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Engineering Assessment Report for

Lake Luzerne Dam

NYSDEC Dam ID No. 205-0409

Village of Lake Luzerne
Warren County, New York

LaBella Project No. CZ321BF.00
April 14, 2022

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1.0 INTRODUCTION

LaBella Associates (LaBella) was retained by the Town of Lake Luzerne to prepare an Engineering Assessment Report for the Lake Luzerne Dam, located in the Town of Lake Luzerne, Warren County, New York. This Engineering Assessment Report includes the following:

- Hazard Classification evaluation,
- Safety Inspection,
- Evaluation of the Dams' spillway capacities,
- Evaluation of the Dams' structural stability,
- Evaluation of the Dams' outlet works (reservoir drain) capacities,
- Review of the Dams' Emergency Action Plan (EAP), and,
- Identification of the Dams conformance with current dam regulations and safety guidance.

2.0 PROJECT DESCRIPTION

Lake Luzerne is in the Town of Lake Luzerne, Warren County, New York. The lake primarily serves as recreational use for the Town and is impounded by a concrete gravity dam founded on bedrock outcrop located on the opposite side of Lake Avenue (State Route 9N) near the intersection of Mill Street and Lake Avenue. The Lake Luzerne dam (the dam) has a maximum height of 5.5-feet, however because of the large storage volume within the Lake, the dam is rated as "large" according to the New York State Depart of Environmental Conservation (NYSDEC) Dam Division. Note that due to a shallower depth starting at the conveyance channel, and a restricting 24-foot-wide arc culvert at Route 9N, the storage volume that can reach the dam is less 1,000 acre-feet.

The dam is owned and operated by the Town of Lake Luzerne and was constructed in 1860. The dam is located 400 feet west of Route 9N at approximate latitude 43.3215 N and longitude 73.8385 W. A Project Location Map is presented in **Appendix A**.

This Engineering Assessment Report is intended to provide data and supporting documentation to determine the condition of Lake Luzerne Dam, relative to the appropriate safety criteria. This report will identify deficiencies and recommend repairs, operational restrictions, monitoring, and/or modifications, as well as identify any analyses or studies needed to further assess identified deficiencies.

The Hydrologic and Hydraulic Calculations are contained in **Appendix B**. Structural Stability Calculations are presented in **Appendix C**. A copy of the Inspection and Evaluation Report for the Lake Luzerne Dam prepared by Chazen is presented in **Appendix D**.

2.1 Lake Luzerne Dam

Lake Luzerne Dam (NYS Dam Id. No. 205-0409) is a concrete gravity dam, constructed in 1860, that consists of an upstream face, a downstream face, a service spillway, an overflow spillway, and crest. The dam is founded on the exposed bedrock; however, no record documentation is available to determine if it is pinned. The dam is approximately 120-feet long, with varying heights from 1.5 foot to 5.5-feet.

The service spillway is approximately 6-foot 10-inches long with an elevation of 622.1-feet (±). The overflow spillway, immediately left of the service spillway, is 71-feet long with an approximate elevation of 624.1 feet (±) and an average width of approximately 6-feet. A non-functioning 32-inch diameter metal pipe is located approximately 25-feet left of the service spillway. Based on NYSDEC inspection reports, the pipe was sealed before 2013.

The left non-spillway section area, left of the overflow spillway, varies in length from 3-feet (upstream side) to 10-feet (downstream side), with an approximate elevation of 624.6-feet (±) and a width of 5.5-feet.

The right non-spillway section, right of the service spillway, has various heights, lengths, and widths before it terminates at the right abutment. The first segment extends approximately 5.5 feet from the spillway, and approximate width of 10-feet and an elevation of 625.0-feet (±). The second segment steps up to elevation 625.5-feet (±) and extends approximately 17 feet with an average width of 5-feet. The third segment steps up to elevation 626.0-feet (±) and then tapers up to elevation 626.4-feet (±) along a length of approximately 17.5 feet and an average width of 2.5-feet.

The last known construction activity was in 2010 when the dam's concrete surface was resurfaced.

3.0 VISUAL INSPECTION

Lake Luzerne Dam was inspected by Chazen on December 1, 2021, and the results of this assessment are identified in our report titled "Inspection and Evaluation Report for Lake Luzerne Dam; NYSDEC Dam ID No. 205-0409", dated December 21, 2021.

The inspection revealed the following maintenance priorities:

Required Maintenance

- Repair cracks and voids along concrete dam and rock-concrete interface.
- Reseal 32" pipe.
- Remove large log immediately downstream of spillway.

Continuing Maintenance

- Monitor seepage areas following repairs.
- Continue biennial dam safety inspections.
- Assess impacts of new development along Stewart Brook.

A review of available information on the dams including documents on file with the NYSDEC and the Town was also conducted. Chazen is preparing an addendum to update the contact information of the Emergency Action Plan and that the current Inspection and Maintenance Plan on file with DEC are appropriate for the current structures.

Appendix D includes a copy of the "Inspection and Evaluation Report for Lake Luzerne Dam; NYSDEC Dam ID No. 205-0409", dated December 21, 2021.

4.0 HAZARD CLASSIFICATION

NYSDEC's hazard classifications are based upon the damage that would result at downstream facilities if a dam should fail. The type of dam, dam height, storage capacity and the location of downstream structures all play an important part in determining the appropriate hazard class. Should a dam failure occur, flooding would be seen along Stewart Brook, which continues 0.35 miles before entering the Hudson River. Since the failure of the dam has the potential to result in damage to isolated houses and roadways, Lake Luzerne Dam is classified as a NYSDEC Hazard Class "B", Intermediate Hazard. A general description is as follows:

> *Class "B": Dams located in areas where failure may result in damage to isolated houses, main highways and minor railroads, interruption to important utilities, and potentially cause personal injury, substantial economic loss, or substantial environmental damage. Loss of human life in not expected.*

5.0 HYDROLOGY

5.1 Watersheds

The contributing watershed to the Lake Luzerne Dam is approximately 25.86 square-miles (sq-mi) and is shown on the Watershed Map in **Appendix B**. The watershed area generally consists of forested slopes and valleys, ponds and creeks, with limited developed and impervious areas. Elevations range from elevation 624-feet (±) at the dam to elevation 2340-feet (±) at Black Spruce Mountain near the northeast edge of the watershed.

NYSDEC's hydrologic criteria are based upon the hazard classification of the dam and require that existing Class "B" structures be rehabilitated to have adequate spillway capacity to pass the Spillway Design Flood (SDF) without overtopping. The SDF for a Class "B" dam is 150 percent of the 100-year, 24-hour storm. Additionally, the service spillway needs to be adequately sized to pass the Service Spillway Design Flood (SSDF), which is defined as the 50-year, 24-hour storm.

The 100-year, 24-hour precipitation is 5.7-inches and was used to determine the 100-year input hydrograph to the lake. The inflow hydrograph into the lake is then multiplied by 1.5 to determine the SDF (150-percent of the 100-year flow). Note that the precipitation was not multiplied by 1.5.

The results of the hydrologic analysis indicate that the inflow hydrograph consists of a dual peak with an initial peak of **1,433** cfs and a second peak of **1,650 cfs** occurring 14 hours after the initial peak. The initial peak consists of contributory areas downstream of Second Lake and in the vicinity of Lake Luzerne totaling 3.7 sq-mi. The second peak consists of watershed area (22.2 sq-mi) contributory to Second Lake and upstream areas (including Fourth Lake).

At the bottom two-thirds of the watershed, a series of lakes contribute to both attenuation and retention of the runoff from the upstream watershed. A closer review of the analysis indicates that Fourth Lake attenuates inflow by more than 50 percent and delays runoff by 5 hours. Second Lake attenuates inflow by nearly 25 percent and delays runoff by an additional 5 hours. The hydrologic calculations and HMR52 input and output are presented in **Appendix B**.

5.2 Lake Luzerne Storage

Lake Luzerne contains a storage volume of approximately 2,000 acre-feet at the normal pool elevation of 623.7-feet. Most of the storage is in the center of the lake where the depth is 50-foot deep. As noted, the dam impounds the top 5.5 feet of the lake and flow to the dam is limited by; the shallower depth starting at the 270-foot-long by 175-foot-wide conveyance channel and the 24-foot-wide concrete arch that supports Route 9N. Therefore, it is estimated that the volume controlled by the dam is less than 830 acre-feet (assuming water at normal pool of 623.7-feet) and as stated all flow reaching the dam is limited by the Route 9N archway. Note that the computed lake volume differs from the volume identified within the on file EAP prepared by C.T. Male Associates, P.C., which was apparently based on the data specified within the NYSDEC Inventory of Dams.

6.0 HYDRAULICS

6.1 Lake Luzerne Dam

As previously mentioned, the Lake Luzerne Dam consists of a 6-foot 10-inches long service spillway section with an elevation of 622.2-feet (±), a 71-foot-long overflow spillway section with an approximate elevation of 624.0 feet (±) and non-spillway sections with varying lengths and elevations. The left non-spillway has an approximate elevation of 624.6-feet (±). The right non-spillway sections have elevations ranging from elevation 625.0-feet (±) near the service spillway to elevation 626.4-feet (±) at the right abutment. The normal pool elevation is assumed to be at elevation 623.7-feet.

The SDF peak at the dam is 627.2-feet, which is 0.8-feet above top of the dam (located at the right non-spillway section, and outflow from the dam is 1,451 cfs.

The results of the HEC-HMS and HEC-RAS were used to assess dam capacity.

HEC-1 Input and Results:

Stage/Discharge Characteristics:

Initial starting water surface (normal pool) elevation is at 623.7-feet.

Service Spillway Section
- Crest Elevation = 622.2-feet
- L = 6-feet 10-inches
- C_d = 3.2

Overflow Spillway Section
- Crest Elevation = 624.0-feet
- L = 71-feet
- C_d = 2.8

SDF (150% of 100-Year) Results:
- SDF Inflow = 1,652 cfs
- SDF Peak Elevation = 627.2-feet, resulting in no freeboard at the dam.
- SDF Outflow = 1,451 cfs

In summary, the spillway capacity of the dam is not capable of passing the Spillway Design Flood (SDF) with the required freeboard. Since the spillway is overtopped at the maximum high-water level, the 75-

percent drawdown time cannot be calculated without including the flow over the entire dam. Therefore, the spillway itself cannot meet the 75-percent drawdown requirement. The 90-percent drawdown capacity was not assessed because there is no functioning low-level outlet at the dam.

Upgrades are required to modify the dam structure such that there is adequate spillway capacity to pass the SDF without overtopping the dam. An existing site wall along the right-side downstream channel provides some scour protection. However, because the dam is founded on bedrock, and passive pressures were excluded in the stability calculations (as discussed in Section 8.0), the loss of soil around the abutments has minimal impact to the dam stability. The placement of erosion control material (turf reinforcement mats, rip rap, etc.) is recommend up to SDF elevation to minimize the potential for erosion.

7.0 SUBSURFACE INVESTIGATION

LaBella representatives conducted a Dam Safety Inspection at the Luzerne Dam on December 21, 2021. An irregular bedrock (outcrop) surface was visible from the left abutment to the first section of the right non-spillway section along the downstream face of the concrete dam. Standing water and minor sediment was observed along the upstream face of the dam, however based on the measured depths, bedrock is assumed level under the width of the dam. Due to accessibility, no core samples were obtained through the dam for site specific direct shear tests at the concrete bedrock interface. Along the majority of the dam length, the concrete to bedrock interface was in good condition.

8.0 STRUCTURAL STABILITY

NYSDEC's structural stability criteria require that existing gravity dams be evaluated under the following loading conditions:

1. Case 1 – Normal loading conditions; water surface elevation is at the normal reservoir level (spillway crest elevation).
2. Case 2 – Ice loading condition; water surface elevation at normal reservoir level plus an ice load of 5,000 pounds per lineal foot, where ice load is applicable.
3. Case 3 – Design loading condition; water surface elevation at the Spillway Design Flood level.
4. Case 4 – Seismic Loading condition; water surface elevation at normal reservoir level plus a seismic coefficient applicable to the location.

For existing dams, NYSDEC indicates that the resultant force from an overturning analysis should be located within the middle third of the base for Case 1 and within the middle half of the base for Cases 2 and 3. The resultant should fall within the limits of the base for Case 4.

When calculating the Sliding Factor of Safety, Section 10.7.4 of the NYSDEC Guidelines, states that when no laboratory results are available, as the case for the Lake Luzerne Dam, the sliding safety factors must be computed using the Friction Factor of Safety. The required safety factors are defined as 1.5 for Case 1, 1.25 for Case 2 and Case 3, and 1.0 for Case 4.

For stability calculation an allowable $\mu = 0.65$ was chosen. Research indicates that the usage of 0.75 is acceptable when the bedrock surface is rough and irregular. Due to a localized area where water appeared to exit at the bedrock concrete interface a reduce value was selected for the stability

calculations. No documentation was available to indicate rock anchors are present, therefore additional stability from there were ignored in all four load case analyses. Further, passive pressure was ignored in the stability calculation because along the overflow section, the concrete to bedrock interface is visible along the entire length.

No signs of significant structural distress or failure have been identified at Lake Luzerne Dam. The recommended repairs to cracks and voids at the dam/bedrock interfaces appear to be minor and have a small impact on the stability of the structure.

Lake Luzerne Dam: Results of Analyses for Overflow Spillway Section

A section along the overflow spillway was selected for analysis because the service spillway is an opening between sections of concrete, and flow is directly on the bedrock surface. Structural stability calculations are presented in Appendix C. From the Stability Analysis Spreadsheets on Pages C-X through C-Y, the results using the Friction Factor of Safety Method and a $\mu = 0.65$ are summarized as follows:

Case 1 – Normal Loading Condition:

Water surface at elevation 623.7-feet

Location of Resultant = 2.88 feet in middle third; **OK**
FS Sliding = 5.6 > 1.5 **OK**

Case 2 – Normal Plus Ice Loading Condition:

Water surface at elevation 623.7-feet

Location of Resultant = -2.51 feet, outside the dam
FS Sliding = 0.39 > 1.25 no
The 5-kip ice load is not applicable at this dam site due winter drawdown and constant flow. No movement has been noted at the dam over its long history, verifying the 5-kip ice load condition is not a valid load condition. Modification to the dam to satisfy this load criteria is not recommended.

Case 3 – Design Loading Condition:

Water surface at elevation 627.15'

Location of Resultant = 1.71 ft in middle half; **OK**
FS Sliding = 1.32 > 1.25 **OK**

Case 4 – Seismic Loading Condition:

Water surface at elevation 623.7'

Location of Resultant = 2.54 ft within the length of the base; **OK**
FS Sliding = 2.24 > 1.0 **OK**

Lake Luzerne Dam: Stability Conclusion for Overflow Spillway Section

The overturning stability of the typical section of Lake Luzerne Dam is satisfactory for all loading conditions. Using the assumed $\mu = 0.65$, the sliding stability of the typical section is also satisfactory for all loading conditions. The typical section of Lake Luzerne Dam complies with NYSDEC's structural stability criteria.

Based on the SDF elevation, non-spillway sections of the dam are being overtopped. Modifications to the dam are recommended to comply with NYSDEC requirements.

9.0 CONCLUSION

Based on the information reviewed, and assuming all maintenance items indicated in the Inspection and Evaluation Report, prepared by Chazen, dated December 21, 2021, will be addressed, it is concluded that there are no serious deficiencies at Lake Luzerne Dam that require immediate attention.

As set forth by the NYSDEC Dam Design Guidelines for meeting the hydraulic and structural stability requirements, Lake Luzerne Dam was analyzed for sliding, overturning and spillway capacity. The calculated sliding factor of safety and resultant location (overturning) were compared to the NYSDEC minimum requirements. In addition, the spillway capacity was analyzed for the SDF (150% of the 100-year storm).

The dam continues to meet NYSDEC sliding factor of safety requirements and resultant location (overturning) criteria. The analysis also demonstrates that the spillway configuration (service spillway plus overflow section) cannot pass the SDF without overtopping the dam.

The structural stability calculations identified that, for the three applicable load scenarios, the sliding factors of safety were meet and the resultant locations fell within the required zone. Currently, load case 2 (ice loading) is not applicable for this dam because of the winter drawdown, continual flow and historical performance.

10.0 RECOMMENDATIONS

LaBella recommends at a minimum erosion protection is installed around the abutments up to the design flood level to minimize the potential of scouring. While the dam is stable, this will limit the potential of sediment downstream.

Additionally, the redesign of the spillway capacity should be evaluated to allow for safe passage of the SDF without overtopping the dam. Any design modifications for the dam shall be coordinated with the NYSDEC and other required regulatory agencies.

LaBella also recommends that the maintenance identified in our Inspection and Evaluation Report be documented in a maintenance log, which should be reviewed at the commencement of the biennial site inspection performed by a licensed engineer.