

APPENDIX A

DESCRIPTION OF PROJECT

Toddy Pond Dam

The Toddy Pond Dam is located at the outlet of Toddy Pond in the Town of Orland, Maine, adjacent to Hatchery Road. The dam is a concrete and masonry gravity structure with gate, spillway, fish ladder and abutment sections. The structure was formerly used for hydropower production but the powerhouse and penstock have since been removed. The structure is primarily used to regulate lake levels in Toddy Pond and provide flows in Toddy Pond Stream for the migration of alewives.

Since no drawings of the Toddy Pond Dam are known to exist, the structure was surveyed by KA engineers for purposes of the breach analysis. All elevations are approximate USGS datum, as converted from site datum which is estimated to be 65 feet lower than USGS datum.

In the center of the structure is a 5' wide wooden sluice gate with a sill elevation of 158.3' (USGS), 6.7' below the normal lake elevation of 165.0'. The concrete gate structure has a width of 11.5', including the gate. Granite masonry spillways abut the gate structure and are nearly 4' thick. The west spillway has a length of 9.2' and an approximate crest elevation of 165'. The east spillway has a length of 10.0' and a crest elevation of 165'. The sills of both spillways are at approximately elevation 160'.

The east spillway is abutted by a 5' wide pier and 5' wide fish ladder. The sill of the fish ladder at the upstream end is at elevation 161.3', with flow in the ladder controlled by wooden baffles. The east abutment is a concrete structure at elevation 167.4' with a top width of 2.3'. The abutment ties into the shoreline of the basin at the outlet of Toddy Pond and is approximately 27' long.

The west abutment is at elevation 167.4' with a top width of 2.4'. The abutment is over 39' long and is abutted by the abandoned and plugged intake structure. West of the abandoned intake is a earth embankment with concrete core wall at elevation 166.5'. The width of the core wall is 1.4'. The core wall extends nearly 82' feet to a house which sits on the shoreline of the Toddy Pond outlet basin. The embankment slopes approximately 3' down to the elevation of Hatchery Road.

Downstream of the dam is a concrete apron that slopes down to an elevation of 152.7' below the Hatchery Road bridge. The bridge has an opening of 11.4' and a low chord elevation of 160.5'. The bridge deck crown is at an approximate elevation of 164.0'.

The Toddy Pond Dam impounds approximately 19,658 acre-feet of water at the normal pond elevation of 165', with a surface area of approximately 2,360 acres. The drainage area contributing to the site is 25 square miles, including the 3.7 square mile surface area of the lake. When the lake elevation is below elevation 165', the principal means of passing flow is through the sluice gate with a small amount of flow also contributed by the

fish ladder. Above elevation 165' overflow of the unregulated spillways occurs in addition to gate flow and fish ladder flow.

Toddy Pond Stream

Toddy Pond Stream flows from Toddy Pond to Alamoosook Lake, a distance of approximately 0.7 mile. The normal level of Alamoosook Lake is elevation 21' (USGS), so that the gross elevation difference between Toddy Pond and Alamoosook Lake is 144'. The steeply sloping stream is defined by a boulder strewn streambed and high wooded banks. The gradient of the stream flattens near the confluence with Alamoosook Lake in a large wetland. Alamoosook Lake flows into the Narramissic River, which is backwatered by the Orland Village dam which separates the Narramissic River from tidewater.

There is little development adjacent to Toddy Pond Stream downstream of the dam. As noted previously, the Hatchery Road bridge has a low chord elevation of 160.5' and a deck elevation of approximately 163.5'. A single residence downstream of the Hatchery Road bridge has a sill elevation of approximately 165'. The only other structures downstream of the dam are properties on the shoreline of Alamoosook Lake and houses along the Narramissic River.

Little information exists about watershed hydrology, lake levels and historic flows at the regulated Toddy Pond site. From lake level records provided by International Paper for the period January 1960 through August 1998, a peak lake level of 166.8' (estimated USGS datum) occurred in December 1969. The flow in Toddy Pond Stream was unknown, but was calculated to be 157 cfs of overtopping flow (1.8' over the spillways and 0.3' over the west core wall) with an unknown amount of gate flow. Assuming a maximum gate opening of 5', the gate could have been contributing as much as 300 cfs additional flow. Typically, Toddy Pond lake levels are between elevations 164' and 165', with the lowest levels occurring during the summer.

Toddy Pond has drainage area of approximately 25 square miles. In watersheds in Maine, average annual flows are approximately 2 cfs/mi² according to records from gaged basins. The average annual flow for the Toddy Pond drainage is therefore estimated to be 50 cfs.

3.0 DAM BREACH ANALYSIS

3.1 Breach Model

The National Weather Service model DAMBRK was used to predict the outflow resulting from a breach in the Toddy Pond Dam. Outflows were routed in Toddy Pond Stream downstream to its confluence with Alamoosook Lake, a distance of approximately 0.7 mile. Cross section data used in the model were derived from the “Orland, Maine” 7.5 minute series USGS topographic map. Ten (10) cross sections were used in the breach analysis to model the project and downstream reach. Manning’s roughness values were approximated for the channel and floodplain.

Level pool routing was used in the model, which is considered to maximize the outflow predicted for a breach in the Toddy Pond dam. At some point, outflow from Toddy Pond may be influenced by other controls, such as the bridge separating the outlet basin from the main body of Toddy Pond or other narrows or shoals within the lake. The use of level pool routing is therefore a conservative assumption for the study. The stage-volume data for Toddy Pond was derived from a report by R. Stevens Kleinschmidt, “Report on Process Water Supply” (January 30, 1968), which studied the water supply available from Toddy Pond, Alamoosook Lake and Silver Lake. (Currently, water is pumped from Alamoosook Lake to Silver Lake, which is the water supply reservoir for International Paper and Town of Bucksport.)

The following stage-volume rating was used in the breach model.

<u>Elevation (feet, USGS datum)</u>	<u>Volume (acre-ft)</u>
156	0
158	3,993
160	8,293
161	10,443
163	14,897
165	19,658 — NP
166	22,115 — 167 TPD
168	26,114

24000

3.2 Breach Parameters

In the absence of specific breach criteria from the State of Maine dam safety program, breach parameters for the Toddy Pond dam were derived from Appendix II-A of the Federal Energy Regulatory Commission's *Engineering Guidelines for the Evaluation of Hydropower Projects* (October 1993). These guidelines are widely used for breach analyses throughout the United States and are considered to be representative of the modes of failure that might occur for different types of dams.

A rectangular breach 10 feet wide, or the entire length of the east spillway, was assumed, with a bottom of dam elevation of elevation 160'. The breach height between the masonry spillway crest and bottom of the breach is 5'. Due to the small size of the masonry spillway a sudden failure with a breach development time of 0.1 hour was also assumed, which is the minimum of the range of breach development times recommended in the *Guidelines* for masonry dams. The location of the breach is illustrated on Figure 3.

3.3 Breach Analysis Results

Since flow records were unavailable for the Toddy Pond Dam, breach runs were performed for Toddy Pond at "sunny day" (normal), maximum historic (1960-1998) and top of embankment lake levels. For the sunny day failure, the headpond was assumed to be at the spillway crest elevation of 165' with a flow of 20 cfs discharging through the gate. For the lake level of record condition (El. 166.8'), the non-breach outflow was assumed to include 157 cfs of overtopping flow and 297 cfs through the gate for a total flow of 454 cfs. For the lake at the top of abutment elevation of 167.4', assumed outflow included 373 cfs of overtopping flow and 312 cfs through the gate for a total flow of 685 cfs.

For all conditions, it was assumed that breach flows are routed immediately downstream with no backwater from the Hatchery Road bridge. Hydraulic control will shift to the bridge in the event of a breach in the Toddy Pond Dam, however, it was

assumed that the bridge would fail so that channel control would prevail. This maximized peak breach outflow and flows downstream in Toddy Pond Stream. The actual flows and water surface elevations at the bridge would depend on actual breach conditions, the presence of a hydraulic jump, and the integrity of the bridge during high flows.

3.3.1 Sunny Day

For a sunny day failure, assuming a rectangular breach 10 feet wide occurring with normal lake level (elevation 165') and a streamflow of 20 cfs, the peak breach outflow was determined to be 346 cfs. Table 1 summarizes the results for a spillway failure during sunny day conditions.

At the dam tailwater (Cross Section 2), the incremental rise between peak non-breach and breach water surface elevations for a sunny day spillway failure was 2.41 feet. The estimated water surface elevation at this section is 156.43' for non-breach conditions and 158.84' for breach conditions, assuming no backwater from the bridge.

Breach flows move rapidly through the steep stream channel downstream of the lake, with little attenuation. Just upstream of the confluence with Alamoosook Lake, the peak breach flow is still 346 cfs with a peak breach elevation of 22.19', only 1.81' feet higher than the peak non-breach elevation of 20.38'. This peak breach stage would occur only 30 minutes after the start of the spillway failure at the Toddy Pond Dam.

Breach outflow would be sustained from Toddy Pond for several days. The resulting rise in elevation of Alamoosook Lake, 0.7 mile downstream of Toddy Pond, would be less than 1' assuming spillage over the flashboards at Alamoosook Dam. The incremental rise at Alamoosook Lake resulting from a breach in the Toddy Pond Dam could be further reduced by opening the waste gate at the Alamoosook Dam and passing additional flow downstream into the Narramissic River.

3.3.2 Lake Level of Record

For a failure during the lake level of record, assuming a breach of one masonry spillway and a discharge of 454 cfs, the peak breach outflow was determined to be 1,000 cfs. Table 2 summarizes the breach results. At the dam tailwater (Cross Section 2), the incremental rise between peak non-breach and peak breach water surface elevations was 3.81 feet, with a peak non-breach elevation of 159.51' and a peak breach elevation of 163.32'. Actual breach elevations depend on the hydraulics at the bridge section, including the possibility of a hydraulic jump or bridge failure.

Breach outflow from Toddy Pond would be sustained for several days due to the large volume of water impounded in the lake. The initial front of the breach wave would travel rapidly downstream through Toddy Pond Stream, with a gradual diminishment of breach outflow as the level of Toddy Pond drops. At Cross Section 10, just upstream of the confluence of the stream with Alamoosook Lake, the peak non-breach stage would be 22.61' and the peak breach stage would be 24.46', representing an incremental rise of 1.85'. The peak breach flow at this location would be 946 cfs and would occur only 39 minutes after the breach in the Toddy Pond Dam commenced.

The increase in the level of Alamoosook Lake depends on the starting elevation of that body of water and initial outflow. Assuming a high lake elevation of 23' and no gate flow, Alamoosook Lake would rise less than 1' after receiving breach outflow from Toddy Pond. This rise in lake level could be reduced by opening the waste gate or failing the flashboards at Alamoosook dam.

3.3.3 Top of Abutments

With Toddy Pond at the top of abutments elevation of 167.4' and an outflow of 685 cfs, a spillway failure would create a peak breach outflow of 1,284 cfs. The results of a breach during this condition are summarized in

Table 3. At Cross Section 2, the dam tailwater, the incremental rise between peak non-breach elevation (161.11') and peak breach elevation (164.66') would be 3.55'. (Actual elevations would depend on the hydraulics at the bridge section, including the integrity of the bridge and presence of a hydraulic jump.)

The breach wave would move rapidly down Toddy Pond Stream, with the peak breach elevation near the confluence of the stream with Alamoosook Lake (Cross Section 10) occurring less than 1 hour after the commencement of the breach at the Toddy Pond Dam. At this cross section, the peak non-breach stage would be 23.71' and the peak breach stage would be 24.94', representing an incremental rise of only 1.23'.

Breach outflow from Toddy Pond would be sustained for several days with inflow to Alamoosook Lake gradually diminishing as the level of Toddy Pond drops. Assuming an initial lake level of 23' for Alamoosook Lake at the time of the spillway failure at the Toddy Pond dam, the level of Alamoosook Lake would rise less than 1 foot. This assumes overtopping of the flashboards at the Alamoosook Dam, with no additional gate flow.

3.4 Downstream Impact

Breach outflows from the Toddy Pond Dam could immediately impact the Hatchery Road bridge by overtopping or failing the structure. Even if the bridge remained intact, and no hydraulic jump or backwater occurred to overtop the bridge, velocities through the bridge opening would approach 20 fps (feet per second) and would have a great potential for erosion and destabilization of the concrete structure. Since the volume impounded by the Toddy Pond Dam is very large, breach outflows would persist for several days. It is not believed that the bridge would withstand such sustained high flows. In any event, the bridge should be considered unsafe for passage in the event of a breach at the Toddy Pond Dam.

The house downstream of the Toddy Pond Dam, at the corner of Hatchery Road and the gravel road South of Toddy Pond Stream, has an approximate sill elevation of 165.0'. Although the house is not likely to be reached by breach flows from the Toddy Pond Dam, significant erosion may occur near the property, including the yard which slopes down to the stream. Since the shoreline is wooded, there is also the potential for a debris jam which could backwater breach flows to higher elevations.

There is no other development along Toddy Pond Stream between Toddy Pond and Alamoosook Lake. Alamoosook Lake is capable of attenuating breach outflow from Toddy Pond with a minimal rise in lake level, so that properties along Alamoosook Lake and along the Narramissic River downstream of the lake are not jeopardized by breach outflow from Toddy Pond.

4.0 INUNDATION MAPPING

Inundation mapping for the entire length of Toddy Pond Stream, from Toddy Pond to Alamoosook Lake, was prepared from the “Orland, Maine” USGS 7.5 minute series topographic map. The map was expanded from a 1” = 2000’ scale to a scale of 1” = 600’. The contour interval of the maps was 20 feet. A site visit was conducted to assess the location of the structures relative to Toddy Pond Stream during typical (nearly average) flow conditions. The site visit also included a survey of the Toddy Pond Dam, Hatchery Road Bridge, and house downstream of the bridge in an overbank area. Inundation lines drawn for the sunny day and top of abutment flood conditions are considered approximate due to the scale and contour interval of the mapping. The map is included in Appendix C.

5.0 SUMMARY AND RECOMMENDATIONS

5.1 Summary

A breach analysis was prepared for the Toddy Pond Dam in Orland, Maine. The dam is located at the outlet of Toddy Pond, approximately 0.7 mile upstream of the confluence of Toddy Pond Stream with Alamoosook Lake. The dam has two masonry spillways, a gate structure with 5' wide sluice gate, fish ladder and abutments. The heights of the spillways are approximately 5', with one spillway 9.2' in length and the second spillway 10.0' in length. The breach analysis using the DAMBRK program assumed a breach of the 10.0' wide masonry spillway. The breach development time was assumed to be 0.1 hour. The impounded volume of the dam is 19,658 acre-feet at the normal pond elevation, with a surface area of approximately 2,360 acres.

Three flow conditions were analyzed. They were "sunny day" (with a normal pond elevation of 165.0' and an outflow of 20 cfs), "lake level of record" (elevation 166.8', occurring in December 1969, with an assumed overtopping and gate outflow of 454 cfs), and "top of abutments" (elevation 167.4' with an assumed overtopping and gate outflow of 685 cfs). Peak breach outflows for the three conditions are 346 cfs, 1,000 cfs and 1,284 cfs respectively. The breach wave would travel rapidly down Toddy Pond Stream, which is characterized by high banks and steeply sloping streambed. Due to the large volume of water within Toddy Pond, breach outflows would be sustained for several days and would drop slowly. Alamoosook Lake, 0.7 mile downstream of Toddy Pond, would rise less than 1 foot in response to breach outflows from Toddy Pond Dam.

Little development exists adjacent to Toddy Pond Stream. Downstream of the Toddy Pond Dam is the Hatchery Road bridge, with a single house downstream of the bridge near the corner of Hatchery Road and the gravel road south of Toddy Pond Stream. The breach analyses determined that although peak breach elevations are not likely to reach the sill elevation of the house, there could be significant erosion of the yard adjacent to the structure. The hydraulics through the bridge are unpredictable at

high flow, but a breach in the Toddy Pond dam is likely to create a condition that would threaten the integrity of the bridge and perhaps fail the structure, especially for a failure of the Toddy Pond Dam when the lake level is high.

5.2 Recommendations

The breach analysis indicated that a rapid failure of one spillway at the Toddy Pond Dam would result in a breach outflow that would create an unstable hydraulic condition at the Hatchery Road bridge, perhaps resulting in an overtopping or failure of the structure. Therefore, it is recommended that an Emergency Action Plan (EAP) be enacted to close the bridge in the event of a breach in the Toddy Pond Dam. Fortunately, Hatchery Road can be accessed by another road off Route 1, thereby minimizing the interruption of traffic.

Review of the downstream reach noted only one structure which has a sill elevation near predicted breach elevations. Although the house at the corner of Hatchery Road and the gravel road south of the stream is not likely to be inundated, water may cover a portion of the yard adjacent to the stream. Erosion near the house should be monitored since the breach outflows from Toddy Pond would be sustained for several days.