Multi-Year Habitat Monitoring at Johnsons Mill Dam Removal – 2023 Annual Report

STONE ENVIRONMENTAL

PROJECT NO.

19-093

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Cover Photo: Bogue Branch looking downstream at former dam location.

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1. Introduction

The Johnsons Mill Dam removal was completed in August 2021. Prior to full removal, the dam was partially breached during a 100-year storm event that occurred on October 31, 2019. The dam was constructed of stone and concrete, and was located along the Bogue Branch in Bakersfield, Vermont. The Bogue Branch is a tributary to the Tyler Branch which flows into the Missisquoi River. The watershed area draining to the Johnsons Mill Dam location (44.83141, -72.75578) is 8.63 mi^2 (StreamStats, 2019). A majority of the watershed is forested, with only 2% considered developed land (StreamStats, 2019).

Post-removal monitoring is being completed along the Bogue Branch to improve our understanding of aquatic organism habitat following dam removal. This will also address knowledge gaps related to a removal design that had a minimal amount of sediment removed from the upstream impoundment prior to dam removal. Monitoring will take place annually over the course of four years and include streambed analysis, topographic and bathymetric surveying, woody debris evaluation, plant survival and coverage assessment, algal analysis, and macroinvertebrate analysis. Data collected will allow us to assess changes in stream habitat over time and increase our understanding of post-dam removal dynamics. This report summarizes the monitoring methods and results for 2023, the second year of monitoring.

2. Monitoring Data Collection & Analysis Methods

The monitoring reach extends from Witchcat Road near the intersection with Joyal Road to just north of 1505 Witchcat Road, as shown in Figure 4. The monitoring reach is subdivided into three sub-reaches numbered from upstream to downstream. Reach 2 correlates to the limits of disturbance during dam removal (Figure 1, Figure 4). Year two streambed sediment, wood recruitment, and vegetation monitoring were performed on October 11, 2023, using a combination of ESRI Field Maps, Survey 123, and a Trimble R2 GPS unit. Monitoring locations are shown in Figure 1. Drone Imagery was collected by Stone Environmental on January 9th, July 17th, and October 26th, 2023, and by Whiteout Solutions on June 12, 2023.

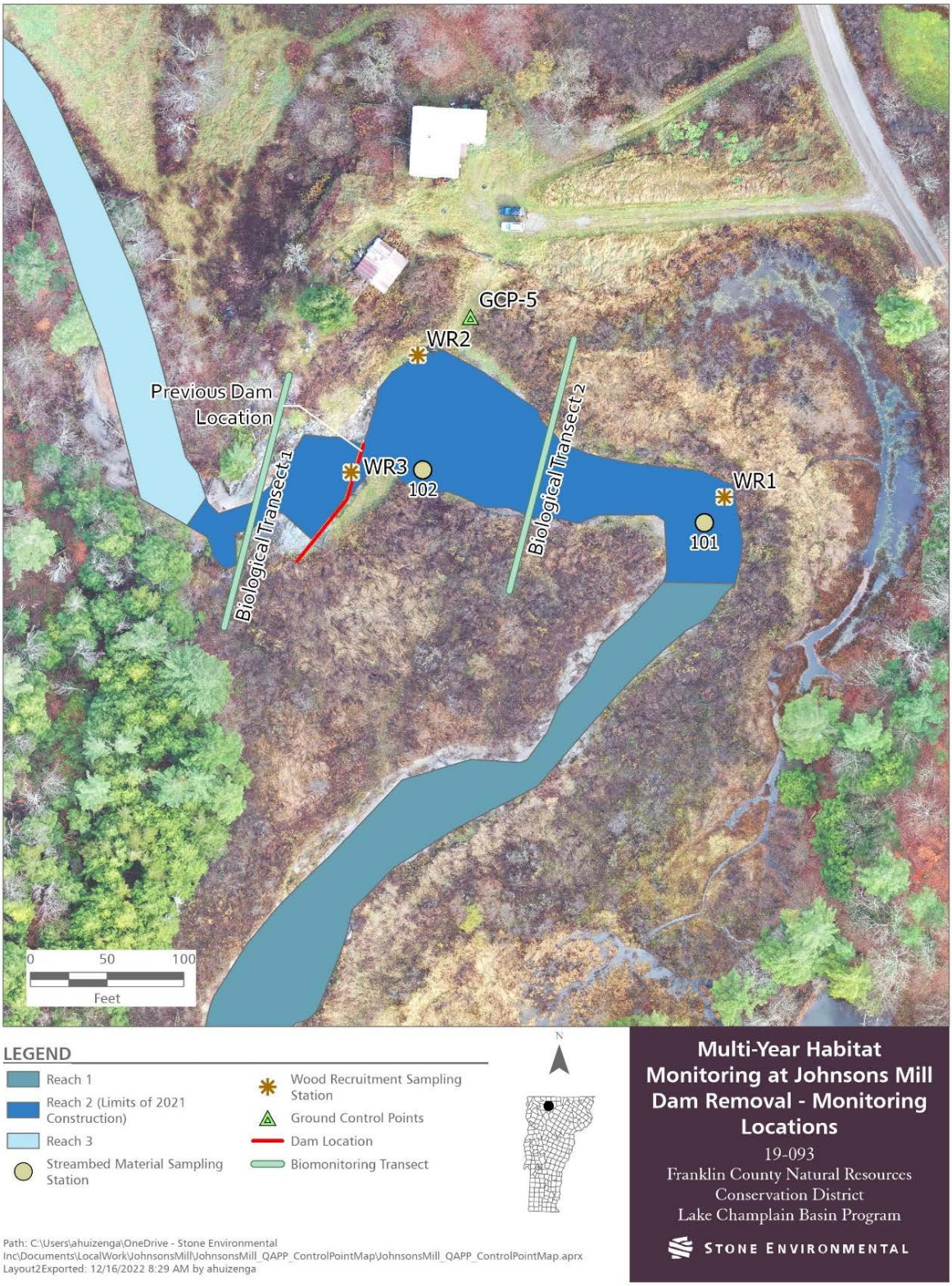

Figure 1. Wood recruitment, sediment sampling, and biological sampling locations established during year one (2022) monitoring and revisited during year two (2023) monitoring.

2.1. Streambed Material Analysis

Stone staff collected streambed material data at two locations on October 11, 2023: Site 101 and 102, representing different habitat types within Reach 2 (See Figure 1 for locations). The same locations were also assessed during year one (2022) monitoring. At each location, Stone staff completed pebble counts using the Wolman pebble count method to determine grain size distributions. After pebble counts were completed, visual and tactile assessment methods were used to determine relative percentages of material beneath the surficial armor layer at one location toward the center of the channel at each streambed monitoring location. Each habitat feature, or monitoring location, was inspected for roughness boulders in accordance with the project Quality Assurance Project Plan (QAPP). Dimensions and angularity were recorded for each identified roughness boulder. Data were entered into ESRI Field Maps and Survey123 field forms and processed in MS Excel to determine grain size distributions and approximate percentage of materials. Photos were taken of each station.

2.2. Evaluation of Wood Recruitment

Wood recruitment is being monitored and evaluated within Reach 2. As explained in the year one (2022) monitoring report, initial monitoring plans consisted of assessing wood recruitment at the rootwad installations completed during construction. These installations were made along two meander bends within Reach 2 and are identified as WR1 (upstream) and WR2 (downstream) in Figure 1. Channel migration and incising that occurred following dam removal resulted in the disconnection of the downstream rootwad installation (WR2) from the main channel and suspension of the upstream rootwad installation (WR1) above the water surface. As a result, a third monitoring location (WR3) was identified while in the field on November 2, 2022. WR3 is located directly upstream of the prior dam location and consists of a timber cribbing that was uncovered following dam removal and has begun to recruit wood. These stations were revisited for monitoring on October 11, 2023.

The following data were collected for each wood recruitment monitoring station:

- Embeddedness in bank (distance from tag to bank) (only applicable for installed rootwads at WR1 and WR2)
- Tag ID
- General condition
- Count, length, diameter, and tag ID of recruited wood
- Photos

Natural woody debris and timber logs greater than 3" in diameter within bankfull width were also tagged, measured, and recorded in ESRI Field Maps and Survey123. Blue metal tags were affixed near the collar of the rootwads or one end of a timber log using nails (Figure 2 and Figure 3). Qualitative notes regarding the potential source of woody debris were recorded (i.e., natural recruitment vs timber log). The total count and distribution of wood length and diameters were quantified in MS Excel. Maps were created using ArcPro 3.1.2 to depict the location and relative characteristics of rootwads and tagged wood in the channel within Reach 2.

Figure 2. Stone staff tagging and collecting GPS locations of wood at monitoring station WR3.

Figure 3. Image of an installed rootwad at WR2 with the blue metal tag highlighted with a blue circle.

2.3. Evaluation of Plant Survival and Coverage

Plant communities were initially assessed on November 2, 2022, and reassessed during the second year of monitoring on October 11, 2023. Stone staff walked from the prior dam location upstream to the beginning of Reach 1 to identify plant communities, tree stands, and individual trees within 30 feet of the channel along

river left and river right. Plant and tree stands were delineated using the GPS unit. The following data were recorded as appropriate for each stand and individual tree:

- Leaf condition
- Stem condition
- Evidence of pests and/or disease
- Species composition
- GPS coordinates
- Photos

2.4. Aerial Imagery

Stone staff collected aerial imagery of the AOI on three occasions in 2023. This imagery provides data on changes that may occur between the annual geospatial data collection completed by Whiteout Solutions and described in Section 2.5. Stone staff collected aerial imagery using a DJI Mavic 2 Pro drone flown at an elevation of approximately 350 ft. Imagery was collected on January 9, 2023, July 17, 2023, and October 26, 2023. Images were processed and orthorectified using DroneDeploy. Due to batteries that lost power earlier than expected, only a portion of the AOI was captured on July 17, 2023. The resulting orthomosaic and digital terrain model (DTM) will be shared with FCNRCD and are presented in maps within this report.

2.5. Topographic, Bathymetric, and Vegetation Indices Surveys

2.5.1. Data Collection

Beginning in 2023 (second monitoring year), Whiteout Solutions collected geospatial data using a fleet of unmanned aerial vehicles (UAVs). The geospatial data collected included topographic, bathymetric, and vegetation indices for the 84-acre area of interest (AOI) shown in Figure 4. Vegetation data (including NDVI imagery) and topographic data were collected using a drone on June 2, 2023. Topobathy data were collected on June 20, 2023.

Prior to collecting geospatial data with UAVs, Stone staff established ground control points (GCP) GCP-1, GCP-2, GCP-3, GCP-5, and GCP-6 as seen in Figure 4. Whiteout Solutions reestablished these GCPs in 2023 to establish the vertical and horizontal datum. Ground control points are 24" lengths of 3/8" rebar driven into the ground with an orange cap flush at existing ground elevation. Grade stakes with survey flagging were also driven adjacent to the ground control points to aid in locating the control in the future.

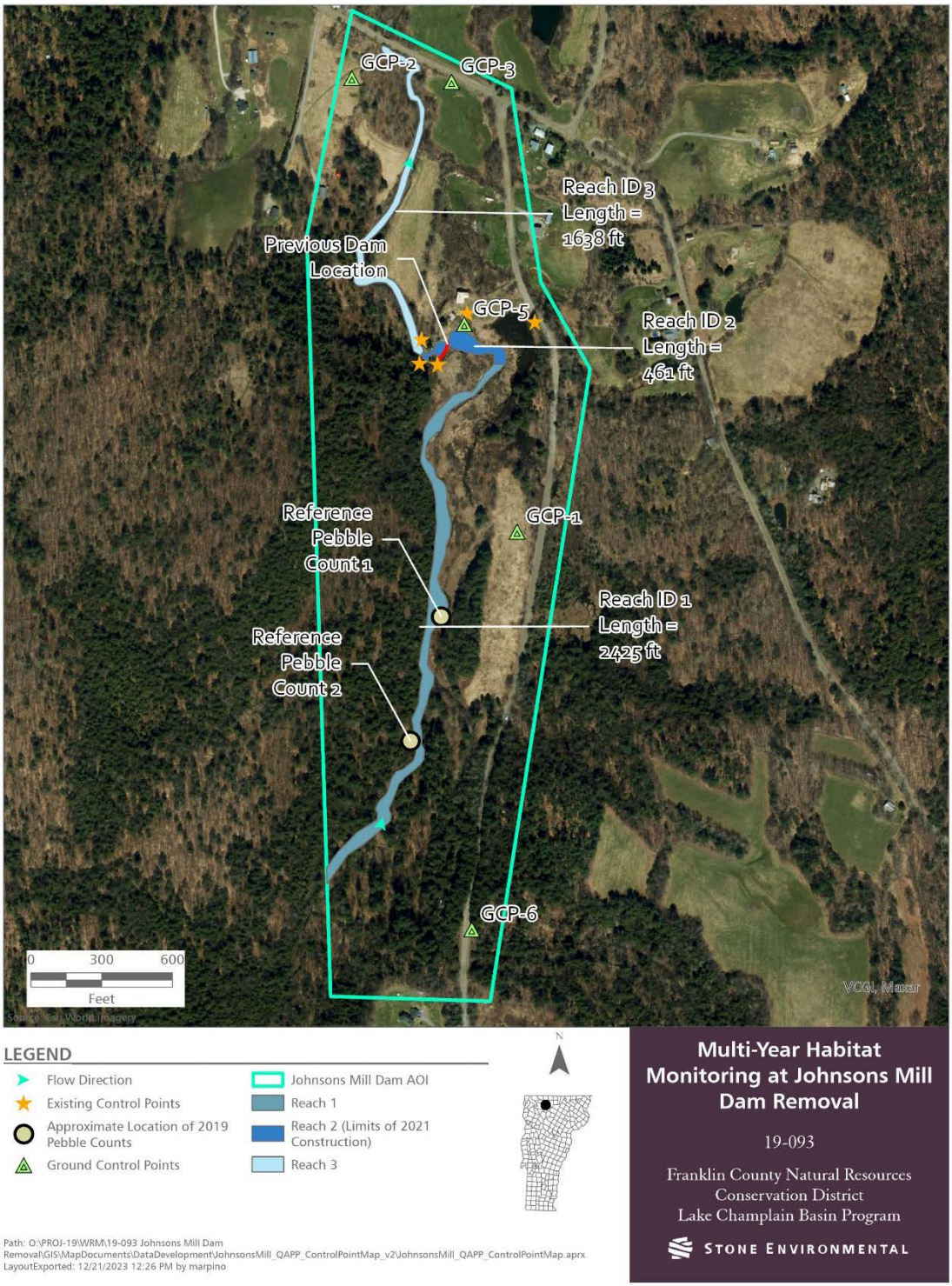

Figure 4. AOI and monitoring reaches identified for multi-year monitoring.

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2.5.2. Topographic and Bathymetric Data Analysis

The availability of topographic and bathymetric data from multiple points in time pre- and post-dam removal makes it possible to assess changes over time at the Johnsons Mill site. However, the available data collected prior to 2023 were not all collected in the same datum, for the same extent, or using the same methods. The available datasets are summarized in Table 1.

Table 1. Summary of Available Datasets

Surface No.	Collection Details	Type	Description
0	December 2019, Stone Environmental	Total Station Survey	Pre-dam breach existing conditions surface
1	January 2020, Stone Environmental	Total Station Survey	Post-dam breach existing conditions surface
2	August 2021, Stone Environmental	Total Station Survey	As-built survey data used to create a DEM
3	April 2022, University of Vermont	Topographic Lidar Only	Post-dam removal lidar for entire 84-acre AOI
4	June 2023, Whiteout Solutions	Topographic and Bathymetric Lidar	Monitoring geospatial data collection using UAVs for the entire 84-acre AOI

Beginning in 2023, the datasets were reviewed and processed to allow initial comparisons of the DEMs. Each dataset was imported into ArcPro 3.1.2 and transformed to match the projection and datum of the Whiteout Solution topographic and bathymetric data. Once the DEMs were in the same project and datum, longitudinal profiles and channel extents were traced to assess vertical and lateral channel adjustments. Additionally, the DEMs created from the pre-breach, post-breach, and post-dam removal survey data are being compared using the cut fill tool in ArcPro 3.1.2 to estimate the volume of sediment released during the dam breach, the volume removed during construction, and sediment transport during the monitoring years. These methods and results will be described in subsequent monitoring reports and in the final monitoring report. One limitation of this comparison is the represented extent as the survey data does not extend upstream of the former impoundment.

2.6. Algal Analysis

Algal data collection was completed in Fall 2023 by Avacal Biological Consulting.

2.7. Macroinvertebrate Analysis

Macroinvertebrate surveys were completed in Fall 2023 by Avacal Biological Consulting.

3. Monitoring Results

3.1. Streambed Material Analysis

Figure 5 presents grain size distribution plots developed using the pebble count data collected at one pool (Site 101) and one riffle (Site 102) within Reach 2 from the 2022 and 2023 monitoring events. Grain size distributions calculated using pebble count data collected in 2019 from riffles in the reference reach (a portion of Reach 1) are provided for comparison. Reference reach pebble counts were completed on October 21, 2019, prior to the dam removal. In 2022, the dominant particle size in the pool (Site 101) was 11.3-16 mm, while the dominant particle size in the riffle (Site 102) was 32-45 mm. In 2023, the dominant particle size in the pool was sand (<2 mm) and silt (<0.0625 mm). This change is likely due to deposition of finer material and the accumulation of finer sediment from the adjacent river right bank due to bank slumping and failure. The dominant particle size in the riffle remained unchanged from 2022, indicating that the streambed may be stabilizing at the location.

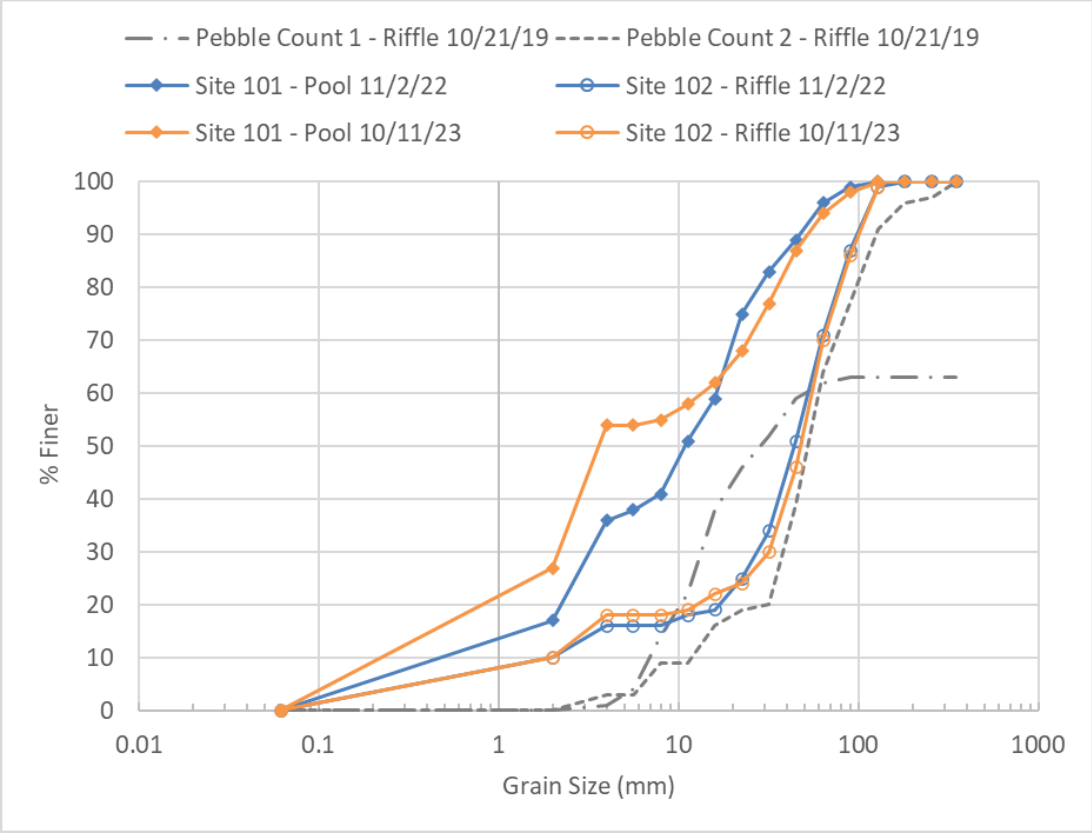


Figure 5. Cumulative grain size distributions pre- and post-removal. Note, pre-removal (2019) pebble counts were completed in the upstream reference reach (see Figure 4 for approximate location) and not at the same locations as the sediment sampling stations established for multi-year monitoring.

During the 2023 monitoring, no roughness boulders were identified in the pool sediment sampling location (Site 101). This was consistent with the year one (2022) monitoring results. One roughness boulder was identified in the riffle (Site 102), compared to four in 2022. It is possible that the previous year's roughness boulders were mobilized during high flood events in 2023 or buried by finer sediment transported from upstream. Roughness boulder characteristics for year one and year two are summarized in Table 2.

Table 2. Roughness boulder characteristics observed within the riffle at streambed monitoring Site 102

Year	Count	Length (in)	Width (in)	Height (in)	Embeddedness (%)	Angularity
2022	1	520	360	300	50	Sub-rounded
	2	350	170	140	0	Sub-angular
	3	280	130	100	5	Sub-rounded
	4	300	155	120	25	Sub-angular
2023	1	470	310	170	50	Sub-angular

Results of the visual and tactile assessment of sediment beneath the surficial armor layer are summarized in Table 3. Photos are provided in Figure 6. Gravel was the dominant sediment type at both locations, followed by sand at the pool and particle sizes smaller than sand below the riffle surficial armor layer.

Table 3. Summary of visual and tactile assessment results for sediment below the surficial armor layer

Year	Location	Gravel (%)	Sand (%)	< Sand (%)
2022	Pool (Site 101)	75	20	5
	Riffle (Site 102)	70	10	20
2023	Pool (Site 101)	33	33	33
	Riffle (Site 102)	50	25	25

Figure 6. Photographs of the sediment below the surficial armor layer at Site 101 (left photo) and Site 102 (right photo).

3.2. Evaluation of Wood Recruitment

Evaluation of wood recruitment included assessing installed rootwads and naturally recruited woody debris within the channel. Figure 7 provides the spatial distribution as well as relative size of tagged woody debris and rootwads within Reach 2.

Each rootwad installment, WR1 and WR2, was inspected during the 2023 monitoring event. Rootwad embeddedness was measured by measuring the distance from the blue metal rootwad tag to the bank. On the day of data collection, Stone staff observed that all of the rootwads from WR1 have been dislodged from the bank (Shown with red circles in Figure 7). Three of the five rootwads were found downstream (migration shown with arrow from red circle indicating original location in Figure 7), while two were not recovered and assumed to have migrated out of the monitoring reach. There had been little to no change at WR2, likely due to the disconnection of these rootwads from the main channel.

In 2023, no new wood was recruited at the WR1 and WR2 locations due to the migration of the channel and bank failure disconnecting or dislodging the installed rootwads. Two new pieces of wood were recorded near WR3 in 2023, likely uncovered pieces of wood from the former dam impoundment and possible pieces of timber cribbing. Possible considerations for the year three (2024) monitoring effort include walking the downstream reach to identify previously tagged woody debris that has moved downstream, and evaluating whether to continue monitoring wood recruitment at the WR1 location now that none of the original wood installments remain.

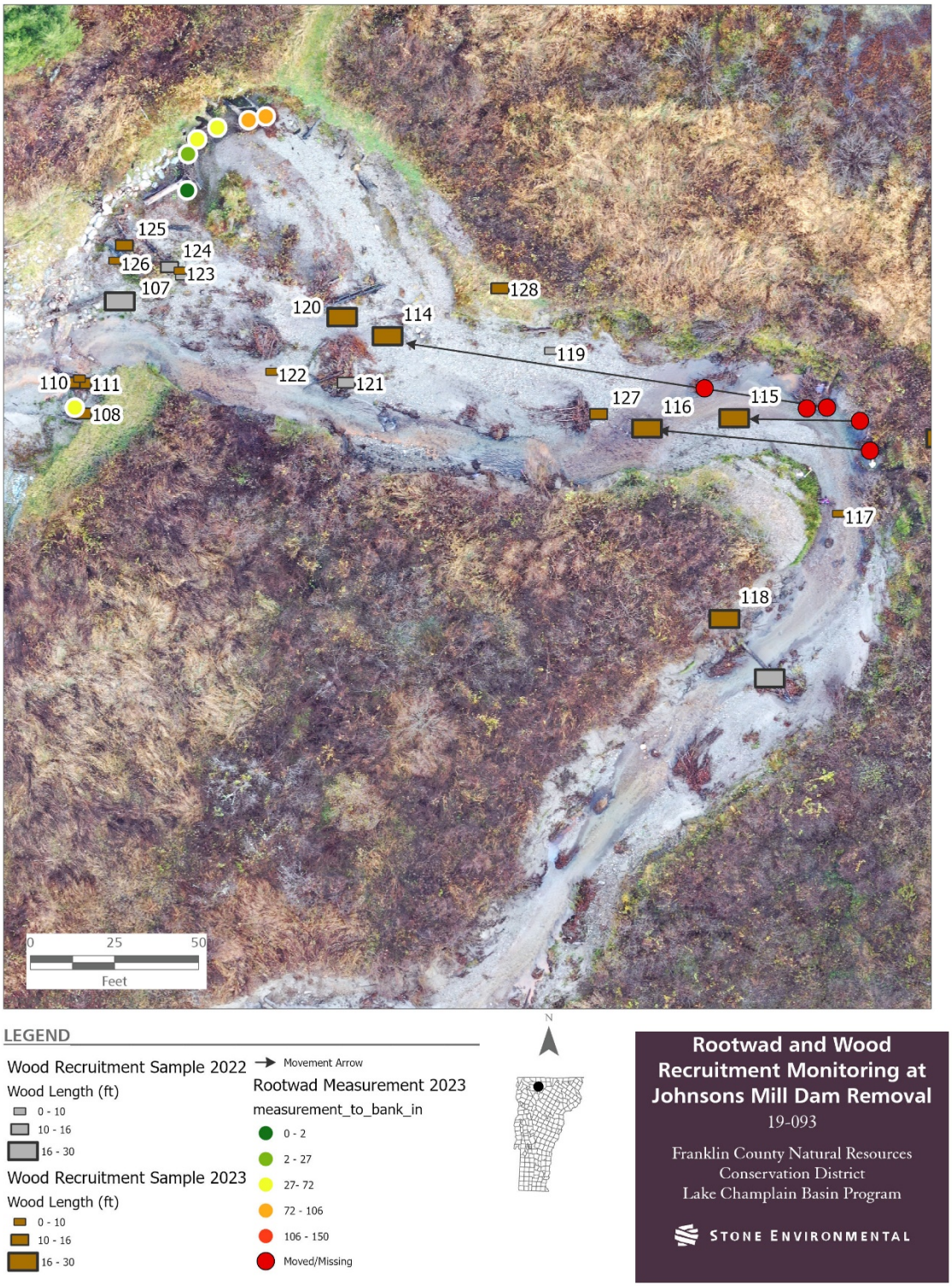


Figure 7. Spatial distribution of rootwads and channel recruited woody debris, along with relative embeddedness of rootwads and size of channel recruited woody debris.

As in 2022, most of the tagged woody debris pieces were timber logs that had previously been buried under the dam impoundment and may have been part of timber cribbing or other structures associated with the dam. These timber logs became exposed following dam removal and the subsequent channel adjustment. Figure 9 through Figure 11 summarize the dimensions and general locations of the wood debris greater than 3 inches in diameter and compare 2022 to 2023. Much of the wood logged in 2022 had migrated outside of the monitoring reach. Migration distances of woody debris from 2022 to 2023 are summarized in Table 4.

Most woody debris in 2023 was located along the right bank, approximately 12 to 18 feet in length, and 6 to 12 inches in diameter. The total volume of the recruited wood equaled approximately 350 cubic feet; however, these data include three rootwads now loose in the channel.

Table 4. Migration distances of woody debris from 2022 to 2023.

Wood Tag ID	Distance Downstream (ft)
107	Beyond monitoring reach
114	127
115	33
116	63
118	Half buried in left bank
119	Beyond monitoring reach
121	Beyond monitoring reach
123/124	Possibly buried

Figure 8. Original location of WR1 with no remaining rootwads in place.

Figure 9. Summary of wood length within the monitoring reach of the Bogue Branch.

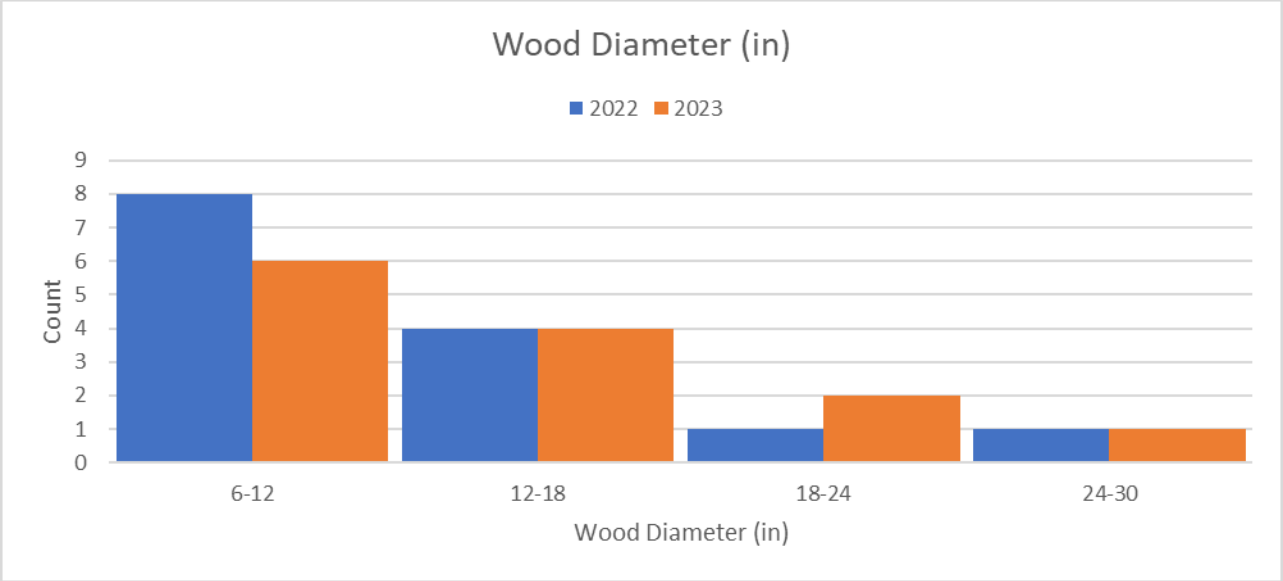


Figure 10. Summary of wood diameter within the monitoring reach of the Bogue Branch.

Figure 11. Summary of wood location within the monitoring reach of the Bogue Branch.

3.3. Evaluation of Plant Survival and Coverage

Plant survival and coverage were assessed to the best of Stone's ability using the initial 2022 assessment as a baseline. Each vegetation stand and mature tree identified was revisited and assessed for plant health. The 2023 assessment, summarized in Figure 13, shows the plant communities and general boundaries between assessed stands of similar vegetation. Stands are distinguished by changes in dominant vegetation type and generally extend to the monitoring extent of 30 feet from the top of bank. The main stands identified were "Planted Willow" (willows planted as part of the stream restoration project), "Natural Willow", "Mature Tree", and "Goldenrod/Grass". Mature trees were marked as individual stands so that their health can be monitored independently of the surrounding stand. Health was assessed using four assessment criteria: leaf

health, stem health, evidence of die-off, and evidence of pests. Then a general score of "GOOD", "FAIR", and "POOR" was given to a stand based on those criteria.

In general, the health of the vegetation communities in the monitoring reach is good. One issue noted was the presence of vines such as virgin's bower and bindweed on a number of the mature trees and woven through the willow stands. These vines were primarily observed on the river left floodplain area and had already enveloped one small tree that had been recorded in 2022 (Figure 12). Stand 6 (S6) and Stand 9 (S9), both mature trees, also showed signs of stress, potentially due to the presence of the vines.

The planted willows in S1 looked healthy and a number of volunteer native willows have spread in this area, while planted willows in S3 were not as healthy and showed signs of die-off. No beaver activity was observed during the 2023 monitoring event. Preliminary comparisons were made between the plant stands surveyed in the field and the Normalized Difference Vegetative Index (NDVI) data collected in June 2023 by Whiteout Solutions. In the NDVI dataset, negative values represent water, clouds and infrastructure, positive values near zero are bare ground, and values above zero to one represent vegetated areas with the higher the number indicating denser vegetation. The NDVI data is shown with surveyed polygons in Figure 14. The stand polygons do not exactly line up with the channel shown in red to yellow tones due to channel migration that occurred between the NDVI data collection and monitoring. Overall, the green tones representative of denser vegetation are consistent with the dense grasses and shrubs overserved in the overbank area.

Figure 12. Young alder tree in 2022 (left) and in 2023 (right)

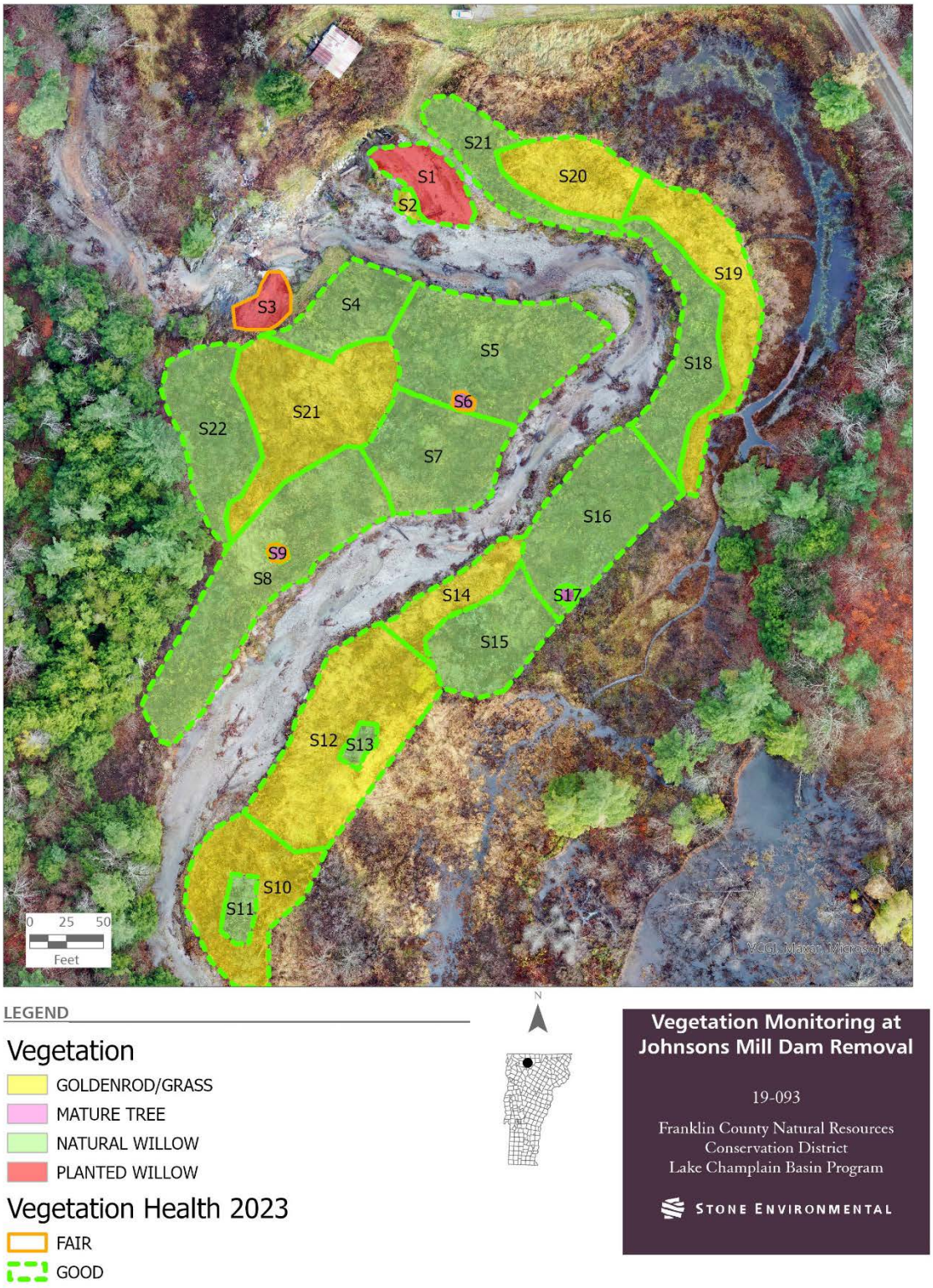


Figure 13. Map of dominant plant species in the monitoring reach of the Bogue Branch.

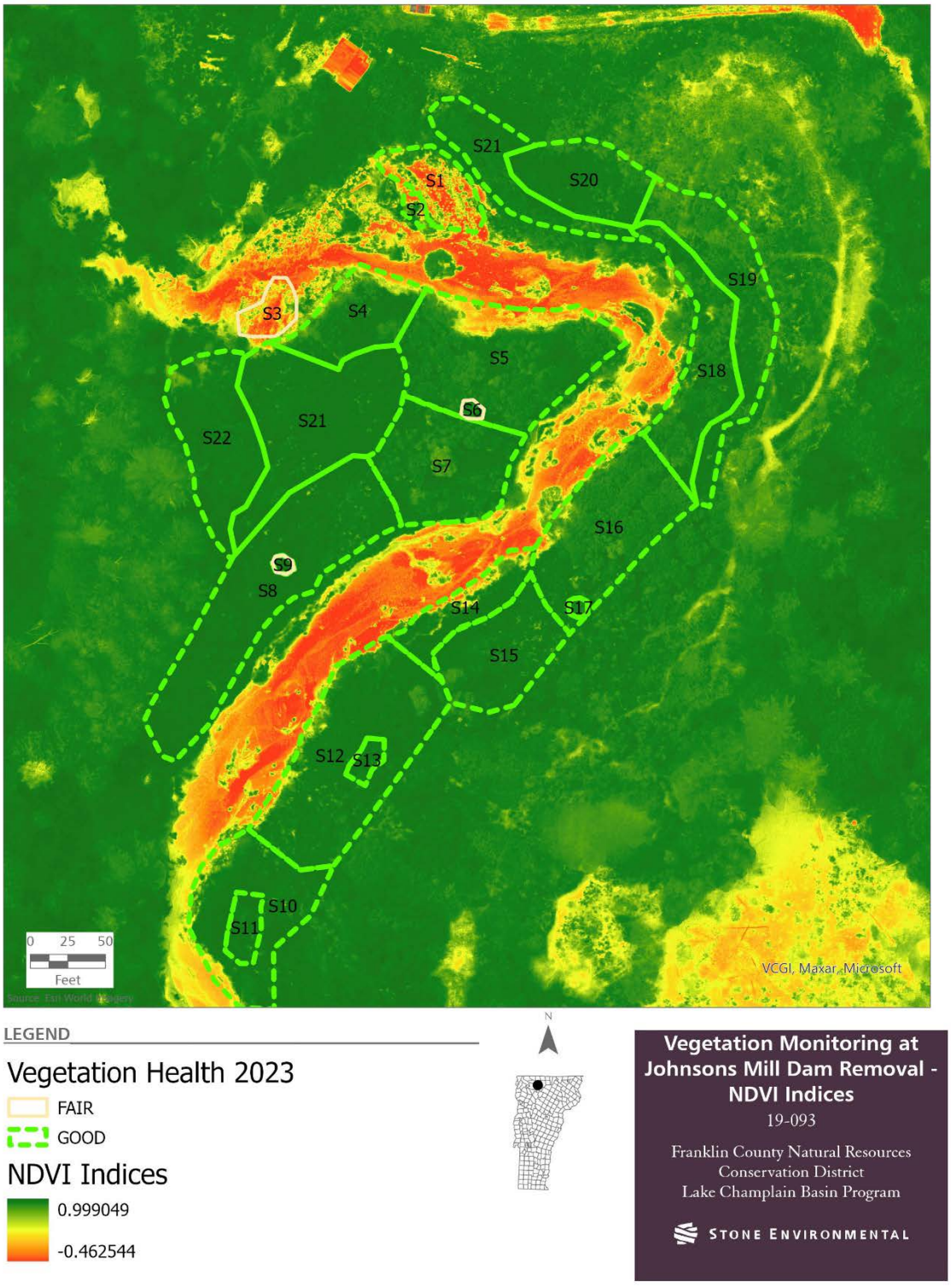


Figure 14. Vegetation monitoring stands assessed in October 2023 show with NDVI data collected in June 2023

3.4. Aerial Imagery

The aerial imagery collected on November 2, 2022, provides additional context for the field data collected on that day. The aerial imagery will be used as a baseline for tracking lateral channel migration and increase our understanding of seasonal changes within the monitoring reach. The processed orthoimage and DEM will be shared with FCNRCD. The aerial imagery was used as the basemap for Figure 7 and Figure 13. The boundaries of the 15-acre and 40-acre flight are provided in Figure 15. Aerial imagery from 2023 is compiled in Attachment 1.

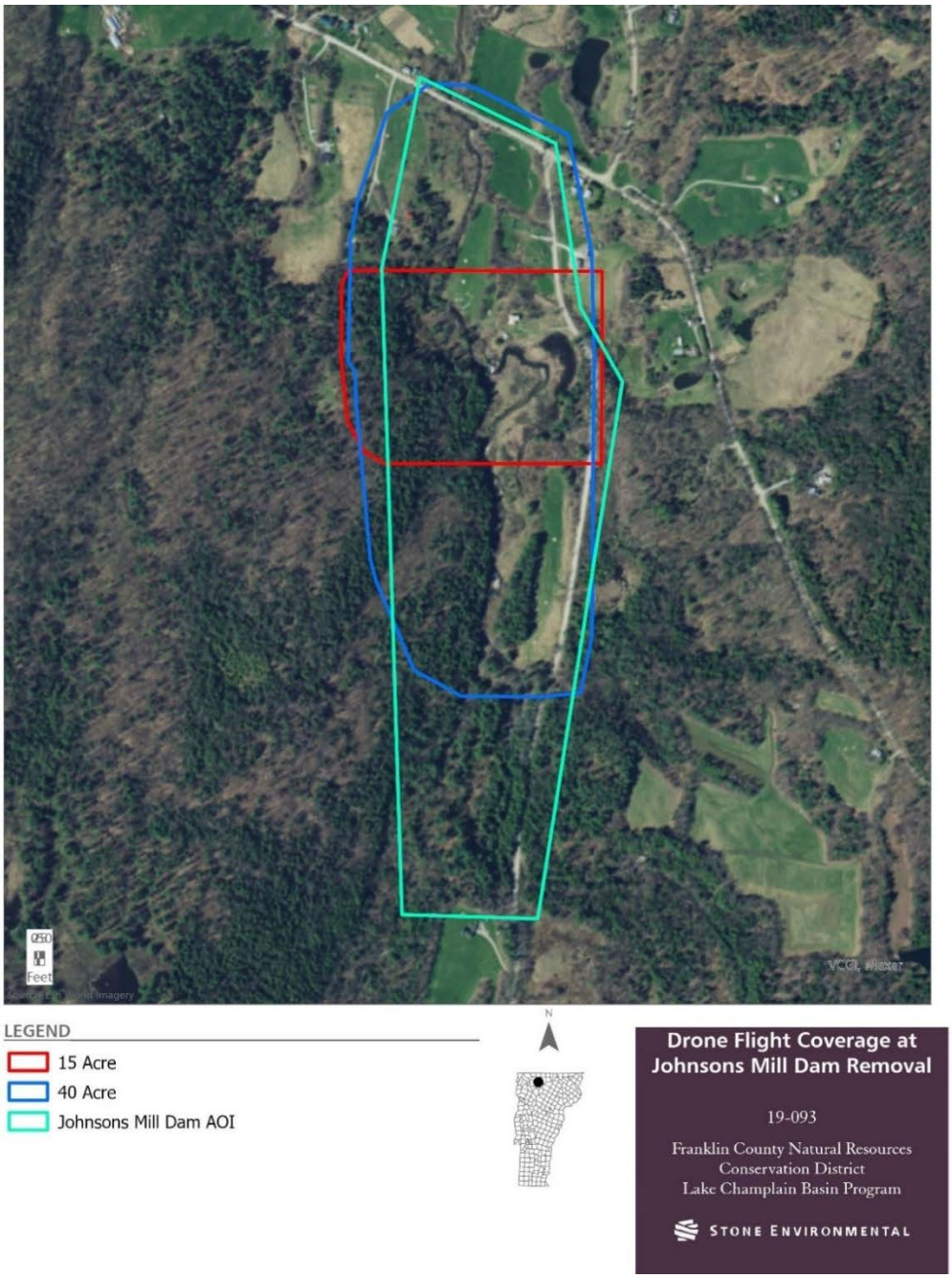


Figure 15. Map of initial drone flight extents as compared to entire AOI.

3.5. Topographic and Bathymetric Comparisons

In 2023, the available pre- and post-removal topographic and bathymetric datasets were reviewed to understand which datasets may be comparable to assess change overtime. Longitudinal profiles created from the DEMs representing pre-breach (2019) through post-removal (2023) conditions are shown in Figure 16. Due to low flow conditions on the day of collection, the lidar data collected by UVM in 2022 was able to be included in this analysis; however, it should be noted that the UVM UAV system was not equipped with a bathymetric lidar equipment and there may be more uncertainty in the thalweg elevations presented due to noise. These profiles provide information on the vertical adjustment of the channel, an approximately 3 ½ to 4-foot drop is seen immediately upstream of the dam and an approximately 3-foot drop at the upstream extent of the impoundment when comparing the pre-breach (2019) data to the year two (2023) elevation data. These changes are consistent with observations made in the field, and also represent the channel incision observed upstream of the original project limits of disturbance. Based on the DEM comparisons, it is estimated that approximately 1,480 cubic yards of impounded sediment was transported downstream following the dam breach in 2019 and prior to construction. Comparisons were not possible upstream of the upstream extent of the total station survey for these datasets; however, starting in 2023 the longitudinal profile will be extended through the entire 84-acre extent with the availability of topobathy data.

The pre-breach through 2023 DEMs and aerial imagery were also compared to assess lateral channel migration over time. These comparisons are shown in Figure 17 and depict the lateral migration of the pilot channel to the south immediately upstream of the former dam location. The figure was created by tracing the approximate water surface outline along each bank on the day imagery was collected. In this portion of Reach 2, the pilot channel cut off a meander bend originally included in the design, subsequently disconnecting wood recruitment station WR2. Not captured in this comparison, but visible in the seasonal aerial imagery collected in fall 2023, is the erosion of the bank where WR1 was installed. It is believed that this bank was likely eroded during the July 2023 flood.

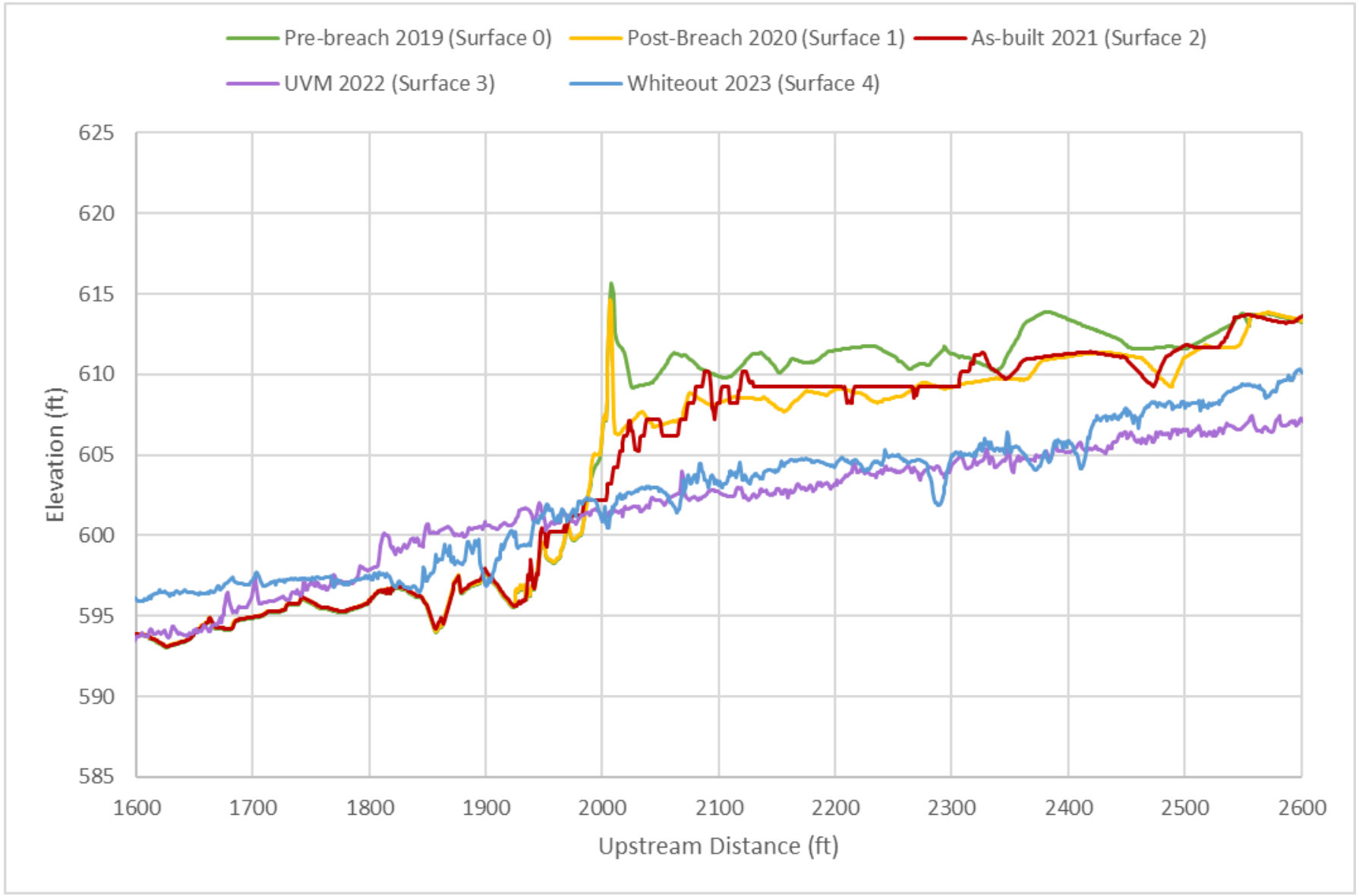


Figure 16. Longitudinal profile comparison of thalweg elevations within the dam removal design extents.

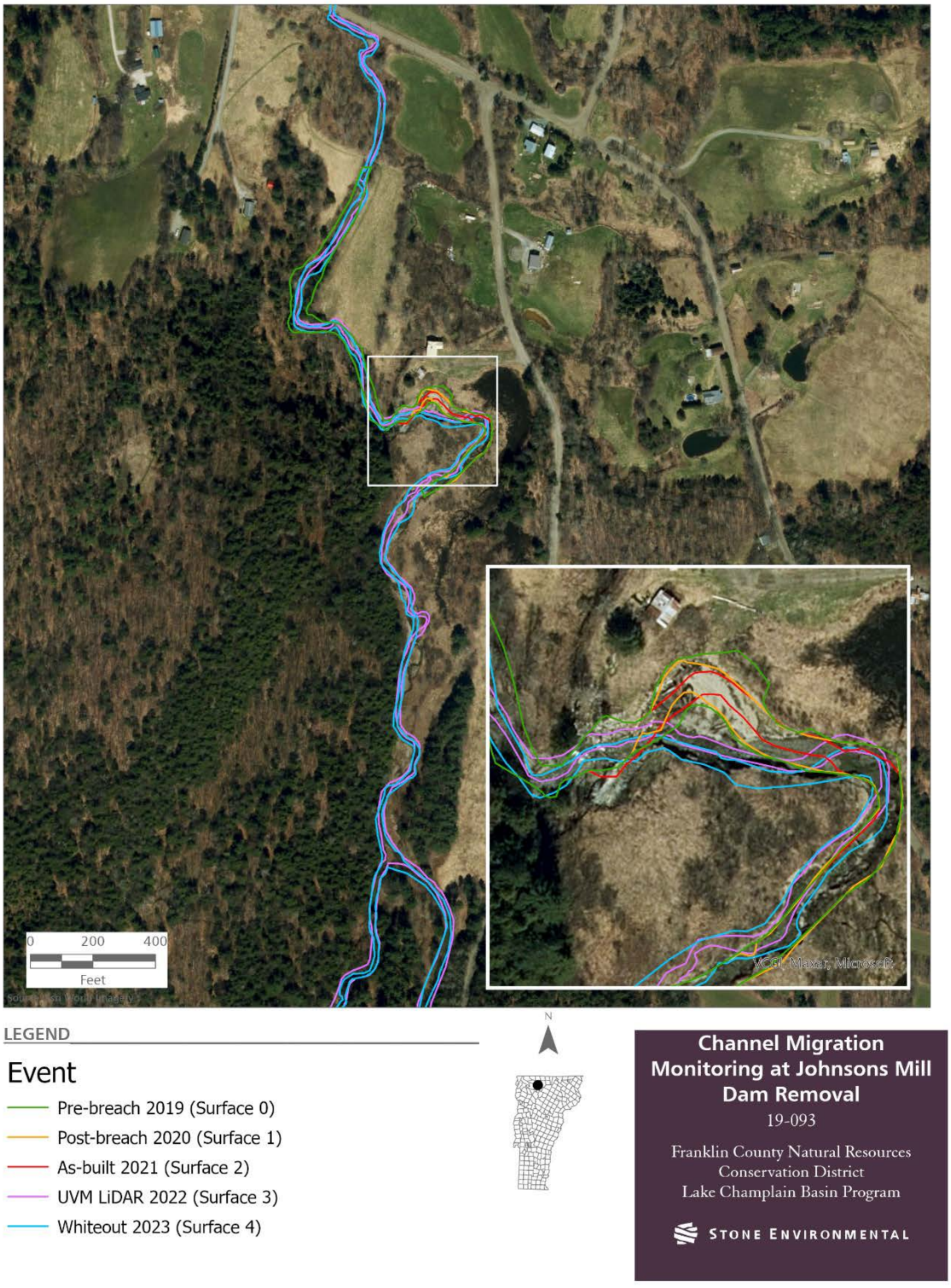


Figure 17. Map depicting lateral channel migration for the approximate water surface outline from pre-breach (2019) through to monitoring year two (2023).

3.6. Algal Analysis

Results of the algal analysis were summarized and provided in a separate report and data package from Avancal Biological Consultants.

3.7. Macroinvertebrate Analysis

Results of the algal analysis were summarized and provided in a separate report and data package from Avancal Biological Consultants.

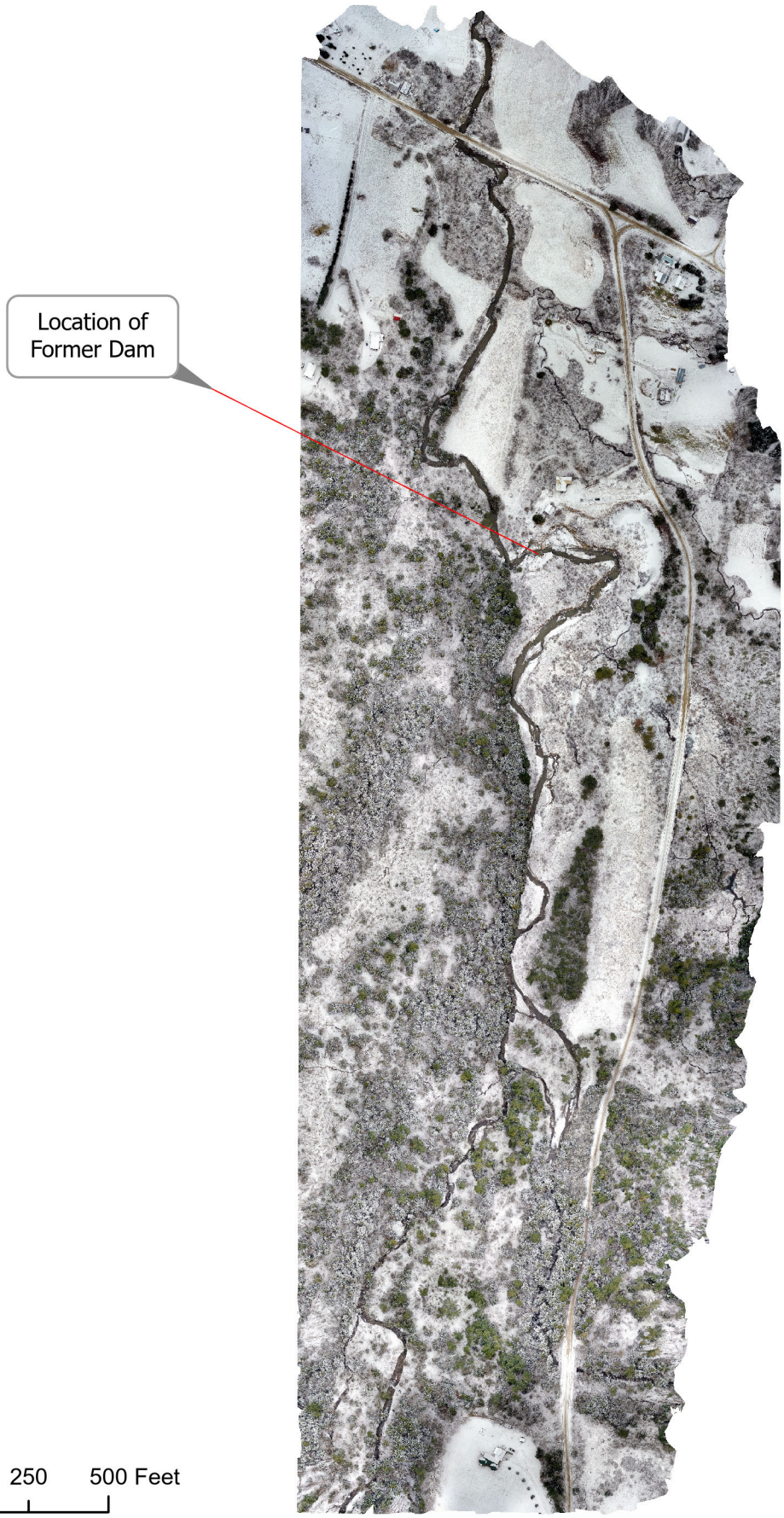
4. Conclusions

The 2023 monitoring data indicates that the Bogue Branch is continuing to adjust in and beyond the vicinity of the former Johnsons Mill Dam and dam removal project extents. These changes are attributable to the dam removal and pilot channel responses to significant flooding events, such as the Halloween 2021 and July 2023 floods. It is anticipated that the pilot channel will continue to adjust in 2024, with the potential for additional lateral migration and vertical incision of the channel as finer sediments are transported downstream and unstable banks continue to erode. However, the data suggests that much of the incision and sediment transport witnessed upstream occurred during the first-year post-dam removal. Monitoring in 2023 confirmed that the installed rootwads at both locations (WR1 and WR2) were no longer functioning as intended. Rootwads at WR1 had been dislodged from the bank and in some cases transported downstream, while the rootwads at WR2 remain disconnected from the main channel. These results suggest that it may be beneficial to allow a pilot channel to adjust prior to installing habitat features in dam removal projects where limited sediment removal is completed. This change may also present an opportunity to reevaluate how wood debris recruitment is assessed in the monitoring reach in subsequent years.

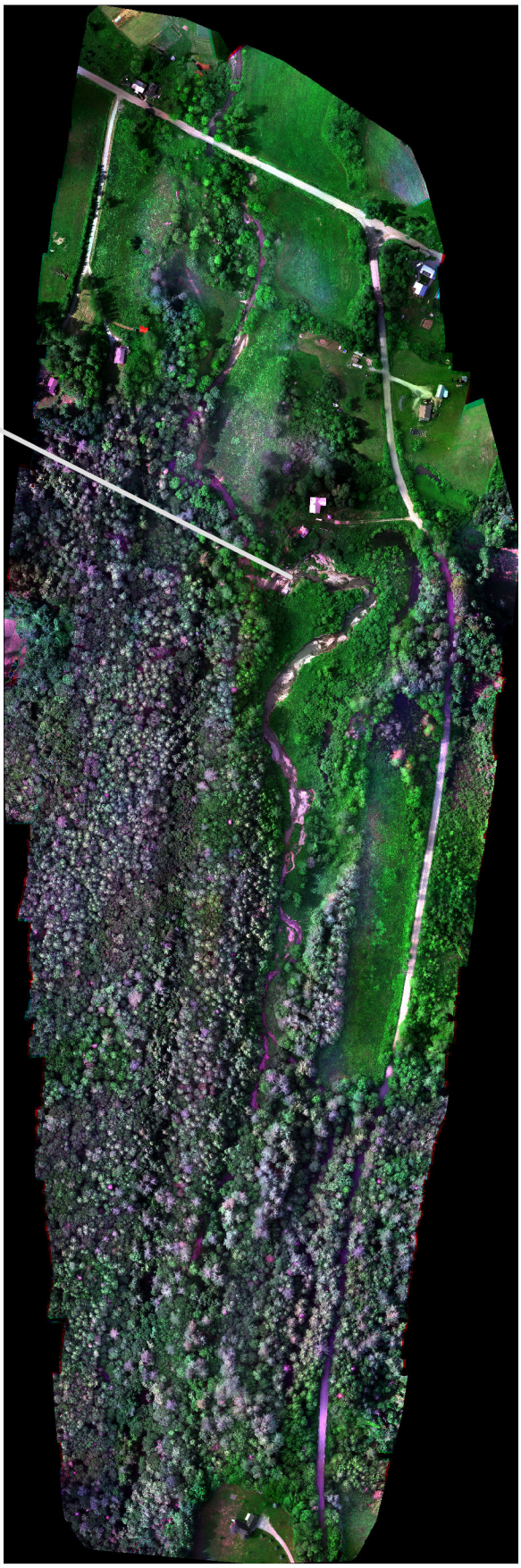
Based on the aerial imagery and monitoring data summarized in this report, the Bogue Branch and stream habitat features in the monitoring reach are also continuing to adjust. Woody debris and the formation of pools are providing habitat for aquatic organisms in the former impoundment. Subsequent annual reports will include a comparison to data collected in 2022 and 2023, as well as additional analysis of DEM and vegetation health data collected by UAV. The longitudinal profile extents will be extended to the entire 84-acre AOI in 2024, with the ability to compare two years of topobathy data. Overall, initial comparisons of streambed elevations show signs of deposition downstream of the former dam location, indicating that the restoration of natural sediment transport processes may be providing a source of sediment for a previously sediment starved reach of Bouge Branch.

Attachment 1: Orthoimagery

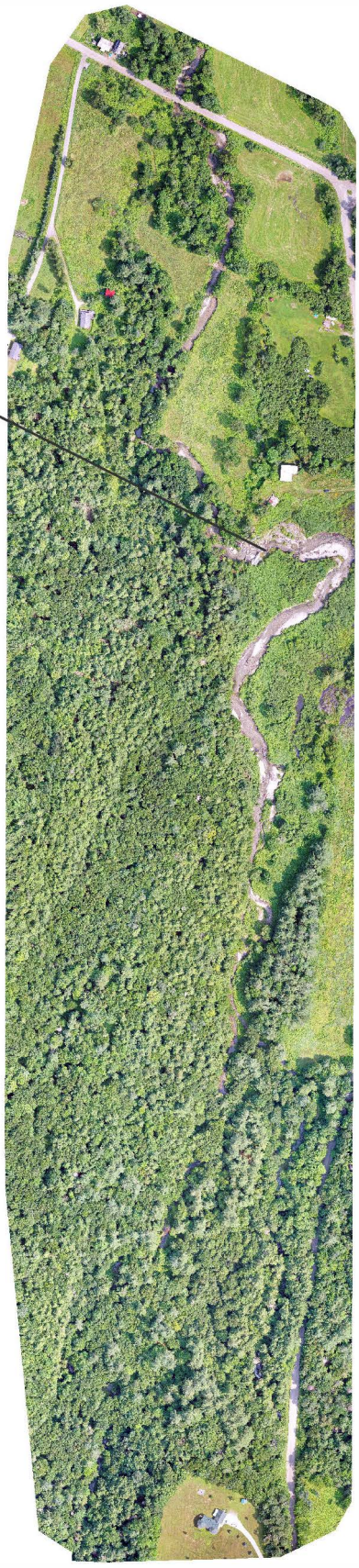
Orthoimagery from January 9, 2023



Orthoimagery from June 12, 2023



Orthoimagery from July 17, 2023



N

0 250 500 Feet

Note: only a portion of the AOI was captured on this date due to a battery failure.

Orthoimagery from October 26, 2023

Multi-Year Biological Monitoring at the Johnsons Mill Dam Removal Site
Annual Report for 2023
Submitted by: Avacal Biological
For: The Franklin County Natural Resources Conservation District

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Study Introduction

In August 2021, the Lake Champlain Basin Program worked with the Franklin County Natural Resources Conservation District to oversee the removal of the Johnsons Mill Dam, located along the Bogue Branch in Bakersfield, VT. After decades of disuse, the stone and concrete dam was in a state of deterioration and recommended for removal by the Vermont Department of Environmental Conservation in 2016. The upstream riverbanks were also stabilized.

Removing the approximately 220-foot-wide dam reconnected an estimated 23 stream miles of aquatic habitat in the Lake Champlain Basin for the first time since the early 1800s, when a sawmill was first constructed at the site. The Bogue Branch is a tributary to the Tyler Branch which flows into the Missisquoi River, a transboundary river that enters Lake Champlain in northern Vermont.

In 2022, Avacal Biological was contracted to assist with yearly biomonitoring of the site, above and below where the dam was removed to document algal and macroinvertebrate populations. In 2022 a baseline was established of algal populations, and 2023 the addition of macroinvertebrate data was collected.

Algal samples were collected at the Johnsons Mill Dam Removal site on October 31, 2022 by Avacal Biological staff, for the Franklin County Natural Resources Conservation District as part of a three-year monitoring project. While the date fell outside of the standard collection timeframe, a baseline of algae present needed to be collected and was treated as such. As the weather was not conducive for collection of macroinvertebrates, no data for 2022 was obtained.

Algal samples and macroinvertebrate samples were collected at the Johnssons Mill Dam Removal site on October 16, 2023, with additional samples collected on November 4, 2023 due to insufficient sample size collected on first sample date. Samples for both macroinvertebrates and algae were low in diversity and relative abundance; still lacking full recolonization following the extreme flooding and rain events from summer 2023.

Multi-Year Biological Monitoring at Johnsons Mill Dam Removal Site- Annual Report 2023
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Algal Biomonitoring

Introduction

Algal bioassessment complements physical and chemical data by providing corroborative evidence for environmental change. Taxonomic composition and diversity of algal assemblages are used to assess ecological health of habitats and to infer probable environmental causes of ecological impairments.

Sampling and Data Acquisition Methods

Field data collection: Algal samples were collected along a transect above where the dam was removed (site 2) and below where the dam was removed (site 1). Site 1 was sampled first as to not disturb Site 2. Samples were collected on October 31, 2022, October 15, 2023 and again on November 4, 2023.

Site 2

A multi-habitat sample was collected across the stream that represents all available habitat. Algal samples were collected off various substrates and include the following protocol:

NATURAL SUBSTRATE SAMPLING – ROCKY SUBSTRATE Sampling will focus on Epilithic algae.

~Clean sample trays, brushes, and other equipment with tap or stream water.

~Establish transects through riffles or runs.

~Across transect, collect scraping, suctioning, scooping of algae present at 10 locations along the transect.

~At each location, identify a cobble or boulder-sized rock, remove rock from water; Pick up the rock and hold it over a second sample tray that is clean. Place sampling device marker on rock and hold firmly. Sampling device/ marker is a piece of plastic with a 1in diameter circle opening in the center. Brush the area within the circle vigorously with a stiff bristled brush while holding rock over collection pan, note, you may need to scrape the area with a metal scraping tool first if the algae is very thick. Rinse tools and sample area on rock with a squirt bottle filled with bottled water and collect sample in the large, white sample tray. Alternately if rock is too large to remove from water, use suction devise to scrap and suction sample from rock and place in white tray. Repeat process for other rocks and composite all rock-scrapings into multi-habitat sample container (rinse the tray and equipment to ensure all algae are in the container).

Site 1

~Thoroughly clean all equipment, especially brush bristles, in water before leaving stream. Discard brushes if they get too grimy or difficult to clean.

NATURAL SUBSTRATE SAMPLING – SOFT BOTTOM (To be included in multihabitat sample)

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~ Sampling soft bottom streams, include the following methods: Epilithic algae from log scrapings, Epiphytic algae from plant clippings, Epipsammic and Epipelic algae from soft substrate.
~Epilithic algae from log scrapings: Clean large, white sample trays, toothbrushes, and metal scraping tools. Find logs or branches within the reach that can be lifted from the water, or suction scraped underwater. Using the following methods to collect samples along the 10 sites along the transect. Pick up a log/branch and hold it over a large, white sample tray. Place sampling device/ marker over the log/branch and hold firmly in place to define surface area to be sampled. Brush the area within the circle vigorously with a toothbrush and wash down brush and log/branch with a squeeze bottle into a collection pan (note, you may need to scrape the area with a metal scraping tool first if the algae are very thick). Alternatively, if the log is too large to remove from water, suction/ scrape sample from log. Rinse tools and sample area on log/branch with a squirt bottle filled with bottled water and collect sample in the large, white sample tray. Repeat process for other logs/branches or other parts of long logs/branches and composite all scrapings into sampling tray. (Rinse the tray and equipment to ensure all algae are in the multi-habitat sample container).
~Epiphytic algae from plant clippings. Clean scissors and large, white sample trays.
At each of the 10 previously identified locations, select plants that are underwater. Clip plant stems near their base, Place each stem into the multi habitat sample container.
~ Epipsammic and Epipelic algae from soft substrate: This method is appropriate for mucky bottom streams. Clean spatula, and white tray. At each location along the transect that contains soft substrate, lift a sample 1 in in diameter up using an unslotted spatula and place in multi habitat sampling container. Thoroughly clean all equipment in water before leaving stream.
Summary: At each of the 10 determined sample locations along the transect that is representative of the stream reach, collect algae from every available substrate and place into one multi habitat container for the entire transect.

Sample Handling and Custody
Samples were placed in a cooler, on ice and transported to the Avacal Biological, Vermont lab for full analysis. Samples were identified and enumerated within two weeks.

Analytical Methods
Algae and cyanobacteria samples:
All samples were examined with a compound microscope at the magnification necessary to identify all forms to lowest taxonomic level feasible.
The taxonomist, Corrina King-Parnapy, has over ten years' experience in the field of identification of algae and cyanobacteria within Vermont, and New York watersheds. She used appropriate taxonomic keys, including Bellinger 2010, Van Vuuren 2006, Sherwood 2004, Round 1990, Prescott 1964, Wehr 2003.

All algal samples were individually homogenized, allowed to settle and a sub sample was taken and prepared according to the Environmental Protection Agencies alternate preparation technique (Validation of U.S.EPA Environmental Sampling Techniques, 2017) and placed on a gridded wet-mount slide. All forms of algae and cyanobacteria were identified to lowest taxonomic level possible and 100-300 algal "cell units" were counted. 300 cell units for diatoms (NYSDEC Periphyton Biomonitoring Protocols) [As Vermont does not yet have Periphyton Biomonitoring Protocols] and 100 for live and regional metrics.

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Algal Metrics Based on Composition

Relative abundance and taxa richness

· Relative abundance of "soft" algae (including cyanobacteria, and chlorophyte) · Relative abundance of diatoms

· Total taxa richness

Metrics of biotic integrity

· **Total number of genera:** The generic richness should be highest in reference sites and lowest in impacted sites where genera become stressed. Total number of genera including diatoms and soft algae may provide a more robust measure of diversity than other estimates.

· **Total number of divisions:** Is represented by all taxa and should be highest in sites with good water quality and high biotic integrity.

· **Percent sensitive diatoms:** The sum of the relative abundance of pollution intolerant taxa.

· **Percent Achnanthes minutissima:** A cosmopolitan species with direct proportional abundance to toxic pollution.

· **Percent motile diatoms:** Indicative of areas containing high sediments.

Identification of cyanobacteria in sample

· In high densities, cyanobacteria are an undesirable component of freshwater ecosystems; they can produce hepatotoxins and neurotoxins that can cause fish kills, harm humans, wildlife and pets. Additionally, toxins produced can pose problems for households that get their drinking water from the body of water.

Diagnostic metrics that infer ecological conditions

· **Percent aberrant diatoms:** The percent of diatoms in a sample that have anomalies in stria or frustules shape. Indication of heavy metal contamination.

· **Percent motile diatoms:** The relative abundance of diatom genera that can crawl to the surface if covered by silt.

· **Pollution tolerance index (PTI):** The impaction level of that site to overall pollutants.

· **Trophic index:** The impaction level of the site to nutrient levels.

· **Salinity index:** The impaction level of the site to salt.

· **Acidity index:** The impaction level of the site to acidic conditions.

· **Siltation index:** The impaction level of the site, as measured by motile genera.

· **Palmer Algae Pollution Index:** A specific group of algae is associated with municipal sewage treatment plants. This group thrives in organically polluted waters and is used as a biological indicator of organic pollution. The Palmer algae pollution index (PPI) was compiled from reports by 165 authors and ranks the species/genera most often encountered in the waters with high rates of organic pollution. *This metric in combination with other metrics and data is being utilized within the Septic Initiative of the Lake George Waterkeeper to assist with prioritization of nearshore septic systems for replacement or upgrades*.

· **Indicator forms:** The notation of forms of algae that indicate eutrophic conditions.

· **Nutrient criteria for soft bodied alga:** determine minimum and optimal levels of nutrients needed for full algal growth. Assists in the determination of water quality impaction.

Other metrics that may be applied:

· **Percent Community Similarity Index:** based on relative abundance of forms present at test site against a reference site/ natural site.

· **Area-specific cell densities and bio volumes:** dividing the number of cells counted by the proportion of sample counted and the area from which the sample was collected.

· **% Cyclotella sp.** summer dominance of Cyclotella can cause a decrease in water clarity by scattering the light.

· **Impairment of ecological conditions:** the deviation between environmental conditions at sample site and a reference site.

Algal Results

Algal Metrics Based on Composition

Baseline data was collected for year one (2022), comparison data collected year two (2023). Data sheets attached for each site.

- Generic Richness; Should be highest in reference sites and lowest in impacted sites. While both site 1 and site 2 had low generic richness, this could be related to the high silt/sand at the location and the high levels of iron oxide.
- Number of Divisions; Highest in sites with good water quality and high biotic integrity. While both site 1 and site 2 had low number of divisions, this could be related to the late sampling date and possible recent higher water events and lack of recolonization.
- Presence of Cyanobacteria; (Blue-green algae) are of greater concern than other forms of algae, as they can, under the right environmental conditions produce toxins and form toxic blooms. Excessive growth of benthic blue-green algae within streams can cause health problems for humans, pets, livestock and wildlife. Excessive amounts of Cyanobacteria present can indicate higher levels of nutrients. Both sites did not have any Cyanobacteria found within samples collected.
- %Sensitive Diatoms; The sum of relative abundance of all intolerant genus of diatoms. Especially important in small-order streams where primary productivity may be naturally low, causing other metrics to underestimate water quality. Site 1 had 0% sensitive diatoms and Site 2 had 1.66% sensitive diatoms. Compared to 2022 data: Site 1 had 0% sensitive diatoms and Site 2 had 2% sensitive diatoms.
- Percent *Achnanthes m*; This cosmopolitan diatom has a very broad ecological amplitude. Frequently dominate in sites subject to acid mine drainage, and toxic pollution. Provisional ranges of impact are: 0-25% = no disturbance, 25-50% = minor disturbance, 50-75% = moderate disturbance and 75-100% = severe disturbance. In 2023 both Site 1 and Site 2 had 0% *Achnanthes m.* In 2022 Site 1 was at 0% and Site 2 was at 0.66% indicating no toxic pollution.
- Pollution Tolerance Index; The sum of relative abundance of forms multiplied by the pollution tolerance class of each form. Provisional ranges for the levels of impact are: >2.5 = non-impacted, 2.01-2.50 = slightly impacted, 1.51-2.00 = moderately impacted, and <1.50 = severely impacted. In 2023 Site 1 was 2.20 and Site 2 was 1.81, in 2022 Site 1 was 2.22 indicating slight pollution impaction, while site 2 was 1.87 indicating it was moderately impacted for pollution.
- Trophic Index; A measure of % mesotrophic to hyperetrophic individuals. Provisional ranges for the levels of impact are; 0-50 = non-impacted, 52-70 = slightly impacted, 71-85 = moderately impacted, and 86-100 = severely impacted. In 2023 Site 1 was 74, and Site 2 was 90, in 2022 Site 1 was 71, meaning it was moderately impacted at the trophic level. Site 2 was 87 meaning it was severely impacted at the trophic level.
- Salinity Index; A measure of % halophilous individuals, indicating dissolved salts. Provisional ranges for the levels of impact are: 0-10 = non-impacted, 11-30 = slightly impacted, 31-50 = moderately impacted and 51-=100 = severely impacted. In 2023 Site 1 was 94 and site 2 was 77,

in 2022 Site 1 was 71, and site 2 was 92 indicating both sites are severely impacted for salinity. However, with not knowing the current makeup of nearby soils and roads where road salt could be utilized, this metric is just used as a baseline purpose.

- Acidity Index; A measure of % acidophilous individuals, reflecting acid effects. Provisional ranges for levels of impact are: 0-20 = non-impacted, 21-50 = slightly impacted, 51-75 = moderately impacted, and 76-100 = severely impacted. In 2023 Site 1 was 2 and site 2 was 0, in 2022 Site 1 was a 2 and site 2 was a 1, indicating no concerns or impaction from acids.
- Siltation Index; A measure of percent relative abundance of individuals belonging to motile genera. Provisional ranges for the levels of impact are: <20 = no siltation, 20-39 = minor siltation, 40-60 = moderate siltation and >60 = heavy siltation. In 2023 Site 1 was 28 and Site 2 was 21, in 2022 Site 1 was a 28, and site 2 was a 22 indicating minor siltation at both sample sites.
- Palmer Pollution Index; A specific group of algae is associated with organic pollution and is utilized as a biological indicator of organic pollution. Provisional ranges for levels of impact are: A score of 20 or more is evidence of high organic pollution, A score of 15-19 indicates probable organic pollution present. Lower scores usually indicate less organic pollution, but they may also occur if something is interfering with algae growth. In 2023, Site 1 was a 9 and site 2 was a 12, in 2022 Site 1 was a 9 and site 2 was a 13, indicating lower levels of organic pollution present.
- Notes: With the abundance of iron oxide located at both sites, there is the possibility that algal growth has been inhibited. In addition, there could be implications for internal loading of phosphorus. With the heavy flooding and Continued rains in 2023, full algal colonization was limited.

Macroinvertebrate Biomonitoring

Introduction

Biological assessments were conducted by analysis of macroinvertebrates. Macroinvertebrates are visible with the naked eye (macro-) and lack vertebrae (-invertebrate). These can include several different organisms including snails, clams, dragonfly nymphs, crayfish, and many others. Macroinvertebrates are used as water quality indicators because they are constantly exposed to instream conditions, are relatively easy to collect, and vary with tolerance to pollution. Macroinvertebrate samples were collected, processed, and analyzed according to the Quality Assurance Work Plan approved for this project.

Sampling and Data Acquisition Methods

Macroinvertebrates were collected and analyzed according to the VTDEC Watershed Management Division Field Methods Manual, Revised January 2022

Lotic Semi-Quantitative Benthic Survey
~ The riffle kick-net and multi-habitat sweep-net methods described here have been used in Vermont to collect consistent and replicable macroinvertebrate data since the late 1980s. macroinvertebrate biocriteria. The assessment methodology used to interpret this community data can be found in the Vermont Water Quality Standards (VTDEC, 2017).
Equipment for Lotic Semi-Quantitative Benthic Surveys: Kick-net - 500-micron mesh, rectangular frame 45 cm wide x 23 cm high x 25 cm deep, Quart size containers (wide mouth preferred), 80% ethyl alcohol (i.e. ethanol or ETOH). Riffle kick-net samples are used to represent the macroinvertebrate community of riffle habitats within a stream reach. Riffles are hard-bottom areas of the stream characterized by shallow depths (< 1 m) and fast, turbulent water (> 0.2 feet per second). Due to their high productivity, riffles are the best stream habitat for providing comparable data over time and across stream reaches. Kick-net samples represent a composite of four subsamples taken throughout the reach. The length of reach used to collect a kick-net sample should be sufficient to capture representative conditions found within the riffles of that section of stream (e.g., shading, depth, flow velocity, and substrate composition).
Procedure:
~ Begin sampling in the farthest downstream section of the stream reach and work upstream. Each of the four subsample composite locations should be chosen to represent the diversity of riffle habitat conditions (e.g., shading, depth, flow velocity, substrate composition) within the stream reach being sampled.
~ Place the net on the stream bottom in a representative riffle location with the 45 cm edge perpendicular to the flow. A representative location has similar characteristics to the overall riffle habitat present in the reach. Make sure water is flowing freely through the net and move substrate immediately downstream of the net if necessary to improve flow. Avoid artificial riffle habitat such as riprap.
~ Collect each composite subsample from an estimated 45 cm x 45 cm (0.20 m2) square area immediately upstream of the net. Move all large coarse gravel and cobble substrates to the mouth of the net and rub clean of attached organisms. Discard cleaned substrate to the side of the sample area. Portions of larger cobbles and small boulders in the 0.20 m2 area that are immobile are left in place and rubbed clean of organisms with the net positioned to capture the organisms.
~ Disturb all remaining small substrate by hand to a depth of 5–10 cm and allow disturbed organic matter to flow into the net.
~ This entire riffle kick-net procedure should last a minimum of 30 seconds per composite but should continue until all substrates within the subsample area have sufficiently been cleaned and disturbed.
~ The procedure is repeated at four different riffle areas within the reach, and composite subsamples are combined into a single sample for that stream reach. The final kick-net sample will equal approximately 0.80 m2 of riffle habitat.
~ After the four composite subsamples have been collected into the kick-net, large pieces of organic matter (i.e. leaves and sticks) and substrate within the net can be carefully rinsed and rubbed clean of organisms and discarded. Transfer the contents of the net into a quart sized container. Any remaining organisms attached to the net should be removed by hand (using forceps if necessary) and placed in the

container. Preserve the contents of the container with 80% ethyl alcohol, submerging all collected matter with alcohol.
~ After sample collection, the kick-net should be turned inside-out and vigorously swept through the water to ensure that all macroinvertebrates have been removed.
~ A replicate sample may be needed at some sites, requiring the sampler to repeat steps 1-5. While collecting the replicate sample, it is imperative to mark and avoid areas previously disturbed with a small cairn or similar structure.
~ After completing sample collection, the sampler should make note of a general trophic rating on a scale of 0-5 Trophy is defined as the total weight of living biological material (biomass) in a river or stream at a specific location and time. This material can be observed and includes benthic algae or periphyton, vascular plants or macrophytes, benthic macroinvertebrates and fine particulate organic matter (not leaf packs, or sand) from the breakdown of all the above.
0 Almost no algae present either macro or micro algae (cannot even draw a line on substrate), cobble squeaky clean, but moss may be present. Fine organic matter also not coating surface of substrate. Macroinvertebrates very low in abundance. 1 Almost no macro algae present, micro algae light (often golden brown), can just draw a line (but no thickness to it). Moss maybe present. Fine organic matter also not coating surface of substrate. Macroinvertebrates low in abundance. Hydropsychidae caddisfly not dominant. 2 Scattered macro algae present, micro algae mostly golden brown with noticeable thickness (up to 1mm), moss can be present, and lush. Fine organic matter can be present coating surface of substrate again very thin layer. Silt rating always 2 or less. Macroinvertebrates moderate in abundance Hydropsychidae caddisfly not dominant but noticeable. 3 Macro algae more common, filaments generally less the 3", and noticeable in favored microhabitat. Micro algae can be up to 2mm thick and appear more brownish, blue green, or green. Moss often sparse. Macrophytes present in favored microhabitats. Fine organic matter noticeable when substrate is disturbed and in back waters. Macroinvertebrates moderate to high in abundance, Trichoptera Hydropsychidae, Ephemeroptera Baetidae and Ephemerellidae abundant. 4 Macro algae often dominant, filaments mostly over 3" in length. Micro algae a thick coating 2-3mm, brownish, blue green, or green colored. Macrophytes abundant in favored habitats. Accumulation of fine organic material present very noticeable 1-3mm thick, Hydropsychidae can be highly dominant, clinging to kick nets, Chironomidae noticeable in field. 5 Macro algae can be lush and often over 6" in length. Micro algae can be very thick up to 5mm brown or blue green. In extreme cases sewage fungus present. Macrophytes can be abundant in favored habitats, often coated with algae or fungus. Organic material abundant in all habitats when substrate disturbed can smell of sulfur (rotten eggs). Macroinvertebrates can be either very abundant or scarce with Diptera, Isopoda, Oligochaeta. The only EPT group noticeable is Hydropsychidae if present.

General Taxonomic Identification and Enumeration:
Identification and enumeration of organisms from the processed sample are used to calculate community metrics, which are used to assess the condition of the macroinvertebrate community using the State's biological criteria.
Equipment: 80% ethyl alcohol (ethanol or ETOH), Binocular dissecting microscope 7x - 60x minimum range, Fiber optic illuminator, Petri dishes –quartered, VTDEC listed taxonomy keys, and others, 3-4" fine pointed watchmakers' forceps, Fine pointed probes, Scalpel - #15 blades, 20 - 30 ml snap cap glass vials, ¼ dram - 2-dram open glass vials
~ Procedure: After a sample has been initially processed and sorted by taxonomic group into petri dishes under 2X magnification, conduct a more thorough and accurate sort under higher magnification. Sort animals by taxonomic groups (order) using a dissecting microscope and place in snap cap vials with 80% ethanol and labels indicating sample laboratory ID number.

~ Identify groups to lowest possible or recommended taxonomic unit (usually genus or species) using a binocular dissecting microscope and keys recommended VTDEC and EPA.
~ Identification of certain groups (e.g., Chironomidae, Oligochaeta) or individuals may require slide mounts for identification with a compound microscope.
~ Organism identifications and number of individuals in each taxonomic unit are recorded by the taxonomist and are documented.

Chironomidae and Oligochaeta Identification.
The following protocols are used to determine the identification of genera and species for Chironomidae and Oligochaeta organisms in a sample unit.
~ Procedure: To the extent possible with a high level of confidence, presort Chironomidae and Oligochaeta into unique genus or species groups using a dissecting microscope.
~ Mount representative individuals of each grouping on individual microscope slides under a dissecting microscope. One to two drops of media are applied to the slide and lightly spread. Usually 2 - 6 organisms can be mounted per cover slip area, equaling 4-12 animals per slide. This may vary depending on the experience of the biologist and the size of the organisms. All organisms should be oriented in the same direction for mounting. Chironomidae specimens should be mounted with the ventral head surface pointed upwards.
~ The taxonomist should be familiar with the specifications of the mounting media being used and adhere to any safety recommendations provided by the manufacturer
~ Sorted genus/species groups represented by many individuals (> 10) may be subsampled in sufficient amounts to ensure a correct identification of the group (10-50% depending on the distinctiveness of the group). Typically, not less than 5 individuals or 10% (whichever is greater) will be identified from a subsampled genus/species group. This may vary based on the sorting experience of the biologist. If all organisms subsampled are identical, the total enumeration (including those not mounted) is recorded. If more than one species is found in the mounted subsample, the ratio of species to the unmounted organisms must be determined.
~Organisms are identified under a compound scope using keys recommended by VTDEC and the EPA.

<u>Applicable Macroinvertebrate metrics</u>

- **Density-** Density refers to the relative abundance of macroinvertebrates in a sample. Calculation: Number of macroinvertebrates in subsample / proportion of sample processed.
- **Total Richness**- Total richness is the number of unique taxa in a processed sample. Calculation: A tally of the total number of unique taxa identified. Note that immature larva identified to family or genus are not considered a unique taxon if a genus or species identification has also been identified within that taxonomic group.
- **EPT Richness** - EPT richness is a subset of Total Richness. It is the number of unique taxa in a processed sample in the generally more environmentally sensitive orders Ephemeroptera, Plecoptera, and Trichoptera. Calculation: A tally of the number of unique taxa identified from the insect orders Ephemeroptera, Plecoptera, Trichoptera. Note that same rules apply as above for Total Richness in determining the number of unique taxa.
- **EPT/EPT & Chironomidae** - This is a measure of the ratio of the relative abundance of the generally intolerant organisms in EPT orders to the relative abundance of EPT organisms plus the generally more tolerant Diptera family Chironomidae. Calculation: The number (relative abundance) of organisms from the orders Ephemeroptera, Trichoptera and Plecoptera, divided by the above plus the number of Chironomidae.

- **% Oligochaeta** - Is a measure of the percent of the macroinvertebrate community made up of the Order Oligochaeta. Calculation: The number (relative abundance) of Oligochaeta divided by the total number of animals in sample.
- **Percent Model Affinity of Orders (PMA-O**) – PMA-O is a measure of taxonomic order level similarity to a model of expected order distribution based on reference streams. Calculation: Determine the percent composition for each major taxonomic order in the sample (Coleoptera, Diptera, Ephemeroptera, Plecoptera, Trichoptera, Oligochaeta, Other). Compare to the "Model" for the appropriate stream type), then add up the lower of the two values for each of the groups (assessment site vs Model), this is the PMA-O for the assessment site
- **Hilsenhoff Biotic Index (BI)** - BI is a measure of the macroinvertebrate assemblage tolerance toward organic and/or nutrient enrichment. Most common taxa are assigned a BI number between zero (highly sensitive to enrichment) and ten (highly tolerant of enrichment. In many ways this index is both an indicator taxa metric and functional group metric, since those taxa which become more dominant in moderately enriched streams are those which are taking advantage of shifts in the available food base in the stream. Calculation: Use only taxa that have been assigned a BI value (o-10) by VTDEC based on published literature. Multiply the number of individuals of a taxon by its assigned tolerance. Total all these products and divide by the total number of organisms.
- **Pinkham-Pearson Coefficient of Similarity of Functional Groups (PPCS-F)** - PPCS-F is a measure of functional feeding group similarity to a model of expected feeding group distribution based on reference streams. It is similar in concept to the PMA-O in that a site is compared to a model of the composition of the functional feeding groups as opposed to order level taxonomic changes. Calculation: Determine the percent composition of six major functional groups in a sample (collector-gatherer, collector-filterer, predator, shredder-detritivore, shredder, herbivore, scraper) as assigned by VTDEC based on published literature. For each functional group determine the ratio (min/max) between the sample and the reference model for that stream type. Sum these calculations and divide by six (i.e., the number of functional groups).

Macroinvertebrate Results

Macroinvertebrate Metrics Based on Composition

Baseline data was collected for year two (2023).

- Density; Density was low at both sample Site 1 and Site 2
- Total Richness; Richness at both sample Site 1 and sample Site 2 were very low, this could be due to the extreme flooding and rain events that moved the stream course and substrate.

The Upstream Sample site consisted of Lepidoptera, Plecoptera, Trichoptera, and Coleoptera. The Downstream Sample site contained a majority of Plecoptera.

Due to inadequate density, richness, and quantity of macroinvertebrates within sample collected on 10/16/2023, a repeat sample was collected on 11/4/2023. Both samples were not adequate to fully apply metrics, as the minimum number of bugs in sample needed was not met. It takes 3-7 months following an extreme flood event for macroinvertebrate populations to even start to rebound. The data collected in 2023 will be utilized as a baseline for forms present, but not for richness, or diversity.

- EPT Richness; Not measured in 2023
- EPT/EPT & Chironomidae; Not measured in 2023
- % Oligochaeta; Not measured in 2023

- Percent Model Affinity of Orders (PMA-O); Not measured in 2023
- Hilsenhoff Biotic Index (BI); Not measured in 2023
- Pinkham-Pearson Coefficient of Similarity of Functional Groups (PPCS-F); Not measured in 2023

Site 1 (Downstream sample site); Had low richness and density due to summer 2023 rain events and extreme flooding. Multiple attempts were made to get an adequate sample size large enough to apply metrics. Due to lack of appropriate sample size, data collected in 2023 will be utilized as a simple baseline of what is present. The sample was dominated by *Plecoptera*, with a majority being *Paragnetina media*. Species present were indicating clean water, containing environmentally sensitive organisms.

Site 2 (Upstream sample site); Had low richness and density as well. Multiple attempts were made to get an adequate sample size large enough to apply metrics. Due to lack of appropriate sample size, data collected in 2023 will be utilized as a simple baseline of what is present. The sample contained *Lepidoptera, Plecoptera, Trichoptera, Coleoptera*, and same as Site 1, the dominate form was *Paragnetina media*. Species present were indicating clean water, containing environmentally sensitive organisms.

2023 Combined Assessment:

Catastrophic flooding and rainfall occurred in early to mid-July 2023, rivaling Tropical Storm Irene from 2011. The increase in flow within the Bogue Branch altered the stream flow at the upstream sampling location (site 2), and substantially impacted the algal and macroinvertebrate populations within the stream reach. The algal and macroinvertebrate populations did not have adequate time to rebuild colonization by the time samples were collected in October of 2023. In addition, leaching iron oxide coming from an unknown source has impacted both algal and macroinvertebrate populations. The high siltation of the stream reach is not conducive to adequate algal and macroinvertebrate colonization. While downstream of the dam removal sections are adequate for fish habitat, the above removal site still does not have adequate riparian cover, substrate, and food sources in the way of algal and macroinvertebrate colonization. With the dam removal, the river has been allowed to follow its own course, which it has changed, as confirmed from the 2023 flooding. The natural meander of the river has returned, allowing for

increased natural deposition of sediment and reduced risk of flooding. Thus far there have been no major changes or impactions noted through biological monitoring, the downstream sample location (Site 1), is functioning as it should and is not showing high variability from the upstream sample site. Both the assessments utilizing algae and macroinvertebrates are indicating that with the exception on the iron oxide, the water is fairly clean at both upstream and downstream sample sites.

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Avacal Biological

	Date	Initials
Entered	1/10/2024	CP
QC'd	1/10/2024	CP

LABORATORY ALGAE SAMPLE ANALYSIS DATA SHEET
Avacal Biological
Biological Assessment Program

Stream Johnsons Mill Dam Removal Site 2
Collection date 10/16/2023
Sample ID date 11/5/2023
ID by CP

Genus	Species	AKA	PT #	pH	Trop	Salt	ni	N	Ti x ni	PTI	pH	tropy	salinity	% A. min	Silt	% Sens.
Achnanthes	minutissima	linearis, affinis	3	0	0	1	0	300	0	0	0	0	0	0	21	1.66667
Achnanthes	lanceolata	rostrata, oblogella	2	0	1	1	0	300	0	0	0	0	0			
Achnanthes	exigua		3	0	0	0	0	300	0	0	0	0	0			
Amphora	Neneta		3	0	0	0	0	300	0	0	0	0	0			
Aulacoseira	granulata		3	0	0	0	0	300	0	0	0	0	0			
Brachysira	serians	vitrea	3	0	0	0	0	300	0	0	0	0	0			
Campylodiscus	clypeus		2	0	0	0	0	300	0	0	0	0	0			
Cocconeis	pediculus	placentula	2.5	0	1	1	0	300	0	0	0	0	0			
Cymbella	naviculiformis		2	0	0	1	7	300	14	0.0467	0	0	7			
Cymbella	aspera		4	0	0	0	0	300	0	0	0	0	0			
Cymbella	tumida		2.5	0	1	1	0	300	0	0	0	0	0			
Diatomella	hiemale		3	0	0	0	0	300	0	0	0	0	0			
Diatomella	parva		3	0	0	0	3	300	9	0.03	0	0	0			
Encyonema	minutum		2	0	0	0	0	300	0	0	0	0	0			
Encyonema	gracile		3	0	0	0	0	300	0	0	0	0	0			
Encyonema	sp.		3	0	0	0	0	300	0	0	0	0	0			
Encyonema	prostratum		3	0	0	0	0	300	0	0	0	0	0			
Epithemia	sorex		3	0	0	0	0	300	0	0	0	0	0			
Epithemia	adnata		3	0	0	0	0	300	0	0	0	0	0			
Eunotia	pectinalis		3	1	0	0	0	300	0	0	0	0	0			
Eunotia	serpentina		3	1	0	1	0	300	0	0	0	0	0			
Eunotia	sp.		3	1	0	1	0	300	0	0	0	0	0			
Eunotia	arcus		4	0	0	1	5	300	20	0.0667	0	0	5			
Eunotia	incisa		3	1	0	0	0	300	0	0	0	0	0			
Eunotia	minor		3	0	0	0	0	300	0	0	0	0	0			
Fragilaria	crotonensis		3	0	1	1	0	300	0	0	0	0	0			
Fragilariforma	viriscens	Fragilaria viriscens	3	0	0	0	0	300	0	0	0	0	0			
Frustulia	rhomboides	amphipleuroides	3	1	0	0	0	300	0	0	0	0	0			
Frustulia	vulgaris		3	0	0	0	0	300	0	0	0	0	0			
Gomphonema	truncatum		3	0	1	1	0	300	0	0	0	0	0			
Gomphonema	parvulum		1	0	1	1	74	300	74	0.2467	0	74	74			
Gomphonema	acuminatum		2	0	1	1	12	300	24	0.08	0	12	12			
Gomphonema	augur		2	0	0	1	0	300	0	0	0	0	0			
Gomphonema	minutum		2	0	1	1	0	300	0	0	0	0	0			
Gyrosigma	spencerii	scalproides	2	0	0	0	0	300	0	0	0	0	0			
Melosira	varians		2	0	1	1	0	300	0	0	0	0	0			
Meridion	circulare		3	0	0	1	0	300	0	0	0	0	0			
Navicula	margalithi	tripunctata	2	0	1	1	0	300	0	0	0	0	0			
Navicula	capitatoradiata		2	0	1	1	0	300	0	0	0	0	0			
Navicula	cryptocephala		3	0	0	1	0	300	0	0	0	0	0			
Navicula	radiosa		3	0	1	1	3	300	9	0.03	0	3	3			
Navicula	angusta		3	1	0	0	0	300	0	0	0	0	0			
Navicula	lanceolata		2	0	1	1	20	300	40	0.1333	0	20	20			
Navicula	rhynchocephala		3	0	1	1	1	300	3	0.01	0	1	1			
Navicula	notha		2	0	0	0	0	300	0	0	0	0	0			
Nitzschia	linearis		2	0	1	1	25	300	50	0.1667	0	25	25			
Nitzschia	curvula	Stenoplerobia/ flexa	2	0	0	0	12	300	24	0.08	0	0	0			
Nitzschia	palea		1	0	1	1	3	300	3	0.01	0	3	3			
Nitzschia	gracilis	acicularis	2	0	0	0	0	300	0	0	0	0	0			
Pinnularia	borealis	gibba	3	0	0	0	0	300	0	0	0	0	0			
Pinnularia	viridis		3	0	0	0	0	300	0	0	0	0	0			
Pinnularia	abaujensis		3	0	0	0	0	300	0	0	0	0	0			
Pinnularia	microstauron		3	0	0	0	0	300	0	0	0	0	0			
Pinnularia	subcapitata		3	0	0	0	0	300	0	0	0	0	0			
Placoneis	sp.		3	0	0	0	0	300	0	0	0	0	0			
Pleurosigma	elongatum		3	0	0	0	0	300	0	0	0	0	0			
Rhopalodia	gibba		3	0	0	0	2	300	6	0.02	0	0	0			
Sellaphora	pupula		2	0	0	0	0	300	0	0	0	0	0			
Semiorbis	hemicyclus		3	0	0	0	0	300	0	0	0	0	0			
Stauroneis	acuta		3	0	0	0	0	300	0	0	0	0	0			
Surirella	striatula		2	0	0	0	0	300	0	0	0	0	0			
Surirella	brebissonii		2	0	0	0	0	300	0	0	0	0	0			
Surirella	sp.		2	0	0	0	0	300	0	0	0	0	0			
Surirella	amphioxys		2	0	1	1	0	300	0	0	0	0	0			
Surirella	ovalis		2	0	1	1	0	300	0	0	0	0	0			
Synedra	acus		2	0	1	1	4	300	8	0.0267	0	4	4			
Synedra	ulna	actinastroides	2	0	1	1	129	300	258	0.86	0	129	129			
Synedra	rumpens	pulchella	2	0	1	1	0	300	0	0	0	0	0			
Synedra	delicatissima		2	0	1	1	0	300	0	0	0	0	0			
Tabellaria	flocculosa		3	1	0	1		300	0	0	0	0	0			
							300			1.81	0	90	94			

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Avacal Biological

Avacal Biological
Biological Assessment Program

Stream	Johnsons Mill Dam Removal Site 1
Collection date	10/16/2023
Sample ID date	11/5/2022
ID by	CP

Genus	Species	AKA	PT #	pH	Trop	Salt	ni	N	Ti x ni	PTI	pH	tropy	salinity	% A. min	Silt	% Sens.
Achnanthes	minutissima	linearis, affinis	3	0	0	1	0	300	0	0	0	0	0	0	28	0
Achnanthes	lanceolata	rostrata, oblogella	2	0	1	1	0	300	0	0	0	0	0			
Achnanthes	exigua		3	0	0	0	0	300	0	0	0	0	0			
Amphora	Neneta		3	0	0	0	0	300	0	0	0	0	0			
Aulacoseira	granulata		3	0	0	0	0	300	0	0	0	0	0			
Brachysira	serians	vitrea	3	0	0	0	0	300	0	0	0	0	0			
Campylodiscus	clypeus		2	0	0	0	0	300	0	0	0	0	0			
Cocconeis	pediculus	placentula	2.5	0	1	1	0	300	0	0	0	0	0			
Cymbella	naviculiformis		2	0	0	1	2	300	4	0.0133	0	0	2			
Cymbella	aspera		4	0	0	0	0	300	0	0	0	0	0			
Cymbella	tumida		2.5	0	1	1	0	300	0	0	0	0	0			
Diatomella	hiemale		3	0	0	0	0	300	0	0	0	0	0			
Diatomella	parva		3	0	0	0	4	300	12	0.04	0	0	0			
Encyonema	minutum		2	0	0	0	2	300	4	0.0133	0	0	0			
Encyonema	gracile		3	0	0	0	0	300	0	0	0	0	0			
Encyonema	sp.		3	0	0	0	0	300	0	0	0	0	0			
Encyonema	prostratum		3	0	0	0	0	300	0	0	0	0	0			
Epithemia	sorex		3	0	0	0	0	300	0	0	0	0	0			
Epithemia	adnata		3	0	0	0	0	300	0	0	0	0	0			
Eunotia	pectinalis		3	1	0	0	0	300	0	0	0	0	0			
Eunotia	serpentina		3	1	0	1	6	300	18	0.06	6	0	6			
Eunotia	sp.		3	1	0	1	0	300	0	0	0	0	0			
Eunotia	arcus		4	0	0	1	0	300	0	0	0	0	0			
Eunotia	incisa		3	1	0	0	0	300	0	0	0	0	0			
Eunotia	minor		3	0	0	0	0	300	0	0	0	0	0			
Fragilaria	crotonensis		3	0	1	1	0	300	0	0	0	0	0			
Fragilariforma	viriscens	Fragilaria viriscens	3	0	0	0	0	300	0	0	0	0	0			
Frustulia	rhomboides	amphipleuroides	3	1	0	0	0	300	0	0	0	0	0			
Frustulia	vulgaris		3	0	0	0	0	300	0	0	0	0	0			
Gomphonema	truncatum		3	0	1	1	0	300	0	0	0	0	0			
Gomphonema	parvulum		1	0	1	1	8	300	8	0.0267	0	8	8			
Gomphonema	acuminatum		2	0	1	1	17	300	34	0.1133	0	17	17			
Gomphonema	augur		2	0	0	1	0	300	0	0	0	0	0			
Gomphonema	minutum		2	0	1	1	0	300	0	0	0	0	0			
Gyrosigma	spencerii	scalproides	2	0	0	0	0	300	0	0	0	0	0			
Melosira	varians		2	0	1	1	0	300	0	0	0	0	0			
Meridion	circulare		3	0	0	1	0	300	0	0	0	0	0			
Navicula	margalithi	tripunctata	2	0	1	1	0	300	0	0	0	0	0			
Navicula	capitatoradiata		2	0	1	1	0	300	0	0	0	0	0			
Navicula	cryptocephala		3	0	0	1	0	300	0	0	0	0	0			
Navicula	radiosa		3	0	1	1	0	300	0	0	0	0	0			
Navicula	angusta		3	1	0	0	0	300	0	0	0	0	0			
Navicula	lanceolata		2	0	1	1	20	300	40	0.1333	0	20	20			
Navicula	rhynchocephala		3	0	1	1	0	300	0	0	0	0	0			
Navicula	notha		2	0	0	0	0	300	0	0	0	0	0			
Nitzschia	linearis		2	0	1	1	57	300	114	0.38	0	57	57			
Nitzschia	curvula	Stenoplerobia/ flexa	2	0	0	0	6	300	12	0.04	0	0	0			
Nitzschia	palea		1	0	1	1	0	300	0	0	0	0	0			
Nitzschia	gracilis	acicularis	2	0	0	0	0	300	0	0	0	0	0			
Pinnularia	borealis	gibba	3	0	0	0	56	300	168	0.56	0	0	0			
Pinnularia	viridis		3	0	0	0	0	300	0	0	0	0	0			
Pinnularia	abaujensis		3	0	0	0	0	300	0	0	0	0	0			
Pinnularia	microstauron		3	0	0	0	1	300	3	0.01	0	0	0			
Pinnularia	subcapitata		3	0	0	0	0	300	0	0	0	0	0			
Placoneis	sp.		3	0	0	0	0	300	0	0	0	0	0			
Pleurosigma	elongatum		3	0	0	0	0	300	0	0	0	0	0			
Rhopalodia	gibba		3	0	0	0	0	300	0	0	0	0	0			
Sellaphora	pupula		2	0	0	0	0	300	0	0	0	0	0			
Semiorbis	hemicyclus		3	0	0	0	0	300	0	0	0	0	0			
Stauroneis	acuta		3	0	0	0	0	300	0	0	0	0	0			
Surirella	striatula		2	0	0	0	0	300	0	0	0	0	0			
Surirella	brebissonii		2	0	0	0	0	300	0	0	0	0	0			
Surirella	sp.		2	0	0	0	0	300	0	0	0	0	0			
Surirella	amphioxys		2	0	1	1	0	300	0	0	0	0	0			
Surirella	ovalis		2	0	1	1	0	300	0	0	0	0	0			
Synedra	acus		2	0	1	1	0	300	0	0	0	0	0			
Synedra	ulna	actinastroides	2	0	1	1	121	300	242	0.8067	0	121	121			
Synedra	rumpens	pulchella	2	0	1	1	0	300	0	0	0	0	0			
Synedra	delicatissima		2	0	1	1	0	300	0	0	0	0	0			
Tabellaria	flocculosa		3	1	0	1	0	300	0	0	0	0	0			
							300			**2.20**	**2**	**74**	**77**			

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