



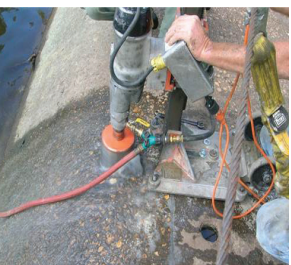
Prince William County
Department of Public Works



Lake Jackson Dam

PHASE I: DATA COLLECTION AND EVALUATION

PHASE II: INVESTIGATION AND CONCEPTUAL DESIGN



Baker

DECEMBER 10, 2012

CONCEPTUAL
REHABILITATION DESIGN

PHASE I: DATA COLLECTION AND EVALUATION



PHASE I



Project: Lake Jackson Dam

Subject: Toe Drain Investigation – Phase I: Data Collection and Evaluation

Date: July 26, 2012 (Revised August 14, 2012)

Site Description

Lake Jackson Dam is located on the Occoquan River, approximately 450 feet west of State Route 234 (Dumfries Road) as shown below in Figure 1. The dam was built in 1928 and was used to generate electricity until the mid-1950's, but it is currently used solely for recreation. The dam is 28 feet high and consists of a fixed crest spillway (EL 148.0) and a 25-foot-wide electrically operated tainter gate (EL 138.0), which together span about 246 feet, as shown in Attachment 1. The tainter gate is normally in the closed position, which results in a normal pool elevation corresponding to the fixed crest spillway. The dam is able to incorporate flashboards to increase the pool level of the dam to elevation 152.0; however, these flashboards are not currently being utilized. A catwalk (EL 167.0) along the top of the dam provides access from the powerhouse (north abutment) to the tainter gate motor house and the south abutment of the dam. Lake Jackson Dam is currently classified as a "Significant Hazard" dam (Virginia Inventory #15306) and is governed by the *Virginia Dam Safety Act* (Code of Virginia §10.1-604 et seq.) and the *Virginia Impounding Structure Regulations* (4VAC50-20 et al.). The dam is currently owned and maintained by Prince William County (County) and operated by the County's Department of Public Works.



Figure 1: Location Map

Background:

An annual inspection of the Lake Jackson Dam was conducted by Baker on July 15, 2011 in compliance with the Virginia Dam Safety Regulations to supplement its re-certification application. During this inspection, it was determined that the concrete spillway of the dam has hollow cavities (chambers) between the piers, as opposed to being a solid concrete dam. Concrete repairs were being conducted at the time of inspection but were limited to the exterior concrete of the dam.

Subsequent to the inspection, an earthquake occurred on August 23, 2011 which resulted in cracking of the masonry mortar of the power house. The County did not document any damage to the structural concrete of the dam and the toe drains were not noted to be active at that time. Construction crews who were performing concrete repairs on the catwalk did experience the catwalk moving with the earthquake and refused to resume work that day on the catwalk due to the concern of aftershocks.

The pool level remained drawn down due to additional repairs to the tainter gate seals through January 2012. Refilling of the lake began in February 2012 with the pool level reaching the top of the concrete spillway (crest) around mid-February 2012. Pool levels fluctuated with storm events but do not appear to have dropped below the crest elevation for the concrete spillway until early-June 2012. A figure illustrating the pool levels from January 2011 through June 2012 is provided as Attachment 1.

While removing debris from the spillway in late May 2012 in preparation for a forecasted storm event (forecasted for May 21, 2012), County staff noted the activation of the left (looking downstream) toe drain of the dam near the power house. At that time, the flow from the toe drain was discolored and the second toe drain within the tainter gate section of the dam was not active. The location of these two toe drains is illustrated in Attachment 2. The May 21, 2012 rain event resulted in approximately 6.75 feet of water over the spillway crest. After the flow subsided to a point where the flow from the toe drains was able to be observed, it was noted that the flow in the left toe drain had increased and flow from the right toe drain had commenced.

County staff indicated that flow through these drains have historically been minimal and for the most part unnoticeable prior to May 2012. Since the activation of the drains, County staff increased its monitoring of the drains and the lake level. In addition, the County observed minor seepage through small cracks in the concrete on the downstream face of the dam. The County requested Baker to inspect the dam to evaluate its condition and to identify potential reasons for the recent activation of the toe drains.

A site observation of Lake Jackson Dam was conducted by Michael Baker Jr., Inc. staff on July 13, 2012, per the request of Prince William County in response to the activation of the toe drains in late May 2012. Attachment 3 illustrates key changes that were noted between the July 2011 and July 2012 site visits.

2012 Site Observations:

Below is a list of observations that were noted as part of the site observation conducted for Lake Jackson in July 2012.

Seepage through Downstream Face of Dam

Seepage through the downstream face of the dam indicates that water is present within the spillway chambers. It was observed that the level at which seepage begins (where water is currently seeping out of the cracks and flows down on the face of the dam) is relatively uniform along the left portion of the spillway (looking downstream). This suggests that there may be cross connection(s) between the chambers which would serve to equalize water levels within the chambers of the dam. The seepage appears to indicate that the water within the chambers is at approximate EL 140, which is above the tainter gate invert elevation (EL 138). Attachment 4 is a photograph that documents the approximate elevation of the water seepage at the downstream face during the site observation. While the seepage through the cracks does result in the wetting of the concrete and efflorescence staining, there is no measureable flow that was noted. Photograph 1 below illustrates the seepage that was noted compared to the 2011 Dam Inspection which was conducted in July 2011 at which time no visible evidence of seepage was noted.



Photograph 1: Seepage through Downstream Face (July 2012)



Photograph 2: No Seepage through Downstream Face (July 2011)

In addition to the measurements of the seepage on the downstream face of the dam, a CCTV camera was inserted into the air vent holes between Pier 1 and Pier 2. Through this investigation, it was determined that water was present and appeared to support the findings of the seepage measurements. In addition, the investigation did determine that concrete/rock was located approximately four (4) feet below the water level within the within that portion of the structure.



Photograph 3: Image from CCTV at End of Air Vent



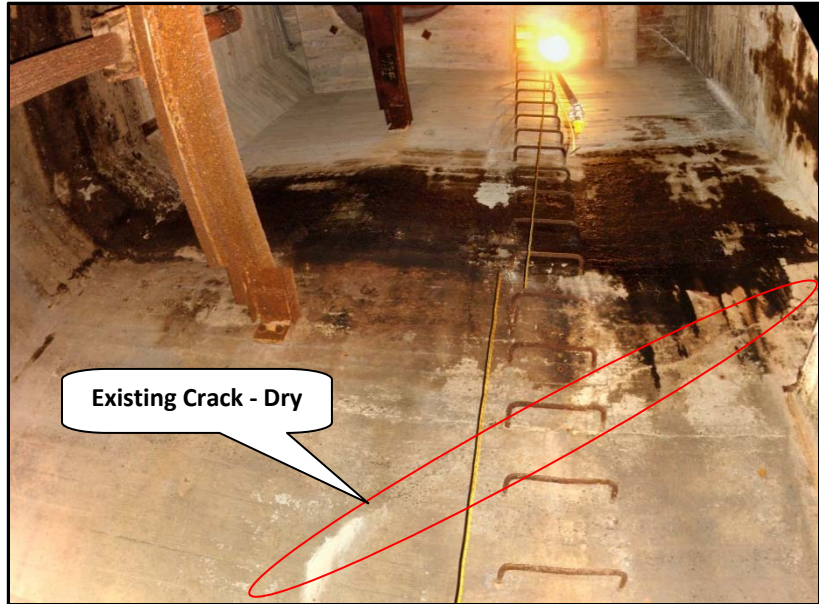
Photograph 4: Image at Water Level within Chamber (reflection of CCTV lights)



Photograph 5: Image from CCTV at Concrete/Rock Located 4ft below Water Level

Investigation of Hydroelectric Turbine Chambers

An internal investigation of the hydroelectric turbine chambers, which shares a common concrete wall with the concrete spillway, was conducted. This investigation was completed to assess if there was an access into the spillway chambers from that side of the dam. After this investigation, it was determined that an access to the spillway chambers does not exist from the hydroelectric turbine chambers and there is no apparent seepage through the common wall with the spillway. Overall the concrete is in good condition for its age. One crack was noted, which is illustrated in red on Photograph 6, is diagonal and extends from the lower left to the upper right through the steps shown in the photograph; but there was no apparent seepage near the crack and the crack did not appear to have formed recently.



Photograph 6: Investigation of Hydroelectric Turbine Chambers

Toe Drains

As described above, the activation of the toe drains was noticed by the County in late May 2012. Since that date, the flow rate has appeared to increase over time. The flow observed from the drains is in excess of 50 gallons/minute at each toe drain location (approximate - based on visual observation) and was clear water. The flow from the drains appears to be coming from the spillway chambers; however, additional investigations are required to determine how the water is entering the spillway chambers.



Photograph 7 & 8: Flow from Left Toe Drain



Photograph 9 & 10: Flow from Right Toe Drain

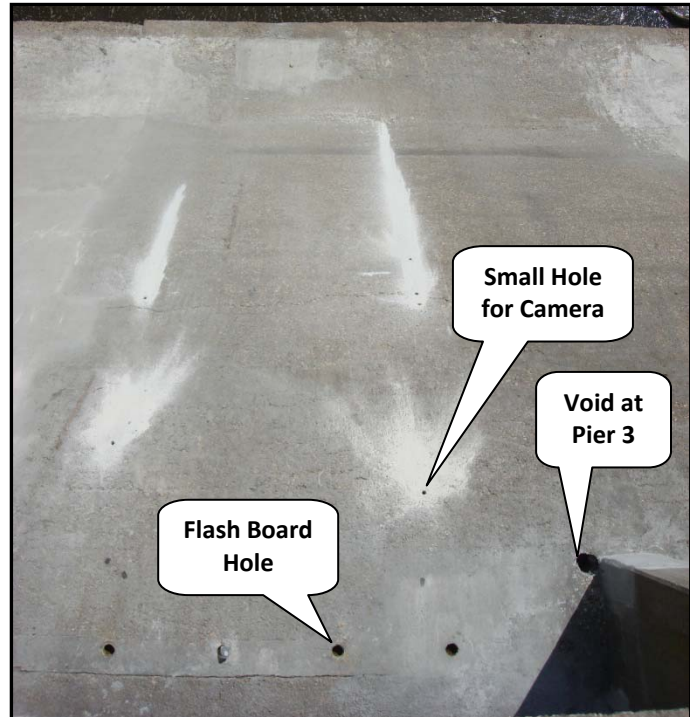
Toe of the Dam

It appears that undermining along the toe of the dam has occurred beyond the extent noted in the 2006 Inspection Report. The undermining is present along approximately 30 feet of the toe of the dam and varies in height and extent under the structure. The undermining appears to be from the removal of large portions of bedrock that had previously protruded up into the concrete at the toe of the dam in some areas. While most of the undermining is limited to removal of rock (or other material) below the concrete structure at the toe of dam for a horizontal distance of about two (2) feet on average, undermining of approximately six (6) feet horizontally under the structure was noted for a portion of the spillway between Piers 2 and 3. Attachment 2 illustrates the location of the undermining noted.

Section from July 15, 2011 Inspection Report:

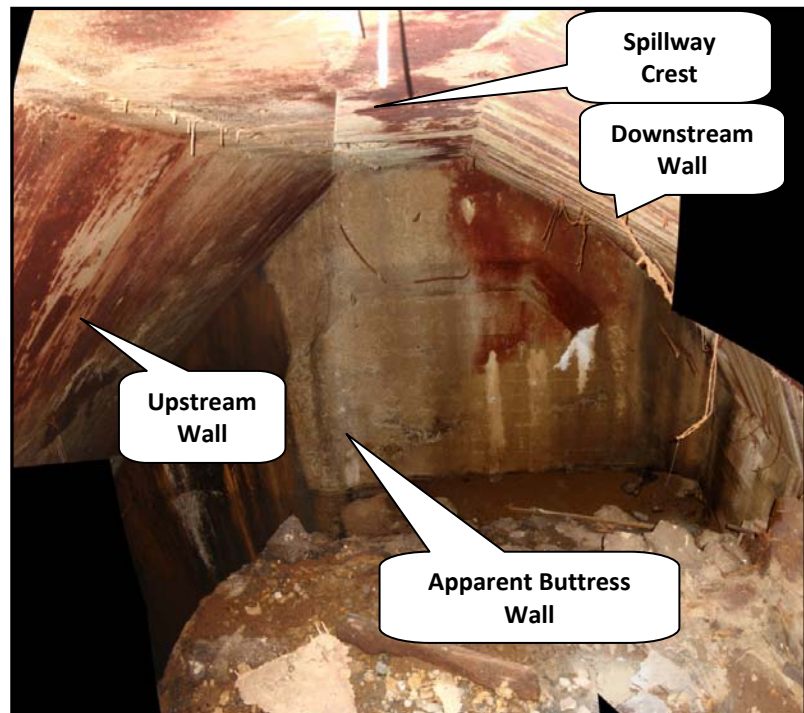
Original Construction

During the repair of the concrete, a void in the concrete at the crest of the dam was observed adjacent to Pier 3 (Pier 3 is noted as P3 in Attachment 2). The County conducted surface-penetrating radar and borescope surveys to determine the extent of void. The results of these surveys were inconclusive. Several small holes were drilled on the face of the dam in order to insert cameras and capture images of the void. During the inspection, a camera was inserted in the void and photographs were taken to determine the extent of the void. The photographs indicate that the inside face of the void was formed, and that the piers that extend up to the catwalk appear to extend down to the foundation of the dam and form interior chambers within the dam.



Photograph 10: Location of Void (July 15, 2011)

Photograph 11 is a composite of images taken by Baker at the time of the 2011 inspection. This photograph indicates that the upstream and downstream faces of the dam are formed on the inside. In addition, the vertical wall in the background is assumed to be the buttress wall at Pier 2. The photograph also indicates the presence of a separate mass that fills a portion of the interior cavity and the presence of construction debris at the bottom of the photograph. There does not appear to be an access hatch through the buttress wall based on Photograph 11. Additional investigation is required to fully understand the extent of the buttress walls and chambers. Also note that the chamber that was photographed in July 2011 was dry.



Photograph 11: Extent of Chamber (July 15, 2011)

Literature Review:

Based on the data obtained, a more in-depth literature review was completed to develop a more complete understanding about the dam structure. Historic accounts were researched, local historic library holdings were checked, and the County/VA Department of Conservation & Recreation (DCR) files were reviewed. Pertinent historic accounts, including several construction photographs, are presented in Attachment 5. A copy of the Phase 1 Dam Inspection report is presented in Attachment 6. In particular, the data obtained included a general plan and elevation, an unnamed partial dam section, and some construction details.

The data reviewed suggests that Lake Jackson Dam was constructed by 2 separate entities. Dam construction was started in 1927 by L.E. Myers Construction Company. In April 1928, ownership was transferred to Virginia Public Service (VPS), which is now known as the Virginia Electric and Power Company (VEPCO), and dam construction was completed in 1928/1929. A cofferdam was used to divert water during dam construction.

Available records indicate that the dam was initially constructed using concrete and steel with rubble masonry interior consisting of “large field stone.” An unnamed sectional view of the dam in historic documents suggests that the masonry rubble was about 23 to 25 feet high with vertical upstream face, 6 feet top width and about 21 feet wide base. Historic photographs indicate that the masonry structure was constructed in segments, to divert stream flow during construction, and then closed-in the open section to fill the reservoir. Historic accounts infer that the design of the Lake Jackson Dam may have utilized design features that were referenced from the Tytam Dam, which was constructed in 1888 near Hong Kong which consisted of rubble block placed in about 2-foot courses, with interior drainage pipe and an outer skin made of plank and Portland cement concrete.

VPS added a powerhouse, catwalk, tainter gate and historic accounts indicate that VPS faced the masonry rubble structure with concrete to form a smooth “ogee” like surface. The upstream face of the dam is sloped and reported to form a hollow interior between the original vertical face of the masonry rubble dam and the sloped upstream concrete face constructed by VPS. Dam Section A-A within Attachment 5 helps to illustrate the masonry rubble, concrete facing, and the hollow interior sections described above. Available plans suggest that the upstream face of the dam may be supported by a series of buttress walls inside the dam, which are spaced at about 15 to 18 feet center-to-center, presumably near each of the exposed piers, which is generally in agreement with the conditions observed in Photograph 11. A plan and elevation from the USACE Phase I Report has been adapted by Baker and placed in Attachment 5 to help illustrate these buttress walls.

Potential Issues Resulting in Toe Drain Activation:

Based on the literature review and site observations, it appears that there may be three potential issues that may be resulting in water entering the chambers and the activation of the toe drains.

- Seepage through the foundation of the dam.
- Seepage through cracks/damaged concrete sections of the upstream face of the dam.
- Seepage through a former bypass pipe/orifice that was used during construction and sealed, but has been subsequently ruptured.

Proposed Next Steps:

Due to the volume of water being released through the toe drains and the unknowns pertaining to how the water enters the spillway chambers from the reservoir, the County should consider the following:

- Continue surveillance and monitoring of the dam to document any changes that may occur.
- Under Phase II, investigate the extent of undermining and its potential impact on the stability of the dam. Evaluate any connection to the toe drain activity. Remediate undermining as necessary. The following are anticipated to complete the Phase II investigation.
 - a. Engage a diver to perform an underwater investigation to detect and document existing conditions at both the upstream and downstream face of the dam. Use a steel bar, survey level, survey rod and 100-foot tape, to document the location and extent of undermined areas encountered at the toe of the dam. Probe the upstream face of dam to determine the actual shape and extent of the reported sloping shell.
 - b. Core holes into the dam crest to obtain access to the dam interior to investigate the dam interior with a combination of chemical tracers, remote-operated TV-camera/survey equipment and submersible pump. Use the submersible pump to attempt to dewater the interior of the dam chamber(s) that is(are) accessed to facilitate visual inspection of the dam interior and assess interior flow paths; and then use a dye tracer to further assess the connectivity of seepage paths within the dam interior.
 - c. Fill access holes with cement mortar at completion of inspection.
 - d. Complete a conceptual level design and conceptual construction cost estimate to evaluate feasible alternatives to mitigate the cause of the existing toe drain activity (and other issues identified in Phase II).
 - e. Prepare a Technical Memorandum to document the Phase II findings.