Construction Report for the Quinsam River Fish Passage Improvement Project Campbell River, BC

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Construction Report for the Quinsam River Fish Passage Improvement Project

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Table of Contents

Introduction

The Campbell River Salmon Foundation (CRSF) contracted Pacificus Biological Services (Pacificus) to perform construction activities for the Fish Passage Improvement Project in the Quinsam River near Campbell River, BC. The purpose of the project was to improve access for coho salmon and Steelhead to the upper reaches of the Quinsam River and Quinsam Lake where access had been restricted in the past. The features in the river which restricted passage by salmon included multiple bedrock cascades, areas of shallow laminar flow and small waterfalls. The goal of the project was to reshape these features to provide pools and channels which adult coho salmon and Steelhead could navigate during migration.

Project Overview

The proposed works within the Quinsam River were designed by Northwest Hydraulic Consultants (Graham Hill, P.Eng.). Dave Burt, (D. Burt and Associates) provided biological guidance throughout the planning stage and through to project completion. The designs called for variety of modifications to two separate work sites; the upper cascades, just below Lower Quinsam Lake, and the lower cascades, approximately 840m downstream of the upper cascades (Figure 1). The modifications called for the cutting, drilling and breaking of bedrock as well as the installation of yellow cedar logs within the river.

The modifications were designed to increase water depth, decrease water speed and reduce the height of drops. This was achieved by excavating pools and channels in the bedrock riverbed, increasing the width and depth of existing pools as well as using logs anchored to the riverbed to slow and confine flows and create pools.

This project could have been constructed using several different approaches, Pacificus chose to conduct the works utilizing hand tools and electrically powered hand tools over the use of larger equipment such as excavators, hydraulic tools, or pneumatic tools in an effort to keep ancillary impacts to a minimum (i.e. tote roads, clearing, impacts to the sandstone, etc).

The site is encompassed within TimberWest Forest Corp’s private forest lands and TimberWest provided the necessary permissions to access the site for movement of equipment and crews.

United Rentals supplied technical guidance for power tool rentals and proved to be an asset to work alongside throughout the project. Power was supplied with two 2.5-2.9 KW gasoline generators. Electric tools used included:

- air compressor,
- angle grinder,
- demolition hammer,
- rock drill, and
- wood auger.

Handheld gasoline power tools were used as well including:

- chainsaw,
- concrete chainsaw,
- dewatering pump, and
- line saw.

Hand tools were used as well including:

- bottle brush,
- cable clamps,
- cables, ¼"
- caulking guns,
- extension cords, 50', 12ga
- miscellaneous tools (knives, funnels, buckets, etc.),
- Pee-Vees,
- pry bars,
- rakes,
- shovels,
- sledge hammers,
- sockets
- wheelbarrows,
- winches, and
- wrenches.

Materials used in the project included:

- Dexpan non-explosive demolition agent (A.K.A. expanding grout),
- diamond cutting saw chain,
- diamond cutting disks blades,
- fuel (gasoline),
- galvanized hex nuts,
- galvanized threaded rod, 1.5” diameter,
- galvanized washers,
- grinding disks,
- plastic tubing,
- quick set two part epoxy with mixing nozzles,
- rebar, ¾”,
- rock drill bits,
- safety consumables (ear plugs, gloves, eye protection, etc.),
- sandbags,
- wood drill bits, and
- Yellow cedar logs approximately 0.4m in diameter, 3.5m long.

Works were conducted in the summer when flows through this section of river were lowest. Specific work sites were dried on a day to day basis by diverting flows and pumping water around work sites. The order in which the features were completed worked from upstream to downstream. This was necessary to see how the water reacted to one set of structures before creating the next structure in the downstream direction.

Transportation and staging of the materials was done by truck to get the large equipment and materials to the head of the nearest logging road spur. A helicopter was used to transport all large material and equipment from the head of the logging road spur to the work site.

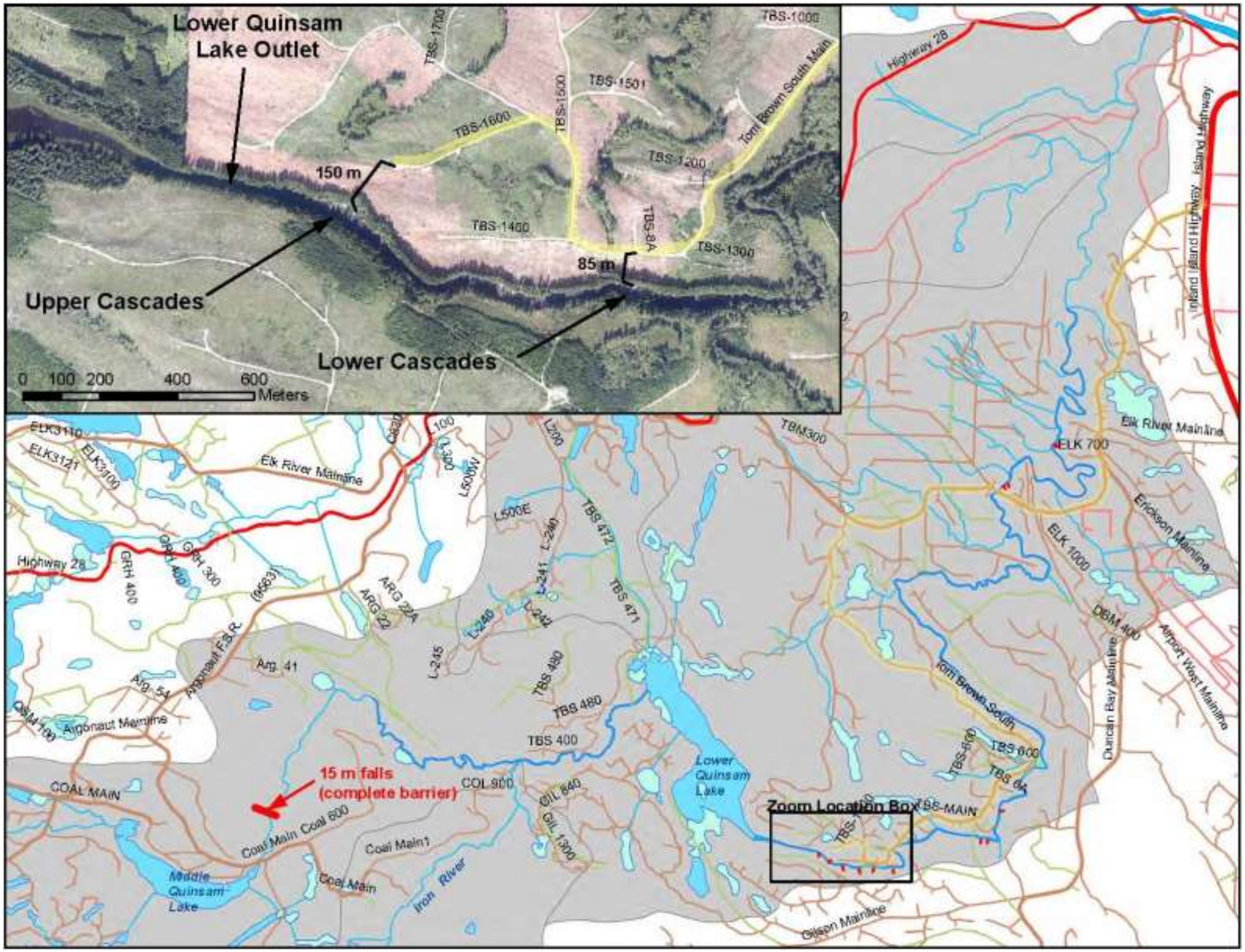

Figure 1. Location map of the Upper and Lower Work Sites on the Quinsam River.

Construction Techniques

Construction techniques used for the Quinsam River Fish Passage Improvement Project were developed over the course of the project. The following is a compilation of the most effective construction techniques including descriptions of case-specific modifications for improving efficiency.

Log Staging

Yellow cedar logs approximately 0.4m in diameter, 3.5m long were delivered to the staging area at the head of a forestry service road near the Quinsam River Fish Passage Improvement Project work areas. Western Forest Products Ltd donated the yellow cedar logs and Pacific Wood Waste Inc. donated the truck and labour to transport the logs to the staging site. From there, logs were slung via a Bell 206 Jet Ranger helicopter into both the upper and lower sites. Once at the work sites, logs were either stored on dry areas of the riverbed or anchored with rope to the bedrock (Photos 1 and 2). Overall this method was very effective and cost efficient. Flying time was approximately 5.5 hours between the two sites which included flying 3 extra logs at each site, flying in sand bags, and moving some equipment from the upper site to the lower site.

Comments

- The Bell 206 Jet Ranger's lifting capacity was not enough to lift the largest of the logs staged at the forestry service road. Enough logs were managed to be delivered to the site as extra logs had been staged.

Drying of the River Channel

A combination of sand bags, plastic sheeting and gas powered pumps allowed the temporary drying of localized areas within the Quinsam River. Sand bags were found to be most effective if used upstream at approximately a 45^{o} angle to the direction of flow (Photo 3). Flow was also redirected by using sand bags to completely dam areas where flow confined resulting in increased flows through alternate routes (Photo 4). When a localized worksite was not able to be dried completely a dewatering pump was found to be effective if used periodically at the worksite to draw down local water levels (Photo

5). Temporary drying of localized work sites was effective in most cases except when river flows were high.

Comments

- Plastic sheeting was found to be effective at improving the effectiveness of sandbag features (Photo 4).

Log Placement and Contouring

Log placement was accomplished by moving logs into position with hand tools (Photo 6). Logs were held in place temporarily with sandbags, angular cobble and rebar (Photo 7). Once positions of logs were finalized contouring of either the bedrock and the bottom of the log or both was conducted to achieve a suitable fit. Contouring of logs was completed using a chainsaw to shape one side of the log. Contouring of the bedrock was accomplished by cutting the footprint of the log with the line saw and using the jack hammer to remove rock from within the footprint. The result was a slightly entrenched and level bedrock surface which mated well with the flattened side of the log. This method was deemed very effective with the majority of each log having no gap between the log and the bedrock, a small portion having a spacing of 2-3cm between log and bedrock and only a few small portions of some logs having a 5cm spacing between the log and bedrock.

Comments

- It was found that creating two flat surfaces to mate together was easier than only contouring the log to match the bedrock.

Log Anchoring

Anchoring of logs was conducted after log placement and contouring was complete. Holes were drilled into the logs vertically with the auger and a 1 1/2”, 1m long auger bit. Once through the log, the bedrock beneath the log was drilled into using a rock drill with a 1 1/8”m 1m long drill bit. In order to ensure the hole in the log was aligned with the hole in the bedrock, the initial rock drilling was completed through the existing hole in the log. Once the rock drilling was limited by the reach of the drill bit through the log, the log was rolled aside and the bedrock was drilled to a depth of approximately 45cm with a 1 1/2” bit. Three sets of holes were drilled for each log.

In preparation for anchoring the logs, an air compressor with a 1m long nozzle was used in combination with a pipe brush to clean the inside of the holes in the bedrock as per the epoxy requirements. Logs were held in position during the anchoring process by inserting rebar through the logs into the bedrock holes. Epoxy was applied to the bedrock holes through the holes in the logs using a heavy duty caulking gun, epoxy mixing nozzle and a length of plastic tubing attached to thin dowel (Photo 8). The plastic tubing was pressure fitted over the epoxy nozzle and the other end of the tubing was guided through the hole in the log to the bottom of the hole in the bedrock using the dowel. Epoxy was forced through the tubing into the hole while lifting the end of the tubing to reduce the chance of air bubbles. Once the epoxy had been emptied into the hole, galvanized threaded rod was sledgehammered through the log to the bottom of the hole in the bedrock. Once the epoxy was set completely, galvanized washers and nuts were screwed onto the threaded rod tight to the log. A line saw was used to remove the excess length from the tops of the threaded rods (Photo 9). Overall this method of log anchoring was very efficient and effective. Only one anchoring throughout the project was noted not holding.

Comments

- Auguring of the logs required lifting the logs off the bedrock to prevent the auger bit making contact with the bedrock. If this occurred it was instantly dulled to the point of being ineffective for drilling wood.
- One tube of epoxy was used per hole as the volume of epoxy left in the plastic tubing required to get to the bottom of the hole was significant and did not leave enough epoxy for two holes to be completed. Also during the very hot days, the epoxy hardened too quickly to allow effective anchoring of two rods.
- Epoxy was found to harden exponentially faster in warmer temperatures. At 30^{o}C epoxy hardened in approximately 2 minutes. To mitigate this effect epoxy was stored in a cooler with ice until it was ready to be used.

Pressure Rock Fracturing – Dexpan

In areas where deep excavations were required into the sandstone bedrock, fracturing was accomplished by drilling a pattern of holes in the rock and filling them with Dexpan (Photos 11, 12 and 13). Each site required a slightly customized pattern of holes, however: there were a few methods which proved generally effective:

- Rock fractured more thoroughly if the pattern of holes directed the pressure from the Dexpan towards an open face of the bedrock formation;
- If no open faces existed in the bedrock feature then relief cuts were made using either a rock chainsaw or a line saw (Photo 10);
- The effectiveness of Dexpan was improved by drilling a high density of holes around the perimeter of the area to be fractured;
- Holes around the perimeter were angled at a downward slope towards the area to be fractured.

Pressure fracturing occurred over a 48 hour period after the Dexpan was poured. Once fracturing was complete, rock was removed by hand or other power tools were used to further free the rock (Photo 14). This method was found to have a high variability of effectiveness and efficiencies. The sandstone proved to be very diverse in composition so some sites would be very effective and some would not. The ability to describe the situations for which one site was more effective than another cannot be conveyed for numerous reasons but what should be known is that this method was generally more efficient and effective at removing higher volumes of rock then by jack hammering.

Comments

- The drier you could get a site the more effective results were
- Dexpan was found to work in submerged situations with the use of specialized thin plastic sleeves that lined the holes and protect the Dexpan from being washed away. Even with the sleeves it was found to be significantly more effective if all flow could be stopped and just standing water was left.
- 1 1/2" diameter holes were found to exert more fracturing force on the rock than 11/8" holes.

Mechanical Rock Fracturing – Demolition Hammer

In areas where shallow excavations were required, mechanical fracturing of the sandstone bedrock was performed with an electrically powered demolition hammer. The demolition hammer was best suited to chipping rock from a bedrock outcrop with at least one exposed vertical face. This allowed fractured rock pieces to fall away rather than congest the area being hammered. If no exposed rock face was present relief cuts were made with a rock chainsaw or a line saw (Photo 15). Periodic clearing of the area being mechanically fractured was required as crushed rock build up impeded the ability to apply impact force directly to the bedrock. Alternatively, mechanical fracturing of rock in shallow moving water cleared debris effectively (Photo 16). Use of a demolition hammer was found to be moderately effective at fracturing rock (Photo 17). The hammer became more effective in combination with the rock chainsaw or linesaw. If there was no face to work off of it was found the hammer would pulverize the sandstone rather than fracturing off chunks which was a very ineffective method.

Comments

- An electric 60 pound hammer was utilized which was the maximum size available without having larger less mobile generators. Anything smaller than a 60 pound hammer was ineffective.
- Due to the size and weight of the demolition hammer, operation was only possible in areas with good footing and a moderately flat work area.
- The demolition hammer required all of the wattage of one generator and was limited to one 50’, 12 gauge extension cord.

Rock Drilling – Electric Rock Drill

Drilling holes in the sandstone was required for both log placement and when the expanding agent was utilized for pool / rock excavation. An SDS max electric hammer drill was utilized with SDS max drill bits ranging from 1” to 1” ½ in diameter. The drill was reasonably efficient with a 1” ½ diameter hole 45 cm deep taking 20-30 minutes to drill depending on the hardness of the rock. A 1” diameter hole 45cm deep would take about 15 minutes.

Comments

- Two drills could work simultaneously off of a single 2.5-2.9 kw generator.

Summary

The approach of utilizing hand tools and smaller power tools powered by portable generators proved to be effective as the project was successfully completed very close to the estimated time and cost. More efficient means could have been utilized such as mini excavators or higher powered pneumatic tools. These alternative options would have come with other undesirable tradeoffs. The method as employed has resulted in a successfully constructed as designed project for which the only evidence of this being a construction site other than the intended structures are some fractured rocks that remain onsite and a foot path from the adjacent road network. As such, it is our opinion that if future works are required at these two sites that methods and strategies similar to those applied during this construction are utilized. The one recommendation would be that if the alternate sites at both the upper and lower river are considered in the future that a combination of generator and hand powered drills be utilized to drill holes but rather than using the expanding grout for these specific deep excavations that the project be planned to utilize explosives. The expanding grout option and or a rock chainsaw with expanding grout option would work but it is our opinion that the time factor to do it this way would prove more costly then looking at utilizing explosives.

Photos

Log Staging

Photo 1. Logs staged in the Quinsam River tied to bedrock.

Photo 2. Logs staged in the Quinsam River ready to me moved into position.

Drying of the River Channel

Photo 3. Sand bags placed at a 45° to the direction of flow effectively redirecting the flow of the Quinsam River.

Photo 4. Plastic sheeting increased effectiveness of sandbag dams.

Photo 5. Dewatering pump being used effectively to draw down the water level at a localized work area.

Log Placement and Contouring

Photo 6. Logs being moved into position using Pee Vees.

Photo 7. Logs being held in position with rebar while they are prepared for anchoring.

Log Anchoring

Photo 8. Epoxy being applied through flexible plastic tubing to an anchor hole in the bedrock beneath a log.

Photo 9. Fully anchored log with epoxied galvanized threaded rod, washer and nut attached.

Pressure Rock Fracturing – Dexpan

Photo 10. Relief cuts in the bedrock improved the effectiveness of the Dexpan. Note the plastic sleeves with the dexpan agent being utilized in standing water. This paticular fracture was very successful.

Photo 11. Drilling holes for more pressure fracturing beneath an area that was previously successfully fractured by Dexpan. Relief cuts on either side of the excavation were made with a rock chain saw which proved very effective.

Photo 12. Holes drilled and prepared for the pouring of Dexpan. PVC tubing allowed for efficient pouring of Dexpan slurry into the plastic hole liners.

Photo 13. Dexpan was mixed in a 5 gallon bucket and poured into the PVC tubing with a funnel.

Photo 14. After successful pressure fracturing of the bedrock debris could be removed using a demolition hammer, pry bars, or by hand.

Mechanical Rock Fracturing – Demolition Hammer

Photo 15. Relief cuts made with a line saw improved the efficiency of the demolition hammer.

Photo 16. Mechanical fracturing of rock was possible with some water flow through the site.

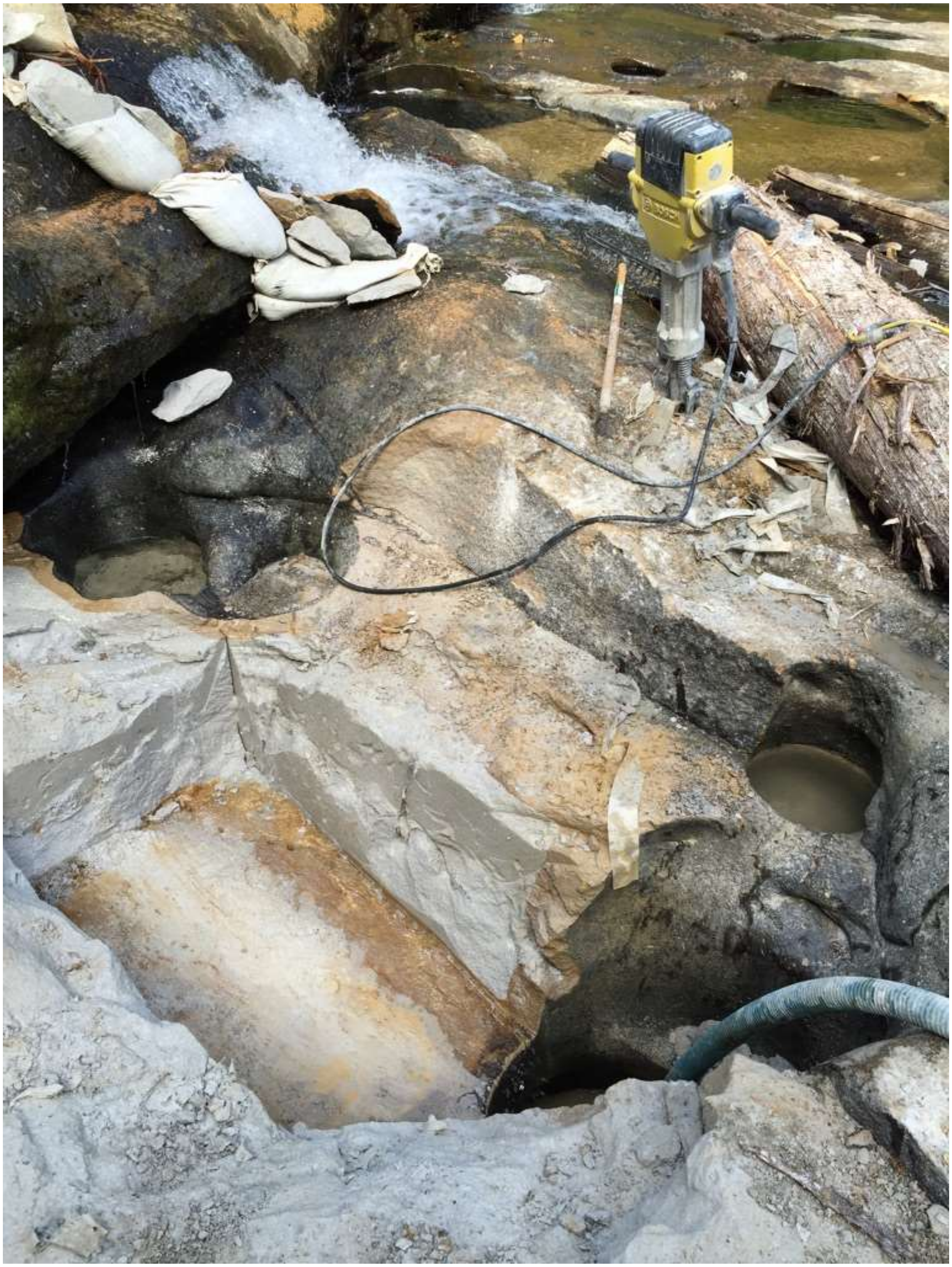

Photo 17. A combination of local dewatering and relief cuts greatly improved the effectiveness of the demolition hammer.

Aerial Photos

Photo 18. Aerial view of the upper site showing the effectiveness of the anchored logs at confining and redirecting flow.

Photo 19. Aerial view of the lower site