This document is a redacted publicly available version. In November 2024, the NRC staff identified information within this document that may be Critical Electric Infrastructure Information (CEII) as defined by the Federal Energy Regulatory Commission (FERC). The original file is non-public, designated as CEII, in ADAMS ML24311A191.

NRC staff actions were taken in accordance with:

- The Memorandum of Understanding Between US NRC and FERC Regarding Treatment of Critical Energy/Electric Infrastructure Information found at: https://www.nrc.gov/reading-rm/doc-collections/memo-understanding/2024/index.html.
- The FERC definition of CEII found at: https://www.ferc.gov/ceii, and, https://www.ferc.gov/enforcement-legal/ceii/designation-incoming-dam-safety-documents.

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June 25, 2009

MEMORANDUM TO: Meena Khanna, Branch Chief
Mechanical and Civil Engineering Branch
Division of Engineering

FROM: Raman Pichumani, Structural Engineer ***/RA/***
Mechanical and Civil Engineering Branch
Division of Engineering

SUBJECT: NRC SITE VISIT TO THE OCONEE NUCLEAR STATION ON JUNE 15, 2009

NRC management and staff conducted a site visit at the Oconee Nuclear Station (ONS) on June 15, 2009. This site visit was in support of the staff's ongoing review of an external flooding issue at ONS to determine whether there is reasonable assurance that the site is adequately protected. NRC management and staff toured the Jocassee dam, the Keowee dam, the Oconee intake dike, the Little River dam, and several saddle dikes on all of the associated lakes. Details of the site visit are provided in the enclosure.

ENCLOSURE: As Stated

CONTACTS: Neil Coleman, ACRS
Rex Wescott, NMSS

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MEMORANDUM TO: Meena Khanna, Branch Chief
Mechanical and Civil Engineering Branch
Division of Engineering

FROM: Raman Pichumani, Structural Engineer ***/RA/***
Mechanical and Civil Engineering Branch
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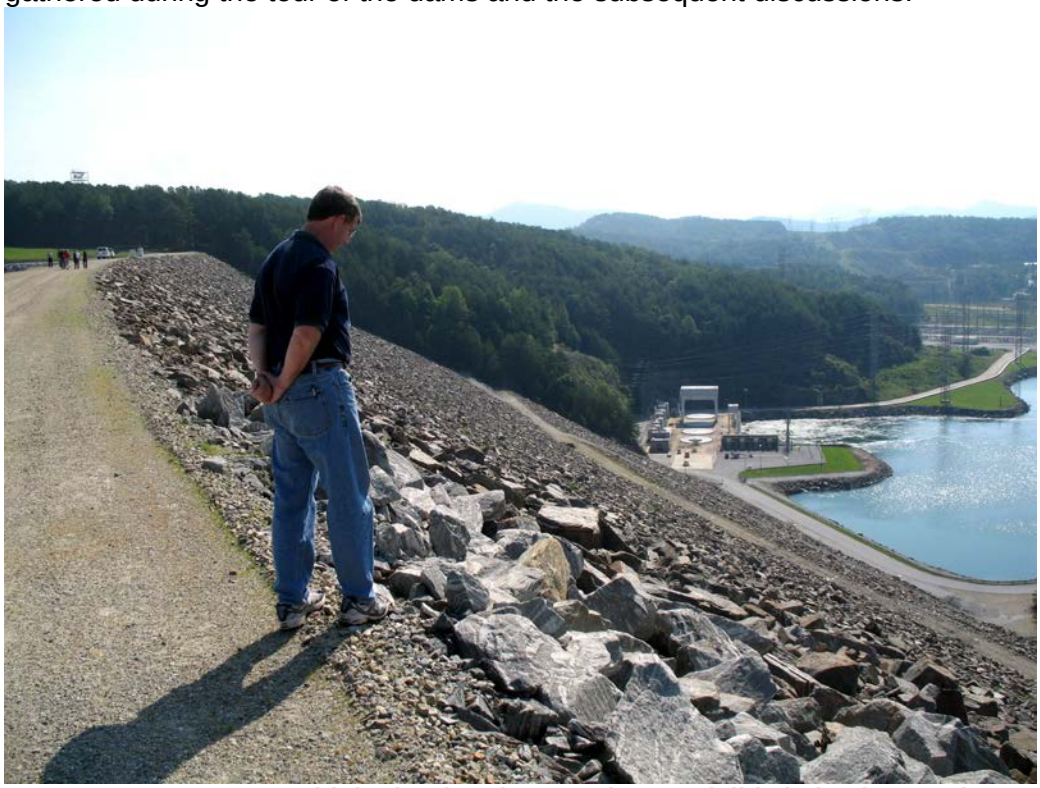
SUMMARY OF NRC SITE VISIT TO THE OCONEE NUCLEAR STATION
JUNE 15, 2009

On June 15, 2009, NRR/DE led a delegation of a staff hydrogeologist, a staff hydrologist, a geo-structural engineer, and a R-II staff member to tour the Jocassee dam, the Keowee dam, the Oconee intake dike, the Little River dam, and several saddle dikes on all of the associated lakes. A complete list of participants is provided in Attachment 1. The purpose of the site visit was to examine the areas affected by the possible flooding at the Oconee Nuclear Station (ONS) caused by the postulated failure of the Jocassee dam and gain first hand knowledge of the ground conditions and engineering structures at the site. This visit was useful in supporting the staff's ongoing evaluation of the assumptions made by Duke in its March 2009 Jocassee-Keowee Dam Breach Model Report. At the end of the tour, the NRC staff discussed with the Duke staff and their consultants questions that had been communicated to Duke prior to the site visit. Duke staff provided several documents in response to the staff's questions; these documents are listed in Attachment 2. Described below is a summary of the information gathered during the tour of the dams and the subsequent discussions.



Jocassee Dam with hydroelectric powerhouse visible in background.

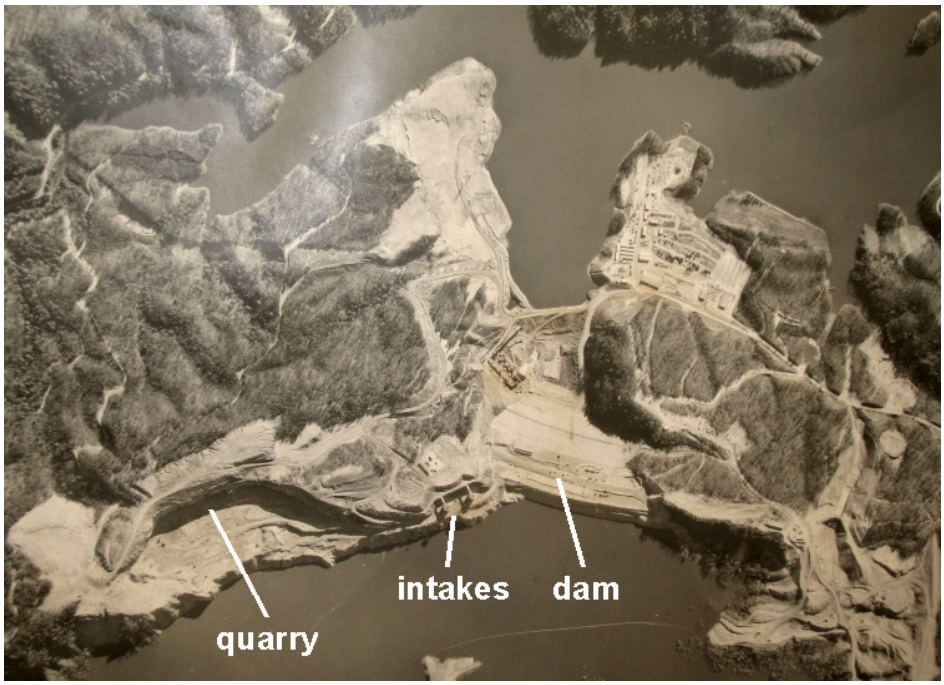
There is a low lying area located northwest of the ONS, which would be flooded following a hypothetical breach of the Jocassee dam and could be a potential path for the flood waters to reach the main site. This area is currently separated from the ONS site by a roadway whose crest elevation is about 827 ft, which is three feet below the predicted flood elevation of 830 ft in Keowee lake following a breach of Jocassee dam with an average breach width of [redacted] (as reported in Duke's March 2009 Jocassee Dam Breach Report). Duke's staff indicated that raising the elevation of this roadway area sufficiently to prevent the flooding of the site is one of several modifications Duke is considering to make after the NRC staff accepts the Jocassee dam breach analysis results.

There are two earthen saddle dikes west of the main Jocassee dam, which could potentially function as an uncontrolled spillway in the event of a severe storm coupled with an inoperable spillway gate. The crest elevations of these dikes are the same as that of the main dam. These two saddle dikes could provide emergency outlets that could prevent overtopping failure of the Jocassee dam. Overtopping failures are the most hazardous for any dam. As shown in the photos below, Saddle Dikes #1 and #2 do not have rip rap on their downstream sides. If overtopped, they would rapidly erode forming breaches that would drain the reservoir down to the base level of the dikes. This would still allow the reservoir to retain most of its water volume, averting a catastrophic emptying of the entire lake. Both dikes are protected from wave erosion by rip rap armoring on the lake-facing slopes. Lowering the saddle dikes by ~0.5 m would provide further assurance that if a probable maximum flood inflow occurred to Jocassee Lake, failure of the saddle dikes would prevent overtopping and catastrophic failure of Jocassee Dam.

Saddle dikes at Jocassee Lake are protected from wave action by rip rap on sides facing lake. Top: Saddle Dike #2. Middle: rip rap on lake side of Dike #1. Right: downstream side of Dike #1 has grass but no rip rap (french drain is visible along toe of dam).

The main Jocassee dam was observed to be in good condition without any obvious signs of instability. The hydrogeologist identified the rock type as biotite gneiss (see figure below) used for rip rap and reportedly used as rockfill material in the Jocassee dam. This rock type is not the kind that would degrade over time. The staff found no evidence of degradation of the rockfill material within the dam because the seepage observed was clear with no obvious suspended solids.

Upper left: Biotite gneiss (metamorphic rock) that serves as rip rap at Jocassee Dam. This rock type is extremely durable and not subject to breakdown over time under saturated conditions. Upper right: Arrow points to lake embayment that Duke representatives identified as the main quarry site (now submerged) used to obtain Jocassee Dam rock fill materials. Structure at right is one of two Jocassee intake structures.



Historic photograph of Jocassee Dam during construction.

In previous inspections of the Jocassee dam, FERC identified the seepage of water from the abutments as potential failure modes for the dam, and recommended that Duke continue the monitoring of the seepage and establish threshold levels for the seepage. During this trip, the NRC review team observed the seepage of water in the abutments and was informed by the Duke staff that the measured seepage was within the "action levels" determined by them based on historical seepage data at the site. Furthermore, the seepage water was clean and clear with no sediment present, indicating no apparent erosion or degradation of embankment materials. Duke provided measured seepage data, which the NRC team is reviewing.

Clear discharge from a flume at the main seepage collection point low on the western abutment of Jocassee Dam.

Duke Power monitors the Jocassee Reservoir level and has a camera trained on a gauge at one of the intake structures for real-time observations. The gauge is shown in the figure below.

Gauge to measure height of Jocassee lake stage.

The NRC staff also visited the spillway for Jocassee Lake. It is located west of the dam and east of the Saddle Dikes. The spillway is controlled by two large radial gates. The report by FEI (2004) discusses potential failure modes (PFM) of Jocassee Dam. One scenario examined was overtopping of the dam caused by failure to operate the radial gates during a flood. Overtopping was classified as Category IV (ruled out) given the current programs of inspection, testing, maintenance, surveillance, and backup power. FEI (2004) reports there are two backup portable compressors that could be used to open the gates, and that the gates could also be opened with a hand crank or with a crane. Our observations at the spillway found that a support frame for an air-operated motor is bolted to the platform where the hand crank would be used. A hand crank could not be used unless a ratchet device is provided or unless the support frame is removed. Also, it was not obvious where a lifting device for a crane could be attached to the radial gates. If water overtopped the gates, they would be under water and the downstream force would be very large, making it challenging to hook onto the gates for lifting.

Spillway structure for Jocassee Reservoir.

In the afternoon of June 15, 2009, the NRC review team visited the Keowee dam and its appurtenant structures, and found them to be in good condition.

The licensee indicated to the NRC staff that they were considering to make modifications at the Oconee site to provide added assurance that it is protected from a flood caused by a failure of the Jocassee dam. The licensee cautioned that this statement is based on preliminary information from running various scenarios with the HEC-RAS model, but they are now considering building flood barriers at up to 3 areas of the site: the west end of the Keowee dam, the road that leads to the site from the Little River basin, and the Oconee intake dike.

Keowee Dam spillway with four radial gates (left), and view of outflow channel (right).

Using a commercial GPS unit the NRC staff took spot measurements of elevations at the crests of both the Jocassee and Keowee dams, and at the saddle dikes for Jocassee. For example, the GPS elevation of the crest of Keowee dam was measured in two places, both indicating approximately 815 ft MSL.

Based on the site visit, the staff determined that it would consider the following issues in its assessment of the external flooding issue at the ONS site:

1. Where would the Keowee Dam fail?
2. What flood level is expected at the ONS site from a Keowee dam failure?
3. Based on a Keowee dam failure, what water level would be seen from the Little River Basin?
4. Where will the intake dike fail and what effect would this failure have on the site?

The licensee plans to meet with the NRC staff on July 23, to discuss the modeling of a failure of the west end of the Keowee dam and overtopping of the Oconee intake dike, that could result form a failure of the Jocassee dam. The licensee also intends to develop a 2-D model of the "west yard" portion of the Oconee site (where the SSF is located) to provide a more accurate estimate of the flood height in the vicinity of the SSF. The licensee will also address the key dam breach parameters they intend to vary as part of their sensitivity analysis.

The licensee has laid out a schedule to complete the inundation study and determine what modifications need to be made by November 2009. The NRC staff will continue to interact with the licensee as the study and potential site modifications are being developed to assure the licensee stays on schedule.

Reference

FEI, 2004 - Potential failure modes analysis – Jocassee Development – Keowee-Toxaway Project (FERC Project No. 2503-SC). Prepared for Duke Power by Findlay Engineering, Inc., December 2004.

List of Participants at the June 15, 2009 Site Visit

NRC Staff:

Dave Skeen, NRR
Meena Khanna, NRR
Raman Pichumani, NRR
Neil Coleman, ACRS
Rex Wescott, NMSS
Curtis Rapp, Region II

Duke Staff:

Rich Freudenberger
Bob Meixell
Jeff Thomas

Duke's Consultants

Chris Ely
Ed Luttrel

LIST OF DOCUMENTS PROVIDED BY DUKE DURING THE JUNE 15, 2009 SITE VISIT AT ONS

1. FERC's Dam Safety Inspection Report dated March 20, 2008 for Jocassee Development of Keowee-Toxaway Project for May 2, 2007 to March 20, 2008.

2. FERC's Dam Safety Inspection Report dated March 18, 2008 for Keowee Development of Keowee-Toxaway Project for May 1, 2007 to March 18, 2008.

3. Duke Energy's Quality Control Records on Jocassee Dam Earthwork dated September 27, 1972

4. Duke Energy's 2008 Jocassee and Keowee Dam Surveillance and Monitoring Report

5. Jocassee PMF Inflow Hydrograph

6. Jocassee Dam Hydrologic Analysis, prepared by Law Environmental, Inc., dated January 1991

7. Keowee-Jocassee reservoir area and volume curves