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## MEMORANDUM

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|-----------------|---------------------------------------------|------------------------------|-------------------------------------------------------|
| <b>TO:</b>      | Dean Lindsey                                | <b>DATE:</b>                 | October 21, 2024                                      |
| <b>COMPANY:</b> | Town of Lake Lure                           | <b>SUBJECT:</b>              | Lake Lure Dam Hurricane Helene<br>Preliminary Summary |
| <b>ADDRESS:</b> | 2948 Memorial Hwy<br>Lake Lure, NC 28746    | <b>PROJECT<br/>NAME/NO.:</b> | Lake Lure Dam / 18C21024.060                          |
| <b>FROM:</b>    | Jonathan Pittman, PE<br>Charles Johnson, PE | <b>CC:</b>                   |                                                       |

### INTRODUCTION

Schnabel Engineering South, P.C. (Schnabel) assisted the Town of Lake Lure (Town) as the Town's dam safety engineering consultant before, during, and after Hurricane Helene, which resulted in an average of approximately 22.5 inches of total rainfall across the Lake Lure Dam watershed from September 24 through September 28, 2024. Hurricane Helene caused catastrophic damage to the Town and surrounding areas after making landfall in Florida and traveling up the east coast. On the morning of Friday, September 27, the dam's Emergency Action Plan (EAP) was activated and elevated to an "Event Level 1, RED URGENT!! DAM FAILURE IMMINENT OR IS IN PROGRESS" due to water flowing over the low-level arches at Bays 4 and 5 (elevation 992.1) and the mid-level arches (photos 2.1 and 2.2) at Bays 9 through 13 (elevation 994 MSL) and continuing to rise above the bottom chord of the bridge (elevation 998.1 MSL). Notifications were made and emergency responders traveled door to door for downstream evacuations. The peak reservoir level rose to within about 3 to 4 feet below the dam crest at the abutments, flowing over all the arches except the tallest arches in Bays 6 through 8 (where the powerhouse and AC breaker building are located). In general, the concrete portions of the dam performed as intended; however, internal erosion occurred within the earthen embankment portion of the dam at the left abutment, creating three depressions across the crest and a slide on the downstream slope. Schnabel personnel arrived onsite around 6:00 PM on September 27 and performed an inspection, which continued on Saturday, September 28. At the time of our site visit, it was our understanding from discussions with local emergency responders that there were no reported casualties in the downstream inundation zone of Lake Lure Dam.

The purpose of this memorandum is to summarize the dam operations during the hurricane, project communications and meetings, observations, recommendations for emergency repairs, and additional preliminary discussions. We have included meeting minutes from an onsite meeting held on the afternoon of Saturday, September 28, between the Town, Schnabel, and Morgan Corp. (contractor for the Reservoir Drain Project) as Attachment 1. A photo log of select site photos is included as Attachment 2. A photo markup of recommended emergency repairs, which were based on discussions in the meeting referenced in Attachment 1 and updated based on follow-up discussions, is included as Attachment 3. A photo log of select site photos for the emergency repair construction is included as Attachment 4. Elevations reported in this document reference the National Geodetic Vertical Datum of 1929 (or Mean Sea Level, MSL) unless noted otherwise. According to the National Oceanic and Atmospheric Administration (NOAA) NGS Coordinate Conversion and Transformation Tool (NCAT), the height conversion from the National Geodetic Vertical Datum of 1929 (or Mean Sea Level, MSL) to NAVD88 is to add 0.56 feet. That is:

$$EL_{NAVD88} = EL_{NGVD29} + 0.56 \text{ feet}$$

This work was performed per verbal request by the Town's Dean Lindsey on September 27, 2024, and under our agreement "Work Order No. 11 - On-Call Professional Engineering Services for Lake Lure Dam" dated May 10, 2023.

DAM OPERATIONS DURING HURRICANE HELENE

The Town reported the lake level was lowered in advance of the peak storm inflows to approximately 4 feet below the normal maximum operating level (elevation 990 MSL) to create additional reservoir storage. The lake level continued to rise due to increased inflow and peaked around 11:00 AM on Friday, September 27, 2024. The maximum spillway gate opening was 12 feet at each of the three spillway Tainter gates, which occurred during the period of peak inflow on September 27. The trash gate operation is unknown; however, the trash gate has a small effect on outflow during the flood. The gates were lowered to 9 feet open, then 8 feet open by the night of September 27. The peak reservoir level, based on observations by Town operations personnel, was estimated to be 3 to 4 feet below the dam crest, which is 1 to 2 feet below the tallest arches in Bays 6 to 8, and corresponds to approximate elevations of 999.1 to 1000.1 MSL. The peak tailwater elevation was estimated to be at approximate elevation 915 MSL, based on visual observations by Town personnel seeing the tailwater at a PVC pipe joint on the downstream side of the powerhouse, approximately 3 to 4 feet above the powerhouse upper level finished floor. We estimate the maximum outflow to be approximately 30,000 cfs, which is somewhere between 50% to 60% of the NCDEQ Dam Safety’s draft 2024 Probable Maximum Precipitation (PMP) values.

The lake level receded to normal pool (elevation 990 MSL) by Saturday morning, September 28. Wind speeds onsite were not reported; however, conditions at the dam during the hurricane reported by the Town were that wind speeds were relatively low compared to previous hurricane events, despite the large amount of rain. One resident we encountered at the Sunny View Fire and Rescue approximately 7 miles south of the dam observed rainfall totals in excess of 20 inches during the hurricane from the rain gauge installed at his house. This is similar to the National Oceanic and Atmospheric Administration (NOAA) reported rainfall totals, which showed approximately 22.5 inches in the Lake Lure watershed from September 24-28, 2024. The preliminary rainfall estimates averaged over the watershed, according to NOAA (<https://water.noaa.gov/>) are shown in Table 1.

Table 1. Lake Lure Watershed Preliminary Rainfall Estimates, Averaged Over the Watershed (NOAA)

| Date                             | Rainfall (inches) |
|----------------------------------|-------------------|
| September 24, 2024               | 0.5               |
| September 25, 2024               | 1.5               |
| September 26, 2024               | 5.5               |
| September 27, 2024               | 10                |
| September 28, 2024               | 5                 |
| Total for September 24-28, 2024: | 22.5              |

## **SITE VISIT**

Around mid-day on September 27, the Town requested that Schnabel attempt to visit the site. Schnabel's Jonathan Pittman, PE, and Charles Johnson, PE, headed towards the dam around 1 PM. Interstate 40 West was closed. We reached a State Highway Patrol office in McDowell County, which directed us to an Emergency Operations Center a few miles away. We were told that the only way in to Lake Lure was from Sugar Hill Road. We attempted to drive in this way and encountered a constant stream of traffic on what amounted to a one lane road due to downed trees and powerlines. We rerouted and were able to reach the dam via Highway 221, Mud Cut Road, Cove Road, Bills Creek Road, and Highway 64. Approximately 3,000 feet downstream of the dam, the Broad River was flooded about 2 feet over the highway near Island Creek Road (photo 2.5). After about 30 minutes of evaluating the depth of water, piloting a drone to evaluate hazards between the water over the road near Lake Lure Outdoor (located at 7183 US 64/74a Hwy, Lake Lure, NC 28746), and discussing alternate options with an emergency responder who drove up from downstream, we noticed that the water on the road had receded enough to allow Schnabel personnel to drive through, escorted by the emergency responder (photo 2.4). The road had numerous downed trees and powerlines; however, clearing had been performed for at least one lane along the entire route to create passage for pickup truck sized vehicles to pass. Due to damage around the dam, the Town had blocked Buffalo Shoals Road with traffic cones and a Town vehicle. With authorization to visit the dam, we passed the roadblock and arrived at the Lake Operations Building on the right abutment, where we met with Town personnel around 7 pm.

Upon our arrival, Town lake operations personnel were removing boats and large debris which had accumulated in front of the spillway Tainter gates and posed a concern for damaging the gates. At the right side of the dam, we observed downed powerlines at the right abutment and erosion of the soil overburden where the arches had overtopped, creating a near vertical soil slope (photo 2.11) close to the Duke Energy substation. We understood powerlines were deenergized throughout the Town. After discussing with the Town personnel the plans for continuing to draw down the reservoir level overnight due to the depressions and slide at the left abutment, we left the site around 8 PM and drove to the Sunny View Fire and Rescue to access Wi-Fi and provide updates to Toby Vinson from NCDEQ Dam Safety and other Schnabel personnel.

We returned to the dam around 8 AM on Saturday, September 28. The lake level was reportedly around elevation 990.6, which was very close to the normal maximum operating pool elevation of 990 MSL. While on site, we encountered two North Carolina Department of Transportation (NCDOT) representatives, including Gavin Proffit, PLS, who was on site to document the condition of the road, including using a drone. We exchanged contact information and requested that if possible, they collect and send us photogrammetry of the slide on the downstream left side to better estimate its size. We used our own drone to take additional aerial photographs of the dam, including those in Attachment 2.

We visually observed the concrete buttresses and arches of the dam in accessible locations from the downstream side of the dam. In many areas at the right end of the dam, adjacent soils were eroded, presumably due to the overtopping of the arches. The concrete buttresses appeared to be founded on bedrock, and we did not observe undermining of the concrete buttresses or excessive seepage. The leakage through the lift lines (construction joints) in the concrete arches and at the arch-to-buttress contacts appeared similar to what we have observed in previous site visits to the dam dating back to 2018, understanding leakage may be impacted by several factors, such as lake level, temperature, and debris accumulation. We observed what appeared to be new spalls at the downstream toe of some of the buttresses near the right side, which were limited in depth to about 12 inches and are expected to have negligible impact on the structural behavior of the dam.

## **Town of Lake Lure**

### **Lake Lure Dam Hurricane Helene Preliminary Summary Memo**

Based on our limited visual observations from the vehicular bridge across the dam, we did not observe obvious newly buckled or bent members to the spillway Tainter gates or debris damage. However, the Town was actively clearing larger debris, such as boats and other watercraft that accumulated in front of the spillway gates, and these visual observations were made from a distance and are not considered a comprehensive assessment of the gates. We understand there is considerable debris accumulation upstream, primarily due to the extensive damage to the Town of Chimney Rock. Gate 2 has leakage under the bottom wooden sill, which was an understood condition prior to the flood event; however, the rate of the leakage under Gate 2 appears to have increased.

In the afternoon, we met with Brian Houston, PE, from LaBella Associates, who was on site to review the sewer damage. The sewer lift station was destroyed, with the superstructure completely gone, a crack and leak in the concrete base, and pipes torn apart (photo 2.28). The sewer pipe crossing the tailrace was submerged, but a fountain of water was formed in the tailrace at an apparent pipe break (photo 2.15). Nearby, the Town's propane tank was partially covered by debris and there was a noticeable smell. The Town observed the tank's gauge was dropping and presumed the tank would be nearly drained by the following day. We understood restoring the Town's sewer system was a top priority and that LaBella would be assisting the Town with the sewer line and lift station repair design.

We approached the powerhouse and looked inside the door to observe that the generators were still rotating and that there was about a foot of debris deposited inside the upper floor of the building with the lower floor apparently filled with several feet of sediment and debris.

We also met with Morgan Corp. representatives Shawn Stipes, Shawn Romig, and Brian Maness, the contractor for the Reservoir Drain Project that was nearing completion. After the site visit, the Town, Schnabel, and Morgan Corp. met at the Town's Lake Operations Building to discuss observations and path forward. Meeting minutes prepared by Schnabel are included in Attachment 1.

## **RECOMMENDATIONS**

### Emergency Repairs and Monitoring (To be implemented as soon as possible)

In the attached Figure 1 in Attachment 3, we have shown recommended emergency repairs. The purpose of the emergency repairs is primarily to fill the depressions and stabilize the left abutment. These repairs were initially discussed in the meeting between the Town, Schnabel, and Morgan Corp. on September 28, 2024, and have subsequently been modified based on additional site observations and material availability. Verbal authorization was given by the North Carolina Department of Environmental Quality (NCDEQ) Dam Safety to proceed with emergency repairs as necessary based on recommended repairs to be determined by Schnabel and communicated to NCDEQ Dam Safety as soon as possible upon design development. This verbal authorization was provided during a call between the Town (Dean Lindsey and Olivia Stewman), Schnabel (Jonathan Pittman and Charles Johnson), and NCDEQ (Toby Vinson) on the evening of September 27, 2024, after the onsite team provided an update to NCDEQ Dam Safety on the observed damage and site conditions at that time.

While on site, after discussions with the Town about the need to balance reducing hydrostatic load on the left abutment and reducing downstream flooding, Schnabel recommended a target maximum lake elevation of 886 feet, which was approximately 4.5 feet below normal pool. Based on the recommended repairs in Attachment 3, Schnabel recommends the lake level be maintained at least 2 feet lower than the lowest excavated depth performed for the depression repairs. Upon further review of the site conditions, and in case of additional unexpected rain within the watershed and to allow for additional storage, we recommend lowering the reservoir to the ogee crest of the spillway by opening the spillway gates, to make sure the target maximum lake elevation is not exceeded. To reduce the potential for creating additional cracks, sloughs, or slides around the reservoir rim, we recommend a maximum drawdown rate of six to twelve inches per day and consideration of other extenuating circumstances around the lake; however, we recommend exceeding this drawdown rate if there is evidence of a dam safety emergency. The goal by lowering the reservoir elevation is to reduce load on the left abutment slope and create increased storage capacity in case of increased inflow, at least until further engineering evaluation and repairs can be performed.

The downstream slope of the left abutment should be visually monitored at least twice per day and the appearance documented with photographs until the permanent repairs are implemented. If there is any indication of additional sliding or seepage at the downstream toe, we request notification of the changes and, if applicable, the lake level may need to be lowered immediately through other means. We recommend Schnabel personnel observe the emergency repairs. We may choose to collect additional subsurface information to inform the permanent repair design after the depressions are cleaned up, prior to backfill.

Due to the erosion at the right end of the dam, we recommend reducing sloughing potential at the right abutment and bridge approach by covering the exposed soil slope with plastic sheeting, staked to the ground above the slope as noted in Figure 2 of Attachment 3.

Restoring downstream vehicular access is critical to cleanup and repairs at the downstream toe. Portions of the downstream channel bank were eroded, and in some cases exposed the sewer pipe and undermined the road. We recommend placing riprap or similar materials on the eroded slope based on the recommendations in Figure 3 of Attachment 3.

Permanent Repairs (To be implemented after completion of design and regulatory approval)

Permanent repairs to the dam crest and abutments are recommended and will require NCDEQ Dam Safety and other applicable permit approvals prior to construction. The assessments required to define the scope of these repairs and the subsequent design of these repairs are not complete. Currently, these repairs are anticipated to include additional measures to address the progression of internal erosion on the left abutment, as described in the following section of this memorandum, and flattening / stabilization of the eroded right abutment slopes. Final repairs should be designed and constructed in coordination with the North Carolina Department of Transportation (NCDOT), who we understand would be responsible for the permanent road construction and are necessary prior to allowing public traffic access to resume and restoration of the lake level to normal pool.

Summary of Repairs to Date (as of October 18, 2024)

The Town retained the Lake Lure Dam Reservoir Drain Project contractor, Morgan Corp. to perform emergency repairs. The contractor started cleanup work on site on October 2, 2024, demobilizing equipment and materials that had been left on site for the reservoir drain project to make way for cleanup efforts. Simultaneous work crews were mobilized to the downstream side and dam crest. The downstream crew's primary goals were to reestablish access to the dam, remove downed powerlines, recover some displaced riprap from the downstream channel and place at the toe of the slope along the access road, cut and remove damaged and undermined asphalt concrete road portions, and backfill the eroded sections of the access road (photo 4.21). The primary goals for the work crew at the dam crest were to remove the damaged asphalt concrete road, excavate the debris in the depressions on the crest, backfill the depressions (photo 4.1), and clean and backfill the slide area on the downstream slope of the left abutment (photo 4.12). Schnabel has provided direction and full-time oversight of the repairs. During the excavation of the depressions, no obvious throat or exit location where soils from the depressions eroded out internally through the abutment was observed. However, due to the close proximity of the depressions to the slide on the downstream face, it could not be ruled out that internal erosion has occurred. Flow from the left spillway sidewall drains appears to have increased, comparing our observations from our December 22, 2023 inspection to our observations on September 27, 2024. Visual observation of flows since September 27, 2024 appear similar. Due to the location of the drains, the flows are not measured. Based on our observations and our concern regarding the possibility that internal erosion has occurred or could occur, we recommended a subsurface investigation.

On October 7, 2024, Schnabel mobilized a drilling subcontractor, F&ME, to perform a subsurface investigation. This included drilling four borings on the left abutment (photo 4.7) and two on the right abutment (photo 4.5). Cone penetration tests (CPTs) were attempted on both abutments, but they generally refused on rocks or other obstructions at depths of less than 20 feet below the road surface. A hand auger was performed on the left abutment within the footprint of one of the depressions. In addition, an inclinometer and piezometer were installed in borings to the left of the observed slide to allow for future monitoring of the slide area. During the backfill grouting of boring B-103, which is located approximately 10 feet from the left sidewall on the dam crest, grout was observed discharging from one of the left spillway sidewall drains (photo 4.8). Loose, soft, gravelly soils were encountered in the left abutment borings. Our observations during the subsurface investigation reinforce our concerns over internal erosion. We are developing recommendations for next steps, which may include additional investigations (e.g., geophysical surveys or additional borings) and repairs (e.g., installation of a cutoff wall down to rock to reduce potential for internal erosion and/or modifying the spillway sidewall drain outlets to have a filtered exit). Our recommendation for the emergency repairs to the slide area on the left abutment was to remove the loose debris in the slide area (photo 4.12) and backfill with a graded filter system, consisting of ASTM C33 sand (photo 4.17), NCDOT 78M crushed stone, NCDOT 57 crushed stone (photo 4.18), and NCDOT Class B riprap (photo 4.20) and continued monitoring of the slide area. The depressions were backfilled with NCDOT ABC dense-graded aggregate, placed and compacted in lifts, following the removal of loose materials from the depressions and flattening of the side slopes of the depressions.

**Town of Lake Lure**

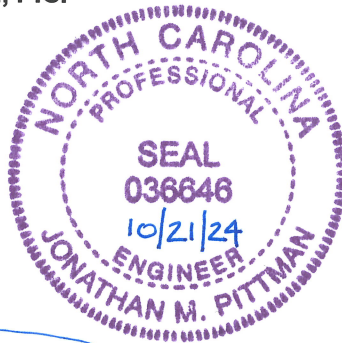
**Lake Lure Dam Hurricane Helene Preliminary Summary Memo**

The left abutment emergency repairs to the depressions in the roadway and the downstream slope slide are largely complete absent some minor modifications to the surface run off collection system and roadway repaving. Photos of the emergency repairs and investigations performed to date are included in Attachment 4. Compilation of data from the subsurface investigation is in progress and will be included in a separate report. The design of permanent repairs will also be addressed in a separate report.

We appreciate the opportunity to be of service during this very difficult time for the Town, project, and all those impacted by this horrific event. Please contact the undersigned if clarification is needed for any aspect of this letter.

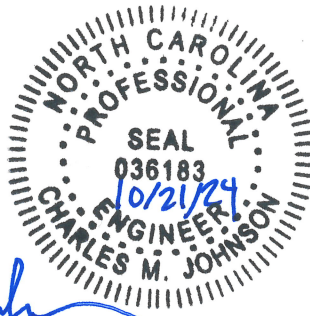
Sincerely,

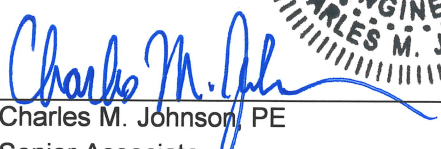
**SCHNABEL ENGINEERING SOUTH, P.C.**



**SIGNED:**

  
Jonathan M. Pittman, PE  
Principal  
North Carolina Professional Engineer No. 036646  
(Geotechnical Content)



  
Charles M. Johnson, PE  
Senior Associate  
North Carolina Professional Engineer No. 036183  
(Structural Content)

Schnabel Engineering South, P.C.  
License No. C-2599

**ATTACHMENTS**

- 1) Meeting Minutes from September 28, 2024
- 2) Hurricane Helene Photo Log
- 3) Recommended Emergency Repairs
- 4) Emergency Repairs and Investigations Photo Log

## **ATTACHMENT 1**

### **MEETING MINUTES FROM SEPTEMBER 28, 2024**

**HURRICANE HELENE MEETING MINUTES****PROJECT NAME:** Lake Lure Dam – Reservoir Drain**DATE/TIME:** September 28, 2024 / 4:00 PM**LOCATION:** Lake Lure Lake Operations  
Building**ATTENDEES:** Dean Lindsey (TOLL)  
Randy Rollins (TOLL)  
Jonathan Pittman (SE)  
Charles Johnson (SE)  
Shawn Stipes (Morgan Corp.)  
Brian Maness (Morgan Corp.)  
Shawn Romig (Morgan Corp.)**1. Objective**

- Purpose of this meeting was to discuss observations from Hurricane Helene after the team had assessed the current conditions onsite and brainstorm next steps, working towards site cleanup, emergency repairs (temporary and permanent), and eventual resumption of the Reservoir Drain Project

**2. General Conditions**

- Town and surrounding areas have very limited communications, with Wi-Fi limited to a couple locations around Town
- In the early afternoon of September 27<sup>th</sup>, lake level reached approximately 3.5 to 4 feet below the crest at the abutments during Hurricane Helene, with maximum lake level approximately 1 to 2 feet below the tallest arches in Bays 6 through 8, with all other arches overtopping while all gates were open 12 feet.
- At the time of this meeting, the lake level is at about El. 986, which is about 4.5 feet below normal pool, and spillway gates are closed to the extent possible
- Boats and other debris continue to accumulate in front of gates and Town is performing ongoing removal
- Sewer lift station is destroyed, pipes appear to be ruptured near old lift station and leaking in tailrace
- Propane tank that was near sewer lift station is partially buried by debris and is leaking
- MC has equipment and materials scattered along the downstream access road
- Intake gate on the penstock is currently open and generators are turning, but gate will be closed tonight

**3. Temporary Crest Repairs and Operations**

- Cut out asphalt and stage materials to be hauled off in area where trees will be cleared by Town on left abutment.
- Clean out sinkholes on left abutment and reduce steepness of slopes to allow for non-woven geotextile placement and staking on top of cleaned up soil surface.

## **Lake Lure Dam – Reservoir Drain Construction Meeting Agenda**

- Place #57 stone in sinkholes on crest to the top of holes, which allow emergency vehicle access across this area, if needed.
- For the downstream slope repair on the right abutment, the team discussed first clearing of trees around the areas and then hydroseeding the exposed soil and placing sheeting at the top in areas that could not be effectively hydroseeded.
- The team discussed various options for more permanent repairs to the downstream slope on the left abutment. Placement of riprap was discussed as the likely primary option. Both Town and MC have access to some sandbags if needed.
- Dump trucks should be able to access the left abutment from Buffalo Shoals Road starting tomorrow.
- Plan for NCDOT to eventually pave road for long-term access.
- MC to install plastic sheeting at eroded soil faces at right abutment to help reduce additional sloughing.
- MC has reached out to materials suppliers and personnel and has them on standby awaiting direction.

### **4. Downstream Repairs and Operations**

- MC needs to remove all equipment and materials related to the Reservoir Drain Project for now since it would be in the way of cleanup. The Town indicated that material MC wanted to leave near the site could be stored at the green space area. Materials to be disposed of will likely need to be disposed of off-site.
- Primary focus on downstream side of dam is clearing of downed powerlines and temporary restoration of eroded riverbank below access road.

### **5. Other Discussion Topics**

- Town verbally authorized Schnabel and Morgan Corp. to proceed with emergency support on a time and materials basis. MC requested written authorization for general scope of work to be performed. Town noted that in order to receive FEMA funding, detailed records will need to be submitted. These are expected to include timesheets, daily field reports, safety meeting records, documentation of waste and where it was taken, and any other documentation requested by Town. Town requested SE perform the initial support work under the current on-call contract (Work Order No. 11).
- Town noted that Flowering Bridge is destroyed and needs to be removed. MC stated it was interested in this work if this will help the Town and acknowledged it is not currently a top priority and can be discussed later.
- A new downstream tailrace crossing will have to be constructed prior to resuming work on Reservoir Drain Project.

### **6. Action Items Identified**

- **Schnabel**
  - i) **Provide written recommendations on recommended temporary repairs and start development of recommended permanent repairs**
  - ii) **Contact NCDOT ahead of permanent road repairs**

- **Town**

- i) **Clear trees on left abutment at crest near slough and at proposed laydown area, leave stumps for now**
- ii) **Hydroseed slough area on downstream slope of left abutment**
- iii) **Cut deenergized powerlines at right abutment**
- iv) **Check w/ Duke Energy on power restoration schedule, ask if all downstream powerlines are to be removed, and reestablish downstream access in advance**
- v) **Identify area that MC can dump waste, which will be required for FEMA funding**
- vi) **Remove fencing around sewage treatment plant**
- vii) **Work with LaBella on new sewer lift station**
- viii) **Close intake gate (“can”) tonight to virtually eliminate flow through turbines**
- ix) **Upgrade wastewater treatment plant to 480V**
- x) **Contact Synagro to clean out the plant for whenever the lift station is functional**

- **Morgan Corp.**

- i) **Move unnecessary Reservoir Drain Project equipment and materials offsite. Town offered temporary storage at greenspace if needed.**
- ii) **Perform temporary repairs at left and right abutments based on meeting recommendations, to be followed up with written recommendations provided by SE.**
  - (1) **Cut and remove asphalt road at sinkholes**
  - (2) **Remove debris in sinkholes**
  - (3) **Install non-woven geotextile (staked) and dump #57 stone in sinkholes**
  - (4) **Install surface diversion to redirect surface runoff at left abutment away from sinkholes and into reservoir.**
  - (5) **Roll out and stake plastic sheeting at right abutment to better protect exposed earthen areas against additional scour, using caution to avoid endangering personnel near steep eroded surfaces**
- iii) **Repair downstream access road temporarily by dumping riprap on failed slopes. Use caution as pipe is currently exposed in some areas.**
- iv) **Remove downstream junction boxes planned for communications from lift station along road if needed**
- v) **Finish removing sewer lift station pipes and fill with aggregate.**
- vi) **Look at leaking propane tank gauge tomorrow before working in vicinity and do not have any flames or smoking while tank is leaking.**
- vii) **Provide timesheets, daily field reports, safety meeting records, documentation of waste and where it was taken, and any other documentation requested by Town so Town can pursue reimbursement by FEMA.**

## **ATTACHMENT 2**

# **HURRICANE HELENE PHOTO LOG**



**Photograph: 2.1**

**Photo Taken:** 9/27/2024

**Location:**

Bay 13, Upstream side

**Comments:**

Arch overtopping and eroding soil downstream of concrete dam



**Photograph: 2.2**

**Photo Taken:** 9/27/2024

**Location:**

Downstream side of dam

**Comments:**

Low and mid level stage arches (all arches except Bays 6 through 8) overtopping and scouring downstream soils



**Photograph: 2.3**

**Photo Taken:** 9/27/2024

**Location:**

Downstream of dam, south of intersection of Memorial Highway (US Route 74) and Island Creek

**Comments:**

Broad River (right), (flooded road center), Island Creek (left)



**Photograph: 2.4**

**Photo Taken:** 9/27/2024

**Location:**

Downstream of dam, south of intersection of Memorial Highway (US Route 74) and Island Creek

**Comments:**

US Route 74 flooded at Island Creek



**Photograph: 2.5**

**Photo Taken:** 9/27/2024

**Location:**

Downstream of dam, looking upstream

**Comments:**

Downstream flooding. Gates open approximately 8 feet each.



**Photograph: 2.6**

**Photo Taken:** 9/27/2024

**Location:**

Upstream of dam, looking downstream

**Comments:**

Downstream flooding. No flow over the arches.



**Photograph: 2.7**

**Photo Taken:** 9/27/2024

**Location:**

Upstream of spillway, looking downstream

**Comments:**

Aerial view of Bays 1 - 3, Tainter gates, gate operating platform, and bridge.



**Photograph: 2.8**

**Photo Taken:** 9/27/2024

**Location:**

Spillway and left abutment, looking down from UAV

**Comments:**

Note the damage to the upstream slope and the roadway surface, and the downstream slope failure on the downstream slope, behind the left spillway sidewall.



**Photograph: 2.9**

**Photo Taken:** 9/27/2024

**Location:**

Downstream side of dam, looking towards the spillway and left abutment

**Comments:**

Tainter gates open approximately 8 feet each.



**Photograph: 2.10**

**Photo Taken:** 9/27/2024

**Location:**

Left abutment, looking right, between bridge and gate operating platform.

**Comments:**

Tainter gates open approximately 8 feet each.



**Photograph: 2.11**

**Photo Taken:** 9/27/2024

**Location:**

Downstream of dam, near Bay 9, looking towards the right abutment

**Comments:**

Erosion from flow over arches. Exposed rock visible.



**Photograph: 2.12**

**Photo Taken:** 9/27/2024

**Location:**

Downstream of dam, looking upstream into Bay 13

**Comments:**

Erosion from flow over arches. Exposed rock visible.



**Photograph: 2.13**

**Photo Taken:** 9/27/2024

**Location:**

Downstream of dam, looking along right bank of Broad River

**Comments:**

Damaged access roads, damaged construction staging area. Exposed rock from scour erosion.



**Photograph: 2.14**

**Photo Taken:** 9/28/2024

**Location:**

Access road downstream of dam, along right bank of Broad River

**Comments:**

Damage to river bank and access road.



**Photograph: 2.15**

**Photo Taken: 9/28/2024**

**Location:**

Above the dam, centered, looking down.

**Comments:**

Gates partially closed - debris beneath gates. Note the damage to the access roads, evidence of scour erosion, exposed bedrock, demolished sewer lift station, demolished river crossing.



**Photograph: 2.16**

**Photo Taken: 9/28/2024**

**Location:**

Downstream side of dam, looking the spillway and left abutment

**Comments:**

Gates partially closed - debris beneath gates. Note the damage to the upstream slope and roadway surface on the left abutment, and the slope failure on the downstream slope.



**Photograph: 2.17**

**Photo Taken:** 9/28/2024

**Location:**

Downstream slope of left abutment

**Comments:**

Slide visually estimated to be approximately 30 feet wide



**Photograph: 2.18**

**Photo Taken:** 9/28/2024

**Location:**

Downstream slope of left abutment

**Comments:**

Upper portion of slide with near horizontal separation at change from possible topsoil collapse into void. Exposed slope is near vertical above the reddish colored material.



**Photograph: 2.19**

**Photo Taken:** 9/28/2024

**Location:**

Downstream slope of left abutment

**Comments:**

Close-up view of bottom of slide near bottom with some rocks observed with soil



**Photograph: 2.20**

**Photo Taken:** 9/28/2024

**Location:**

Left abutment

**Comments:**

Damage to Buffalo Shoals Road.



**Photograph: 2.21**

**Photo Taken:** 9/28/2024

**Location:**

Downstream of dam, near Bay 5, looking right

**Comments:**

Overview of the right, downstream area. Note the damage to the access roads, scour erosion, exposed bedrock, damaged powerhouse, demolished sewer lift station, demolished river crossing.



**Photograph: 2.22**

**Photo Taken:** 9/28/2024

**Location:**

Bay 5, downstream end, looking upstream

**Comments:**

Partially completed reservoir drain system.



**Photograph: 2.23**

**Photo Taken:** 9/28/2024

**Location:**

Bay 5, upstream end, looking upstream

**Comments:**

Debris and partially completed reservoir drain system - Knife gate valve (blue), reservoir drain pipe (gray - obscured by tarp), and concrete block beneath arch.



**Photograph: 2.24**

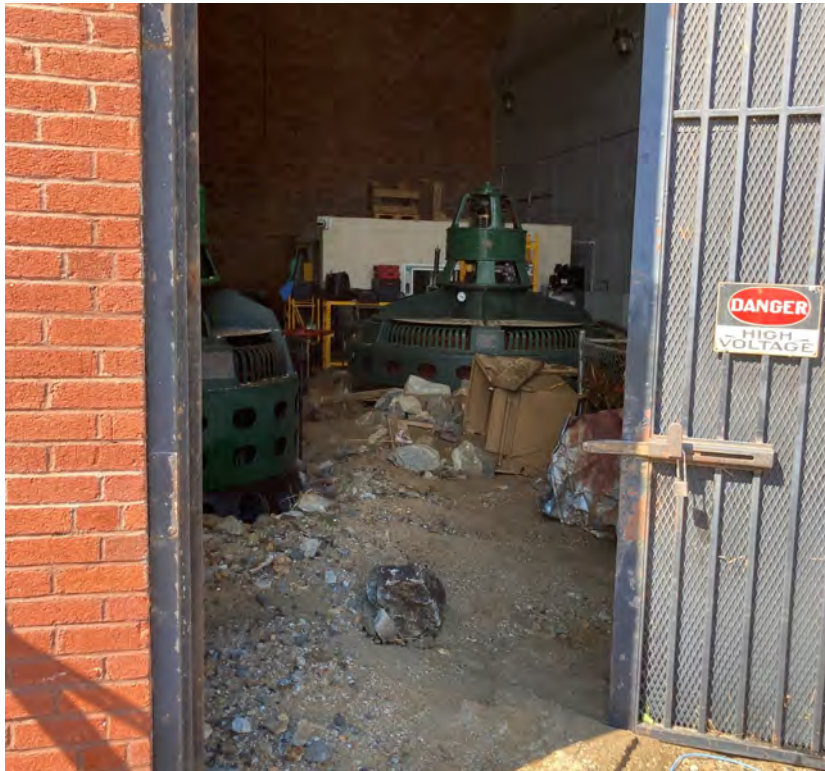
**Photo Taken:** 9/28/2024

**Location:**

Bay 8, looking upstream at electrical building

**Comments:**

Sediment and rock deposited in front of structure. Displaced electrical boxes (green, right)



**Photograph: 2.25**

**Photo Taken:** 9/28/2024

**Location:**

Powerhouse entrance

**Comments:**

Sediment and rock deposited inside the powerhouse.



**Photograph: 2.26**

**Photo Taken:** 9/28/2024

**Location:**

Downstream end of buttress between Bays 10 and 11

**Comments:**

Soil eroded to contact where concrete buttress and overpoured to appear to bear on bedrock.



**Photograph: 2.27**

**Photo Taken: 9/28/2024**

**Location:**

Downstream end of buttress  
between Bays 10 and 11

**Comments:**

Spall approximately 6 inches deep  
maximum at corner. Soil backfill  
was eroded around buttress, but  
concrete appeared to be placed  
against rock.



**Photograph: 2.28**

**Photo Taken: 9/28/2024**

**Location:**

Sanitary sewer lift station,  
downstream of dam

**Comments:**

Remnants of the sanitary sewer lift  
station structure and piping.



**Photograph: 2.29**

**Photo Taken: 9/28/2024**

**Location:**

Access road, looking upstream at dam

**Comments:**

Damaged power poles. Debris on access roads.

# **ATTACHMENT 3**

## **RECOMMENDED EMERGENCY REPAIRS**

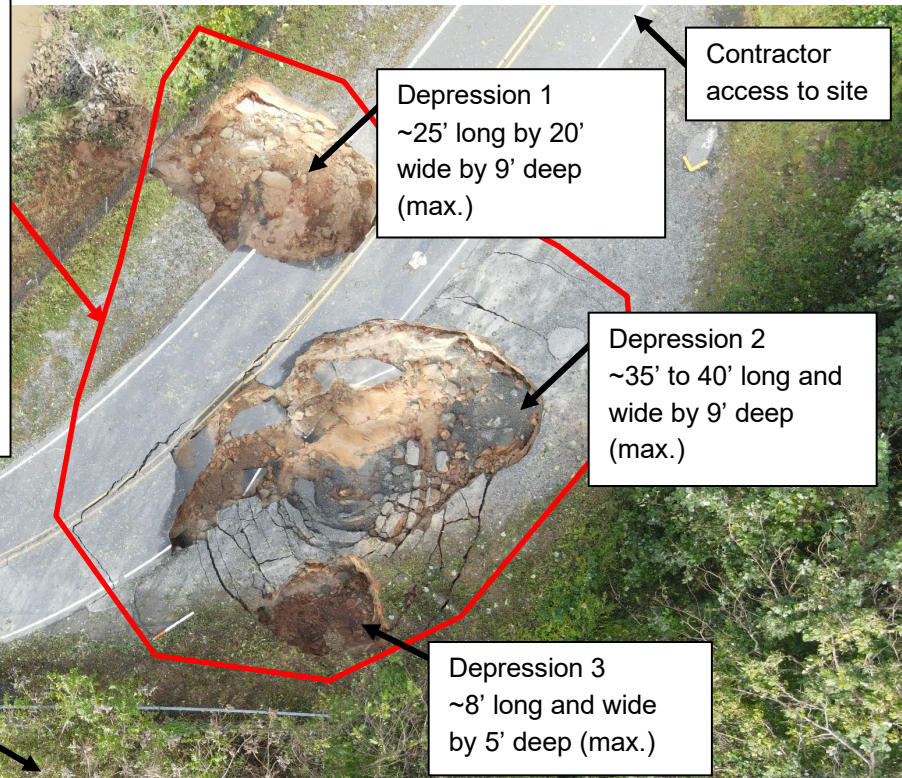
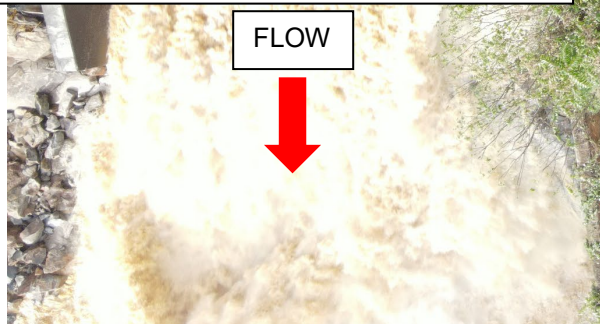
Depression Emergency Repairs

1. Remove and dispose of pavement and excavate slopes around edges to be no steeper than 1H:1V. Do not excavate deeper than 2 feet above lake level. Owner to lower lake level if needed to meet this requirement.
2. Fill depression area to top of the original roadway with NCDOT ABC dense-graded aggregate. Place the stone in approximately 6-inch lifts and compact it to at least 95 percent of the material's maximum dry density using a vibratory, padsfoot, walk-behind roller.
3. Prevent drying of the stone by adding water as needed during the placement and compaction processes.



Notes

1. Downstream slope at slide is very steep, near vertical at top. Contractor to avoid disturbing slope with equipment or personnel.
2. Perform work under fulltime observation of Schnabel Engineering South, P.C. representative, typical for all recommended emergency repairs.



Downstream Slope Slide Emergency Repairs

1. Cut and remove trees at top of slope and within the slide where can be safely performed.
2. Remove loose materials from the slide using a long-reach excavator or similar equipment.
3. Additional investigation and repairs are expected, but are still being evaluated. Slide area was filled with a graded filter consisting of ASTM C33 sand, NCDOT 78M stone, NCDOT 57 stone, and NCDOT Class B riprap.

Figure 1. Photo Markup of Recommended Emergency Repairs to Left Abutment (Not to Scale)



**Figure 2. Photo Markup of Recommended Emergency Repairs at Right Side (Not to Scale)**



Figure 3. Photo Markup of Downstream Access Road for Recommended Emergency Repairs

## **ATTACHMENT 4**

# **EMERGENCY REPAIRS AND INVESTIGATIONS PHOTO LOG**



**Photograph: 4.1**

**Photo Taken:** 10/5/2024

**Location:**

Crest at left abutment

**Comments:**

Backfill compaction in area of depressions.



**Photograph: 4.2**

**Photo Taken:** 10/6/2024

**Location:**

Crest at left abutment

**Comments:**

Compaction testing of backfill.



**Photograph: 4.3**

**Photo Taken:** 10/6/2024

**Location:**

Downstream channel

**Comments:**

Excavation of material in downstream channel at lift station and stream crossing.



**Photograph: 4.4**

**Photo Taken:** 10/7/2024

**Location:**

Downstream access road

**Comments:**

Undermined road asphalt concrete removed and slope backfilled.



**Photograph: 4.5**

**Photo Taken:** 10/7/2024

**Location:**

Right abutment

**Comments:**

Drill rig set up adjacent to substation, downstream of bridge.



**Photograph: 4.6**

**Photo Taken:** 10/7/2024

**Location:**

Right abutment

**Comments:**

Drill rig set up adjacent to substation, downstream of bridge.



**Photograph: 4.7**

**Photo Taken:** 10/8/2024

**Location:**

Sampling from boring B-103 at crest on left side near bridge abutment

**Comments:**

Soft material from depth of 66 to 68 feet below top of hole.



**Photograph: 4.8**

**Photo Taken:** 10/9/2024

**Location:**

Left sidewall

**Comments:**

Grout discharge through left sidewall drain during backfill grouting of boring B103.



**Photograph: 4.9**

**Photo Taken:** 10/9/2024

**Location:**

Left abutment

**Comments:**

Trees cut at slide area.



**Photograph: 4.10**

**Photo Taken:** 10/11/2024

**Location:**

Left abutment

**Comments:**

Riprap placed on upstream slope in depression area.



**Photograph: 4.11**

**Photo Taken:** 10/12/2024

**Location:**

Left abutment

**Comments:**

Excavation at crest to access slide area on downstream slope.



**Photograph: 4.12**

**Photo Taken:** 10/12/2024

**Location:**

Left abutment

**Comments:**

Excavation of loose material in slide area on downstream slope.



**Photograph: 4.13**

**Photo Taken:** 10/13/2024

**Location:**

Left abutment

**Comments:**

Backfill and compaction testing at crest access to downstream slope slide area.



**Photograph: 4.14**

**Photo Taken:** 10/14/2024

**Location:**

Downstream channel

**Comments:**

Rock and debris removal.



**Photograph: 4.15**

**Photo Taken:** 10/14/2024

**Location:**

Left sidewall at downstream slope

**Comments:**

Slide area after removing loose surface material.



**Photograph: 4.16**

**Photo Taken:** 10/14/2024

**Location:**

Downstream channel

**Comments:**

Sewer pipe leakage at stream crossing.



**Photograph: 4.17**

**Photo Taken:** 10/15/2024

**Location:**

Slide area at left abutment

**Comments:**

Backfill with crushed stone over top of sand layer to create filter.



**Photograph: 4.18**

**Photo Taken:** 10/15/2024

**Location:**

Slide area at left abutment

**Comments:**

Telebelt placement of crushed stone over top of sand layer.



**Photograph: 4.19**

**Photo Taken:** 10/17/2024

**Location:**

Slide area at left abutment

**Comments:**

Riprap placement over crushed stone on lower portion of slope.



**Photograph: 4.20**

**Photo Taken:** 10/17/2024

**Location:**

Slide area at left abutment

**Comments:**

Riprap placement over crushed stone and sand layers.



**Photograph: 4.21**

**Photo Taken:** 10/18/2024

**Location:**

Downstream access road

**Comments:**

Backfill and flattening of slopes with riprap.



**Photograph: 4.22**

**Photo Taken:** 10/18/2024

**Location:**

Left abutment

**Comments:**

Geotextile placed at crest with riprap placement in progress on downstream slope.



**Photograph: 4.23**

**Photo Taken:** 10/18/2024

**Location:**

Sewer lift station

**Comments:**

Excavation and cleanup of remaining lift station infrastructure.