VERMONT

Vermont Department of Environmental Conservation
Facilities Engineering Division
1 National Life Drive, 1 Main
Montpelier, VT 05620
Phone: 802-622-4093

Agency of Natural Resources

MEMORANDUM

TO:	To The File
FROM:	Benjamin Green, PE, Dam Safety Engineer Steven Hanna, Dam Safety Engineer
DATE:	December 23, 2019
SUBJECT:	Visual Dam Safety Inspection of Hardwick Lake Dam, Hardwick, Vermont State ID No: 93.01, National ID No: VT00186

On July 15, 2019, Steven Hanna, and Nick Brustin of the Dam Safety Program performed a visual dam safety inspection of Hardwick Lake Dam. The dam is owned by the Hardwick Electric Department, which is managed by Mike Sullivan. Mr. Sullivan granted permission for the inspection. Refer to the Dam Safety Inspection Program General Information page at the end of this report for more information and definitions of terms used in this report. The last documented inspection of the dam was on June 16, 2015.

BACKGROUND

Hardwick Lake Dam (also known as Jackson Dam) is a concrete gravity dam with a principal spillway, auxiliary spillway, and outlet works founded on bedrock. The dam is currently classified as a SIGNIFICANT hazard. According to our files, the dam has a total length of approximately 520 feet and a structural height of 23 feet. The principal spillway consists of a divided ogee weir with a total length of about 144 feet with a crest at El. 794.8 (all elevations in this report reference the National Geodetic Vertical Datum, NGVD, in feet). The spillway is fitted with slots and receivers for flashboard installation, although no flashboards were installed at the time of our inspection. Dividing the two principal spillway sections is a structure containing a 6-foot diameter, gate operated low-level outlet (LLO) with an invert of El. 780.0. To the right of the principal spillway is an approximately 40-foot-long auxiliary spillway at El. 797.3. To the left of the principal spillway is a structure containing two 6-foot diameter gate operated mid-level outlets with inverts at El. 786.0. It is our understanding that the right outlet is plugged and abandoned. To the left of this structure is an approximately 300-foot-long non-overflow concrete wall that extends to the left abutment with a crest at El. 801.0.

The dam impounds Hardwick Lake, which has a surface area of 180 acres, a drainage area of 78,144 acres, and normal and maximum storage of 900 acre-feet and 2,000 acre-feet, respectively. The dam was constructed in 1920 and reportedly was rebuilt in 1952. The dam was formerly used to store water for hydroelectric production downstream but has not been used for that purpose in many years. The Department of Environmental Conservation was given jurisdiction on this dam from the Public Service Board (now called the Public Utility Commission) circa 2008.

CONDITION RATING AND RECOMMENDATIONS FOR OWNER

Based on this visual inspection, the overall condition of the dam is considered **POOR**. This condition rating is consistent with past condition ratings for the dam and is due to the deteriorating condition of the concrete comprising the dam and the apparent hydraulic inadequacy of the dam. The specific concerns are identified in more detail in the Inspection Findings section. The following recommendations and remedial measures describe the recommended approach to address current deficiencies at the dam. It is intended that maintenance level activities can be performed by the Owner while Studies and Analyses and Remedial Repair Recommendations will require the services of a qualified professional engineer registered in the State of Vermont who is experienced in dam safety engineering design, permitting, and construction.

Maintenance Level Recommendations:

1. Establish clearing limits for brush and trees a minimum of 15 feet from all portions of the dam. This includes removal of the thick brush located on the left portion of the dam. After brush and vegetation removal, re-inspect the left side of the dam for any deficiencies that were not detected during this inspection.
2. Maintain the spillways, approaches, and discharge areas free of debris to promote free flow conditions.
3. Test operate the LLO and mid-level gates at least once per year and perform deferred maintenance.
4. Continue to monitor the deteriorated concrete comprising all elements of the dam.
5. Monitor the square opening on the left downstream concrete wall where seepage/leakage is emitting.
6. During low flow or winter drawdown conditions, inspect the spillway weirs. Also, during low flow conditions, visually observe the condition of the outlet conduits.

Studies and Analyses:

1. Perform an updated hydrologic and hydraulic analysis of the dam to determine hydraulic adequacy dam. As part of the analysis, perform dam breach and flood inundation mapping for use in hazard classification confirmation and emergency action planning.
2. Update the Emergency Action Plan and provide to the Dam Safety Program and Vermont Emergency Management for recordkeeping and informational purposes. Conduct a tabletop exercise of the updated EAP.
3. Develop an Operations and Maintenance Manual for the dam that documents monitoring, operations, as well as regular maintenance activities and provide to the Dam Safety Program.
4. Based on the monitoring of the deteriorated concrete conditions, consider developing a program to begin addressing the concrete repair/resurfacing.

Remedial Repair Recommendations:

1. Design and implement repairs to the dam based on the findings of the work performed above, including addressing concrete deterioration and hydraulic inadequacy. Alternatively, dam removal could be pursued.

INSPECTION FINDINGS

Hardwick Lake Dam was inspected on July 15, 2019. At the time of the inspection, the weather was partly cloudy with temperatures in the 70s. The water level in the lake was near normal levels. Photographs to document the current conditions of the dam were taken and are kept on file. Only exposed, accessible portions of the dam were inspected (i.e. underwater areas were not inspected).

- ***Abutments:*** The right abutment area appeared to be in fair condition. There is encroaching brush that should be removed and large trees in the area that should be monitored. The left abutment area also appeared to be in fair condition but is heavily overgrown with thick brush that made accessing the dam difficult.

- ***Upstream Face:*** The exposed portions of the upstream face consist of the LLO and mid-level outlet structures and the concrete wall section located on the left end of the dam. Surfaces generally appeared to be in fair to poor condition.

  The visible portions of the upstream concrete face at the LLO and mid-level outlets appeared to be in fair to poor condition. Some minor surface cracking as well as horizontal cracking and efflorescence was noted. The upstream face appeared to have good alignment and no unusual movement was observed. There was however some concrete that appeared to be delaminating and crumbling off the dam face.

  The several feet of exposed upstream face of the left wall section was obscured by wetland and brushy vegetation that prevented a thorough inspection. Some deteriorated surface conditions were observed. Near the right end multiple large logs were observed just upstream and against the face.

- ***Downstream Face:*** The downstream face of the dam consists of the LLO and mid-level outlet structures and the concrete wall section on the left end of the dam. Surfaces generally appeared to be in fair to poor condition.

The visible portions of the downstream face of the LLO and mid-level outlets appeared to be in fair to poor condition. Surface cracking and efflorescence was observed in multiple areas. Some horizontal cracking and general concrete deterioration were noted.

The several feet of exposed downstream face of the left wall section was obscured by brush and other vegetation preventing a thorough inspection. Several areas of delamination and exposed rebar were noted. The section near the outlet structure is deteriorated with exposed aggregate. No unusual movement was observed.

- ***Crest:*** The crest of the concrete wall section at the left end of the dam appeared to be in fair to poor condition. The crest had a width of approximately 4 feet. The horizontal and vertical alignment appeared to be good. Surface cracking, exposed aggregate, and delamination was observed in several areas. No unusual movement was observed.

- ***Drains/Seepage Collection:*** There is no drains or seepage collection systems at the dam.

- ***Instrumentation:*** There is no instrumentation at this dam.

- ***Principal Spillway:*** The condition of the spillways appeared to be fair to good at the time of inspection, although flow of over the weirs prevented a thorough inspection. The concrete walls on each side of the spillway were deteriorating slightly. There was also slight undercutting observed on the left side of the spillway. The spillway has slots and receivers for flashboards, which were not installed at the time of the inspection and as we understand, have not been used in some time. There were some small logs observed in the spillway but the approach area and discharge area were both clear.

- ***Auxiliary Spillway:*** The auxiliary spillway appeared to be in fair to poor condition. The approach area consists of long wetland vegetation and some debris that could potentially restrict free flow conditions. The discharge area was clear. There was no unusual movement observed at the time of inspection. Deteriorated surface conditions were noted at the right concrete training wall of the auxiliary spillway.

- ***Low Level Outlet/Drawdown Facility:*** The LLO and mid-level outlets were not inspected due to flowing water in the discharge channel. The outlets were not test operated during this inspection.

- ***Downstream Area:*** The downstream area was clear during the inspection. The left downstream are consists of a concrete training wall that directs flow from the spillway and mid-level outlet to the bridge opening downstream. A square opening in the downstream training wall just downstream of the dam was observed with seepage/leakage emitting from it. The discharge flows under Vermont Route 15 approximately 80 feet downstream of the dam.

- ***Reservoir Area:*** The reservoir area consists of Hardwick Lake. Located about 100 feet upstream of the dam is a boat barrier that appeared to be in good condition. The shoreline is generally vegetated and undeveloped with some development and a state highway along the western shore. The slopes around the reservoir generally appear to be mild and not overly susceptible to erosion.

- ***Access Roads and Gates:*** The left side of the dam is accessed from Route 15 while the right side of the dam is accessed from the convenient store at the Route 14/15 intersection. Access to the spillway and gates is restricted by locked gates. The access to the LLO pier requires crossing a pedestrian suspension bridge. These restricted areas were not accessed as part of this inspection.

- ***Operation and Maintenance:*** There is no formal Operation and Maintenance Manual (O&M) for the dam on file with the State. It is our understanding that some regular monitoring and maintenance is performed. It is also our understanding that the reservoir is lowered in the winter months by the Owner per US Army Corps of Engineers guidance to reduce ice jams in the Lamoille River upstream in Hardwick.

- ***Emergency Action Plan (EAP):*** The most current EAP in State files was developed in May 1993. Since the dam is currently classified as a SIGNIFICANT hazard, it is recommended that an EAP be developed, or at least properties downstream of the dam that could be damaged in the event of a dam failure be identified, contact information for affected property owners/tenants and local/State emergency personnel be collected, and triggers for making emergency contacts and taking preventative measures be identified.

  Based on cursory map and aerial photograph review of the downstream area, the following infrastructure was noted along the Lamoille River:

  - Approximately 80 feet downstream of the dam is the Vermont Route 15 Bridge. Downstream of this crossing for some distance is a fairly wide flood plain area bordered to the north by Route 15 and to the South by a railroad embankment. It does appear, in the event of a dam failure, there is potential for damage to infrastructure within and along this flood plain area.
  - Approximately 1.1 miles downstream is McAllister Farm Road Bridge crossing that appears to service two 911 addresses.
  - Approximately 1.5 miles downstream is a private driveway crossing.
  - Approximately 2.4 miles downstream is the Kate Brook Road crossing.
  - Approximately 3.6 miles downstream is a railroad bridge crossing.
  - Approximately 4.0 miles downstream is the Vermont Route 15 crossing.
  - Approximately 4.8 miles downstream is the Wolcott Dam, a HIGH hazard hydroelectric dam also owned by the Hardwick Electric Department.

- ***Hydrologic/Hydraulic Data:*** Since Hardwick Lake Dam is a SIGNIFICANT hazard dam, the Spillway Design Flood (SDF) is considered to be between the 100-year and ½ Probable Maximum Flood (PMF) event according to Army Corps of Engineers Guidance (ER 1110-2106) generally used in the State of Vermont. The most recent hydrologic and hydraulic study performed on the dam in the State files was the 1980 Phase I Inspection Report. As part of that study, the ½ PMF was selected as the SDF for the dam. It was estimated that the dam can only pass 16% of the SDF before overtopping non-overflow areas.

  Under normal pool conditions, the dam has approximately 6 feet of freeboard between the normal water level and the dam crest, which exceeds the minimum normal pool freeboard (3 feet) required by State standards. However, based on the results of the Phase I Study, the dam cannot safely pass the SDF and is therefore considered hydraulically inadequate. If should be noted that the Phase I Study, at nearly 40 years old, uses outdated and simplified analysis techniques that are not in compliance with current requirements or practice.

- ***Structural Stability:*** Detailed stability analyses were not available in the file and have not been performed as part of this study. At the time of the inspection, the structural elements of the dam including the spillways and other concrete elements appeared stable under normal loading conditions based on visual observation.

- ***Seepage:*** No uncontrolled leakage or seepage was observable at the time of the inspection. It should be noted that flows over the spillway and in the discharge, channel prevented access and thorough inspection of all areas.

- ***Inspection Safety Considerations:*** Other than the standard safety protocols when working adjacent to reservoirs and/or flowing water, there are no inspection safety considerations for this dam.

DAM SAFETY INSPECTION PROGRAM GENERAL INFORMATION

The Dam Safety Program conducts periodic safety inspections of non-federal, non-hydroelectric dams to determine their condition and the extent, if any, to which they pose a potential or actual threat to life and property. Dams that impound more than 500,000 cubic feet of liquid require approval from the Department under provisions of 10 VSA Chapter 43 before alternating, reconstructing or breaching. The Department's current policy is to inspect only those dams that are capable of impounding more than 500,000 cubic feet unless specifically requested by the owner.

The condition rating assigned to the dam reported herein was based on available data and visual inspection. Detailed investigations and analyses were beyond the scope of this report. It should be realized that the reported condition of the dam was based on observations of field conditions at the time of inspection, along with data available to the inspection team. The condition of the dam depends on numerous and constantly changing internal and external conditions and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Hazard Classifications: (U.S. Army Corps of Engineers Guidance)
High Hazard: Dams where failure is expected to cause loss of more than a few lives and excessive damage to homes, industrial or commercial facilities, important public utilities, main highways or railroads.
Significant Hazard: Dams where failure is expected to cause loss of a few lives and appreciable damage to homes, industrial or commercial facilities, secondary highways or railroads.
Low Hazard: Dams where failure is not expected to cause loss of life and only minimal property damage.

Condition Ratings:
Good: No existing or potential deficiencies recognized except for minor operational and maintenance deficiencies. Safe performance is expected under all loading including the Spillway Design Flood.
Fair: Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual or extreme loading conditions up to and including the Spillway Design Flood.
Poor: Significant structural and or operation and maintenance deficiencies are clearly recognized under normal loading conditions.

Definitions:
Upstream: The side of the dam that borders the impoundment.
Downstream: The high side of the dam, the side opposite the upstream side.
Right: The area to the right when looking in the downstream direction (also known as "river right").
Left: The area to the left when looking in the downstream direction (also known as "river left").
Height of Dam: The vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.
Embankment: The fill material, usually earth or rock, placed with sloping sides so it creates a permanent barrier that impounds water.
Crest: The top of the non-overflow portion of the dam, often provides a road or path across the dam.
Abutment: The part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed at the interface with a concrete gravity section.
Normal Pool: The elevation of the impoundment during normal operating conditions.
Maximum Storage Capacity: The volume of water contained in the impoundment at maximum water storage elevation, which is typically considered the crest of the dam.
Normal Storage Capacity: The volume of water contained in the impoundment at normal water storage elevation or normal pool levels.
Impoundment: The body of water or other liquid created by the dam.
Principal Spillway: A structure over or through which normal water flows are discharged. A "controlled" spillway is controlled by gates or boards, while an "uncontrolled" spillway is one with a fixed crest and no gates or boards.
Auxiliary Spillway: A structure over or through which only abnormal or extreme storm flows are discharged.
Outlet Works: A means to lower or control the water level in the impoundment below the normal pool level.
Spillway Design Flood (SDF): The flood used in the design of a dam for sizing items such as the spillway, outlet works, and dam height. Based on Army Corps of Engineers Guidance and State Statue, the following ranges of SDF's are typically used in Vermont, Low Hazard = 100-year Storm, Significant Hazard = 100-year Storm to ½ Probable Maximum Flood (PMF), High Hazard = ½ PMF to PMF.
Emergency Action Plan (EAP): A predetermined and properly documented plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam failure.
Operations & Maintenance Manual (O&M): Document identifying routine maintenance and operational procedures under normal and storm conditions.