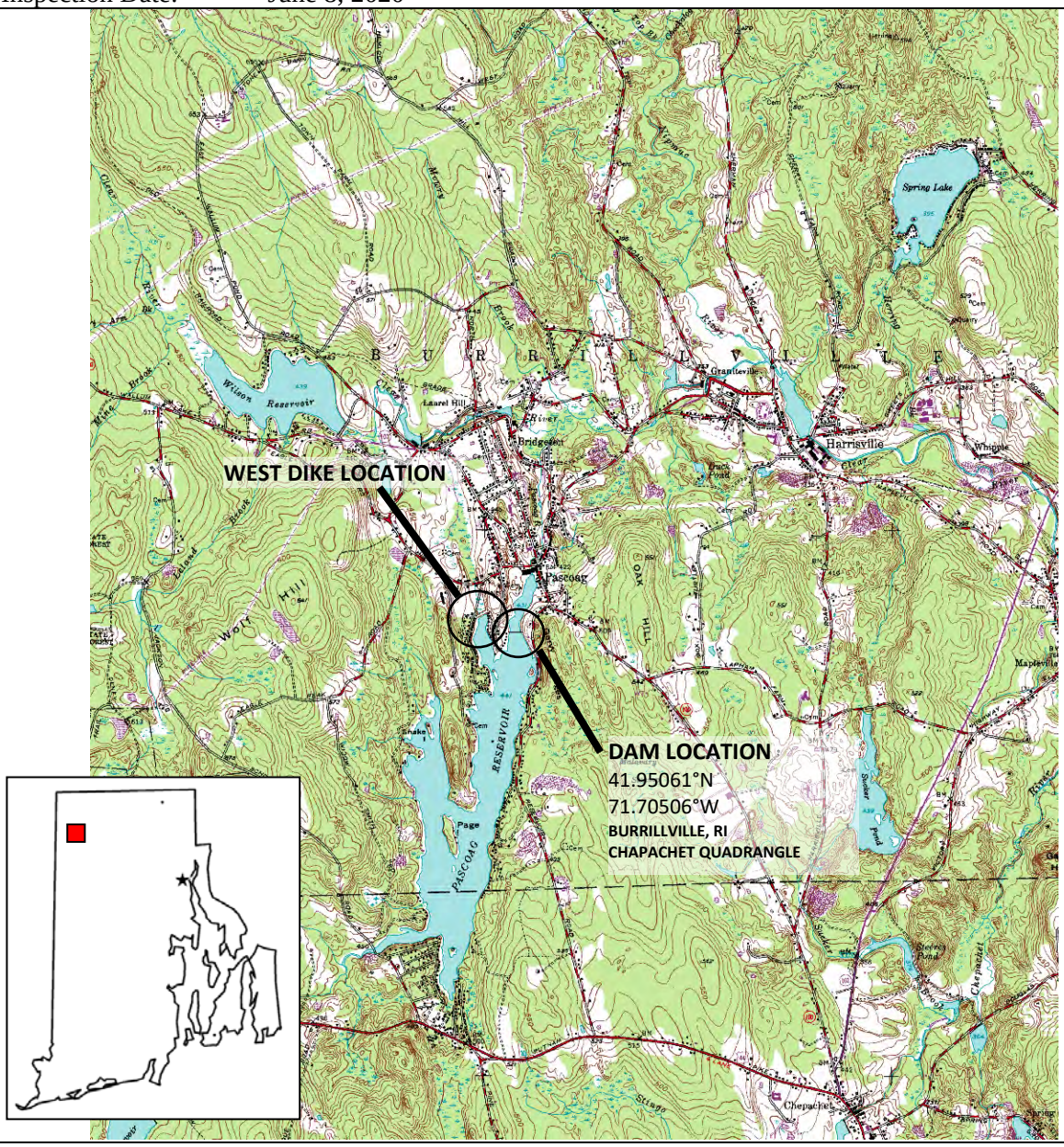
-- PASCOAG RESERVOIR UPPER DAM --
VISUAL
INSPECTION / EVALUATION REPORT

Dam Name:	***Pascoag Reservoir Upper Dam***
State Dam ID#:	***016***
Owner:	***Colleen Conley (Main Dam); Leo Plouffe (West Dike)***
Town:	***Burrillville***
Consultant:	***Pare Corporation***
Date of Inspection:	***June 8, 2020***

PARE CORPORATION

INSPECTION SUMMARY

Dam Name (No):	Pascoag Reservoir Upper Dam (016)
Location:	Burrillville
Hazard Classification:	High
Inspector:	Matthew Dunn, P.E.
Inspection Date:	June 8, 2020



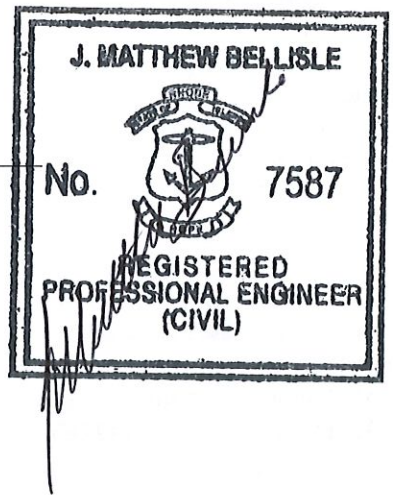
When describing the dam, "left" and "right" refer to the respective sides of the dam as viewed when facing downstream (with normal flow of water).

PREFACE

The assessment of the general condition of the dam reported herein was based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations were beyond the scope of this report unless reported otherwise.

In reviewing 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.

It is critical to note that 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.



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PARE CORPORATION
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1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The RIDEM Office of Compliance and Inspection has retained Pare Corporation (Pare) of Foxboro, Massachusetts and Lincoln, Rhode Island to perform a visual inspection and develop a report of conditions for the Pascoag Reservoir Upper Dam and West Dike along the Brandy Brook in Burrillville, Rhode Island. This inspection and report were performed in accordance with current Rhode Island laws.

RIDEM will develop an overall condition rating based upon the data presented herein. It is understood that this rating will consider operational and structural deficiencies and will be presented under a separate cover.

1.1.2 Purpose of Work

The purpose of this investigation was to inspect and evaluate the present condition of the dam and appurtenant structures in accordance with current dam safety regulations to provide information that will assist in both prioritizing dam repair needs and planning/conducting maintenance and operation.

The investigation was divided into three parts: 1) obtain and review reports, investigations, and data pertaining to the dam and appurtenant structures available within the Rhode Island Department of Environmental Management files; 2) perform a visual inspection of the site; and; 3) prepare and submit a final report presenting the evaluation of the structure, including recommendations for additional studies, repairs, and remedial actions.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided at the end of this report. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) hazard classification; 4) general; and 5) condition rating.

1.2 Description of Project

1.2.1 Location

The Pascoag Reservoir Upper Dam is located at the northern end of the impoundment near coordinates 41.95061ºN/71.70506ºW. The West Dike is located approximately 0.17 miles northwest of the dam near coordinates 41.95201ºN/71.70820ºW. The dam system is accessible via the north end of Lake Drive, located to the west (left) of the dam in Burrillville. Please refer to the inspection summary at the beginning of this report for a locus plan depicting the area of the dam and its immediate surroundings.

To reach the dam from Interstate I-295 in Rhode Island, take I-295 to exit 12B (formerly exit 7B) for US-44 West/Putnam Pike towards Smithfield. After 9.5 miles, keep right onto RI-102 North/Putnam Pike/Victory Highway. After 0.1 miles, continue onto RI-100 North/Money Hill Road and continue to follow RI-100 North. After 3.2 miles, turn left onto Pascoag Main Street. After 0.1 miles, take a slight left onto High Street. After 0.1 miles, take a slight left onto Rock Avenue. After 0.4 miles take the 1st left onto Lake Drive. After approximately 300 feet, Lake Drive ends. The left abutment of the dam is approximately 100 feet to the right/east of the end of the roadway.

The West Dike can be reached from the main dam by heading south on Lake Drive. Take a right onto Rock Avenue in about 400 feet. Take a left onto Shore Road, and continue down shore road to the end which is approximately 0.2 miles. The West Dike is accessible through the yard of a private residence on the left.

1.2.2 Owner/Caretaker

The Pascoag Upper Dam is owned by Colleen Conley. The West Dike is owned by Leo Plouffe. The Pascoag Reservoir Dam Management District has responsibility for the operations and maintenance of the dam and dike.

1.2.3 Purpose of the Dam

The dam currently provides an environmental and recreational resource. As stated in previous reports, the dam was originally constructed to provide a continuous supply of process water and hydropower to downstream mills. Since the closing of the mills, the dam no longer serves this purpose.

1.2.4 Description of the Dam and Appurtenances

The Pascoag Reservoir Dam is an earth embankment structure approximately 475-feet long, 27-feet high, with an average crest width of 22 feet. The upstream face is sloped at 1.5H:1V and is protected by stone armor. The downstream slope is approximately 1.5H:1V. Both the upstream and downstream slopes have areas of steeper slopes closer to 1H:1V.

The spillway structure is located near the left abutment of the embankment and is constructed of cut stone masonry. The spillway weir is a broad crested section, approximately 22-feet long. Discharges from the spillway flow into the lower reservoir. A steel trussed, timber-planked service bridge spans the spillway training walls and provides access to the embankment.

The outlet control structure (i.e., low-level outlet) is located on the upstream face of the dam approximately 50 feet right of the spillway. The intake inlet is constructed of cast-in-place concrete over cut stone masonry. The control mechanism for the 36-inch diameter outlet pipe is a vertical slide sluice gate housed within a concrete block gatehouse atop the inlet structure. Water is withdrawn from the upper reservoir through the 36-inch diameter pipe and is discharged through the submerged outlet on the downstream slope of the dam to Pascoag Lower Reservoir. The outlet approach opening has provisions for stop logs for maintenance purposes.

An approximately 240-foot long earthen dike (West Dike) is located in an adjacent cove of the reservoir west of the main embankment. The upstream and downstream faces are vertical supported by upstream and downstream stone masonry walls and the average crest width is 25 feet.

Two sections of the downstream wall have been buttressed with trap rock. There is one low section of the crest near the left abutment that would likely serve as an informal auxiliary spillway.

1.2.5 Operations and Maintenance

The dam and dike are operated and maintained by the Pascoag Reservoir Dam Management District. According to Mr. Bud Leonhardt (current chairman of the District) operation and maintenance activities include: clearing of vegetation from the dam embankment annually, maintaining and operating the low-level outlet gate to control pool levels and minimum baseflow requirements, and partially clearing vegetation from the West Dike.

The low-level outlet gate is routinely operated to control pool levels and provide minimum baseflow requirements set forth by RIDEM. Every winter a 5-foot drawdown is implemented and maintained by low-level outlet operation. The gate is also kept at least 2 inches open to pass the minimum required baseflow to the downstream channel.

1.2.6 Hazard Potential Classification

In accordance with current classification procedures, the RIDEM Office of Compliance and Inspection classifies the Pascoag Reservoir Upper Dam as a **High** hazard potential dam.

2.0 INSPECTION

2.1 Visual Inspection

The Pascoag Reservoir Upper Dam and West Dike were inspected on June 8, 2020. At the time of the inspection, temperatures were near 75°F with clear skies. Photographs to document the current condition of the dam were taken during the inspection and are included at the end of this report. The level of the impoundment appeared to be near normal summer operating levels (approximately 1-inch below the spillway. Underwater areas were not inspected as part of the inspection.

For reference purposes, a baseline was established along the crest of the dam embankment consistent with previous inspection reports. Station 0+00 was located at the left abutment and extended to Station 4+75 at the right abutment. A baseline was established along the West Dike with station D0+00 located at the fence line across the left portion of the dike and station D2+40 on the right abutment; the baseline was extrapolated to near D0-100 at the left abutment. Observations are reported in relation to their location along the baseline as noted herein.

2.1.1 General Findings

The following describes findings of the inspection completed at the Pascoag Reservoir Upper Dam and the West Dike:

2.1.2 Dam Embankment

The following was noted along the embankment portion of the dam

Upstream Side

- The slope was steep, approaching 1H:1V.
- The top 5 feet of the slope was generally covered with bare soil and varying scrub and grass vegetation.
- The riprap below the bare soil was irregular but quite large and likely of sufficient size to withstand wave action.

Crest

- Vegetation was varying, but fairly well developed with the only bare area consisting of a footpath that winds along the crest centerline. The vegetation was tall (approximately knee high) at the time of the inspection, which limited the inspection.
- The crest was irregular in vertical alignment, but such alignment did not appear to be indicative of embankment movements / settlement.

Downstream Slope

- The trap rock slope left of the spillway appeared to be generally clear of vegetation with no signs of unusual movement.

- The downstream wall left of the spillway appeared to be in good condition. No deficiencies were apparent along the downstream stone wall left of the spillway.
- The slope right of the spillway was vegetated with various vegetation types from grass to maintained brush.
- The slope was steep, approaching 1.5H:1V. Evidence of sloughing was noted in two locations (both approximately 5 feet wide and less than 12 inches deep)
- Signs of apparent seepage was present at the toe of the right groin with lush vegetation and soft saturated soils within 20 feet of the groin.
- Other areas of the toe of the slope were observed to be soft and saturated. It was unclear if this was related to seepage through the dam or the result of capillary action associated with the downstream tailwater.
- Two sets of animal burrows were present at the upper third point of the slope. Both sets were approximately two 12-inch diameter by 18-inch deep animal burrows spaced approximately 10 feet apart. Each had a spoil pile that consisted of light brown silty fine sand.

2.1.3 Appurtenant Structures

Spillway

- The approach and discharge areas appeared clear of debris.
- In general, the joints of the masonry (control section and training walls) appeared to be repointed recently and the mortar was intact and in good condition.
- Leakage was present through the spillway control section (approximated at 200-300 GPM.
    - The apparent source of the leakage appeared to be through several sections of the open masonry along the top of the control section. Several vortexes were observed along this section.
    - The majority of the leakage exited from the toe of the control section with some of it flowing out of the second course of stone from the bottom.
    - The caretaker indicated that they would reevaluate the leakage at a lower pool level when the top of this control section is unsubmerged to determine if the sole source of the leakage is the top of the weir. If confirmed to be the sole source; a repointing program will be implemented in an attempt to stop the leakage.
- Leakage was also present (approximated at 2 GPM) from the base of the right training wall located approximately 10 feet downstream of the control section.

Low Level Outlet/Gatehouse

- The trash rack appeared rusted but no section loss was noted.
- There was no apparent debris upstream of the trash rack.
- No apparent deficiencies were noted within the gatehouse interior.
- The caretake indicated that the gate was in their maximum fully closed position (which is leaving it 2 inches open to maintain minimum baseflows).
- The gate was operated during the inspection without issue.
- No apparent deficiencies were noted along the downstream headwall.
- The outlet end of the outlet conduit was submerged and not visible.

2.1.4 West Dike

Upstream Side

- The upstream wall has variable alignment with areas of missing stones and small voids.
- Portions of the top of the wall were collapsed/missing.
- Large trees with diameters ranging from 6 to 12 inches were growing in front of, through, and behind the wall. Trees and stumps have resulted in displacement of the wall in areas.
- The wall was discontinuous at the left end of the dam with a breach through the wall present at an apparent boat ramp. It was reported that this portion of the dike was demolished during installation of a sewer system many years ago.

Crest

- The crest was vegetated with thin grass and moss with areas of exposed gravel.
- Numerous trees larger than 6 inches in diameter were growing along the crest. Exposed root systems were typical.
- The vertical alignment was variable with undulating surfaces typical along the length of the dike.
- Beyond a fence on the crest near D0-25, in the area of the reported sewer line. the crest was roughly 4 feet lower than the top of the dam
- The crest left of the breach includes maintained grass, planting beds, and several large trees.

Downstream Side

- The downstream wall has numerous areas of apparent movement and questionable stability.
- Two trap rock buttresses have been installed along the steepest sections of the wall (presumably at the two failed sections of the wall that were reported on in the 2017 report)
- A wetland complex was present downstream of this section of the intact portion of downstream wall. It is unknown if seepage through the dike feeds and/or creates this wetland complex.

2.1.5 Downstream Area

The area immediately downstream of the dam is the Pascoag Lower Reservoir, which is impounded by a structure (Union Mill Pond Dam RI#015) approximately 1,800 feet downstream of the dam. The perimeter of the Pascoag Reservoir Lower is primarily wooded with light residential development within 350 feet of the shorelines. Immediately downstream of the control structure is an area of moderately commercial and residential development at the intersection of RI-100, RI-107, and Salves Avenue, a local road.

2.1.6 Reservoir Area

The dam is located at the northern end of the irregularly shaped impoundment and the West Dike is located at the northern end of a cove west of the main dam. The immediate perimeter of the impoundment is generally developed with residential structures along the edges of the pond with wooded hillside behind the residences and one roadway running parallel to the shoreline. Water enters the impoundment from the south and southwest.

2.2 Caretaker Interview

Mr. Bud Leonhardt, chairman of the Pascoag Reservoir Dam Management District, was present during the inspection. Information provided by Mr. Leonhardt was incorporated into this report.

2.3 Operation and Maintenance Procedures

A formal operations and maintenance manual for the dam was not available for review.

2.3.1 Operational Procedures

The Pascoag Reservoir Dam Management District keeps a log of the low-level outlet gate operations and exercises the gate during storm flows to control impoundment levels. The log is kept on a clipboard within the gatehouse structure.

The low-level outlet gate is routinely operated to control pool levels and minimum baseflow requirements set forth by RIDEM. Every winter a 5-foot drawdown is implemented and maintained by low level outlet operation. The gate is also kept at least 2 inches open to pass the minimum required baseflow to the downstream channel.

2.3.2 Maintenance of Dam and Operating Facilities

Maintenance on the dam includes annual vegetation mowing, periodic masonry repointing work, general maintenance to the bridge and gatehouse structures, and maintaining the low-level outlet controls. Maintenance on the West Dike is limited to partial tree removal and maintaining a clear surface on the crest.

The caretaker indicated that the Dam Management District has in the past and continues to address the ongoing animal burrow activity at the dam including hiring a contractor to trap burrowing animals as well as filling of any animal burrows that are observed.

The former chairman (Mr. Leo Plouffe) had indicated during the previous inspections that he is in the process of coordinating with an engineering firm to complete work along the dike embankment to address dam safety concerns identified within a Notice of Violation he received for the dike. Pare was unaware of this at the time of the current inspection and therefore did not ask the current chairman (Mr. Bud Leonhardt) for an update on the status of this work.

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

The following apparent deficiencies and potential dam safety concerns was noted during the inspection of the Pascoag Reservoir Upper Dam and West Dike:

Dam

1. Steep and irregular slopes along the upstream side of the dam with areas of exposed embankment soil.
2. Steep and irregular downstream slope with areas of potential past sloughing and variable surface coverage throughout.
3. Active animal burrows of significant depth and diameter at several locations along the downstream slope.
4. Possible seepage in several areas of the downstream toe.
5. Variable surface coverage and vertical irregularities throughout crest
6. Leakage through the stone masonry of the spillway.

West Dike

1. Irregularly aligned and partially failed stone masonry walls with questionable stability.
2. Apparent seepage in several areas of the downstream toe.
3. Numerous large trees along the length of the dike.
4. An apparent intentional breach that would function as an unregulated spillway.
5. Variable vertical alignment along the crest.

The following table lists the major deficiencies and recommended repairs (in italics) at the Pascoag Reservoir Upper Dam as stated within the 2017 Inspection Report and the conditions of the deficiencies as observed during the current inspection.

Table 3.1: Pascoag Reservoir Upper Dam Conditions Comparison

Previously Identified Recommendation	***Resolution or Current Condition / Recommendation***
1. Continue regular inspection, maintenance, and operations at the dam.	*Ongoing*
2. Continue maintenance and removal of vegetation from the upstream slope left of the spillway; monitor surface erosion.	*Specific area was not apparent during current inspection / May have been addressed*
3. Evaluate the completed repair on the downstream slope left of the spillway. Review conditions and potential relation between the previously observed hole and the sediment transport noted at the base of the downstream wall. Design and implement remedial measures if required.	*No indications of soil transport or subsidence noted / Repair may have addressed the issue*
4. Fill areas of erosion along the embankment slopes.	*Active erosion not apparent, but steep slopes with bare soils prone to erosion are present / Address areas*
5. Trap and remove burrowing animals from the embankment of the dam. Properly fill any	*Trapping efforts continued with minimal success / Install a stone surface coverage along the*

Table 3.1: Pascoag Reservoir Upper Dam Conditions Comparison	
Previously Identified Recommendation	***Resolution or Current Condition / Recommendation***
burrows with compacted fill material.	*downstream slope to address both the animal burrow concern as well as the downstream slope stability concern.*
6. Complete regular mortar maintenance along the spillway structures.	*Repointing is reportedly completed periodically; Leakage still persists in areas / Address condition*
7. Repair the downstream face of the downstream wall left of the spillway. Prior to implementing repairs, the observed leakage should be evaluated and necessary design(s) incorporated to address the leakage. The wall repair should include cleaning the surface, removing loose and aged mortar, chinking the joints, and repointing.	*Deficiencies were not apparent along the downstream wall left of the spillway.*
8. Repair the downstream headwall and training walls of the low level outlet, including resetting the stones as required, providing additional chinking stones, and repointing.	*Deficiencies were not apparent along the headwall*
9. Continue gatehouse maintenance including replacing the stop log stanchions at the outlet approach, removing rust from and painting the trash rack.	*Ongoing maintenance items*
10. Grub stumps from embankment.	*Stumps not apparent due to height of vegetation / Same recommendation if they do still exist*
11. Develop a monitoring program to evaluate the apparent leakage through the spillway control section and right training wall.	*Leakage still persists and is indicative of flow through the jointed masonry construction of the control section and training walls / Continue monitoring*
12. Evaluate the wet areas along the downstream toe. If related to seepage implement a seepage mitigation system	*No apparent change / Same recommendation*
13. Complete a seepage and slope stability analysis of the dam embankment.	*No apparent change / Same recommendation*
14. Based on the results of the seepage and slope stability analysis; design and implement repairs to the dam embankment	*No apparent change / Same recommendation*

The following table lists the major deficiencies and recommended repairs (in italics) at the West Dike as stated within the 2017 report and the conditions of the deficiencies as observed by Pare during the current inspection.

Table 3.2: West Dike Conditions Comparison	
Previously Identified Recommendation	***Resolution or Current Condition***
1. Clear the trees from the dike embankment.	*No apparent change / Same recommendation*
2. Regrade the dike's crest to a level section; loam and seed.	*No apparent change / Same recommendation*
3. Remove stumps and root systems.	*No apparent change / Same recommendation*
4. Protected embankment surface from continued erosion.	*No apparent change / Same recommendation*
5. Complete a seepage and stability analyses.	*No apparent change / Similar recommendation*
6. Repair the upstream and downstream walls as required.	*No apparent change / Similar recommendation*
7. Evaluate low area at the left end of the dike.	*No apparent change / Same recommendation*

The following recommendations generally describe the recommended approach to address current deficiencies at the dam. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of environmental permits needs to be determined for activities that may occur within resource areas under the jurisdiction of RIDEM or other regulatory agencies.

3.2 Recommendations

The following present additional studies, routine and recurrent operations and maintenance activities, and repairs recommended to address deficiencies noted during the inspection and the completion of this report. The recommendations provided below should be implemented in accordance with general dam safety practice. Further, if left unaddressed, many of the conditions identified above will continue to deteriorate and could compromise the future safety of the dam and appurtenant structures.

Main Dam

1. Develop and implement a formal monitoring program and evaluation to further assess the observed vortices, large flow of leakage, and observed ponded wet area near the toe of the spillway right training wall and flow through the base of the wall 10-feet from the downstream end of the training wall. The program should include procedures for locating sources of flow and recording observed flow rates and ponded levels, in relation to varying levels of the impoundment, and monitoring the wet areas for indications of sediment transport and volume of transported soil.
    a. Conditions are as suspected with either flow through open joints of masonry and/or stone masonry founded on bedrock. Continued monitoring is still recommended; however a concrete approach slab tied into bedrock or other means of leakage deterrent may be needed to address the ongoing leakage.

2. Continue regular inspection, maintenance, and operations at the dam.

3. Continue maintenance and removal of vegetation from the upstream slope left of the spillway; monitor surface erosion.

4. Evaluate the completed repair on the downstream slope left of the spillway. Review conditions and potential relation between the previously observed hole and the sediment transport noted at the base of the downstream wall. Design and implement remedial measures if required.

5. Fill areas of erosion along the embankment slopes.

6. Fill the dam crest to a uniform elevation while maintaining the design elevation. Reseed to establish grass growth.

7. Trap and remove burrowing animals from the embankment of the dam. Properly fill any burrows with compacted fill material.
    a. Consider installing a stone surface (i.e. riprap, etc) along the entire surface of the slope to not only deter continued burrowing activity, but to aid in apparent slope

stability concerns. This should be completed in conjunction with Item # 12 and #13 to address all three potential concerns with one approach.

8. Complete regular mortar maintenance along the spillway structures.

9. Deficiencies along the downstream wall left of the spillway were not apparent during the current inspection. The following describes the recommendation included within the 2017 report that do not appear necessary at this time.
    a. *Repair the downstream face of the downstream wall left of the spillway. Prior to implementing repairs, the observed leakage should be evaluated and necessary design(s) incorporated to address the leakage. The wall repair should include cleaning the surface, removing loose and aged mortar, chinking the joints, and repointing*.

10. Deficiencies along the downstream headwall of the low-level outlet were not apparent during the current inspection. The following describes the recommendation included within the 2017 report that do not appear necessary at this time:
    a. Repair the downstream headwall and training walls of the low-level outlet, including resetting the stones as required, providing additional chinking stones, and repointing.

11. Continue gatehouse maintenance including replacing the stop log stanchions at the outlet approach, remove scaling rust from and painting the trash rack.

12. Grub stumps and roots from the embankment. Stumps greater than 6 inches in diameter need to be removed, the root systems grubbed from the cleared areas and the resulting holes promptly filled with suitable compacted material. Depending upon the type of tree stumps to be removed, the procedure for removing the root system may vary. Some trees have taproots while others have a shallow network of roots that cover a large area. The impacts to the embankment should be evaluated by a registered professional engineer prior to grubbing roots. ***Given the conditions prevalent at the time of the work, instability, seepage or piping conditions could develop if not undertaken in a controlled manner.***

13. Complete an evaluation of the wet areas along the downstream slope to determine the source of these wet areas. Based on the results of this evaluation, install a blanket drain and/or toe drain designed to control embankment seepage.

14. Complete stability analyses to evaluate the stability of the downstream and upstream slopes of the dam. In order to complete these analyses, the completion of subsurface investigations will likely be required to assess the current composition of the embankment soils. Based on the results of the slope stability analyses, regrade the dam's upstream and downstream embankment slopes to provide stable sections complying with current design standards.

<u>West Dike</u>

1. Clear the trees from the dike embankment. Significant root systems should also be pulled, and the resulting holes properly filled. The impacts to the embankment should be evaluated by a registered professional engineer prior to grubbing roots. ***Given the conditions prevalent at the time of the work, instability, seepage or piping conditions could develop if not undertaken in a controlled manner.***

2. Regrade the crest to a level section with compacted fill; reseed to establish grass growth.

3. Complete stability analyses to evaluate the observed bulges and overall condition of the upstream and downstream walls. In order to complete these analyses, the completion of subsurface investigations will likely be required to assess the current conditions of the embankment soils.

4. Based on the results of the stability analyses, repair both the upstream and downstream walls. Reset the displaced stones as necessary to form vertically and horizontally regular walls. This may include providing additional chinking stones, repointing, or installing a stone buttress in front of the walls for added stability.

5. Evaluate the impact of the breach in the embankment left of the fence line; determine the necessity to formalize this area to function as an auxiliary spillway or to restore the apparent original dike section across this area. Implement measures as determined to be required

6. Evaluate the apparent seepage along the toe of the dike. Based on the results of the evaluation, design and implement a seepage mitigation system.

General

1. Implement a program of regular inspection and monitoring of the dam. As the dam is currently classified as a high hazard potential dam, the completion of a formal visual inspection by a RI registered professional engineer familiar with dam engineering is recommended every 2 years.

2. Complete detailed hydrologic and hydraulic (H&H) analyses to evaluate the capacity of the structure to accommodate various storm events that would be typical for the watershed. It is recommended that the analyses consider flows associated with the 100-year through the one half probable maximum flood (1/2 PMF) storm events. The analysis should account for the routed inflow that utilizes the full storage capacity within the impoundment and drainage area. A structure that cannot discharge the inflow associated with normal storm events will be overtopped in an uncontrolled manner that could damage the structure and threaten downstream areas. The H&H shall also assess as to whether the breached section at the dike will act as an unregulated spillway and what storm event would cause the section would overtop.

3.3 Alternatives

The following alternatives are presented based upon a conceptual review of the concerns. Additional studies and or considerations may indicate that some or all of the options presented below are not suitable for the conditions specific to this dam and dam site. In addition to the general activities, appropriate environmental permits will be required to complete many of the alternatives presented below.

Dam Removal/Breaching: As an aalternative to implementing any of the repairs noted above, breaching of the dam is a viable alternative for addressing safety and stability concerns at the dam. While this alternative will address the safety concerns at the dam, it will result in the loss of the recreational and environmental resource and reduce flood control capacity provided by the dam and

impoundment. Additionally, while removal will result in elimination of yearly operating and maintenance expenses, permitting activities and construction costs associated with dam removal may exceed those of rehabilitation and operations and maintenance.

Lower the Dam: Complete modifications to the dam to reduce the dam height, thereby reducing the maximum height and volume of water that may be impounded by the dam. Evaluate the impact of the lowered dam upon the hazard potential. While this alternative may result in reducing the hazard potential, recommendations listed above remain valid and should be implemented in accordance to general dam safety practice. Additionally, permitting activities and construction costs associated with reducing the dam height may exceed those of repair.

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to State of Rhode Island Rules and Regulations for Dam Safety, or other reference published by FERC, Dept. of the Interior Bureau of Reclamation, or FEMA.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.
Downstream – Shall mean the high side of the dam, the side opposite the upstream side.
Right – Shall mean the area to the right when looking in the downstream direction.
Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – means any barrier made by humans, including appurtenant works, which impounds or diverts water.
Embankment – means the fill material, including but not limited to rock or earth, placed to provide a permanent barrier that impounds water.
Crest – Shall mean the top of the dam, usually provides a road or path across the dam.
Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.
Appurtenant Works – means any ancillary feature of a dam including such structures as dikes, training walls, spillways, either in the dam or separate there from, low level outlet works, and water conduits such as tunnels, channels, pipelines or penstocks, either through the dam or its abutments.
Spillway – means a structure, a low area in natural grade or any part of the dam which has been designed or relied upon to allow normal flow or major flood flow to pass over or through while being discharged from a reservoir.

Hazard Classification

High Hazard – means a dam where failure or misoperation will result in probable loss of human life.
Significant Hazard – means a dam where failure or misoperation results in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare. Examples of major economic loss include but are not limited to washout of a state or federal highway, washout of two or more municipal roads, loss of vehicular access to residences, (e.g. a dead end road whereby emergency personnel could no longer access residences beyond the washout area) or damage to a few structures.
Low Hazard – means a dam where failure or misoperation results in no probable loss of human life and low economic losses.

General

EAP – Emergency Action Plan – Shall mean 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.
O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.
Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.
Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam– means the vertical distance from the elevation of the uppermost surface of a dam to the lowest point of natural ground, including any stream channel, along the downstream toe of the dam.
Hydraulic Height – means the height to which water rises behind a dam and the difference between the lowest point in the original streambed at the axis of the dam and the maximum controllable water surface.
Maximum Water Storage Elevation – means the maximum elevation of water surface which can be contained by the dam without overtopping the embankment section.
Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.
Maximum Storage Capacity – The volume of water contained in the impoundment at maximum water storage elevation.
Normal Storage Capacity – The volume of water contained in the impoundment at normal water storage elevation.

Condition Rating

Unsafe – Means the condition of a regulated dam, as determined by the Director, is such that an unreasonable risk of failure exists that will result in a probable loss of human life or major economic loss. Among the conditions that would result in this determination are: excessive vegetation that does not allow the Director to perform a complete visual inspection of a dam, excessive seepage or piping, significant erosion problems, inadequate spillway capacity, inadequate capacity and/or condition of control structure(s) or serious structural deficiencies, including movement of the structure or major cracking.*
Poor – A component that has deteriorated beyond a maintenance issue and requires repair.; the component no longer functions as it was originally intended.
Fair – Means a component that requires maintenance
Good – Meeting minimum guidelines where no irregularities are observed and the component appears to be maintained properly.

* Structural deficiencies include but are not limited to the following:

- Excessive uncontrolled seepage (e.g., upwelling of water, evidence of fines movement, flowing water, erosion, etc.)
- Missing riprap with resulting erosion of slope
- Sinkholes, particularly behind retaining walls and above outlet pipes, possibly indicating loss of soil due to piping, rather than animal burrows
- Excessive vegetation and tree growth, particularly if it obscures features of the dam and the dam cannot be fully inspected
- Deterioration of concrete structures (e.g., exposed rebar, tilted walls, large cracks with or without seepage, excessive spalling, etc.)
- Inoperable outlets (gates and valves that have not been operated for many years or are broken)

REFERENCES AND RESOURCES

The following reports were located during the file review completed at RIDEM Offices in Providence, Rhode Island and within PARE's archives:

1. "Pascoag Reservoir Upper Dam, Visual Inspection/Evaluation Report", Pare Corporation, Foxboro, Massachusetts, May 4, 2017.
2. "Pascoag Reservoir Upper Dam, Visual Inspection/Evaluation Report", Pare Corporation, Foxboro, Massachusetts, October 30, 2013.
3. "Pascoag Reservoir Upper Dam, Visual Inspection/Evaluation Report", Pare Corporation, Foxboro, Massachusetts, May 14, 2010.
4. "Pascoag Upper Reservoir Dam, Dam No. 16, Dam Inspection Report", RI Department of Environmental Management. February 24, 1998.
5. "Pascoag Res. Upper Dam, Dam No. 16, Site Inspection Report", RI Department of Environmental Management. August 15, 1997.
6. "Pascoag Res. Upper Dam, Dam No. 16, Dam Inspection Report", RI Department of Environmental Management. February 12, 1996.
7. "Pascoag Res. Upper Dam, Dam No. 16, Dam Inspection Report", RI Department of Environmental Management. April 21, 1993.
8. "Pascoag Res. Upper Dam, Dam No. 16, Dam Inspection Report", RI Department of Environmental Management. April 7, 1989.
9. "Pascoag Res. Upper Dam, Dam No. 16, Dam Inspection Report", RI Department of Environmental Management. May 6, 1987.
10. "Pascoag Res. Upper Dam, Dam No. 16, Dam Inspection Report", RI Department of Environmental Management. December 13, 1985.
11. "Pascoag Upper. Dam No. 16, Visual Inspection Checklist", RI Department of Environmental Management. May 10, 1985.
12. "Pascoag Res. Upper Dam, Dam No. 16, Dam Inspection Report", RI Department of Natural Resources. May 7, 1984.
13. "Plan of Work. Flood Plain Study for Pascoag Reservoir Upper and Lower Dams, Burrillville, RI", U.S. Department of Agriculture Soil Conservation Service. August 1984.
14. "Pascoag Res./Upper, Dam No. 16. Dam Inspection Report". Department of Natural Resources. April 21, 1978.
15. "Pascoag Reservoir. Dam No. 16 Special Inspection Report", RI Department of Public Works. Division of Harbors and Rivers. September 18, 1946.
16. "Pascoag Reservoir (16)" Plan No. B-16. RI Department of Public Works. Division of Harbors and Rivers. 1940.
17. "Plan of Dam at Pascoag Reservoir". Pascoag, RI. Works Progress Administration. RI Department of Public Works. 1939.

The following were referenced during the completion of the visual inspection and preparation of this report and the development of the recommendations presented herein

1. "Design of Small Dams", United States Department of the Interior Bureau of Reclamation, 1987.
2. "ER 110-2-106 - Recommended Guidelines for Safety Inspection of Dams", Department of the Army, September 26, 1979.
3. "Guidelines for Reporting the Performance of Dams" National Performance of Dams Program, August 1994.
4. *Bing Maps*, Microsoft Corporation, 2013.

The following provides an abbreviated list of resources for dam owners to locate additional information pertaining to dam safety, regulations, maintenance, operations, and other information relevant to the ownership responsibilities associated with their dam.

1. RIDEM Office of Compliance and Inspection Website: http://www.dem.ri.gov/programs/benviron/compinsp/
2. "Dam Owner's Guide To Plant Impact On Earthen Dams" *FEMA L-263,September 2005.*
3. "Technical Manual for Dam Owners: Impacts of Plants on Earthen Dams" *FEMA 534, September 2005.*
4. "Dam Safety: An Owners Guidance Manual" *FEMA 145,December 1986.*
5. Association of Dam Safety Officials – Website: www.asdso.org/
6. "Dam Ownership – Responsibility and Liability", ASDSO.

VISUAL DAM INSPECTION LIMITATIONS

Visual Inspection

1. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

2. In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team.

3. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

4. It is critical to note that 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 present 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.

Use of Report

1. The applicability of environmental permits needs to be determined prior to undertaking maintenance activities that may occur within resource areas under the jurisdiction of any regulatory agency.

2. This report has been prepared for the exclusive use of the RIDEM for specific application to the Pascoag Reservoir Upper Dam in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made

3. This report has been prepared for this project by Pare. This report is for preliminary evaluation purposes only and is not necessarily sufficient to support design of repairs or recommendations or to prepare an accurate bid.

Photo No. 1: Overview of the upstream face of the dam from the left abutment.

Photo No. 2: Impoundment overview from the dam crest.

Photo No. 3: Downstream impoundment overview from the left abutment.

Photo No. 4: Upstream slope left of the spillway.

Photo No. 5: Upstream slope between the spillway and low-level outlet. Note bare soil along top of slope.

Photo No. 6: Upstream slope right of the low-level outlet. Note bare soil throughout the slope.

Photo No. 7: Upstream slope from the right abutment.

Photo No. 8: Crest from the low-level outlet looking left.

Photo No. 9: Crest from the low-level outlet looking right.

Photo No. 10: Crest looking right.

Photo No. 11: Crest from the right abutment looking left.

Photo No. 12: Downstream wall and downstream slope left of the spillway.

Photo No. 13: Downstream slope from the low-level outlet looking right.

Photo No. 14: Pair of animal burrows (arrows) located 50 feet right of the low-level outlet.

Photo No. 15: Downstream slope looking right.

Photo No. 16: Pair of animal burrows (arrows) located approximately 100 feet from the right abutment.

Photo No. 17: View of one of the burrows. Note diameter (12 inches) and soil spoil pile (silty fine sand) typical of all four apparent burrow locations.

Photo No. 18: Downstream slope from the downstream right abutment looking left.

Photo No. 19: Apparent seepage area at the toe of the right groin of the downstream slope.

Photo No. 20: Approach to the spillway. Not apparent bedrock outcrops.

Photo No. 21: Spillway control section.

Photo No. 22: Vortexing (arrow) of leakage flow through the open masonry of the control section.

Photo No. 23: Leakage through the spillway control section.

Photo No. 24: Leakage through the base of the downstream right training wall approximately 20 feet downstream of the control section.

Photo No. 25: Discharge area of the primary spillway.

Photo No. 26: Trash racks at the inlet end of the low-level outlet system.

Photo No. 27: Gate operator for the low-level outlet system.

Photo No. 28: Outlet end and downstream headwall for the low-level outlet conduit.

Photo No. 29: Impoundment from the dike crest.

Photo No. 30: Overview of the upstream face of the dike from the right abutment looking left.

Photo No. 31: Upstream face of the dike from mid-length looking right.

Photo No. 32: Dike crest from right abutment looking left.

Photo No. 33: Dike crest from near the left end of the dike looking right.

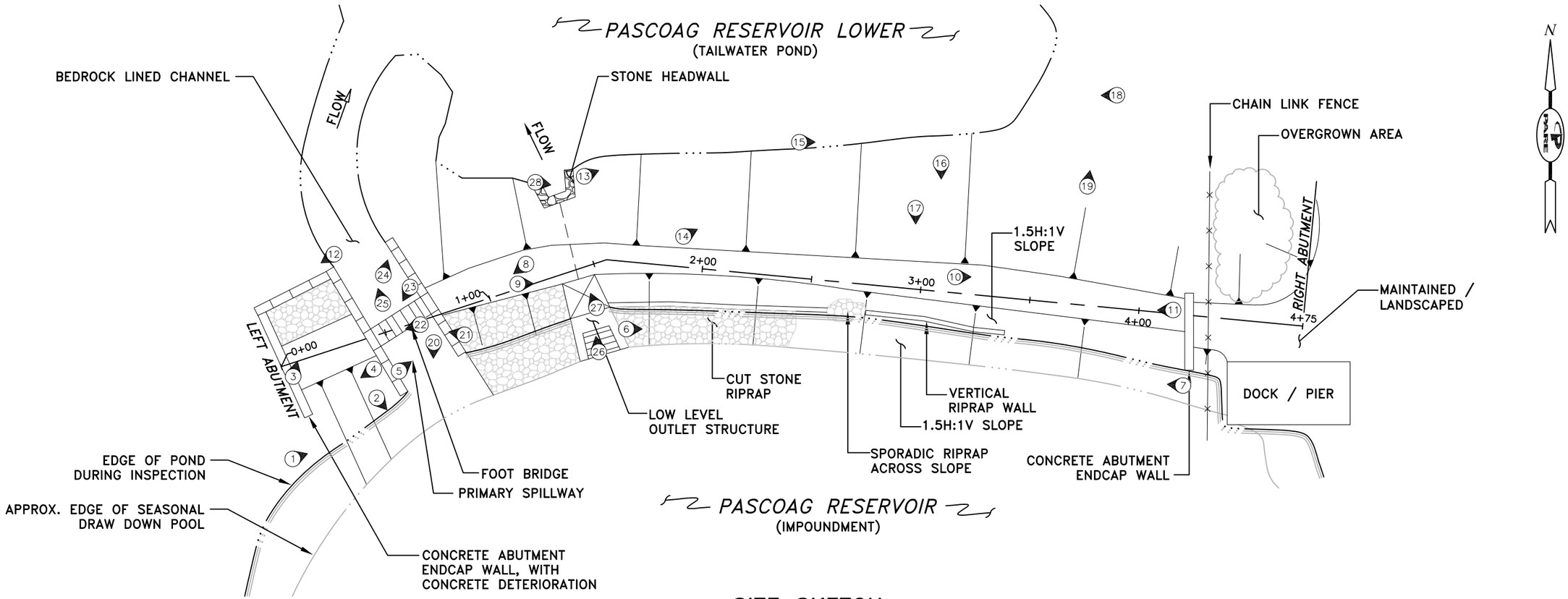
Photo No. 34: Dike crest from near the left end looking left.

Photo No. 35: Downstream side of the dike from the right abutment looking left.

Photo No. 36: Downstream side of the dike from near the tallest section looking right. Note the two trap rock buttresses and ponded water within the downstream area.

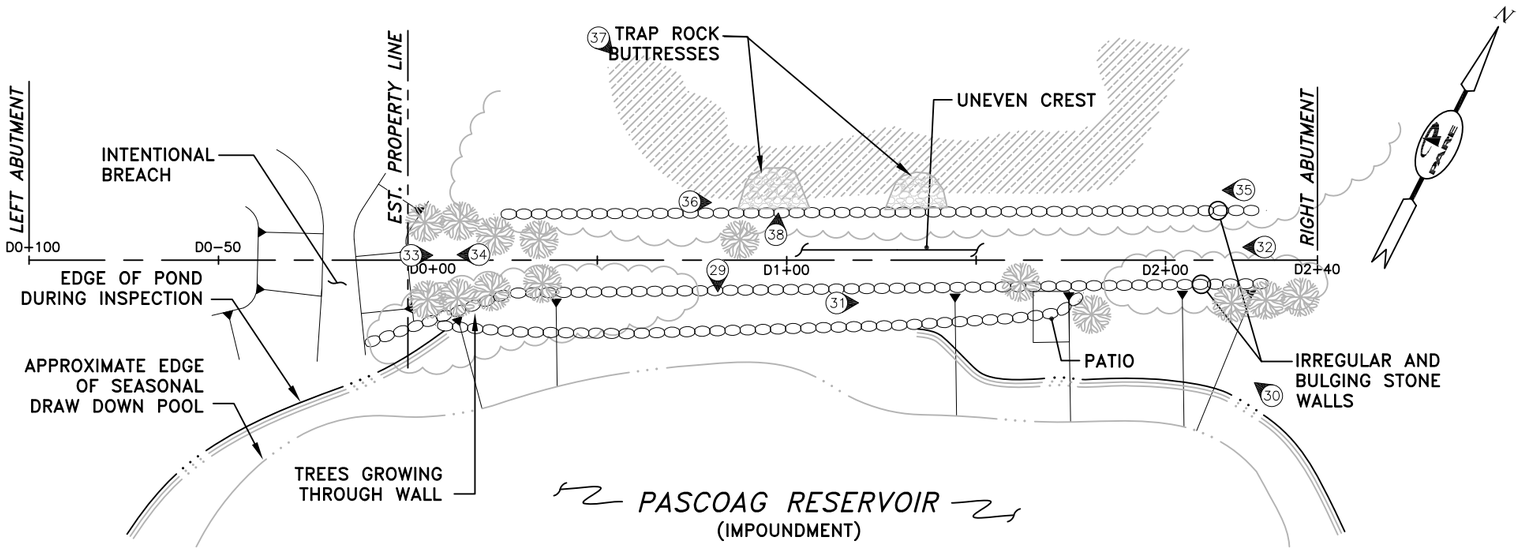
Photo No. 37: View of the tallest section of the downstream side from 50 feet downstream looking upstream.

Photo No. 38: View of the area downstream of the dike. Note ponded water and wetland type vegetation.



SITE SKETCH

SCALE: 1"=50'±



WEST DIKE SKETCH

SCALE: 1"=40'±

NOTES AND LEGEND

1. PLAN DEVELOPED FROM NOTES TAKEN DURING THE INSPECTION, PREVIOUS REPORTS, AND AVAILABLE AERIAL IMAGERY FROM RIGIS. INFORMATION IS PROVIDED FOR REFERENCE PURPOSES ONLY.

(#) DENOTES APPROXIMATE LOCATION AND DIRECTION OF PHOTOGRAPH.

1+00 BASELINE AND STATIONING

PARE CORPORATION
ENGINEERS • SCIENTISTS • PLANNERS
10 LINCOLN ROAD, SUITE 210
FOXBORO, MA 02035
508-543-1755

SCALE ADJUSTMENT GUIDE

0" 1"

BAR IS ONE INCH ON ORIGINAL DRAWING.

PASCOAG RESERVOIR UPPER DAM

RI DAM No. 16

BURRILLVILLE, RHODE ISLAND

MAIN DAM OWNER: COLLEEN CONLEY
WEST DIKE OWNER: LE0 PLOUFFE

DOWNSTREAM
LEFT RIGHT
UPSTREAM

REVISIONS:		

PROJECT NO.:	16178.04/002
DATE:	JUNE 2020
SCALE:	AS NOTED
DESIGNED BY:	MED
CHECKED BY:	MED
DRAWN BY:	MLP
APPROVED BY:	JMB

SITE SKETCH

FIGURE NO.: 1

Y:\JOBS\16 Jobs\16178.04 RIDEM 2020 Dam Inspections – RI\Task 002 – 016 PascoagReservoirUpper–Burrillville\DWG\Fig 1 Site Sketch.dwg