TO: Town of Cabot

FROM: Milone & MacBroom, Inc.

DRAFT DATE: July 26, 2016
FINAL DATE: August 22, 2016

RE: Dam Removal Feasibility Assessment
Clark Saw Mill Dam – Cabot, Vermont
MMI #5729-01-01

Introduction

The Clark Saw Mill Dam (VT#39.04) is located approximately 225 feet upstream of Saw Mill Road in the town of Cabot, Vermont on the Winooski River (Figure 1). The dam is a stone masonry structure with a concrete cap that sits on bedrock (Figure 2). The spillway is 70 feet wide and 14 feet tall at its highest point. The dam is currently in disrepair with numerous seeps, dislocated stones, dislodged concrete, and a failed intake structure. At this time, the deteriorating structure has no use and does not store and release water (i.e., is run-of-the-river). The impoundment is mostly filled with sediment and has little flood storage.

Figure 1: Project Location Map
(Map Clipped from Vermont Agency of Natural Resources [VTANR] Atlas)

Figure 2: Clark Saw Mill Dam (Looking Upstream on the Winooski River)
(Photo Taken by B. Cote, 5/5/2016)

The unsafe, obsolete dam is owned by Headwaters Lumber Company, Inc. and is being considered for purchase and removal by the Town of Cabot. The collapsed former millworks on the right (facing downstream) side of the river downstream of the dam would also be removed (Figure 3).

Figure 3: Deteriorated Remains of the Clark Saw Mill (Looking Downstream from the Dam) (Photo Taken by B. Cote, 5/5/2016)

This feasibility study includes field observations of the dam, impounded area, channel, and floodplain; limited survey; and limited sediment probing. The primary outcomes of this study include an initial prediction of how the channel will change if the dam is removed and how much sediment is sitting in the impounded area.

History

A dam is reported to have first occupied the project site in 1797 to store water for mechanical power for a saw mill in the newly settled village of Lower Cabot. In 1849, the dam became part of Haines Brothers Woolen Mill, which was located on the site of the modern Clark Saw Mill buildings (Llewellyn, 1998). By 1873, Haines Brothers Woolen Mill had built a dam at the site of the existing dam.

The precise age of the existing dam is not known, but it is likely that it is a replacement or enhancement of a former woolen mill dam. The concrete cap and the metal penstock suggest that the dam was modernized in the late 19th or early 20th century (Petersen, 2000).

In June 1925, the woolen mill was destroyed by a fire and replaced by a woodworking shop and saw mill. An inspection in the mid-1900s (Haybrook, 1949) described the dam as in good condition with minor leakage at the penstock and indicated the mill was operational. The mill was described as "in ruins" nearly 30 years later (VDHP, 1979). It is unknown precisely when the dam stopped being used for mechanical power.

The historical review suggests that a larger pond, and possibly a second dam, existed at the project site. The *Beers Atlas* (Beers, 1873) (Figure 4) shows a larger impoundment upstream of the dam and an island. This area appears to now be filled with sediment and vegetation and to contain a wetland. The river channel bends around this area during low and normal flow.

Dam Safety Assessment

The Vermont Dam Inventory database indicates that the Clark Saw Mill Dam is classified as a low hazard potential structure. The drainage area at the dam is 21.5 square miles. The dam falls under the jurisdiction of 10 V.S.A Chapter 43 of the Vermont State Statutes since it impounds more than 500,000 cubic feet (11.5 acre-feet) of water and sediment. Storage capacity is listed as 16 acre-feet at the spillway crest and 21 acre-feet at the top of the dam.

Field data and survey were collected at the dam on May 4, 2016. The dam consists of a dry-stacked stone masonry structure founded directly on a bedrock outcrop that dips across the river from east to west. The rock outcrop was observed extending several hundred feet away from the dam to the east. Evidence of bedrock was also observed to the west of the dam in the yard of neighboring homes.

A concrete cap tops the stone masonry structure. Evidence that the concrete cap may have been fitted with flashboards at one time was also present. Measurements taken during the field visit indicate that the overall height of the dam is approximately 17 feet. The spillway length is approximately 70 feet, and the overall length of the dam is approximately 115 feet.

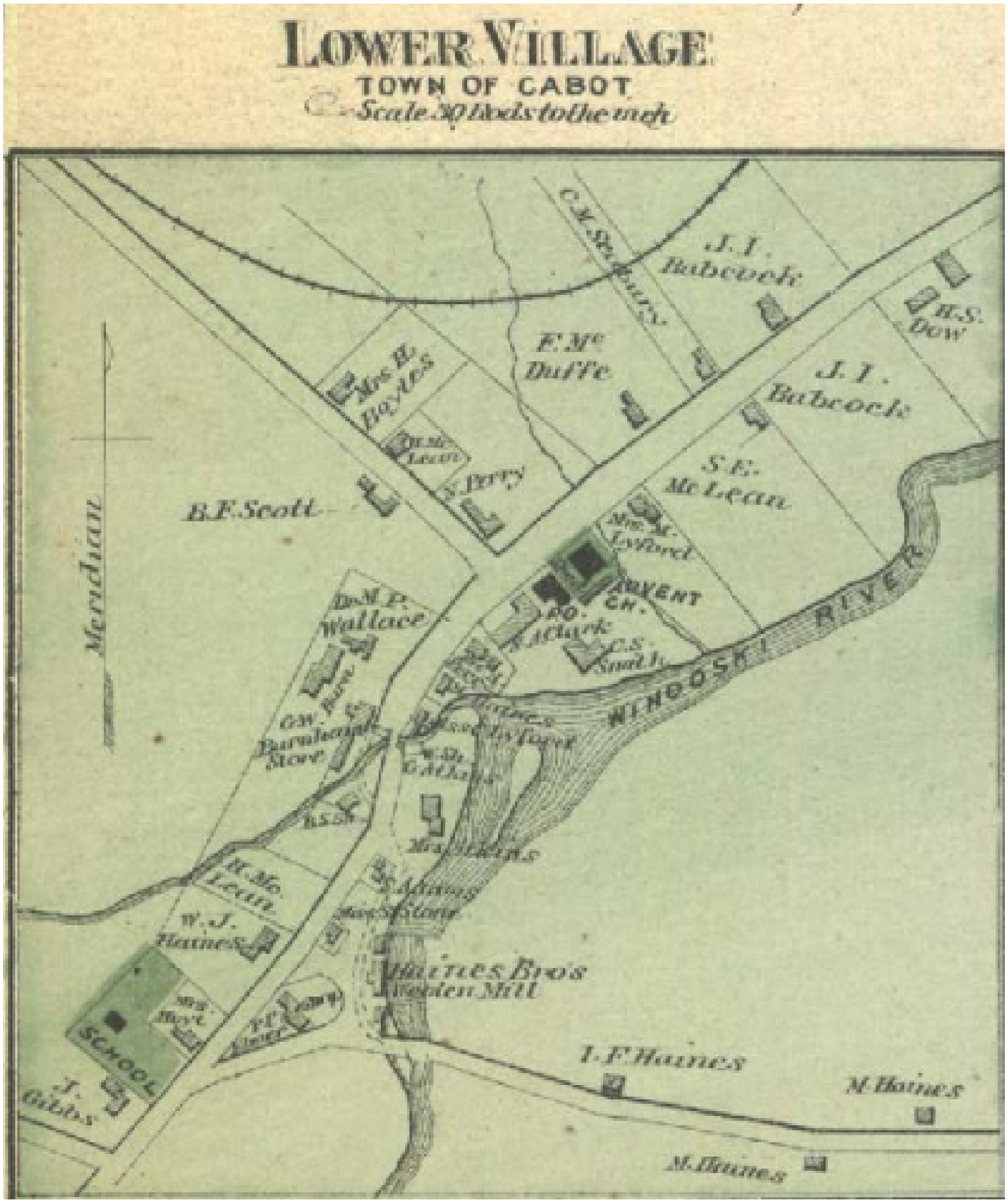

Figure 4: Historic Map of Lower Village, Town of Cabot
(Map from the 1873 Beers Atlas)

A rapid dam safety assessment was conducted (Appendix A). The dam and its features including the former mill building located downstream were found to be in poor condition. The dam has major structural deficiencies and may be in danger of failing during a flood. A sudden failure could lead to local damages and a sudden release of the impounded sediment that would cause long-term habitat and water quality impacts. The dam safety assessment indicates that the dam is in need of removal or replacement.

Dam and Spillway

The stone masonry was observed to be in poor condition. Seepage under the dam between the stone masonry and the bedrock was observed at numerous locations as well as through the joints in the stone. Vegetation and roots were also observed growing within the joints between the stones. The top of the stone masonry appeared to be missing sections and uneven, which indicates that portions of the stone masonry may have been damaged or dislodged in the past. Stones that resemble those in the face of the dam were visible in the downstream channel.

The concrete cap on top of the stone masonry was found to be in poor condition. The concrete appears to be newer construction compared to the remainder of the dam. Two sections of concrete were missing along the spillway where flow was concentrated. Some water was flowing over a slight low point in the spillway crest located near the left end of the spillway. Vegetation and small trees were found growing on top of the concrete cap. Spalling of concrete was visible along the cap. In addition, a large log was found lodged along the concrete spillway between the crest and downstream channel. Sediment has built up behind the dam and spillway to within 2 feet or less of the spillway crest.

Left Abutment

The left abutment (looking downstream) of the dam ties into the existing bedrock outcrop located to the east of the dam. Seepage at the abutment was observed flowing out from underneath the stone masonry structure. A large buildup of sediment behind the left abutment that was heavily overgrown with trees, shrubs, and vegetation was observed during the site walk.

Right Abutment

The right abutment (looking downstream) contains the remains of a former training wall or potentially a foundation wall of a former mill building. The land behind the training wall is low and is likely subject to periodic flooding. Some erosion around the end of the right abutment was observed during the assessment. Voids that appeared to be animal burrows were observed in the riverbank at the edge of water and also behind the training wall. The intake to the former mill building is located at the right abutment. Sediment has built up behind the abutment and training wall, which has vegetated with small trees, shrubs, and grasses. A sanitary sewer system exists along the right bank of the river.

Intake Structure

The intake structure and former penstock were found to be in poor condition. The intake located in the upstream pool at the right of the dam was clogged with sediment and wood. Whirlpooling was observed above the intake indicating that water is seeping through the dam in this location. The penstock was disconnected from the intake opening through the stone masonry at the right of the dam and was largely unsupported along much of its length.

Nearby Structures

Saw Mill Road Bridge (B37)

Changes are not anticipated at the Saw Mill Road bridge located downstream of the Clark Saw Mill Dam. The bridge was constructed in 2008 and is in good condition. The bridge spans the bankfull width of the channel and should be able to pass floodwaters, sediment, and debris.

VT Route 215 Bridge over Jug Brook (B5)

Dam removal could influence the bed elevation on Jug Brook at the Main Street Bridge. No plans exist for this structure. Probing is required to understand where the footings sit relative to the current bed and the potential lowering of the bed in this location following dam removal. Armoring of the footings may be recommended before dam removal if scour and undermining are possible.

VT Route 215 Bridge over the Winooski River (B7)

The dam removal is not likely to change the bed elevation at the Main Street Bridge on the Winooski River. However, documentation of the bridge footing location and condition is warranted since the channel will likely continue to meander in its floodplain near the structure. No plans exist for this structure. Quick observations revealed some structural issues with the bridge such as spalled concrete, exposed and rusted rebar, and large cracks in the structure.

The Floodwall at the Lower Cabot General Store along Jug Brook

Dam removal could influence the bed elevation on Jug Brook at the floodwall at the Lower Cabot General Store. No plans exist for this structure. Probing is required to understand where the footings sit relative to the current bed and the potential lowering of the bed in this location following dam removal. Armoring of the footings with large rock may be recommended before dam removal if deep scour and undermining are possible.

River Channel Assessment

Data Collection

Limited field survey was performed by Milone & MacBroom, Inc. in May 2016 to initially define the dam, six channel cross sections, and the channel profile. Survey was performed with an engineer's transit and rod extending from Saw Mill Road to upstream of Jug Brook (1,000 feet) (Figure 5).

Site reconnaissance also included a channel walk on the Winooski River to the Main Street Bridge on VT Route 215 (5,000 feet) and on Jug Brook to just upstream of the Main Street Bridge (700 feet). Typical channel dimensions, bed particle characteristics, and site notes were recorded (see Figure 5).

μ 0 125 250 500 Feet

Legend

Survey Cross Sections

Observation Locations

D GPS Points

Stream Centerline

Floodplain

No excess sediment
observed at
Main Street Bridge

Planform adjustment

Dogs

Ditch

Winooski River

Sign of moving water,

Slope to Cows

(Portable) electric fence

Deep, lots of

soft sediment

sediment delta

Excess

sediment

Gulley

Depth increasing and softer sediment

Shrubby floodplain

Bedrock ridge that dam sits on

Sphagnum

climbs to southeast and forms

Alder

Beaver

pond/wetlands

Clark Saw Mill Dam

River Station (STA) 0+00 Saw Mill Road Bridge

Left bridge abutment
assumed vertical datum
Elevation = 100 feet

Figure 5: Survey and Channel Assessment Notes

SOURCE(S): Location:
Bing Maps - Aerials
VCGI - Stream Centerlines

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Sediment probing was conducted in the impoundment just upstream of the dam and at three of the surveyed cross sections. The bed sediment consisted of deep sandy deposits that typically were thicker than the 5-foot steel rod used for probing. Repeated sediment probing was also performed during the channel walk to predict the thickness and extent of deposited sediment. Locations of likely channel change upon dam removal were noted.

Channel Geomorphology

Geomorphic assessment was performed in 2004 on the Winooski River in Cabot for the free-flowing reaches near the project site (Table 1) (BCE, 2004).

TABLE 1
Past Geomorphic Data on the Winooski River (BCE, 2004)

Location	**Downstream of Saw Mill Road**	**Upstream of Jug Brook**	**Downstream of Route 215**
Length (feet)	1,950	2,600	1,732
Reach ID	R37-D	R38-A	R38-B
Bankfull Width (feet)	36.3	28.3	27.6
Mean Bankfull Depth (feet)	3.7	3.1	3.2
Floodprone Width (feet)	506	595	668
Bed Form	Riffle-Pool	Riffle-Pool	Riffle-Pool
Dominant Substrate	Gravel and Cobble	Sand and Gravel	Gravel and Sand
Channel Type	E	E	E
Incision Ratio	1.7	1.3	1.3
Channel Evolution	III F	III F	III F
Notes	Incised and straightened, plane bed, historic degradation, widening	Abundant bank erosion, historic incision, aggradation from dam, planform adjustment	Abundant bank erosion, some avulsion, extreme planform adjustment, building new floodplain

The current assessment confirmed that the past measurements of the channel size mostly remain accurate today. A key finding in terms of the dam removal is the confirmation of finer sediment due to aggradation behind the dam upstream of Jug Brook (reach R38-A). This area is upstream of the channel area that is obviously impounded due to the presence of ponded water and defines the extent of the portion of the channel that is most likely to undergo adjustments following dam removal as sediment transport resumes.

Bankfull channel dimensions were measured during data collection and were similar to those observed in 2004 other than the expected widening upstream of the dam in the impounded area (Table 2). Field observations of sediment and channel stability were also recorded and show the thinning and coarsening of the trapped sediment moving upstream.

Past data and current field observations indicate that the expected bankfull channel width following dam removal is 30 to 35 feet. The expected mean bankfull channel depth following dam removal is 3 to 3.5 feet.

TABLE 2
Channel Measurements and Observations

Location	Upstream of Dam	Upstream of Jug Brook Confluence	Channel	Route 215 Bridge
River Station* (feet from Saw Mill Road bridge)	2+26	10+80	19+73	49+87
Bankfull Width (feet)	50	25	42	23 (bridge opening)
Bankfull Depth (feet)	2.5	4.5	3.2	Unknown
Bed Form	Dune-ripple, buried riffles	Dune-ripple, buried riffles	Riffle-Pool	Riffle-Pool
Dominant Substrate	Sand	Sand and gravel in flow; fine sand and silt in slack water	Sand and gravel	Sand and gravel
Sediment Depth (feet)		1-2	1-2.5	0

Notes	A lot of fine sand accumulated upstream of dam	Sediment transport to change following dam removal	More developed hydraulic features and coarser sediment	Coarser bed material and fully developed hydraulic features. Not likely influenced by dam removal.

* River Station is feet with tens and hundreds separated by a "+" (e.g., River Station 2+26 equals a distance of 226 feet).

The anticipated stable bankfull channel width is 50 feet, and the average depth is 3 feet based on plots (USACE, 1994) of typical dimensions as a function of the estimated bankfull discharge of 684 cubic feet per second (Olson, 2014). This finding assumes an average level of cohesiveness or coarse granular banks. The texture and stability of the banks need to be confirmed by testing in order to refine the prediction of the channel width following dam removal.

The surveyed channel profile shows a decrease in slope approaching the dam due to the trapped sediment (Figure 6). The upstream channel has an approximate slope of 1.2%, the channel at the dam has a slope of 0%, and the channel downstream of the dam approaching Saw Mill Road is 3.8%. Based on the profile, the anticipated channel slope upstream of the removed dam is 1.5% to 1.8%. At this slope, the channel bed would likely be comprised of coarse gravel and cobble (USACE, 1994). A 3-foot bedrock falls will likely exist at the dam that will control the channel grade following dam removal.

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Figure 6: Existing Channel Profile of the W

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Impounded Area

The dam appears to impound approximately 600 feet of the Winooski River to the confluence with Jug Brook and nearly 300 feet on Jug Brook. In this area, water is noticeably backed up, and thick, sandy sediment deposits exist. A transitional zone extends further upstream where the channel has some free-flowing areas and is developing bedforms, yet trapped sediment exists indicating the dam is still influencing the channel. The transition area on the Winooski River is approximately 1,000 feet long, and the transition area on Jug Brook is approximately 300 feet long. Changes to the channel upstream of these transition areas are less likely to be a function of dam removal.

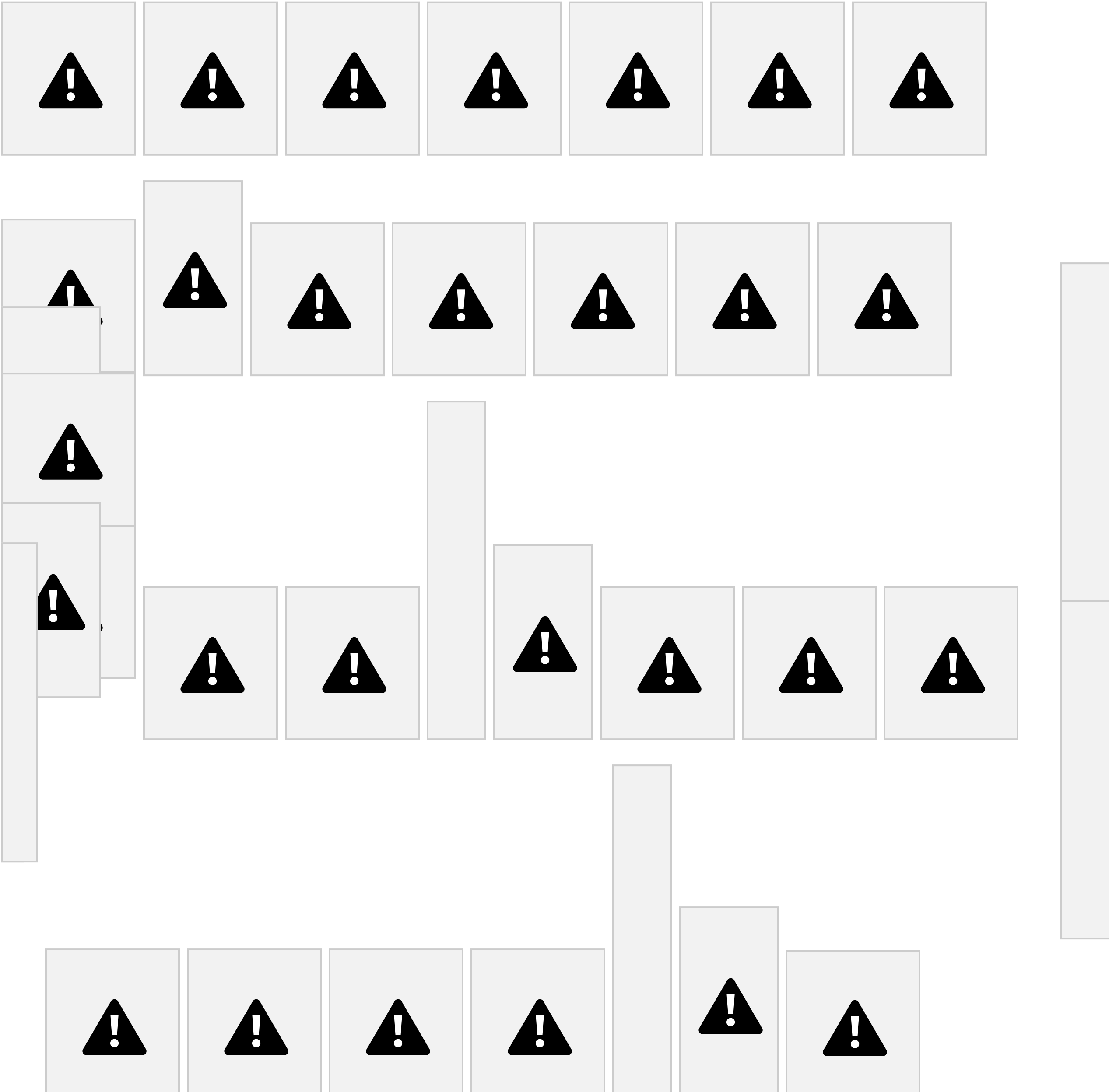
Downstream Scour Pool

The channel immediately downstream of the dam consists of exposed bedrock and a deep scour pool extending approximately 20 feet downstream from the face of the dam. The tailwater of the scour pool is controlled by a deposit of many large boulders and a few pieces of stone masonry from the dam that collectively control the normal elevation of the water in the scour pool.

A vegetated island exists in the center of the channel that extends downstream from the scour pool control cross section. Large amounts of woody debris exist on the island.

Floodplains

The project site is located in a Federal Emergency Management Agency (FEMA) approximate floodplain (Zone A) (FEMA, 2013) (Figure 7) and the Vermont River Corridor (VTANR, 2015) (Figure 8) and is thus prone to inundation and erosion. Although the dam is holding up the bottom of the channel due to the sedimentation, the channel is not well connected to its floodplain most likely due to historical straightening and incision. For example, at river station 10+80, the incision ratio is nearly 1.9, and further upstream at river station 29+55, the incision ratio is 1.7. Measurements in 2004 upstream of the dam indicated an incision ratio of 1.3 indicating that the channel may be cutting down. This is consistent with the channel evolution model stage III designation in 2004 where the channel would be predicted to cut down and eventually widen (Schumm et al., 1984; FISRWG, 1998) – two processes that appear to have taken place on the Winooski River over the past decade in the project area. Dam removal is likely to accelerate incision and widening in the area just upstream of the existing dam while floodplain inundation is likely to decrease in the near term.



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Sediment

Sediment

Sediment Distribution

Milone & MacBroom, Inc. probed the impounded sediment with a 5-foot rebar rod upstream of the dam during survey and the site walk. The rod was hammered into the bed until full submergence or until encountering firm, coarse substrate that felt like either bedrock or gravel/cobble.

The estimated cross-sectional area of impounded sediment was determined by finding the area of the irregular polygon between the surveyed top of sediment (i.e., the current channel bottom) and bottom of sediment as approximated by probing (Figure 9). The impounded sediment volume over the project site was determined by the average-end area method. Approximately 4,500 cubic yards of sandy sediment are trapped upstream of the Clark Saw Mill Dam (Table 3).

TABLE 3
Estimated Sediment Volume Calculations Upstream of Clark Saw Mill Dam

Section ID	**River Station**	**Area**	**Average Area**	**Distance**	**Volume**	**Volume**
	(feet)		**) (square**	**(feet)**	**(cubic feet)**	**(cubic yards)**
XS 2 (Dam)	2+26	478	478	0	0	0
XS 4	3+30	224	351	104	36,504	1,352
XS 5	6+21	140	182	291	52,962	1,962
XS 6	9+86	35	88	365	31,938	1,183
TOTAL	**7+60**			**760**	**121,404**	**4,496**

Approximate Sediment Budget

The risk of a sudden sediment release from dam failure or following dam removal if the material is left in the channel can be estimated by comparing the amount of impounded sediment with the amount of sediment that is produced in a watershed and transported downstream by a river channel over a year (i.e., the mean annual sediment yield) (MacBroom and Schiff, 2013). Long-term measurements of sediment yield or load do not exist on the upper Winooski River, so sediment yield has been approximated based on sediment gauges throughout New England that indicate a mean yield of 50 tons per year per square mile of watershed (range is 25 to 150 tons per square mile). Based on a watershed size of 21.5 square miles, the annual watershed yield of sediment is roughly 1,000 tons per year incident to the impoundment.

Figure 9: Ex

l Cross Sections of the Winooski River near Clark Saw Mill Dam

At a typical density of 75 pounds per cubic foot for loose sandy sediments, each ton of sediment is estimated to occupy a volume of 1 cubic yard of material. The total sediment volume generated by the watershed on an annual basis is thus 1,000 cubic yards. Based on the estimated 5,000 cubic yards of impounded sediment, the existing material is the product of 5 years assuming a trap efficiency of 100%. Reservoir trap efficiency is typically lower than 100%, especially in a setting like at the Clark Saw Mill Dam where flow and sediment are able to flow over and through the structure, so the amount of material present could have built up over a longer period of time.

If the dam is removed, some sediment removal will be required since 5 years of accumulated sediment is too large an amount to allow to move downstream and redistribute over time. This amount of material will likely lead to habitat and water quality impacts over the long term if it is released.

Sediment Stability

The sediment deposited in the impoundment appears to be mostly sand that can mobilize at a velocity of approximately 1.5 feet per second (Fischenich, 2001). All of the impounded sand is likely to mobilize following dam removal, specifically during future floods and ice movement. If left in place, the channel would likely cut down through the sand until reaching the gravelly substrate that appears to dominate outside of the primary influence of the dam. This gravelly material would resume moving through the reach over time if the dam were removed.

The bedrock on which the dam is founded and that appears to cross the channel and floodplain will set the channel profile following dam removal. The bedrock will periodically store and release sediment over the long term. Areas of gravel and cobble bed are likely in the current impoundment.

The pond area where the river once flowed as shown on the *Beers Atlas* may be an area where fine sediment could erode following dam removal. At this time, it appears that this location on the inside of the bend would remain mostly intact, yet if the channel migrated into this area following dam removal, some fine materials could begin to migrate downstream and reestablish a channel in this location.

Summary of Predicted Changes with Dam Removal

Based on past and current observations, the channel has been divided into three areas indicative of the level of anticipated change following dam removal (Figure 10; Table 4).

TABLE 4
Predicted Channel Change Following Dam Removal

Location	Area 1	Area 2	Area 3
Likelihood of Change	High	Moderate	Low
Winooski River Station	1+80 to 8+30	8+30 to 19+30	19+30 to 49+90
Winooski Distance (feet)	650	1,100	3,060
Jug Brook Distance (feet)	400	350	300
Flow	Release ponding	Development of more complete hydraulic features	None
Sediment	Transport of all sandy sediment not removed	Pockets of sand to migrate downstream	Naturalization of gravel and cobble transport
Floodplain Inundation	Decrease	Initial decrease, then as existing	Limited to no change
Channel Profile	Slope increase	Local minor slope increases	None

Channel Cross Section	Down-cutting, bank slumping, building new floodplain	Minor down-cutting; widening	Continued localized widening
Channel Planform	Remeandering and new floodplain connection	Continued lateral migration	Continued lateral migration

The primary change to take place with dam removal is the naturalization of sediment transport. The sandy accumulated sediment in the impounded area needs to be removed, and gravel and cobble will begin to flow past the site of the dam and into the downstream channel. The highly incised downstream channel should stabilize with the sediment input and improve connection to the floodplain. The channel may initially be less stable once the dam is removed but will then become more stable once the meander belt is restored and encroachments are removed.

µ 0 125 250 500 Feet **Legend**

Survey Cross Sections

Observation Locations

Predicted Level of Channel Change High

Moderate

Low

Area 3:
Limited change in sediment transport predicted. Continued planform adjustments as currently taking place.

Winooski River

Area 2:

pl
Secondary channel change area.
ac
Moderate sediment transport and

bed erosion to reform riffles and pools

Area 1:

Largest predicted channel change following dam
removal. Transport of all accumulated
fine sediment. Slope will increase. Some likely bank erosion and incision.

Clark Saw Mill Dam

Figure 10: Areas of Potential Channel Change Following Dam Remo

SOURCE(S): Location:
Bing Maps - Aerials
VCGI - Stream Centerlines

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1st Version: Revision:

7/25/2016 **1 S. Main Street Waterbury, VT 05676 (802) 882-8335 Fax: (802) 882-8346**

Scale:
1 in = 250 ft
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Dam removal will likely accelerate channel down-cutting and lead to some localized channel widening, especially in Area 1 where the most change is expected. This could lead to some loss of the edge of lawn for the three properties on the Winooski River on river right (facing downstream) and the two properties along Jug Brook between the confluence and Main Street. A slow, controlled drawdown and creating an initial channel cross section that pulls the channel toward the east will lower the risk of losing land. The rate of channel widening and down-cutting will be a function of the size and frequency of floods following dam removal.

The river channel could reoccupy the low wetland area on the river left side (facing downstream) of the channel that appears to have been river channel in the past (see Figure 4). Historical incision limits the likelihood of that happening following dam removal, yet this channel realignment could take place following a large flood, ice jam, or debris jam. This channel alignment could push the river toward river right where back yards are located that could lead to some loss of land along the existing channel. A sewer line exists in this area that could be exposed if erosion takes place in the area.

A small tributary exists near river station 19+73 that is incised. Although only small changes are predicted to the Winooski River where the two channels join, dam removal could initiate some local change that could lead to down-cutting in the tributary. A small grade control structure may be considered following dam removal if down-cutting begins.

Sediment Management Alternatives

An important consideration for the potential removal of the Clark Saw Mill Dam is to limit the risk of excessive downstream sedimentation since so much material is sitting in the impounded area. A rapid, unchecked sediment transport event would smother habitat and increase turbidity for a long period of time in the downstream channel. Excessive sediment transport could also lead to an unstable channel where head-cutting takes place through the existing impoundment.

It is important to understand that sediment transport and deposition occur naturally and are an essential and unavoidable part of a river channel, even one downstream of a historically impounded reach. A key objective of a successful dam removal is to restore natural sediment transport processes while maintaining or improving channel stability.

Potential sediment management options for the Clark Saw Mill Dam removal include the following:

→ Do nothing and allow the river to erode the impounded sediment.
→ Sediment removal through excavation
→ A phased sediment removal that consists of alternating steps of sediment and dam removal to incrementally lower the water and sediment levels
→ Stabilize the fine sediment to remain in place following dam removal.

Do Nothing

Due to the large amount of sandy sediment currently stored behind Clark Saw Mill Dam that is the result of 5 years of deposition from the watershed, the unchecked erosion of this material following dam removal would smother downstream habitat if allowed to erode over time. Some sediment is currently transported downstream during flood flows, yet this periodic release

of material is very small relative to the amount of material stored in the impoundment. Although this is the lowest-cost alternative, it is the alternative with the highest level of sediment impacts and may not be allowed by the United States Army Corps of Engineers and the VTANR, which would have jurisdiction over a future project.

Sediment Removal

Removal of the of the large volume of sandy sediment behind the Clark Saw Mill Dam would reduce impacts to the downstream channel and reduce the channel recovery time. Also, a controlled removal will reduce the risk of erosion compared to a failure or no sediment removal following dam removal.

Some of the sediment near the upstream end of Area 1 will be hard to reach with an excavator, and removal of that material will likely lead to more impacts than benefits, so this material could be left in place to reduce construction impacts. Some downstream sediment transport is tolerable such as that mobilized during a flood and will not have long-term negative impacts. The initial site work suggests that partial removal of the impounded sediment would strike a good balance of controlling impacts and costs. Partial sediment removal is likely to be acceptable to project regulators.

Phased Sediment Removal

Phased sediment removal and incremental dam lowering uses the dam to hold back sediment during excavation while allowing exposed sediment time to dry and compact prior to excavation. Consolidation of the sediment makes the material easier to access with construction equipment and easier to haul away. A phased sediment and structure removal is a common dam removal practice implemented as part of construction phasing.

The Clark Saw Mill Dam has very little water flowing over the dam crest during summer low flows due to the leaking, so sediment removal can readily begin during low flow. After initial removal of surface sediment, the water can be lowered by removing a section of the top of the dam or by digging out sediment in front of the clogged intake structure. Prior to releasing water, existing boulders from around the structure or pieces of the dam would be used to armor erodible flow paths to resist scour.

Like sediment removal, this approach reduces the risk of a sudden sediment release and uncontrolled erosion since the dam remains partially in place over the course of sediment removal. This approach has the advantage of providing for water control and incremental dewatering even when functioning outlet works do not exist.

Phased sediment removal with incremental dam lowering is effective at reducing risks, can reduce downstream impacts since more work takes place out of the water, can be a cost-effective method, and is familiar to dam removal contractors.

Bed Sediment Stabilization

Stabilization of the current bed sediment at the existing channel slope cannot be used in place of some level of sediment removal due to the change in elevation at the dam that would take

place upon removal and the large amount of erodible sediment that exists upstream of the dam. Attempting to stabilize the sandy sediment in place would likely be costly, futile, and ultimately lead to downstream channel impacts due to eventual sediment erosion and deposition that should be avoided. The grade of the channel at the dam site will be controlled by the bedrock ledge on which the dam now sits.

Some grade control may be possible moving upstream from the dam as the sediment coarsens. This could reduce some of the predicted channel adjustment in Area 2 and possibly Area 3 following dam removal (See Figure 10). With the steep slopes entering and leaving the dam area and a large ice flow in the spring, hard armoring would be needed to attempt to fix the grade.

Grade control such as two or three riffles made of embedded large rock could be used to replicate natural riffles that exist at the site. The concern with this approach is that the potential for the channel to move off the installed rock riffle installations is high given how dynamic the channel is in the project area. This approach could get costly and require frequent repairs and maintenance to function properly. The riffles would need to be designed to match existing riffles in the system to maintain the appealing natural aesthetics of the channel.

Recommendation

The current recommendation is to perform phased sediment removal of 3,500 cubic yards of trapped sandy sediment as the dam is removed. No sediment would be removed at river station 9+86, and just the thickest deposits of sediment would be removed at river station 6+21. Assuming a 15-cubic-yard load capacity for a dump truck, this sediment removal would require approximately 230 dump truck trips. The ballpark cost for this level of sediment excavation would be around $40,000 based on a typical excavation and local hauling rate of $12 per cubic yard.

Sediment in the wetland/possible former channel location north of the bedrock ridge on which the dam is founded should be left in place and remain fully vegetated. Some erosion from this area is possible following dam removal, yet the risk of a single large release of material that could impact the downstream channel is low unless a large flood takes place.

Sediment removal through mechanical dredging or excavation can be accomplished under nearly dry conditions during low flows. Sediments need to be disposed of in upland areas at another location since there is no space for the fill in the project area due to the floodplain. The finer sandy fill is likely rich in organics and likely contains some topsoil, so the sediment could serve as a valuable resource for the town, construction contractor, or public. All fill disposal sites must meet local, state, and federal regulatory requirements. The sediment must be properly tested for toxics prior to dam removal design and considering uses for the material.

It is unlikely that a large excavator will be able to safely travel on all of the soft impounded sediment planned for excavation. A haul road of gravel may be needed as a work platform for heavy machinery. A long excavation boom is recommended, and pontoons (i.e., large timbers or poles) or truck mats (e.g., metal plates, timber mats, or tire mats) may be used to create travel paths and work areas for machinery.

Summary

The Clark Saw Mill Dam and old mill works are in ruins and need to be removed to improve public safety and to prevent a large, sudden release of sediment and unchecked erosion of the channel. The dam removal will likely initiate channel change as natural sediment transport resumes, especially in the area just upstream of the existing dam. Floodplain inundation will likely decrease, yet the channel may build back up behind the likely waterfalls that will exist in the area to maintain a similar level of floodplain access. Some bank stabilization may be needed if minor loss of land is not acceptable. A phased dam removal with incremental sediment removal is recommended.

The removal will likely require the following permits:

- State of Vermont Authorization to Construct or Alter a Dam Permit (Dam Order, 10 V.S.A Chapter 43 of the Vermont State Statutes)
- United States Army Corps of Engineers General Permit (Section 404 of the Clean Water Act)
- Local floodplain permit to meet the requirements of the National Flood Insurance Program

A summary of some of the next steps toward dam removal follows.

1. Conduct public outreach to discuss the findings of this study and seek consensus for dam removal.
2. Perform probing with a drill rig and visual structural assessments of the bridges and floodwall in the project area in relation to predicted channel bottom elevation.
3. Conduct a survey of the site.
4. Review the ongoing historic preservation study being administered by the Vermont Division of Emergency Management and Homeland Security and take the necessary steps to attain a clearance for cultural resources.
5. Perform borings at the site near the dam and upstream of the dam to try and refine the location of the historic channel bed.
6. Design and permitting
7. Bid and construction

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APPENDIX A

RAPID DAM SAFETY ASSESSMENT AND PHOTOGRAPH LOG
CLARK SAW MILL DAM
CABOT, VERMONT

RAPID DAM SAFETY ASSESSMENT
Inspector: BMC/MMG Location: Cabot, VT Description: On Winooski River approximately 225 ft upstream of Saw Mill Rd Date: 5-May-16 Weather Conditions: high rain, ≈40°F
3 acres (VT Dam Inventory)
3 ft
17 ft/115 ft
14 ft/70 ft
stone masonry/concrete dam founded on bedrock outcrop
135 ft (VT Dam Inventory)
16 acre-feet at spillway crest, 2 ac-ft at dam crest (VT Dam Inventory)
21.5 square miles
poor condition
wing on both dam abutments where sediment has accumulated, and roots/grass observed growing in joints of stone masonry
end of the right (looking downstream) dam abutment, burrows observed near right training wall/former building foundation
of the dam appears to be canting significantly in a downstream direction indicating a potential for failure by overturning
eepage observed through the stone masonry and under and between the stone masonry at the interface with the bedrock outcrops
none observed
found to be in poor condition, stones appear to have been dislodged near the top of the dam
concrete cap above the stone masonry in poor condition with spalling observed and portions of the cap missing
cracking in concrete cap observed
[illegible] in front of the wall within the impoundment
poor condition, crest of spillway failing and portions of concrete cap missing or dislodged
rete cap was observed along the left (looking downstream) portion of the crest, portions of cap missing concentrating flow
one masonry in poor condition, appears to have been capped in concrete at some point in time to raise the crest elevation
concrete spalling was observed, portions of concrete cap missing
oderate to significant cracking observed, especially where concrete cap has been damaged and where portions are missing
none observed
appears concrete cap may have been fitted with flash boards at some point in time, however no longer functional

Project Name: Clerk Sewell Mill Dam
Project No.: 57290.01
Dam ID: VT #39.04

Physical Properties	
Impoundment Area:	
Freeboard:	
Dam Height / Width:	
Spillway Height / Width:	
Embankment Material:	
Embankment Width:	
Storage Capacity:	
Drainage Area:	

Dam/Embankments	
General Conditions:	
Vegetative Cover:	vegetation observed gro
Erosion/Burrows:	erosion observed around the and along the riverbank
Settlement/Alignment/Movement:	downstream face
Seepage/Foundation Drainage:	s
Riprap:	
Stone Masonry:	
Concrete Condition:	
Cracks:	
Other:	a former retaining wall or building foundation exists t are overgrown with vegetation, land behind walls

Spillway/Training Walls/Apron	
General Conditions:	
Settlement/Alignment/Movement:	a low point in the conc
Stone Masonry:	st
Concrete Condition:	
Cracks:	m
Scouring/Undermining:	
Other:	

RAPID DAM SAFETY ASSESSMENT
Inspector: BMC / MMG Date: 5-May-16 Location: Cabot, VT Weather Conditions: light rain, ±40°F Description: On Winooski River approximately 225 ft upstream of Saw Mill Rd
xtending ~20ft away from dam. held up by boulders/masonry stone acting as a tailwater control for normal water surface
y debris lodged on dam crest extending into downstream channel and lodged with downstream channel and vegetated island
no formal riprap observed
none observed
n/a
n/a
n/a
n/a
n/a
n/a
n/a
n/a
n/a
none observed
n/a
n/a
n/a
n/a
n/a
n/a
n/a
n/a
n/a

Project Name: Clark Saw Mill Dam Project No.: 5729-01 Dam ID. VT #39.04	
D/S Channel	
Scouring:	scour pool at downstream face
Debris:	wood
Riprap:	
Emergency Spillway	
General Conditions:	
Vegetative Cover:	
Erosion/Burrows:	
Settlement/Align./Movement	
Seepage/Foundation Drainage:	
Riprap:	
Stone Masonry:	
Concrete Condition:	
Cracks:	
Other:	
Outlet Structure(s)	
General Conditions:	
Vegetative Cover:	
Erosion/Burrows:	
Settlement/Align./Movement	
Seepage/Foundation Drainage:	
Riprap:	
Stone Masonry:	
Concrete Condition:	
Cracks:	
Other:	

RAPID DAM SAFETY ASSESSMENT

Inspector: BMC / MMG Date: 5 May, 16

Location: Cabot, VT Weather Conditions: Light rain, 40°F

Description: On Winooski River approximately 225 ft upstream of Saw Mill Rd

poor condition
n/a
n/a
er penstock is unsupported along much of its length and has become disconnected from the intake opening through the dam
seepage observed at intake opening through the dam
none observed
med with stone masonry along the downstream face. opening remains however sediment and debris is clogging he dam in the impoundment
n/a
n/a
e clogged with debris and sediment. creating a hazard in the impoundment upstream. If the clog were to rain rapidly causing a safety hazard.
n/a
n/a
former mill building located on river right (looking downstream) is in poor condition and portions have collapsed

Project Name: Clark Saw Mill Dam

Project No.: 5729-01
Dam ID. VT #39.04

Intake Structure	
General Conditions:	
Vegetative Cover:	
Erosion/Burrows:	
Settlement/Alignment/Movement	form
Seepage/Foundation Drainage:	
Riprap:	
Stone Masonry:	intake opening through the dam for the intake on the upstream side of t
Concrete Condition:	
Cracks:	
Other:	intake opening through the dam has become release suddenly. the impoundment could d
Miscellaneous Features	
Access, Roads, Bridges, etc.	
Safety, Fencing, Railings, etc.	
Structures, buildings, etc.	

Overview of Clark Saw Mill Dam from downstream channel looking towards the right abutment.

Overview of Clark Saw Mill Dam from downstream channel looking towards the left abutment.

Close up view of the dry - stacked stone masonry with seepage and vegetation growing in joints and on spillway crest.

Close up view of the concrete cap along the dam spillway showing missing concrete.

View of left spillway and abutment of dam founded on bedrock.

Close up of the left end of the dam, note seepage at the base of the stone masonry along the bedrock and vegetation growing on top of the structure.

View across the face of the dam looking towards the right abutment at the former penstock. Note bedrock dipping away and pool just downstream.

Right portion of dam with missing section of spillway. Note large boulders in foreground controlling downstream pool elevation. Penstock in background is unsupported along much of its length and has become dislodged from the intake opening through the dam.

Close up view of penstock unsupported along much of its length. End of penstock resting on bedrock. Note log lodged along the top of the
spillway crest.

Close up of the penstock

dislodged from the former intake opening through the dam. Note vegetation growing within the joints of the stone masonry.

View of penstock formerly used to supply stored water to the mill.

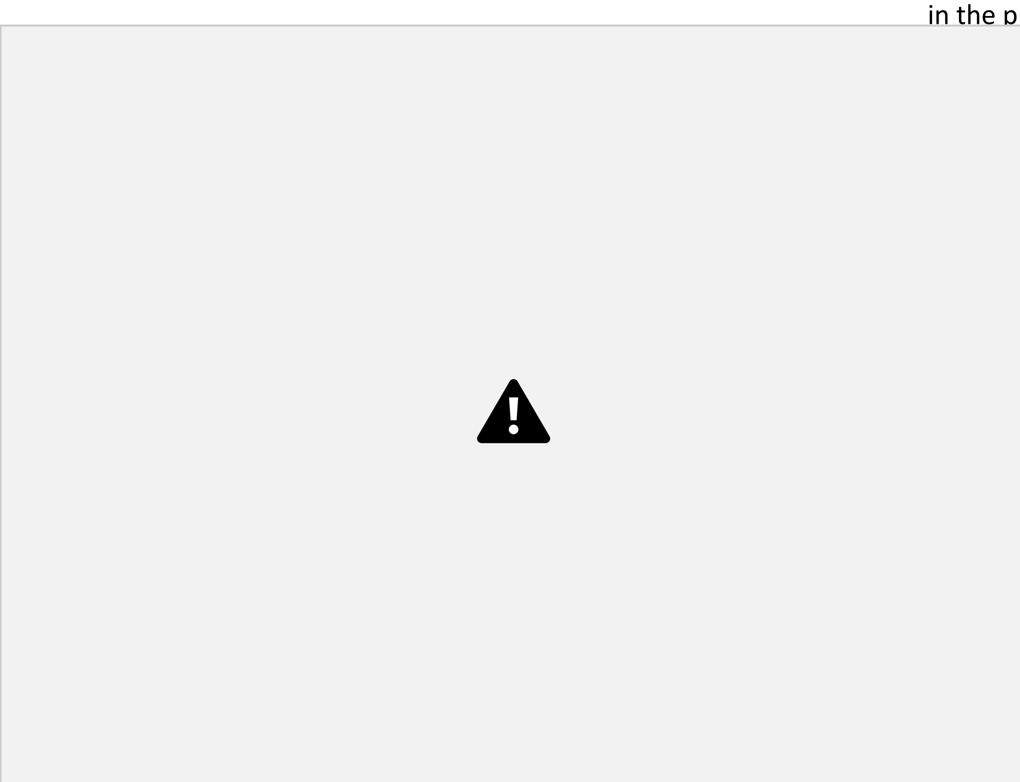
View of pool, control section, and

island
downstream of dam. Former mill building visible in the background.

View of downstream channel looking towards the Saw Mill Road Bridge.

View of downstream channel looking towards the Clark Saw Mill Dam from the Saw Mill Road Bridge.

View of spillway crest looking left from the right abutment. Note woody debris lodged on the spillway crest, voids and displaced portions of the spillway crest, and heavy vegetation growing on top of the left portion of the dam. Former intake now clogged with sediment and debris is located just upstream of the dam at the end of the log visible in the photo.



View of impoundment upstream of the dam looking towards the confluence with Jug Brook.

View of impoundment upstream of the dam looking towards a large existing wet area located on the left overbank just upstream of the dam.

View of training wall or former foundation located at the right dam abutment upstream of the spillway. Sediment has filled in behind the spillway and training wall and become overgrown with vegetation. Former intake now clogged with sediment and debris is located nearby.