PREPARED FOR: TOWN OF DURHAM, NH

MILL POND DAM
VISUAL INSPECTION REPORT
DURHAM, NEW HAMPSHIRE
DAM #071.03

PREPARED BY:

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PARE PROJECT NO. 19169.00

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PARE CORPORATION

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1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The Town of Durham has retained Pare Corporation of Foxboro, Massachusetts, working under subcontract to VHB, Inc., to perform a visual inspection and develop a report of conditions for the dam at Mill Pond along the Oyster River in Durham, New Hampshire. This inspection and report were performed in general accordance with the New Hampshire Department of Environmental Services Env-Wr 100-700 Dam Rules.

1.1.2 Purpose of Work

The purpose of this investigation was to inspect and document 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 scope of the inspection and report development is also intended to provide a baseline inspection of the entire structure as required per Condition #1 of the February 12, 2018 Letter of Deficiency issued by the New Hampshire Department of Environmental Services.

The investigation was divided into three parts: 1) obtain and review available files including reports, investigations, and data pertaining to the dam and appurtenant structures; 2) perform a visual inspection of the site; and; 3) prepare and submit a final report presenting the evaluation of the structure.

1.1.3 Common Dam Safety Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in Appendix C. 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 Mill Pond Dam is located in the Town of Durham, approximately 600 feet southeast of the Durham Town Hall. The dam impounds water along the Oyster River to form Mill Pond. The dam is located at the eastern side of the impoundment near coordinates 43.1305°N/70.9194°W as shown on Figure 1: Locus Plan and Figure 2: Aerial Plan.

The dam is accessible from a vegetated area at the left abutment. There is no parking area at the dam. To reach from dam from I-95N, take exit 6N towards Dover and keep left at the fork to continue toward US-4 W. Follow US-4 W for 4.8 miles and turn left onto US-4W (Boston Harbor Road). Continue straight on US-4 W for 0.2 miles. At the traffic circle take the second exit to continue onto US-4W. Follow US-4 W for 3.4 miles. Take the exit for NH-108 towards Durham/Newmarket

and turn left onto NH-108 S/Dover Road. Follow Dover Road for 0.7 miles and turn left onto Newmarket Road. After 0.2 miles, the dam will be on the right.

1.2.2 Owner/Caretaker

The dam is currently owned and operated by the Town of Durham. Maintenance for the structure is primarily completed by the Town's Department of Public Works.

1.2.3 Purpose of the Dam

The dam currently impounds water for recreational purposes. The dam was originally constructed in 1913 to provide hydropower to the Jenkins Mill that previously existed at the right abutment.

1.2.4 Description of the Dam and Appurtenances

The Mill Pond Dam is an approximately 140-foot long concrete dam. The Mill Pond Dam has a maximum structural height of approximately 13 feet. The dam consists of three components: 1) Primary Spillway; 2) Gated Outlets; and 3) Fish Ladder.

The spillway structure for the dam is an approximately 100-foot wide reinforced concrete modified Ambursen type buttress dam. The spillway consists of a reinforced concrete shell supported by reinforced concrete ribs spaced approximately 12 feet on center beneath the crest. Flow over the spillway discharges into a bedrock plunge pool before discharging beneath the bridge carrying Newmarket Road/NH-108.

The gated outlets are located at the right end of the dam and consists of two 4-foot wide timber gate controlled bays. The gate operators consist of rack and pinion type operators with timber gate stems. The right-most gate structure was previously used to supply the mill downstream with hydropower and is currently not utilized; the left gate structure is presently used as the low level outlet. Flows from the low-level outlet enter the gate structure and outlet to the downstream channel where the masonry structure for the previous mill foundations are located.

A Denil (baffle) fishway is located at the left end of the dam.

1.2.5 Operations and Maintenance

The Town of Durham is responsible for operations and maintenance at the dam. Operations at the dam include the operation/exercising of the gate. Maintenance activities at the dam include cutting of vegetation along at the abutments.

1.2.6 Hazard Potential Classification

In accordance with current classification procedures under State of New Hampshire Dam Rules, Mill Pond Dam is currently classified as a **Low** hazard potential dam.

1.3 Engineering Data

1.3.1 Discharges at the Dam Site

No records of discharges at the dam site were made available during the preparation of this report.

1.3.2 General Elevations (feet)

Elevations are based upon a survey completed by VHB in December 2019 and January 2020. Elevations reference the NAVD88 vertical datum.

A. Top of Dam	
i. Left abutment:	15.5 ft ±
ii. Right Abutment:	12.9 ft ±
B. Normal Pool (Spillway Crest)	10.85 ft ±
C. Maximum Pool	12.89 ft ±

1.3.3 Primary Spillway

A. Type	Broad Crested Weir (Ambursen type dam)
B. Width	100 ft ±
C. Spillway Crest Elevation	10.85 ft ±

1.3.4 Low-Level Outlet

A. Type	Gate Controlled Structure
B. Conduit	
i. Right	18-inch Steel Pipe (corroded)
ii. Left	48-inch Wide Concrete Opening
C. Right Gate Invert	
i. In	Unknown
ii. Out	0.8 ft ±
iii. Outlet Diameter	18 inches ±
D. Left Gate Invert	
i. In	Unknown
ii. Out	1.7 ft ±
iii. Outlet Size	4 ft by 6 ft ±
E. Outlet Control	Two Gates of unknown size

1.3.5 Fish Ladder

A. Type	Denil (Baffle)
B. Width	4 feet
C. Invert	
i. In	12.2 ft ±
ii. Out	0.1 ft ±

1.3.6 Construction Records

The Mill Pond Dam was constructed in 1913 to replace the last of a series of timber dams that provided hydropower. The Mill Pond Dam provided hydropower to the Jenkins Mill when it was first built. No construction documents were available for review.

The Mill Pond Dam was repaired in 1974. No construction documents were available for review. Repairs to the dam in 1974 consisted of:

- Repairs to the concrete within the cells of the spillway.
- Construction of the fish ladder at the left abutment.
- Reconstruction of the downstream edge of the spillway crest

1.3.7 Operations Records

No operations records are available or known to exist for this structure.

2.0 INSPECTION

2.1 Visual Inspection

Mill Pond Dam was inspected on December 18, 2019. At the time of the inspection, temperatures were near 36°F with partly cloudy skies. Photographs to document the current condition of the dam were taken during the inspection and are attached at the end of this report.

To facilitate inspection of the spillway, the Durham DPW implemented a shallow drawdown of the impoundment through opening of the left gated outlet. The drawdown lowered the level of the impoundment approximately 4 to 5 inches with the pool level slowly rising as the inspection was completed.

Underwater areas were not inspected as part of the field activity.

2.1.1 General Findings

In general, the overall condition of the Mill Pond Dam was found to be **Poor** condition**.** The specific observations are identified in more detail in the sections below. Please note that snow cover throughout the right and left abutments limited inspection of these areas.

2.1.2 Primary Spillway

For the purposes of the report, inspection of the spillway was segmented between three distinct components of the spillway including the spillway slab, training walls, and spillway cells (defined as the void space between adjacent ribs).

Spillway Slab

- While observing the impoundment filling, flow over the spillway started within the left third section of the spillway, indicating the right portion of the spillway is slightly higher than that of the left portion of the spillway. It was not apparent if this was the result of differential settlement, uneven crest scour, or an as-built condition.
- Two construction joints were noted on the spillway approximately 30-feet apart. The condition of the construction joints could not be observed due to snow coverage during the drawdown.
- A full inspection of the spillway crest could not be completed due to snow coverage during the drawdown and water flow over the spillway when the pond refilled. Previous reports noted transverse cracks along the crest of the spillway.
- Scour was present along the spillway crest.

Training Walls

- Scour was present at the joint between the right training wall and spillway, measuring 9-inches deep, 12-inches tall, and 5-feet long.
- Minor scour (less than 1 inch deep) was noted along the water level at the left training near the spillway.

- A spall (approximately 3 feet long) is located at the bottom right side of the right training wall with debonded rebar at the downstream face of the right training wall at the water line.
- Two diagonal cracks are located along the right training wall with efflorescence along the crack. The lower diagonal crack is more significant with delamination within two feet of the crack.

Spillway Cells

For the purposes of inspection, individual cells were number consecutively from Cell No. 1 at the right end of the spillway to Cell No. 9 at the left end of the spillway adjacent to the fish ladder. The following conventions were applied:

- The right and left sides of the cells are defined by the face of the rib adjacent to each cell facing into the cell (i.e., the left wall of Cell No. 1 refers to the right side of the rib between Cell No. 1 and Cell No. 2).
- The underside of the spillway slab was subdivided into 5 sections from downstream to upstream with:
    - Section 1 being the bottom of the downstream lip of the slab,
    - Section 2 being the upstream face of the downstream lip of the slab
    - Section 3 being the underside of the downstream slope of the spillway slab crest.
    - Section 4 being the underside of the spillway slab crest
    - Section 5 being the underside of the upstream slope of the spillway slab.

The following deficiencies were noted within the cells of the spillway following the preceding naming convention. Major deficiencies are listed in the table below. Please reference the Spillway Cell Inspection Figures for minor deficiencies and more specific detail about the dimensions and locations of the deficiencies listed below. The Spillway Cell Inspection Figure are included in Appendix A.

- In general, the concrete within the cells had scour along the apparent normal tailwater waterline.
- Map cracking was noted throughout the cell walls.
- Efflorescent staining was typical within all of the cells and typically indicated more severe deterioration.
- The spillway and ribs appeared to be constructed of concrete with aggregate up to 4 inches in diameter.
- The following was noted within the individual spillway cells:

Cell No	Section	Observations
1	Right Wall	• The joint at Face No. 3 appeared to be leaking as indicated by ice buildup on the wall. The joint was open approximately 0.5 inches. • Spalling was present along the wall up to 1.5-inches deep on the upstream half of the wall and on the bottom downstream half of the wall.

	Left Wall	▪ A 10-inch tall by 6-inch wide area of section loss was present through the wall between cell 1 and cell 2. Spalling was present within this area. Exposed aggregate around the hole was loose in areas and could be easily broken away with limited effort.
	1	No major deficiencies noted. See Appendix A for more detail.
	2	No major deficiencies noted. See Appendix A for more detail.
	3	▪ The downstream half of this face was repaired, with an 18-inch spall and delamination up to 1.5 inches deep present at the joint between the repair and original concrete. ▪ An open joint with efflorescent staining was present at the joint between the left wall.
	4	No major deficiencies noted. See Appendix A for more detail.
	5	▪ A spall approximately 4-feet long with exposed rebar was present at the left joint. ▪ A repair was present along the right side, that was up to 0.25-inches thick. An approximate 0.5-inch separation was present between the existing and repaired concrete. ▪ Orange staining was noted at the upstream most right corner. ▪ Delamination with slight bulging was present along the center of the face.
	Misc	None
2	Right Wall	▪ A spall approximately 3-inches wide, 0.5-inches deep with iron oxide staining was present along the full length of the upstream side of the wall. ▪ A large spall with a 10-inch by 6-inch section of 100 percent section loss was present along the downstream end. The spall measures approximately 44-inches by 24-inches.
	Left Wall	▪ A spall with a crack in the center was present along the downstream side of the wall and measured approximately 30-inches from the top to the bottom of the spall, 12-inches wide, and 5-inches deep.
	1	▪ A spall was present at the downstream left end measuring 12-inches long, 4-inches wide, and up to 4-inches deep.
	2	No major deficiencies noted. See Appendix A for more detail.
	3	No major deficiencies noted. See Appendix A for more detail.
	4	No major deficiencies noted. See Appendix A for more detail.
	5	▪ Delamination was present along the right side of the wall face. The repaired area appeared to be delaminating from the original concrete. Minor bulging within this area was also noted. The dimensions of the area of delamination vary and can be seen in more detail in Appendix A. ▪ Iron oxide staining was noted at the right upstream most corner.
	Misc	• Ceiling face numbers 1, 2, and 3 were repaired or partially repaired. The repair on Ceiling face No. 3 typically measured 2 feet from the downstream joint with Ceiling Face No. 2. The repair was approximately 0.5-inches thick.
3	Right Wall	• A spall was present at the downstream end measuring 25-inches long, 18-inches wide, and up to 2-inches deep.
	Left	• A spall with debonded rebar was present at the downstream end measuring

	Wall	25-inches long and 8-inches wide. A hand could be wrapped around the piece of rebar. • An open crack/spall with delamination was present, approximately 3 to 4-inches wide. The crack within the spalled area is tight (near 1/8-inch wide).
	1	• Areas of a past repair are apparent; the repair appears intact
	2	• Areas of a past repair are apparent; the repair appears intact
	3	• A partial repair was present along this face. The dimensions of the repair can be seen in more detail in Appendix A. • At the joint between the repair and the original concrete was a spall that measures up to 9-inches wide, 68-inches long, and up to 3.5-inches deep.
	4	No major deficiencies noted. See Appendix A for more detail.
	5	No major deficiencies noted. See Appendix A for more detail.
	Misc	None
4	Right Wall	• A spall with a 4-inch long, 0.040-inch wide crack was present at the downstream end. The spall measured 30-inches tall, 22-inches wide and up to 4-inches deep. A 5-inch deep cored hole was present within the approximate center of the spall. • A crack with iron oxide staining was present along the upstream edge. The crack was up to 6-inches wide and 2-inches deep. Seepage appeared to be evident based upon ice along the wall below the crack.
	Left Wall	• A spall with debonded rebar was present along the downstream end measuring 18-inches long, 18-inches wide, and up to 4-inches deep.
	1	• Debonded rebar and spalling was present on the right end, measured to be approximately 6-inches wide by 16-inches long.
	2	• Areas of past repairs are apparent; the repairs appear to be intact.
	3	• Areas of past repairs are apparent; the repairs appear to be intact.
	4	No specific observations
	5	• Three spalls were present along the upstream toe of this wall. Iron oxide staining was present on either side of this wall within the spalls. An section of debonded rebar was also present.
	Misc	None
5	Right Wall	• A spall with debonded rebar was present at the downstream end measuring 3-feet long, 1-foot wide and approximately 3.5-inches deep.
	Left Wall	• No significant areas of deterioration were noted.
	1	• Areas of past repairs are apparent; the repairs appear to be intact.
	2	• Areas of past repairs are apparent; the repairs appear to be intact.
	3	No major deficiencies noted. See Appendix A for more detail.
	4	No major deficiencies noted. See Appendix A for more detail.
	5	No major deficiencies noted. See Appendix A for more detail.
	Misc	None
6	Right Wall	• No significant areas of deterioration were noted.
	Left	• A spall with delamination and efflorescent staining was present on the

	Wall	upstream side measuring 18 inches long by 6 inches wide.
	1	• Spall with debonded rebar was present on the left portion of the ceiling face and measured 14-inches long and up to 2-inches deep.
	2	• A 2 to 6-inch wide repair was present along the downstream edge of the face.
	3	• An 8-inch diameter previously repaired spalled area was present on the right side of the ceiling face.
	4	No specific observations
	5	• Three spalls with delamination were present along the left edge of the wall.
	Misc	None
7	Right Wall	• A spall with exposed aggregate was present on the downstream end measuring 14-inches wide and up to 3-inches deep. • An open crack with exposed aggregate was present along the upstream perimeter of the wall approximately 1 to 6-inches from the ceiling. The spalling around the crack was approximately 6-inches wide and up to 2.5-inches deep. Seepage appeared to be evident based on ice on the wall below the crack. • The concrete above the crack was sounded for deterioration and appeared to be delaminated.
	Left Wall	• A spall up to 1.5-inches deep was present on the downstream end of the wall.
	1	• Areas of past repairs are apparent; the repairs appear to be intact.
	2	• Areas of past repairs are apparent; the repairs appear to be intact.
	3	• The face was sounded and appeared to be significantly delaminated. Significant efflorescent staining buildup was present.
	4	No major deficiencies noted. See Appendix A for more detail.
	5	No major deficiencies noted. See Appendix A for more detail.
	Misc	None
8	Right Wall	• A total of eight repairs appeared to be present on the wall; five of the apparent repairs were not visible due to timber falsework over the repairs.
	Left Wall	• Five apparent repairs were present on the wall, the repairs were not visible due to timber falsework over the repairs.
	1	• Areas of past repairs are apparent; the repairs appear to be intact.
	2	• Areas of past repairs are apparent; the repairs appear to be intact.
	3	• A 3-inch diameter, 0.5-inch deep spall with exposed rebar was present on the upstream edge of the ceiling face.
	4	No specific observations
	5	• A spall with exposed rebar was present on the downstream end of the face that measured 4-feet long and up to 8-inches wide.
	Misc	None
9	Right Wall	No major deficiencies noted. See Appendix A for more detail.
	Left Wall	No major deficiencies noted. See Appendix A for more detail.
	1	No major deficiencies noted. See Appendix A for more detail.

	2	No major deficiencies noted. See Appendix A for more detail.
	3	No major deficiencies noted. See Appendix A for more detail.
	4	No major deficiencies noted. See Appendix A for more detail.
	5	No major deficiencies noted. See Appendix A for more detail.
	Misc	No major deficiencies or specific observations were noted in Cell No. 9.

- The following was noted on the downstream side of the ribs:
  - In general, spalling was present along either side of each rib.
  - The rib between Cell Nos. 3 and 4 was spalled with debonded rebar. A hand could be wrapped around the debonded rebar.
  - The rib between cells 4 and 5 had a 3-foot tall spall with debonded rebar.

2.1.3 Gated Outlet Structure

The following was noted at the outlet structure:

Upstream Face

- A spalled section, approximately 6 to 8-inches wide, was present on the right side of left gate invert at the waterline.
- The right gate invert was submerged at the time of the inspection.
- Moss/ice/snow cover was present on the upstream face of the concrete at the low level outlet structure, limiting inspection.

Crest

- Moss/ice/snow cover was present on the crest of the concrete at the low level outlet structure, limiting inspection.

Downstream Face

- Map cracking was present throughout the gate structure headwall.
- Concrete spalling with exposed rebar was present to the left of the left gate outlet. The spall measured approximately 2-feet wide by 2-feet tall and up to 3.5-inches deep.
- The concrete along the bottom portion of the wall (approximately 5 feet from mudline at the wall) was significantly deteriorated with efflorescence/iron oxide staining.
  - Significant delamination with exposed rebar was present on either side of the old pipe from the mill structure. The scour and spall were up to 4-inches deep.
- Seepage, approximately 0.5 gpm, was present through the downstream face of the gate structure at the concrete to the left of the right outlet.
- Seepage, approximately 1 to 2 gpm, was present through the downstream face of the gate structure between the two outlets approximately 2 feet above the top of the left gate opening.
- Signs of potential seepage appeared to be present due to the presence of ice along the downstream face of the concrete at the gate headwall.

- The right gate outlet pipe was fully corroded.
- Section loss and scour was present at the right end of the concrete cap surrounding the outlet pipe.
- The downstream masonry wall immediately right of the right outlet appears to bulge in the downstream direction approximately 6-inches between the gate section and the old mill foundation. Seepage was present at the base of this section of wall, flowing at approximately ten gallons per minute.
- No chinking stones or mortar were present within the downstream wall or the walls at the abutment.
- A crack/spall was present on the to the left of the left gate outlet extending from the right side of the right training wall to the gate outlet. The crack was approximately 3-inches wide and up to 2-inches deep

Gates/Conduits

- The left gate was operable, but the gate was reportedly limited to an opening of 8-inches.
- Leakage through the left gate is approximately 1 to 3 cfs.
- The left gate was operated during the inspection to lower the levels within the impoundment.
- The right gate was reportedly inoperable. The gate was historically used for the mill that was once downstream of this gate.

2.1.4 Fish Ladder

The following was noted at the fish ladder:

- The fish ladder structure consisted of timber baffles.
- The stop logs at the upstream side of the fish ladder exit pool were leaking approximately 5 gpm.
- Scour was present along the water line of the fish ladder pool structure.
- The grating over the fish ladder structure appeared to be in good condition.
- The footing for the training wall between the fish ladder and Cell No. 9 was undermined at the base of the wall. The void was probed up to 3 feet under the training wall. The undermined area was approximately 2-feet long and 1-foot in height.
- An open construction joint was present at the 180-degree turn in the fish ladder and was approximately 1-inch wide.
- A repair was present along the right side of the downstream training wall. The repair area showed indications of delamination.
- An open joint with vegetation growing was present at the concrete between the primary spillway and fish ladder structure. This area was previously reported to be leaking, but flow over the spillway limited the view of any leakage.

2.1.5 Downstream Area

The water immediately downstream of the Mill Pond Dam is tidal and is considered brackish. Immediately downstream of the spillway is a 10 to 15-foot wide plunge pool lined with boulders and bedrock. Water flows from the plunge pool and passes under Newmarket Road in a bedrock and boulder lined channel, approximately 100 feet downstream of the spillway. The bridge at Newmarket Road appeared to be founded on bedrock and in good condition with no signs of scour. Flows through the Newmarket Road Bridge then pass under a pedestrian bridge approximately 200 feet downstream before entering Little Bay and eventually the Piscataqua River.

2.1.6 Reservoir Area

The dam is located at the eastern end of the impoundment. Mill Pond extends approximately 1,000 feet upstream of the dam; however, the dam also impounds water upstream along the Oyster River and Hamel Brook with backwater influences from the dam extending 2,800 feet upstream of the pond along the Oyster River and approximately 1,900 feet upstream of the Oyster River along the Hamel Brook.

The perimeter of the impoundment is generally un-developed along the immediate shoreline with few residential properties around the impoundment. Mill Pond Road borders the impoundment to the north. Slopes are generally flat surrounding the impoundment area.

2.2 Caretaker Interview

Ms. April Talon was present during the inspection. Information provided by Ms. Talon has been incorporated into this report.

2.3 Operation and Maintenance Procedures

There was no formal operations and maintenance manual for the dam available at the time of the inspection.

2.3.1 Operational Procedures

Operable components include the two gates at the low-level outlet. The right most-gate is inoperable and was previously used as hydropower when the mill was operational. The left-most gate is operable though the range of operability is limited to approximately 8 inches. The fish ladder structure does not appear to have significant capacity to be considered as an operational outlet to the dam; stoplogs may be adjusted as necessary to support fish migration.

2.3.2 Maintenance of Dam and Operating Facilities

Maintenance activities at the dam include cutting of vegetation along the left abutment and clearing the spillway and discharge area of debris. The caretaker also routinely completes informal inspections and responses to public comments to check the condition of the dam. In general, the caretaker was knowledgeable of current conditions at the dam.

3.0 ASSESSMENTS

3.1 Assessments

In general, the overall condition of the Mill Pond Dam is **Poor** with the following deficiencies identified:

TABLE 3.1: Deficiency Summary

Deficiency Number	*Description*
1	Concrete deterioration of the spillway cells and ribs including: • Cracks and spalls with evidence of seepage; • Section loss of the rib between Cell Nos. 1 and 2; • Delamination of the repaired concrete from the original concrete; • Debonded rebar within multiple cells;
2	Seepage at the downstream corner of the right stone masonry abutment wall;
3	Seepage through the downstream face of the gate structure;
4	Inoperable right gate outlet;
5	Concrete deterioration at the gate outlet structure including delamination, cracking, and spalling;
6	Insufficient capacity to pass the SDF;

In general, the conditions observed during this inspection have continued to deteriorate since the previous inspections.

The following table provides a summary of previous recommendations and their status at the time of the inspection:

Previously Identified Deficiency	***Resolution or Current Condition***
Concrete deterioration and spalling on the downstream face of the outlet works, ribs, interior of the spillway cells	*Deterioration has continued to progress. The area of section loss between Cell Nos. 1 and 2 has increased in size since the 2018 inspection by NHDES. Seepage through the outlet structure was not previously observed.*
Minor seepage at the downstream corner of the right masonry abutment wall	*Seepage continues*
Insufficient ability to pass the design storm with one foot of freeboard at the dam	*Same deficiency*
Deterioration of the mid-1970's concrete repair work	*Deterioration has continued to progress*
EAP needs updating and testing	*No apparent change*
Update O&M manual	*No apparent change*
Area of section loss between cells 1 and 2	*Section loss had continued*

3.2 Current Hazard Potential Classification

The Mill Pond Dam is currently classified as a **Low** hazard potential dam due to the impacts dam failure may have on the adjacent and downstream properties and because the height exceeds 6 feet and the storage capacity exceeds 50 acre-feet.

According to an NHDES letter dated September 2018, Mill Pond Dam is classified as low not only because of the "6/50" case, but also the potential for damage to be done to the property to the right of

the dam if failure or overtopping occurs. Previous overtopping events have cased erosion damage to the said property. In order to properly assess the impacts of various storms to the residence at the right abutment, a detailed hydraulic/hydrologic study should be completed.

The project team is currently proceeding with a study to assess the hazard classification of Mill Pond Dam.

3.3 Hydraulic/Hydrologic Data

Mill Pond Dam is a **Low** hazard structure and in accordance with current state dam safety regulations, the spillway design flood (SDF) for the site is the 50-year storm event. No detailed hydraulic and hydrologic analysis has been completed for the dam. According to the 2009 Stephens Associates Dam Evaluation Report, NHDES performed an informal H&H analysis of the dam in 2008. The following table summarizes the results of the NHDES H&H analysis.

Table 3.2: NHDES H&H Analysis

Storm Event	Inflow (cfs)	Peak El. (ft)	Spillway Discharge (cfs)		Discharge with operations (cfs)	
			With 1 ft freeboard	At top of Dam	With 1 ft freeboard	At top of Dam
50-year	1,452	14.0	385	1,110	618	1,360
100-year	1,833	14.4				

According to the NHDES analysis, with one foot of freeboard, the spillway can pass 385 cfs and, with operations, can pass 618 cfs. The inflow for the 50-year flood was 1452 cfs and for the 100-year flood was 1,833 cfs. Based on that information, the dam cannot pass the SDF with one-foot of freeboard. However, NHDES assumed a spillway length of 110 feet, instead of the shortened spillway length of approximately 100-feet due to the fish ladder installation in 1975.

Weston & Sampson, under contract with VHB, Inc., completed a draft analysis currently under review by NHDES. The following table summarizes the preliminary data.

Table 3.2: Draft W&S H&H Analysis

Storm Event	Inflow (cfs)	Peak El. (ft)	Spillway Discharge (cfs)	
			With 1 ft freeboard	At top of Dam
50-year	3,352	14.62	352	1,015
100-year	3,877	15.04		

Based on the updated results, the dam will be overtopped on the right abutment by 1.74 feet and cannot pass the 50-year storm with one-foot of freeboard.

3.4 Structural and Seepage Stability

A structural stability analysis was performed by Stephens Associates as part of the 2009 Inspection Report. No records of the original design computations were available for review at the time of the preparation of this report.

3.4.1 Structural Stability of Dam

Stephens Associates completed a structural stability analysis as part of the 2009 Inspection report. The following table summarizes the results of that analysis:

Table 3.3: Results of Stability Analysis

Case	FS for Sliding	Eccentricity (ft)	Maximum Bearing Pressure (psf)
Spillway – Normal Flow	2.0	0.33	7,300
Spillway – Flood	2.2	1.14	9,500
Right Abutment – Normal Flow	1.7	1.3	1,030
Right Abutment – Flood	1.4	2.3	840
Right Abutment – Ice and Normal Flow	<1	6.4	1,040

According to NHDES Env-Wr 303.12(c)(2), the stability analysis shall follow the methods outlined in "Engineering Guidelines for Evaluation of Hydropower Projects" published by the Federal Energy Regulatory Commission (FERC) Chapter 3 dated 2002 and Chapter 4 dated 1991. The guidelines mentioned state that a minimum factor of safety of 1.5 must be met for the worst static load case.

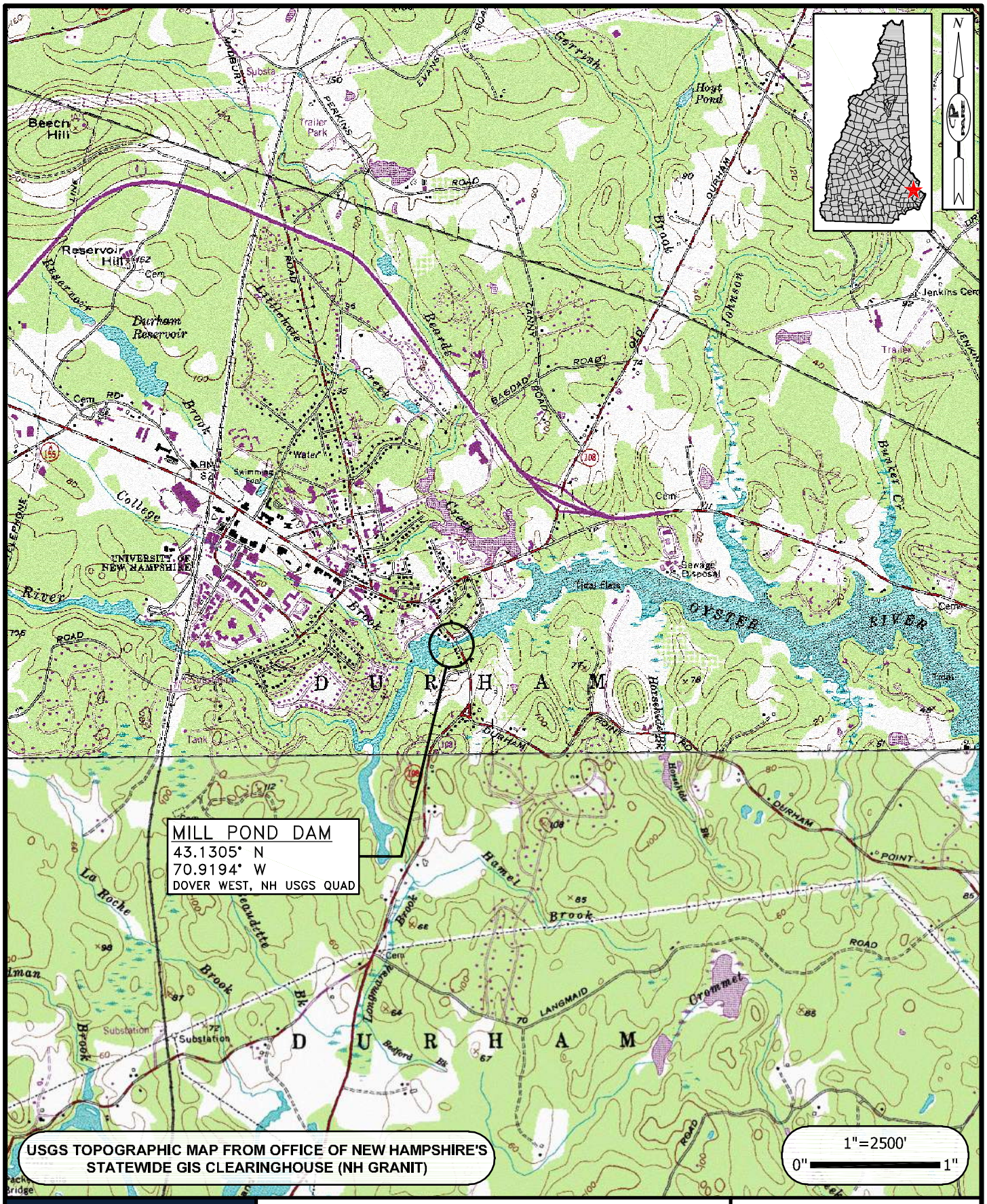
The results show that the spillway is stable against flood conditions and the spillway and right abutment (gated outlet structure) are stable against normal flow conditions. The right abutment does not meet the factor of safety of 1.5 for the flood and normal pool with ice conditions.

The downstream masonry wall and right abutment masonry wall are generally vertical. The right abutment masonry wall was reconstructed in 2009 after a storm event overtopped the right abutment and washed out the previous masonry wall. The right abutment masonry wall is slightly bulging, but appears to be stable. The spillway continues to deteriorate with section loss through the rib between cell 1 and 2. The section loss was not apparent during the inspection in 2009.

3.4.2 Seepage Stability

No formal seepage analyses have been completed for this structure. Seepage and orange staining were observed at the bottom of the masonry walls along the right abutment and through the downstream side of the outlet structure. It is unknown whether the seepage through the right abutment masonry wall is due to potentially high water table right of the dam or from the dam impoundment. Two areas of seepage were noted through the concrete of the outlet structure. Orange staining and ice buildup was also noted on the downstream side of the low level outlet structure, potentially indicating additional seepage through the structure.

Orange staining and ice apparently from cracks were noted within some of the spillway cells. No active seepage was present during the time of the inspection; however, active seepage was previously noted within Cell No. 1 on the connecting low level outlet wall and within Cell No. 2 on the right wall as indicated within the inspection report by NHDES dated September 18, 2017.



PARE CORPORATION

MILL POND DAM

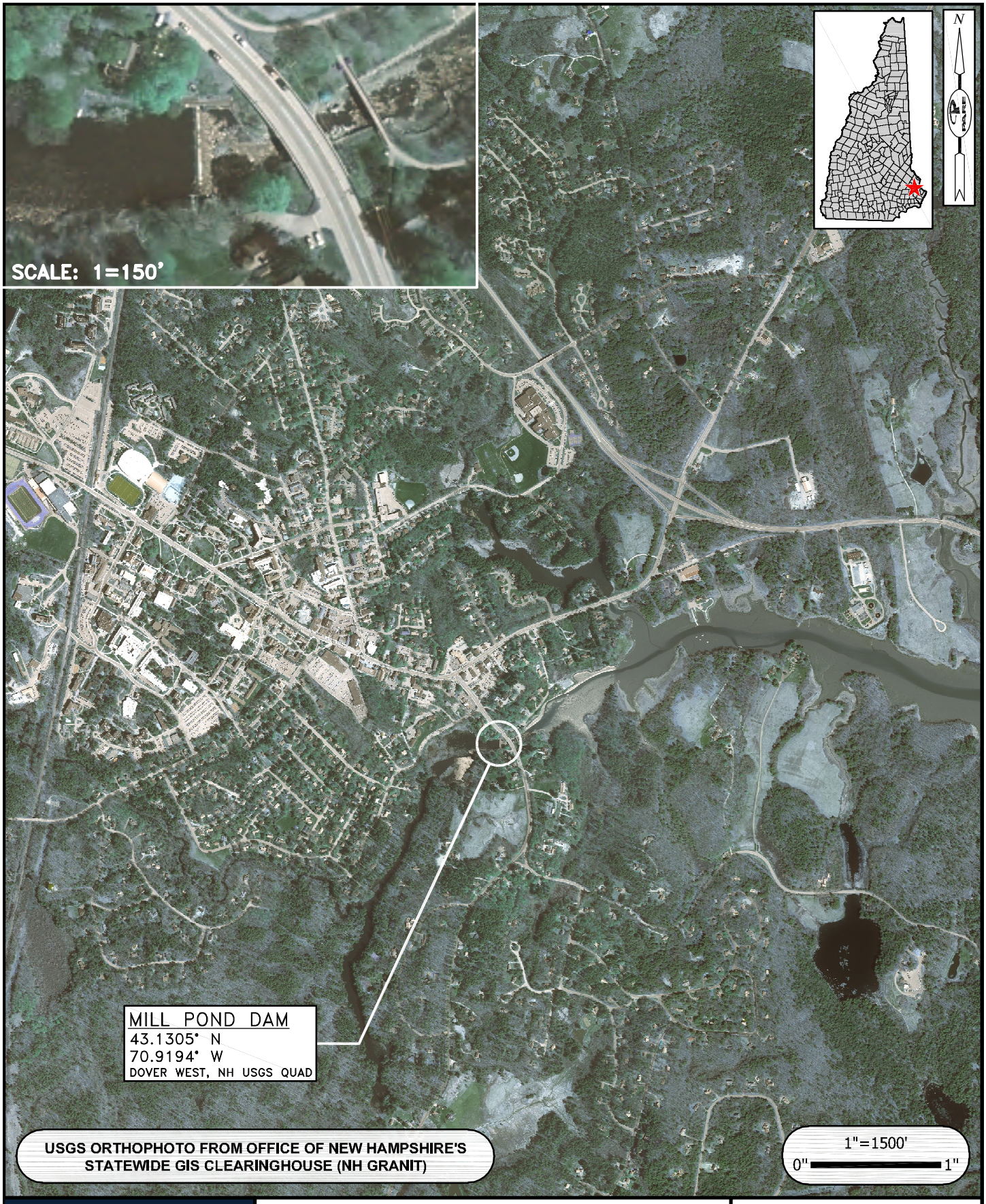
DAM #071.03

DURHAM, NEW HAMPSHIRE

OWNER - TOWN OF DURHAM

LOCUS PLAN

MARCH 2020 FIGURE 1



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MILL POND DAM

DAM #071.03

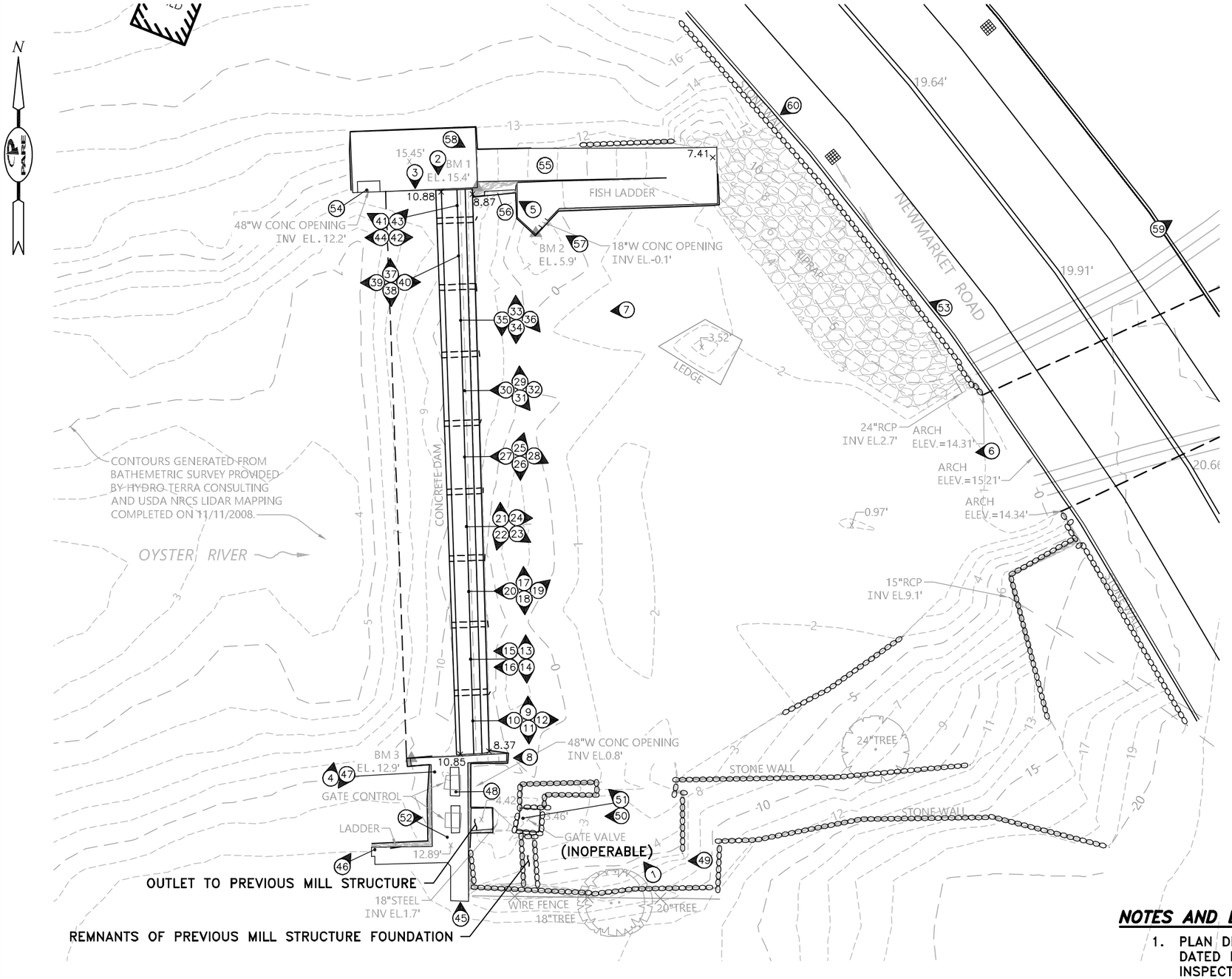
DURHAM, NEW HAMPSHIRE

OWNER - TOWN OF DURHAM

AERIAL PLAN

MARCH 2020

FIGURE 2



SITE SKETCH

SCALE: 1"=20'±

NOTES AND LEGEND

1. PLAN DEVELOPED FROM A SURVEY PLAN PREPARED BY VHB, INC. DATED DECEMBER 18, 2019 AND NOTES TAKEN DURING THE INSPECTION. INFORMATION IS PROVEDED FOR REFERENCE PURPOSES ONLY.
2. ELEVATIONS REFERENCE THE NAVD 88 VERTICAL DATUM.

×3.0 SPOT ELEVATION AS DETERMINED BY VHB, INC. REFERENCING EITHER BM 1, BM 2, OR BM 3.

◁# DENOTES APPROXIMATE LOCATION AND DIRECTION OF PHOTOGRAPH.

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0" 1"

BAR IS ONE INCH ON ORIGINAL DRAWING.

MILL POND DAM

DAM #071.03

DURHAM, NEW HAMPSHIRE

OWNER: TOWN OF DURHAM

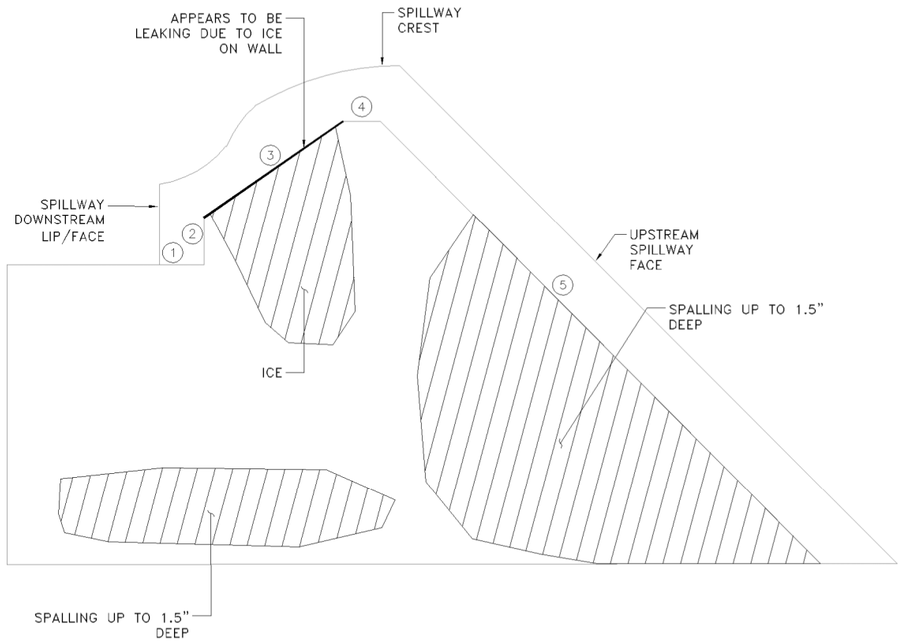
REVISIONS:		

PROJECT NO.:	19169.00
DATE:	MARCH 2020
SCALE:	AS NOTED
DESIGNED BY:	HMS
CHECKED BY:	ARO
DRAWN BY:	LMC
APPROVED BY:	ARO

SITE SKETCH

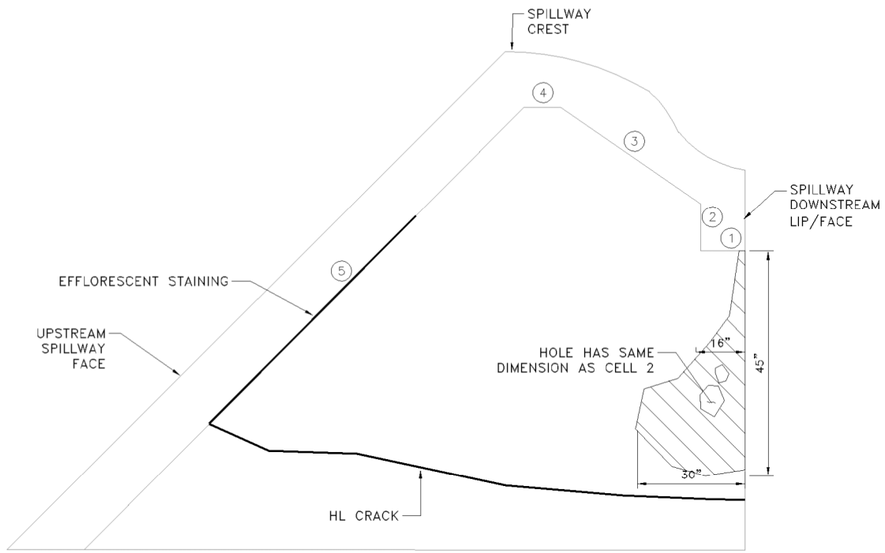
FIGURE NO.: 3

APPENDIX A
Spillway Cell Inspection Figures
Mill Pond Dam
Durham, NH



RIGHT CELL WALL

NOT TO SCALE



LEFT CELL WALL

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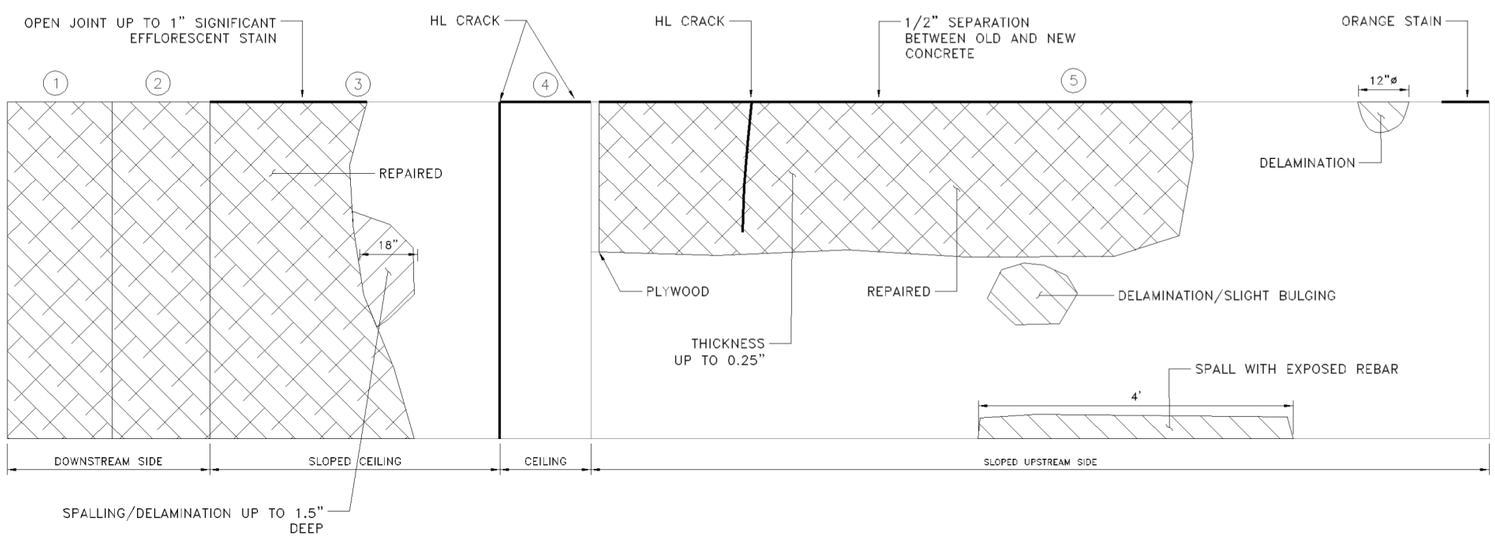
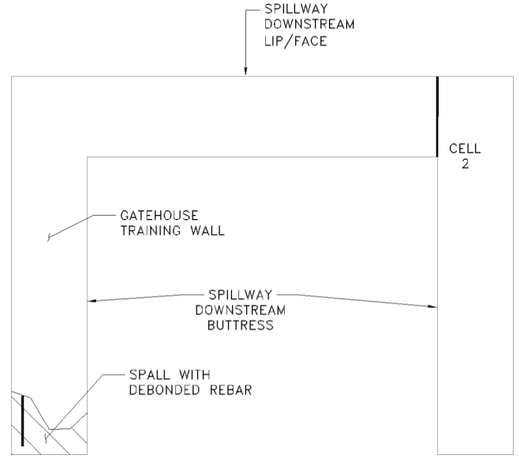


UPSTREAM WALL AND CEILING OF CELL

NOT TO SCALE



SPILLWAY DOWNSTREAM FACE AND BUTTRESSES

NOT TO SCALE

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MILL POND DAM FEASIBILITY STUDY

DURHAM, NH

OWNER: TOWN OF DURHAM

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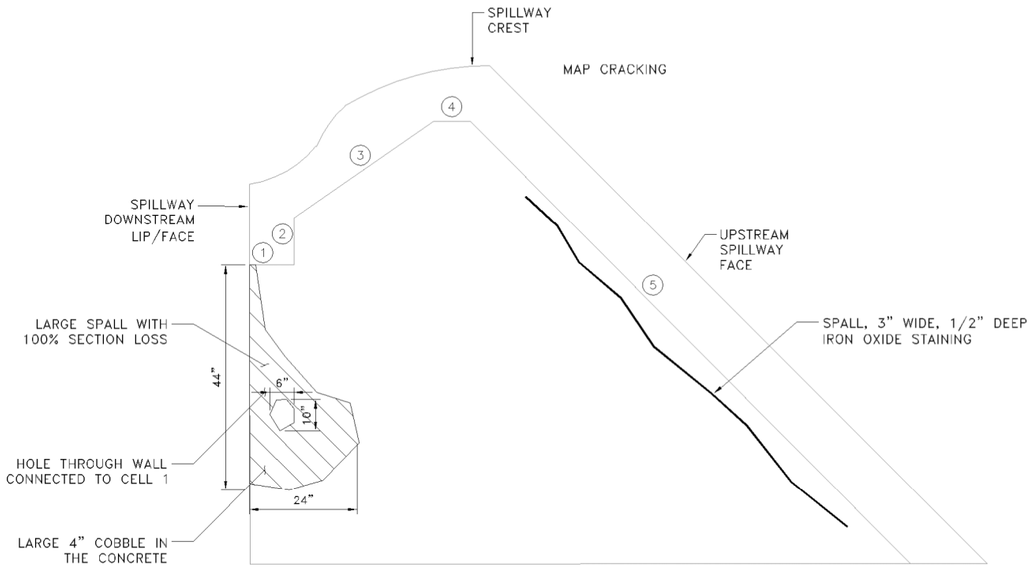
CELL NO. 1

SHEET NO.:

1



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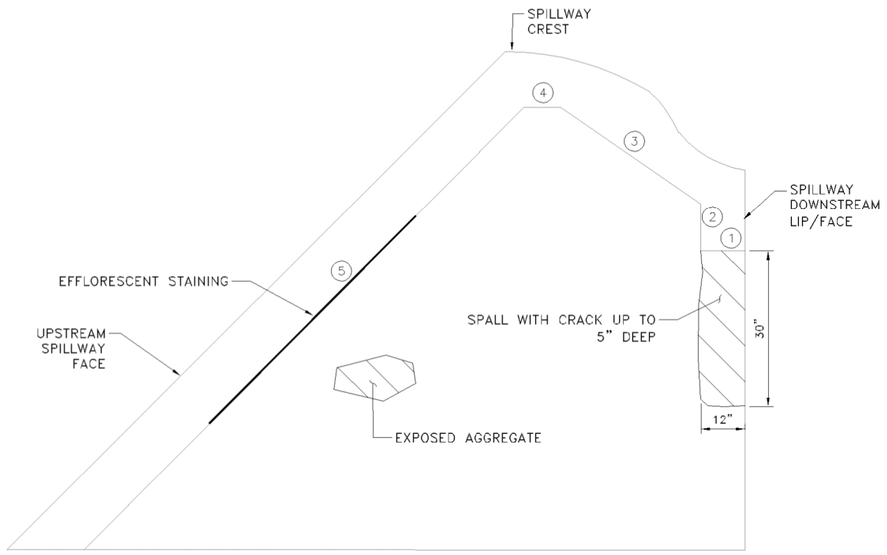

LEFT CELL WALL

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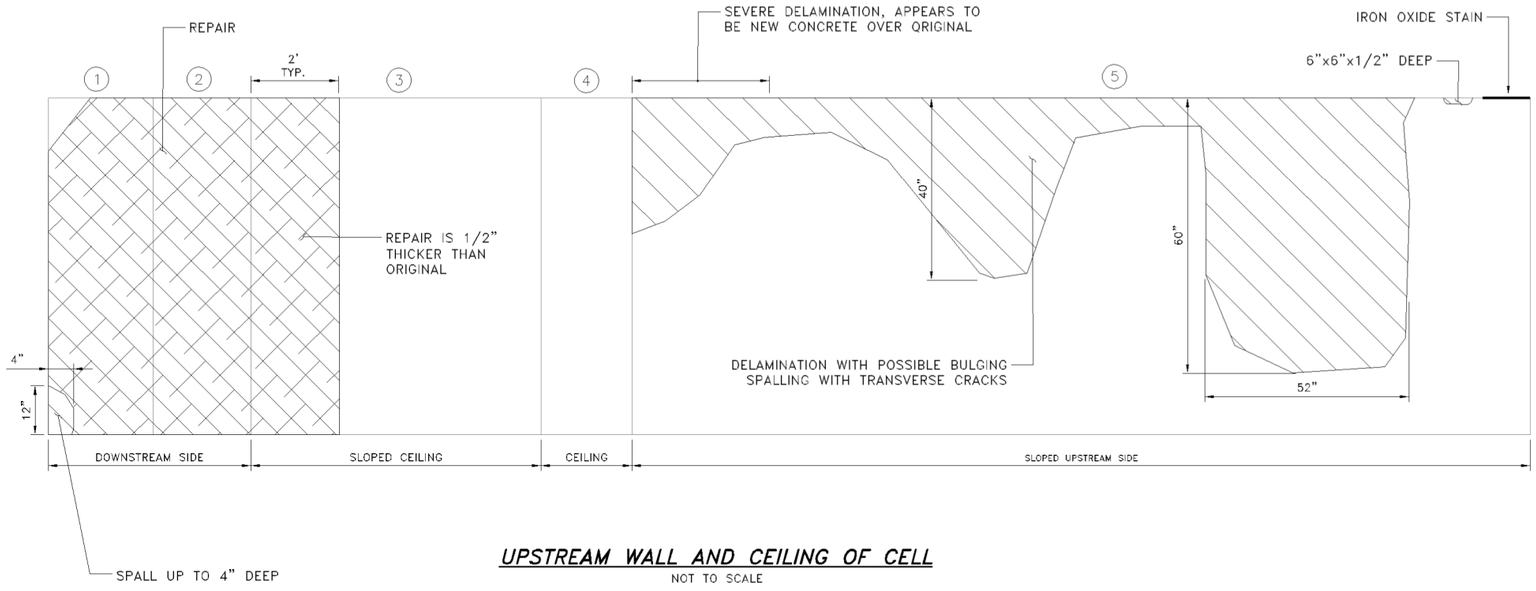
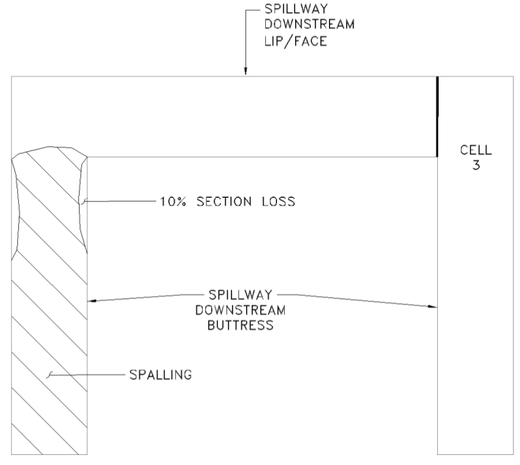


UPSTREAM WALL AND CEILING OF CELL

NOT TO SCALE



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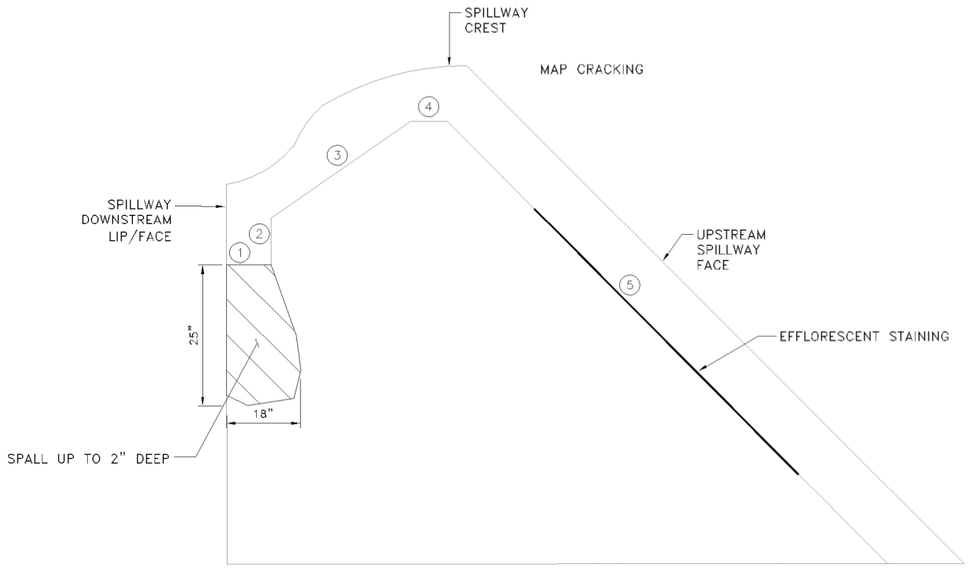
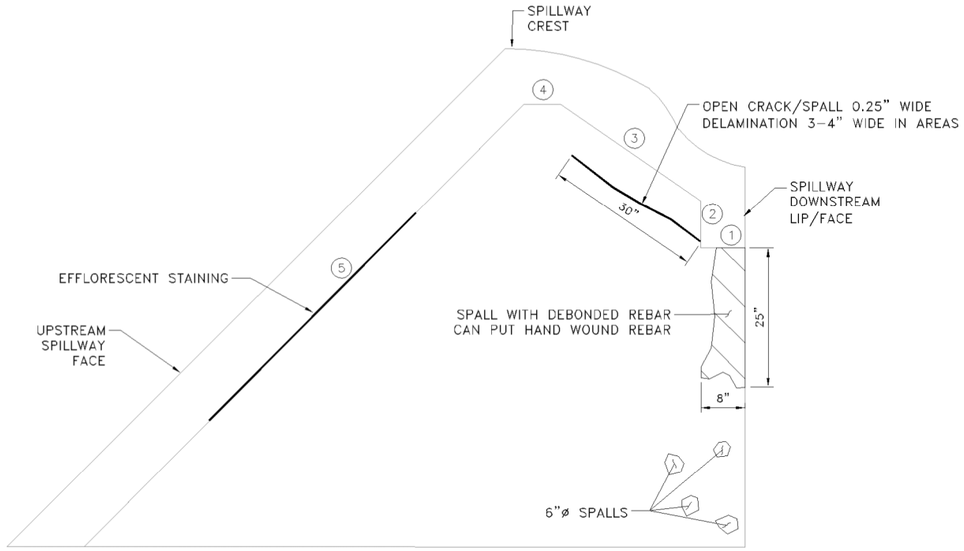
CELL NO. 2

SHEET NO.:

2



RIGHT CELL WALL
NOT TO SCALE



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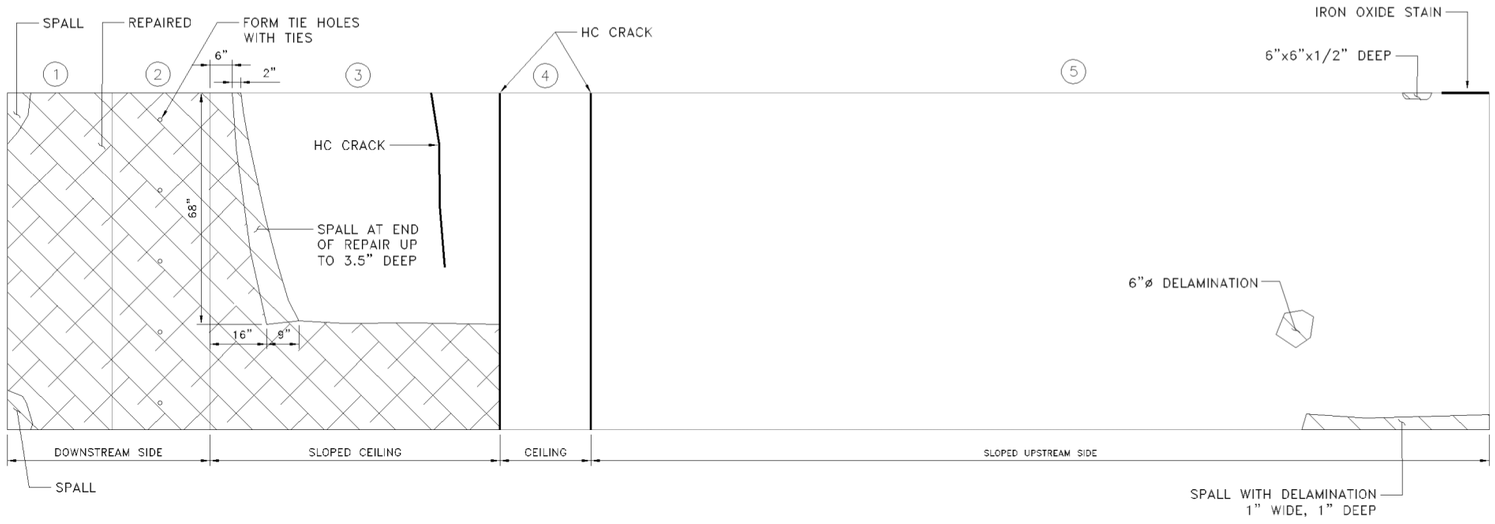
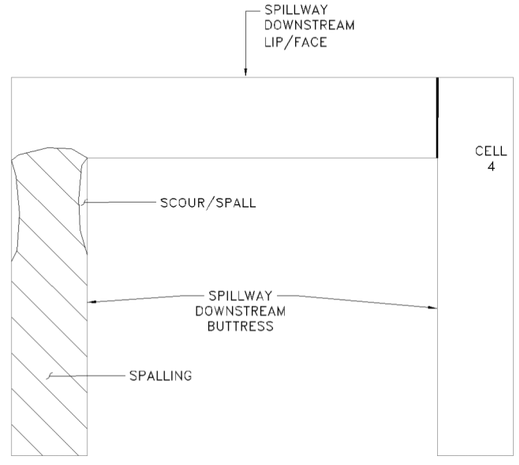


UPSTREAM WALL AND CEILING OF CELL
NOT TO SCALE



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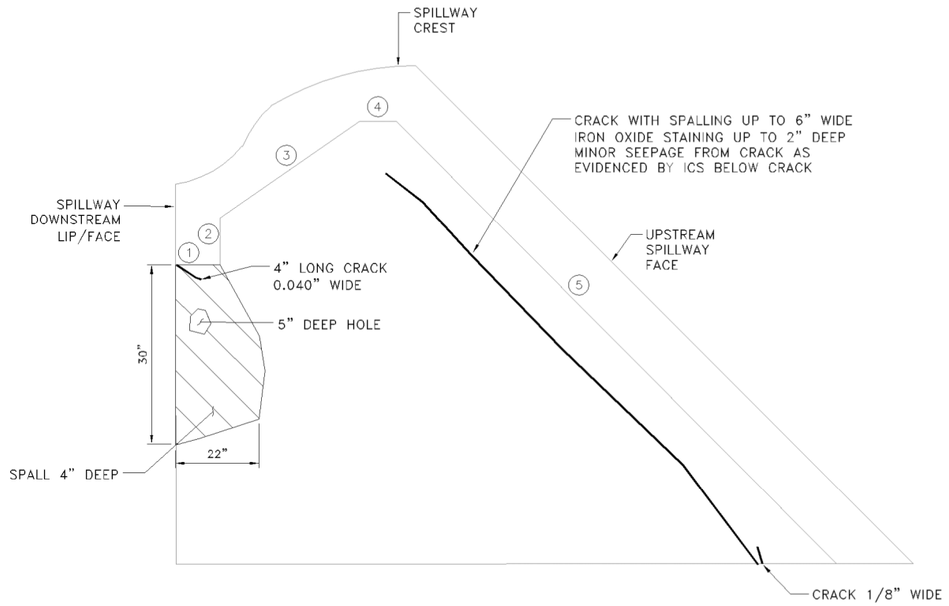
APPROVED BY:	

CELL NO. 3

SHEET NO.:
3



RIGHT CELL WALL

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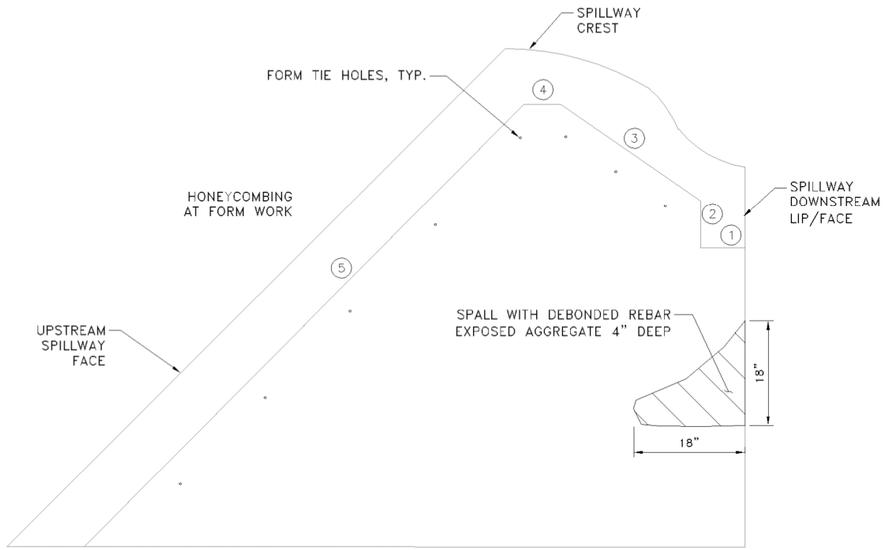

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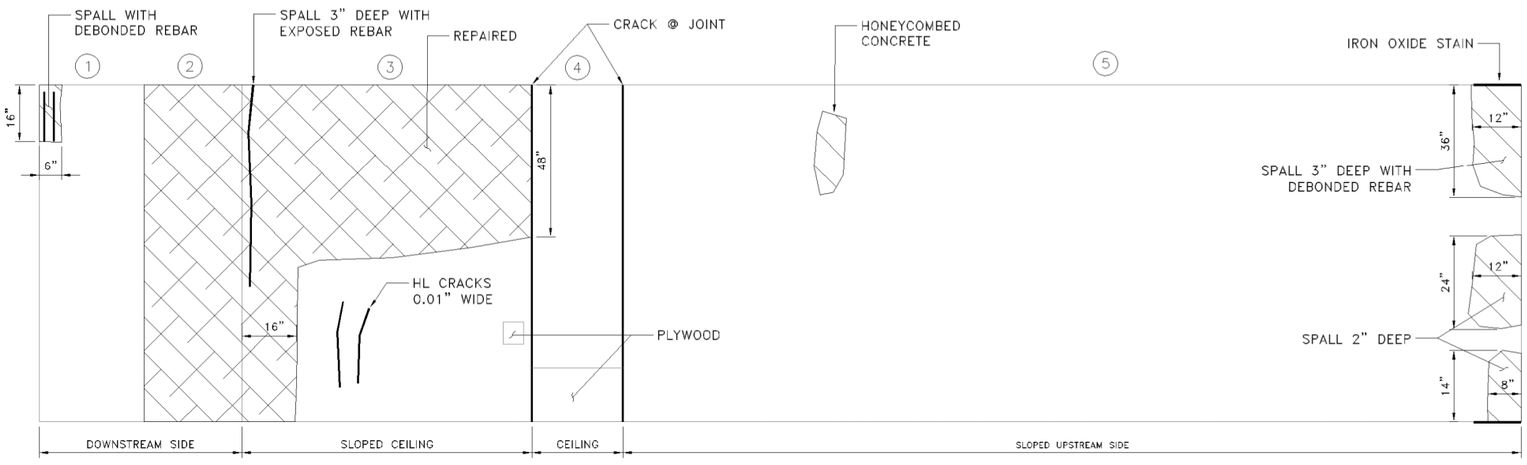

UPSTREAM WALL AND CEILING OF CELL

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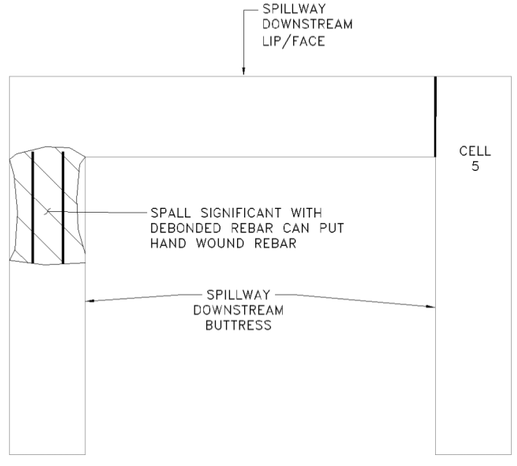

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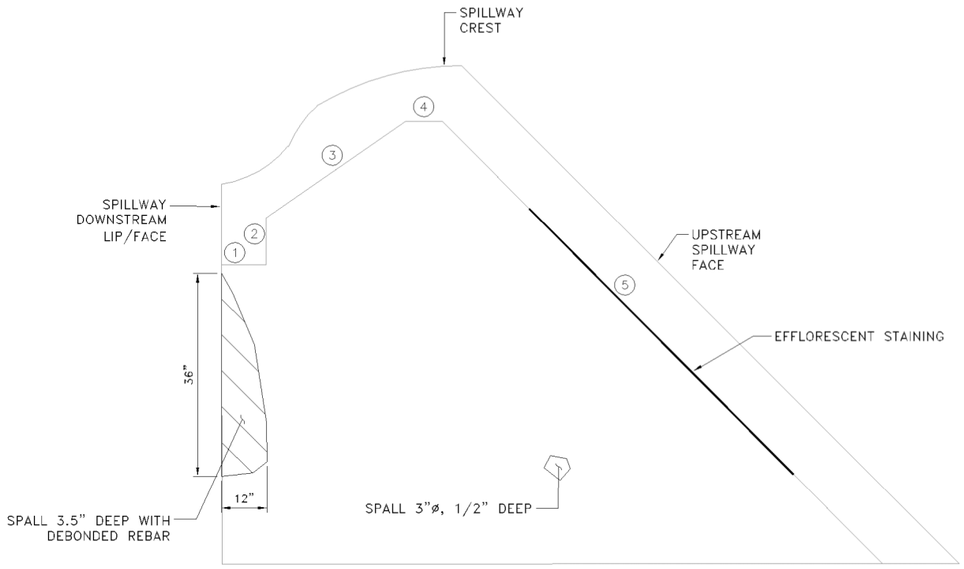
CELL NO. 4

SHEET NO.:

4



RIGHT CELL WALL

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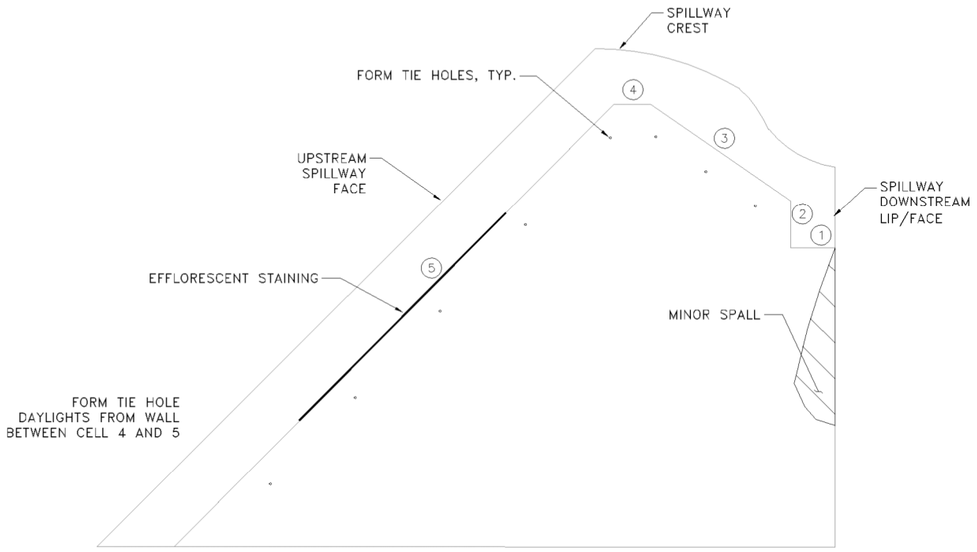

LEFT CELL WALL

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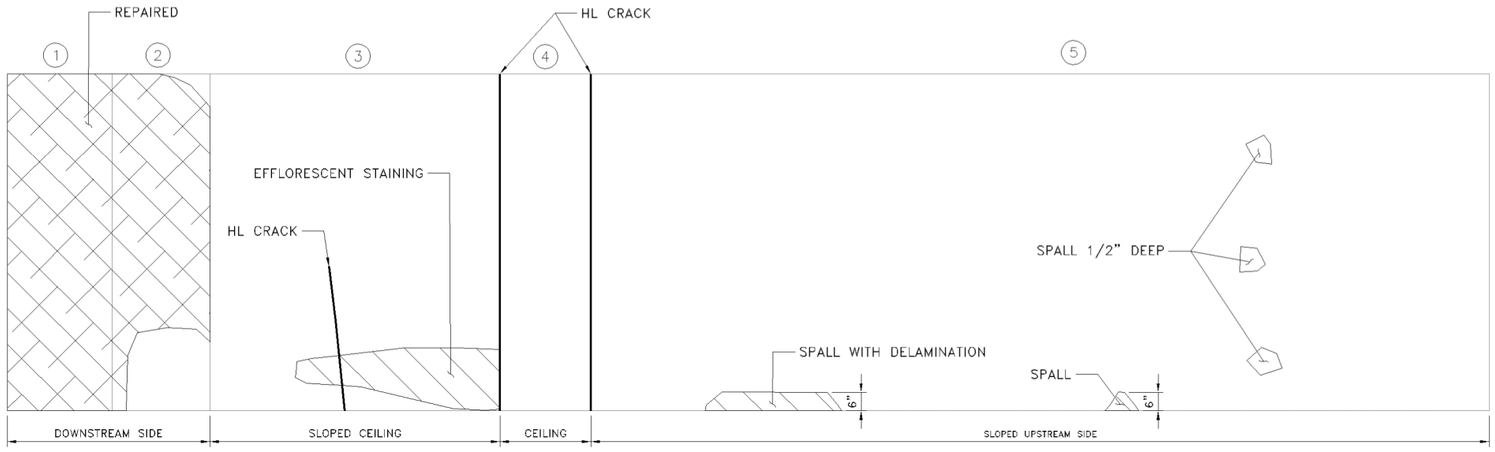

UPSTREAM WALL AND CEILING OF CELL

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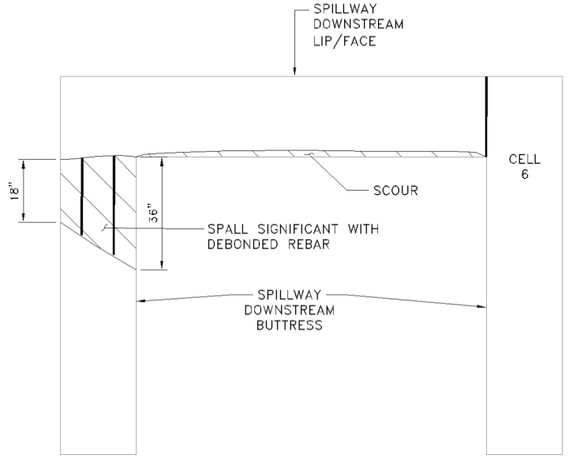

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MILL POND DAM FEASIBILITY STUDY

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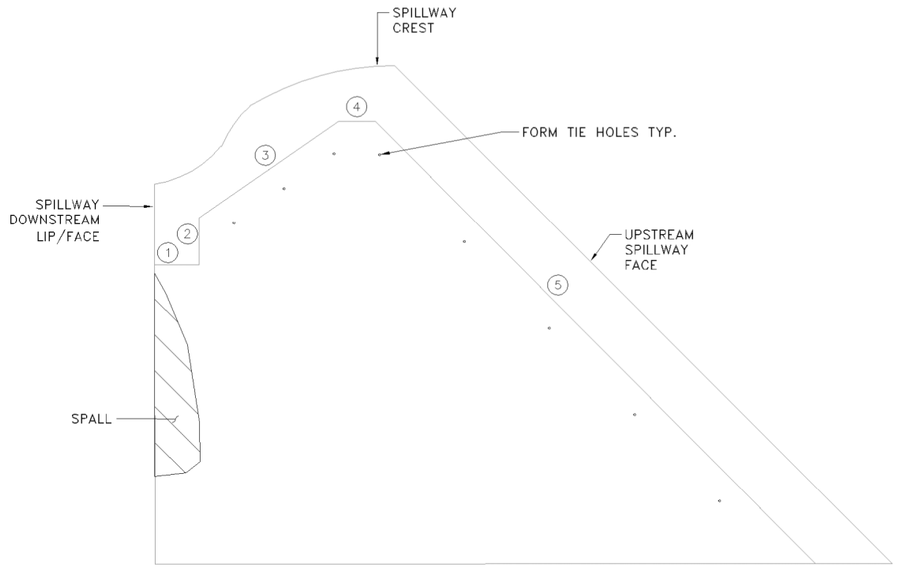
CELL NO. 5

SHEET NO.:

5



RIGHT CELL WALL
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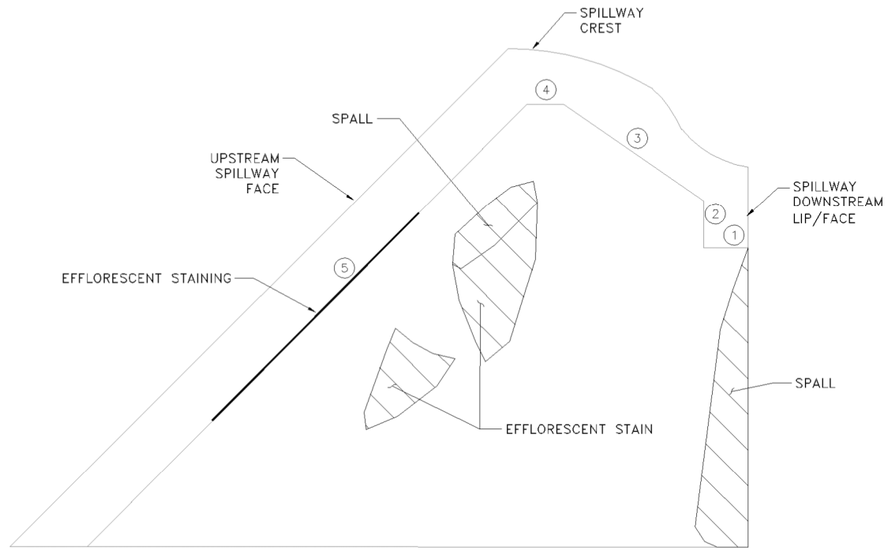

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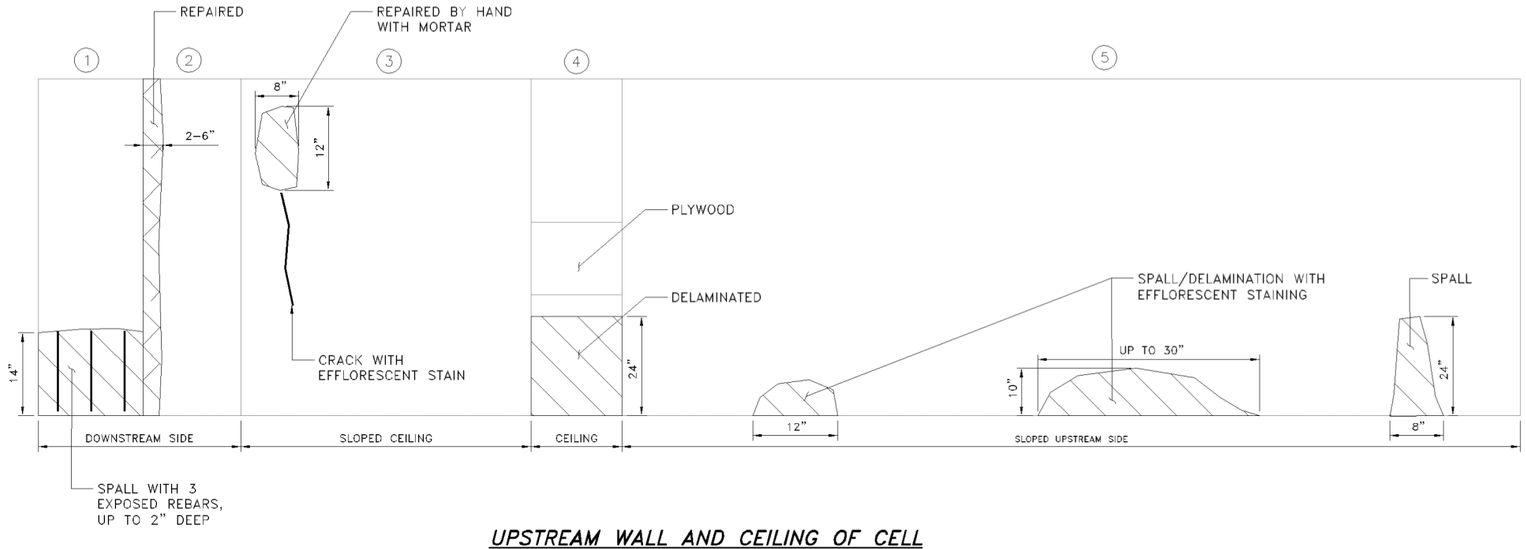

UPSTREAM WALL AND CEILING OF CELL
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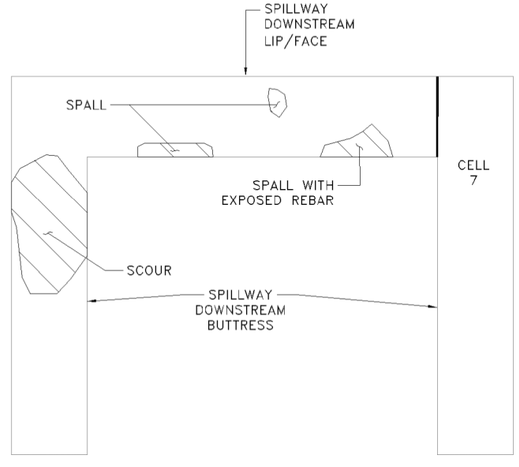

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MILL POND DAM FEASIBILITY STUDY
DURHAM, NH
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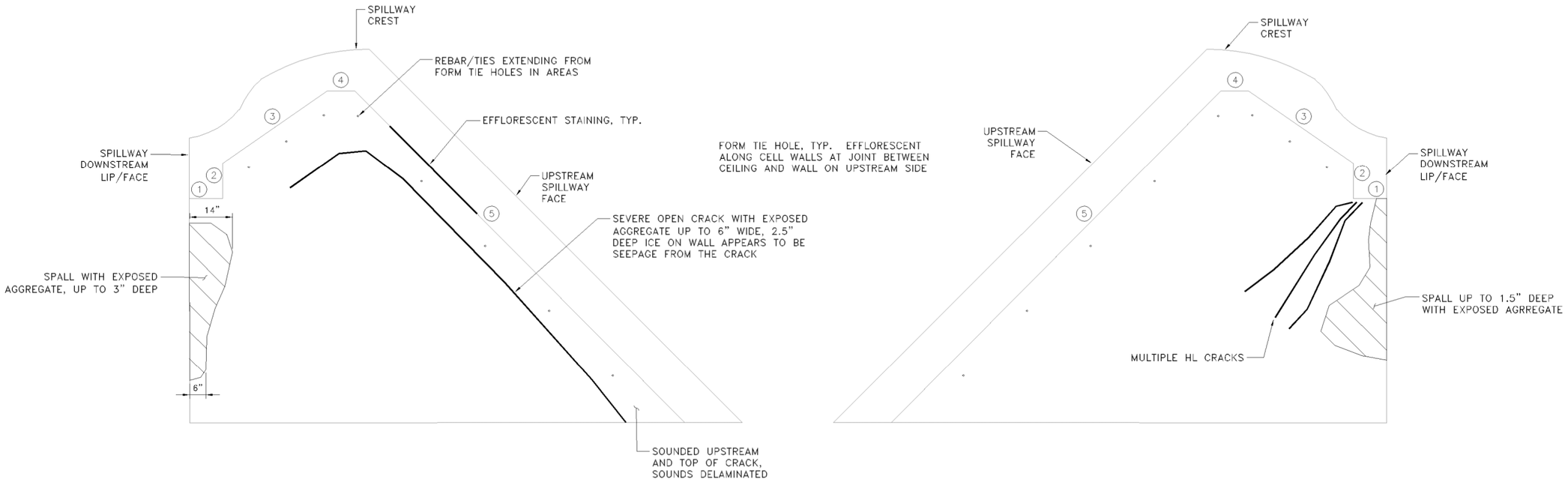
APPROVED BY:	

CELL NO. 6

SHEET NO.:
6

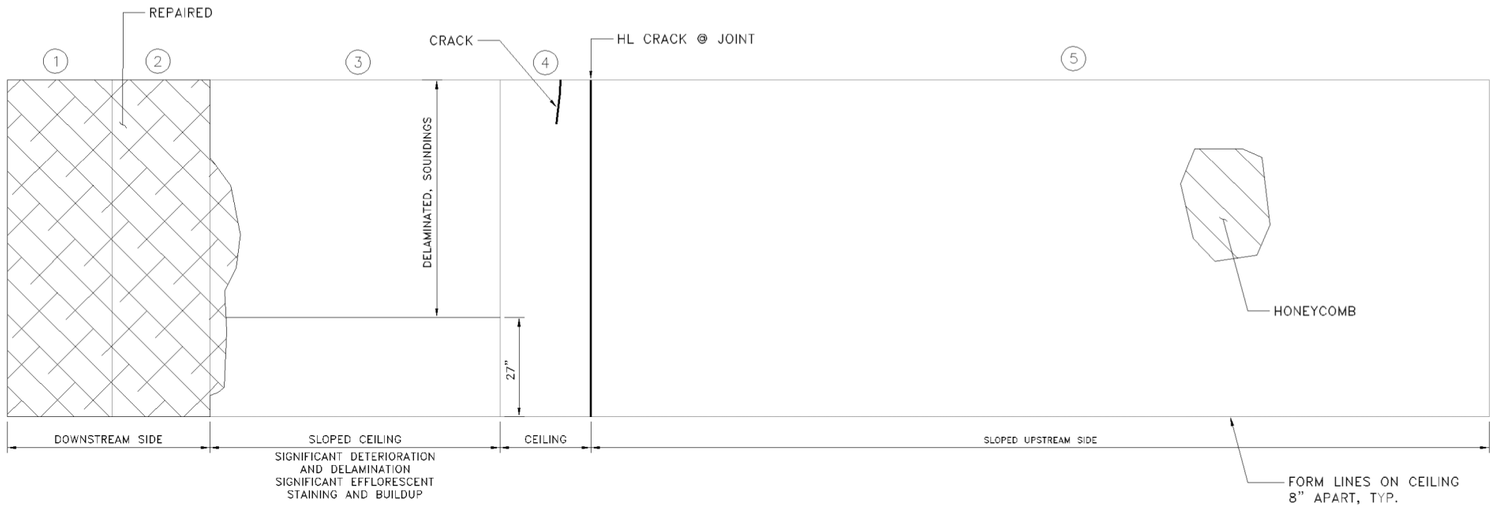


RIGHT CELL WALL

NOT TO SCALE

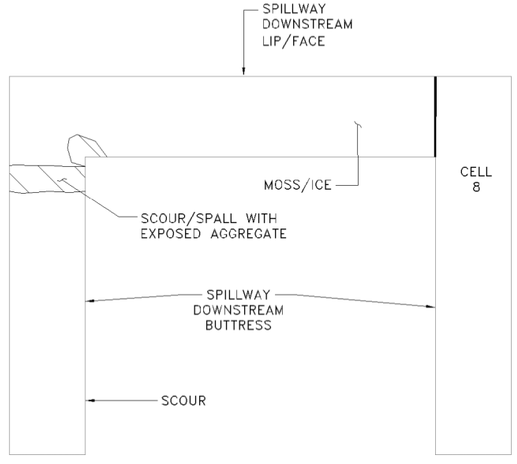
LEFT CELL WALL

NOT TO SCALE



UPSTREAM WALL AND CEILING OF CELL

NOT TO SCALE



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MILL POND DAM FEASIBILITY STUDY

DURHAM, NH

OWNER: TOWN OF DURHAM

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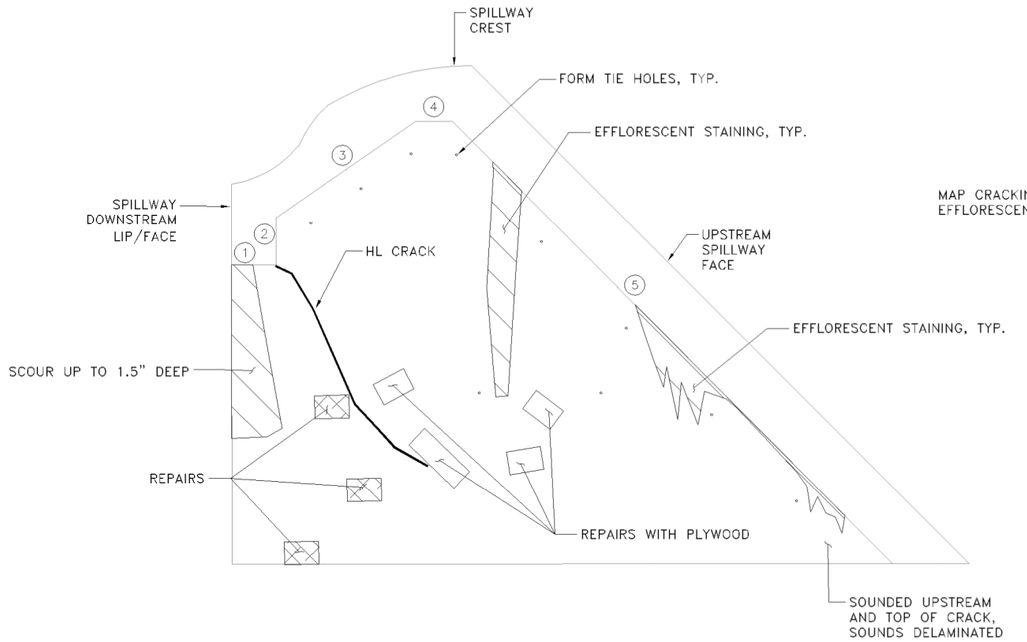
APPROVED BY:	

CELL NO. 7

SHEET NO.:

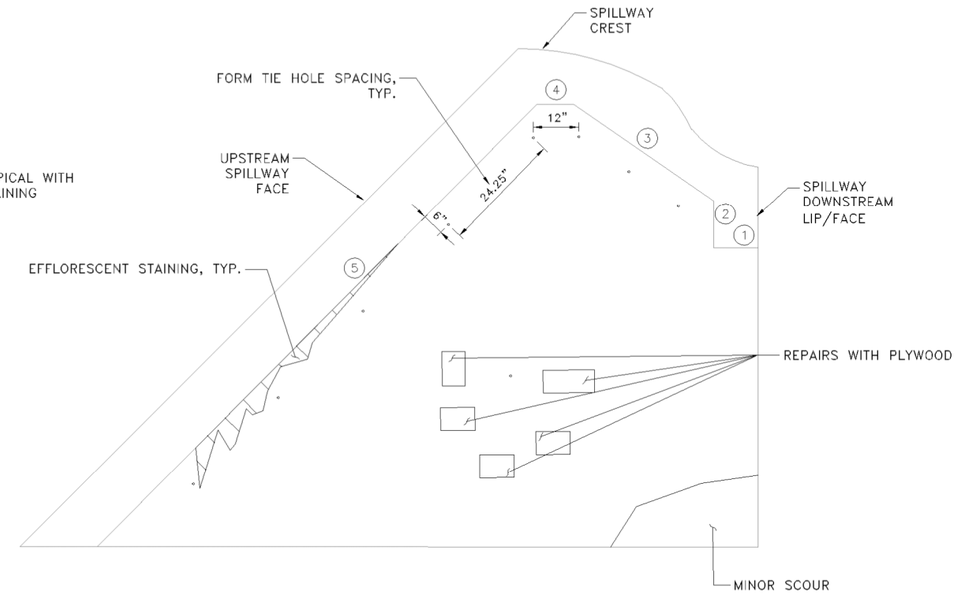
7



RIGHT CELL WALL

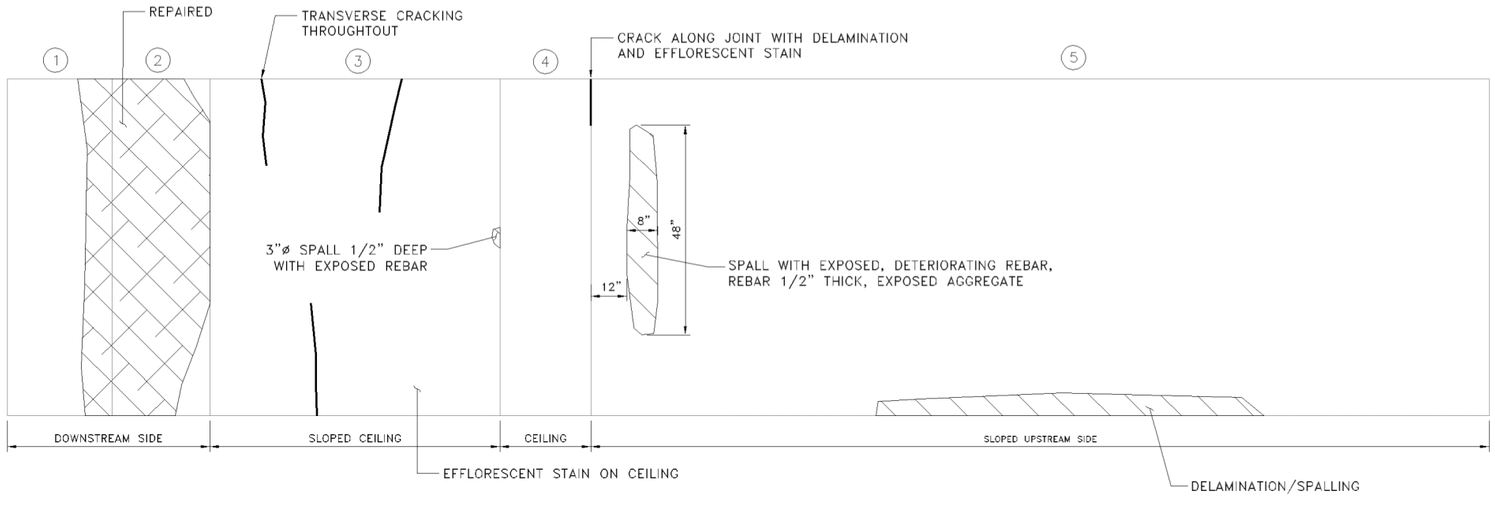
NOT TO SCALE

MAP CRACKING TYPICAL WITH EFFLORESCENT STAINING



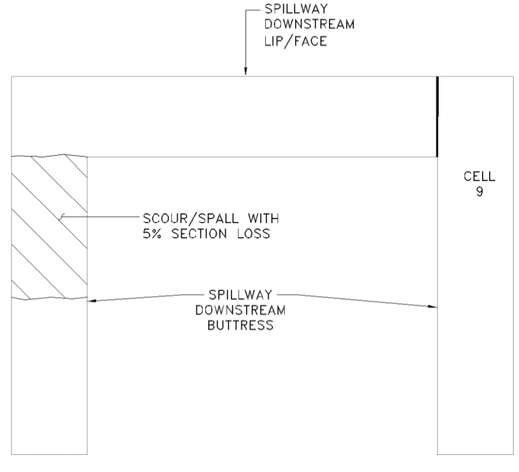
LEFT CELL WALL

NOT TO SCALE



UPSTREAM WALL AND CEILING OF CELL

NOT TO SCALE



SPILLWAY DOWNSTREAM FACE AND BUTTRESSES

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MILL POND DAM FEASIBILITY STUDY

DURHAM, NH

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REVISIONS:		

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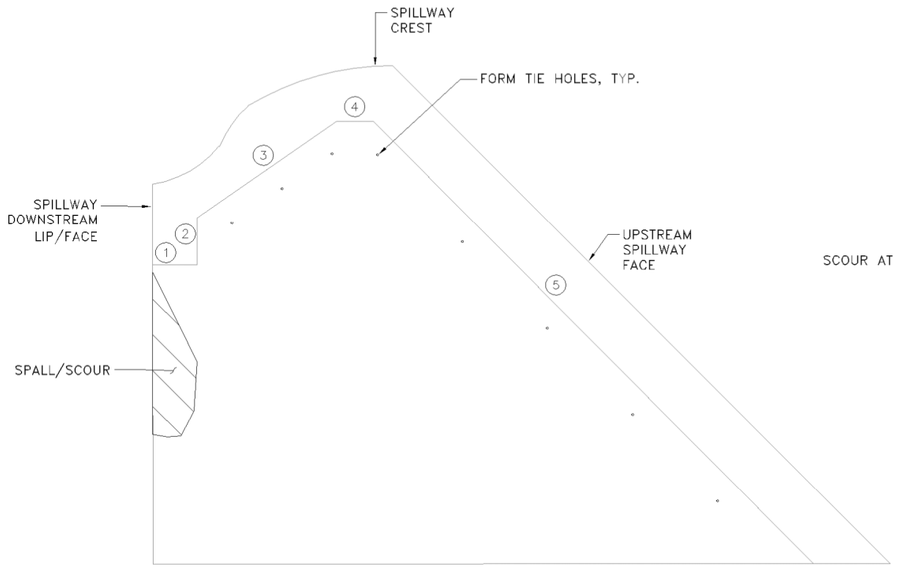
DRAWN BY:	HMS
APPROVED BY:	

CELL NO. 8

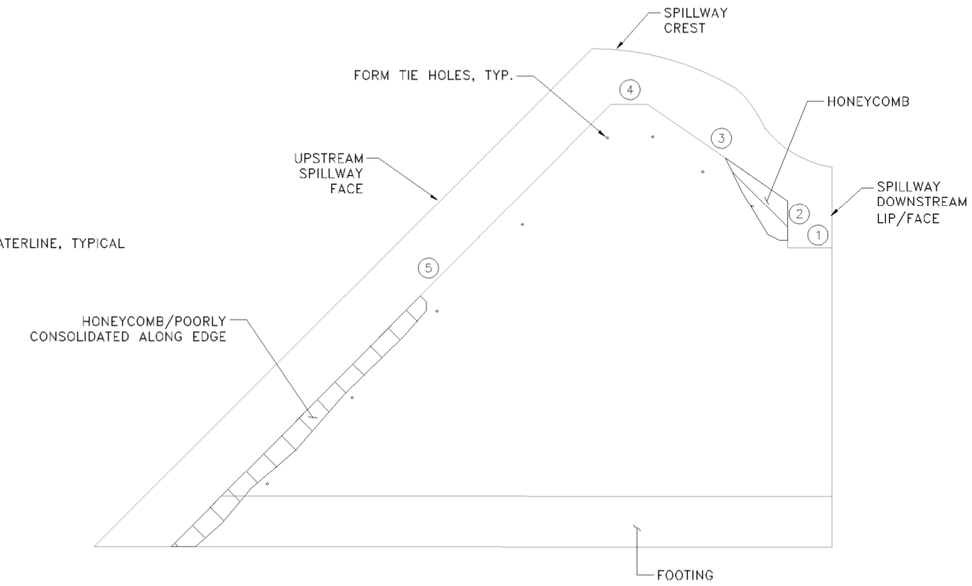
SHEET NO.:

8



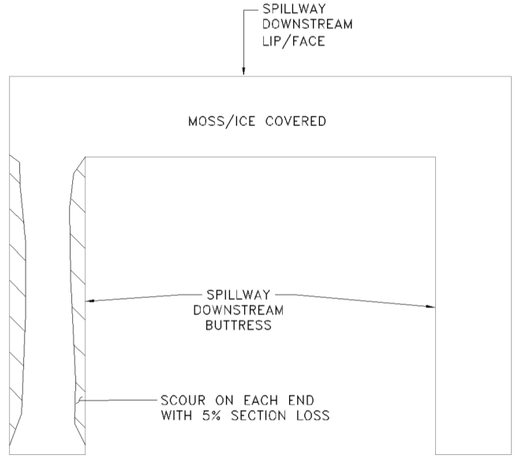
RIGHT CELL WALL
NOT TO SCALE

SCOUR AT WATERLINE, TYPICAL



LEFT CELL WALL
NOT TO SCALE

UPSTREAM WALL AND CEILING OF CELL
NOT TO SCALE



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SCALE ADJUSTMENT GUIDE
0" 1"
BAR IS ONE INCH ON ORIGINAL DRAWING.

MILL POND DAM FEASIBILITY STUDY
DURHAM, NH
OWNER: TOWN OF DURHAM

REVISIONS:	

PROJECT NO.:	19169.00
DATE:	DEC 2019
SCALE:	NTS
DESIGNED BY:	HMS
CHECKED BY:	
DRAWN BY:	HMS
APPROVED BY:	

CELL NO. 9

SHEET NO.:
9

APPENDIX B
Photographs
Mill Pond Dam
Durham, NH

Photo No. 1: Dam from the right abutment looking left with flow over the spillway.

Photo No. 2: View of the upstream side of the crest from the top of the fish ladder looking right.

Photo No. 3: Scour on the left side of the right training wall upstream of the spillway crest.

Photo No. 4: View of the left end of the primary spillway and training wall.

Photo No. 5: Area of the previously reported leakage from the left training wall. Note vegetation within the joint and repair along the wall.

Photo No. 6: View of the downstream side of the dam with no flow over the spillway from under the bridge at Newmarket Road looking upstream.

Photo No. 7: Close-up view of the typical interior of a cell.

Photo No. 8: Scoured and severely deteriorated concrete with debonded rebar at the downstream side of the right training wall.

Photo No. 9: Left wall. Note section loss with spalling and scour on the downstream end.

Photo No. 10: Right side of the upstream sloped ceiling. Note the delamination of the repairs.

Photo No. 11: Right wall. Note spalling and delamination throughout the wall.

Photo No. 12: Repair on the downstream sloped ceiling section (ceiling face no.3). Note delamination above the repair and efflorescence.

Photo No. 13: Left Wall. Note the scour and spalling on the downstream end.

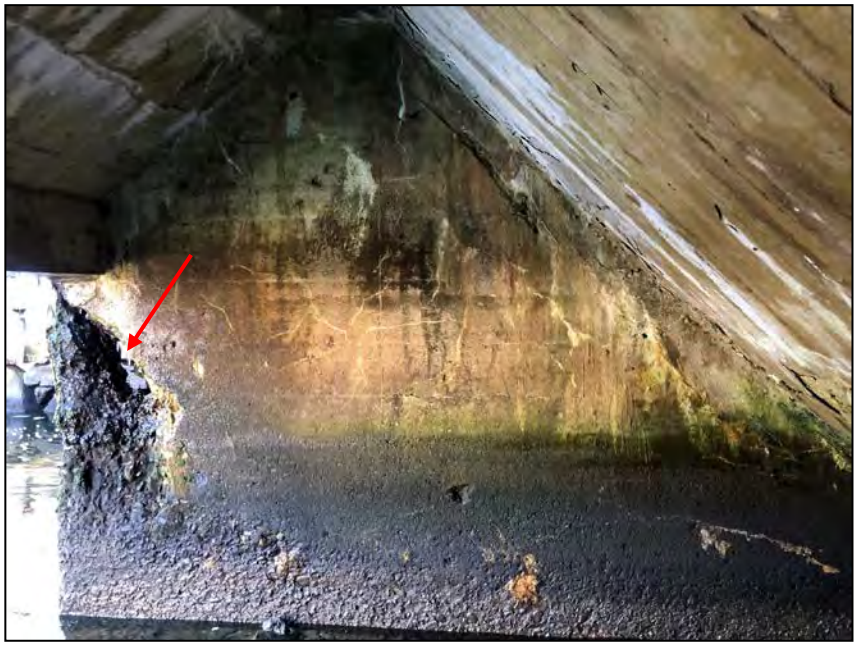

Photo No. 14: Right Wall. Note the section loss on the downstream end.

Photo No. 15: Delamination on the lower part of the upstream sloped ceiling (ceiling face no. 5).

Photo No. 16: Delamination on the upper part of the upstream sloped ceiling (ceiling face no. 5).

Photo No. 17: Left wall. Note scour and spalling on the downstream end and delamination on the upstream joint with the ceiling.

Photo No. 18: Right wall. Not scour and spalling on the downstream end.

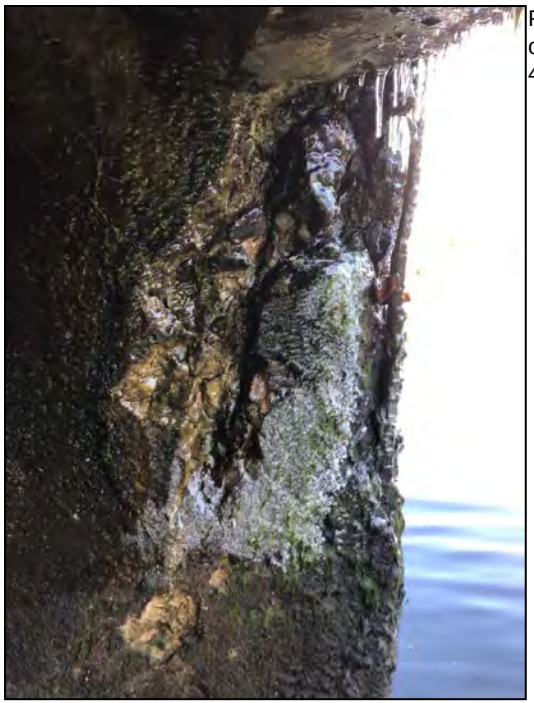

Photo No. 19: Delaminated rebar on the rib between Cell 3 and Cell 4.

Photo No. 20: Overview of the upstream sloped ceiling.

Photo No. 21: Left wall. Note debonded rebar and spalling on the downstream end.

Photo No. 22: Large crack and spall along the right wall with iron oxide staining on the upstream end.

Photo No. 23: Spall with debonded rebar and 5-inch deep hole on the downstream end of the right wall.

Photo No. 24: Downstream sloped ceiling with repair and exposed rebar.

Photo No. 25: Left wall. Note scour and spalling on the downstream end approximately 1 foot above the waterline.

Photo No. 26: Right wall. Note debonded rebar and spalling on the downstream end.

Photo No. 27: Efflorescent staining and delamination on the right side of the upstream sloped ceiling

Photo No. 28: Downstream sloped ceiling (ceiling face no. 3).

Photo No. 29: Left Wall. Note efflorescent staining and cracks.

Photo No. 30: Delamination and staining along the joint between the ceiling and the left wall.

Photo No. 31: Repair on the right side of the downstream sloped ceiling,

Photo No. 32: Spalling with debonded rebar on the underside of the downstream most ceiling (ceiling face no. 1).

Photo No. 33: Left wall. Note efflorescent staining.

Photo No. 34: Right wall. Note crack and delamination extending along the upstream and upper side of the wall.

Photo No. 35: Delamination and crack with seepage below on the top of the right cell wall.

Photo No. 36: Delamination and efflorescence throughout the downstream sloped ceiling.

Photo No. 37: Left wall. Note repairs covered with timber falsework.

Photo No. 38: Right wall. Note repairs covered with timber falsework and spalling on the downstream end.

Photo No. 39: Exposed and deteriorated rebar on the upstream sloped ceiling.

Photo No. 40: Area of exposed and deteriorated rebar on the downstream sloped ceiling.

Photo No. 41: Upstream left corner of the cell with iron oxide staining.

Photo No. 42: Repair on the downstream side of the cell (ceiling face no.2).

Photo No. 43: Downstream sloped ceiling.

Photo No. 44: Overview of the cell.

Photo No. 45: Overview of the top of the low-level outlet structure.

Photo No. 46: Intake of the gate structure.

Photo No. 47: Right abutment upstream of the dam from the gate structure. Note snow cover.

Photo No. 48: Inside of the top of the gate opening. Note irregular concrete typical in both gate openings.

Photo No. 49: The gate structure and mill foundation from downstream of the dam looking upstream.

Photo No. 50: Left and right low-level outlets. Note the severe concrete deterioration and ice buildup throughout the downstream face of the structure.

Photo No. 51: Right side of the right training wall and concrete downstream of the left gate. Note cracking with efflorescent staining and ice on the concrete. Additionally, note the leakage through the left gate.

Photo No. 52: Remnants of the mill foundation downstream of the gate structure.

Photo No. 53: Overview of the fish ladder at the left end of the spillway..

Photo No. 54: Fish ladder inlet with stop logs in. Note leakage from the stop logs.

Photo No. 55: Inside of the fish ladder.

Photo No. 56: Scour and undermining underneath the right training wall of the fish ladder. Note void probed up to 3 feet.

Photo No. 57: Outlet of the fish ladder.

Photo No. 58: Downstream area of the dam from the top of the fish ladder.

Photo No. 59: Overview of Mill Oyster River downstream of Newmarket Road Bridge

Photo No. 60: Mill Pond Dam and the impoundment from the top of the bridge at Newmarket Road.

APPENDIX C
Previous Reports and References
Mill Pond Dam
Durham, NH

REFERENCES AND RESOURCES

The following reports were referenced during the preparation of this report:

1. "Mill Pond Dam – D071003, Hazard Classification Assessment", New Hampshire Department of Environmental Services, dated September 10, 2018.

2. "Dam Evaluation Report – Oyster River Dam", Stephens Associates Consulting Engineers, dated March 17, 2009.

3. "Letter to Andrea Bodo", New Hampshire Division of Historical Resources", dated February 4, 2009.

4. "Site Inspection Form", New Hampshire Department of Environmental Services, dated September 18, 2007.

5. "Dam Inspection Report", GZA GeoEnvironmental, Inc, dated October 3, 2000.

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.

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. NHDES Dam Bureau Website: https://www.des.nh.gov/organization/divisions/water/dam/index.htm
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

APPENDIX D
Common Dam Safety Definitions
Mill Pond Dam
Durham, NH

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to State of New Hampshire Env-Wr 100-700 Dam Rules, 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 – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms 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 – Shall mean structures, either in dams or separate therefrom, including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

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 to structures or property, structural damage to a class I or class II road which could render the road impassable or otherwise interrupt public safety services, or major environmental or public health losses.

Low Hazard – means a dam where failure or misoperation results in no probable loss of human life, low economic losses, structural damage to a town or city road or private road accessing property other than the dam owner's which could render the road impassable or otherwise interrupt public safety services, the release of liquid industrial, agricultural, or commercial wastes, septage, or contaminated sediment if the storage capacity is less than 2 acre-feet and is located more than 250 feet from a water body or water course, Reversible environmental losses to environmentally-sensitive sites.

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 lowest point of natural ground on the downstream side of the dam to the highest part of the dam which would impound water.

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.

APPENDIX E
Visual Dam Inspection Limitations
Mill Pond Dam
Durham, NH

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 is evolutionary in nature and depends on numerous and constantly changing internal and external conditions. 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

5. 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.

6. This report has been prepared for the exclusive use of the Town of Durham for specific application to the referenced dam site in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

7. 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.