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1 Introduction

1.1 Facility Description

Estling Lake Dam is located on Den Brook, a tributary of the Rockaway River, in Denville Township, Morris County, NJ (Figure 1). The Estling Lake Corporation (ELC) maintains the lake and associated spillway, and the embankment that impounds the lake is owned by New Jersey Transit Rail Operation. Estling Lake Dam qualifies as a Class I dam according to the New Jersey Bureau of Dam Safety, which means that failure would likely cause loss of life or extensive property damage.

Estling Lake Dam is comprised primarily of an embankment approximately 1,200 feet long and 19 feet high, originally constructed in 1870 by the Delaware tribe, Lackawanna tribe, and Western Railroad to support a two-track railroad operation. The construction of this embankment created the impoundment known as Estling Lake. The embankment material is reportedly from local sources, but was not engineered.

Estling Lake was used as a source of ice by a railroad subsidiary, the Estling Lake Ice Co. In the early 1900s the embankment was widened to accommodate four tracks by placing fill on the upstream side of the existing embankment. In subsequent years, the system was electrified and the two northern most tracks were removed from the downstream portion of the dam crest. Due to changes in railroad ownership, the records concerning the details of the embankment construction, detailed spillway design and culvert design are not available and reportedly have been lost.

Located along the embankment is the spillway made of concrete, block, and stone. It has two installed, manually operated drawdown valves, one of which has never been used. Under normal conditions, water cascades over this spillway onto energy dissipating steps, which lead to a 14'-high, 57'-wide stone arch culvert under the embankment. This constitutes the main outlet for the lake. It discharges to Indian Lake. A 36-in reinforced concrete pipe (RCP) storm water pipe penetrates the embankment approximately 1800 feet west of the spillway.

Downstream, along the toe of the embankment, is the backwater of Indian Lake, owned by a separate entity. Indian Lake has a water elevation of approximately 6 feet lower than Estling Lake at normal capacity.

The crest of the Estling Lake Dam is approximately 30 feet wide and carries two railroad tracks along its southern or upstream side and a gravel roadway for railroad maintenance vehicles along its northern, or downstream side. The upstream slope of the embankment consists of large rip rap mixed with small stones. The downstream and upstream slopes of the embankment generally lay on a 1.5(H):1.0(V) to 2.0(H):1.0(V) gradient.

The spillway and all its components are made of stone masonry. The spillway crest consists of 32-foot long capstones. The spillway itself has no defined approach channel, as the Lake abuts the spillway weir. There is a stepped arch drop box. The spillway wing walls are on the north and south side. The spillway crest is in fair condition. The drop box

is also made of stone masonry and is in fair condition. The rationale for these assessments is presented in the report recommendations section.

1.2 Purpose of Document

The New Jersey Dam Safety Program is implemented by the Department of Environmental Protection's Engineering and Construction, Division of Dam Safety and Flood Control, Bureau of Dam Safety. The objective of the program is to protect lives and property from the consequences of a dam failure or the improper release of impounded water. A primary means of achieving this goal is through the maintenance and periodic inspection of in-service dams.

The New Jersey Dam Safety inspection program is intended to identify conditions that may adversely affect the safety and functionality of a dam and its appurtenant structures; to note the extent of deterioration as a basis for long term planning, periodic maintenance or immediate repair; to evaluate conformity with current design and construction practices; and to determine the appropriateness of the existing hazard classification.

Per requirements of the Safe Dam Act, N.J.S.A. 58:4-1, Class I dams are to have a visual inspection every two years and a formal inspection every six years. Formal inspections require a detailed field examination and should include a thorough review of the records on project design, construction, and performance. Detailed underwater inspections should be included as needed. A Department approved Emergency Action Plan and Operation and Maintenance Manual should be confirmed and their adequacy determined.

The purpose of this report is to provide documentation that the Safe Dam Act Formal Inspection requirements have been met.

1.3 Overview of Report Sections

The report provides a description of the inspection team and their efforts, a summary of findings by discipline, and a discussion of the findings in support of recommended immediate, short-term, and long-term actions.

2 Summary of Findings

2.1 Logistics – Inspection Team and Information Sources

Five professional engineers completed a Visual Inspection of Estling Lake Dam and spillway on November 18, 2017. Appendix A includes a copy of the checklist for that inspection.

The inspection team was comprised of the following individuals:

- Mr. Joe Skupien, PE in NJ – Hydrology and Hydraulics;
- Mr. Michael Vecchio, PE in NJ and CA – Civil Design, Earthen Dams and Levees;

- Mr. Jason Abendroth, PE in LA and MD – Hydraulic Structures, Levees;
- Mr. Greg Yankey, PE in eight states – Geotechnical Engineering, Dam Safety; and
- Steve Gardner, PE in PA – Underwater Inspection.

This team inspected the top and downstream face of the embankment dam, the spillway from the top of the embankment and on the upstream side of the embankment. They walked the downstream toe of the embankment on the west and east sides of the spillway. They recorded notes and photographed various observations. An underwater inspection of the spillway and low-level outlet was conducted.

Documents reviewed by the team included the 2015 visual inspection report, drawings of the spillway and low-level outlets. No other design documentation reports or drawings are known to exist. Together, with previous hydraulic evaluations of the reservoir and spillway, the information described provided the basis of the findings reported herein.

2.2 Discipline-Specific Summaries

2.2.1 Hydrology and Hydraulics

As noted above, no hydrologic or hydraulic design data, computations, or plans for Estling Lake are known to exist. However, there are a number of hydrologic and hydraulic analyses of the existing Dam that have been performed since 1982 that are on-file with NJ Transit, the Estling Lake Corporation (ELC), and the Bureau of Dam Safety and Flood Control (BDS&FC) of the NJDEP. A description of these analyses and related documentation is presented in Appendix B.

A review of these analyses indicates that, contrary to the NJDEP's Dam Safety Standards (NJAC 7:30), Estling Lake Dam is not capable of safely conveying the flow from the Dam's 0.5 Probable Maximum Precipitation (PMP) Spillway Design Storm (SDS) without overtopping the earthen railroad embankment that serves as the dam for the Estling Lake impoundment. This deficiency has been acknowledged by NJ Transit, the ELC, and the BDS&FC and a series of preliminary analyses have been performed by NJ Transit to begin development of appropriate remedial measures. As noted above, a description of available analyses and related documentation is presented in Appendix B.

2.2.1.1 Civil

Embankment Side Slopes

The side slopes of the Estling Lake earthen embankment are generally steeper than that defined in the New Jersey Administrative Code (NJAC) 7:20, which define a 3(H):1(V) limit for the upstream embankment and a 2(H):1(V) limit for the downstream embankment. The up- and downstream slopes range from 1.5(H):1.0(V) to 2.0(H):1.0(V), with isolated downstream areas that are steeper.

Low-Level Outlets

The spillway has two low-level outlets – both 24-inch, valved cast iron pipes with intake trash racks, according to the design drawings that were reviewed. The west-low-level outlet was observed to be buried and abandoned. The east low level outlet is operable. The middle of its three trash racks is missing.

Embankment Vegetation

Best practice for vegetation management on earthen embankment dams is to keep the entire embankment and an offset from the embankment toe completely clear of all vegetation except grass cover. The objective of maintaining that vegetated condition is to prevent penetration of tree and shrub roots into the embankment which can provide preferential seepage pathways and destabilize the embankment, particularly when a plant dies and the roots deteriorate, as well as facilitating more effective inspection of the embankment.

The Estling Dam earthen embankment has extensive vegetated cover, ranging from brush and grasses to full-grown trees with trunk diameters in excess of 12 inches. Although vegetation, as noted, can compromise the stability of the embankment, there is concern that removal of trees and shrubs, including their root balls, could destabilize it as well. As a result, selective clearing of vegetation and an arborist survey are recommended. See Recommendations section of this report for details.

These measures will begin transitioning the facility to maintenance operations consistent with earthen embankment dam best practice.

2.2.1.2 Structural

The main structures at Estling Lake consist of a stone masonry arch bridge, a reinforced concrete culvert, and a stone masonry arch Spillway. The following are the observed conditions of each feature.

Stone Masonry Arch Bridge

On the downstream stone masonry arch bridge there is mortar loss below the waterline. Along the interior face of the arch there is gunite loss with exposed masonry joints. These masonry joints have minor seepage. There is joint deterioration on the downstream face of the arch with vegetation grown.

Reinforced Concrete Culvert

The upstream side of the reinforced concrete culvert has spalling, cracking, and efflorescence. There is roughly 48" of exposed rebar on the ceiling of the upstream side of concrete culvert. The rebar has surface corrosion and some section loss. This area of spalling appears to have had a repair done with a majority of the repair missing. The

concrete wing walls extending upstream toward the spillway have spalling. There is efflorescence and minor staining on the interior faces of the culvert.

Stone Masonry Arch Spillway

The rounded concrete crest on top of the masonry spillway contains 10 transverse ¼" cracks extending from the upstream side to the downstream side. Some of these cracks continue down through the upstream face of the spillway to the mudline. While the exact cause of the cracks is unknown, it is suspected that it is either due to 1) ice loading or 2) foundation movement. We suspect that it is possibly caused by ice expansion/jacking - phenomena often seen in winter around locks and dams in colder temperatures. Photos 49 through 54 show examples of the observed cracks. However, the crack shape and orientation shown in Photo 50 indicate that the causative factor may be foundation-related. Further investigation is needed to identify the cause(s) of cracks observed on the spillway.

The masonry wing walls have deteriorated grout between stones, with seepage on both sides of the masonry spillway.

2.2.1.3 Geotechnical

As noted in the Civil section, significant unwanted overgrowth of trees and underbrush on the downstream slope of the structure exists, with minor amounts on the upstream slope. These items significantly limit clear observations. This situation is beyond a maintenance or nuisance problem, and will take a concerted effort of long-term tree control, and establishment of healthy grasses. See recommendations section for details.

The downstream slopes are hummocky in regions, and generally undulating. This is consistent with a slope that is too steep for generally clay materials, but temporarily stabilized by vegetative tree growth. Because the slopes are steep, long term stability is a concern that needs to be investigated. Lastly, numerous areas of seepage and ponded water were noted on the downstream slopes and areas near the downstream toe of the dam. In conclusion, vegetation, slope stability and seepage are concerns at the structure.

Estling Lake Dam will not meet USACE seepage and slope stability criteria[1], and should be examined further with geotechnical investigations and companion analytical studies. Specifically, the areas of ponded water, and steep slopes cause concern, and violate criteria. After further studies, remediation strategies can then be considered.

3 Recommendations

The following recommendations are offered as a part of a comprehensive program of dam maintenance and criteria adherence. The recommendations are categorized as

[1] The New Jersey Administrative Code, Part 7:20, Dam Safety Standards provides some design criteria that dams must meet, but not an exhaustive set that addresses acceptable slope stability and seepage conditions. When contacted about this omission they stated that federal guidelines, such as those developed by USACE or the Bureau of Reclamation should be referenced.

immediate (30-90 days), short-term (1 year), and long term (2-3 year) actions. For specific dates, see the compliance schedule in Section 3.4 Conclusion.

3.1 Immediate Actions (30-90 Days)

3.1.1 Vegetation Management

Develop and implement a vegetation management plan. Selective clearing to ground level of all trees and shrubs having trunk diameter of 8 inches or less is recommended to create better conditions for observing the embankment condition. The trunks should be cut at ground level leaving the root balls in place. Brush and grass should be cut to approximately a 2-inch height.

In addition, it is recommended that a professional arborist complete a comprehensive survey of the condition of shrubs and bushes having trunk diameters in excess of 8 inches. The results of that survey should be used to evaluate whether removal of unhealthy shrubs or trees is warranted. Such action, and associated site restoration, would need to be designed by a professional engineer and may require additional embankment stabilization measures in conjunction with vegetation removal actions. Areas cleared should be seeded to prevent erosion of the exposed embankment, as well as the prevention of further vegetation growth.

3.2 Short-Term Actions (1 Year)

3.2.1 Spillway Survey and Crack Mapping

Perform a crack survey of the spillway and map all existing cracks and occurrence of deteriorated grout. This task will establish the number, size and spatial extent of cracks and deteriorated grout on the spillway – examples of which were observed during the visual inspection. Subsequent crack mapping will be compared to the baseline to allow determination of whether the cracks are growing.

Perform a baseline high-precision survey of the spillway structure. This effort will help to inform future work involving potential movement or degradation of the spillway structure.

3.2.2 Spalling Concrete Repair

The areas of spalling on the concrete culvert and culvert wing walls should be properly repaired following standard industry practices. The exposed rebar should be cleaned of corrosion prior to the repair. The efflorescence and staining could be cleaned to be more esthetically pleasing but is not a major issue.

3.2.3 Spillway Joint Repair

The mortar loss under the water line of the stone masonry arch is likely caused by the constant flow of water over the past century. These joints should be repacked with mortar to prevent the loss of any blocks in the future. Vegetation should be removed from the face of the masonry and a plan established for future maintenance of this feature. Lack of

proper maintenance could lead to further damage/degradation of the spillway and eventually a potential failure of the structure. The maintenance plan should include regular cleaning and repair of the joints to prevent the accumulation of further vegetation.

3.2.4 Gunite Repair

The gunite lined portion of the arch should be repaired to prevent further loss of surfacing. The regular maintenance of gunite should appear in the above plan.

3.3 Long-Term Actions (2-3 Years)

3.3.1 Comprehensive Embankment and Spillway Evaluation

A comprehensive study of embankment and spillway performance when loaded with all forces produced by the SDS is recommended. This effort will include field investigations and analyses needed to better understand seismic loading, ice loading, hydraulic loads; embankment seepage and stability, overtopping erosion, and spillway structural stability.

3.3.2 Develop Remedial Measures to Provide Safe Conveyance of the SDS

As noted in Section B above, Estling Lake Dam cannot safely convey the Dam's 0.5 PMP SDS without overtopping the Dam's earthen embankment. As such, remedial measures must be analyzed and designed and subsequent construction plans and specifications prepared to address this deficiency. Upon completion, applications for the various NJDEP permits must be prepared and submitted for approval.

Based upon a review of the previous analyses described above and presented in Appendix B, it is recommended that new hydrologic and hydraulic computer modeling of Estling Lake Dam be developed as part of the remedial measure development. At this time, the basic structures of the hydrologic and hydraulic models used to develop 1) the current NJDEP-approved overtopping analysis, 2) the Dam's Spillway Design Flood, and 3) the downstream inundation mapping contained in the Dam's Emergency Action Plan (EAP) are considered adequate. However, it is recommended that this basic model structure be updated in the following ways:

- Due to variations in key elevations and dimensions of the Dam's spillway, railroad bridges, and top of embankment between the various studies and analyses listed above, final hydraulic model data should be based on new field surveys of the spillway, bridges, embankments, and other pertinent hydraulic features. This work should be integrated with the survey work required for the Comprehensive Embankment and Spillway Evaluation in Recommended Long-Term Action No. 1 above.
- The stage-storage-discharge relationships at Shongum Lake Dam and Lake Openaka Dam upstream of Estling Lake Dam should be updated based upon the latest data for these Dams on-file with the NJDEP BDS&FC.

- The stage-storage relationship for Estling Lake Dam should be updated based upon the Lake bathymetry data prepared in 2007 by Princeton Hydro, LLC for the Estling Lake Corporation.
- The stage-discharge relationship for Estling Lake Dam should be based upon a detailed hydraulic analysis of the interaction between flow over the Dam's spillway and through the railroad embankment bridges.
- Rainfall data used in the model should be based upon the most current NOAA data for the Estling Lake watershed.
- Land Use/Land Cover data used in the model should be based upon the most current data from the New Jersey Office of GIS or another appropriate source.
- Soil data used in the model should be based upon the most current data from the Natural Resources Conservation Service (NRCS).

3.4 Conclusions and Compliance Schedule

New Jersey Dam Safety Compliance Schedule
Estling Lake

CONCLUSION

DAM INSPECTION PROGRAM GUIDELINES

The following new guidelines have been established by the NJDEP Bureau of Dam Safety & Flood Control to help meet the requirements of the National Inventory of Dams condition assessment of existing dam structures. Please follow the guidelines/definitions below and select the appropriate checkbox.

SATISFACTORY
No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria. Minor maintenance items may be required.

FAIR
Acceptable performance is expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations.

POOR
A dam safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. POOR also applies **when further critical studies or investigations are needed to identify any potential dam safety deficiencies**.

UNSATISFACTORY
Considered unsafe. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary.

I certify that the dam structure referenced herein was personally inspected by me and was found to be in the following condition **(select one only):**

- ☐ SATISFACTORY
- ☐ FAIR
- ☑ POOR
- ☐ UNSATISFACTORY

CONCLUSION (continued)

Recommended repairs be to be made immediately (30-90 days):

1. Develop and implement a Vegetation Management Plan. (New Jersey Transit). The following elements should be considered as part of that plan.

   For upstream and downstream embankments, extending 10 feet from downstream toe:

   a) Cut shrubs and trees with trunk diameters of 8 inches or less to the ground. Do not remove root balls.

   b) Clear all brush throughout the noted extents.

   c) Have an arborist assess the health of trees and shrubs with trunk diameters greater than 8 inches and recommend removal of unhealthy plants with advice and oversight buy a professional engineer.

Recommended improvements to be made long term (2-3 year):

1. Restore spalling concrete on culvert wingwalls (Estling Lake Corporation) and culvert (New Jersey Transit).
2. Restore and regrout spillway joints (Estling Lake Corporation).
3. Replace missing low level outlet intake trash rack. It is the middle trash rack on the east low level outlet. (Estling Lake Corporation).
4. Complete baseline spillway crack mapping and high precision survey (Estling Lake Corporation)

The following studies are recommended (New Jersey Transit):

- X Hydrologic and Hydraulic Engineering Evaluation to update the 0.5 PMP SDS
- X Potential Failure Mode Analysis for dam and spillway
- X Comprehensive Embankment and Spillway Stability Evaluation for all modes of potential failure due to seismic loads, ice loads and those caused by the updated 0.5 PMP SDS flood, including through-seepage, under-seepage, overtopping, and spillway failure
- X Design of remedial measures to address spillway inadequacy and dam overtopping and additional deficiencies identified in the studies above

- ☐ Failure/Inundation analysis

- ☐ None

New Jersey Dam Safety Compliance Schedule Form – NJ Transit (Railroad Embankment and Bridge)

Name: Estling Lake Dam (Embankment and Bridges)

File No: 25-169

Owner: New Jersey Transit
Address: One Penn Plaza East
Newark, New Jersey
07105-2246
Phone: 973-491-7227
Email: LFanning@njtransit.com

Owners Engineering Firms:
Name: SWM Consulting, LLC
Address: PO Box 727 Ringoes, New Jersey 08551
Phone: (908) 806-7700
Name: HDR Engineering, Inc.
Address: 1037 Raymond Blvd, Newark, NJ 07102
Phone: (862) 236-1700

Owner: Estling Lake Corporation
Address: P.O. Box 281
Denville, New Jersey
07834-0281
Phone: 973-520-3952
Email: estling52@yahoo.com

The purpose of this form is to allow the dam owner, through consultation with their engineer, to establish a time line for addressing the deficiencies identified in the inspection report for the dam and bringing the dam into compliance with the New Jersey Dam Safety Standards, N.J.A.C. 7:20-1.1 et seq.

Proposed time frame for submission of required information and implementation of recommended repairs:
(Engineer should check required sections and propose appropriate time frames. However, the Dam Safety Section reserves the right to require additional dates and/or information as needed.)

☐ **Performance of Maintenance and Repairs Not Requiring Approval from the Dam Safety Section:** (This work includes grass mowing, brush removal, debris removal, filling of animal burrows, minor concrete repairs, minor gate repairs, filling of areas of minor surface erosion, etc. The NJEP Dam Safety Section must be notified upon completion of these activities.)

Work to be completed no later than: End of Fall 2018 (See List Below. See 'Recommended Repairs' Above for Details)

1. Develop and Implement Vegetation Management Plan (New Jersey Transit)
2. Restore spalling concrete on culvert wingwalls (Estling Lake Corporation) and culvert (New Jersey Transit)
3. Restore and repoint spillway joints (Estling Lake Corporation)
4. Replace missing low level outlet intake trash rack (Estling Lake Corporation)
5. Complete baseline spillway crack mapping and high precision survey (Estling Lake Corporation)

☐ **Engineering Report / Studies:** (This work includes any required hydrologic and hydraulic analysis, structural analysis, alternative analysis, geotechnical investigations or dam breach analysis that may be recommended by your engineer and/or required by the Dam Safety Section.)

Studies to be submitted for review no later than: End of Fall 2020 (See List Below. See 'Studies' Above for Details)

1. Hydrologic and Hydraulic Evaluation
2. Potential Dam Failure Mode Analysis
3. Comprehensive Embankment and Spillway Stability Evaluation
4. Remediation Design

☐ **Permit Application:** (A permit application must be submitted for any construction activity at the dam. The permit application must address all deficiencies as identified in the inspection report and the subsequent engineering report / studies.)

Permit application to be submitted no later than 24 Months after the date of the Dam Safety Section's approval of any required studies.

☐ **Construction:** To start no later than 18 Months after the date of issuance of the permit by the Dam Safety Section.

☐ **Operation and Maintenance Plan (O&M Plan):** (An O&M Plan is required for all dams. O&M Plans should be submitted with the permit application or sooner if possible. Existing O&M Plans may need to be updated if a dam is being rehabilitated. Please indicate a date that a new or revised O&M Plan will be submitted if there is not an existing and approved Manual on file with this office.)

O&M Plan to be submitted no later than: N/A – Revisions provided with Formal Inspection Report

☐ **Emergency Action Plan (EAP):** (EAPs are required for all high and significant hazard dams and should be submitted as soon as possible. Existing EAPs should be reviewed on a yearly basis and revised as necessary. Please indicate date a new or updated EAP will be submitted if there is not an existing and approved Plan on file with this office.)

EAP to be submitted no later than: N/A – Revisions provided with Formal Inspection Report

The dates provided above will be reviewed by the Dam Safety Section to determine if the schedule is acceptable to achieve compliance with the Dam Safety Standards. Requests for extensions to the accepted time frames outlined above must be submitted to this office in writing along with appropriate justification and will be considered on its merits on a case by case basis.

Signed: Dam Owner – NJ TRANSIT **Date**

Signed: Owner's Engineer – SWM 8/20/18 **Date**

Daniel Blaney 8/20/18

Signed: Owner's Engineer – HDR **Date**

Signed: Dam Owner – Estling Lake Corporation **Date**

Additional information including Dam Safety Section forms, standards and inspection guidelines as well and EAP guidelines and a sample O&M is available at http://www.state.nj.us/dep/damsafety or contact this office via e-mail at Damsafety@dep.state.nj.us or telephone at (609)984-0859. Please submit the completed form to: NJDEP, Bureau of Dam Safety & Flood Control, P.O. Box 419, Trenton, NJ 08625