

MEMORANDUM

TO: Michael and Deborah O’Loughlin, Dam Owners

FROM: Benjamin Green, PE, Dam Safety Engineer
Steven Hanna, Dam Safety Engineer

DATE: March 25, 2021

SUBJECT: Visual Dam Safety Inspection of Amherst Lake Dam, Plymouth, Vermont
State ID No: 156.05, National ID No: VT00131

On March 18, 2021, Benjamin Green and Steven Hanna of the Dam Safety Program (DSP) performed a visual dam safety inspection of the Amherst Lake Dam. The dam is owned by Michael and Deborah O’Loughlin (Owner) who provided permission for and attended the inspection. Todd Menees, PE, of the DEC Rivers Program also attended the inspection. The inspection was prompted by outreach by the Owners to various DEC programs regarding a proposal to remove or not re-install the timber flashboards at the dam as a risk reduction measure. 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 July 8, 2019.

BACKGROUND

Amherst Lake Dam is a concrete gravity dam with a principal spillway and outlet works. The dam is currently classified as a SIGNIFICANT hazard potential. According to DSP files, the dam is approximately 115 feet long with a structural height of about 17 feet high and a hydraulic height during normal pool of approximately 6 to 8 feet. The principal spillway is an approximately 80 foot long concrete weir fitted with approximately 2-inch diameter steel pipe flashboard supports that are approximately 2 feet on center. The flashboards are 1.5-inch thick by 11.5-inch-high timber boards. The principal spillway weir crest is approximately 9.4 feet below the dam crest/top of concrete training walls. To the right of the principal spillway is an outlet works consisting of a 5-foot-wide channel with an 8-foot-high timber slide gate operated from by a hand wheel mechanism on the concrete bridge above. The top and bottom of the gate are approximately 5.9 feet and 13.9 feet below the dam crest/top of concrete training wall, respectively.

It is our understanding the gate and flashboards are typically seasonally operated as follows:

- In the fall, the flashboards are removed and the concrete principal spillway weir controls flows and water levels from fall to spring (i.e., winter drawdown).
- In the spring, the flashboards are installed by stacking two boards high above the concrete principal spillway weir to a total height of approximately 23 inches.
- During flashboard removal and installation, the gate is operated to lower the water level and pass flows.

The drainage area of the dam is about 19.1 square miles. The dam impounds Amherst Lake, which is a recreational water body with a normal pool surface area of about 80 acres and normal and maximum storage capacities of 380 and 1,050 acre-feet, respectively. The dam raises the water level on this natural lake on the order of 6 to 8 feet. The dam discharges directly into Echo Lake and the Black River. The dam is reportedly founded on glacial till soils. The dam was reportedly constructed circa 1950 to replace a timber crib structure at the site. It is our understanding that in 2015, new flashboards were installed and maintenance was performed to the supporting pins.

The dam has been inspected by the DSP in 1984, 2005, 2014, and 2019. The 2005 and more recent inspection reports are available in our files and rate the dam in POOR condition. The inspection reports note the deterioration of the right abutment

and outlet works gate area including concrete cracks, section loss, and spalling that threaten the structural integrity of the dam.

CONDITION RATING AND RECOMMENDATIONS FOR OWNER

Based on this visual inspection, the overall condition of the dam is considered **POOR**, consistent with the condition ratings from previous inspections. Continued deterioration of some concrete elements that threaten stability were noted. Risk reduction measures including reservoir-level restriction/reduction until the dam can be rehabilitated or removed are recommended below. 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.

For Immediate Attention:

The following items shall be performed with assistance from the DSP and other DEC programs.

1. Remove the flashboards and pins and modify the gate as a public safety/risk reduction measure. The lower pool should be maintained until the dam is rehabilitated, removed, or conditions worsen further requiring additional reservoir-level reduction. It has been estimated that these risk reduction activities will reduce normal pool loading on the dam on the order of 30%, and by reducing flood levels in the lake, greater load reductions during flooding events. The following actions are specifically recommended:
 - Develop a Water Control Plan that includes a narrative on the background of the dam and the public safety/risk reduction need to perform these actions, outlines the procedure for how the risk reduction measures will be achieved, and address considerations of DEC Programs including Dam Safety, Wetlands, Flow Protection, and Lakes and Ponds. Dam Safety Staff will remain available to assist in the development and implementation of this plan and help in consultation with other DEC programs.
 - Remove and do not reinstall the flashboards to lower the normal water level to the concrete principal spillway crest.
 - Cut off the flashboard pins at grade to reduce debris clogging, for operator safety, and to reduce the potential for unauthorized operation.
 - Cut out the top timbers of the slide gate (not the frame) so that the top approximately matches the crest of the principal spillway to reduce loading on the marginally stable structure.

Maintenance Level Recommendations:

1. Maintain clearing limits for brush and trees a minimum of 15 feet from all portions of the dam, including the abutments. Monitor stumps as they decay.
2. Maintain the approach and discharge areas of the dam clear of debris to promote free flow conditions.
3. Test operate the outlet works gate at least once or twice annually and perform maintenance.
4. During low flow conditions, inspect the principal spillway apron to determine the degree and extent of undermining and if there is seepage coming under the dam.
5. Regularly monitor the condition and stability of the concrete training walls. Take care to note continued deterioration, tilting, or displacement.
6. Monitor the condition of the timber gate and any associated leakage.

Studies and Analyses:

1. Perform an updated hydrologic and hydraulic analysis of the dam to determine hydraulic adequacy. As part of the analysis, perform dam breach and flood inundation mapping for use in hazard classification confirmation and emergency action planning, recommended below.
2. Address the comments provided below on the Emergency Action Plan. Perform more detailed dam breach and flood inundation analysis under sunny and stormy day conditions to determine the timing, depth, and velocity of flooding of homes downstream.

3. Perform an assessment of the structural stability of the training walls and identify repair alternatives.
4. Investigate the undermining of the spillway apron and seepage/stability impacts.
5. Develop an Operations and Maintenance Manual for the dam.

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 stability of the outlet works. Alternately, consider a dam removal alternative and the associated risk reduction and environmental benefits versus public and recreational uses/benefits.

INSPECTION FINDINGS

The Amherst Lake Dam was inspected on March 18, 2021. The weather was overcast with light rain and temperatures in the 30s. At the time of the inspection, one set of 11.5-inch-high timber flashboards were installed over the principal spillway weir and the lake level was approximately 15.5-inches above the concrete weir with approximately 4-inches of flow depth over the flashboards. Snow covered the abutments of the dam. Photographs to document the current conditions of the dam were taken and are kept on file. Several select photographs documenting the deficiencies are appended to this report. Only exposed, accessible portions of the dam were inspected (i.e., underwater areas were not inspected).

- **Changes/Updates from Previous Report:** The intent of this section is to document any newly observed deficiencies, observed changes to the dam, as well as any operation or maintenance measures implemented by the owner since the previous inspection. Further detail on these items are incorporated in the sections below:
 - Tree and brush removal within the dam footprint was completed.
 - The handwheel on the outlet gate has been secured to discourage unauthorized operation.
 - The Emergency Action Plan was updated.
 - Safety signage warning of safety hazards were observed at both abutments.
 - Continued deterioration of concrete elements including the right abutment/training wall and wall separating the principal spillway from the outlet works was observed through additional concrete section loss, tilting, crack propagation, and displacement, threatening the stability of the structure.
- **Abutments:** The abutments key into natural ground. The abutment contacts appeared to have good horizontal and vertical alignment, although were snow covered preventing a thorough inspection.
- **Drains/Seepage Collection:** There is no drains or collection systems at the dam.
- **Instrumentation:** There is no instrumentation associated with this dam. Painted water level markings were observed on the left training wall.
- **Principal Spillway:** The broad crested weir appeared to be in fair condition. The approach and discharge areas were generally clear with some minor debris. At the time of the inspection, the flashboards were installed one board high with what is typically the upper flashboard installed adjacent to the lower flashboard. The flashboards appeared to be in fair condition. The steel supporting pins, which are grouted in place, generally appeared to be in fair condition. Typically, flashboard support pins are designed to bend over or release at a certain reservoir level or load to reduce loading on the dam during a severe flood event. It is not clear if these support pins were designed in this way and under what storm event/depth of overtopping they may release. Several pins have rotated slightly in the downstream direction and the left most pin has corroded through. A section of steel flashing meant to reduce flashboard leakage was observed.

The flow over the installed flashboards obscured the view of the boards and concrete downstream preventing a thorough inspection. The surficial conditions of the sloping and level concrete splashpad appeared fair. The concrete joints also appeared to be in fair condition. There was up to approximately 12 inches and potentially deeper undercutting under the downstream end of the splashpad/apron where it could be accessed. Tailwater prevented

further investigation into the undercutting and detection of any under leakage. At the right downstream end of the splashpad, a large concrete mass was observed. The purpose of this concrete mass is not known.

The left concrete training wall appeared to be in fair condition. Minor surficial surface cracking was observed in a few areas. The wall is tilted inwards towards the spillway approximately 1 to 3 degrees past vertical (approximately 0.5 to 1 inch horizontally per 24 inches vertically)

The right concrete training wall is also the dividing wall between the spillway and the gated outlet channel. The condition of this wall is poor as the downstream end of the wall is completely undermined with loss of support for approximately 10 feet laterally except for several corroded, 0.75-inch diameter rebar. The concrete is heavily deteriorated with exposed aggregate, delamination, and cracking. A horizontal crack extends on the gate side of the wall from the gate in the downstream direction and displacement towards the spillway along the crack was observed. The wall above the crack is tilted towards the spillway greater than 3 degrees past vertical. It should be noted that at the top of the wall is a short concrete bridge that supports the gate mechanism and ties the wall to the right abutment wall. The connection of the wall to this bridge appeared good, but it was noted that both the walls are similarly tilted (racked) towards the spillway. Based on review of past inspection report photographs, continued concrete section loss, cracking, and tilting was observed. The wall appears marginally stable under normal loading conditions.

- **Auxiliary Spillway:** There is no auxiliary spillway at the dam.
- **Low Level Outlet/Drawdown Facility:** The outlet consists of a concrete channel and timber slide gate that can be opened to discharge flow/lower the impoundment. The gate was not test operated as part of the inspection, but the Owner reported the gate was last operated without issue in Fall 2020. The right concrete training wall of the outlet works is also the right abutment wall of the dam. The wall has a vertical crack between the main portion of the wall and the wing wall on the upstream side that has an opening up 2-inches. On the face of the wall at this location near the normal water level, an approximately 18-inch-deep section loss with exposed spalling concrete/aggregate was observed and appears to be worsening based on review of past inspection photographs. The wall appears to be tilted inwards towards the outlet/spillway on the order of 1 to 3 degrees, similar to the left wall dividing the outlet channel from the spillway. As noted above, the left wall is in poor condition, cracked at the gate contact, tilted towards the spillway, and undermined at the downstream end.

The gate appeared to be in fair condition overall. The right and left sides are set in a steel channel lined slots/guides. Some concrete deterioration and section loss was observed at the water level on the right gate slot/guide. Minor leakage was observed around the ends of the gate in several locations. The timber boards comprising the gate generally appeared to be in fair condition, although the top two appeared to be rotting. The operating mechanism appeared to be in fair condition and was secured to prevent unauthorized use. The concrete bridge that spans the outlet channel and supports the operating mechanism appeared to be in fair condition.

- **Downstream Area:** The downstream area is a short channel centered on the right side of the dam that leads directly into Echo Lake. Some evidence of scouring of the stone armoring downstream of the principal spillway was observed. During a storm event, the hydraulic capacity of the dam may be impacted by backwater from Echo Lake.
- **Reservoir Area:** The reservoir area consists of Amherst Lake. The shoreline is generally vegetated and largely undeveloped except for some residential homes/camps and a state highway along the western and north/northeastern shore. The slopes around the reservoir generally appear to be moderate to steep but do not appear to be overly susceptible to erosion.
- **Access Roads and Gates:** The dam can be accessed on the right/west from Amherst Road, that extends approximately 600 feet from Vermont Route 100 to the right abutment of the dam. Access to the left abutment and dam is from the owner's property on Scout Camp Road.

- **Operation and Maintenance:** There is no Operation and Maintenance Manual on file for the dam. As noted above, there are seasonal operations at the dam and the current owner has been performing some dam maintenance.
- **Emergency Action Plan (EAP) and Hazard Classification:** The most current version of the EAP was provided by the Owner during development of this report and was reportedly updated recently. Since the dam is currently classified as a SIGNIFICANT hazard, it is recommended that an EAP be maintained and kept up to date. Review of the EAP and updates including names and phone numbers of key emergency personnel and review of inundation mapping for any new development is recommended, at a minimum, on a two-year basis.

Based on review of the EAP, a sudden failure of the dam could result in the inundation of approximately 19 homes and 1 State Park located along Echo Lake, immediately downstream of the dam. It is anticipated that Echo Lake, Lake Rescue, and Lake Pauline (also known as Reservoir Pond) located downstream along the Black River would provide some flood attenuation/storage and ability to “absorb” flood flows, potentially lessening impacts further downstream. The current version of the EAP was reviewed, our comments are as follows:

- It is noted that this EAP was originally developed in 2018 and has undergone some minor revisions since. It is recommended that each time a revision is made, the table, “Record of Revisions and Updates Made to EAP” be updated and the date of the revision be placed on the cover for document control.
- On page 4 under roles and responsibilities, it is noted that personnel from Hawk Mountain Resort are the Owner’s representative. During the site visit, it was indicated by the Owner that this relationship was informal. It is suggested that expectations and roles and responsibilities of the Owner’s representative be made clear and confirm the chosen entity in this role understands and agrees.
- On page 6:
 - It is noted that the Municipal Manager is responsible for classifying the event emergency level. The Municipal Manager does not appear to be defined or used elsewhere in the EAP. Typically, emergency level determination, depending on time available, would be a decision made between the Dam Owner, technical representatives, and emergency management personnel.
 - The EAP appears to indicate participation in an emergency by Natural Resource Conservation Service (NRCS) personnel. In our experience, it is unlikely the NRCS would play a role in dam safety emergencies. The mention of NRCS personnel in the EAP should be addressed throughout.
 - Flow through the earth spillway is noted on this page. This dam does not have an earthen auxiliary spillway. It is recommended this statement be removed.
- On page 7, it is recommended that the earth spillway flow event be removed and the table and following pages be reviewed for events that are probable given the configuration of the dam.
- On the Emergency Level Notifications, please confirm the role of the State Conservation Engineer. In our experience, he does not play a role in dam safety emergencies. It is also recommended for Level 1 notifications, that the Incident Commander and Emergency Coordinator be informed of the situation at the dam with no necessary action for them, but to make them aware of the potential for event progression.
- Emergency Services Contacts on page 15, remove Vermont DEC Facilities Engineering Division, this is the former name of our division and Stephen Bushman was our former, but now retired lead.
- Page 21, Record of Holders, please note under copy number 8, the VT ANR is no longer located in Waterbury, but at the address at the top of this report.
- It is noted that the signature and concurrence pages are not signed. While not critical, the more important thing is that key emergency management personnel have reviewed this plan, provided any comments, and agreed to their role and responsibilities.
- It appears that the inundation map and estimate of impacted properties downstream was developed using ANR’s Flood Ready Map, which depicts potential flooding extents from a 100-year storm event without dam failure. While this may give a good indication of potential flood impacts from a dam failure under certain conditions, it did not consider a dam breach under sunny day and storm conditions and it is not clear how backwater impacts from Echo Lake were accounted for. Since 19 homes are anticipated to be flooded based on this mapping, the estimated time to flooding, flood depths, and velocities at and near these structures should be determined to better understand the risk associated with the dam and confirm the hazard

classification (i.e., determine if the hazard classification is correctly classified as SIGNIFICANT or if a different classification is more appropriate).

- **Hydrologic/Hydraulic Data:** Since Amherst Lake Dam is a SIGNIFICANT hazard dam, the Spillway Design Flood (SDF) is considered to be the 1,000-year flood event according to Federal Guidance currently used in the State of Vermont. It appears that there were two cursory studies performed in the 1950s that considered potential impacts of flashboard failure at the dam. However, no comprehensive hydrologic and hydraulic study of the dam was found in State records.

With water levels at the concrete principal spillway crest or the top of timber flashboards (23-inches above), the dam has approximately 9.3 feet and 7.5 of freeboard, respectively, between the water level and the dam crest. In both cases, this exceeds the minimum normal pool freeboard (3-feet) required by State standards. Since there is no available hydrologic and hydraulic study for the dam, the ability of the dam to safely pass the SDF is considered unknown.

- **Structural Stability:** Engineering analyses of static and dynamic stability of the training walls, outlet structure, and spillway were not available and have not been conducted for this study. The principal spillway weir appeared stable under normal loading conditions based on visual inspection. The left training wall of the spillway appeared to be tilting slightly. The right spillway training wall/left outlet wall is undermined, cracked, tilting towards the spillway, and appeared marginally stable under normal loading conditions. Continued deterioration of this wall or the application of flood load conditions could cause instability and failure of this wall, which supports the gate, resulting in a partial failure of the dam and uncontrolled release. The right outlet works training wall is cracked with section loss and exposed aggregate and is also tilted towards the spillway. Structural evaluation and repair of these elements is recommended to ensure continued, reliable service.
- **Seepage:** No uncontrolled leakage or seepage was observed at the dam.
- **Inspection Safety Considerations:** Other than the standard safety protocols when working adjacent to reservoirs and/or flowing water, there are no special inspection safety considerations for this dam.

Amherst Lake Dam



Photo 1: March 2021, an overview of the dam from the left abutment area



Photo 2: March 2021, an overview of the dam from the downstream area looking upstream.

***Photos 3 through 6 from 2010 to 2021 to show rate of change of condition of concrete wall**



Photo 3: August 2010, downstream end of concrete wall separating the spillway from the outlet works.



Photo 4: July 2014, downstream end of concrete wall separating the spillway from the outlet works, note continued section loss and deterioration.



Photo 5: July 2019, downstream end of concrete wall separating the spillway from the outlet works, note continued section loss and deterioration.



Photo 6: March 2021, downstream end of concrete wall separating the spillway from the outlet works, note continued section loss and deterioration.

***Photos 7 and 8 from 2014 and 2021 to show rate of change of condition of concrete wall**



Photo 7: July 2014 looking upstream at the gate structure and wall separating the outlet from the spillway. Note the crack and deteriorated concrete.



Photo 8: March 2021 looking upstream at the gate structure and wall separating the outlet from the spillway. Note the continued deterioration of concrete and displacement of the wall towards the spillway above the crack.



Photo 9: March 2021 looking downstream from the right abutment area. Note the section loss of the right training wall.

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 removing.

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 Potential Classifications:

HIGH: Dams where failure or mis-operation will probably cause loss of human life.

SIGNIFICANT: Dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

LOW: Dams where failure or mis-operation results in no probable loss of human life and low economic and environmental losses.

MINIMAL: A dam that meets the LOW hazard definition, above, but is only capable of impounding less than 500,000 cubic feet.

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 side of the dam 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”).

Structural Height-of-dam: The vertical distance from the lowest point in the stream bed or native ground surface at the downstream toe of the dam to the elevation of the lowest nonoverflow section of the dam crest.

Embankment: An artificially constructed feature usually consisting of earth and rock with sloping sides and a flat crest, intended to provide a permanent barrier that impounds or is capable of impounding water.

Dam Crest: The top of the nonoverflow portion of 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 water elevation, reservoir surface area, and reservoir storage capacity that is prevalent at the site or typical under normal, non-storm conditions. Typically, this level is controlled by the principal spillway.

Maximum Pool: The highest water elevation, reservoir surface area, and reservoir storage capacity that could be impounded by the dam, including accumulated sediments, with the water or liquid level at the top of the lowest nonoverflow part of the structure or dam crest.

Impoundment: The body of water or other liquid created by the dam.

Principal spillway: A structure that maintains normal pool conditions and over which daily nonstorm related and flood flows are discharged. Also called a primary or service spillway.

Auxiliary Spillway: The secondary spillway not in use under normal conditions but used when needed to pass flood flows that exceed the capacity of the principal spillway.

Low-level outlet or “LLO”: An installed pipe and operable gate or valve typically located in or near the foundation of a dam that can be used to alter water levels, drain the reservoir, or otherwise meet operational or safety needs. Also called a pond drain.

Spillway Design Flood or “SDF”: The storm event which the hydraulic capacity of the spillway structure and dam is designed and required to safely pass. Based on Army Corps of Engineers Guidance, the following ranges of SDF’s are have historically been 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. New dam safety rules currently under development are considering the following prescriptive SDF’s, Low and Minimal Hazard = 100-year Storm, Significant Hazard = 1,000-year storm, High Hazard Dam = PMF. The use of incremental consequence analysis or risk-informed decision making to evaluate the potential of selecting a smaller/site specific SDF is permitted.

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.

Operation and Maintenance Plan or “O&M”: A plan that provides guidelines for the necessary, regular operation and maintenance activities at a dam.