WINTER RIVER - TRACADIE BAY
WATERSHED ASSOCIATION

Supporting The Watershed,
So It Can Support You

2021 Annual Field Report

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1. Executive Summary

As another field season ends, the Winter River-Tracadie Bay Watershed Association (WRTBWA) is able to look back at the great amount of hard work completed by staff and volunteers. While still affected by the ongoing COVID-19 pandemic, crew members were able to work safely and comfortably with less intense restrictions but continuous caution. Since the previous year, health officials realized the virus spreads more easily through airborne particles compared to touching contaminated surfaces. For this reason, social distancing was still practiced and whenever staff were in close contact or inside the office masks were worn. Protocols for sharing equipment were not as strict as in 2020, although staff were still instructed to regularly clean commonly touched surfaces. The Annual General Meeting was held in person this year, but board meetings were still held by Zoom.

There are many accomplishments from the 2021 field season to be highlighted. A total of 1,040 waypoints were taken by staff members and 3,117 trees were planted. There were 12 brush mats created and 16 wildlife habitat brush piles made. The Watershed field crew cleared 10.54 kilometres of stream and cleaned up garbage from 14.23 kilometres of shoreline and 8.16 kilometres of roadside. All garbage collected from shoreline and roadside cleanups, old dumpsites and items found near streams in total weighed in at 1,450 kilograms. 2 bridges were built at the Watershed property on Suffolk Road by WRTBWA volunteers and staff.

Water monitoring instruments used this year included depth loggers, temperature loggers, dissolved oxygen loggers, v-notch weirs, and water quality measurements with a YSI meter. Surveys included headwater surveys, redd surveys, crop mapping surveys, rapid geomorphological assessments, and estuary checks. Other activities involved microplastic sampling, CABIN sampling, TSS sampling. No culverts were surveyed this season although there was a large culvert replacement on Suffolk Road crossing Tim's Creek.

The following link leads to an interactive map with photographs and marked points presenting some of the field work completed in the 2021 season including wildlife habitat brush piles, brush mats, depth loggers, temperature loggers, dissolved oxygen loggers, stream clearing, and shoreline and roadside cleanup areas.
https://www.google.com/maps/d/u/0/edit?mid=1NJ-EmTMB7I1GT9j5pQyt4oEr4OBcuTo0&usp=sharing

2. Staff

Table 1. *Staff employed for the 2021 field season.*

Name and Position	Year with WRTBWA	Term of Employment
Sarah Wheatley - *Coordinator*	7	Year round
Jennifer Woods - *Field Supervisor and Chainsaw Operator*	1	May - December
Raena Parent - *Data and Reporting Supervisor*	2	May - March
Evan Cahill - *Chainsaw Operator and Field Crew*	3	May - August
Sam MacSwain - *Chainsaw Operator and Field Crew*	4	May - June
Jessica McBride - *Field Crew*	2	June - August
Sarah McBride - *Field Crew*	5	May - August
Ashley Artz - *Field Crew*	1	May - August
Liam Poirier - *Field Crew*	1	June - December
Jackson Paquet - *Field Crew*	1	July - August
Lyndsay MacWilliams - *Water Monitoring and Restoration Intern*	1	September - March
Benjamin Henger - *Field Crew*	1	September - November

3. Project Activities

3.1 Tree Planting

Trees and shrubs, native to PEI, are delivered by the Frank J. Gaudet Tree Nursery each spring and fall to be planted by WRTBWA staff within the Watershed boundaries. This year, planting began 2021-05-11 following the first delivery of trees and shrubs. A total of 3,117 trees and shrubs were planted by our group this year. Tree deliveries were made directly to the Watershed Coordinator's residence. Sarah had dedicated an area of land where trees were stored and irrigated with multiple sprinklers connected to a timer. Trees and shrubs were labelled by staff and grouped based on species. The trees and shrubs were weeded multiple times by staff members. Most of May was dedicated to planting. Trees and shrubs were delivered by employee vehicles to various locations for planting on both residential and public properties, with a heavy focus on buffer zone enhancement. Photographs were taken at all sites, displaying the 'before' and 'after' images of plantings. Trees were planted at least 2 metres apart, while shrubs were planted a bit closer together. Hardwood trees were dressed with a tree guard to mitigate small rodents from chewing on the bark. Plants were pruned using small hand pruners if needed.

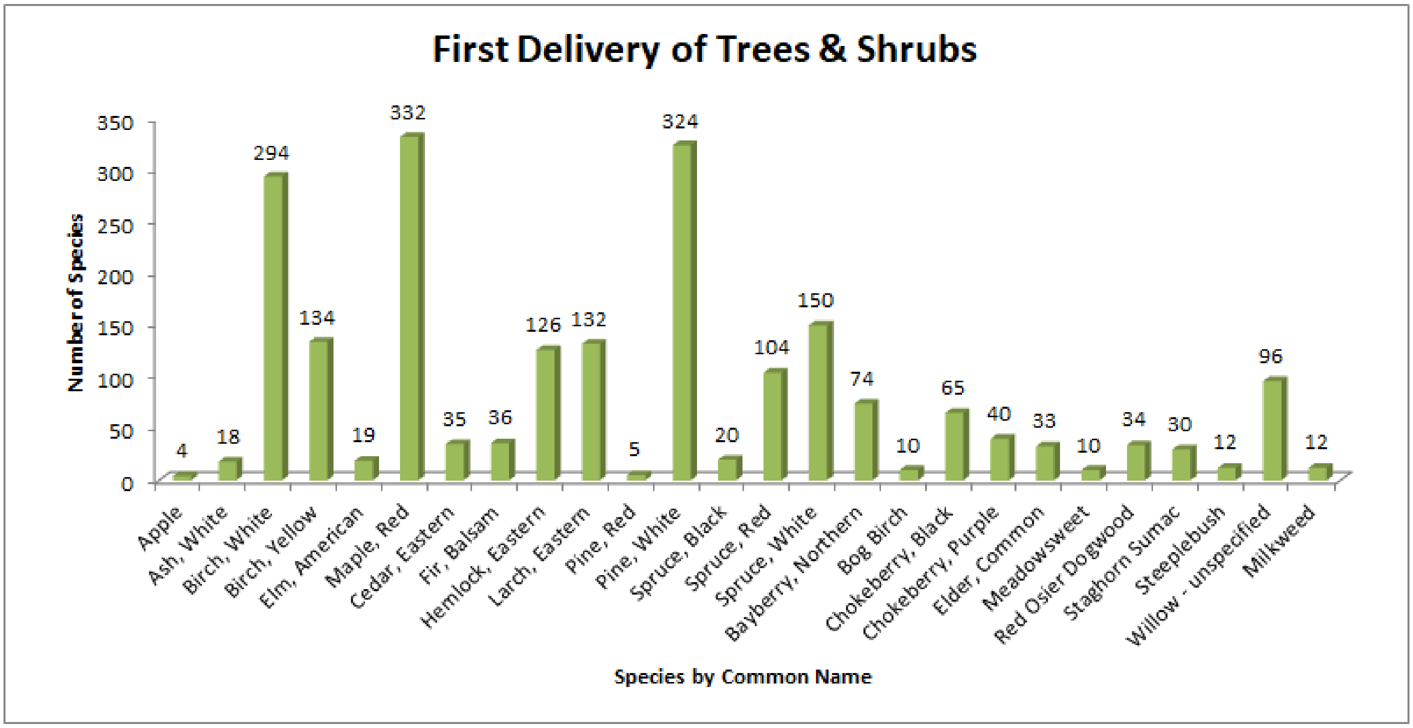

Figure 1*. Number and types of trees and shrubs that were delivered in the first order to WRTBWA by Frank J. Gaudet Nursery.*

Figure 2*. Staff member Ashley planting a tree as part of a buffer zone enhancement project.*

Buffer zone enhancement plantings, as well as hedgerow plantings, are an integral activity for improving watershed health. Buffer zones and hedgerows have a direct correlation to stream health. A buffer zone is established to help mitigate the impacts of agricultural runoff. The roots from these plants in these zones are meant to stabilize the soil, as well as filter many excess nutrients and toxins before they can enter a watercourse. Hedgerows create windbreaks and provide travel corridors for the movement of wildlife between forested areas. Hedgerows are also important for their soil retention abilities. WRTBWA happily works in conjunction with farmers and property owners within the Watershed to encourage these types of plantings. In addition to planting trees and shrubs, swamp milkweed (*Asclepias incarnata*) was planted as well. Swamp milkweed is planted for its importance to pollinators, specifically the monarch butterfly (*Danaus plexippus*). This plant is the one and only source of food in all stages of the monarch butterfly's life.

***Figure 3**. Before (left) and after (right) the planting of a white pine (Pinus strobus) sapling.*

The second order of trees and shrubs in the fall featured both tree plugs and 1-gallon pots. Northern red oak (*Quercus rubra*) tree plugs went to residential plantings and a city-owned property in Brackley that used to be farm fields and a ball diamond. Other trees and shrubs were allocated to various sites in need of planting with a heavy focus remaining on the enhancement of buffer zones.

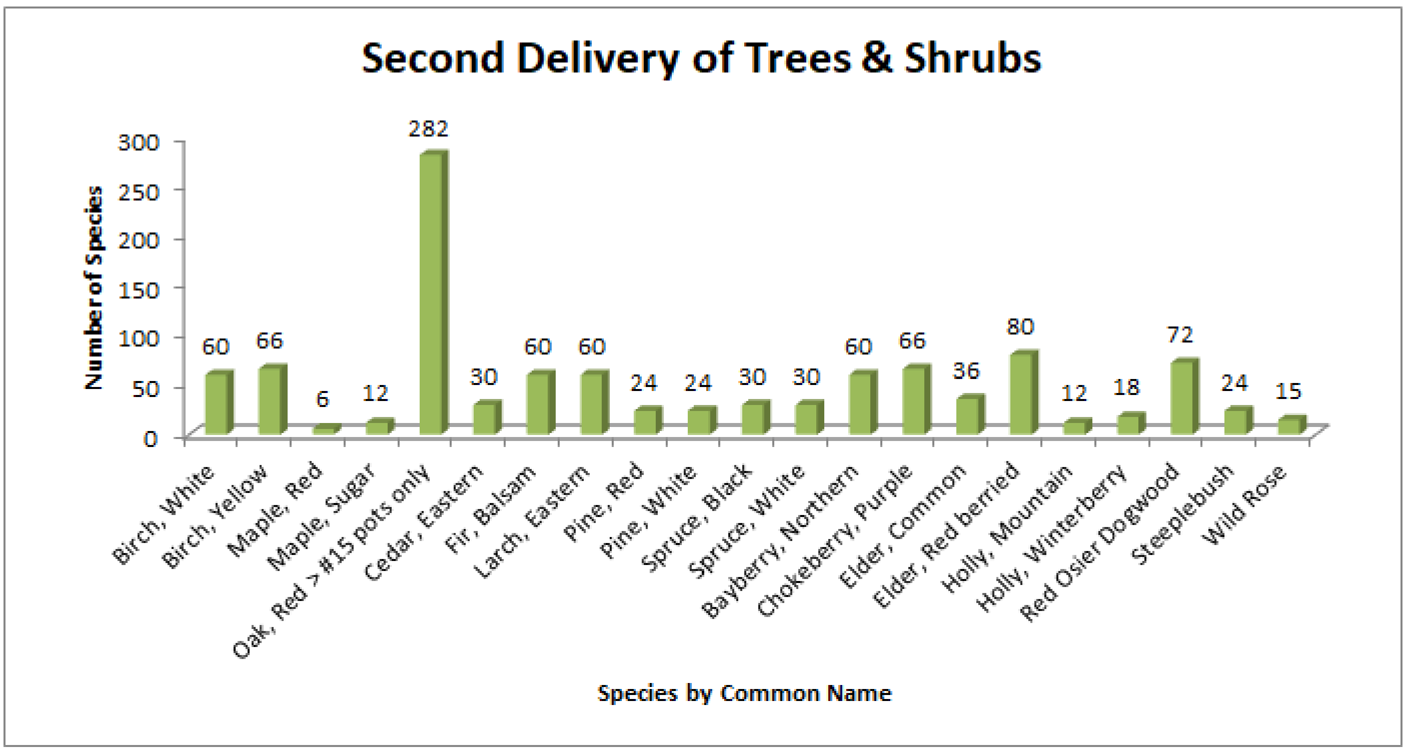

***Figure 4**. Number and types of trees and shrubs that were delivered in the second order to WRTBWA by Frank J. Gaudet Nursery.*

Figure 5*. Before (left) and after (right) a white birch was planted and pruned by a staff member.*

Figure 6*. Willow cuttings are collected by a staff member to be propagated.*

Willow cuttings were collected from the shoots coming off of 2 fallen willow trees within the Watershed boundaries. Approximately 100 willow cuttings were collected 2021-05-25. These cuttings were placed in water and sat in the sun. A large portion of the willow cuttings had begun sprouting roots by the third week of the propagation. These cuttings were taken to a site on the Hardy Mill Road where they were then fixed into the ground in a moist, but well-drained area. This was a part of a buffer zone enhancement project. A few of the cuttings were retained by Sarah for potting and extended rooting before planting. In the fall these remaining cuttings were planted at the banks of a stream at a previous culvert location in an attempt to prevent erosion along the banks. These will be monitored in the upcoming field season.

Figure 7*. A before (left) and after (right) of tree plugs that were collected from a residential property to be repotted. The result is very healthy, rejuvenated plugs.*

Table 2*. Trees planted by site. Numbers are approximately based on 2021 tree plans.*

East Suffolk #1 (private residence)	36
Millcove (private residence)	24
East Suffolk #2 (private residence)	485
City plantings	1,056
Area in between Union pumping station and Vanco - Right beside Confed trail	114
Winter River Trail	84
Vanco	402
Pater (Buffer zone enhancement)	708
Bedford (private residence)	8
Winter River Rd. (private residence)	38
Queens Pt #1 (private residence)	42
Queens Pt #2 (private residence)	30
Eco Action Prep (Sarah's land, WRTBWA land, GLN, Pater)	90
TOTAL	**3,117**

3.2 Agricultural Projects

This season the crew was given the opportunity to touch up some washed-out grass waterways in a field which has had some significant issues with runoff over the years, causing detriment to the natural waterways downslope. A grassed waterway is essentially a shallow channel between crops containing grass seed, which absorbs much of the surface water moving over the farmland, slowing down the surface runoff and controlling the erosion of the channel and the crops. The issue with the current grass waterway system at the location of interest is that when it was first added to the farmland, an unusual frost for the time of year caused the grass seed to not germinate properly; In turn, the overland flow was not absorbed by the grass seed and not slowed down, which caused the majority of the waterway to wash-out, forming a trench which was fairly deep in some areas.

In an attempt to remedy this, the crew filled in the trenched areas with soil in some areas and tilled and raked the existing soil in other areas before adding a grass seed and barley mixture to the trenched waterway. To aid in the germination of the grass seed compost was worked in with the soil as well as fertilizer, and of course, some watering. In some of the more worrisome areas, jute and hay were added on top of the added grass seed; this was held down with stakes. The process and progression of this task can be shown in Figure 8.

***Figure 8**. (From top left to bottom right) Beginning to fill in a large section of the gully; Soil in the gully after tilling; Covering seeded section with loose hay; Complete juted section of diversion terrace.*

Ideally, the entire trench would have been filled in, seeded, and covered with jute, but time and equipment constraints meant that this could only be done for one portion of the trench. In other deep areas, the crew placed hay bales in the trenches, spaced apart evenly, to slow down the water flowing in the trench gradually and promote water infiltration. In addition to this, large stones were placed on each side of the hay bales to keep them in place. The surface roughness of these stones should also assist in slowing down the water flow through the channel.

The soil that was dug up to fill in sections of the trench was taken from the outflow of the grass waterway. The pre-existing outflow pool was made to be much larger and was also seeded and covered with jute. This larger pool would theoretically slow down the flow that much more while again, promoting infiltration and grass growth. Following the pool was a rock check dam, where the surface roughness of the rocks would slow down the flow.

***Figure 9**. Straw bales and rocks in a deep part of the gully.*

***Figure 10**. Left: Outflow pool with rock check dam. Right: Digging out outflow pool.*

Figure 11. *Left: Seeding and composting the outflow pool. Right: Staking the jute covered outflow pool.*

After only a couple of rainfall events, the freshly planted grass and barley began to grow, especially in the juted sections of the grass waterway, as shown in Figure 12.

Figure 12. *Grass growing in juted section of diversion terrace.*

However, after the first heavy rainfall event of 40 milimeters, the straw bales washed out of the gully. This showed that the rocks holding the bales in place were not heavy enough to deal with this amount of flow. Also, the seeded sections further uphill between the bales did not seem to produce much grass and washed out as a result. This heavy rainfall event also caused some of the stakes in the juted sections to fall down, uplifting some of the jute (Figure 13). To remedy this, heavy-duty stakes were used to replace the old handmade stakes; these go into the soil much deeper and should remain more stable when the soil is highly saturated.

Figure 13. *Left: Washed out gully after heavy rain; Right: stakes and jute moved by heavy rain.*

Figure 14. *Left: Brush mat created on terrace. Right: Rock check dam placed at the end of an outflow pool.*

To address what happened after the heavy rainfall event, several brush-mats were added to the gullies, as well as additional rock dams. A brush mat should slow down the water flow through the gully while also trapping some of the sediment in it. Over time, the voids in the brush mat should fill in with sediment, filling in the gully.

As for the new rock check dams, heavier rocks were placed downslope from the smaller rocks, holding the small rocks in place in periods of heavy flow. Gravel and small rocks were placed in the voids of the rock check dams to create less space for water to pass through. These were placed several meters apart throughout the gully and also at the end of each outflow pool as shown here.

After more rainfall events, it was discovered that the rock dams and brush mats did not significantly slow down the water flow in the gully; a lot of the dams were slightly washed out and even a couple of brushmats (see Figure 15 below).

Figure 15*. Rock check dam before (left) and after (right) a big rain.*

Initially, the rock check dams and brush mats filled in the gully but also slightly covered the pathway of overflow on the grass next to the gully. After meeting Tyler Wright with the Department of Agriculture, we learned that it was more important to focus more on filling in the trench and not focusing as much on the overflow of water going on the grass. The grass will slow down the water if it is to flow over it, and the water will also promote the growth of the grass. Over time, covering the grass would kill it, which is unfavourable. The brush mats were left as they were for the time being and the check dams that were washed out were reassembled in the trench only, again trying to have the heavier rocks on the downslope end, acting as an anchor for the smaller rocks placed on the upslope side.

Figure 16*. Improved rock check dam with heavier rocks on the downslope end acting as anchors and smaller rocks on the upslope end.*

After not seeing much progress from all of the hours of work put in, the WRTBWA board of directors made the decision to stop further work on this grass waterway project. Beginning in mid August, a silt trap was constructed as a final attempt for the time being to inhibit agricultural runoff from going into a nearby stream. A summary of the work done can be viewed in Figures 17 through 20.

Figure 17*. Construction day one - 2021-08-13.*

Figure 18*. During the heavy rain associated with former Hurricane Ida (2021-09-02) when construction was mostly complete.*

Figure 19*. Excavator creating a berm in a laneway directly into the buffer zone.*

Figure 20*. Berm on laneway to divert water coming from ends of furrows directly into buffer zone, rather than joining with flow from diversion terrace.*

3.3 Stream Restoration

Stream restoration is carried out by staff members beginning June 1st of every year. This start date is appointed to all watersheds by the government of Prince Edward Island to allow adequate and undisturbed spawning by various aquatic species throughout the spring. Restorative projects are conducted to help enhance the overall quality and health of streams, rivers, and estuaries. This field season a total distance of 5.8 km of stream was cleared.

This year, stream restoration was focused on a section of the Winter River that staff accessed through fields off of Hardy Mill Road. This area was referred to as the soil erosion site by staff members. Many projects were conducted here as this area historically suffers from flooding, siltation build-up, and vegetation die-off. However, in recent years, watershed enhancement activities done by WRTBWA have allowed for the regeneration of a diverse amount of wetland plants including cattails (*Typha sp*.), bullrushes (*Typha latifolia*), sedges (*Cyperaceae sp*.). The result of flooding led to a large amount of standing dead trees occupying the area. The main species of dead trees identified were large-toothed aspen (*Populus grandidentata*), trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), red spruce (Picea *rubens*), and white birch (*Betula papyrifera*). Dead trees were removed by staff using chainsaws. A small number of dead trees were left for wildlife habitat. Staff who wish to operate a chainsaw are required to complete their certification in silviculture practice offered by the Forestry Department of PEI. This year, three staff members were certified in chainsaw operation. Standing dead trees were felled, cut into six-foot logs, and placed adjacent to the stream to build height on the banks and reduce the amount of flooding. Logs were placed perpendicular to the stream and in areas where water had pooled in order to create a base. After logs were placed, brush from spruce trees was added to create brush mats. This brush was brought in by truck from a woodlot within the Watershed, moving forward referred to as the Pleasant Grove woodlot.

Figure 21*. Left: Large standing dead trees. Right: After standing dead trees were removed.*

Figure 22*. Left: Logs placed on banks of the stream at the soil erosion site. Right: Brush collected from white spruce trees at the Pleasant Grove woodlot.*

Figure 23*. Large brush mat in place at soil erosion site.*

Figure 24. *Staff using logs to guide water flow of the stream.*

Figure 25. *Brush mat and logs in place.*

The Pleasant Grove woodlot contains a stand of trees that WRTBWA was given permission to access for forestry practice purposes. This year, staff used this stand to collect brush to be used at the soil erosion site for brush mats. Chainsaw operators were responsible for using the thinning method to fell and limb spruce trees in the area. Thinning is a spacing treatment done to young stands to remove competition for desired trees. The stand of trees mainly consists of white spruce; a particularly good tree for using to create brush mats. The white spruce in this area are so densely packed together that trees are not growing to their optimal standards. White spruce in this stand is often found with limited branches growing, except near the top of the tree where sun is best absorbed. When brush was cut, the field crew would haul brush to an access road to be picked up by truck.

3.4 Brush Mats

Building brush mats are a watershed's way of mitigating erosion and increasing productivity within a stream. Brush mats are piles of tree debris placed along or atop banks to collect silt and build bank size while narrowing the stream. The narrow stream helps increase the flow rate and depth of water. The collection of silt in these piles is vital for the overall health of the stream.

Brush mats are made up of spruce branches. The needles from a spruce tree will stay attached to a branch long after it has been cut. The branches are placed in the stream with their branch stem facing upstream so that the needles move with the flow of the water. Branches are piled by interlocking stems to create a flat, but full structure. Wooden stakes are hammered into the ground and then sisal rope is tightly weaved around the stakes to hold the branches in place.

The goal of a brush mat is that it will last a long time, collecting enough silt to eventually establish a base for vegetation to grow. Brush mats are an important part of stream restoration and using the technique is vital to the longevity of healthy streams on PEI.

Figure 26. *Before (left) and after (right) the installation of a brush mat.*

3.5 Wildlife Habitat

Dead debris piles are deliberately made up by Watershed members to make habitats for various wildlife. They are built using small trees and boughs - often from byproducts of brush piles and other forestry activities carried out in the watershed. Wildlife such as songbirds, voles, chipmunks, squirrels, rabbits, salamanders, frogs, snakes, and insects use piles as dens or nesting spots, to shelter from bad weather, to escape predators, and to forage.

Birds		**Mammals**	**Reptiles**
That use the inside of a pile	*That use the outside of a pile*	Chipmunks	Alligator lizards
Bushtits	Grouse	Cottontail rabbits	Snakes
Chickadees	Hummingbirds	Ground squirrels	Toads
Dark-eyed juncos	Jays	Fox	Turtles
Flycatchers	Pheasants	Mice	
Golden-crowned sparrows	Robins	Shrews	**Amphibians**
Grouse	Song sparrows	Skunks	Salamanders
Pheasants	Towhees	Voles	
Quail	Warblers	Weasels	**Insects**
Song sparrows	White-crowned sparrows	Woodrats	Bees
Thrushes	Woodpeckers		
Towhees			
White-crowned sparrows			
Wrens			

Figure 27. *"Who uses habitat piles?" From Landscaping for Wildlife in the Pacific Northwest (p. 320), by R. Link, 2017, Seattle, WA: University of Washington Press. Copyright [1999] by Washington Department of Fish and Wildlife. Reprinted with permission.*

Figure 28. *Habitat pile created from the debris of felled trees while patch cutting a dense white spruce stand.*

Snags, large downed logs, and big dead trees provide habitat for various wildlife. This woody debris provides important structures for cavity-dependent birds and small mammals, as well as food sources for woodpeckers and other foragers. They are great for the environment as the wood slowly releases nutrients into the ecosystem with the help of decomposers.

Figure 29. *Wildlife habitat piles located on WRTBWA property in the Suffolk area.*

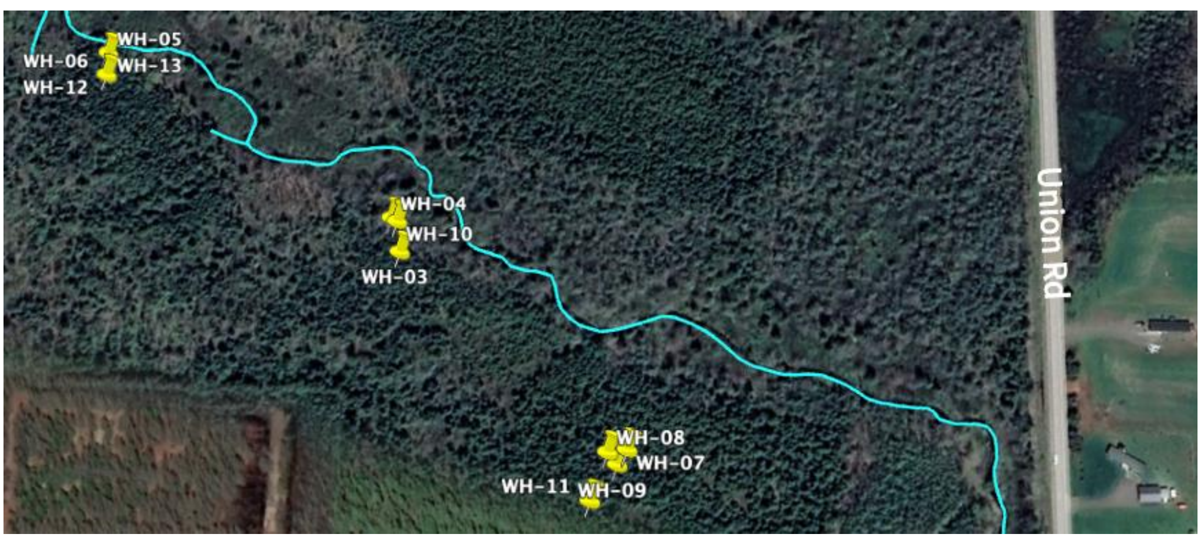

Figure 30. *Wildlife habitat piles located in the Brackley branch.*

3.6 Shoreline, Roadside, and Streamside Cleanups

Garbage cleanups are done regularly throughout the field season, across the Watershed. Staff members try to cover a significant amount of area, but mostly spend time along shorelines as these are the areas where garbage is most accumulated. Staff members start cleaning at an area that can be accessed by truck to remove the garbage collected. They track the distance they have covered using GPS applications. A GPS point is put at the garbage collection area and then at the end point before staff turn around and walk back. Staff bring along garbage bags, gloves, and twine. The twine is used to attach buoys that are found along the shore. They are strung on the twine like beads on string and since they float they can be easily dragged through the water back to the garbage collection point. When staff are out in the field they are encouraged to GPS any areas of garbage that cannot be removed but to collect anything that can be carried out. Most garbage collections consist of fishing debris including: styrofoam buoys, pieces of rope, or netting. Other common garbage that is collected are aluminium cans, plastics, tires, shotgun shells, and glass.

***Figure 31**. Left: Staff member Sam collecting garbage from a shoreline (aquaculture and fishing debris are visible). Right: Garbage collected along a shoreline and placed at a pickup location.*

***Figure 32**. Map showing shoreline cleanups completed. A total of 14 kilometres were covered this field season.*

3.7 Donated Woodlot (Watershed Trail)

Compared to the previous year, trail work on the donated woodlot in Suffolk was not a high priority. However, any work that was done focused on making steep inclines safer and more accessible. In the late fall, WRTBWA received funding to build 2 bridges along the trail. Sheldon Wheatley, a retired contractor, volunteered to lead the fall staff in the construction of both bridges over a span of a few weeks. Pictures summarizing bridgework can be viewed below (Figures 33 to 36).

Figure 33*. Left to right: Lyndsay (face obscured), Liam, John, Sheldon, Jenn - installation of mudsill.*

Figure 34*. Left to right: John Hughes, Sheldon, and Liam levelling posts.*

Figure 35. *Left to right: Sheldon, Liam, and Sarah nailing down planks to create bridge floor.*

Figure 36. *Mostly completed bridge.*

Future plans for the trail moving forward will involve more work on making the trail more accessible. This will involve regrading slopes and putting in retaining walls to make a more flat walking surface in areas that are tricky to manoeuvre.

3.8 Culvert Replacement

From 2021-07-14 to 2021-08-24 a culvert replacement was completed at the intersection of Suffolk Road and Tim's Creek, near where the creek joins the main channel of the Winter River. The purpose of the project is to create better fish passage through the culvert. The previous culverts (2 small culverts side-by-side) were undersized for sufficient passage of water during high flows, were easily blocked by debris at the inlet, and the hung culverts did not allow fish passage during most of the year.

This site was located due to its proximity to the head of tide, the area of upstream habitat, the quality of the upstream habitat, landowner engagement, proximity to important trout spawning locations, and construction feasibility.

This project is the first attempt at a large, over-embedded culvert in Atlantic Canada. The design was created by Paul Strain with the Department of Transportation. The contractors who carried out the project was Maritime Dredging. They worked 4 days a week with a WRTBWA staff member often present to observe the progress of the project. Evan Cahil, an environmental engineering student, was present for the majority of the project until his contract for the summer ended. This opportunity allowed him to witness the successful implementation of a project and ask questions to the professionals throughout. For more in-depth details on this project (including daily descriptions of work) please refer to Appendix A.

3.9 Forest Enhancement at Glenaladale Estate

This year with construction going on at the Glenaladale Estate and various time constraints with other projects, WRTBWA did not spend much time with forest enhancement activities on Glenaladale properties in the 2021 field season. A few days were spent thinning and pruning trees but that was the extent of the work completed by WRTBWA staff.

4. Community Outreach

The Lady’s Slipper self-guided tour was a walking experience on the Winter River trail through a descriptive brochure that highlighted the PEI plant, Pink Lady’s Slipper (*Cypripedium acaule*). The tour took place from 2021-06-05 to 2021-06-14, when the native plant was in bloom. The tour featured 9 stations that hikers would stop at to learn interesting information about the trail. The information displayed in the brochure was provided to WRTBWA staff by longtime locals John Hughes and George Coade. Hikers used numbers painted on wooden cookies to help identify when they had come to a station. The tour was 5 kilometres in length and hikers were encouraged to share photos of their experience on social media along the way.

***Figure 37**. Board member John pictured pointing out key features along the Winter River trail.*

This year, WRTBWA was joined by the UPEI Star’s program at the Glenaladale House to receive an educational demonstration on the movement of groundwater across PEI. Sarah (Coordinator) used a groundwater model simulator to describe the topic. The group was taught the importance of keeping our groundwater clean through the responsible practice of daily tasks such as farming. The group was then given a tour of the historic building and later helped staff with collecting garbage from the Tracadie Bay shoreline.

Figure 38. *UPEI STARS are pictured walking to the beach to help with shoreline cleanup.*

5. Habitat Monitoring Activities

5.1 Stream Assessments

Stream assessments are conducted by staff members to determine the health and productivity of watercourses within the Watershed. The most commonly conducted stream assessment is done by identifying the presence or absence of different principles based on a guided list. Staff members start at the most accessible point when conducting a stream assessment and walk upstream until there is a change in morphology. Staff record different points of interest along the way using GPS apps on personal phones. Photos are encouraged to be taken for evidence. In some cases, samples are collected as well. A major part of these assessments is to record areas where water is being blocked due to different obstructions. Most of these obstructions are of natural debris such as large fallen trees. When these are recorded, the chainsaw operator can then be sent in along with a team to remove the blockages, creating better water flow and fish passage. Beaver activity is recorded and is monitored if they are within the Watershed's beaver-free area. This covers an area where beavers will be removed via trapping so as not to cause disturbance to man-made structures. Other points of interest can include the presence of invasive species, riparian zone violations, and any other activity that would be of concern/interest to theatershed. Fish habitat is another important point of interest that staff identify along watercourses. Common components of fish habitat are the presence of riffles and pools, overhead cover, shade, and rocky substrate. This information is collected into a master sheet where areas can be easily monitored over time.

Figure 39. *While conducting a stream assessment of the Winter River, staff are checking substrate conditions.*

Rapid Geomorphological Assessments (RGAs) have been introduced to the Watershed's assessment techniques this year. The PEI Watershed Alliance graciously welcomed members of environmental programs from across the Island to participate in a 4-day training program that was conducted by 5R Environmental Consulting Inc. The course, *The Introduction and Understanding of Fluvial Morphology*, consisted of in-class presentations as well as a field component. The concept was to understand how our watercourses are changing over time, what may be influencing them, and how we can predict where they will be in the future. The assessments use a scoring system where staff members identify the presence or absence of features in a watercourse. The score determines whether the area surveyed is in a state of aggradation- sediment is accumulating, degradation- there is a lack of sediment, widening, or in an adjustment phase. Each member who attended the course was given a binder of notes on the course and papers to conduct surveys. WRTBWA began practicing RGAs on 2021-10-05. Information has since been compiled in order to determine the phase in which our watercourses are going through. The watershed will continue to keep conducting these assessments and improving the quality in which they are done. Total kilometres of stream that was assessed (according to the RGA spreadsheet) = 21.26 km of stream in the Winter River-Tracadie Bay watershed has been assessed using the RGA method.

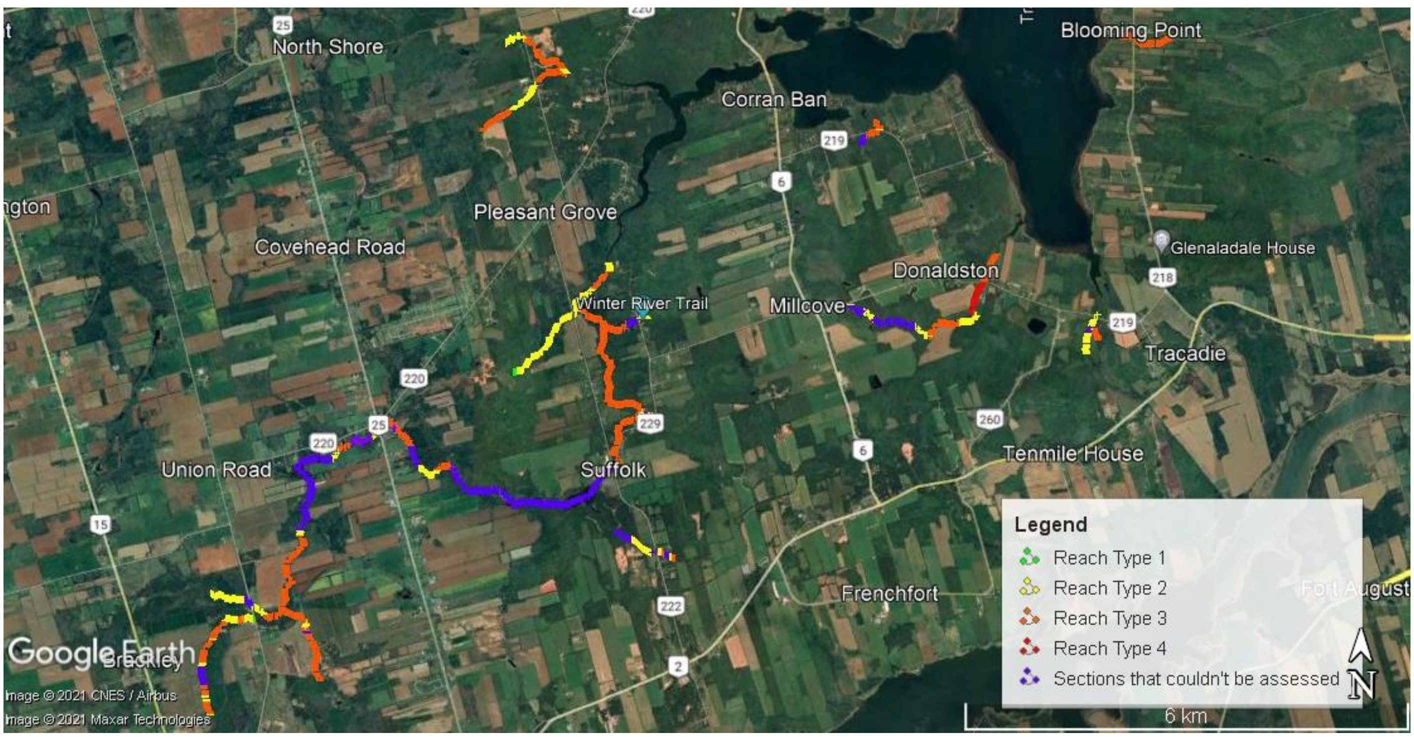

***Figure 40**. Map of Rapid Geomorphological Assessments (RGA) completed in the 2021 fields season. Note the purple areas could not be assessed using the RGA format due to that section being a wetland, being influenced by beaver activity, or having wetland characteristics.*

5.2 iNaturalist

iNatualist is a social network that allows users of various backgrounds (nature lovers, biologists, etc.) to upload pictures and other identifying information of different plant species they find and other plant enthusiasts help to identify the species. There is also the option to upload sounds; this could be useful when trying to identify a certain animal, bird, or insect.

Uploads and interactions with other posts can be done on the iNaturalist website or, like the WRTBWA staff, users can download and use a free, user-friendly phone app. There are also several convenient functions; if users are without an internet source, they can still take pictures and everything will upload as soon as a network is available; all observations are saved for future reference; different groups can create their own pages where pictures taken nearby that are related to predetermined keywords, for example, a given region, invasive species, or species type like fungi, will automatically be uploaded to these pages. The crew at WRTBWA frequently uses this app to document different species they observe throughout the Watershed.

5.3 Crop Data

Introduction & Methods

The type of crop planted in a set field should be changed routinely to ensure productive soil health. Different crops require more of some nutrients and less of others, so changing up what crops are planted can help soil retain the proper balance of nutrients. For example, corn takes nitrogen out of the soil, while peas are nitrogen fixers meaning they put nitrogen into the soil. A crop rotation that involves both these plants would help to keep nitrogen levels balanced. Failure to properly rotate crops could lead to nutrient deficiencies in soil, leading to poor crop health; or to an overabundance of nutrients which may raise the potential of nutrient leaching into groundwater, which in turn impacts the rest of the ecosystem. However, even if nutrients are balanced, another major reason for crop rotation is soil erosion. Row crops such as potatoes, cause a large amount of soil erosion, so PEI has regulations dictating how often these types of crops can be grown within a rotation system (Campbell, 2021; Government of Prince Edward Island, 2012). Crop rotations can also help mitigate pests. If the same crop is planted year after year, crop-specific pests may become abundant.

This 2021 field season, crew members Ashley and Liam travelled around the Winter River-Tracadie Bay Watershed area taking GPS points of what crops were being grown in fields visible from public roads and walking trails. Ashley has a background in agriculture which proved to be advantageous with crop identification. Once all visible fields were accounted for, the GPS points were uploaded to a Google Earth map where each field was labelled and colour-coded by crop type. This compiled information gives an overview of what crops make up most of the agricultural land in the Watershed and helps the WRTBWA keep track of how often and what kinds of crop rotations take place year to year.

Results & Discussion

A total of 471 fields consisting of 3,196 hectares were surveyed in the 2021 field season. It should be noted that only fields that were visible from streams or public trails and roads were surveyed. This means that overall the data collected by staff is only an estimate and does not fully represent all fields within the Watershed. Staff observed the following crops in the Winter River-Tracadie Bay watershed area: hay, wheat, barley, winter wheat, corn, hay, pastureland, apples, blueberries, soybeans, peas, potatoes, raspberries, pumpkins, buckwheat, and a variety of other cover crops. A colour-coded map of common crops with the boundaries of the Watershed is below (see Figure 41). Note that the Watershed boundary lines have expanded; Feehan Shore (top right of the map) has recently been added, thus adding more fields to survey.

About 34% of fields in the Watershed area were not accounted for through crop map surveying due to the lack of accessibility to fields as previously mentioned. The crops that accounted for the most space were hay at 18% and perennials, making up 17.5% of fields. Perennials included mostly blueberries but also apples, and raspberries. Grain only made up about a tenth of fields, potatoes were 7% and corn was around 5%. Remaining fields including soy, pasture, and other crops that are less common each made up under three percent of surveyed land. See Figure 42 for a visual of the percentages of each field surveyed in 2021. Comparing results to the previous field season shows that most crops had the same representation with very small variations. General changes included small decreases in grain and soy (5% and 2% drops respectively), and a small 2% increase in both corn and potatoes.

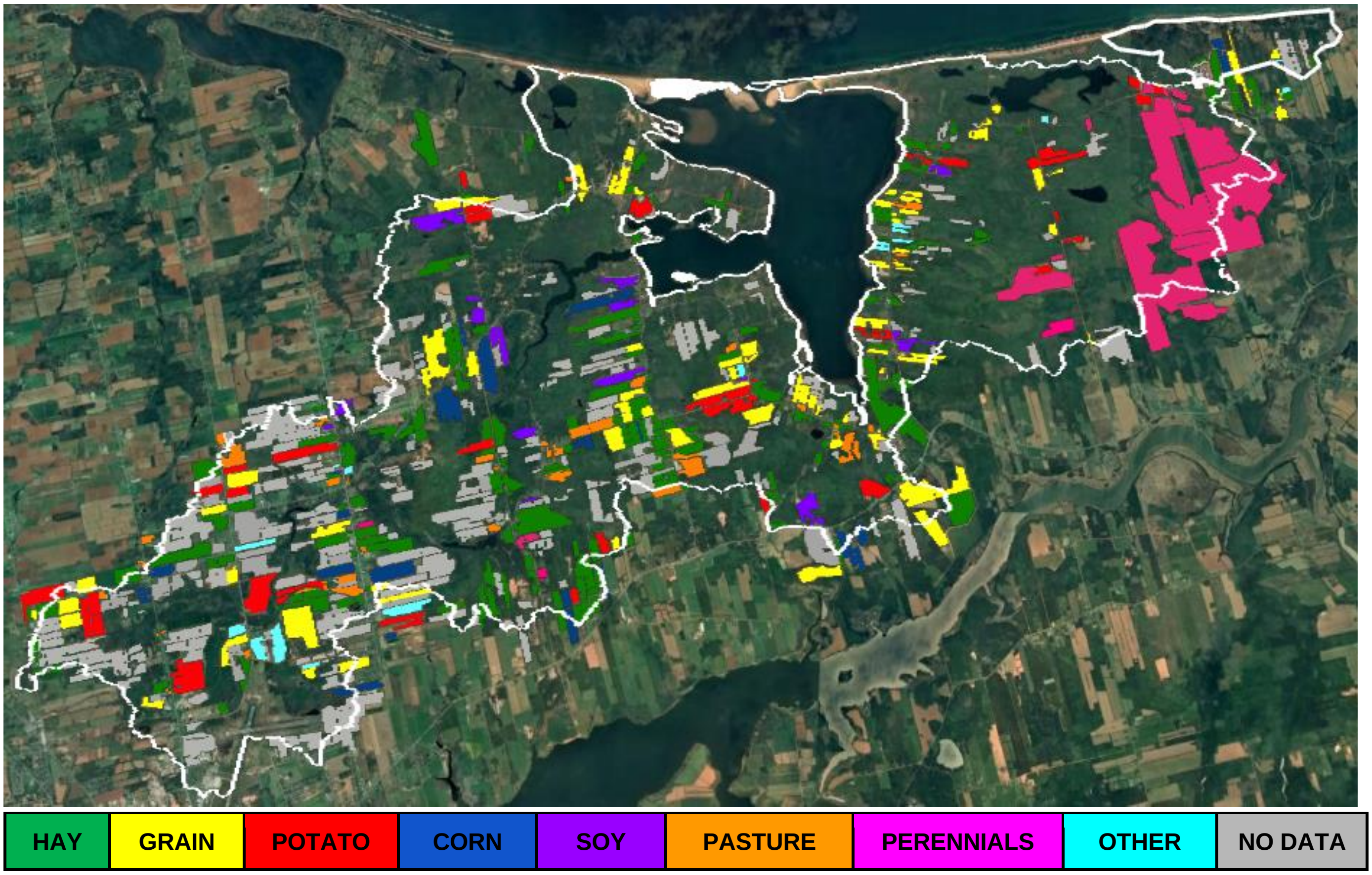

Figure 41. *Map of crops growing in the Winter River-Tracadie Bay watershed in the 2021 season, as recorded by staff. Note the addition of Feehan's Shore to the watershed boundaries (top right).*

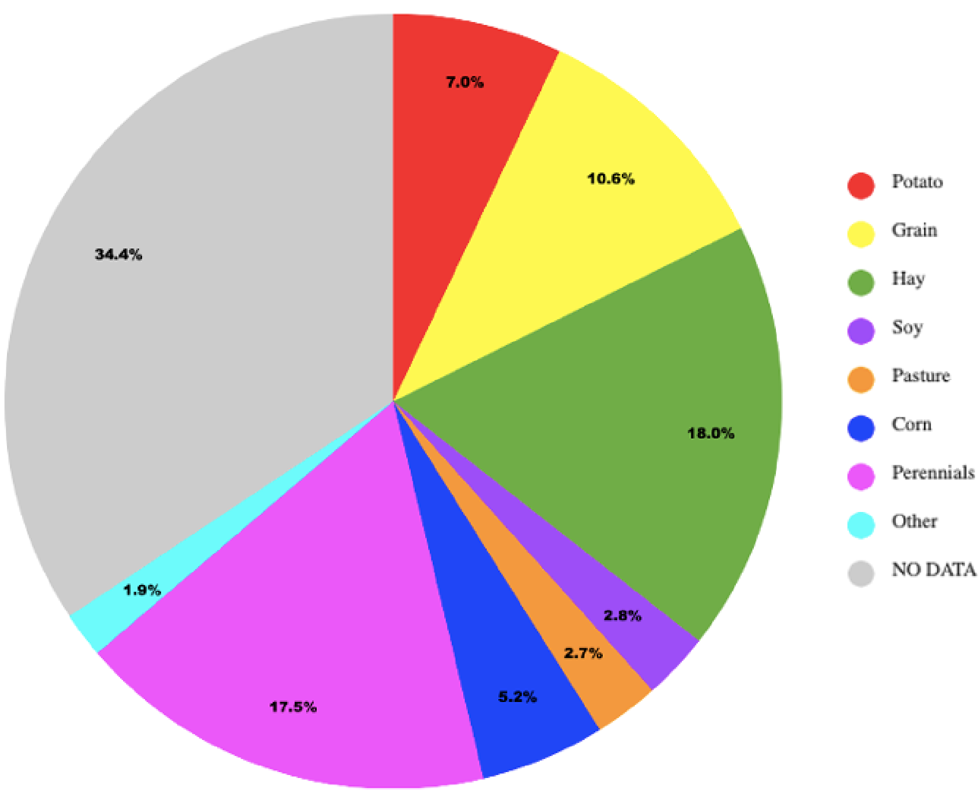

***Figure 42**. Crop data collected by WRTBWA staff in the 2021 field season. “No data " encompasses all fields that are not monitored due to their inaccessibility from public lands.*

5.4 Soil Health

Introduction

Soil sampling is a great way to test the soil health and chemistry of agricultural land. Soil sampling can help with issues such as “1) low yields due to lack of fertility, 2) acidic soils, 3) identification of appropriate fertilizer mixes, [and] 4) excessive fertilizer application” (PEI Analytical Laboratories, 2014a). Soil health reports can also help document longer term efforts to improve the function of the soil.

The WRTBWA encourages local farmers to get the soil of their fields tested and when the option is available through free testing initiatives. The Association offers to send crew members to go out and conduct the soil sampling themselves. When this takes place, the WRTBWA puts a lot of care into keeping the names of participating farmers, the specific fields sampled, and the test results from their fields strictly confidential. To do so the watershed coordinator is the only individual with access to any identifying information and the number of staff working with the soil sampling results is very limited.

Methods

Soil sampling guidelines recommended by the PEI Analytical Lab were followed when sampling at each location. This involved crew members walking in a zigzag pattern across the span of the chosen field and taking slices of soil at 6 random points. Tire tracks and areas of low elevation in relation to the rest of the field were avoided as sampling points since they did not represent the field as a whole. To obtain a soil slice, a crew member would dig a hole approximately 9 inches deep, making sure to keep one edge straight and vertically level. Using the shovel, a cross-section was then taken, approximately 1 to 2 inches wide and 7 to 8 inches deep. All slices were then mixed together in a large container and samples were scooped into sample bags, one for soil nutrient sampling (Soil Analysis Report) and the other for soil health sampling (Soil Health Test Report). Soil samples were then delivered to the PEI Analytical Lab to be analyzed.

The Soil Analysis Report indicated the levels of organic matter, pH, phosphate, potash, calcium, magnesium, boron, copper, zinc, sulfur, manganese, iron, sodium, aluminium, and lime in the soil. Along with the report details, recommendations for how much limestone to apply to achieve the desired pH were provided as well as suggestions for nitrogen, phosphate, and potash amounts to apply per hectare/acre based on the conditions of the field.

The Soil Health Test Report revealed information such as soil texture (broken down into percentages of sand, silt, and clay), organic matter, active carbon, soil respiration, aggregate stability, and biological nitrogen availability. Each of these categories was assigned a score out of 100 and then based on their score, given a rating from low to high (see Figure 43). Other information provided in this report included pH, and measurements of phosphorous, carbon, and nitrogen levels.

Rating	Interpretation
Low (0-25)	The "Low" rating means the test value is among the lowest 25% for all sites sampled across PEI and may be limiting the productivity of the system. Short and long term management strategies should be implemented to build up the soil health within the field.
Low+ (26-50)	The "Low +" rating means the test value is below average of all sites sampled across PEI. Review management practices and consider including additional short and long term management. Re-test again after one full rotation to determine if the field is trending towards improvement or decline.
Medium (51-75)	The "Medium" rating means the test value is above average of all sites sampled across PEI. Consider which practices are currently working on the farm and where areas for improvement may exist. Prioritize this against the status of other tests and fields reported to determine where resources and time should be spent.
High (76-100)	The "High" rating means the test value is among the top 25% of all sites sampled across PEI. Consider field history and previous management practices to identify ways of maintaining the strong rating. If making changes to cropping practices, consider how it may affect soil health and in this event, plan future re-sampling to observe changes or trends. Focus management strategies on other lower-rated soil health test results if they exist.

Figure 43*. The rating system used in the PEI Analytical Lab Soil Health Test Report. The categories rated included Organic Matter, Active Carbon, Soil Respiration, Aggregate Stability, and Biological Nitrogen Availability.*

Results & Discussion

This year the field crew took soil samples from a total of 28 agricultural fields in the fall of 2021. Crops grown in these fields included potatoes, hay, grain, buckwheat and sorghum-sudangrass. The tillage of all fields was between 1 and 7inches and a number of fields had animal manure added in recent months.

Looking at the results from the Soil Analysis Report (see Table 3), grades ranged on average in the mid to low section, suggesting there is room for improvement in most categories. Specific areas of concern include Potash, Calcium, Magnesium, Boron, and Copper, all of which had median grades of 2 or 3 which indicate low and medium levels of soil fertility. The highest grade, being 6 came from all results for iron which is understandable as the soil on the Island is known for being made up of high quantities of iron.

Table 3*. Results from the Soil Analysis Report conducted by the PEI Analytical Lab. Grades are scored from 1 to 6, with 1 being "Very Low" and 6 being "Very High".*

Soil Chemistry						
	Minimum	**Grade**	**Median**	**Grade**	**Maximum**	**Grade**
Organic Matter (%)	1.60	N/A	2.20	N/A	3.30	N/A
pH	5.20	N/A	5.70	N/A	6.40	N/A
Phosphate (ppm)	104	2	315	5.5	574	6
Potash (ppm)	34	1	66	2	114	3
Calcium (ppm)	242	1	617	2	1102	3
Magnesium (ppm)	19	3	55	3	139	3
Boron (ppm)	0.10	3	0.30	3	0.50	4
Copper (ppm)	0.30	2	0.90	2	3.40	5

Zinc (ppm)	0.50	3	1.10	4	16.80	4
Sulfur (ppm)	12	3	18	4	49	6
Manganese (ppm)	15	3	27	3.5	52	5
Iron (ppm)	113	6	241	6	381	6
Sodium (ppm)	15	N/A	20	N/A	39	N/A
Aluminum (ppm)	954	N/A	1404	N/A	2198	N/A
Lime Index	6.30	N/A	6.70	N/A	7.10	N/A

The results from the Soil Health Test Report (see Table 4) were not as promising as anticipated. Out of all the categories rated, the minimum results all fell in the "Low" ranking, meaning they are among the lowest 25% of sites that have been sampled on PEI. Median ratings were also quite low with 3 categories in the "Low" ranking and two in the "Low+" ranking meaning while not the lowest, these categories still sit below average compared to other sampled sites on the Island. Maximum results were better with the majority falling under the "Medium" ranking, meaning above average while only 1 category, Biological Nitrogen Availability, fell in the "High" ranking, meaning it was among the highest 25% of sites sampled on PEI.

***Table 4**. Results from the Soil Health Test Report conducted by the PEI Analytical Lab.*

Soil Health						
	Minimum	**Rating**	**Median**	**Rating**	**Maximum**	**Rating**
Organic Matter (%)	1.60	L	2.20	L	3.30	M
Active Carbon (µg/g)	231	L	336	L	532	M
Soil Respiration (mg/g)	0.31	L	0.45	L	0.72	M
Aggregate Stability (%)	18.40	L	35.70	L+	56.80	M
Biological Nitrogen Availability (mg/kg)	11.80	L	21.10	L+	42.60	H
pH	5.00	N/A	5.70	N/A	6.40	N/A
Phosphorous Index (P/Al) (%)	2.99	N/A	10.21	N/A	23.32	N/A
C:N Ratio	8.92	N/A	11.60	N/A	17.40	N/A
Total Carbon (%)	0.93	N/A	1.28	N/A	1.91	N/A
Total Nitrogen (%)	0.10	N/A	0.12	N/A	0.18	N/A

Results from both tests show pH levels that are between 5.0 and 6.4 meaning the soil is very acidic. This is normal for PEI soil as crops such as potatoes grow best in these conditions (PEI Analytical Laboratories, 2014b). The percentage of organic matter in both tests suggests there is room for improvement in this area since higher percentages such as 3-6% indicate better quality of soil. Organic matter can be positively influenced by proper tilling methods, crop rotations, cover cropping, crop residues, and animal manure (Fenton, Albers, & Ketterings, 2008).

5.5 Redd Surveys

In the months of late fall, Brook Trout (*Salvelinus fontinalis*) spawn and lay their eggs in the WRTB Watershed. The upturned cobble and depressions created in the spawning process, are called redds. When the female trout is ready to lay her eggs, she will find an area that has good flow, cobble/gravel and riffles. The fish make a nest in the stream bed by pushing their tail side to side to move rocks around and dig away fine sediment. This is where they deposit their eggs. Monitoring redds in our Watershed every fall is one way we can monitor the Brook Trout population. Brook Trout is our species of interest, as we no longer have Atlantic Salmon in our Watershed.

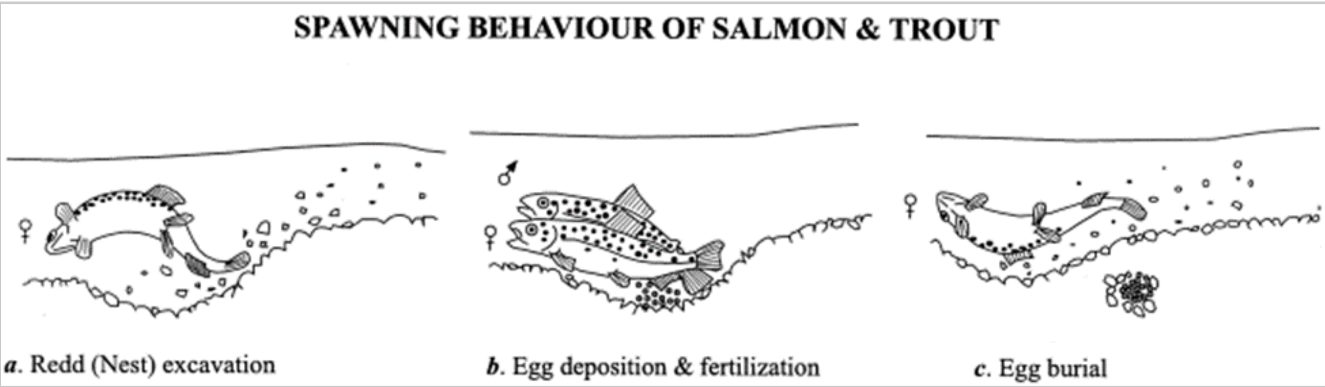

***Figure 44**. Diagram showing the redd formation process used by Brook Trout ("Spawning behaviour of salmon & trout", from Fine sediment influence on salmonid spawning habitat in a lowland agricultural stream: A preliminary assessment (p.298), by Soulsby et al., 2001, Science of the Total Environment).*

Brook Trout typically choose sites near springs to spawn, where the temperature is consistent, near 7-8°C, and there is a coarse substrate (Franssen, 2011). When looking into the stream, the redd appears as a lighter patch in the stream bed, and you can see overturned rocks. On PEI, due to our red soils and high iron content, when a redd is created on the stream bed, it looks red in colour.

Redd surveys are conducted by walking the streams when the sea-run Brook Trout move up to spawn in the freshwater rivers. Using a GPS and field notebook, the crew records all spawning grounds.

These surveys are done to determine the number of spawning areas in the Watershed. Afterwards, the data is added to a database to compare year to year. These surveys can prove to be very subjective since, depending on experience level, one may overestimate or underestimate the actual number of redds.

This year, redd surveys were conducted along 5 sections of stream. Only a handful of actual redd surveys were done, while most redds were observed during RGAs that the crew conducted. In total, 39 potential redds were observed by the crew in the fall of 2021.

***Table 5**. 2021 redd summary of potential redds.*

Location	# of Redds
Winter River Main	24
Apple Orchard	6
Friston North	1
Friston South	7

VanWesterneng	1
Total	39

***Figure 45**. Still from a GoPro video taken by staff member Benjamin, showing Brook Trout congregating during spawning season in Winter River Main.*

5.6 Beaver Management

The North American Beaver (*Castor canadensis*) has been present and abundant in North America long before settlers arrived. They are the largest rodent on the continent and are one of the few animals other than humans who are able to engineer their environment to suit their needs. They are a strong, semi-aquatic species that are entirely herbivorous. They feed on wood and bark, preferably species of aspen trees (*Populus spp.*).

***Figure 46**. Beaver chew marks on a tree stump; the colour is light indicating it has not been dead for very long.*

Prince Edward Island has very little elevation and therefore has very low-gradient streams. As a result, beavers have a significant amount of habitat that they can utilize. This creates a unique problem for PEI watershed groups, as beavers can be prolific causing habitat degradation for a number of aquatic species, not to mention damaging private and provincial property and infrastructure. This happens when a beaver impoundment slows the flow rate of a stream and increases sediment deposition on the upstream side of the impoundment. This can cover valuable habitats for numerous aquatic species, as well as completely block access to these locations. Beavers can flood farm fields, roads and properties as well as drown valuable tree and shrub species due to flooding. Also, unlike bigger/steeper rivers, beaver dams on PEI do not wash out in the spring freshet meaning that old dams stay in place even after beavers stop inhabiting an area. Thus, watershed groups on the Island must be vigilant and always be looking for beaver activity in susceptible areas.

Figure 47*. A map of our beaver management area. Red symbolizes areas where beavers will be trapped if they are found, and green indicates areas where beavers will not be disturbed unless they become a threat to infrastructure or under other special circumstances.*

Only a handful of surveys regarding beaver activity were completed this year. Any observed beaver activity was marked during any stream surveys, including during Rapid Geomorphological Assessments. In terms of beaver dam removals, there were several that staff worked on this A beaver dam near Afton road was notched by the field crew, and an old dam no longer in use was slowly removed in Black River. After noticing flooding of the Brackley weirs, an investigation by staff led to a beaver dam recently created in a culvert passing under the Union road. Since the location of the dam was in a culvert, it was in the jurisdiction of the PEI government’s transportation sector so WRTBWA reported the issue to an official. The dam was taken apart after a professional trapper was hired to remove the beavers. Finally, a dam located near the Hardy Mill Pond was left because WRTBWA did not want to cause further complications with a situation involving pet goldfish released into the pond (for more information, see Goldfish Extraction with Fish and Wildlife PEI).

6. Water Quality Monitoring

6.1 Temperature Loggers

Introduction
One way WRTBWA monitors stream health throughout the Watershed is by recording water temperature. The health of a stream is dependent on water temperature, with temperatures too high being detrimental to marine life. To record water temperature there were 8 temperature loggers (HOBO Pendant UA-001-08 and HOBO Pendant MX2201) deployed at 5 locations in the 2021 field season. Tim's Creek, Friston South, Friston North and Friston Main each had 1 temperature logger placed at the bottom of each streambed. In the wetland of Black River at Dougan Rd, 4 temperature loggers were deployed at 2 locations with each site having 1 logger at the water surface and 1 near the bottom. Temperature was also recorded using depth loggers (HOBO U20L-01) at six locations: Beaton's Creek, Hardy Mill Pond Outlet, Officer's Pond Outlet, Winter River at the Union Pumping Station, Winter River at Apple Orchard, and Winter River at Tim's Creek.

Methods
All temperature and depth loggers were attached to a piece of rebar using zip ties and brightly coloured tape for easy retrieval. The temperature loggers at Tim's Creek, Friston South, Friston North, and Friston Main were originally deployed on 2021-06-07 but the logger at Friston South was placed further upstream (due to improper placement) on 2021-06-09 and the logger at Tim's Creek was moved further upstream (in preparation for the culvert replacement) 2021-07-12. The temperature loggers at Black River were deployed 2021-06-30. All 8 temperature loggers were removed from streams 2021-10-04. Depth loggers at Hardy Mill Pond Outlet, Officer's Pond Outlet, Winter River at the Union Pumping Station, and Winter River at Tim's Creek were deployed 2021-05-13 while the loggers at Beaton's Creek and Winter River at Apple Orchard were deployed 2021-06-22. All depth loggers were removed from streams 2021-12-17.

Following the Nature Conservancy of Canada (NCC) guidelines for temperature class, a rating system for freshwater systems, it was determined how different water temperatures relate to stream health. These guidelines state average summer temperatures of water that are 18°C and lower are considered "cold", 19°C to 21°C are considered "cool", and average summer temperatures that are 22°C and higher are considered to be "warm".

Results & Discussion
A technical error occurred with the temperature loggers stationed at Friston Main and Friston South causing neither logger to collect data past the first few days of deployment. These locations were thus omitted from any analysis.

Summaries of the data collected from each logger are presented in Table 6. Throughout all of the monitoring sites, the maximum temperatures ranged from 15.4°C to 33.42°C with average temperatures ranging from 9.06°C to 20.12°C. The highest temperature readings were from both Black River surface temperature loggers (for more information, please refer to Black River Fish Kill).

Table 6. *Summary of 2021 temperature data from the Winter River - Tracadie Bay watershed. Temperature classes are determined according to NCC guidelines. Includes data from both temperature loggers (TL) and depth loggers (DL).*

Logger	Logging Period (days)	NCC Temperature Class	Average Temperature (°C)	Average Summer Temperature (°C)	Maximum Temperature (°C)	Longest # Hours in Stress Zone
Tim's Creek TL	120	Cold	9.06	8.90	15.4	0
Friston North TL	120	Cold	14.61	15.05	19.85	0
Black River Surface #1 TL	97	Cool	19.99	21.53	33.07	163
Black River Bottom #1 TL	97	Cool	17.71	18.49	21.62	87
Black River Surface #2 TL	97	Cool	20.12	21.45	33.42	256
Black River Bottom #2 TL	97	Cool	17.93	18.97	23.21	133
Union Station DL	219	Cold	9.95	12.14	19.47	0
Hardy Mill Outlet DL	219	Cold	13.31	17.52	22.05	17
Apple Orchard DL	179	Cold	11.67	15.32	18.52	0
Officer's Outlet DL	219	Cool	15.31	21.15	26.78	703
Tim's Creek DL	219	Cold	13.00	17.00	21.19	16
Beaton's Creek DL	179	Cold	11.93	15.97	21.28	7

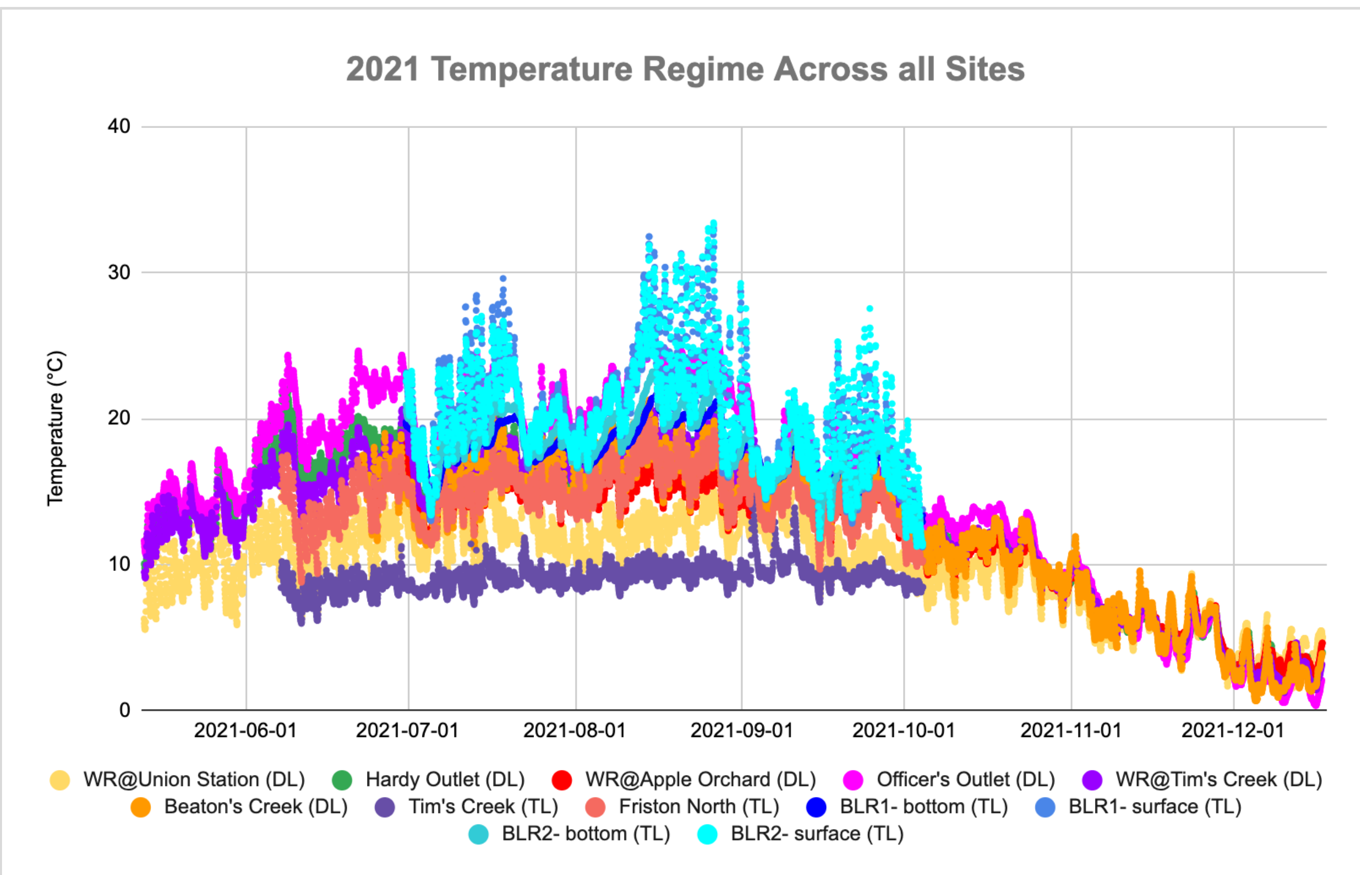

***Figure 48**. Temperature monitored across the Winter River - Tracadie Bay watershed for the 2021 field season at both temperature logger (TL) and depth logger (DL) sites.*

In comparison to the previous year, average temperatures were much cooler this 2021 field season. According to the NCC temperature ranking system, seven monitoring locations were “cold”, five were “cool” and none were “warm”. In contrast, in the 2020 field season, 5 monitoring locations were “cold”, 3 were “cool” and 2 were “warm”. This is a reasonable difference considering the extremely hot weather in 2020 with much lower temperatures and more rainfall events experienced in the 2021 season.

Brook Trout thrive in water temperatures between 11°C and 18°C but can survive in temperatures between 0°C and 20°C (Millar et al., 2019). When water reaches temperatures over 20°C, this is considered the “Stress Zone” and is a state in which Brook Trout struggle to survive. This field season, Tim’s Creek TL, Friston North TL, Union Station DL and Apple Orchard DL spent no time in the Stress Zone, while Hardy Mill Outlet DL, Tim’s Creek DL and Beaton’s Creek DL locations spent no more than seventeen consecutive hours in it. All temperature loggers at Black River spent significant amounts of time in the Stress Zone, ranging from 87 to 256 consecutive hours. Officer’s Pond Outlet spent the most time in the Stress Zone, reading a high of 703 consecutive hours.

Depth loggers at Beaton’s Creek and Winter River at Apple Orchard were not deployed until 2021-06-22, meaning they were unable to account for all of the summer temperatures. This should be considered when observing the average temperature and average summer temperature of both locations.

6.2 Dissolved Oxygen Loggers

Introduction

Dissolved oxygen (DO), the amount of free oxygen present in water, is a very useful indicator of estuary and stream health. Fish and aquatic life require very specific DO levels to survive and with levels that are too high or too low, these beings risk being harmed a great deal (Fondriest Environmental Inc., 2013). DO values between 5-12 mg/L are what most fish require to thrive while values of 4 mg/L and less can be detrimental to fish health and cause stress or in worst cases death (*YSI Parameter Series: Dissolved Oxygen*, n.d.).

When water is hypoxic there is an alarmingly low amount of dissolved oxygen present, measuring at about 2 mg/L or less while anoxic water conditions are when there is almost none or absolutely no dissolved oxygen present, measuring at 0.2mg/L or less. There are a number of factors that can influence levels of dissolved oxygen but a few that WRTBWA often finds to be the cause of changes in the Winter River estuary include salinity, temperature, and excess nutrients. Water cannot hold as much free oxygen when there is a high salt content and when temperatures are warmer (Utah State University, 2019). Whenever there is an excess amount of nutrients in the water, often caused by human influences such as fertilizer runoff, this can cause a process called eutrophication; this is when an increase in nutrients leads to large quantities of aquatic plants and algae growth. With so much plant life growing, light becomes blocked from reaching the lower regions of a waterbody and plants below end up dying. The bacteria that eat these decaying plants use up a lot of dissolved oxygen, causing anoxic conditions (Water Resources, 2019) which in turn can lead to fish kills. It is thus very important to constantly observe water conditions and be aware of sources that have the potential to affect the estuary.

Methods

WRTBWA has 3 HOBO U26-001 dissolved oxygen loggers that were placed at 2 locations this field season. The DO loggers were first placed in the wetland of Black River at Dougan Road from 2021-06-25 to 2021-

06-30. This was done in an attempt to figure out the cause of a fish kill that took place at this location around the end of June (for more information, please refer to 8.1 Fish Kill ar Black River). The loggers were then redeployed from 2021-07-08 to 2021-09-21 but this time in the Winter River estuary; 2 DO loggers were placed near the Corran Ban bridge (one at the water surface and one at the bottom), and 1 logger was placed near the Pleasant Grove boat launch along with a conductivity logger. All loggers were attached to ropes with buoys using zip ties and brightly coloured tape for easy retrieval. They took DO and temperature readings once every hour when in use.

Routine checks on the DO loggers consisted of 2 to 3 staff canoeing the Winter River estuary. YSI readings were taken, measuring temperature, DO, conductivity, and pH, and observations were recorded if there were any evident sides of anoxic conditions. Loggers were removed and brought to dry land to upload data onto a laptop that was brought in a waterproof bag. Loggers were then reattached.

Results & Discussion
There were issues with DO logger malfunctions and data processing this year so results have been omitted from this report. Dissolved oxygen data collection has been conducted as part of a 4-year project aimed at measuring the health of the Winter River estuary. Having completed the timeline for this project and with multiple roadblocks involving logger malfunctions, WRTBWA plans to retire the DO loggers for the time being.

6.3 Estuary Monitoring

Aside from collecting DO logger data, another method that was used to monitor the health of the estuary involved routine checks of the channel. Field crew members would canoe to 12 predetermined points along the river and take YSI readings as well as any meaningful observations. Monitoring was completed whenever crew members went out to the Winter River estuary to routinely check on the dissolved oxygen loggers. At this time they also took measurements for temperature, dissolved oxygen, conductivity and pH at the points indicated in Figure 49. Nitrate levels were not checked because the probe risks being damaged in saltwater so was thus removed before monitoring.

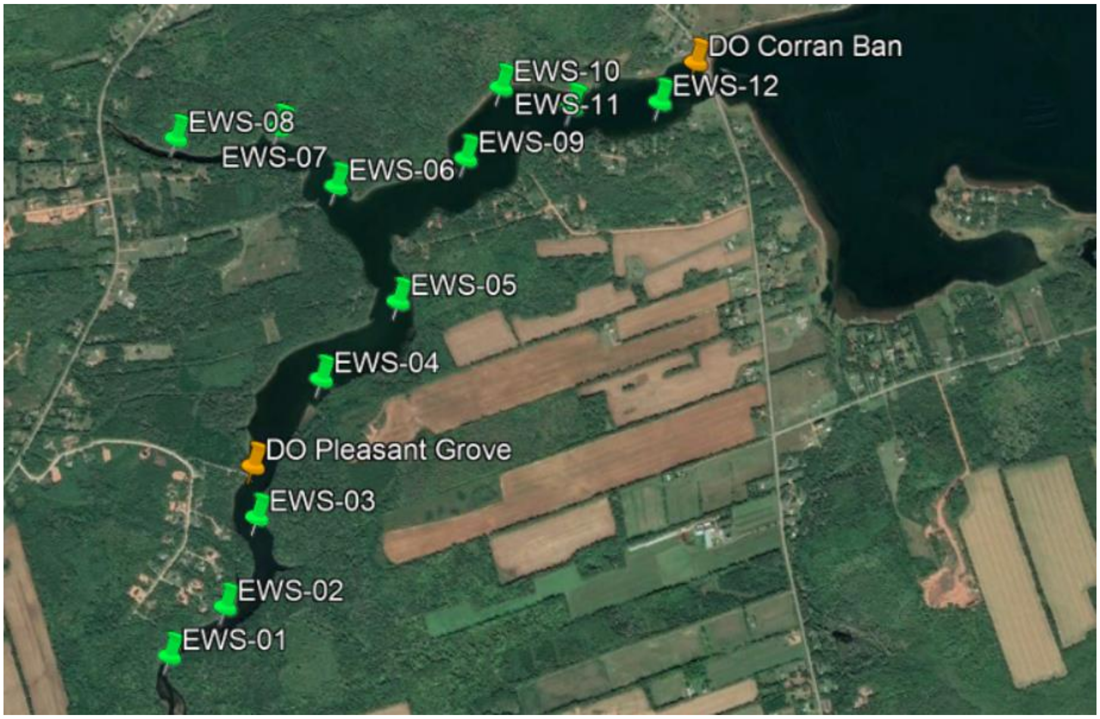

Figure 49. *Map of predetermined observation points of Winter River estuary in 2021 field season. The same points were used from the previous year.*

Results & Discussion

While all YSI readings were analyzed, temperature and DO were considered the biggest factors in assessing estuary health. See Section 6.1 Temperature Loggers and Section 6.2 Dissolved Oxygen Loggers for more details on the importance of both measurements. Table 7 and Table 8 show summaries of DO and temperature readings respectively.

Overall, dissolved oxygen values are relatively normal except for hypoxic values on 2021-08-23 and 2021-09-14. On the first day, there were only 2 sites reaching hypoxic conditions reaching values of 0.35 mg/L and 1.7 mg/L. On the second day, there were 4 sites with hypoxic values with all other locations having lower than normal DO values. On this day the lowest value was 0.15 mg/L and the highest value was only 5.96 mg/L. This suggests there could have been unacceptable living conditions for aquatic life in the estuary within that time frame. The temperatures were reasonable other than on 2021-08-23 when values were not only above liveable conditions but were dramatically high with values reaching over 28°C at some points. This could be connected to the few hypoxic points measured for DO on the same day since warmer waters cannot hold dissolved oxygen as well as cooler temperatures (Utah State University, 2019).

Table 7. *Dissolved oxygen readings (in mg/L) measured with a YSI Pro at 12 monitoring sites on the Winter River estuary. Red boxes highlight hypoxic values. Missing values on 2021-08-04 are due to time constraints on that day.*

Dissolved Oxygen												
	ESW-01	**ESW-02**	**ESW-03**	**ESW-04**	**ESW-05**	**ESW-06**	**ESW-07**	**ESW-08**	**ESW-09**	**ESW-10**	**ESW-11**	**ESW-12**
2021-07-23	8.45	8.41	6.0	3.31	5.01	2.21	6.04	8.53	7.12	3.9	4.72	4.2
2021-08-04	14.41	9.7	14.4	9.86		6.26	8.69	12.73				
2021-08-23	6.57	14.04	12.12	8.04	9.29	0.35	7.23	5.88	5.54	6.72	1.7	4.78
2021-09-14	1.22	1.26	4.47	0.49	5.73	3.01	0.15	4.33	8.6	5.53	5.89	5.96
Minimum DO by site	**1.22**	**1.26**	**4.47**	**0.49**	**5.01**	**0.35**	**0.15**	**4.33**	**5.54**	**3.9**	**1.7**	**4.2**

Table 8. *Temperature readings (in °C) measured with a YSI Pro at 12 monitoring sites on the Winter River estuary. Red boxes highlight high values. Missing values on 2021-08-04 are due to time constraints on that day.*

Temperature												
	ESW-01	**ESW-02**	**ESW-03**	**ESW-04**	**ESW-05**	**ESW-06**	**ESW-07**	**ESW-08**	**ESW-09**	**ESW-10**	**ESW-11**	**ESW-12**
2021-07-23	17.1	17.4	18.9	21.0	21.1	20.7	21.2	20.1	19.9	20.0	20.3	19.9
2021-08-04	21.7	22.4	23.4	13.5		20.8	22.5	20.5				
2021-08-23	27.7	28.8	28.2	26.5	27.2	24.6	26.2	25.1	24.2	24.4	24.4	24.1
2021-09-14	19.6	21.0	19.2	19.7	18.7	19.0	19.9	19.5	19.2	18.8	18.8	18.8
Maximum temp by site	**27.7**	**28.4**	**28.2**	**26.5**	**27.2**	**24.6**	**26.2**	**25.1**	**24.2**	**24.4**	**24.4**	**24.1**

6.4 Microplastic Sampling

In the fall of 2020 staff from the WRTBWA took part in a workshop hosted by Coastal Action to learn about microplastic sampling that was already being conducted around the Maritimes in areas of Nova Scotia and

Newfoundland. The workshop introduced 2 methods for collecting microplastics; the first method involves collecting samples of sand from the shoreline and the second method uses a Low-tech Aquatic Debris Instrument, or LADI trawl for short, which is a device that is dragged from a boat and collects microplastics that are floating on the water's surface. WRTBWA used both methods in the Tracadie Bay area. For maps of both locations, see Figure 50.

The Winter River - Tracadie Bay Watershed Association was one of two watersheds (the second being Bedeque Bay Environmental Management) that has started microplastic sampling here on Prince Edward Island with the 2021 field season being the first year.

Figure 50. *Left: Map of shoreline microplastic sampling sites. Right: Map of microplastic trawling locations.*

Shoreline Samples

In order to take microplastic samples from the shoreline, a length of 100 feet was measured out horizontally to the water then using a random number generator, 4 distances were selected as the sample transects. Each transect was measured out into a 1x1 meter square. Crew members then filled half of a 5-gallon bucket by scooping the top 5 centimetres of the transect, everything including sand, debris, and organic material. The remaining space in the bucket was filled with water. Everything was mixed by hand to allow any plastics in the sample to float to the top and the water was then poured through a sieve measuring 335 µm. This process of mixing the collected sand with water and pouring it through the sieve was done three times per sample. The sample was then rinsed off using Gatorade bottles filled with water and then placed inside a glass jar with a cap full of hydrogen peroxide.

There were 4 sites chosen for the shoreline microplastic sampling and these locations were referred to as Queen's Point, Old Bedford Road, Black Bush, and Corran Ban Bridge. At each site, samples were taken at the high-tide line as this is the most probable area where plastics would be located. The Old Bedford Road site being the first sampling location took samples at both the high tide and mid-tide lines. It was decided afterwards that at the remaining sites staff would take samples only at the high-tide lines as this saves on time and materials while still getting an accurate representation of the shoreline. There were a total of 20 shoreline microplastic samples collected for testing.

Figure 51. *Shoreline microplastic sampling process.*

Samples from water with LADI trawl
In order to retrieve the microplastic samples from the water, a LADI trawl was used. With the help of a building manual, the Coordinator along with a volunteer constructed the LADI during the 2021 winter months.

A total of 6 sampling sites were chosen for microplastic sampling using the trawl; these locations were referred to as Winter Bay, North End of Tracadie Bay, Old Bedford Road Beach, South End of Tracadie Bay, Offshore, and Winter River. Each location had 3 separate tracks and each track, measured out to be around 2km, was travelled twice for a total of 6 trawls per location. Each trawl took roughly 20 minutes with the speed of the boat going no more than 5 knots. After every trawl, the LADI was taken out of the water and the cod-end was removed and cleaned out into a 335 μm sieve. Similar to cleaning samples from the shoreline microplastic sampling, Gatorade bottles were used to rinse the sample until no dirt/sand remained then the sample was transferred into a jar with a cap full of hydrogen peroxide to be sent away for testing.

Out of the 6 locations, trawls at Winter Bay, North End of Tracadie Bay, Old Bedford Road Beach, and South End of Tracadie Bay were all executed successfully. Staff were only able to complete microplastic sampling for 2 of the 6 trawls at the Offshore locations because of issues with the size of the boat being used; with the boat being a smaller size, waves were felt more intensely making staff unable to process the samples in such rough conditions. In the future, a bigger boat is recommended for the Offshore trawl locations. The second problematic location was the Winter River. 4 of the 6 trawls were run through successfully but 1 location had a large amount of algae that continuously built up and caused the cod end to come off (see Figure 52). After multiple attempts to complete 1 trawl, 2 of the 3 cod ends were lost within the algae and it was decided to exclude this location from further sampling. There were a total of 31 microplastic samples collected from the LADI trawl for testing.

***Figure 52**. Left: LADI trawl in action. Right: LADI trawl weighed down by algae, causing improper sampling conditions.*

Results

At the time this report is being written, the results from microplastic sampling are still being processed and are not yet available for reporting purposes. Results will be provided in the 2022 Final Report.

6.5 Groundwater Monitoring

When there is time in the spring and fall seasons, the WRTBWA sends crew members out to check the water chemistry of springs along different stream branches in the Watershed. Measurements are taken at each spring (most of which are already marked with coordinates) and a few measurements are taken in the streams themselves for a comparison of the incoming groundwater with the water from the stream channel. While readings for temperature, dissolved oxygen, conductivity, pH and nitrate are taken, those of the most interest are the nitrate readings since this can indicate agricultural runoff or leaching of fertilizers.

During this field season, there were numerous technical difficulties with the YSI, which led to an inability to take readings as frequently as normal circumstances would have allowed. The first issue was regarding delays in receiving the nitrate probe for the YSI. Although the probe was ordered ahead of time, delays in shipping caused it to arrive in late June rather than the desired period of early spring. For this reason, the window of opportunity to collect groundwater data in the spring was missed.

Upon receiving the nitrate probe, issues arose right away; the probe would not calibrate properly and took a great deal of troubleshooting before finally working. Within a month the probe stopped calibrating properly again and had to be sent away for maintenance while it was still under warranty. Nitrate readings were not taken for the rest of the field season. Near the end of October, the pH probe also stopped properly calibrating. The crew continued to use the YSI with only 2 of the 4 probes for another month before the YSI along with all probes was shipped back to the manufacturer for formal maintenance and troubleshooting. With so many issues with the YSI along with time constraints, no groundwater monitoring was conducted in the fall season other than at the routine weir sites.

6.6 Suspended Sediments in Water

Introduction & Methods

Total suspended solids (TSS) can be defined as organic or inorganic particles in water that are bigger than 2 microns (Fondriest Environmental Inc., 2014). TSS sampling can help identify issues with stream erosion or runoff. The amount of TSS is also of concern as it can affect the clarity of water and the higher the concentration, the more the water will heat since solar heat can be captured by each particle.

TSS testing took place 3 separate times throughout the 2021 field season, each taken after a heavy rain event. The first sampling day was 2021-07-10. A total of 31 samples were collected although 1 sample was destroyed by PEI Analytical Lab in a lab error thus leaving data for only 30 sites. The second sampling day was 2021-09-07 and all 31 routine sites were successfully sampled and tested. The third sampling day was 2021-11-25. Only 4 sites were sampled on this day, 2 of which were in the Tim's Creek area in an attempt to monitor the flow of water through and around the newly installed culvert connecting Tim's Creek to the Winter River.

Results & Discussion

A summary of results can be viewed below in Table 9. Compared to previous years (since 2015), TSS values were overall lower than average. From 2021-07-10, there were only 4 sites that were higher than average values. From 2021-09-07, there were 5 sites higher than average with 2 of these sites being the same sites with high results from 2021-07-10. Lastly, looking at results from 2021-11-25, all 4 sampling sites had values higher than average.

Table 9*. Summary of results from 2021 total suspended solids testing.*

	Number of sites	Minimum (mg/L)	Median (mg/L)	Maximum (mg/L)
2021-07-10	30	2	4.5	152
2021-09-07	30	2	8	82
2021-11-25	4	5	38.5	55

All high TSS results have possible explanations, although they are not all for certain. Oftentimes high TSS readings have been associated with runoff from dirt roads, but this year all high values from 2021-07-10 and 2021-09-07 were mostly from areas of potato production. As already mentioned, 2 of the sites sampled on 2021-11-25 were taken at the location of a new culvert where the streambed is still settling so higher TSS results are understandable. In terms of the other 2 locations, 1 was connected in the past with a culvert erosion problem upstream at a farm equipment crossing so there is a possibility this is a similar issue to be investigated in the future. There is no exact conclusion to make of the second location; there are no agricultural fields nearby or dirt roads close enough to have made an impact. There could have been an unknown issue upstream that will require a deeper look next field season.

6.7 CABIN Sampling

Introduction & Methods

The Canadian Aquatic Biomonitoring Network, also known as CABIN, is a standardized program used to monitor and compare the health and condition of freshwater ecosystems across Canada. The program involves several different sampling techniques using chemical, physical and biological measurements. CABIN assessments are not specific enough to determine exactly what may be wrong with a section of a stream, but they can determine what type of condition a section of a stream is in. CABIN assessments are conducted during the late summer and fall. This year, they were conducted throughout the months of October and November. Both Jenn Woods (Field Supervisor) and Sarah Wheatley (Watershed Coordinator) previously received formal CABIN training, but all members of the crew participated in the assessments.

The most important sampling method used in CABIN is the collection of benthic invertebrates. Benthic invertebrates are the invertebrates that live on the stream bed. The invertebrates are good biological indicators because different invertebrates have different tolerances to water quality. The more sensitive the invertebrate, the less tolerant it is to poor water quality and pollution. Therefore, if you find more sensitive invertebrates in an area of a stream, you can assume that that area has good water quality and little pollution, etc. If it had bad water quality, those more sensitive invertebrates would not be present. The same can be said in the reverse; if you are finding invertebrates in the area that are very durable and hardy, this could mean the water quality in that area isn't the best and could contain pollution. Benthic invertebrates are also long-lived so they can offer a more "long-term" view of the condition of a section of stream.

The invertebrates were collected using a kick net method. One crew member would use the kick net along the stream bed kicking up sediment while holding the net behind where they were kicking. The crew member would continue kicking while moving in a zigzag pattern for 3 minutes. The sample collected from the kick net was then sifted using a sieve and rinsing method. Vegetation and rocks were removed, and samples were placed in jars with a 3:1 ratio with formalin. Sample jars were then sent to a taxonomist out of the province for the invertebrates to be identified.

Other data was collected during the assessment including; primary site data, for example, name and code, GPS point; site description, things like the areas' habitat type, its canopy cover, streamside vegetation; reach characteristics and channel measurements including measurements of the stream's slope, wetted width, bank full width and velocity; substrate characteristics were measured using a rock walk. 100 rocks were randomly selected, and their intermediate axis was measured. For every tenth rock, embeddedness was measured. Organic material, bedrock and sediment were also counted in the rock walk. Finally, water chemistry data was collected using a YSI. Some water samples were also collected in bottles and sent to the PEI Analytical Lab to be tested for pH, TSS (Total Suspended Solids), nitrogen and phosphate content.

The complete field manual is available online: https://publications.gc.ca/site/eng/422979/publication.html

***Figure 53**. Top left: Handful of substrate from the stream bed. Mid left: CABIN datasheet for one of the sites. Top right: Benjamin using transect to define slope of the stream. Bottom right: Sarah adding formalin to rinsed kick net sample.*

***Figure 54**.Top: Jenn completing kicknet procedure. Bottom left: Crew rinsing off the kicknet sample. Bottom right: Dragonfly nymph collected from kicknet sample.*

WRTBWA completed CABIN sampling at 15 different sites around the Watershed. Sites were chosen based on accessibility and sections of stream that represented what was happening in several areas. Figure 55 is a map highlighting the points where each CABIN assessment took place across our Watershed. Data and samples have been sent to be analyzed. Results will be available sometime in 2022.

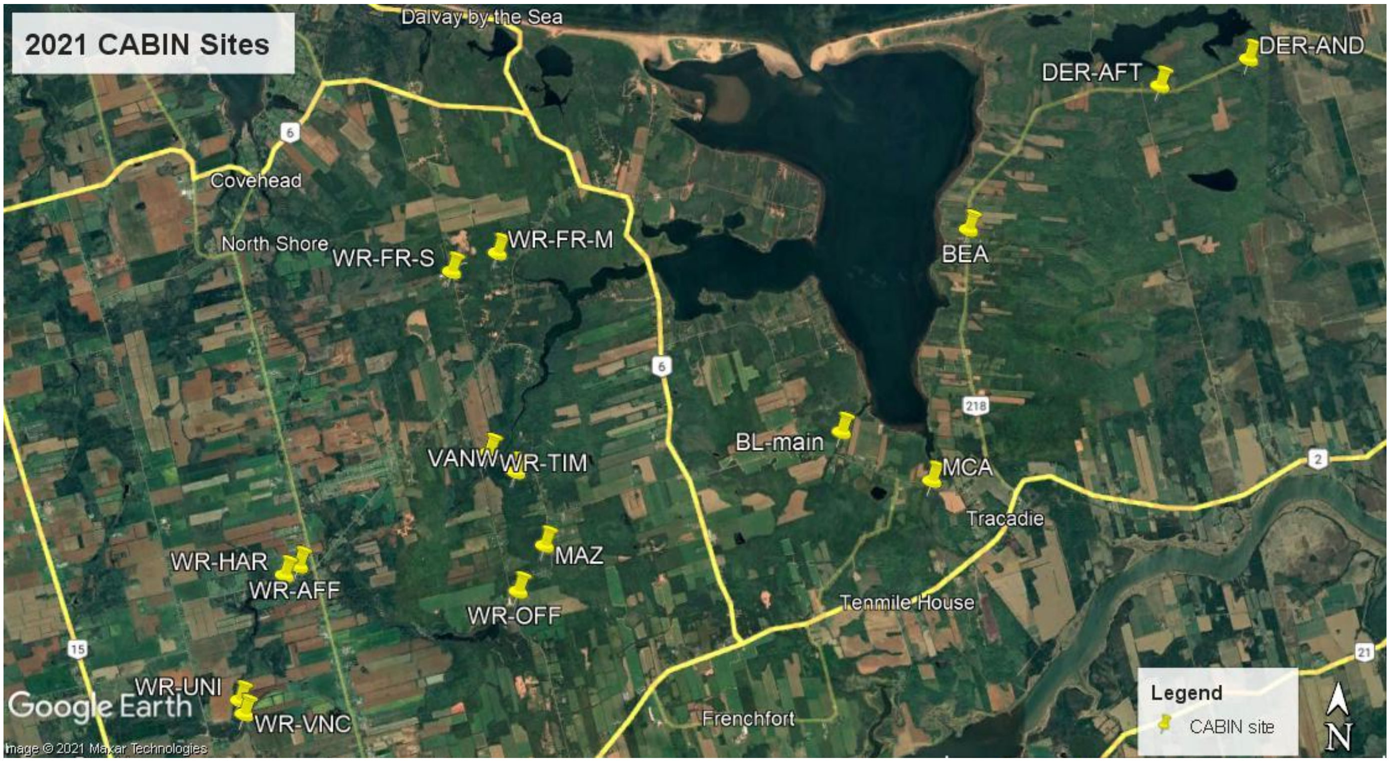

***Figure 55**. 2021 CABIN sites in Winter River-Tracadie Bay watershed.*

Results & Discussion

Since there is still no Reference Condition Approach (RCA) model within the CABIN database for Atlantic Canada, individuals must complete a different lengthy process which only provides partial information.

7. Water Quantity Monitoring

7.1 Headwater Surveys

Introduction & Methods

Headwaters are first-order streams and are the furthest upstream point of a river where the initial flow of water begins. Headwater surveys give an indication of where stream flows are most impacted by changes in groundwater.

For Headwater surveys, WRTBWA follows the 2015 protocol developed by David Cody, Qing Li, and Shawn Hill. Mandatory measurements must take place from May 1 to May 15 and September 1 to September 15. The optional measurement period is from April to May as well as from September to November. Measurements can only be taken if there has been no significant runoff or snowmelt event in the last 3 days as well as at the time of measurement, and the cumulative rainfall in the last 3 days must be less than 5 millimetres. When conducting the surveys, sections of the stream are classified into 1 of 5 categories based on a visual assessment: 0 – no surface water, 1 – surface water in pools only, 2 – surface water present but no visible flow, 3 – flow only interstitial, 4 – surface flow continuous. Categories 0 and 1 are considered dry streams due to no flow or no connection in the stream; categories 2 to 4 are considered streams with flow (Cody, Li & Hill, 2015). Stream categories are recorded above and below the surveyed point. For example, upstream may be a category 3 while downstream may be a category 4.

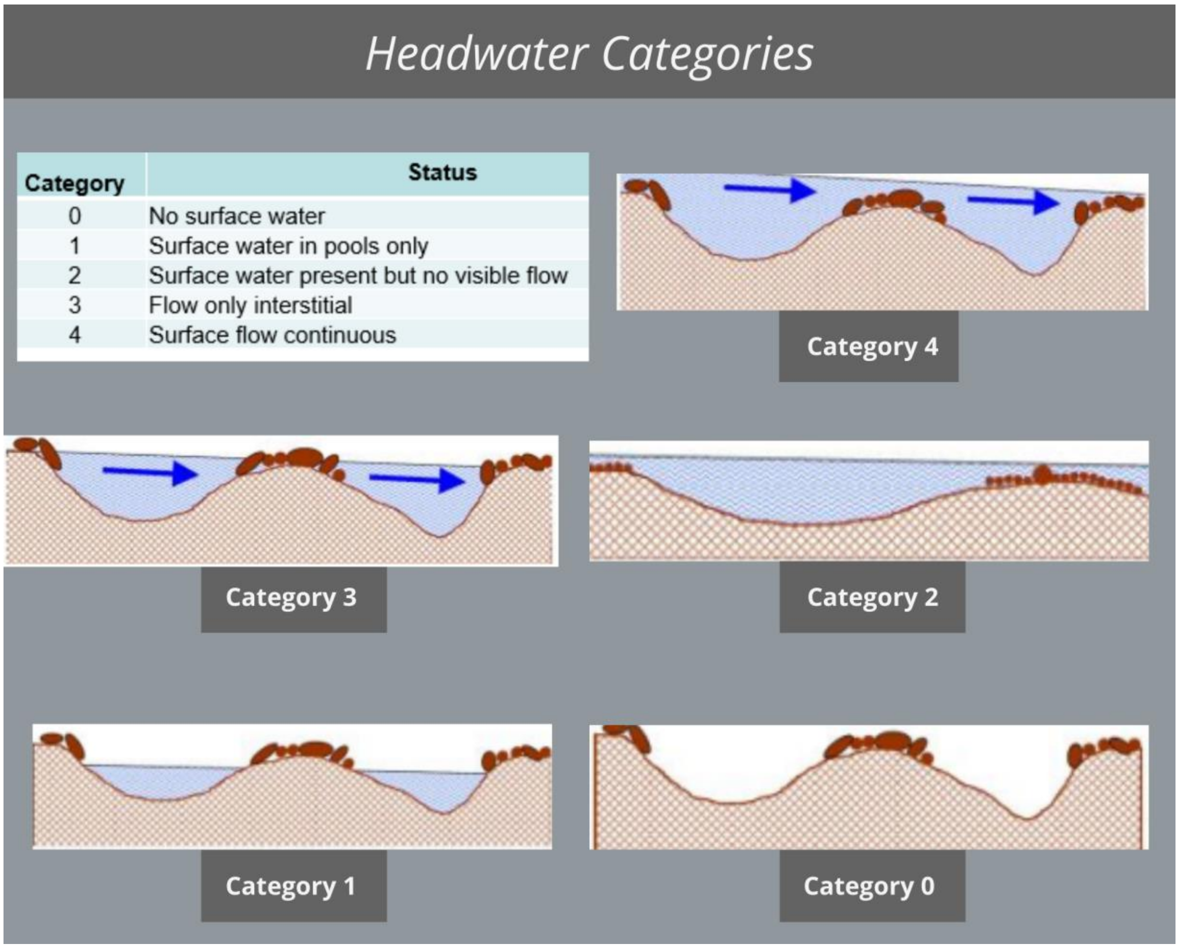

Figure 56. *Visuals of headwater categories 1-4, and table with category descriptions.*

Results & Discussion

The Brackley branch, Lowe's Creek, Lawton's Creek, and Lyon's Creek were surveyed this year. Staff walked up these headwater streams until they reached either a point that was dry, a wetland, or the most upstream point of the waterway. Along the way, GPS points were taken as the streambed shifted between the different categories. Photos were taken at each point, and notes were recorded. In May headwater surveys were conducted at Lyon's Creek, Lawton's Creek, Lowe's Creek and the Brackley Branch. In September surveys were only conducted at Lowe's Creek, Lawton's Creek and Lyon's Creek. The Brackley Branch could not be accurately surveyed in September because of the influence of a beaver dam.

Table 10. *The difference in distance of dried up stream from May to September 2021.*

Stream	Distance dried up over summer
Lyon's Creek	May had a longer dry length vs September by 8.1 meters.
Lawton's Creek	106 meters of stream dried up from May to September.

Lowe's creek	No change. The stream had flow throughout both survey periods.

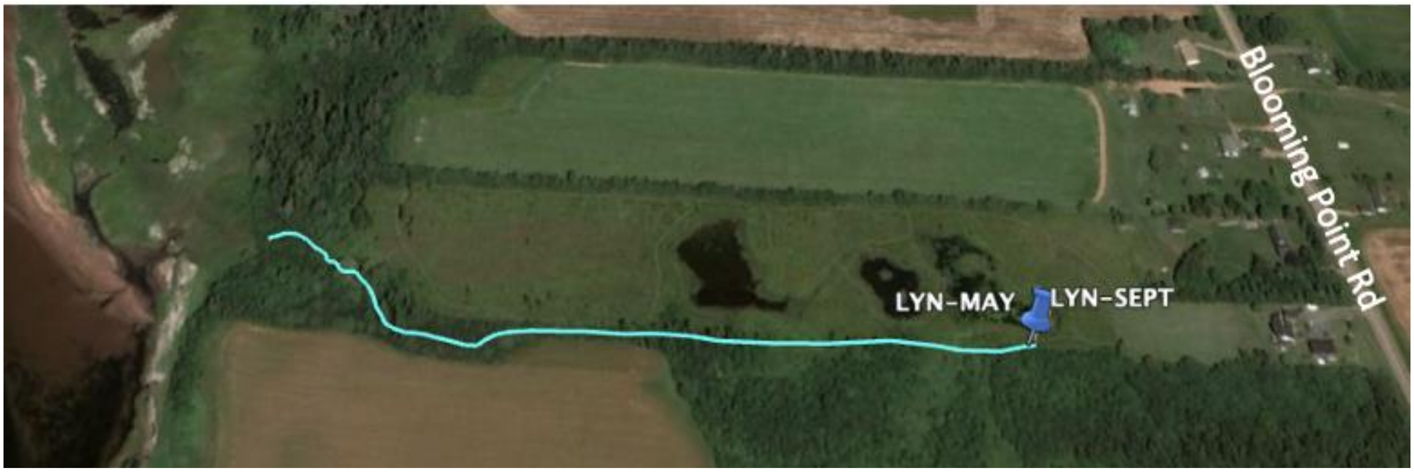

Figure 57. *Map of headwater surveys conducted in September and May 2021 at Lyon's Creek, showing where the stream dried up.*

Figure 58. *Map of headwater surveys conducted in September and May 2021 at Lowe's Creek, showing where the stream dried up.*

***Figure 59**. Map of headwater surveys conducted in September and May 2021 at Lawton's Creek, showing where the stream dried up.*

7.2 Depth Loggers

Introduction

Depth loggers were deployed at 6 locations during the 2021 field season, the same locations used the previous year. Loggers were located at Winter River at Union Station, Hardy Mill Pond Outlet, Winter River at Apple Orchard, Officer's Pond Outlet, Winter River at Tim's Creek and Beaton's Creek. Depth loggers collect data on temperature and pressure. Pressure readings can be used to calculate discharge, also called flow, which is defined as the volume of water moving over a specific point during a fixed period of time (U.S. Environmental Protection Agency, 2012).

Flow data can be used to measure a stream's "flashiness" with the Richard-Baker Flashiness Index (R-B Index). "It measures oscillations in flow (or discharge) relative to total flow (or discharge), and as such, appears to provide a useful characterization of the way watersheds process hydrologic inputs into their streamflow outputs" (Baker et al., 2004, p. 506).

Methods

A total of 6 HOBO U20L-01 depth loggers (also called water level loggers) were deployed. Initially, due to technical difficulties with 2 loggers, only 4 loggers were deployed on 2021-05-13; these were located at Officer's Pond Outlet, Hardy Mill Pond Outlet, Winter River at Union Station and Winter River at Tim's Creek. There was also a depth logger stationed outside the WRTBWA office to give a reference for atmospheric pressure. 2 new loggers were purchased and once they arrived were deployed on 2021-06-22 at the Beaton's Creek and Winter River at Apple Orchard locations. All depth loggers were removed from their locations for the 2021 field season 2021-12-17.

All loggers were attached to a piece of rebar using zip ties and brightly coloured tape for easy retrieval. The rebar was pounded into the streambed so that the logger lay flat on the bottom. Each site was routinely monitored throughout the field season either weekly or biweekly depending on the priority of other ongoing projects. Monitoring procedures were similar to those used in the 2020 field season. Monitoring a depth logger site first involved checking that the logger was still present and secured to the rebar and clearing away any built-up algae, sediment, or debris. Measurements were then taken for the wetted width, distance from the left bank to the logger, logger depth and six depth measurements across the wetted width. Lastly, water quality was monitored separately to have a better overall picture of stream health throughout the watershed. Water chemistry was recorded by using a YSI Pro that measured temperature, dissolved oxygen, conductivity, pH and nitrate. For a more in-depth description of depth logger monitoring procedures, refer to Appendix B.

Results

The minimum flow values among the 6 sites fell between 0.011m^3/s to 0.534m^3/s, median flows were between 0.37m^3/s and 0.772m^3/s, and maximum discharge varied dramatically from 0.371m^3/s to 38.406m^3/s. The biggest variation in minimum and maximum flows was measured at Union Station and Hardy Mill Pond Outlet sites. This is characteristic of the 2 locations, following a similar pattern to previous years. Both are also the flashiest of all sites, with the highest R-B Index (see Table 11).

***Table 11**. The depth and flow data collected from the 2021 depth logger sites.*

Site	Average Wetted Width (m)	Average Depth at Logger (m)	Median Flow (m³/s)	# High Flow Pulses	R-B Index Value
Union Station	4.56	0.401	0.079	14	1.012
Hardy Pond Outlet	3.14	0.233	0.123	22	0.740
Apple Orchard	6.31	0.444	0.305	9	0.233
Officer’s Pond Outlet	9.24	0.604	0.772	2	0.208
Tim's Creek	10.76	0.201	0.667	2	0.152
Beaton's Creek	2.74	0.246	0.037	6	0.182

***Table 12**. R-B Index values from the 2017-2021 field seasons using data collected from the depth loggers. The higher the value, the flashier the site is while lower values are less flashy. Beaton’s Creek data from 2018 was only a half-season as the depth logger started off in Friston.*

Site	R-B Index Value				
	2017	2018	2019	2020	2021
Union Station	0.33	0.92	0.62	0.26	1.012
Hardy Outlet	0.17	0.68	0.48	0.10	0.740
Apple Orchard	0.03	0.25	logger lost	0.02	0.233
Officer’s Outlet	0.02	0.22	0.14	logger malfunction	0.208
Tim’s Creek	0.05	0.12	0.12	0.04	0.152
Beaton’s Creek	logger used to be at Friston	0.01*	0.09	0.08	0.182

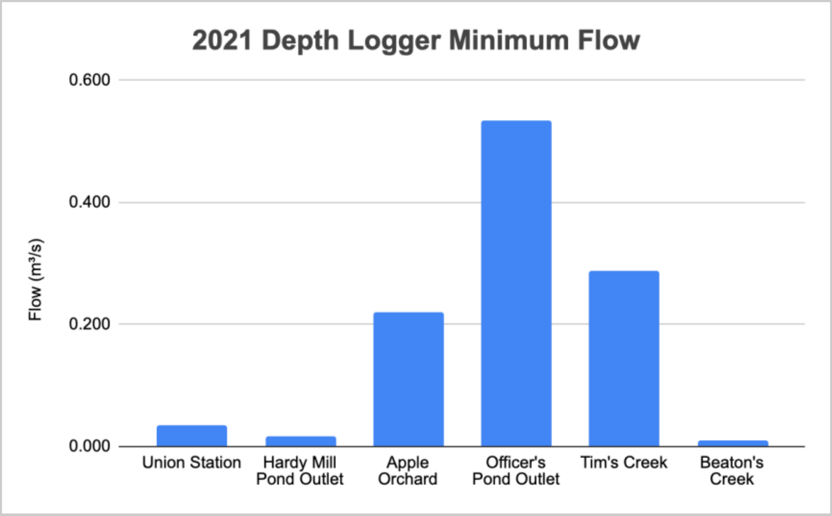

***Figure 60**. Minimum flow values for the 2021 field season at each depth logger site, ordered upstream to downstream.*

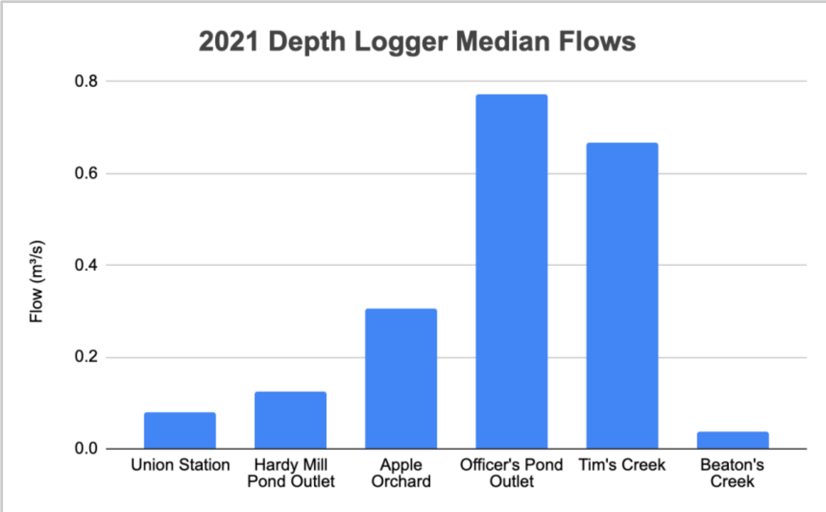

Figure 61. *Median flow values for the 2021 field season at each depth logger site, ordered upstream to downstream.*

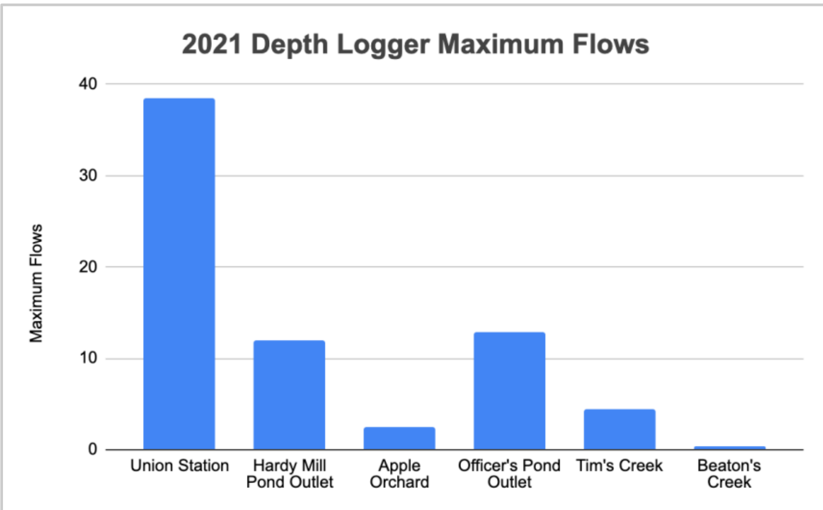

Figure 62. *Maximum flow values for the 2021 field season at each depth logger site, ordered upstream to downstream.*

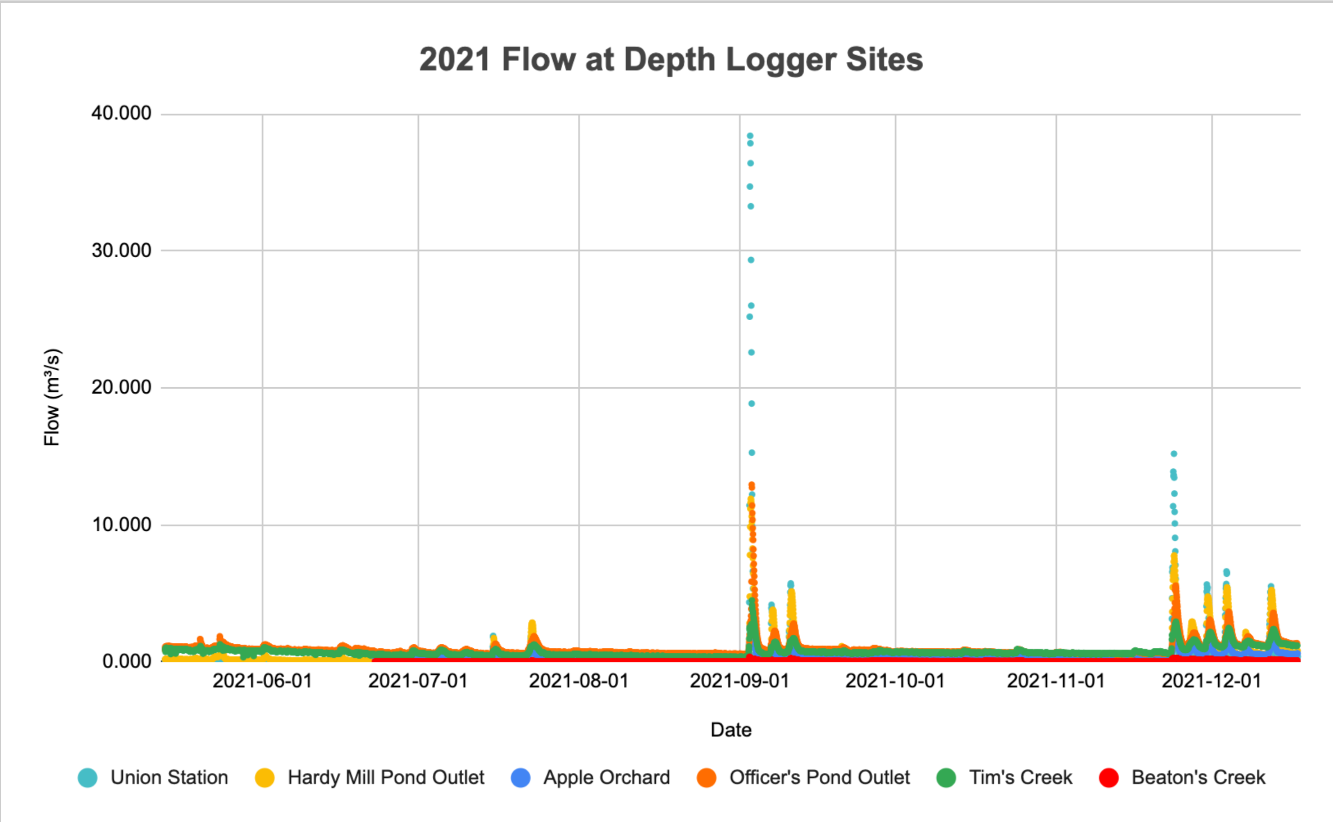

Figure 63. *Flow values for the 2021 field season at each of the depth logger sites, emphasizing multiple high flow events that had a big impact on the river.*

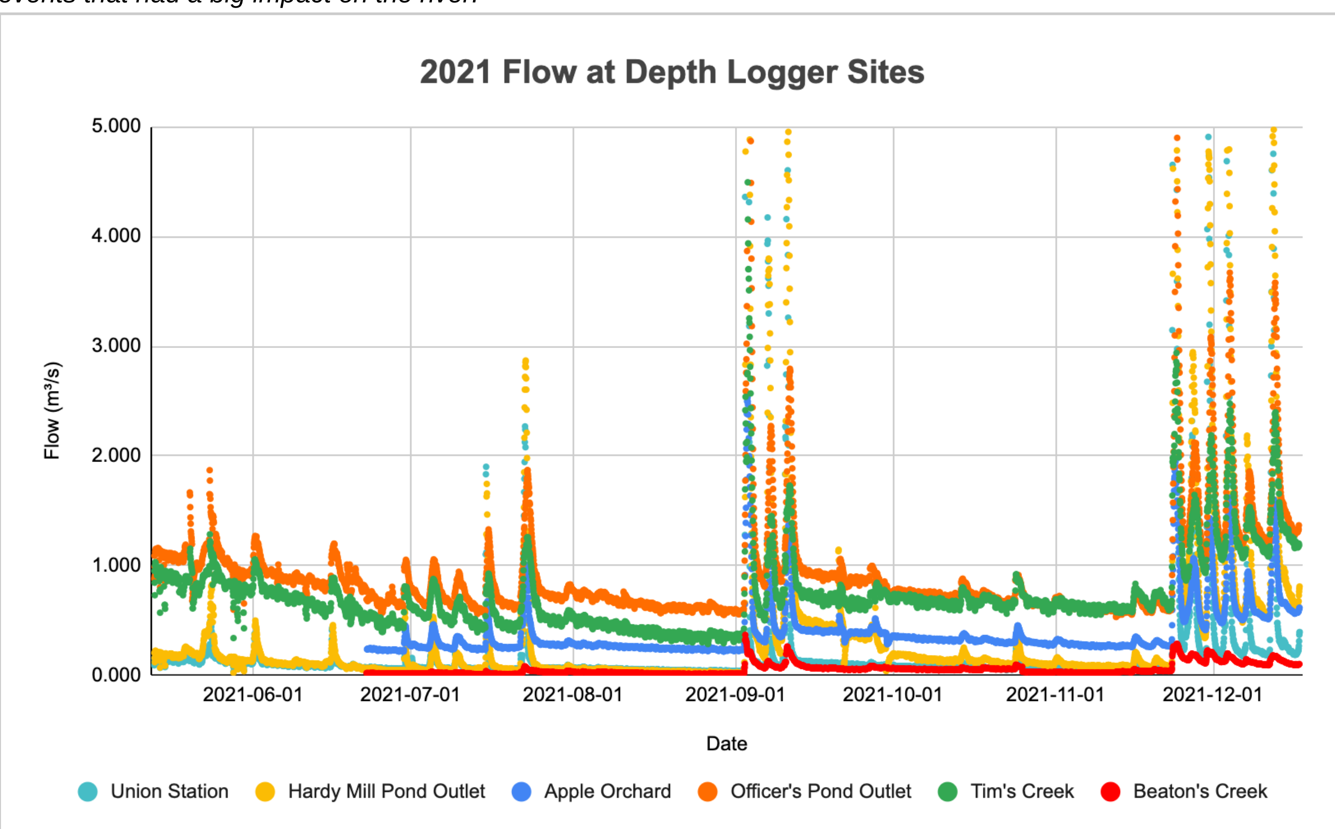

Figure 64. *Flow values for the 2021 field season at each of the depth logger sites. Note that flow values above 10m³/s were omitted to emphasize lower flows that are more commonly seen.*

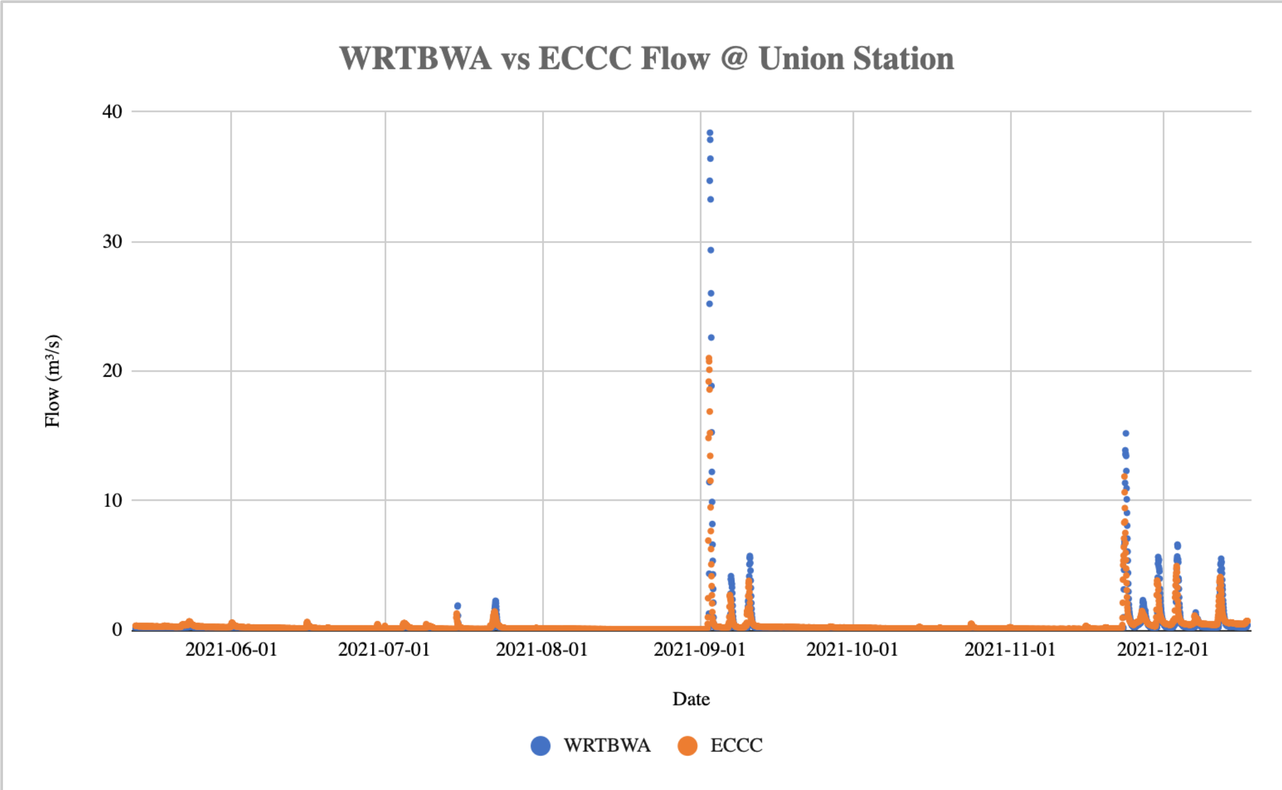

***Figure 65**. Measured flow at Union Pumping Station comparing data from WRTBWA depth logger and Environment and Climate Change Canada (ECCC).*

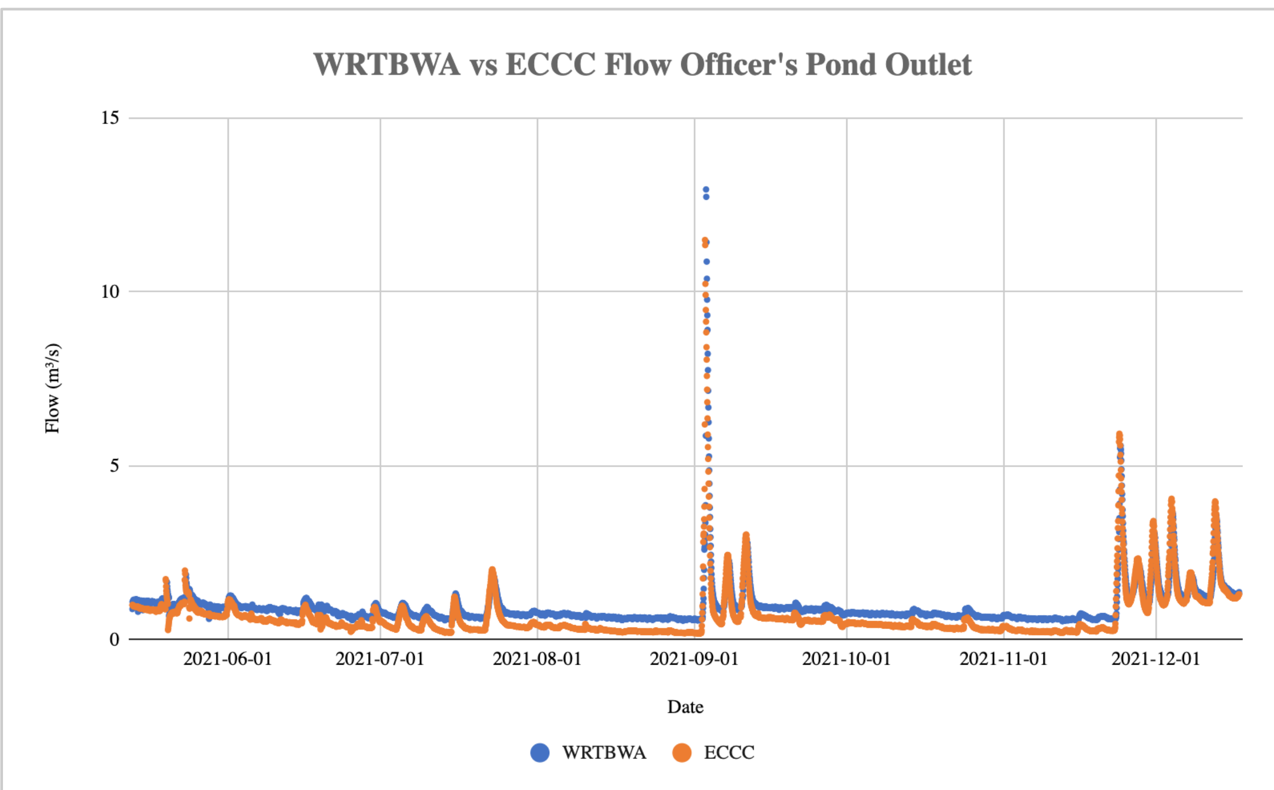

***Figure 66**. Measured flow at Officer's Pond Outlet comparing data from WRTBWA depth logger and Environment and Climate Change Canada (ECCC).*

Discussion

It should be noted that the high flow experienced at Hardy Mill Pond Outlet on 2021-09-20 was when Rosie

MacFarlane and her team dropped the pond level, then the very low flow on 2021-09-21 occurred when the fish ladder flow was blocked off to allow for goldfish cull.

All spikes in this year's depth logger readings can be accounted for with reasonable explanations, all related to weather. There were multiple heavy rainfalls and thundershower events that are visible in Figure #63 to Figure #66 with very obvious increases especially in September with a total of 226.8mm of precipitation.

Smaller streams are commonly flashier than larger streams (Baker et al., 2004). This is because whenever there is a weather event such as heavy rainfall, there is less of an area for water to go in a smaller stream, causing the water depth to spike for a brief period. While flashiness is expected in smaller streams, the R-B Index for Winter River at Union Station was record-breakingly high. While an R-B Index higher than 1.0 is possible, it is rare in the streams of this watershed (see Table 12).

Total flow should increase as water moves downstream. All sites followed this trend except for the difference between Officer's Pond Outlet and Winter River at Tim's Creek, where Officer's Pond Outlet had a higher flow. It is unclear what caused this variation although it may have had to do with constant algae build-up on the Officer's Pond Outlet logger; each time crew members performed routine monitoring of this location, a large amount of algae had to be removed from around the rebar and logger. This was an issue in the previous field season as well.

The comparisons between WRTBWA and Environment and Climate Change Canada (ECCC) for both Union Pumping Station and Officer's Pond Outlet were very promising. Both datasets appear to follow the same trends and while WRTBWA at Union Pumping Station has a higher spike around 2021-09-02, there is usually a variation considering loggers are not placed at the exact same coordinates.

7.3 V-Notch Weirs

Introduction & Methods

The use of v-notch weirs helps WRTBWA to keep an eye on springs in the watershed. In the summer season, increased water consumption from the City of Charlottetown requires nearby pumping stations to take more water. This along with hot, dry weather can cause the springs near the pumping stations to go dry. For this reason the field crew goes out to monitor several springs throughout the season to forecast any possible issues the stream may face.

Following the directive of the Data Management Committee of the board of directors, which set out to create a more effective strategy for staff time allocated to water quantity data collection, several weir sites were retired in the 2021 field season. Retired weir sites included Affleck, Pleasant Grove #2, Pleasant Grove #5, Tim's Creek Upper, and Tim's Creek Lower. The remaining weir sites that continued to be monitored this field season were Brackley #3, Brackley #4, Brackley #6, Brackley #7, Brackley #8, Vanco, and Cudmore #6. See Figure 66 for a map of weir locations in relation to nearby water pumping stations. Although Cudmore #3 has been retired for the last few years, the water level where it was once located was still monitored throughout the field season. This was done to gauge if the spring was wet or dry but no data from this site was further analyzed. All the Brackley weirs as well as Cudmore #6 were never removed at the end of the 2020 field season because dramatically low water levels required monitoring into the 2021 year. This left only the Vanco weir to be installed in the 2021 field season but this required multiple attempts due to issues with leaks and flooding. For this reason, water flow was not able to be properly measured at the Vanco weir until mid-July with more issues with leaks in the fall. At one point in the field season, all five Brackley weirs flooded because of a beaver dam created in a culvert under the Union Road. No flow measurements were taken at this time. All seven weirs were removed for the 2021 field season on 2021-11-04.

Routine monitoring of the weir sites was done every two or more weeks. The frequency was not as necessary as the previous year since the season was very wet and no weirs went dry. Monitoring involved taking pictures of the weirs, clearing away any built-up debris, fixing visible leaks. The depth of water at the v-notch in the weir was then measured followed by water chemistry testing using a YSI.

Figure 67*. All 2021 weir sites shown in relation to the Brackley and Union water pumping stations.*

Results & Discussion

Compared to the 2020 field season which was very dry, overall spring discharge was very promising. All springs remained flowing (see Figure 68) with noticeably higher than average discharges from all Brackley springs except Brackley #7 which could not be accurately measured due to frequent flooding. The highest averaging discharge came from Brackley weir #7 at 0.002775 m^3/s although this does not take into consideration the times monitoring was not permitted with flooding. The lowest average discharge came from the Vanco weir at 0.00062 m^3/s which is abnormal considering this spring is usually among the highest for discharge. This may have had to do with the many flooding and leaking issues that were faced at this site this field season.

Groundwater Spring Monitoring 2021														
		YYYY-MM-DD												
Spring Location	Wellfield Distance (m)	2021-05-27	2021-06-08	2021-06-23	2021-07-12	2021-07-20	2021-08-05	2021-08-27	2021-09-28	2021-09-29	2021-10-12	2021-10-25	2021-11-04	Days Monitored
Brackley #3	698	W	W	W	W	W	W	F	X	W	W	W	W	11
Brackley #4	736	F	W	W	W	W	W	F	X	W	W	W	W	11
Brackley #6	764	F	W	W	W	W	W	F	X	W	W	W	W	11
Brackley #7	871	F	W	W	W	W	W	F	X	F	F	F	F	11
Brackley #8	932	W	W	W	W	W	W	W	W	X	W	W	W	11
Vanco	1386	X	F	F	W	W	W	W	W	X	W	W	W	10
Cudmore #6	1572	X	X	W	W	W	W	W	W	X	X	W	W	8
Cudmore #3 (rebar)	1710	X	X	X	W	W	W	W	W	X	X	W	W	7

W	Water
D	Dry
F	Flooded
X	Not monitored

Figure 68. *Monitoring summary of 2021 weir sites. Cudmore #3 is no longer an active weir but is marked with a piece of rebar where depth measurements are taken.*

Table 13. *Average discharge of 2021 weir sites from lowest to highest.*

Site	Average discharge (m³/s)
Vanco	0.00062
Brackley #3	0.000797
Brackley #6	0.00138
Cudmore #6	0.001531
Brackley #8	0.002527
Brackley #4	0.002578
Brackley #7	0.002775

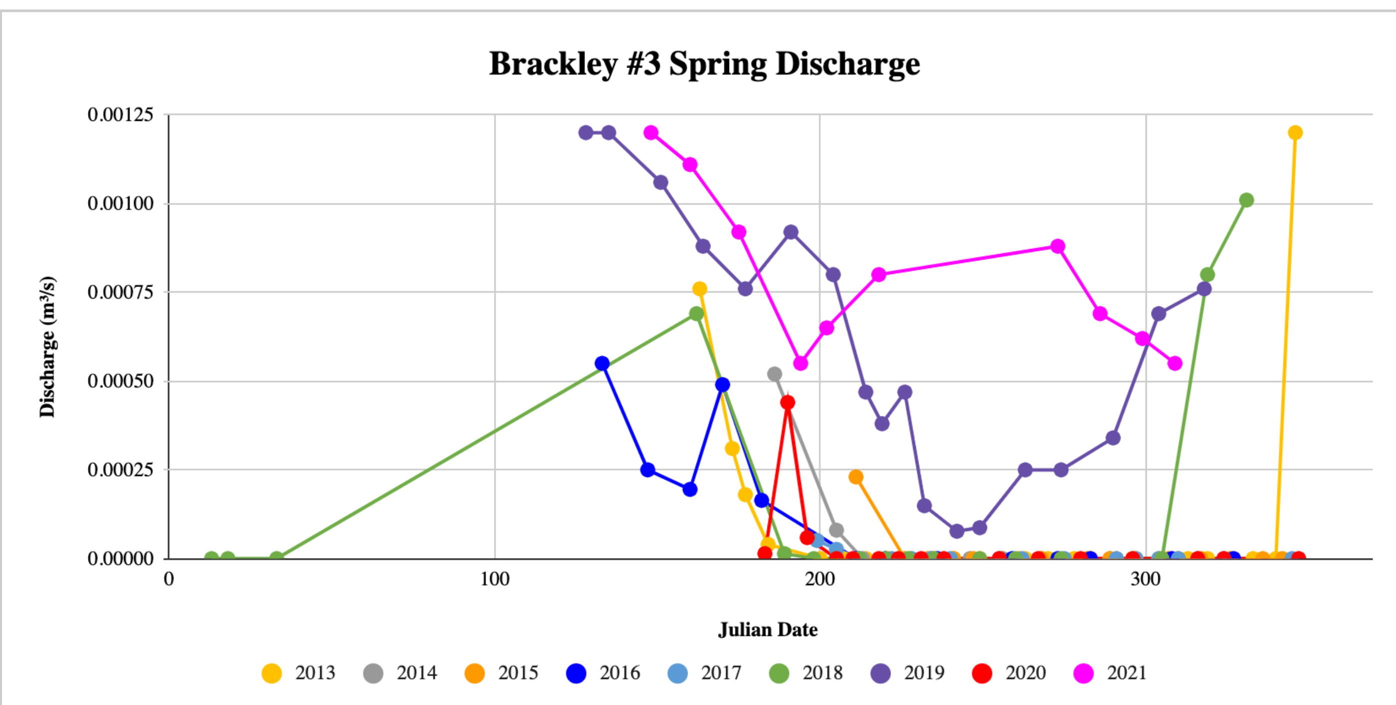

Figure 69. *Discharge calculated at the Brackley #3 weir, comparing years 2013 to 2021.*

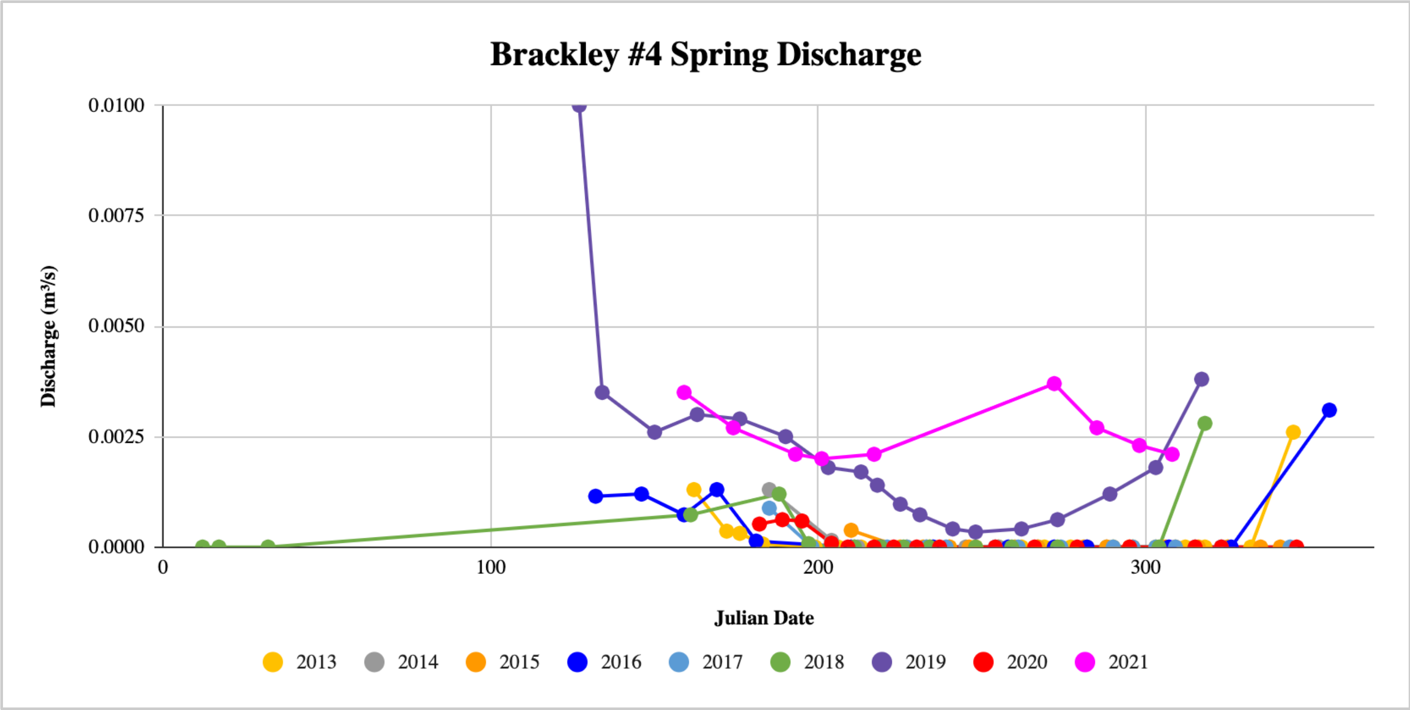

Figure 70. *Discharge calculated at the Brackley #4 weir, comparing years 2013 to 2021.*

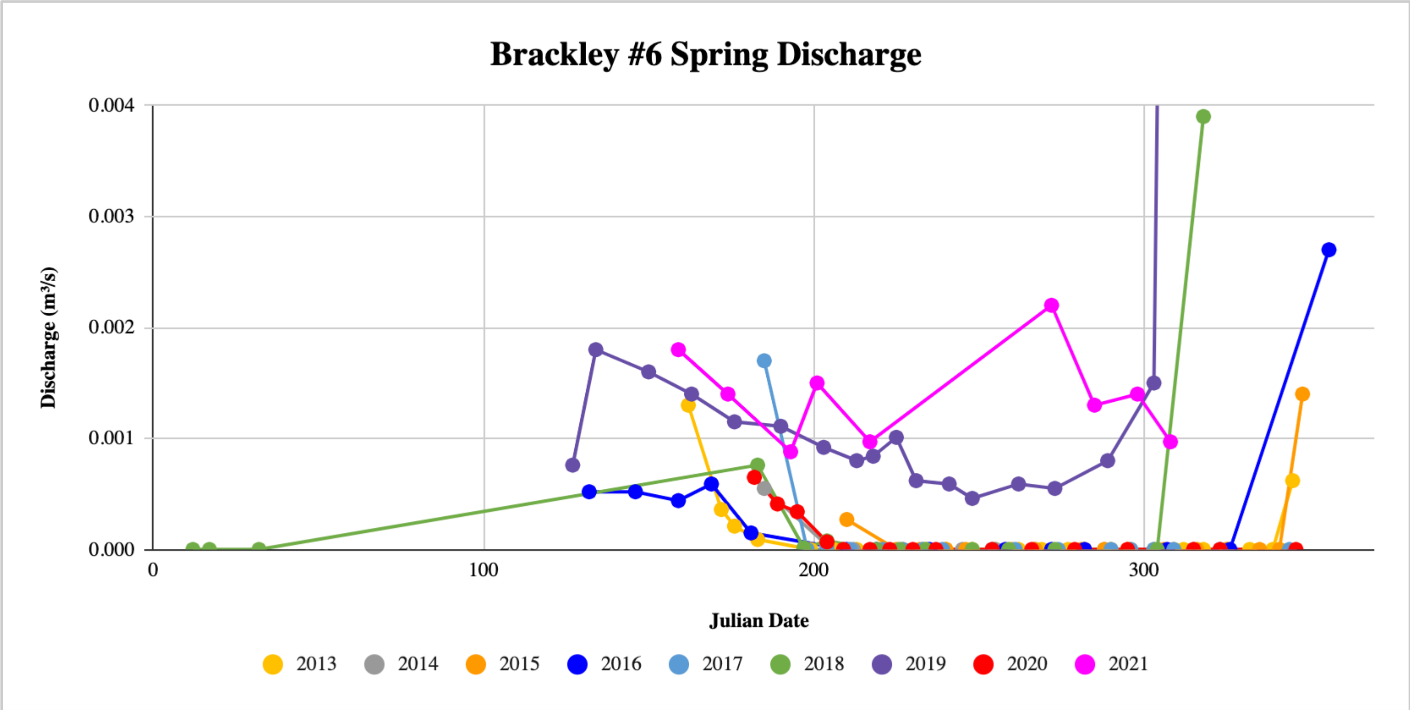

Figure 71. *Discharge calculated at the Brackley #6 weir, comparing years 2013 to 2021. Values higher than 0.004 are not characteristic and were omitted from the graph for easier viewing. The value extending beyond the chart for 2019 was 0.037m*^{3}*/s.*

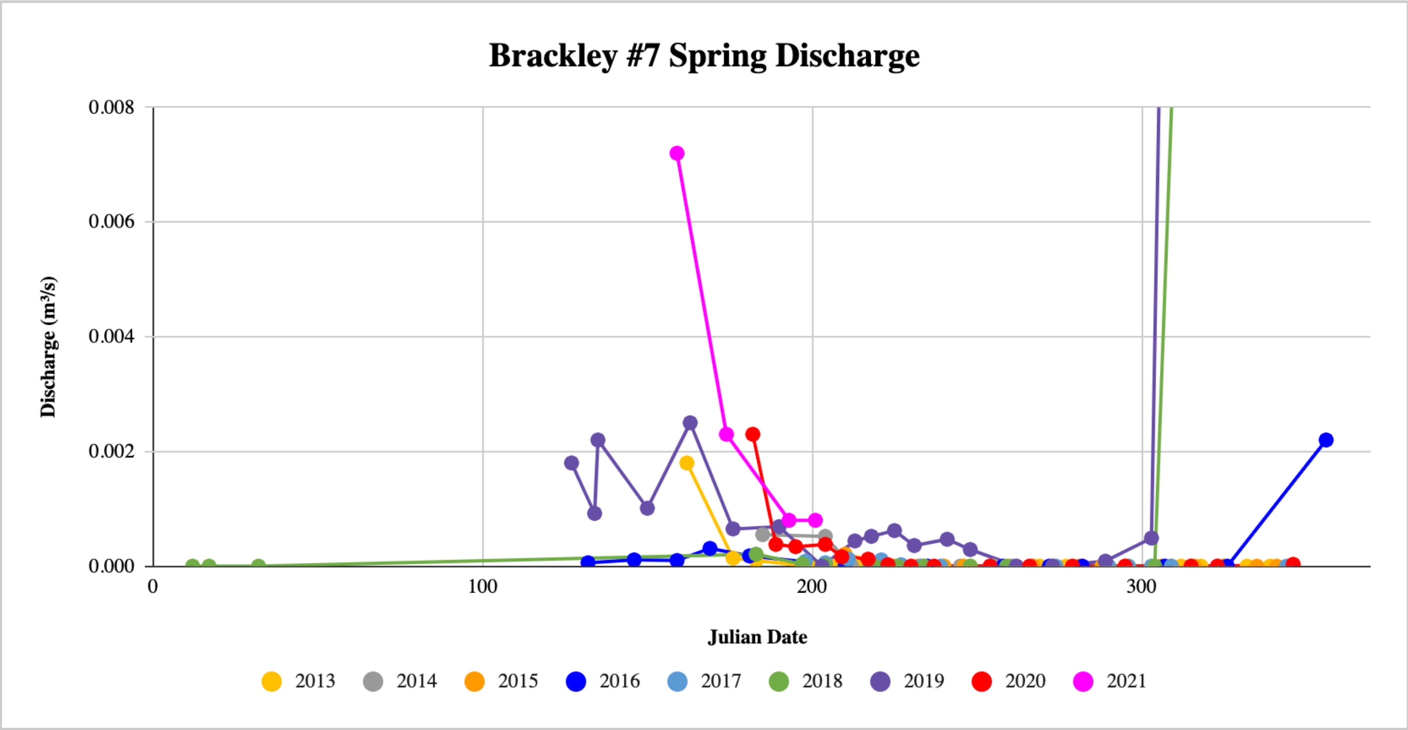

Figure 72. *Discharge calculated at the Brackley #7 weir, comparing years 2013 to 2021. Values higher than 0.008 are not characteristic and were omitted from the graph for easier viewing. The value extending beyond the chart for 2019 was 0.0476m³/s. and for 2018 was 0.022 m³/s.*

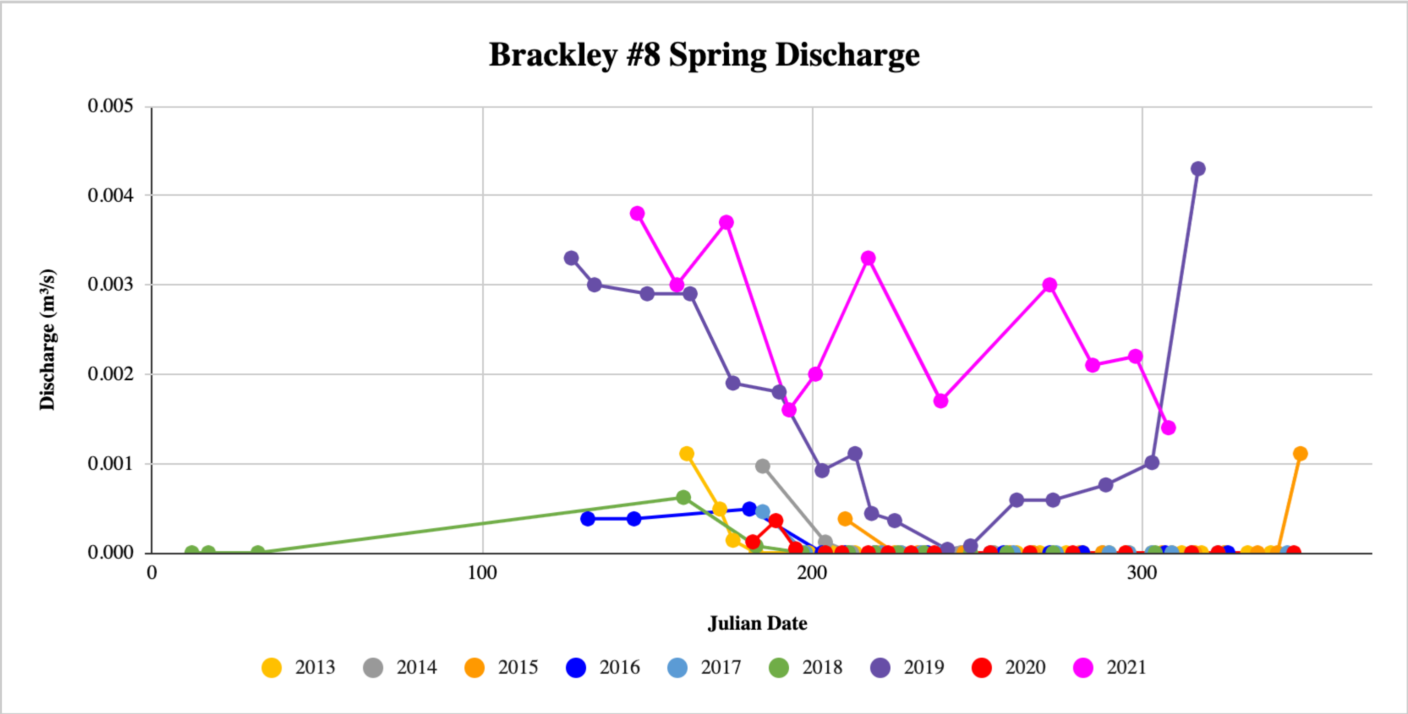

Figure 73. *Discharge calculated at the Brackley #8 weir, comparing years 2013 to 2021.*

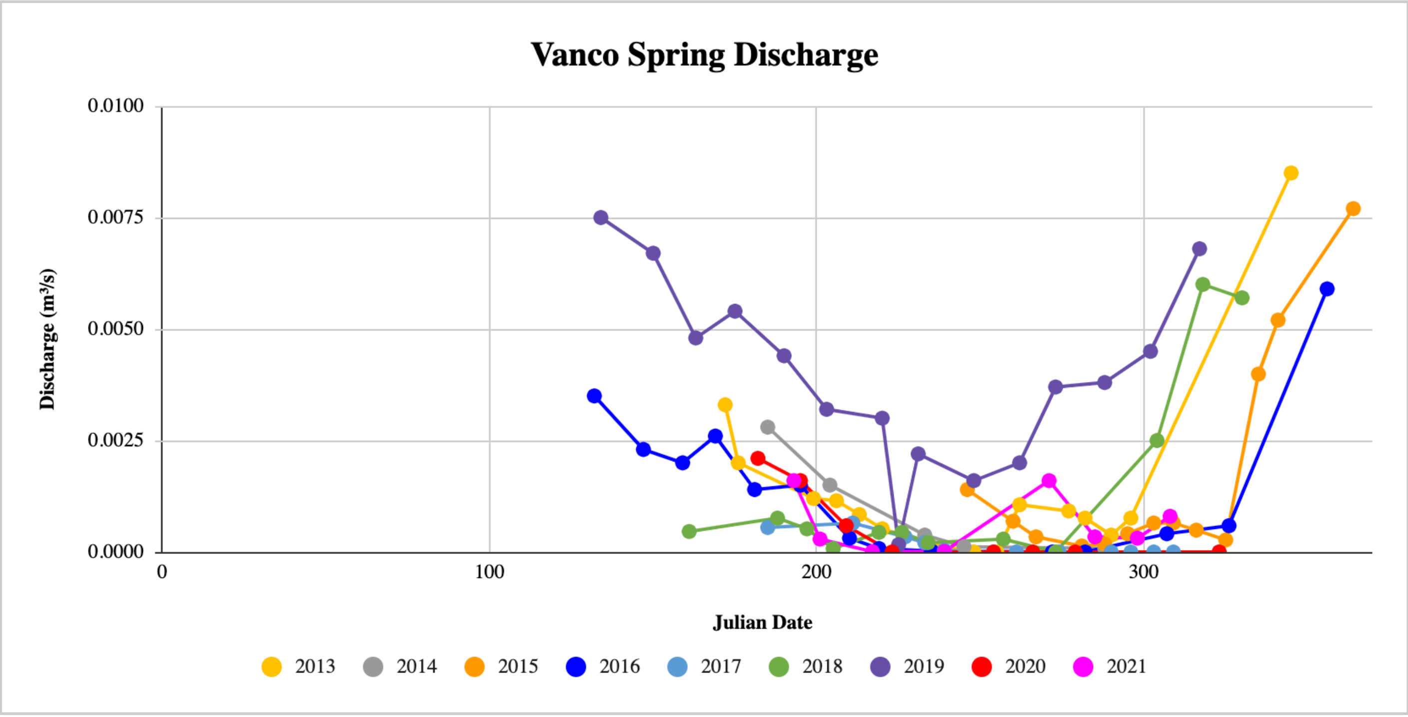

Figure 74. *Discharge calculated at the Vanco weir, comparing years 2013 to 2021.*

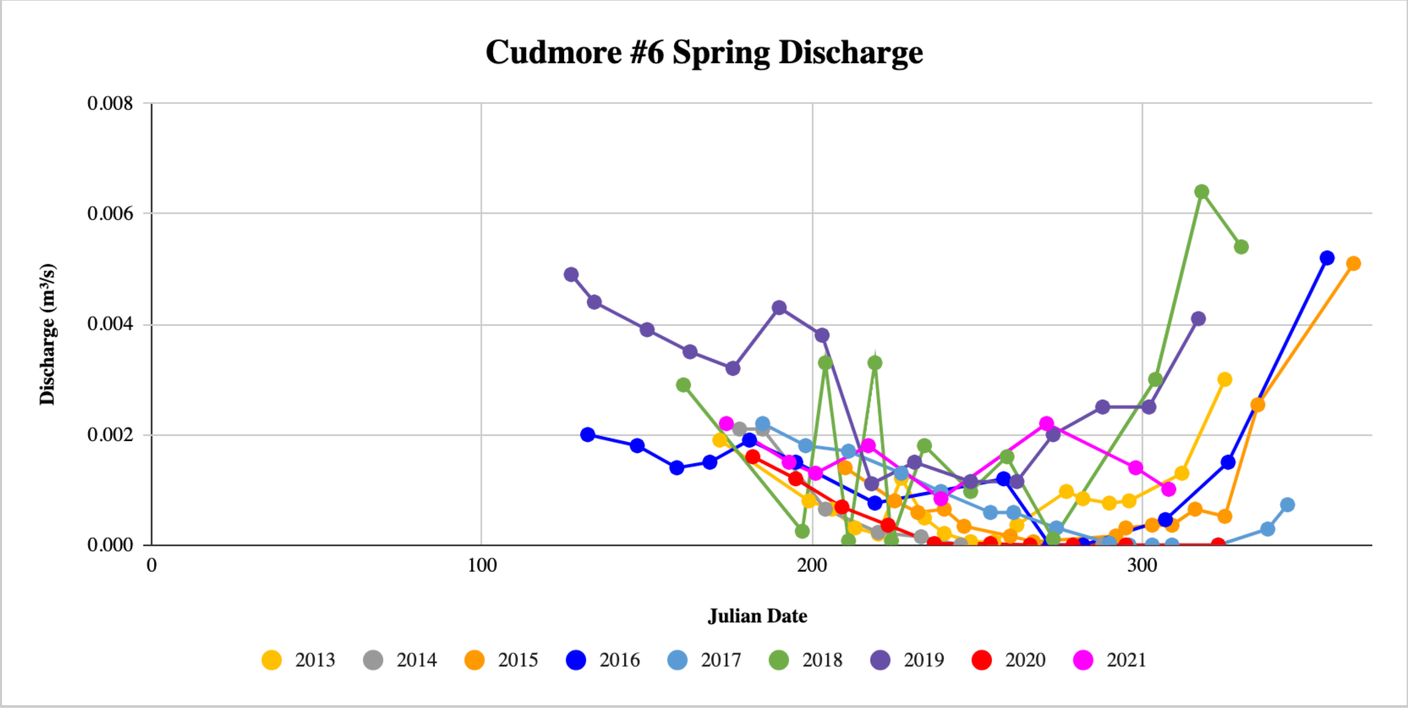

Figure 75. *Discharge calculated at the Cudmore #6 weir, comparing years 2013 to 2021.*

8. Other

8.1 Fish Kill at Black River

This year a fish kill was reported in the Black River system within the Watershed. On 2021-06-24 WRTBWA was notified by staff from the PEI Department of Environment, Energy and Climate Action, that there were multiple dead fish observed on Black River above Dougan Road. Staff coordinated with conservation officers who had responded to assess the situation. The conservation officers assessed the pond upwards to the headwaters, while staff collected YSI readings and made observations in the pond and downstream area. Staff were instructed to collect any evidence, including deceased fish. Staff returned to the site, multiple days after, to continue observing.

Figure 76 and Table 14 show the summary of results recorded by WRTBWA. Overall temperatures appeared to be very high with surface values surpassing 30°C in August. The YSI measurements also indicate potential issues. For example, the median temperature was 21.4°C which is troubling considering what was already mentioned in Section 6.1 Temperature Loggers, Brook trout can only survive in waters that are temperatures between 0°C and 20°C (Millar et al., 2019). The dissolved oxygen appeared to be dangerously low with a median of 1.36 mg/L. DO levels of 2 mg/L and lower are considered hypoxic conditions and at levels of 4 mg/L and less, fish health is at great risk with a possibility of death (*YSI Parameter Series: Dissolved Oxygen*, n.d.). Conductivity measurements were normal which is a good sign since spikes can indicate excess nutrients. However, the differentiation of the minimum, median, and maximum pH measurements is questionable; with pH being on a logarithmic scale, the difference between a pH of 5 and 6 is very large. A minimum value of 5.99 and a maximum value of 8.47 is thus a very big difference in the acidity of the water in this area. Most aquatic life prefers a water pH of 6.5 to 9 although trout can handle a minimum pH of 5 (Fondriest Environmental, Inc., 2013b). Finally, in terms of nitrate measurements, the differences in the minimum and maximum values are large. Higher nitrate values can indicate excess nutirents although with a median nitrate reading of 2.94 mg/L, this may not be the case as this is a normal value in freshwater systems.

Lab results from fish samples were collected by conservation officers. The Coordinator has been following up with the conservation officers on this case, but the process is very slow when it may result in legal actions.

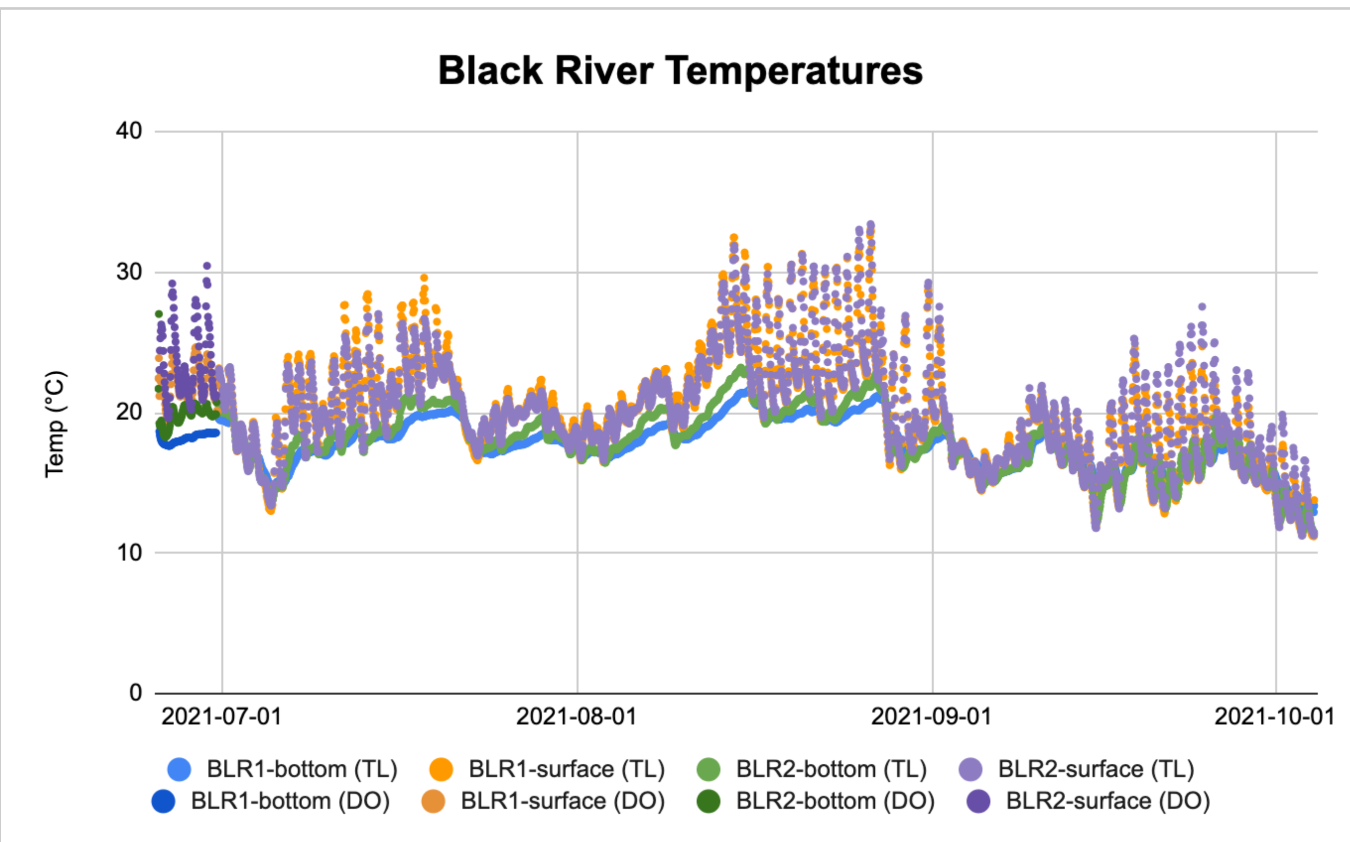

***Figure 76**. Temperature readings at the fish kill location at Black River. Readings were taken with dissolved oxygen loggers (DO) and temperature loggers (TL).*

***Table 14**. Average YSI readings from points at the fish kill location at Black River.*

	Temperature (°C)	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH	Nitrate (mg/L)
Minimum	11.2	0.04	136.1	5.99	0.45
Median	21.4	1.36	208	6.94	2.94
Maximum	25.4	15.55	422.7	8.47	10.09

8.2 Excavation of Springs

Occasionally a spring can accumulate a large amount of silt; this can occur from runoff of agricultural fields and dirt roads or erosion of stream banks. A significant amount of built-up silt can eventually be problematic by inhibiting the flow of water exiting the spring. This can cause difficulties with monitoring springs that have weirs as they can appear “flooded” where the level of water in the spring is the same level as the water in the connecting stream.

In the late fall of 2020 crew members excavated 1 spring in the Pater branch as well as Brackley #4 and Cudmore #6. This was done by staff shovelling silt into buckets and then carrying and dumping the buckets far from the spring to prevent it from refilling with the silt that was just removed. These springs showed improvement with water flow this following year so in the 2021 fall season crew members proceeded to excavate Brackley #7 (see Figure 77) which appeared flooded for the majority of the field season. This spring will continue to be monitored in 2022 for improved discharge.

***Figure 77**: Brackley spring #7 before (left) and after (right) excavation.*

8.3 Goldfish Extraction with Fish & Wildlife PEI

The discovery of more than 200 goldfish in the Winter River watershed was reported to Fish & Wildlife PEI, who in turn contacted the Watershed Coordinator on 2021-09-20. Staff from Fish & Wildlife removed and disposed of goldfish which were found near Hardy Mill dam. Rosie MacFarlane, a freshwater fisheries biologist for the province, led the extraction using electrofishing techniques. The results are unclear as to how the fish got there in the first place, but an investigation is ongoing.

WRTBWA staff assisted by checking the pond area for goldfish via canoe, and walking a section of the river after Fish & Wildlife staff had completed their work. Watershed staff caught several goldfish in nets through their assessment. Fish were removed and disposed of immediately upon discovering them. "'Finding an invasive species such as goldfish in an Island waterway is problematic', said MacFarlane. 'They could be carrying diseases or parasites that might affect our native fish. They also compete with other fish for food and space. They can simply become a nuisance in some areas. If they get into a pond that they are constantly rooting in the bottom of to get their food, they could create turbid conditions" (McEachern, 2021). WRTBWA continues to remind the public to refrain from releasing their unwanted pets into the wild.

8.4 Silt Trap Project at Union Pumping Station

Mid-September the instream silt trap located near the Union Pumping Station was excavated. WRTBWA hired a contractor with a long-reach excavator to remove accumulated material from the silt trap. Silt traps are used to accumulate silt that is travelling through the stream to prevent it from continuing down the water channel where it could damage marine habitat. Since silt is continuously collected in this one location, it occasionally needs to be emptied so this is done once every few years. The last year this silt trap was excavated was in September of the 2016 field season.

9. Recommendations for Future

Jenn:

Gardening would be a great activity for staff who don't have a task or when the weather is bad. Weeding, pruning, and general maintenance of the garden(s) could be good to keep people busy, while teaching them how to garden. Two gardens on either side of the door would be a nice addition to the outside of the Watershed office. Pollinator gardens housing native plants such as swamp milkweed, yellow coneflower, clover, etc. could help attract native species that feed on them. Drought-tolerant gardens are a good way of teaching people the value of water. Items used are rocks, and wood along with drought-tolerant plants (ostrich fern, cinnamon fern, sensitive fern, purple coneflower, rosemary, chicks and hens).

Learning how to build and implement rain barrels could teach us and others the value of water. The water from the rain barrel could be used for gardening and cleaning purposes as well. Community members might be interested in installing one, and so the Watershed could help with the process.

With the land owner's permission, we should consider planting small trees and shrubs in the overgrown area behind the office and shed. Planting trees would be a good way of learning species monitoring, pruning, and ID'ing.

Bat habitat - P.E.I.'s bat population has struggled for a long time because of the disease white-nose syndrome. This year, it seemed there was a particular interest from the public in this issue about bats. PEI watershed groups encouraged the community to consider offering up abandoned wells for bat habitat. The Alliance is currently in the second year of a three-year project monitoring bats all across P.E.I. They would probably be helpful in helping with projects related to this.

Newsletter - Writing could be a great rainy day project for the students to do, and something the supervisors or coordinator could edit later. If unable to find a local newspaper or newsletter, emailing a subscribed list of people/community members would help them remain informed about our projects. We could use this to thank volunteers throughout the year as well.

T Shirts - tshirts are a good way for team members and others to recognize the watershed. Grey or orange would help our logo stand out while orange could be used for high visibility. Ordering in bulk reduces the costs and extra shirts can be sold in support of future watershed projects. They can also be used as ‘thank-you’s’.

Fall/winter wear - It should be considered that staff who continue on in the fall and winter have a budget set aside for safety and comfort wear. Neoprene waders can be purchased from Canadian Tire and are a good way of keeping staff warm and comfortable through the season. Orange toques can also be purchased from places like Canadian Tire and Princess Auto - staff may feel safer wearing these during hunting seasons while crossing fields.

Raena

1. Temperature loggers- to prevent losing data like we did this past year with the Friston Main and Friston North loggers, it would be wise to do one or two check-ins where we download the data and make sure the loggers are functioning properly

2. More training/educational opportunities- staff really seem to enjoy these and have mentioned looking forward to going to training events and workshops

3. “Updates on past projects” section in the yearly report- it might be nice to include an update on previous tree-planting sites, brush mats we encounter during stream assessments that appear to be working, old culvert removal sites, etc. to show we check back on our work and what we’ve done is making a difference. This could also be a good way to reflect on what has been working and give ideas for future projects

4. I noticed when going through old annual reports that there was a section for “Educational Training Opportunities”. This could be a nice addition seeing that a big goal of WRTBWA is to educate staff and while we do take part in training it isn’t noted anywhere on the report.

5. End of contract survey for staff - I hear a lot of good comments and suggestions from staff so I think it would be a great idea to get their voices heard. If it’s at the end of a contract, people are more likely to share what they did not like as well which is always useful to know. Through a general questionnaire where staff can share what they liked about working for WRTBWA we could also get quotes to use in future job advertisements.

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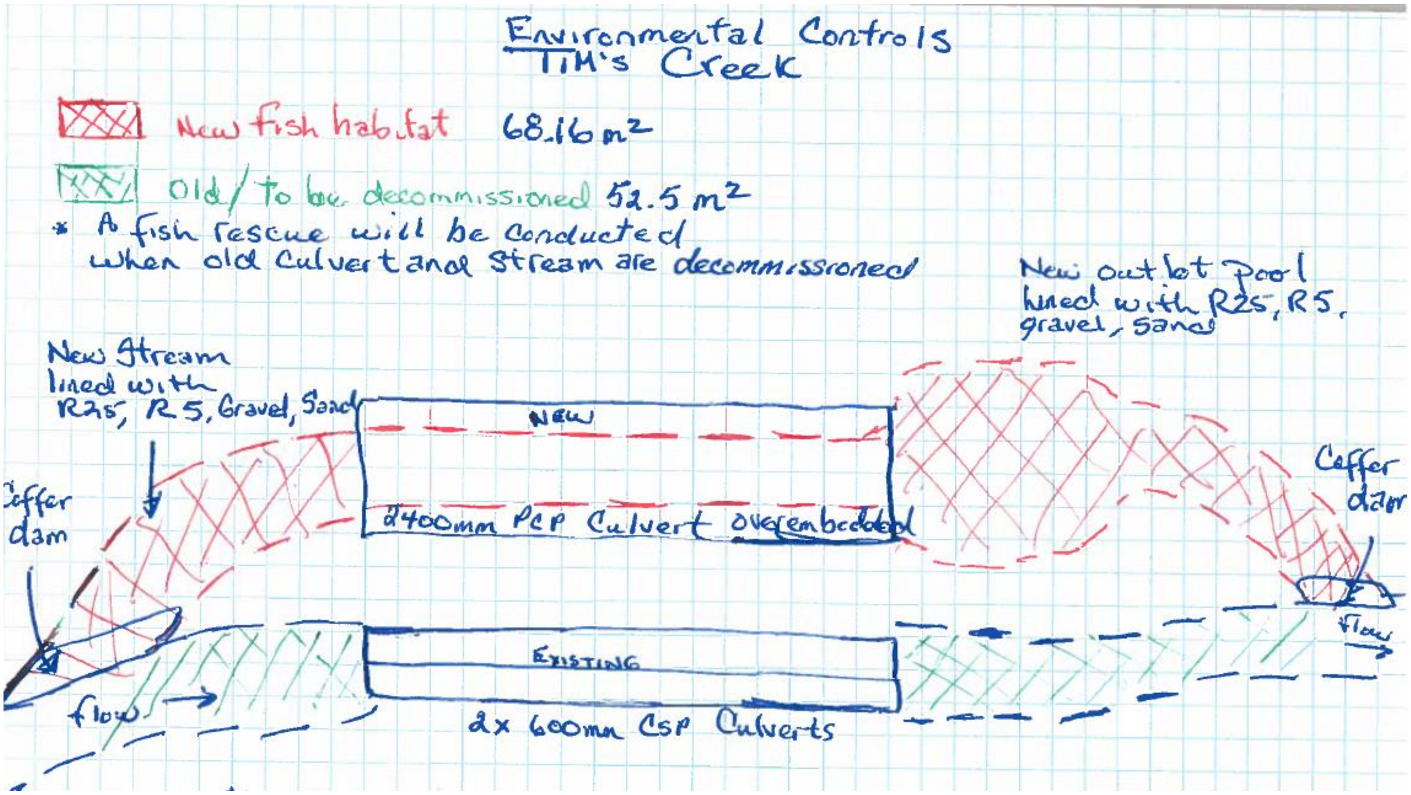
Appendix A: Construction Details for Tim's Creek Culvert Replacement

Construction days are numbered by the days that the contractor team was onsite (which was 4 days per week)

Day 1: July 14

The upstream and downstream sections around the Tim's creek were cleared by the contractors with chainsaws and an excavator. The tree trunks were cut up and moved off site, while the rest of the small branches and limbs were piled and will be put through a wood chipper and put back into the nearby woodland later. There was a brief meeting on-site around 11am where further planning was discussed. This included how much pit-run (gravel mixture for the bottom of culvert) was needed, the approach for damming and diverting the stream, the length of culvert and number of sections, and more. Attendees included PEI Government staff (Paul Strain, Matt Fortier, Hannah Jenkins, Jason Affleck), supervisor (foreman) for the contractors, Phillip for Maritime Dredging, WRTBWA staff (Sarah and Evan).



Day 2: July 15

Site clearing
In the morning, the clearing continued until it was completed.

Coffer Dam
A barrier was placed upstream from the culvert inlet, up against the surrounding bank. The barrier contained several bags of gravel laying on top of a thick plastic sheet. The purpose of this is to keep the bank stable while the excavator digs near it, minimizing erosion.

Excavation for new culvert
Both the upstream and downstream banks were then slightly dug up with the excavator, and a large hole was made on the upstream side of the road.

Erosion control
The loose dirt on the banks was then covered with a roll containing hay, coconut fibre, grass seed, and plastic. These areas were also bound by a stake and plastic sheet barrier placed into the ground. These erosion control measures were put in place to reduce the amount of potential runoff caused by any precipitation over the weekend. All of the dug-up soil was placed uphill in piles at each end of the road. As another method for preventing this from running off into the stream downslope (sort of), a plastic sheet and stake barrier was placed parallel to the road for several meters downslope from the dirt pile.

Day 3: July 19

Excavation/site clearing
Excavation continued today. The water accumulating in the bottom of the pool is now being pumped into a silt trap. This is basically all that happened today.

Day 4: July 20

Excavation
The excavation on one of the sides of the road is now complete. The first of four sections of culvert arrived today also. The initial plan to dig up half of the road and put in half the culvert changed because the foreman found that there would not be enough space to do this. Instead, the plan is to excavate the entire road width and assemble the culvert before dropping it in the hole. The water at the bottom of the hole is still being pumped uphill into the silt trap – it is getting pretty full.

Erosion control
Straw bales were placed downslope from the silt trap in the pathway of flow to try to slow down the silty water from reaching the creek below. Later in the day, the pump broke down so it had to be replaced

Preparing floor
In the afternoon, Class A gravel was placed in the bottom of the hole and flattened using rakes. After this, the excavation on the other side of the road commenced, now there is no possibility of passing through Suffolk road.

Day 5: July 21

Surveying floor / Excavating

The excavation continued for the morning until the survey crew showed up. They were there to check the grade of the gravel bottom at the inlet side of the hole in relation to pre-existing benchmarks. After some back and forth it was found that the surveyors had made a benchmark error when surveying a couple of years ago and that Phillip, the foreman, had the correct grade.

They began piling soil on the opposite side of the road after this and put silt fence on one of the sides – this could use more fencing probably; otherwise, a lot of the soil will runoff into the ditches and down the laneway.

Day 6: July 22

Water maintenance

After periods of heavy rain overnight, and more rain throughout the entire day, all that was really done was water control out of the hole. It was being pumped into the silt traps like the past days. There is a lot of red water coming from the worksite. The erosion control could have been improved. The hay rolls that were used before were rolled back up and currently are not being used. Also, some bales aren’t being used either; they should be placed downslope from the silt traps, where the water is being pumped.

Day 7: July 26

Preparing floor for culvert placement / Culvert placement

Excavating continued in the morning. Water is always being pumped from the hole into the silt traps upslope which are beginning to get shallower as they fill with sediment. Later, the hole was filled with gravel to give the floor more of a dense surface to minimize settling of the culvert over time. The survey crew was present, taking elevation readings as the hole was filled and raked to ensure that it had the correct grade.

In the afternoon, the crew pieced together two sections of the culvert and dropped it in the hole (half of the entire culvert)

Day 8: July 27

Culvert placement

Now that the culvert is in place, gravel was placed on each side of it and packed in using shovels; this is to stabilize the culvert. After each side was filled in approximately half of the diameter of the culvert, soil was added on top.

Day 9: July 28

Stream Bed Methodology / Excavation

Today the conveyor belt was brought to the worksite and the pit run was dropped off. The crew bagan to fill in the culvert with the pit run using this belt. The pit run contains 60 percent gravel, 20 percent sand, and 20 percent fines (clay). Apart from the gravel, it greatly resembles the natural soil in the streambed upstream and downstream from the culvert. The idea is to have a very similar substrate so that if any pit run was to wash out, the composition of substrate downstream would not change significantly. But given the 8 foot width of the culvert and the deflectors and meanders inside the culvert (see Aug 5), the water should not be flowing through at high enough velocities for such a wash out, even in periods of high flow in the spring and fall. The pit run is supposed to be very stable given its low overall porosity, being the spaces of voids in the overall soil; the fines and sand should fill in most of the voids between the larger pieces of gravel. The pore water pressures within the saturated pit run in theory should create tight bonds between the different soil grains, solidifying it.

After they put in all of the gravel they had for the day, they started excavating more, near the downstream end of the culvert.

Day 10: July 29

Excavation / Culvert placement / Filling culvert

To start the day, they began to excavate a ‘shelf’ so that they could get closer to the culvert with the excavator. After this, the third section of the culvert arrived and the crew fastened this to the two sections already in the trench. After this section was attached, more pit run arrived and the crew filled in more of the culvert.

Day 11: August 2

Excavation / filling culvert

The first thing that was done in the morning was excavating a laneway down to the culvert outlet so that the mini-excavator could get down, close to the culvert. The large excavator uphill then passed pit run down to the mini excavator, which then dropped loads of it inside a conveyor belt, placed inside the culvert. There were crew members at the other end of the conveyor belt raking and moving the pit run. This took up the majority of the day. At the end of the day, the last section of the culvert was dropped off.

Day 12: August 3

Installing culvert
In the morning, the last section of the culvert was installed; this took a long time. Next, class A gravel was used to fill in the spaces on the sides (bottom half) of the culvert to stabilize it. After this, soil was added on top of the gravel and finally on top of the culvert to cover it.

Day 13: August 4

Filling culvert / Excavating new channel
In the morning, more pit run gravel was dropped off and the crew got the mini-excavator again so they could put more pit run inside of the culvert. Now they are excavating what will become the new channel on the outflow side of the culvert. They then added R5 rock at the bottom of this channel and will then be covering this with pit run gravel, to match what's inside the culvert.

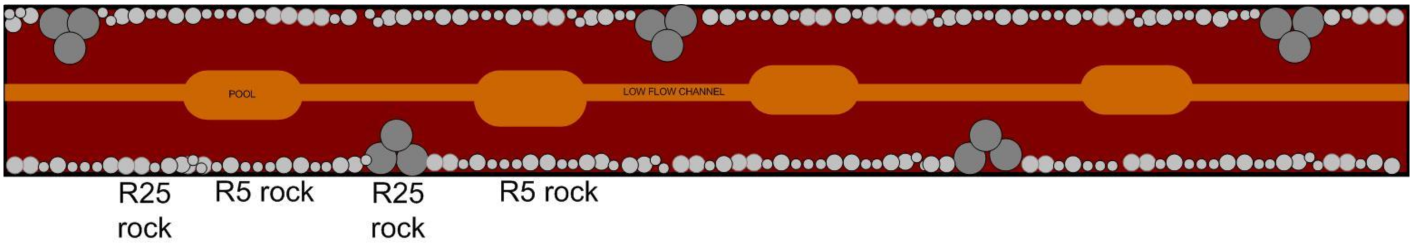
Day 14: August 5

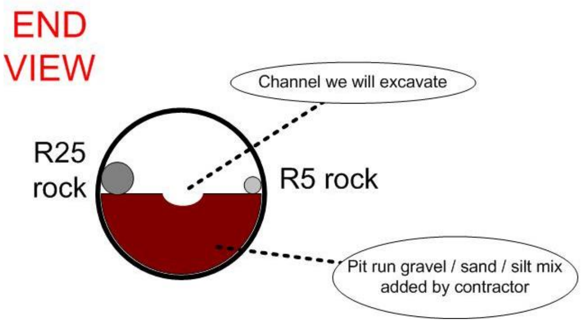
Excavating / forming channel
In the morning, some trees were being cleared both upstream and downstream close to the inflow and outflow to make more work-space. More R5 rock was then added to the downstream channel and pit-run, while grade readings were being taken simultaneously to make sure the slope from the outlet to where the stream connects is 2.5%, as per the design.

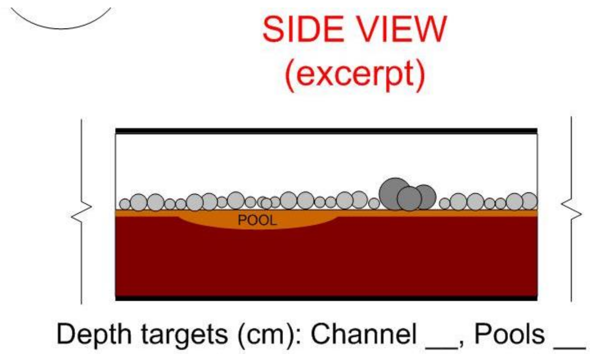
Paul Strain came by to show us a design for the streambed within the culvert. It involves a series of deflectors and pools made with R5 and R25 gravel and some raking and digging, creating a meandering stream which will slow down the water flow and will create resting areas for fish in the edis and the pools. The crew will be going in tomorrow to assemble this inside the culvert.

Schematic of design inside culvert - drawn to scale
R5 and R25 rock are drawn as circles for dimensioning, but rocks are rough

Top view







WRTBWA work day: August 6

WRTBWA staff worked on the culvert on this day (as the contractors don't work Fridays) to move rock along edges of pipe, and dig a low-flow channel in the middle of the pit run gravel/sand/silt. This was completed on the downstream half of the pipe where pit run gravel had been installed.

Day 15: August 9

The crew continued to excavate the inflow side of the culvert. The bank on the outflow side of the culvert was enhanced with R25 rocks.

Figure #: The figure above shows the rock that was placed along the bottom side of the bank located on the outflow side of the culvert.

Day 16: August 10

A conveyor belt from Caterpillar in Moncton was ordered and was delivered today. The purpose of the conveyor belt is to transport granite rock which is from Nova Scotia into the natural substrate floor of the culvert. The crew positioned the conveyor belt on the inflow side of the culvert. Water was pumped out of the inflow side of the culvert to allow for a more manageable work area. Rock was delivered by dump trucks periodically throughout the day. More R25 rock was placed along the bank of the outflow side of the culvert. The bank on the outflow side of the culvert was flattened out more to minimize the bank's slope angle.

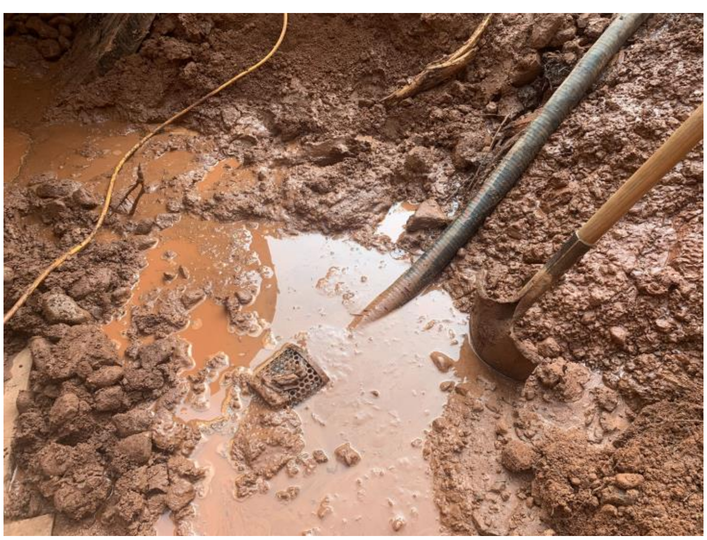


Figure #: The figure above shows the water being pumped out of the inflow side of the culvert to allow for a more manageable work area.

Figure #: The figure above shows the quantity of water in the inflow side of the culvert as pumping began. This image also shows the conveyor belt that was ordered and delivered from Caterpillar in Moncton.

Figure #: The figure above shows the outflow side of the culvert. In the image you can see that the bank along both sides of the culvert have been flattened out to decrease the slope's angle. In addition, more rock was placed along the banks.

Day 17: August 11

Rocks inside culvert

First thing in the morning the watershed crew continued the same project as started on August 6 on the upstream half of the culvert, after contractors had completed installing the pit run gravel/sand/silt mix the day before.

Preparing for opening of new channel

After the watershed crew finished inside the pipe, the contractors got set up to wash out the new channel. To do this water was pumped through the culvert, in a loop, before pumping it back to the silt trap upslope. The purpose of this is to wash out some of the looser fines on the surface of the streambed; this will aid in reducing the amount of washout that happens when the channel is finally opened up. This process went on for about 3 hours, until the water was running clear. The channel was now ready for stream water.

Channel opened

The sandbag cofferdam was moved to divert water flow through the culvert and shut off water through the old culvert. Water flowed through the culvert, some sediment was disturbed in this process. The river below Tim's Creek looked similar to after a heavy rain, though with all the sediment coming from Tim's Creek rather than from farther upriver.

Day 18: August 12

Many staff were sick, so we were not able to collect data on this date.

Day 19: August 16

Today dump truck loads of shale were continuously being brought in. The giant dirt piles have now been depleted, they were used to begin to fill in the new road. Dirt was continuously dumped throughout the day on what will be the road. The roller flattened the dirt after each dump truck load.

Day 20: August 17

Today the construction crew had a wood chipper to get rid of any old dead wood. Today more dirt was brought in throughout the day, the roller was flattening the dirt after each dump truck load.

Day 21: August 18

Today the construction crew did very similar tasks as they have done the past two days. More dirt was continuously trucked in throughout the day. The roller continued to flatten each dump truck load of dirt.

Day 22: August 19

Today the construction crew finished filling the road in, they then laid asphalt down and flattened it. The final step to complete the culvert project was to add guard rails to both sides of the road. The guard rails were added and the project was completed.

Day 23: August 23

Small crew from the contractor was onsite to tidy up the worksite, retrieve all equipment, and do other small jobs. Road has been opened back up to traffic.

Figure #. Panorama photo of upstream side of culvert

Figure #. Downstream side of culvert

Summary of Equipment Used

Manual labourers - 5
Excavator - onsite at all times; Excavator operator/Crew Foreman
    Second excavator for some days
    Mini Excavator and operator (contracted from another company)
Loader - onsite at all times, Operator
Dump truck

Conveyor belt

Water pumps

Excavator loading material into dump truck, survey equipment and water pumps in foreground. Jobsite viewed from upstream.

Mini excavator being used to load material onto conveyor to backfill the culvert to the appropriate level of embedment. Large excavator working in background on the downstream end of the culvert. Jobsite viewed from upstream.

Two large excavators, one mini excavator (only partly visible on right of photo - orange arm extended), one loader, and one dumptruck all operating simultaneously. 2021-08-04. Jobsite viewed from the southern edge.

Post-Construction follow-up

2021-09-02 heavy rains from Hurricane Ida

Silty water running from ditch northwest of culvert, through the upstream side of the work site

Downstream side of worksite as seen from road

Downstream side as seen from stream. Some of the straw matting washed down the slope.

Materials inside culvert were quite stable

October 21, Grass growing on upstream side, and extra rock added where runoff from ditch to the north enters the stream

Oct 21 after additional asphalt millings were added to edges of road

TIE plans to complete additional erosion control work next week > gabion baskets, rock dams, excavate silt traps in ditches, put millings (aka crushed asphalt) across a wider section of the road because the shoulders are very soft right now, etc.

Next Year

- See how substrate inside culvert handles the winter
- Add live stakes of willow and/or red osier dogwood to stabilize the steep banks
- Plant trees and shrubs in disturbed areas that were temporarily stabilized with plastic mesh/straw and grass seed

APPENDIX B: Depth Logger Monitoring Procedure

The following depth logger monitoring procedure was copied from the WRTBWA 2020 Final Report with a few modifications.

Methods for depth loggers were adopted from the Parks Canada, PEI National Park protocol (Hawkins, 2014). Depth values were calculated by comparing the pressure the loggers were experiencing under water in the streams to the pressure readings from a control logger set up outside the watershed office. This data was analyzed in the winter and cleaned up of any abnormalities due to logger malfunctions, to provide a running value of the depth of water above the logger.

To calculate the volume of water passing by the data logger, additional measurements were needed. Repeated measurements of the cross sectional area of the channel at the location where the logger was located, and the average velocity of water at this location were used to calculate the discharge (the volume of water flowing through this point in the river in a given time). These discharge values were plotted against the depth of water at the logger during each measuring event, to create a rating curve, and then an associated formula to relate water depth to water discharge. This formula was applied to all hourly depth measurements to create a series with hourly discharge measurements.

The routine measurements included velocity, distance from bank to logger, depth at logger, wetted width, and depth measurements at every 1/6th across the wetted width. A measuring tape was stretched across the wetted width from the left to right bank (when facing downstream), and a meter stick was used to take the depth readings. The velocity of water within the stream was measured using a tennis ball method; a distance of 3 meters was measured from the depth logger, and a stopwatch recorded how long it took for a dropped ball to travel that distance downstream. Measurements were taken at the left, right, and center of the stream, to get an average velocity value. The velocity and channel measurements were used to calculate the discharge from the stream. The discharge values were then graphed for each site and provided an equation that was used to perform flow statistics for each depth reading. The maximum, minimum, and average flows were calculated, and the number of high flow pulses per site recorded. Through these sets of calculations, the flashiness and R-B Index values were determined for each stream site.