased significantly.

- The design of the Kingston coal ash dredge cells should have included a thorough engineering evaluation of all potential failure modes.

- It is considered sound engineering practice to design such facilities with features that provide a reasonable degree of redundancy or "second line of defense" in the event that one or more of the systems become inoperable. To some extent, establishing higher factors of safety provide this protection. However, other considerations are appropriate such as specifying a sufficient number of internal drains in the event one or more become clogged or compromised in some fashion. The same applies to specifying the degree of compaction of the dike materials since weather conditions, the level of experience of the equipment operators and other variables can affect the final condition and ultimate behavior of the structure. In MM&A's opinion, it is important that this design philosophy be applied to all of TVA's ash disposal facilities.

- The recommendations made by Geosyntec following its peer review of the 2004 TVA document entitled "*Operations Manual–Dredge Cell Lateral Expansion*" were appropriate, and the failure of TVA to respond to such warnings and affect necessary revisions to the design shows that conservative engineering design principles were not being followed within TVA. Furthermore, had corrective measures been completed in a timely manner, it is possible that TVA could have potentially prevented the occurrence of the failure.

- With regard to the TVA reaction to the 2003 ash slope failure along Swan Pond Road, buttress construction was a reasonable immediate response. As an emergency response, buttressing areas of observed sloughing and/or seepage outbreak is a common and accepted reaction to arrest such immediate problem(s), pending prompt review and formulation of a more permanent remedial plan by a qualified geotechnical/dam engineer. If 50 feet of riprap addressed the immediate problem(s) and stopped or precluded the progression of the failure, then the decision of the manager of Coal Combustion Byproducts was reasonable under the emergency situation. However, use of riprap material alone without proper

filter materials between the existing ash dikes and riprap buttress, whether 50 feet or 250 feet wide, was not a technically acceptable longer term solution. Rather than adopting a "wait and see" approach with the 50-foot wide buttress, the problems and potential longer term solutions warranted prompt evaluation by a qualified geotechnical/dam engineer. If the ash ponds had been included in the Dam Safety Program, this closer evaluation and a more sound "engineered" solution probably would have occurred.

- It is evident from findings and recommendations in the Geosyntec report that, in addition to consideration for liquefaction, modifications to the expansion design should have been made to require compliance with a more stringent design configuration. Upon completion of the proposed Phase 2/3 expansion, which had not occurred at the time of the failure, more height and weight would have been added to what is now the failed ash pond. TVA's concurrence with the recommendations would have resulted in additional extensive analyses and modeling.

- It is not prudent to presume that, if the slimes layer observed in the failed section at Kingston does not exist at other plant sites, there is adequate stability of these structures. On the contrary, the information developed from the extensive studies conducted by both **Stantec Inc. (*Stantec*)** and AECOM indicates that there is a reasonable risk of other dike failures if changes are not made in the design construction, oversight, and operation of the wet ash disposal sites throughout TVA.

Item 9: CLOSING

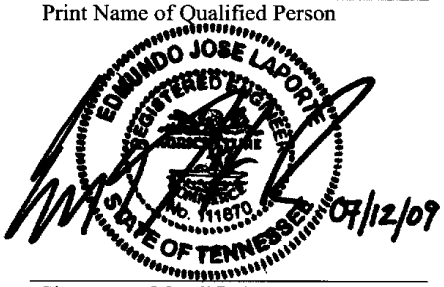
In preparing this report, the professional services of MM&A have been utilized, findings obtained, and conclusions made in accordance with generally accepted engineering principles and practices. MM&A reserves the right to amend and supplement this report based on new or additional information that might be obtained or become known. If OIG, TVA, TVA's consultants, or others discover additional information pertinent to the Kingston ash pond failure or related studies, MM&A requests the opportunity to review the information for significance relative to MM&A's findings and conclusions as presented herein.

Item 10: DATE AND SIGNATURE PAGE

The effective date of this Summary Report is July 12, 2009.

Signature of Qualified Person — July 12, 2009 (Date of Signing)

William S. Almes, P.E.
Print Name of Qualified Person



Signature of Qualified Person — July 12, 2009 (Date of Signing)

Edmundo Laporte, P.E.
Print Name of Qualified Person

Signature of Qualified Person — July 12, 2009 (Date of Signing)

Christopher J. Lewis, P.E.[9]
Print Name of Qualified Person

[9] Christopher J. Lewis, P.E. is a Geotechnical Subconsultant of MM&A and is employed by D'APPOLONIA, ENGINEERING DIVISION OF GROUND TECHNOLOGY, INC., Monroeville, Pennsylvania.

Item 11: LIST OF REFERENCES

The following references were provided to MM&A by TVA and were reviewed and used in preparation of this report:

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12. Moses, D., Correspondence to Tennessee Press Service, Inc., "TVA - Kingston Fossil Plant, IDL 73-0094 - Final Permit Decision", Tennessee Department of Environment and Conservation, September 28, 2000.

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15. Reed, E.A., Correspondence to Tennessee Valley Authority Fossil Power Group, "Public Notice of Receipt of Part I Application – Proposed Lateral Expansion TVA Kingston Fossil Plant Class II Landfill – IDL 73-0094", TVA, January 20, 2004.

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17. Tockstein, C.D., Haston, M.B., Justice, C.T., "Report of Geotechnical Exploration, Ash Disposal Area, TVA Kingston Fossil Plant, Kingston, Tennessee", MACTEC, May 4, 2004.

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20. Parsons E&C, "Presentation - Proposed Dredge Cell Repair Supporting Information", April 2005.

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22. Watts, J.K., Correspondence to, Tennessee Department of Environment and Conservation, Division of Solid Waste Management "TVA Request Approval for New Dredge Cell - Kingston Fossil Plant (KIF)", TVA January 6, 2004.

23. Walton, W. H., Butler, W., "Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008", AECOM, Vernon Hills, IL, June 25, 2009.

EXHIBITS

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TED STATES GOVERNMENT

lemorandum

TENNESSEE VALLEY AUTHORITY
B65 '85 040 001

: C. C. Schonhoff, Director of Fossil and Hydro Power, 716 EB-C

M : R. G. Domer, Director of Engineering Projects, W12A5 C-K

E : APR 03 1985

JECT: KINGSTON STEAM PLANT - DIKE C SOILS INVESTIGATION AND ENGINEERING STUDY RESULTS

We have completed the soils investigation and engineering analysis for dike C. As you are aware, the dike was not built according to design drawings. A layer of ash extends to within a few feet of the exterior of the dike slope (see attachment A).

The minimum "as built" factor of safety against a dike slide failure is 1.2± (see attachment B). Since a factor of safety of 1.5 is desirable, we recommend continued daily inspections of this dike by plant personnel.

Construction of an engineered dredge pond dike adjacent to dike C will not increase the probability of a slide failure of the exterior dike; however, the dredge pond would increase the risk of seepage through dike C. The new dredge dike must be constructed in accordance with attachment C.

At one zone in the stilling pool compartment (see attachment D), the ash layer transports ash pond water to the exterior surface of the dike. OE will recommend a repair scheme and submit an order of magnitude cost estimate to you by April 26, 1985.

Original Signed By
Carl M. Goolsby
R. G. Domer

OPT:MHM:EFS
Attachment
cc (Attachment):
RIMS, SL26 C-K
R. O. Barnett, W9D224 C-K
C. Bonine, 12-108 SB-K
C. A. Chandley, W7C126 C-K
O. P. Thornton, W3D224 C-K
F. Van Meter, 10-103 SB-K (3)

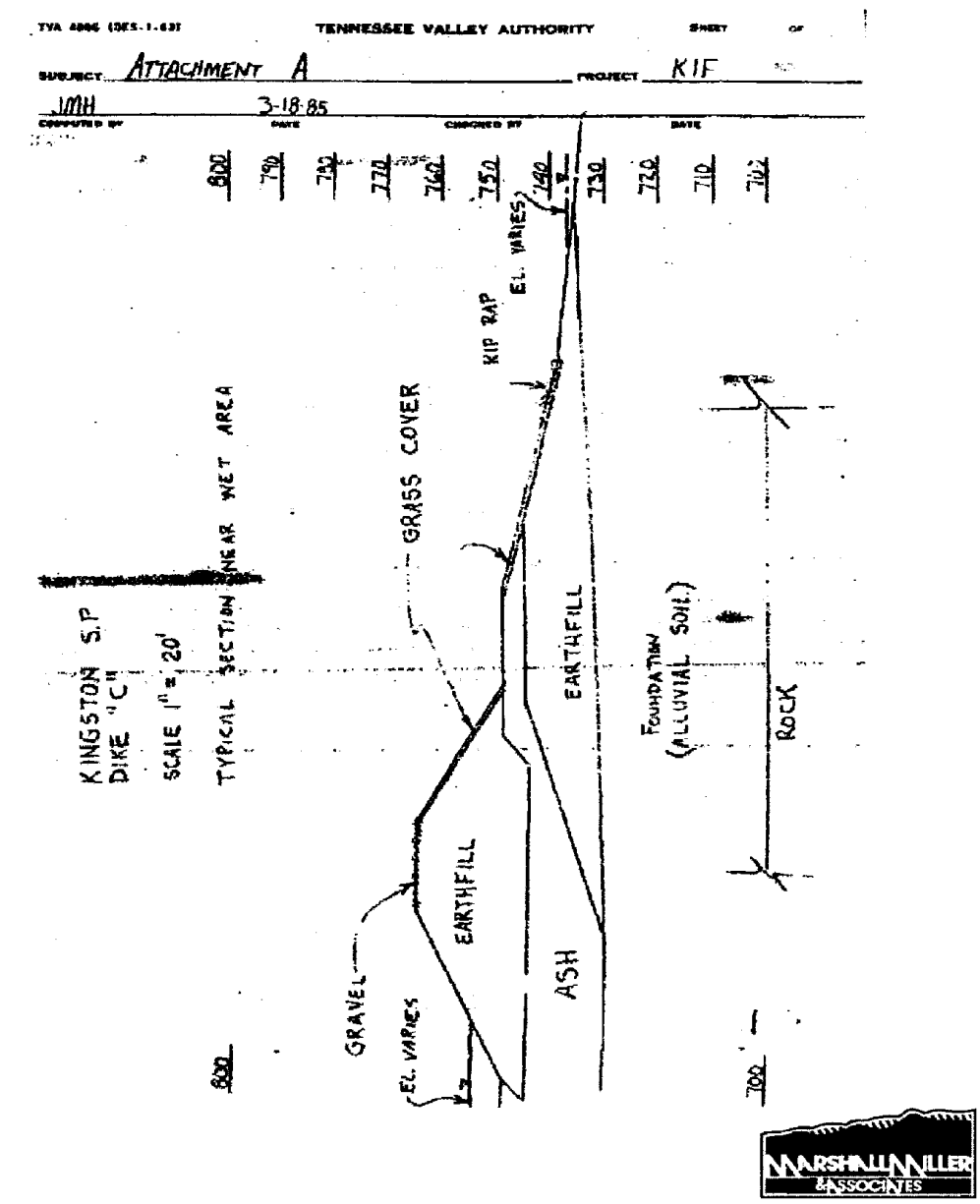
Principally Prepared By: M. H. Miller, Extension 3806

S65085.01

BC/PM: _____

MO: _____

MARSHALL MILLER & ASSOCIATES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GRAVEL
EL. VARIES
FOUNDATION
(ALLUVIAL SOIL)
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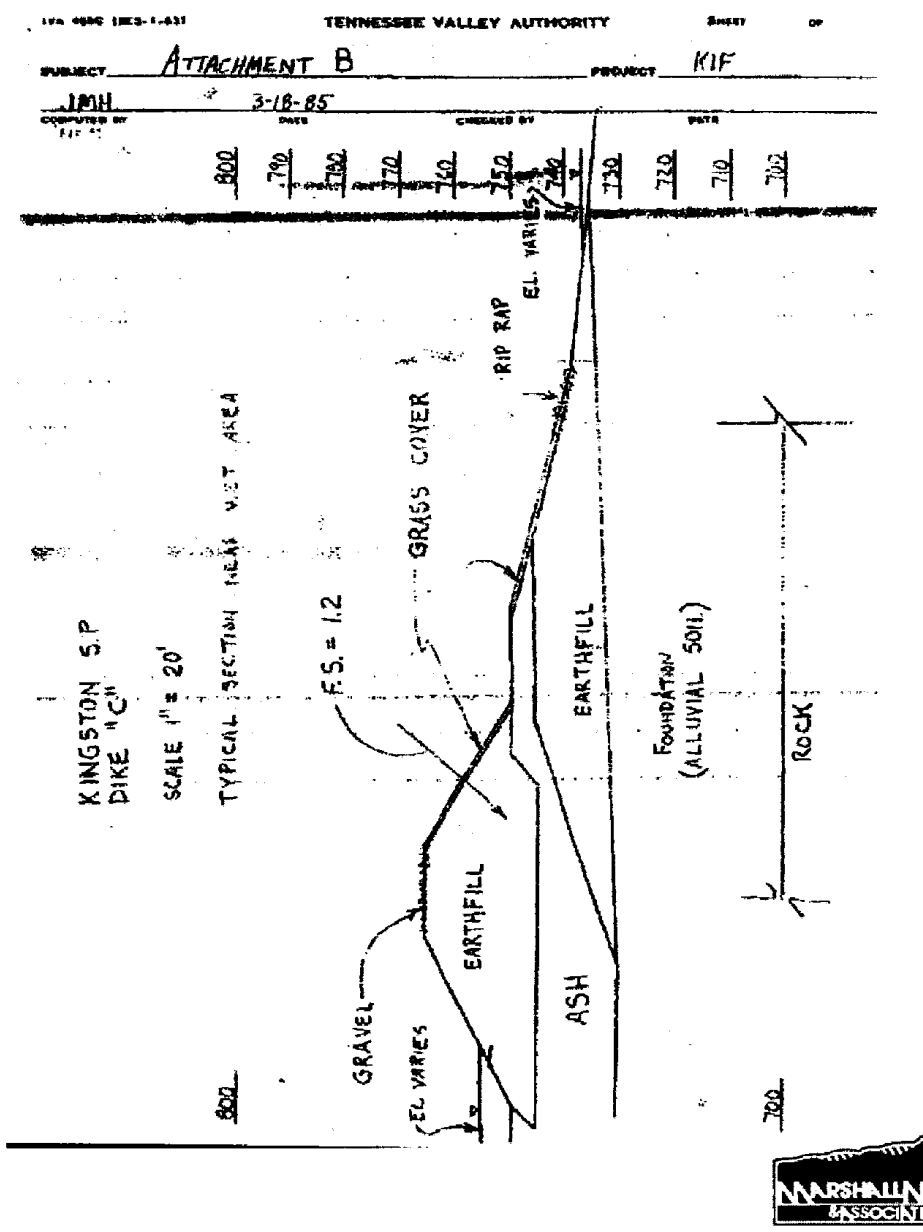
KINGSTON S.P.
DIKE "C"
TYPICAL SECTION
SCALE 1" = 20'
MARSHALL MILLER
& ASSOCIATES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SUBJECT ATTACHMENT B
PROJECT KIF
JMH 3-18-85
KINGSTON S.P.
DIKE "C"
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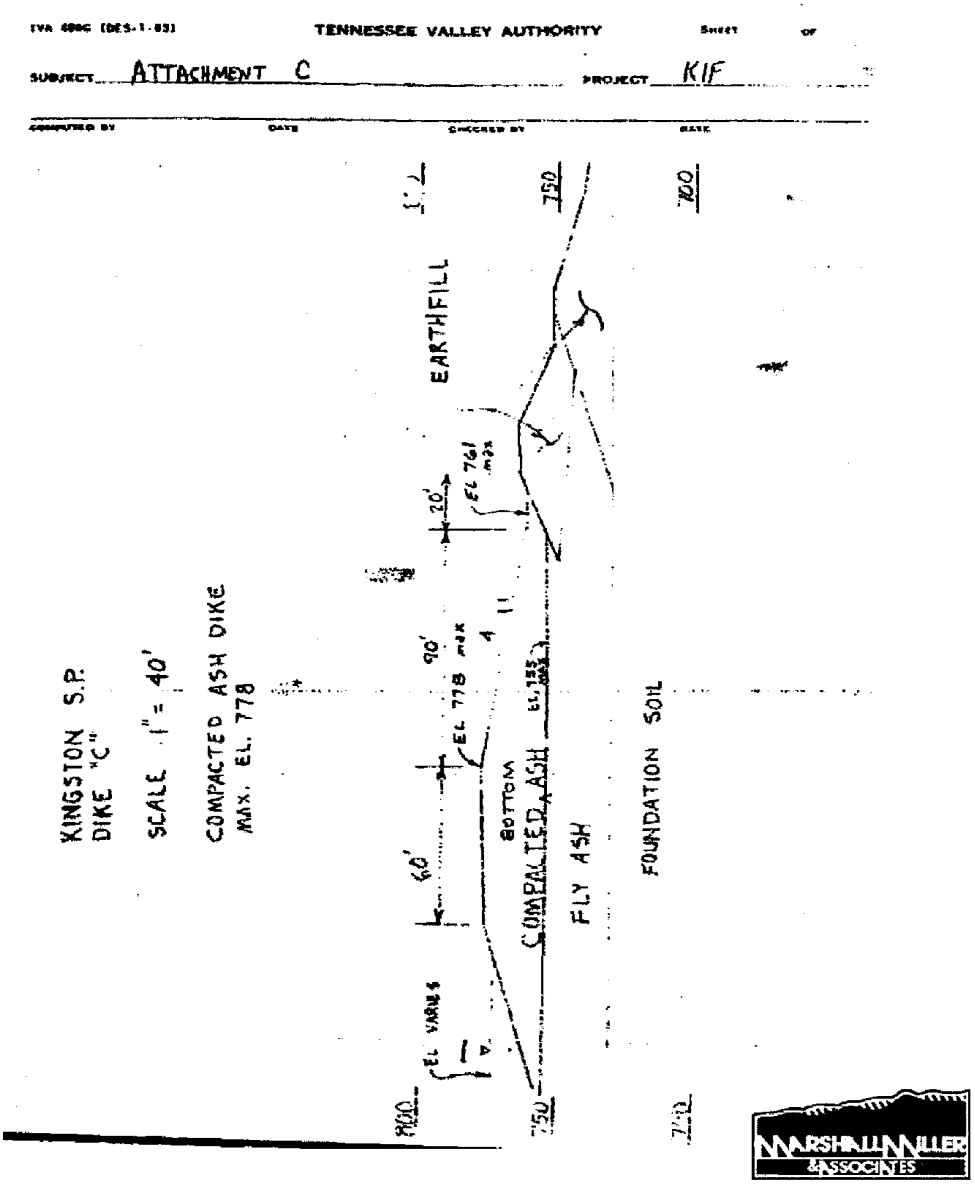
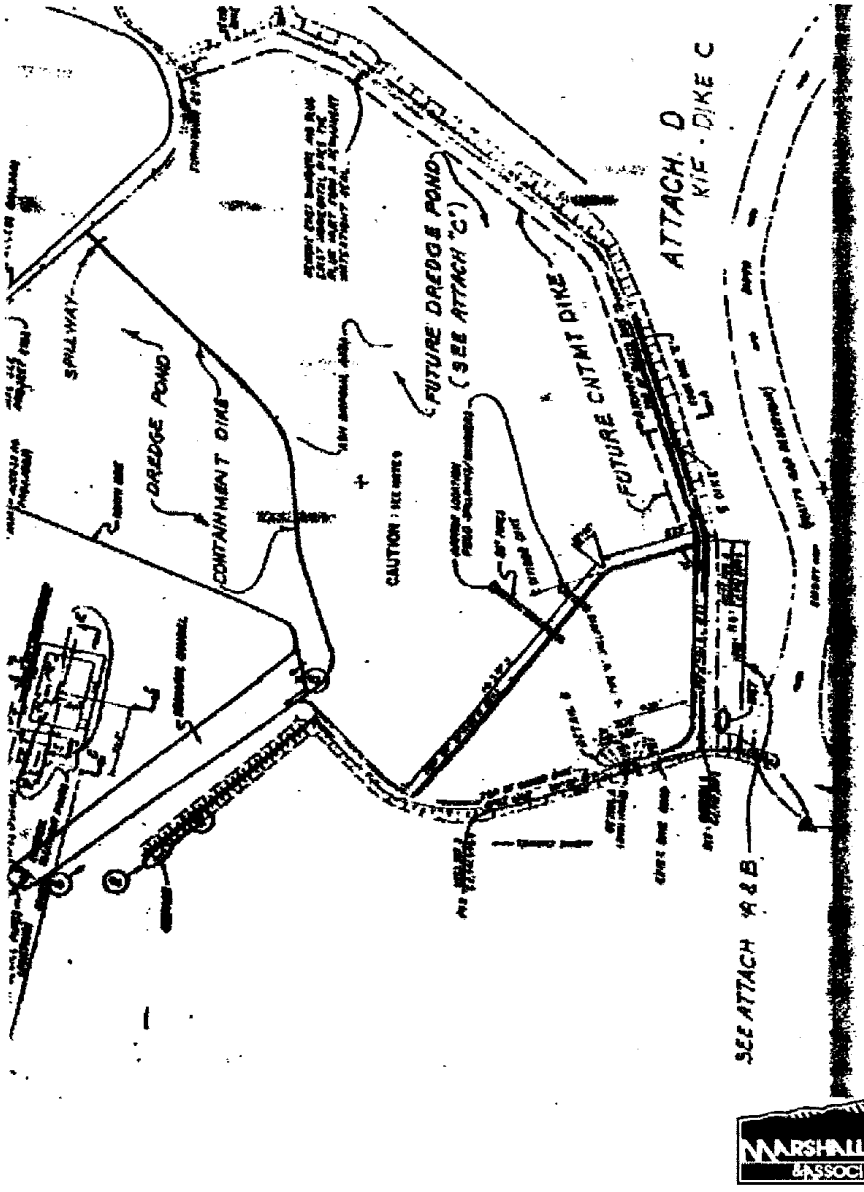
F.S. = 1.2
GRASS COVER
RIP RAP
EL. VARIES
EARTHFILL
ASH
GRAVEL
EL. VARIES
EARTHFILL
FOUNDATION
(ALLUVIAL SOIL)
ROCK
800
790
780
770
760
750
740
730
720
710
700
800
700
MARSHALL MILLER & ASSOCIATES


TVA 40BG (DES-1-83)
TENNESSEE VALLEY AUTHORITY
SUBJECT ATTACHMENT C
PROJECT KIF
KINGSTON S.P.
DIKE "C"
SCALE 1" = 40'
COMPACTED ASH DIKE
MAX. EL. 778
EARTHFILL
EL 761 max
20'
90'
EL 778 max
60'
EL VARIES
BOTTOM
COMPACTED ASH
EL 735 max
FLY ASH
FOUNDATION SOIL
750
760
740
MARSHALL MILLER
& ASSOCIATES


SPILLWAY
DREDGE POND
CONTAINMENT DIKE
FUTURE DREDGE POND
(SEE ATTACH "C")
FUTURE CNTMT DIKE
ATTACH. D
KIF - DIKE C
SEE ATTACH "A & B"
MARSHALL MILLER
& ASSOCIATES

DRAFT

TO: MORRIS G. HERNDON, MANAGER, DAM SAFETY PROGRAM, 350 EB-K

FM: W. H. BIVENS, VICE PRESIDENT OF POWER ENGINEERING AND CONSTRUCTION, LP 3S 60K-C

DT: DECEMBER 29, 1988

RE: RELATIONSHIP OF ASH DISPOSAL AREAS TO DAM SAFETY

This is in response to your November 10 memorandum to me in which you sought our opinion as to which ash ponds may meet the Federal guidelines definition of "dam", and further, their inclusion as facilities under the Dam Safety Program.

TVA has consistently taken the position that such facilities do not constitute "dams" as defined by FEMA in the Federal Guidelines for Dam Safety and believe that no change to that postion is warranted. In addition, we believe ash disposal facilities, even those that contain significant amounts of ash sluice water, are not appropriate for inclusion in the TVA Dam Safety Program. Our position is based on the following:

1. The FEMA definition of "dam", which your memo quotes in part, also includes the phrase "which impounds or diverts water" and refers to "the natural bed of the stream or watercourse" as a benchmark for determining applicability. It is clear that the intent of the guidelines is to regulate those facilities, including tailings or waste disposal ponds, which block natural streamflow. An ash pond, essentially a basin on flat ground, does not meet that definition.

2. In its environmental permitting experience, TVA has occasionally submitted dam safety information to State (notably Kentucky) dam safety officials. We were careful to clarify that the data was being provided for information only in order to facilitate the processing of the permit application. The basis for this position was both that the facilities were not dams per se as well as TVA is not strictly subject to the Federal guidelines (we do conform to them as a matter of policy).

3. The electric utility industry does not generally register ~~any of its~~ ash disposal facilities with State emergency management agencies. Federal

4. Because of concerns about groundwater contamination, TVA is moving away from wet ash disposal techniques to dry stacking. While not prohibited by the applicable environmental

regulations, it is quite unlikely TVA will construct any new ash ponds.

5. In our view, these facilities are appropriately managed and maintained as pollution control facilities. They already receive routine structural inspections, effluent quality checks, and other measurements (active volume certifications, etc.). ~~We can identify no particular advantage with reassigning their management responsibility to the Dam Safety Program.~~

Accordingly, ~~we recommend that~~ responsibility for ash disposal facilities remain outside of the auspices of the Dam Safety Program.

The technical information you requested in your November 10 memo is attached for your information.

Please contact me or Jim Coulson with any additional questions on this matter.

JLG:WMP:wmp
Attachment
cc: R. L. Copeland
J. L. Golden
W. G. Ruffner

0371I

MARSHALL MILLER & ASSOCIATES

1.1.2 Objectives and Scope of Work

AECOM was retained to perform a Root Cause Analysis (RCA) of the December 22, 2008 dredge cell failure to determine the most probable cause(s) and location of failure at the site. AECOM conducted interviews, reviewed project files, performed site reconnaissance, drilled test borings, advanced piezocone probes, collected undisturbed samples, observed test pits, logged test trenches, performed laboratory testing and conducted seepage and stability analyses to define the probable failure mode leading up the sudden failure. A summary of the RCA methodology employed by AECOM follows:

- Define the problem
- Gather physical data/evidence
- Identify the technical issues impacting failure
- Perform testing and analyses
- Identify the root causes (most probable failure scenario)
- Report the findings
- Peer review remedial designs by others at Kingston and to check if the designs are consistent with the post-failure geotechnical conditions encountered in AECOM investigations

AECOM was not assigned to opine or offer services in the following areas:

- Review the standard of practice used by TVA or their consultants for the design and construction of the ash ponds and dredge cells
- Review the fate and transport of potential ash and possible contaminates from the cells into environment
- Design of remedial construction measures to clean-up and restore the Kingston site
- Review of designs and operations at other TVA wet dredge cell disposal sites

It was not AECOM's charge to implement the restoration program nor was it to institute performance monitoring to ensure effectiveness of the restoration/cleanup program. This work was and will be performed by TVA or by consultants and contractors retained by TVA.

July 20, 2009

Richard W. Moore, ET 4C-K

REQUEST FOR COMMENTS - DRAFT INSPECTION 2008-12283-02 - REVIEW OF KINGSTON FOSSIL PLANT ASH SPILL ROOT CAUSE STUDY AND OBSERVATIONS ABOUT ASH MANAGEMENT

I am attaching a summary of management's response to the subject report, which was transmitted to me on the evening of July 13. The report and attachments consist of over 100 pages of detailed materials, so it is obviously difficult to respond in the type of detail that may be warranted.

As a preliminary matter I want to emphasize that since the time of the Kingston ash pond failure, TVA has taken responsibility for the cleanup and recovery of the site, has worked diligently with the community, and has made substantial changes within TVA. We will of course continue those efforts, as well as the thorough and comprehensive analysis of TVA's other impoundments that is currently underway, and the other efforts that we are undertaking to prevent such an event from ever happening again at TVA.

I understand the concern that OIG is now addressing about the scope of the root cause analysis, and I want to emphasize that our work here is far from finished. Our first step was to fully and completely understand, from an engineering and forensic perspective how the failure actually occurred physically, and then to apply that knowledge in our assessment of TVA's other impoundments. We feel that the AECOM report gives a very sound factual basis that we can build on going forward.

On a parallel track, the Board's counsel, McKenna Long & Aldridge, has been performing a review to determine, among other things, what remediation is necessary to processes, systems, and accountabilities to prevent an event like Kingston from happening again.

Other corrective actions, both physical and cultural, will occur. We have more work to do, and we welcome all comments about the physical and organizational deficiencies that may have contributed to this event. There was no intent to do anything except a completely independent root cause of the Kingston ash pond failure, and to move toward remedies for all causes found.

Tom Kilgore
President and Chief Executive Officer
WT 7B-K

Attachment

Attachment
Response to Specific Recommendations

Our responses to the report's six specific recommendations are as follows:

Recommendation:

Commission a dedicated cadre of professionals skilled in change management focused solely on driving compliance throughout TVA and measuring positive changes in the culture that effects ash management and other TVA programs.

Response:

I am committed to driving positive cultural change. Some changes have already been implemented by TVA by establishing the new Coal Combustion Products (CCP) organization that is separate from the fossil plants and which brings operations, maintenance, engineering, and projects under a single executive. Organizational program and process changes linked to culture change have been initiated in Fossil Generation earlier this year and are ongoing. More broadly, TVA is also implementing a cultural focusing initiative across the agency, incorporating lessons learned from Kingston.

Recommendation:

Assess the culture of the fossil fuels group to determine what changes need to be made, if any, to insure the support for sound policies and procedures related to ash management.

Response:

Responsibility for ash management now resides in the CCP organization; significant changes already have resulted in that area, and these efforts will continue.

Recommendation:

Assess the management practices of TVA for ash management to determine whether those practices contributed to the failure of the dike at Kingston.

Response:

Now that TVA has a detailed, technical explanation of what and how the Kingston dike failure occurred, we are better suited to make more specific inquiries as to how the failure could have been prevented in fact and, more importantly, what steps we can take to ensure that it never happens again and to safely close the failed cell.

Recommendation:

Complete the assessments of TVA ash storage facilities and determine which ones are at risk of failure. The determination should be, as suggested by Marshall Miller, based on whether any of the four conditions contributing to the failure at Kingston exist sufficiently to pose a significant risk of failure. The determination should not be limited to just looking for the existence of the combination of all four contributing conditions found at Kingston.

Response:

The comprehensive program for assessment of all of TVA's combustion by-product impoundments has been underway since January. The Phase One report of that assessment was publicly released on July 16, 2009. That assessment is not, and never has been, limited to determining whether the four conditions found to have combined to cause the Kingston failure exist at any other facility, either alone or in combination. While the causes of the Kingston failure, now that they are known, certainly are considered, each site is being fully evaluated based on any design or risk factor applicable to it, whether such a factor was identified for Kingston or not.

Recommendation:

Develop policies and procedures for the storing, handling, and maintaining of ash and ash disposal facilities.

Response:

More detailed and rigorous policies and procedures for storing, handling, and maintaining ash and ash disposal facilities are being developed and implemented in the CCP organization, and a comprehensive program for future CCP remediation and conversion is being developed and implemented.

Recommendation:

Continue the efforts to drive the Enterprise Risk Management Program further down into the organization to increase the future likelihood that known risks will be identified and addressed.

Response:

TVA is implementing improvements to its ERM to better achieve the goals of the program.