WINTER RIVER - TRACADIE BAY WATERSHED ASSOCIATION

2018-19 Work Year Report

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Contents

1 Executive Summary

The crew at Winter River - Tracadie Bay Watershed Association (WRTBWA) had a busy year. Some of our accomplishments included planting 1717 trees, clearing debris from 4.5 km of stream, creating 13 new brush mats, updating 2 existing brush mats, removing 1030 kg of waste from the shoreline, assembling a natural silt fence made of straw bales, and removing an old culvert. Furthermore, a bathymetric map of Officer's Pond was created to compare with a previous version from a 1994 study.

Water monitoring activities this year included the deployment of depth loggers, temperature loggers, dissolved oxygen loggers, and v-notch weirs. This data can be used to assess ecosystem health and records can be compared between years to determine trends in water quality and quantity. However, this year's flow data should be interpreted with caution, due to some degree of error caused by the replacement of a culvert with a bridge, debris on loggers, very high water events and beaver dams.

The main branch of the Winter River is categorized as a beaver-free zone within the Watershed. This is to prevent significant issues for fish passage and habitat. As a result, a large beaver dam was removed, and 8 beavers that were causing flooding issues in this area were trapped.

In 2017, WRTBWA received a donation of land on Suffolk Road. The crew has been cleaning up waste debris on the site and removing hazardous trees. This work is essential before any new projects can take place on the new parcel of land.

The Water Makeover Program came to an end with 71 residents and 4 businesses taking part. After some follow up, this project will be complete.

2 Staff

Sarah Wheatley has been the Watershed Coordinator at WRTBWA since 2015. Matt Barr, Vanessa Jackson, and Emma Spence all returned from last year and assumed similar roles, with some rearrangement of duties. The rest of the summer field crew included: Trent MacSwain (chainsaw operator), Sarah McBride (field crew), Carley Ross (field crew), and Samantha MacSwain (field crew). Drew Lorenzen, Chayla Exner, and Fred Johnston were hired for the fall as field crew members.

Table 1. Staff employed in 2018.

Name	Term of Employment		Name	Term of Employment
Sarah Wheatley	Year round		Carley Ross	Summer
Vanessa Jackson	Spring-fall		Samantha MacSwain	Summer
Matt Barr	Spring-fall		Drew Lorenzen	Fall
Emma Spence	Spring-fall		Fred Johnston	Fall
Trent MacSwain	Summer		Chayla Exner	Fall
Sarah McBride	Summer			

Figure 1. From left to right: Sarah Wheatley, Liam (volunteer), Sam MacSwain, Trent MacSwain, Matt Barr, Emma Spence, Carley Ross, Sarah McBride, and Vanessa Jackson all pose for a staff photo.

3 Project Activities 2018

3.1 Tree Planting

The staff planted a total of 1,717 trees and shrubs in the watershed this field season. There were also trees given away to the Water Makeover Program and watershed residents that wished to plant the trees themselves. In total, this came to 2,164 plants consisting of 32 different species. Tree planting is a beneficial activity, creating diversity in our forests, providing food and cover for fish and wildlife, and supporting stream banks. WRTBWA encouraged watershed residents who wished to connect a hedgerow to woodland behind their properties to contact us for planting. We first collaborated with residents to find out the number and species of trees they would like, then returned to plant the trees. The crew planted over 100 Common Elder, Eastern Cedar, Red Osier Dogwood, and Spirea tomentosa. As well, over 200 Northern Bayberry, White Spruce, and Willow were planted. The most trees planted at a single location was 316 at the Glenaladale Shore Field site.

Table 2. Types and number of tree/shrub species planted at each site for the 2018 Tree Planting Project.

	Glenaladale Shore Field	York Bridge	Officers Clubhouse	Suffolk Pumping Station	East Suffolk	Pleasant Grove Rd	Donaldston Rd	East Suffolk Rd	Winter River Trail & Tim's Creek	Union Station	MacGillivray Rd	Friston South	Pater Branch	MacLauchlan Branch	Glenaladale	Suffolk Rd	Water Makeover	TOTAL
American Mountain Ash	0	12	0	0	0	35	0	18	6	12	0	0	0	0	0	0	0	83
Aronia P.	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6
Balsam Fir	0	6	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	15
Balsam Poplar	0	12	0	7	0	0	0	0	18	30	0	0	0	0	0	0	0	67
Bayberry	48	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	58
Black Chokeberry	0	0	0	0	0	0	0	0	0	0	0	0	5	0	12	0	18	35
Black Spruce	0	6	0	0	0	0	0	0	0	6	0	6	0	6	0	0	0	24
Bog Birch	0	6	0	0	0	0	0	0	6	12	0	0	0	12	0	0	0	36
Common Elder	0	0	0	0	0	34	20	12	11	0	0	0	0	0	6	4	50	137
Eastern Cedar	0	6	0	0	96	0	0	0	19	18	0	6	0	12	12	2	0	171
Eastern Hemlock	0	0	0	0	0	0	0	0	0	0	0	6	0	0	12	12	0	30
Eastern Larch	0	6	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	12
Elm	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0	24
Hemlock	0	0	0	0	0	0	0	0	19	0	0	0	0	0	0	0	0	19
Honey Suckle	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	6
Northern Bayberry	0	0	0	0	0	34	0	0	6	0	30	0	0	0	0	0	141	211
Purple Chokeberry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6
Red Osier Dogwood	72	0	0	0	0	34	0	12	0	0	0	0	0	0	0	0	0	118
Red Pine	0	0	0	1	0	0	15	0	0	12	0	0	0	0	0	0	0	28
Red Spruce	0	0	0	0	0	0	0	42	0	0	0	0	0	12	0	0	0	54
Spirea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	22
Spirea latifolia	0	0	0	0	0	0	0	0	16	0	0	0	0	0	6	0	0	22
Spirea tomentosa	0	18	0	0	0	0	0	30	16	12	30	0	0	6	6	2	0	120
Sweet Fern	0	0	0	0	0	0	0	6	6	0	0	0	0	0	0	0	0	12
Sweet Gale	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
Tamarack	0	0	0	0	0	0	0	0	12	18	0	0	0	0	0	0	0	30
White Birch	0	18	0	0	0	0	0	18	0	12	20	0	0	0	24	0	0	92
White Pine	0	0	0	0	0	0	0	0	38	0	0	0	0	0	12	0	0	50
Wild Rose	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53
White Spruce	95	0	30	0	0	47	40	24	7	0	39	0	0	0	0	0	0	282
Willow	48	12	0	5	0	0	0	0	0	42	59	0	76	0	0	0	0	242
Yellow Birch	0	6	0	9	0	24	0	18	19	6	0	0	0	0	12	0	0	94
TOTAL	316	111	30	22	96	208	85	180	208	219	178	18	81	48	102	20	242	2,164

3.1.1 *Glenaladale Shore Field*

In 2018, the Glenaladale Trust purchased a large property known as Glenaladale Homestead. This property is in the Watershed area, so WRTBWA was eager to help with tree planting at the site. This year we planned on creating hedgerows in between some of the fields, but since the fields were still being rented out and Roundup was being applied, we decided to postpone until at least the 2019 field season. Glenaladale Trust plans on farming organically in the future. There was an unused field by the shoreline, so we decided to plant salt tolerant species in the area with the help of student volunteers. Planting in this area will help prevent erosion by stabilizing the banks, creating food sources, and providing cover for wildlife.

Table 3. The types and numbers of species planted at Glenaladale shore field 2018.

Species	#
Wild Rose	53
Red Osier Dogwood	72
White Spruce	95
Willow	48
Bayberry	48
TOTAL	316

Figure 2. Left: Area planted (yellow) at the Glenaladale shore field, off Blooming Point Road. Right: Student volunteers who helped plant trees.

3.1.2 *York Bridge*

There had been construction work last year at York Bridge, leaving the buffer zone stripped of its vegetation. The stream needed more cover for fish, so WRTBWA planted a variety of trees and shrubs in the area. The planting will also benefit birds and wildlife, providing food and cover.

Table 4. The types and numbers of species planted at the York Bridge site.

Species	#		Species	#
White Birch	18		Eastern Larch	6
Yellow Birch	6		Black Spruce	6
American Mountain Ash	12		Bog Birch	6
Balsam Poplar	12		Honey Suckle	3
Eastern Cedar	6		Spirea tomentosa	18
Balsam Fir	6		Willow	12
TOTAL				111

Figure 3. Area planted (yellow) at York Bridge (left). Right: Staff member Vanessa Jackson, planting a tree at the site.

Figure 4. Shrub planted at York Bridge.

3.1.3 *Officer's Clubhouse*

A total of 30 White Spruce plugs were planted at the Officer's Clubhouse property. This area was chosen for planting to help stabilize the banks at the pond and provide fish cover.

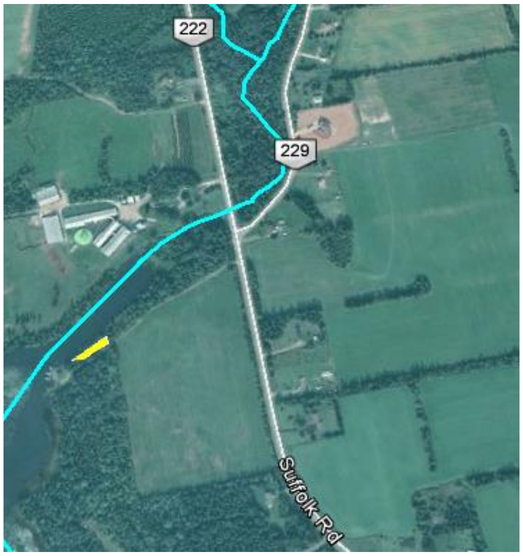


Figure 5. Area planted (yellow) at Officer's Clubhouse.

3.1.4 *Suffolk Pumping Station*

This location mostly consisted of Alders. Last year there were some Alder patch cuts made here. The Suffolk Pumping Station was selected for planting to create diversity, helping the entire ecosystem flourish. Planting in this area also helps to sturdy the stream banks to prevent erosion and add fish cover.

Table 5. The types and numbers of species planted at the Suffolk Pumping Station.

Species	**#**
Willow	5
Yellow Birch	9
Red Pine	1
Balsam Poplar	7
TOTAL	22

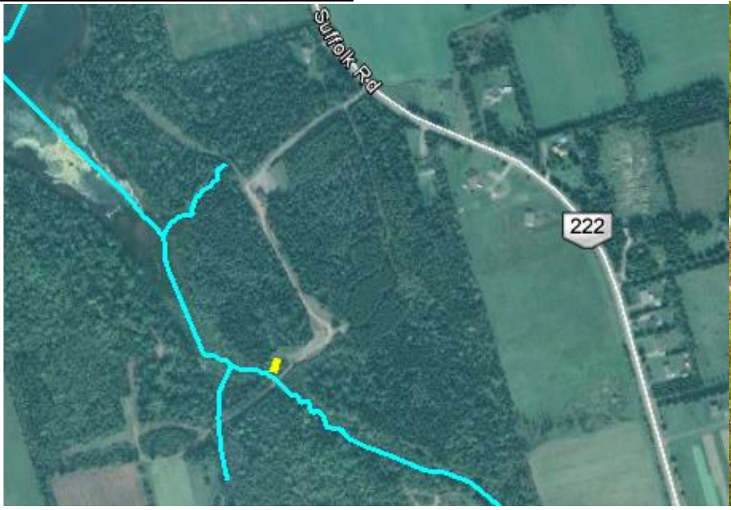


Figure 6. Left: Area planted (yellow) at Suffolk Pumping Station. Right: Shrub planted at Suffolk Pumping Station.

3.1.5 *East Suffolk*

The WRTBWA crew planted 96 Eastern Cedars to create a hedgerow for wildlife. The landowner also purchased additional Spruce to create 2 hedges.

Figure 7. Left: Area where hedgerows were planted (yellow) at site in East Suffolk. Right: Eastern cedar hedgerow planted at site in East Suffolk.

3.1.6 *Pleasant Grove Road*

The landowner at this property was looking to re-create a hedgerow, as the current one had been deteriorating year after year. We followed guidelines provided by the Macphail Woods website for proper hedgerow creation. First, a hedgerow of trees spaced 3 m apart should be planted, then a second hedgerow should be planted running parallel with the first, composed of shrubs and smaller trees spaced 1.5 m apart. Following this guide, WRTBWA created a similar hedgerow on the property. The first hedgerow consisted of trees following a pattern of 2 White Spruce then 1 White Birch all the way up the hedge. The second hedgerow consisted of shrubs: Common Elder, Red Osier Dogwood, Bayberry, and American Mountain Ash. Not only do the hedgerows create a windbreak, but they also provide important habitat, food, and wildlife corridors.

Table 6. The types and numbers of species planted at the site on Pleasant Grove Road.

Species	**#**		**Species**	**#**
White Birch	24		Northern Bayberry	34
American Mountain Ash	35		Red Osier Dogwood	34
White Spruce	47		Common Elder	34
TOTAL				208

Figure 8. Left: Area where hedgerows were planted (yellow) at site on Pleasant Grove Road. Right: The hedgerow that was planted at the site on Pleasant Grove Road.

3.1.7 *Donaldston Road*

The landowner reached out to WRTBWA to discuss hedgerow creation along various sections of their property. They had already started a Spruce hedgerow at the back of the property and wanted to finish it. They also wanted to create a hedgerow at the front of the property by the road and add trees to the side hedge. The crew helped with this project to create a windbreak and habitat for birds and wildlife.

Table 7. The types and numbers of species planted at the site on Donaldston Road.

Species	#
Red Pine	15
White Spruce	40
Bayberry	10
Elder	20
TOTAL	85

Figure 9. Left: Areas planted (yellow) at site on Donaldston Road. Right: Vanessa Jackson, staff member, planting at site on Donaldston Road.

3.1.8 *East Suffolk Road*

A Watershed resident reached out to WRTBWA to help with hedgerow extensions on their property. The crew extended the back and side hedges with trees and shrubs. This will create a windbreak, lengthen habitat, and create food sources for birds and wildlife.

Table 8. The types and numbers of species planted at the site on East Suffolk Road.

Species	**#**		**Species**	**#**
Red Spruce	42		Sweet Fern	6
White Spruce	24		Red Osier Dogwood	12
White Birch	18		Common Elder	12
Yellow Birch	18		Spirea tomentosa	30
American Mountain Ash	18			
TOTAL				180

Figure 10. Left: Areas planted (yellow) at the site on East Suffolk Road. Right: Hedgerow extension at the site on East Suffolk Road.

Figure 11. Staff Sam MacSwain planting trees at the site on East Suffolk Road.

3.1.9 <u>*Winter River Trail and Tim's Creek*</u>

At the Winter River trail, 5 patch cuts were planted, each consisting of: 2 White Pine, 1 Yellow Birch, 1 Cedar, 1 White Spruce, and 1 Hemlock. The rest of the trees and shrubs in Table 9 were planted by the stream banks along the Winter River and Tim's Creek to help stabilize the banks, create diversity, offer food sources, and provide cover for fish, birds, and other wildlife.

Figure 12. Left: Areas planted (yellow) at the Winter River Trail and Tim's Creek. Right: Trees and shrubs planted by stream banks along the Winter River Trail.

Table 9. The types and numbers of species planted at the Winter River Trail and Tim's Creek.

Species	**#**		**Species**	**#**		**Species**	**#**
Bog Birch	6		Tamarack	12		American Mountain Ash	6
Yellow Birch	19		Spirea latifolia	16		Honey Suckle	3
Eastern Cedar	19		Common Elder	11		Aronia P.	6
White Pine	38		Sweet Fern	6		Northern Bayberry	6
Balsam Poplar	18		Spirea tomentosa	16		White Spruce	7
Hemlock	19						
TOTAL							208

Figure 13. Carley Ross, staff member, carrying a tray of trees to be planted at the Winter River Trail.

3.1.10 *Union Station*

An area by the culvert on the Union Pumping Station lane was planted with trees and shrubs to fill in some open patches, add diversity, and create bank stability. Moisture loving trees and shrubs were selected for this area. A Southern section of the property was also planted to create diversity and wildlife habitat.

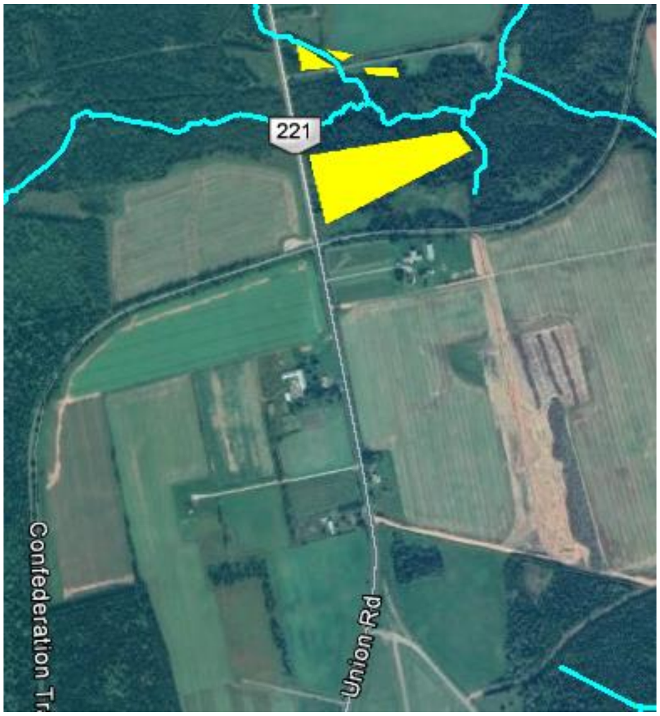


Figure 14. Areas planted (yellow) at Union Station in 2018.

Table 10. The types and numbers of species planted at 1st Union Pumping Station culvert.

Species	#		Species	#
White Birch	12		Eastern Larch	6
Yellow Birch	6		Red Pine	12
American Mountain Ash	12		Black Spruce	6
Balsam Poplar	12		Willow	6
Eastern Cedar	12		Elm	18
Balsam Fir	9			
TOTAL				111

Table 11. The types and numbers of species planted at Union Pumping Station field.

Species	#		Species	#
Balsam Poplar	18		Eastern Cedar	6
Bog Birch	12		Willow	36
Tamarack	18		Spirea tomentosa	12
Elm	6			
TOTAL				108

3.1.11 *MacGillivray Road*

At this site, the property owners were interested in creating hedgerows around their property. The first hedgerow consisted of trees and the second of shrubs to help establish wildlife corridors. We also removed deadwood from the front woodlot to create room for more trees to be planted. This will help to prevent erosion in years to come.

Table 12. The types and numbers of species planted at the site on MacGillivray Road.

Species	#
White Spruce	39
White Birch	20
Northern Bayberry	30
Spirea tomentosa	30
Willow	59
TOTAL	178

Figure 15. Left: Areas planted (yellow) at the site on MacGillivray Road. Right: Hedgerow planted at the site on MacGillivray Road.

Figure 16. Staff Sarah McBride planting at the site on MacGillivray Road.

3.1.12 *Friston South*

In the past, the Friston South site had a major sedimentation problem; staff could barely access the site without getting stuck in the sediment. The past few years have seen much improvement to this stream branch, as there was a large brush mat built in 2016, with additional work to it in 2017. In 2017 there were a number of shrubs planted on the established brush mat that proved to have a very high survival rate. We returned this year to plant some moisture loving trees, just a bit back from the shrubs and the banks. This will help provide fish cover and shade, and habitat for wildlife.

Table 13. The types and numbers of species planted at Friston South.

Species	#
Black Spruce	6
Eastern Cedar	6
Eastern Hemlock	6
TOTAL	18

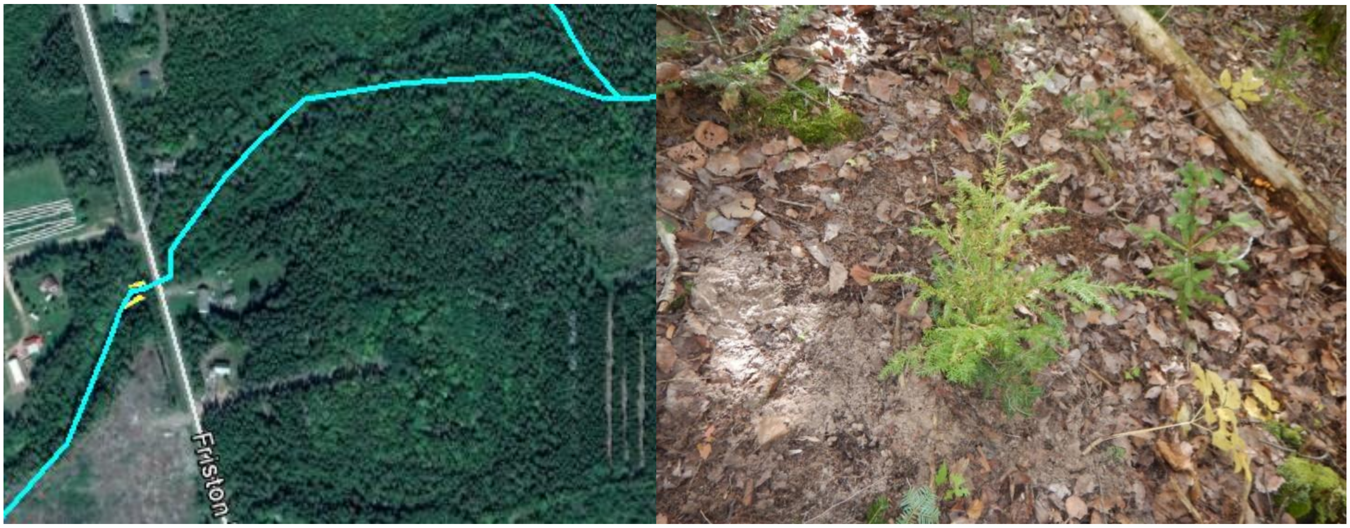


Figure 17. Left: Areas planted (yellow) at Friston South. Right: An eastern hemlock planted at Friston South.

3.1.13 *Pater Branch – By Silt Fence*

There were many Willows and a few Black Chokeberries planted to add to the buffer zone at the Pater branch.

Table 14. The types and numbers of shrub species planted at the Pater Branch site.

Species	#
Willow	76
Black Chokeberry	5
TOTAL	81

Figure 18. Left: Area planted (yellow) at the Pater Branch site (left). Right: A willow planted at the Pater Branch site.

3.1.14 *MacLauchlan Branch*

Down by the community mailboxes on the Pleasant Grove Road, there was a bare patch that the crew thought could use some planting. There was major flooding in this area due to a beaver dam in the spring, so the crew planted moisture loving trees and shrubs to add shade and help reduce flooding

Table 15. The types and numbers of species planted at the MacLauchlan Branch site.

Species	#
Eastern Cedar	12
Bog Birch	12
Black Spruce	6
Red Spruce	12
Spirea tomentosa	6
TOTAL	48

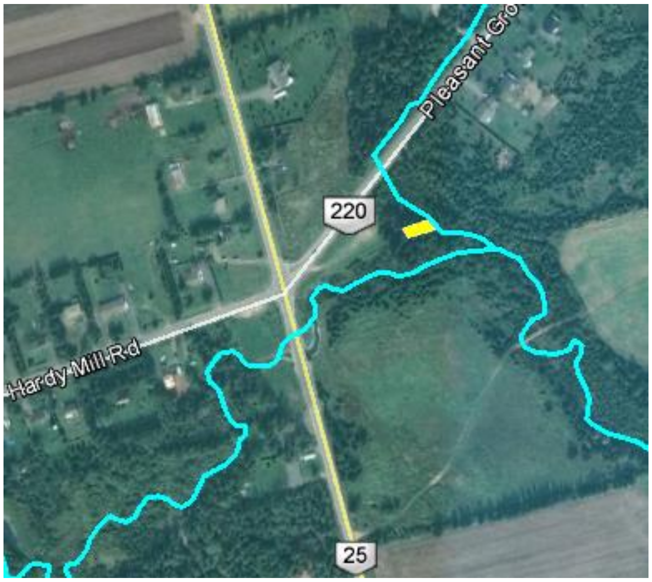


Figure 19. Area planted (yellow) at the MacLauchlan Branch site.

3.1.15 *Glenaladale Woodlot*

A woodlot that had not been managed in some time at the Glenaladale property needed some work. The Glenaladale Heritage Trust gave us permission to clean it up. There were a number of fallen trees and standing deadwood that the crew piled up to make way for new trees. The trees planted at this site will add diversity and provide food and cover for wildlife.

Table 16. The types and numbers of species planted at the Glenaladale Woodlot.

Species	#		Species	#
White Birch	24		Black Chokeberry	12
Yellow Birch	18		Spirea tomentosa	6
Eastern Cedar	6		Spirea latifolia	6
Eastern Hemlock	12		Common Elder	6
White Pine	12			
TOTAL				102

Figure 20. Left: Areas planted (yellow) at the Glenaladale Woodlot. Right: Vanessa Jackson, staff member, planting a tree at the Glenaladale Woodlot.

3.1.16 *Suffolk Road*

There were many dead trees to cut by the stream at a property on Suffolk Road to allow room for more species to be planted. These additions will help stabilize the stream banks and provide cover for fish. It also helps diversify the area and adds food for wildlife.

Table 17. The types and numbers of species planted at the site on Suffolk Road.

Species	#
Eastern Cedar	2
Eastern Hemlock	12
Common Elder	4
Spirea tomentosa	2
TOTAL	20

Figure 21. Left: Areas planted at the site on Suffolk Road. Right: An eastern hemlock planted at the site on Suffolk Road.

3.1.17 *Water Makeover Program*

There were 242 shrubs provided to participants of our Water Makeover Program. Participants were given a list of appropriate flowering shrubs available from the Forestry nursery, and we delivered the selected shrubs in the spring. All shrubs are native to PEI and do not need to be watered, thus saving water coming from our Watershed.

Table 18. The total number and types of species given out for the Water Makeover Program in 2018.

Species	#
Common Elder	50
Black Chokeberry	18
Purple Chokeberry	6
Spirea	22
Sweet Gale	5
Northern Bayberry	141
TOTAL	242

3.2 Forest Enhancement - Patch Cuts

The forest surrounding the Winter River trail consists mostly of Balsam Fir, which has likely regenerated naturally over the years. Patch cutting is a method used to allow sunlight into dense forest, while breaking up some of the monoculture and creating space for new trees. This will help to increase the diversity of the forest. Increasing diversity supports other species, such as birds and mammals, by creating different niches, habitats, and food sources. It also creates greater forest stability in the event of an insect or disease outbreak.

This year, the forest along the Winter River trail was assessed, and areas that had large amounts of standing dead trees were marked using a GPS. In these areas, 25 m^2 (5 m by 5 m) patch cuts were created using flagging tape, and later cut using a chainsaw. The woody debris was piled along the outside of the patch to create wildlife habitat. Inside each of the patches, 2 White Pines, 1 Yellow Birch, 1 Cedar, 1 White Spruce, and 1 Hemlock were planted. Plastic tree guards were added to only the young deciduous trees, to protect them from potential damage. In 2018, 7 new patch cuts and 9 brush piles were created along the Winter River trail.

Figure 22: A finished patch cut with a brush pile in the background, ready to be planted.

Figure 23. 2018 patch cut and brush pile locations near Winter River Trail.

3.3 Stream Clearing

During the 2018 work year, a total of 4.5 km of stream was cleared. The areas needing stream clearing were the Winter River main branch, Cudmore, Friston South, and MacAulay's Creek. Stream clearing allows fish to move through the stream freely, which is especially important for species migrating to spawning grounds. If a tree falls over across the stream, the crew typically limbs the branches to prevent stream flow blockages, while leaving the tree as a crossing log for wildlife.

Figure 24. Locations where blockages were removed in the 2018 field season.


Figure 25. Before (left) and after (right) image of Matt Barr, chainsaw operator, removing a blockage by the Apple Orchard on the main Winter River branch.


Figure 26. Large blockage before (left) and after removal (right) at the main branch of Winter River off Suffolk Road.

3.4 Brush Mats

In summer 2018, 2 brush mats were updated, and 13 new mats were created. These mats were in Beaton's Creek, Friston South, Friston North, Van Westerneng Branch, and Cudmore Branch. Brush mats improve our streams by trapping sediment and building up the stream bank. There was a beaver dam in a section of stream where brush mats had previously been installed. Once the dam was removed, staff had to dig some sediment out of the stream, so it could flow, and install a brush mat to help catch excess sediment.

Figure 27. Before (left) and after (right) Van Westerneng Branch brush mat installation, summer 2018.

3.5 Shoreline and Roadside Cleanup

Over the summer, the crew and volunteers collected 1030 kg of garbage from 20 km of shoreline. Most of the waste was Styrofoam buoys, ropes, bait bags/mussel socks, and beverage cans. The crew also found dumping sites in fields, with things such as old backpacks, and old closet doors by the stream at Tim's Creek.

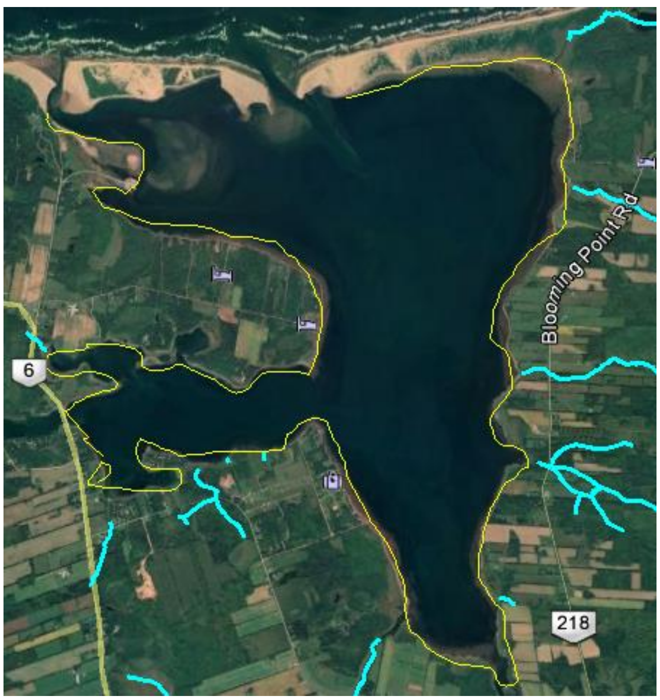


Figure 28. The yellow line shows the areas around Tracadie Bay where beach cleanups were completed.

3.6 Culvert Removal

The 2018 summer crew removed a culvert along the Vanco branch, just off the Union Road. This culvert was hanging and in bad shape, causing issues for fish passage. Since it was on an abandoned farm road, we decided it was best to remove it. Most of the culvert removal process was done by hand. The crew used a chainsaw to cut all trees and shrubs on the road, then proceeded to dig it out with shovels and other hand tools. Once the crew dug out all around the culvert, a bobcat hauled it out of the stream. Jute fabric was staked into the ground on both sides of the stream, and grass seed planted, to reduce the amount of sediment ending up in the stream.

Figure 29. The location of where the culvert was removed and a before photo of the culvert.

Figure 30. During culvert removal - pictured are Trent MacSwain, Sam MacSwain, Emma Spence, Carley Ross, Sarah McBride, and Matt Barr all digging out the culvert.

Figure 31. Left: Immediately after culvert removal, with erosion control fabric in place. Right: After grass was established at the culvert removal location.

3.7 Straw Bale Project

By a section of stream accessed from Hardy Mill Road, there were potatoes planted for the 2018 growing season. This area has had erosion problems before and had a silt fence installed within the buffer zone of the field. This year WRTBWA decided to install straw bales as a natural alternative to hold the silt back and prevent it from entering the stream. The crew staked in over 400 straw bales in the buffer zone (between the field and the stream), to act as a natural silt fence. After the first heavy rainstorm, the silt ran down the field and was collected by the bales. In 2 parts of the fence, the flowing water moved the bales, so staff had to add more bales to repair this section. The silt fence covered an 87 m section of the buffer zone.

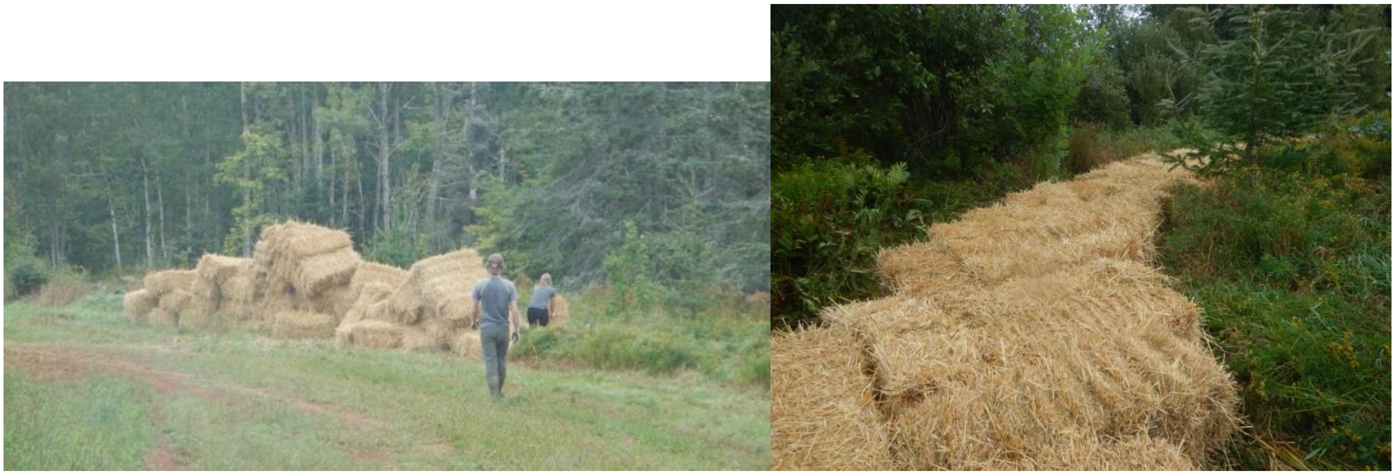


Figure 32. Left: Straw bales in a pile before they were put into place. Right: Straw bales staked into the ground in herringbone pattern to act as a natural silt fence.

Figure 33. Left: Straw bales after heavy rain where runoff broke through the bales. Right: Additional straw bales that were staked down afterwards, to hold silt back from the stream.

3.8 Insect Hotels

Other than the typical honeybee and bumblebee species, which live in colonies, there are many solitary bee species that live alone. These bees greatly benefit their community by acting as pollinators for plants while they collect nectar and pollen from flowers. They typically nest in holes in the ground, piles of sand, hollow plant stems, or tunnels previously created in wood. It is possible to recreate their nesting sites by drilling tunnels into logs or blocks of wood and positioning them appropriately (Carlton, 2017). These are referred to as insect hotels.

While performing forest enhancement activities, such as patch cutting or removal of standing deadwood, some trees were cut into small logs. These were collected and brought back to the office, where tunnels of various sizes were drilled into one side using an electric drill. Care was taken to not drill all the way through the log, as the bees prefer a closed end tunnel (Carlton, 2017). The logs were then stacked into bundles and taken to various locations across the Watershed. The bundles were placed at least 1 m off the ground and facing sunlight. Some bundles were supplemented with a much wider log sawed in half placed on top, extending over the entrance of the tunnels to provide some shelter from rain.

WRTBWA created 4 insect hotels, located at Glenaladale, Union Pumping Station, and 2 along the Winter River trail. This was our first attempt at creating insect hotels, later inspection will be required to determine if they were successful. The biggest challenge was finding an appropriate way to position the bundles in the sun and above the ground. If this project is undertaken again, it is recommended to build a stand of some sort, so the bundles remain securely in place.

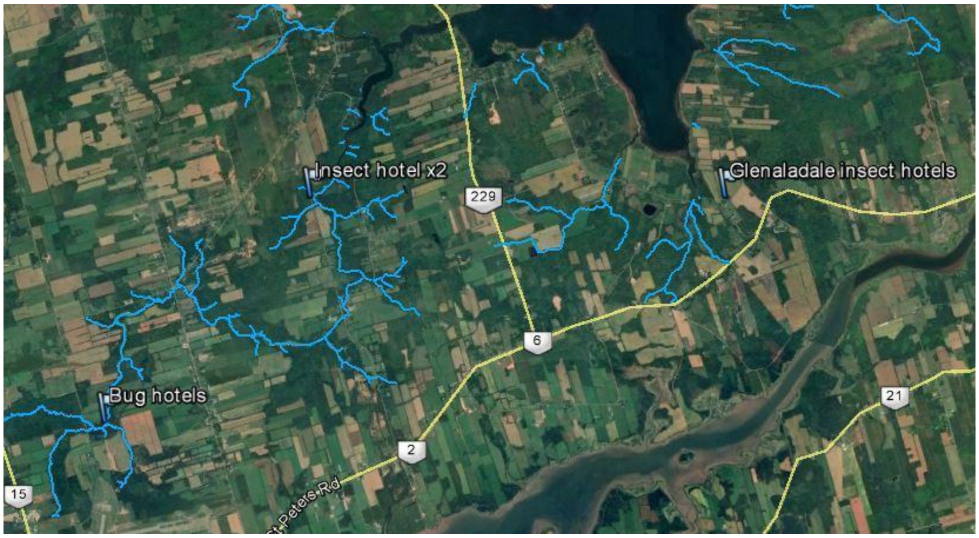


Figure 34. Insect hotel locations.

Figure 35. Left: Bundle of insect hotel logs at Winter River trail. Right: Bundle of insect hotel logs near Union Pumping Station.

3.9 Watershed Property

A parcel of property located on Suffolk Road was donated to WRTBWA. Vanessa and Carley completed transect line surveys to record which plant and tree species were growing in the area. We explored the property and discovered an old playhouse with lots of garbage. We tore down and disposed of 820 kg of waste material. Staff removed any potentially dangerous trees in the area for safety. In the future we plan to have trails and a garden here and perhaps use the property as a tree storage area for summer rather than storing them at Sarah’s house.

Table 19. Land Suffolk Road, Property Assessment Summary 2018-15-14.

Assessment	Findings
Invasive species	Nightshade, Dwarf Mistletoe
Trees	Spruce, Aspen, Red Maple, Balsam Fir, Birch, Beech, snags
Understory	Various shrubs
Mammals	Chipmunk, squirrel
Birds	Redwing black bird

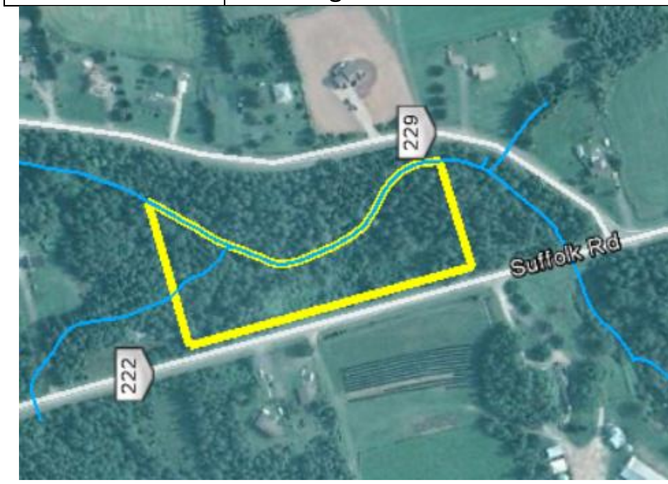


Figure 36: Map of property owned by WRTBWA.


Figure 37: Playhouse on WRTBWA property (left). Playhouse materials after demolition (right).

4 Assessments and Surveys

4.1 Beaver Assessments

In the middle of July there was a large beaver dam located before a footbridge at Spike's Paintball, which was reported to us by a concerned neighbor. WRTBWA was able to obtain a permit to trap the beavers since the beavers had settled in an area of the Watershed that is designated as a beaver-free zone in our Beaver Management Plan. Normally the beavers would have been trapped in the winter during the trapping season, however, the trapper that was hired last winter was unable to catch the beavers, so we had to get a nuisance permit.

A local trapper was hired to trap and remove the beavers this season. On 2018-07-17, the trapper arrived at our access point from the York Road. The previous day, staff had notched the dam to drop the water level to improve safety for the trapper. The trapper set up both conibear and foothold traps to remove the beavers. From the period of 2018-07-17 to 2018-07-24 a total of 8 beavers were trapped.

It is important to monitor for beaver activity in the Watershed, as they can cause a lot of problems in a short time. The biggest problem they cause is the construction of dams, which impede fish passage. They also cause flooding and fell a lot of trees that we plant on the stream banks. We monitor beavers by walking the beaver-free zone regularly to check for any signs or activity. If there are any active beavers in our beaver-free zone, we hire a trapper to come out during trapping season. However, we cannot always trap them if we do not get permission from the landowner.

WRTBWA has hired another trapper for this fall, for the area between Hardy Mill Pond and the Union Pumping Station.

Figure 38. Location of beaver dam removed in 2018.

Figure 39. Large beaver dam at bridge by Spike's Paintball. Carl Balsar, trapper, setting foot-hold trap by the beaver dam.

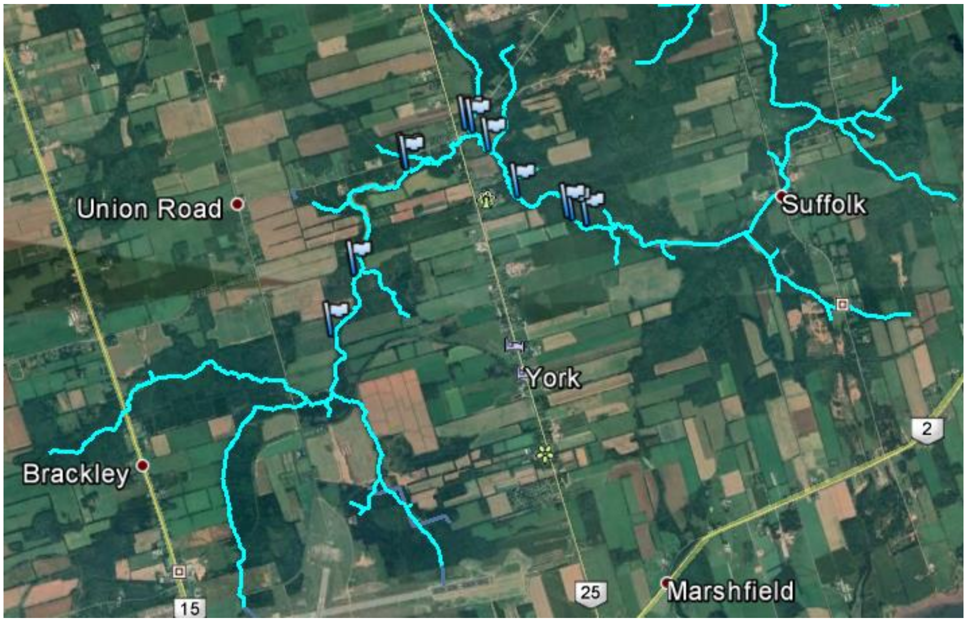
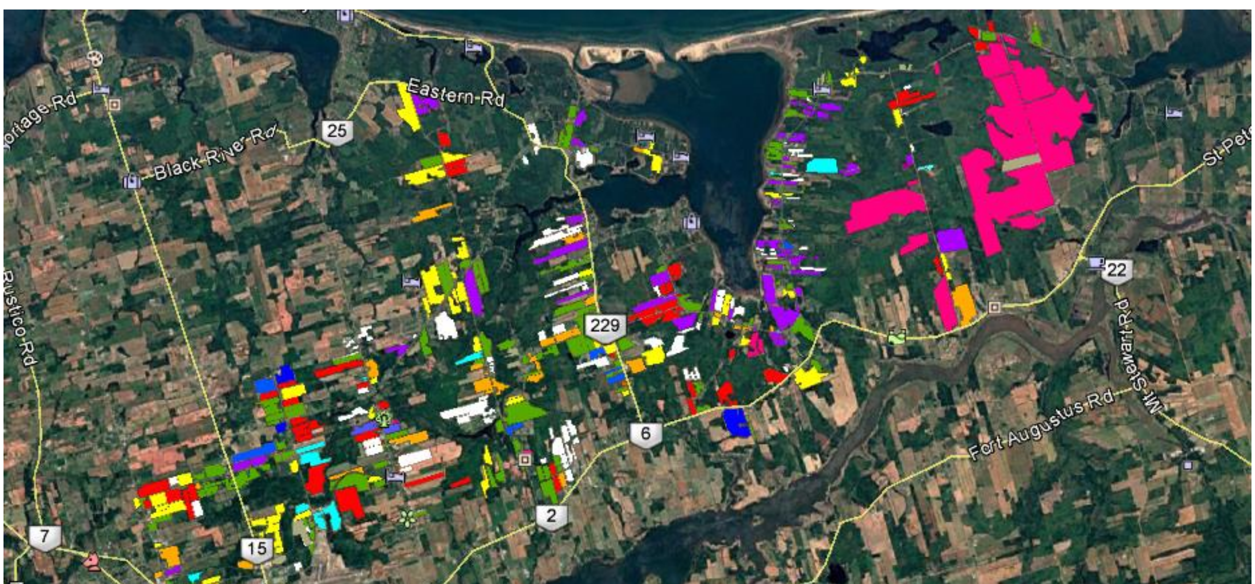


Figure 40. All waypoints are indicating where beaver activity was found in the beaver free zone in 2018.

4.2 Crop Mapping

Every year, WRTBWA documents the type of crops growing in the fields within the Watershed that are visible from a public road, trail, woodlot, or stream. After identifying what is growing in each field, the information is mapped using Google Earth. Every crop type is assigned a color, and fields are mapped as such. By identifying which crops are growing in the fields year after year, it helps us see the farmer's crop rotation. This information can help us prepare for erosion issues close to the streams. It is also important to know what is growing in case we have any concerns after receiving water or soil sample results.



Crop	Hay	Grain	Potato	Corn	Soy	Pasture	Perennial	Other
Color	Green	Yellow	Red	Blue	Purple	Orange	Pink	Aqua

Figure 41. Color-coded map that identifies what crop is growing in every field in the watershed for 2018.

4.3 Soil Sampling

4.3.1 *Introduction*

Soil sampling is a practice that is beneficial to both farmers and the environment. Fertilizers are a major cost when producing crops and can cause environmental damage. Knowing the soil's nutrient and mineral content prior to fertilizer application helps avoid over-fertilizing. By testing soil in a field prior to the planting season, the nutrient and limestone requirements can be determined to maximize crop yields, save money, and reduce environmental harm.

4.3.2 *Methods*

Soil sampling was performed in late fall to predict the field's requirements for the upcoming growing season. Tools used for soil sampling included: a shovel, bucket, soil compaction meter (borrowed from the provincial government), and notebook. At each field to be sampled, 4-6 sampling points were chosen in a zigzag formation, based on the size and shape of the field. Areas to be avoided for sampling points included tire tracks and areas of low elevation with respect to the rest of the field, as these would not represent the field as a whole.

At each sampling point, a square hole about the width of the shovel was dug. The size of the sample was the width of the shovel, by about 1 inch thick, by 6 inches deep. This was taken from the side of the hole and mixed into a bucket. Vegetation from the soil surface was kicked out of the way before taking the sample. Somewhere within 1 m of the soil sample point, a compaction reading was taken. To accomplish this, vegetation was kicked out of the way until the soil was visible. The compaction meter was held with the tip just barely touching the exposed soil, and slowly pushed straight down into the soil at a steady pace until it could not go any further. Compaction readings in PSI were recorded at every inch of depth.

Once soil was taken from each sampling point, it was mixed around in the bucket. A large Ziploc bag was filled with the mixed soil and brought back to the office. The soil was spread out on a pan and left to dry for a few days. After drying, large pieces of organic matter were picked out, and the soil was put in a large bag to be tested for soil health. A smaller bag provided by the Prince Edward Island (PEI) Analytical Lab was also filled to be tested for soil chemistry.

4.3.3 *Results*

Table 20. 2018 soil-sampling results, received from PEI Analytical Lab.

Field #	Org (%)	pH	P_2O_5 (ppm)	Potash (ppm)	Ca (ppm)	Mg (ppm)	B (ppm)	Cu (ppm)	Zn (ppm)	S (ppm)	Mn (ppm)	Fe (ppm)	Na (ppm)	Al (ppm)	Lime Index
ROW-001	2.3	5.6	400	167	561	26	0.2	1.0	1.2	41	33	172	27	1447	6.8
GLN-003	2.3	5.1	436	128	277	19	0.2	0.7	1.3	42	24	202	25	1457	6.7
GLN-004	2.1	5.6	492	112	510	49	0.2	1.1	1.1	19	43	215	34	1300	6.9
GLN-002	2.2	5.3	491	132	472	27	0.2	0.9	1.2	24	22	311	32	1335	6.7
GLN-001	2.5	5.2	426	109	294	21	0.2	0.6	1.0	30	20	205	28	1549	6.6
Pat Upper	2.9	5.7	167	95	638	76	0.4	0.9	2.0	21	38	311	24	1230	6.7
Pat Lower	1.6	5.7	176	80	414	52	0.3	0.6	1.2	19	20	346	21	1044	6.8
Hug	3.7	6.1	238	46	825	77	0.2	1.6	1.3	16	31	202	25	1356	6.8
Mac	2.9	6.5	227	90	946	49	0.3	3.6	1.3	16	25	149	20	1432	7.0

Table 21. 2018 soil sampling base saturation results, received from PEI Analytical Lab.

Field #	P/Al (%)	Ratio Ca/Mg	MAN	SOD	CEC (Meq/ 100g)	K (%)	Mg (%)	Ca (%)	H (%)	Na (%)	Total Base Saturation (%)
ROW-001	12.07	22	0	0	6	6.1	3.7	47.6	40.7	2.0	57.4
GLN-003	13.07	15	0	0	6	4.9	2.9	25.1	65.2	2.0	32.9
GLN-004	16.53	10	0	0	5	5.3	9.0	56.1	26.4	3.3	70.4
GLN-002	16.06	17	0	0	7	4.3	3.4	35.7	54.5	2.1	43.4
GLN-001	12.01	14	0	0	7	3.4	2.6	21.6	70.6	1.8	27.6
Pat Upper	5.93	8	0	0	8	2.6	8.2	41.3	46.6	1.3	52.1
Pat Lower	7.36	8	0	0	5	3.3	8.4	40.1	46.5	1.8	51.8
Hug	7.66	11	0	0	7	1.3	8.7	55.9	32.5	1.5	65.9
Mac	6.92	19	0	0	7	2.8	5.9	68.2	21.8	1.3	76.9

4.3.4 *Discussion*

Appropriate nutrient and pH requirements vary for each crop to be grown. For example, potatoes do well in soil with a pH of 5.5-6.0, whereas other crops would typically do better with a higher soil pH. The availability of most other nutrients increases when pH is higher (Government of Prince Edward Island, 2014).

It is recommended to complete soil sampling early in the summer of 2019, before the weather turns. This will give the crew an adequate amount of time to collect soil and allow samples to dry to be sent to the PEI Analytical Lab for proper testing and more accurate results. It is also recommended to continue soil sampling over the years so that WRTBWA can analyze the data, create graphs to show trends, and identify areas that need to be improved to meet regulations. This is important data to collect to establish areas of concern and take action to protect the future health of the Watershed.

4.4 Bathymetry of Officer's Pond

4.4.1 *Introduction*

Officer's Pond was surveyed in 1994 as part of a master's thesis project to determine the depth of the water and area of the main flow channel (see Appendix in section 8.1). The purpose of resurveying this pond in 2018 was to determine how siltation and erosion have affected the pond's depth and channel structure since the last study. This was achieved by taking various depth measurements throughout the pond.

4.4.2 *Methods*

Officer's Pond was divided into 27 transects, with a North and South (or in few cases, East and West) endpoint of each segment positioned on Google Earth and loaded onto a portable GPS device. Crew members were sent out on the pond by canoe with GPS devices, waterproof notebooks, and 2 depth-measuring tools. A tool used was a 2-by-4 wood board with a measuring tape affixed to it, which would rest on the top of the silt to determine the depth of the water. The other tool was a long piece of rebar with a measuring tape affixed to it, which could be pushed through the silt.

The crew always began at the North (or in few cases, East) endpoint of each transect. Measurements were taken with both tools to determine the depth of water and the depth of water-plus-silt at each location, then recorded in the waterproof notebook. By taking the difference of these 2 measurements, the total amount of silt at each location was calculated. At each measurement location, a new waypoint was created using the GPS and labeled according to the section it was a part of. The first measurement was taken as close to the marked endpoint as possible, and each subsequent measurement was taken approximately 20-30 meters apart along the transect line until the other endpoint was reached. Care was taken to keep the measurement points in as straight of a line as possible between transect endpoints.

Crew Members also used the GPS to mark the perimeter of the areas of aquatic vegetation, by creating a waypoint every few meters along the edge of the vegetation from the canoe. The perimeter of the pond's edge was also marked using the GPS by walking around the pond and taking a waypoint every few meters. All this data was imported into Google Earth and Microsoft Excel, and then was used to create a bathymetric map of Officer's Pond in QGIS similar to the map from the 1994 study (see Appendix, section 8.2).

Figure 42. Summer students Sarah and Carley taking depth measurements from the canoe using both tools. A view from the canoe of Officer's Pond, and the instrument used to measure silt depth. Algae helped keep the canoe steady while taking measurements.

4.4.3 *Results*

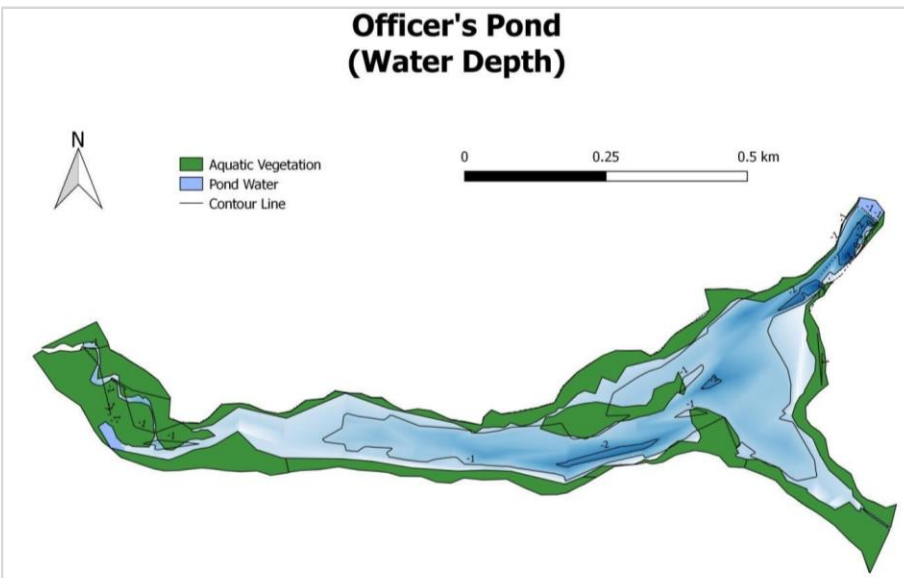


Figure 43. Bathymetric map of Officer's Pond, demonstrating the depth of water with contours lines at 1 m intervals.

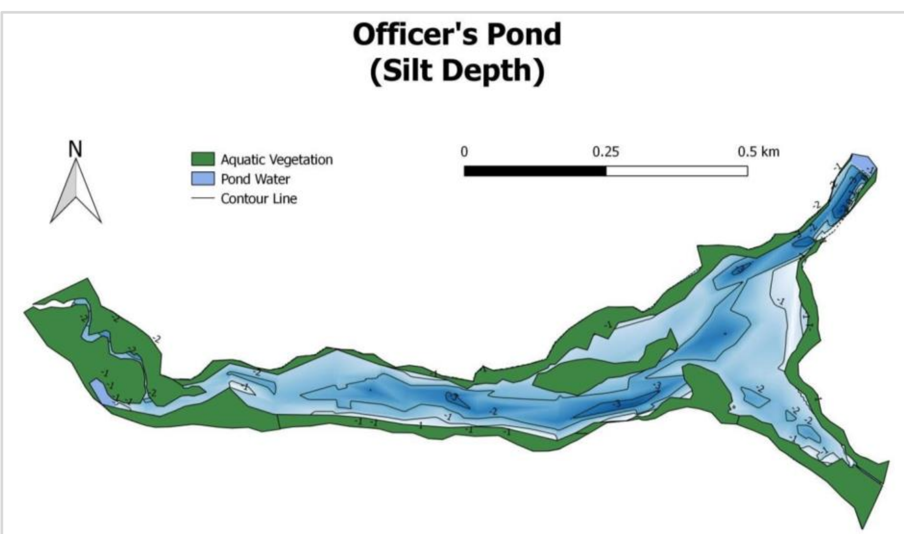


Figure 44. Bathymetric map of Officer's Pond, demonstrating the depth of water and silt combined with contour lines at 1 m intervals.

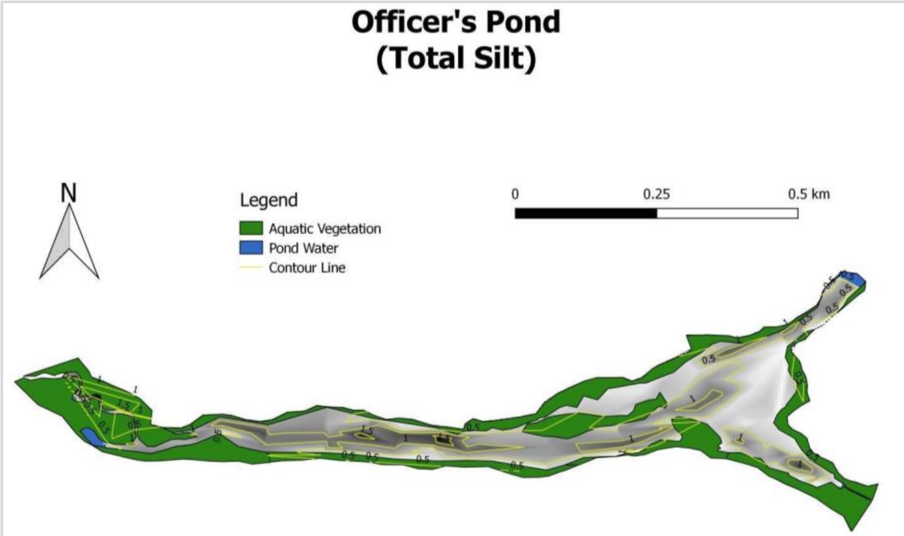


Figure 45. Map of Officer's Pond, Winter River demonstrating the amount of silt present with contours at 0.5 m.

4.4.4 *Discussion*

The main flow channel of the pond appears to have kept its overall shape, which can be seen by visually comparing the new bathymetric maps (Figures 43 to 45) to the map created in the 1994 study (See Appendix section 8.1). The deepest area is still the Northeastern section, and the pond is still quite shallow on the Western side. It should be noted that the depth values of the 1994 study's bathymetric map are most comparable to those of the "Water Depth" version of the new bathymetric map, as that study did not include silt measurements. It can be seen on the "Total Silt" map that there is more loose silt present on the upstream (West) side of the pond than downstream (East). This is likely due to the large proportion of agricultural land use in the upstream drainage area of the pond. Runoff from agricultural land is carried downstream and gets deposited as the water slows down when entering the pond.

4.5 Culvert Surveys

4.5.1 *Introduction*

Surveys are performed to assess areas for culvert removal, replacement, or modifications to allow for better water flow and fish passage. Deteriorating, poorly positioned, or improperly sized culverts pose issues during high flow events and create difficult conditions for fish to navigate.

Various culverts were assessed throughout the Winter River – Tracadie Bay Watershed, beginning in August and continuing into the fall. Some assessments were performed using the same method as in previous years (*Part 1*); however, this year *Part 2* of culvert assessments was introduced to determine slope. The slope of a culvert influences the depth of water throughout, and how easily fish can enter and exit the culvert.

4.5.2 *Methods*

For *Part 1* of a culvert assessment, each culvert was assigned a unique ID, and the stream name, road name, and GPS coordinates were recorded. The culvert was then checked for the following: culvert type, baffles, armor, bottom material, fill line, rust line, diameter, obstructions, undercutting, overtopped, hanging, and crushed percentage. Road information was also noted, along with bridge information if applicable. Various stream measurements were then taken upstream, downstream, and at the culvert itself, and photos were taken in each of these areas.

Part 2 of culvert assessments was completed using survey equipment, including a telescopic level, extendable survey rod, and tape measure. There were 3 different methods used, depending on the elevation and size of the culvert. The first method was to set up the level on the road and measure the elevation from the bottom of the culvert at each end using the survey rod. The second method was performed when the extendable survey rod was too short to be seen from the road. This method involved setting up the level downstream from the culvert outlet, in order to see through the culvert.

An elevation reading was then taken from the bottom of the culvert at each end. The final method was performed when a clear line of sight could not be obtained through the culvert. This method involved using turning points to obtain elevation values from the bottom of each end of the culvert. The final method was taught by Chayla, an environmental engineering graduate who had been trained in surveying and was hired during the fall. For this method, the difference in elevation was calculated and divided by the measured length of the culvert to obtain the slope.

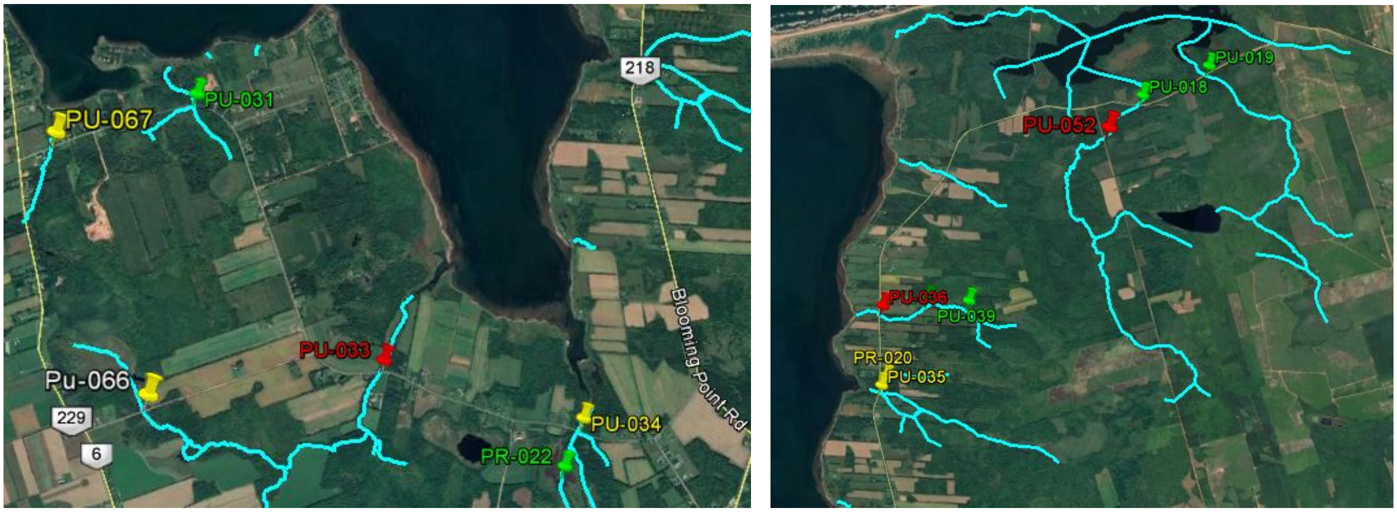


Figure 46. Left: Locations of culverts assessed in 2018 south of Tracadie Bay. Right: Locations of culverts assessed in 2018 east of Tracadie Bay.

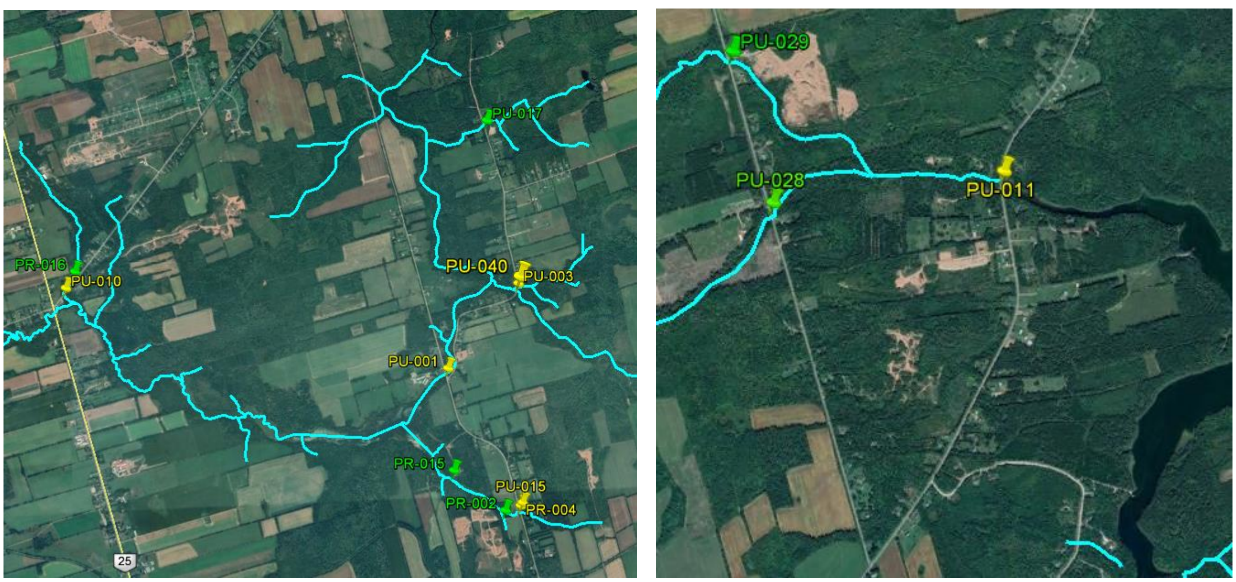


Figure 47. Left: Locations of culverts assessed in 2018 between York and Suffolk. Right: Locations of culverts assessed in 2018 near Friston.

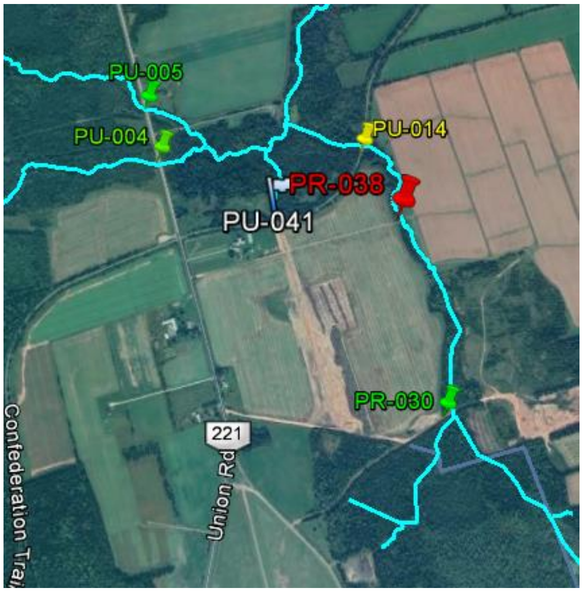


Figure 48. Locations of culverts assessed in 2018 near Union Road.

4.5.3 *Results*

Table 22. Culverts assessed in 2018 using "Part 1" survey methods.

Culvert ID	Stream reach above (km)	Stream Name	Road Name	Culvert type	Obstructions	Undercut	Crushed	Over topped	Hanging Distance (cm)	Rust Line (%)
PU-003	1.50	Mazer South	East Suffolk	CMP	no	yes	no	no	16	40
PU-033	5.72	Black River	Donaldston	CMP	no	no	no	no	24	N/A
PU-035	4.88	Piper's Branch	Blooming Point	CMP	no	no	no	no	11	0
PU-040	1.50	Mazer North	East Suffolk	CMP	no	no	10	no	45	35
PU-067	0.62	Peter's Creek	Donaldston	CMP	no	no	no	no	24	20
Legend: CMP = corrugated metal pipe, CPP = corrugated plastic pipe										

Table 23. Culverts assessed in 2018 using "Part 2 - slope" survey methods.

Culvert ID	**Stream Reach Above (km)**	**Stream Name**	**Road Name**	**Culvert Type**	**Slope (%)**
PU-039	0.66	Beaton's	Old Bedford Road	CMP	4.65
PR-015	1.52	Wheatley Branch	Suffolk Pumping Station	CPP	4.51
PU-036	2.27	Beaton's	Blooming Point Road	CMP	4.00
PR-002	0.10	Wheatley Branch	Wheatley Pit Road	CMP	3.50
PU-010	1.55	MacLauchlan	Pleasant Grove Road	CMP	3.47
PU-003	1.50	Mazer South	East Suffolk Road	CMP	3.00
PU-015	0.40	Wheatley	Suffolk Road	CMP	3.00
PU-014	1.60	Vanco	Confederation Trail	CMP	2.53
PU-040	1.50	Mazer North	East Suffolk Road	CMP	2.52
PR-004	0.40	Wheatley Branch	Enman Pit Lane	CMP	2.44

Culvert ID	Stream Reach Above (km)	Stream Name	Road Name	Culvert Type	Slope (%)
PR-016	1.36	MacLauchlan Branch	Pleasant Grove road	CMP	2.15
PU-028	2.00	Friston South	Friston Road	CMP	2.11
PU-033	5.72	Black River	Donaldston Road	CMP	1.84
PU-017	1.82	Van Westerneng	East Suffolk Road	CMP	1.78
PU-066A	0.82	Black River	Dougan	CMP	1.75
PR-038	2.00	Vanco Branch	Private farm road	CMP	1.58
PR-020	1.55	Piper's Creek	Private dirt road	CMP	1.46
PU-052A	6.62	Afton (14)	Afton Road	CMP	1.22
PU-034	5.25	MacAulay's Branch	Donaldston Road	CMP	1.15
PU-041	0.60	Vanco ditch	Confederation Trail	CPP	0.97
PU-029	1.34	Friston North	Friston Road	Box	0.94
PU-019	7.11	Afton Branch	Point Deroche Road	Box	0.87
PU-031A	1.03	Courts Island Stream	Donaldston Road	CPP	0.74
PU-001	23.65	Winter River	Suffolk Road	CMP – Arch	0.70
PU-031B	1.03	Courts Island Stream	Donaldston Road	CPP	0.66
PR-022	3.40	MacAulay's Creek	Road between blueberry fields	CMP	0.54
PU-035	4.88	Piper's Branch	Blooming Point Road	CMP	0.48
PU-011	5.26	Friston Main	Pleasant Grove Road	CMP	0.47
PU-005	3.48	Brackley branch	Union Road	Box	0.33
PR-030	0.50	Vanco Branch	Pit Road	CMP	0.19
PU-018	8.03	Trout Branch	Point Deroche Road	Box	0.13
PU-038	1.67	Beaton's	Old Bedford Road	CPP	0.12
PU-004	2.43	Cudmore Branch	Union Road	CPP	0.05
Legend: CMP = corrugated metal pipe, CPP = corrugated plastic pipe					

4.5.4 *Discussion*

In 2018, 5 culverts were assessed for *Part 1* and 32 were assessed for *Part 2 (slope)*. Of the 5 culverts for *Part 1*, 4 were reassessments of culverts that were checked in previous years, and 1 (PU-067) was a new assessment. Reassessments focused on examining the hanging distance of the culverts, potentially for future installation of portable steel fishway add-ons.

Culvert PU-003 on East Suffolk Road was found to have the same hanging distance as when previously assessed. It was previously determined by Shelley Cole-Arbing and Paul Strain on 2016-08-02 and found to have good flow, good substrate, and would be well suited for a check dam project. Culvert PU-033 was found to have an increased hanging distance, from 0.12 m to 0.24 m, since the last assessment. This, along with the large stream reach above the culvert, makes it an excellent candidate for a fishway add-on. Culvert PU-035 on Blooming Point Road was found to have a similar hanging distance to when it was previously assessed. Culvert PU-040 on East Suffolk Road was previously assessed by Shelley Cole-Arbing and Paul Strain, however no hanging distance was recorded. They had recommended excavating to create a pool below the culvert before installing check dams. This year's assessment has determined that it is hung quite badly and supports the recommendation for check dam installation. Culvert PU-067 had very little water flowing through, along with some of the bottom boards beginning to rot. It was also hung 0.24 m, which may impede fish passage.

Slope was added as a second part of culvert assessments in 2018 in order to determine potential obstacles for fish passage that were previously missed. The success rate of fish passing through a culvert is inversely proportional to the culvert's slope and flow rate, and it is recommended that culverts with a slope greater than 1% should have baffles (Khodier and Tullis, 2016). In total, 19 of the 32 culverts assessed for slope were found to have a slope greater than 1%, and all of these were corrugated pipes with unnatural bottoms, meaning they could cause issues for fish travelling through them.

4.6 Pond Outflow Surveys

4.6.1 *Introduction*

Several ponds were made in the Winter River – Tracadie Bay Watershed around the 1970's, before fish passage was of much concern, by damming water with clay berms. This has created an obstacle for fish, as the outlet of these ponds tend to have a steep incline. The outflows of these ponds were surveyed to determine the slope, and if it was an appropriate location for the installation of check dams to improve fish passage.

4.6.2 *Methods*

Wheatley, Mazer, and Van Westerneng ponds were each surveyed in the fall of 2018. For Wheatley and Van Westerneng ponds the survey began in the pond, just before the dam, and continued down the outflow until the stream became relatively flat. Mazer's pond survey began from the culvert outflows at East Suffolk Road, continued through the pond, and finished where it connects to the Winter River.

The survey was performed by first reading the elevation values off an extendable survey rod through a telescopic level at various points in the pond outflow, then measuring the distance between each of these points. Points were chosen to be at the beginning and end of any significant looking drop in the water, in order to more accurately depict hurdles for fish. Points were also chosen to be at corners where the flow changed direction in order to keep a straight line over the water while measuring distance between points. At each point to be measured, a stake was hammered in and a GPS waypoint was created.

The entire area to be surveyed at each pond could not be seen from a single place, so multiple stations for the level needed to be chosen. The first reading at the second station needed to be at the last point of the first station, in order to calculate the difference in elevation between stations and have comparable data throughout the entire survey area.

Once all the elevation readings were taken, and distance between each point was recorded, the data was entered into a Microsoft Excel spreadsheet. Elevation values were adjusted to look as if they were all taken from the first (highest) station, by adding the calculated difference in elevation between stations. An elevation value of 100 m was assigned to the final point for visual purposes, and the adjusted elevation was added to this value for all other points. The slope for each pond was then plotted.

4.6.3 *Results*

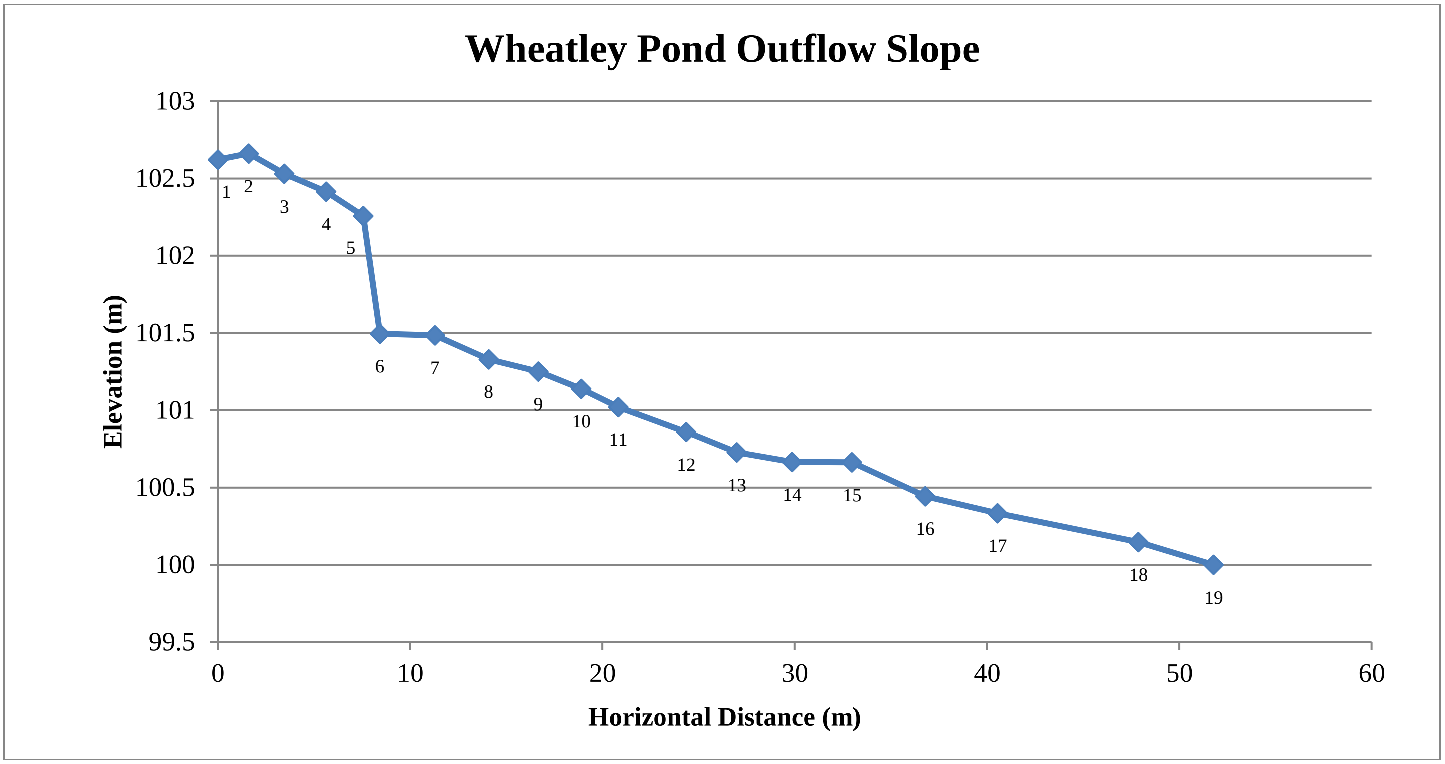


Figure 49. Slope of Wheatley Pond outflow, beginning in the pond just before the dam.

Table 24. Slope between each measurement point of the Wheatley Pond outflow.

Point	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
Slope (%)	-2.5	7.1	5.3	8.1	89.6	0.4	5.6	3.1	4.9	6.2	4.6	5.0	2.2	0.1	5.7	2.9	2.6	3.8

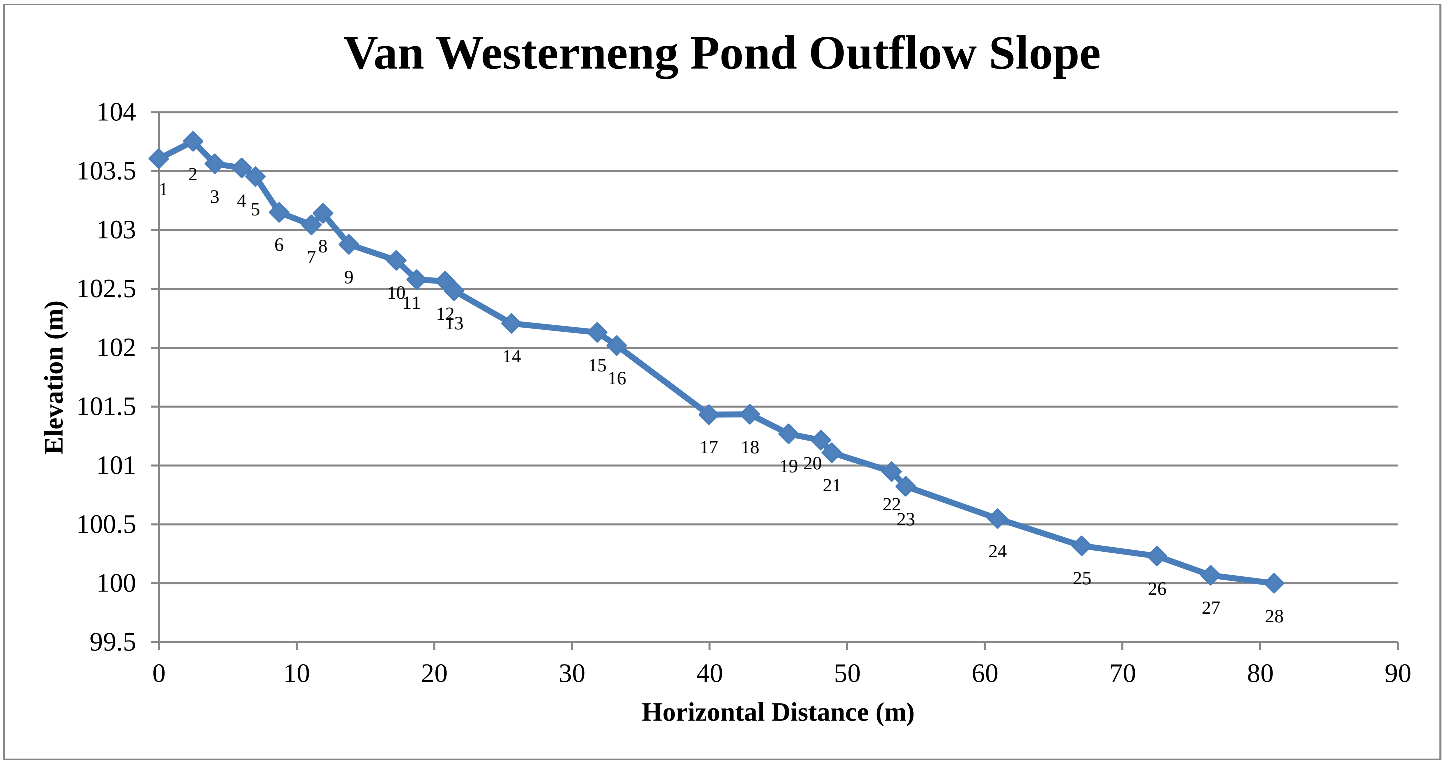


Figure 50. Slope of Van Westerneng Pond outflow, beginning in the pond just before the dam.

Table 25. Slope between each measurement point of the Van Westerneng Pond outflow.

Points	Slope	Points	Slope	Points	Slope
1-2	-6.0%	10-11	10.9%	19-20	2.4%
2-3	12.0%	11-12	0.7%	20-21	13.1%
3-4	1.8%	12-13	12.5%	21-22	3.7%
4-5	7.2%	13-14	6.7%	22-23	12.5%
5-6	17.7%	14-15	1.2%	23-24	4.1%
6-7	4.5%	15-16	7.7%	24-25	3.8%
7-8	-11.4%	16-17	8.8%	25-26	1.6%
8-9	13.9%	17-18	-0.1%	26-27	4.1%
9-10	3.9%	18-19	5.9%	27-28	1.5%

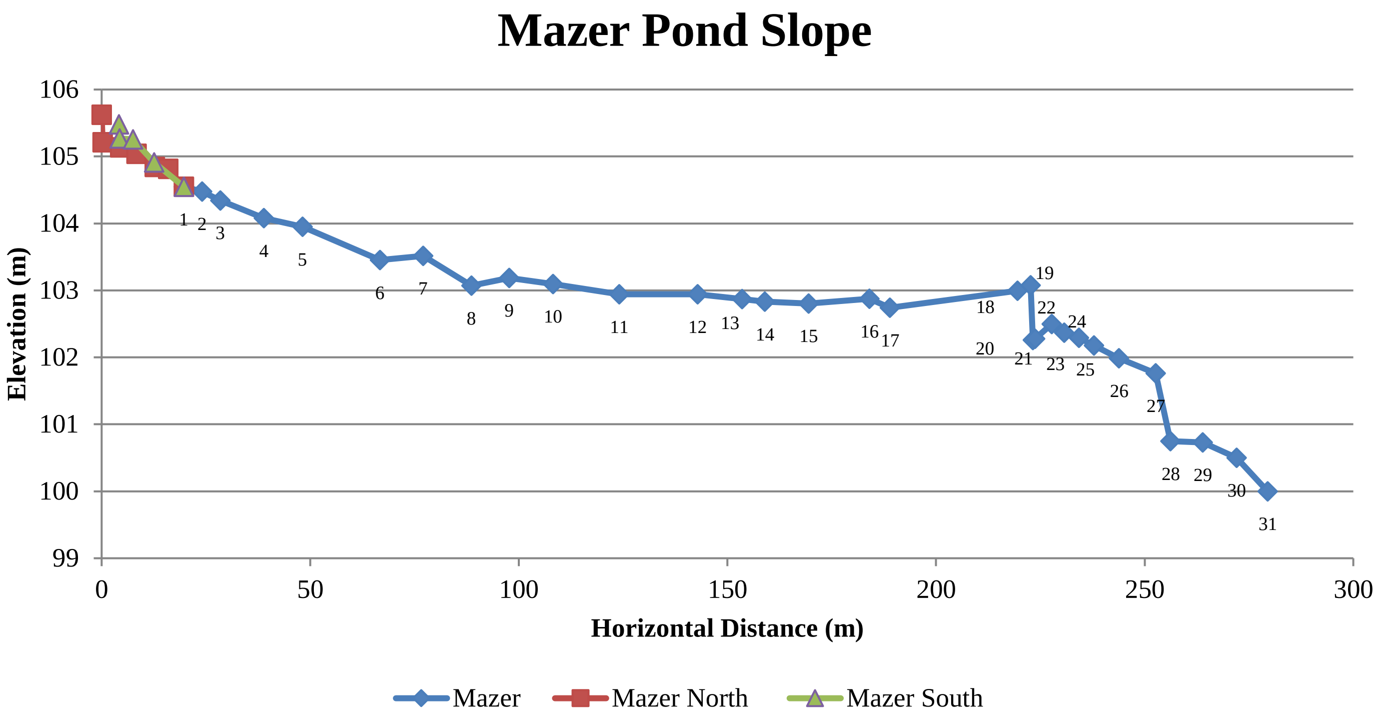


Figure 51. Slope of Mazer Pond, beginning with both culvert outlets at East Suffolk Road and ending at Winter River (main).

Table 26. Slope between each measurement point of Mazer Pond, beginning where Mazer North and Mazer South meet.

Points	Slope	Points	Slope	Points	Slope
1-2	1.6%	11-12	0.0%	21-22	-5.6%
2-3	3.1%	12-13	0.7%	22-23	4.4%
3-4	2.5%	13-14	0.7%	23-24	2.2%
4-5	1.4%	14-15	0.2%	24-25	3.2%
5-6	2.7%	15-16	-0.5%	25-26	3.2%
6-7	-0.6%	16-17	2.7%	26-27	2.5%
7-8	3.8%	17-18	-0.8%	27-28	28.3%
8-9	-1.3%	18-19	-2.8%	28-29	0.2%
9-10	0.9%	19-20	149.1%	29-30	2.9%
10-11	1.0%	20-21	-3.6%	30-31	6.7%

4.6.4 *Discussion*

It has been shown that Brook Trout of any size struggle to make it past a jump greater than 43.5 cm in height when coming from a pool with a depth of 10 cm or less (Kondratieff and Myrick, 2006). Most of the outflows that were surveyed in 2018 did not have many pools deeper than 10 cm, and there were jumps greater than 43.5 cm found in Wheatley and Mazer.

The Wheatley Pond had 1 significant jump with a slope of 89.6%, whereas the rest of the outflow did not exceed a slope of 8.1%, shown in Table 24. Van Westerneng did not have any jumps with a slope greater than 17.7%, presented in Table 25, and it appeared to have rocks positioned to create deeper pools just after the pond outlet. The Mazer Pond had 2 significant jumps with slopes of 149.1% and 28.3%, while the rest of the stream did not exceed a slope of 6.7%, displayed in Table 26.

Creating check dams to reduce the height of the jumps and add pools is an option to aid fish passage in these pond outflows. Mazer and Wheatley would both be suitable for this option, as there only appears to be an issue at specific jumps below where the dam was created. Van Westerneng appears to be in relatively good condition compared to the other 2 outflows. However, given the available habitat upstream, it is a relatively high priority location, where a small improvement could result in great increases in fish habitat connectivity.

4.7 Headwater Surveys

4.7.1 *Introduction*

The purpose of headwater surveys is to measure how much the streams dry up over the summer. This determines if the stream is stable by displaying the seasonal variability in stream flow and allows for the correlation of low flows with extraction well locations. It is important to collect this data to raise public awareness about the importance of water conservation and the effect extraction has on headwater streams and ground water recharge. The Province encourages and facilitates Island Watersheds to undertake headwater stream surveys and has developed a protocol for us to follow when doing so.

4.7.2 *Methods*

Headwater surveys must be conducted between May 1st and 15th and September 1st and 15th, without any significant rainfall or snowmelt events occurring in the previous 3 days. The headwater streams are assessed visually to document changes in surface water connectivity and water velocity throughout the length of the stream. Sections of the stream are classified into 1 of 5 categories: 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 is continuous. The collection of this data year after year aids in understanding how water extraction and other natural conditions affect water levels and flow.

4.7.3 *Results*

Figure 52. Affleck headwater survey 2018, 0.45 km of stream became dry.

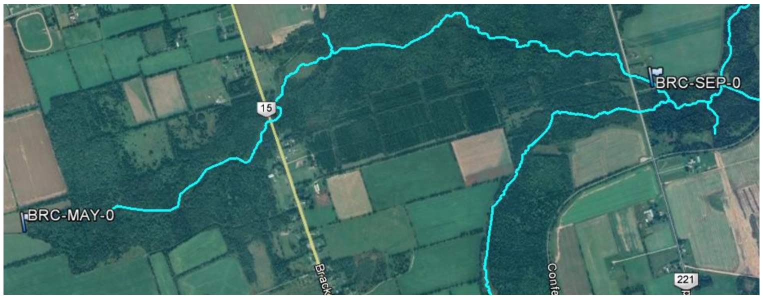


Figure 53. Brackley headwater survey 2018, 3.77 km of stream became dry.

Figure 54. Pater headwater survey 2018, 0.10 km of stream became dry.

Figure 55. Van Westerneng headwater survey 2018, 0 km of stream became dry.

4.7.4 Discussion

Factors that can increase the likelihood of headwater streams to become dry include evapotranspiration and extraction of groundwater by commercial and/or residential wells (Andreozzi, 2018). The summer of 2018 was particularly warm, with record-setting consecutive high temperature days (Cooke, 2018). This would have caused increased amounts of evapotranspiration and drier streams.

Affleck, Brackley, and Pater streams all went dry to some extent in 2018. Pater and Affleck are within less than 4 km of the Union and Brackley pumping stations, where there are 9 high-capacity wells. Brackley, however, is less than 1 km away from all 9 of these wells. For this reason, the Brackley branch had the greatest distance of stream dry up again this year. The spring that feeds the head of the Van Westerneng stream was found to be flowing in May and September. This stream was 2.7 km from the Suffolk Pumping Station.

4.8 Redd Surveys

There were several attempts made to look for redds this fall. Unfortunately, the site where redds are usually found every year had dark, cloudy water every time the crew went out to check for them. There were 2 pools in which the crew spotted larger Brook Trout, but no other signs were observed. Brook Trout is our species of interest, as we no longer have Atlantic Salmon in our Watershed. Monitoring redds in our Watershed every fall is a way we can monitor the Brook Trout population. It is debatable, since the stream bottom was hard to see in some places, whether this means the fish are not spawning or are late spawning. The weather may also play a factor, as we had received a lot of rain, snow, and wind around spawning time.

4.9 Wetland Assessment

In October 2018, Vanessa and Sarah attended a course on Wetland Ecosystem Service Protocol for Atlantic Canada (WESP-AC). The creator of the wetland assessments, Dr. Adamus, held the course. The course was designed to teach us how to conduct a rapid wetland assessment to assess environmental impacts along with the monitoring of restoration projects. It was a 2 day course with both a classroom and field component. These assessments will be useful to collect information and improve areas in a timely manner within the watershed.

5 Water Monitoring

Water monitoring activities are critical so we can maintain and restore water quantity and quality to support fish and wildlife habitats in balance with the economic and social needs of our Island community. We measure water quality by utilizing temperature loggers, dissolved oxygen (DO) loggers, spring water monitoring, and estuary watch surveys. It provides insight into the health and composition of our water bodies over time, to ensure that everyone in the watershed—whether human, animal, or plant—has good quality water. We measure water quantity with water-level loggers and v-notch weirs. This allows us to keep track of water extraction by the City of Charlottetown, which may impact the ecosystem. Monitoring water also helps to determine whether we are making progress in cleaning up our waterways and using our water sustainably. WRTBWA is involved in ongoing projects to improve and protect our watershed.

5.1 Water-Level Loggers

5.1.1 *Methods*

There were 6 water-level loggers (also called depth loggers) deployed in the 2018 field season. These were installed in May 2018 and retrieved in December 2018. The loggers were set up at Officer's Pond, Tim's Outlet, Apple Orchard, Hardy's Outlet, Union Pumping Station, and Friston (which was later moved to Beaton's Creek.) The loggers at Officer's, Hardy, and Union Pumping Station have been in the same location since August 2015.

The flow meter was not used during the 2018 field season, due to accuracy errors. In its place, we used a modified device made of a tennis ball, wire, and duct tape, constructed to float within the water column. The tennis ball alone would simply float on top of the water, creating inaccurate readings, as wind could affect the speed it travelled. The wire weighed the tennis ball down and the tape held them together.

To determine velocity, a 3m section near the logger was measured out. The ball was then placed in the water at a cross-section of the stream, with a timer starting when the ball hit the water and stopping at the 3mr mark. This was done 3 times for each logger, at 3 different places along the width of the stream. The velocity was then calculated by dividing the distance (usually 3m) by the time in seconds to give an average reading in meters per second.

Each of the sites were monitored on a weekly basis by taking measurements of wetted width, logger distance from the left bank, depth at the logger, water depths and velocities across the width of the stream, and water chemistry. A YSI was used for the chemistry portion, recording readings of temperature, dissolved oxygen, nitrate, pH, and conductivity levels.

With the water-level data the flow was calculated, and the "flashiness" of each stream was determined. "Flashiness is counted by the number of times in the season that the discharge reaches 3 times that of the median flow. The term 'flashiness' refers to the frequency and rapidity of short-term changes in streamflow during runoff events. Changes in the flashiness of streams can greatly affect the presence and distribution of stream biota" (Hawkins, 2014).

The R-B Index is another indicator used to quantify stream health. "The 'R-B Index' is a measure of flow variability and flashiness. The index measures oscillation in discharge relative to total discharge, and as a result, characterizes the way a catchment processes inputs into its stream flow outputs" (Hawkins, 2014). "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 stream flow outputs" (Baker, 2004). The R-B index was calculated for each site to compare flashiness of different locations and to compare changes in individual locations over time.

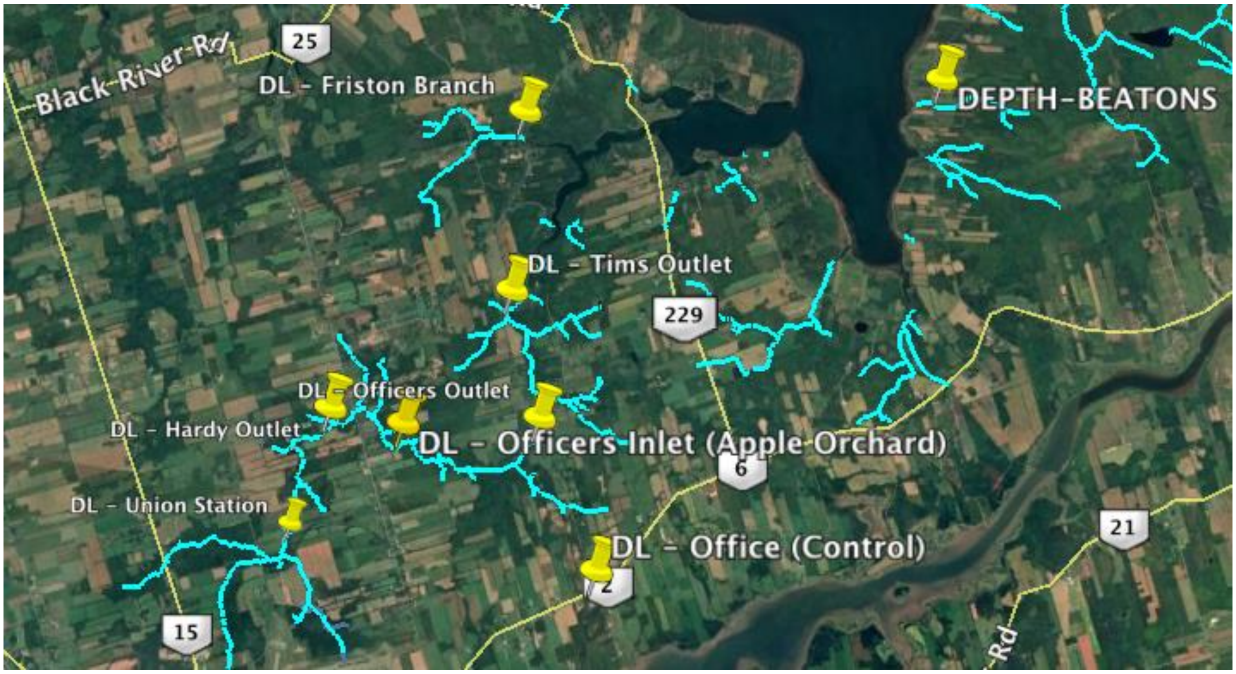


Figure 56. 2018 depth logger locations.

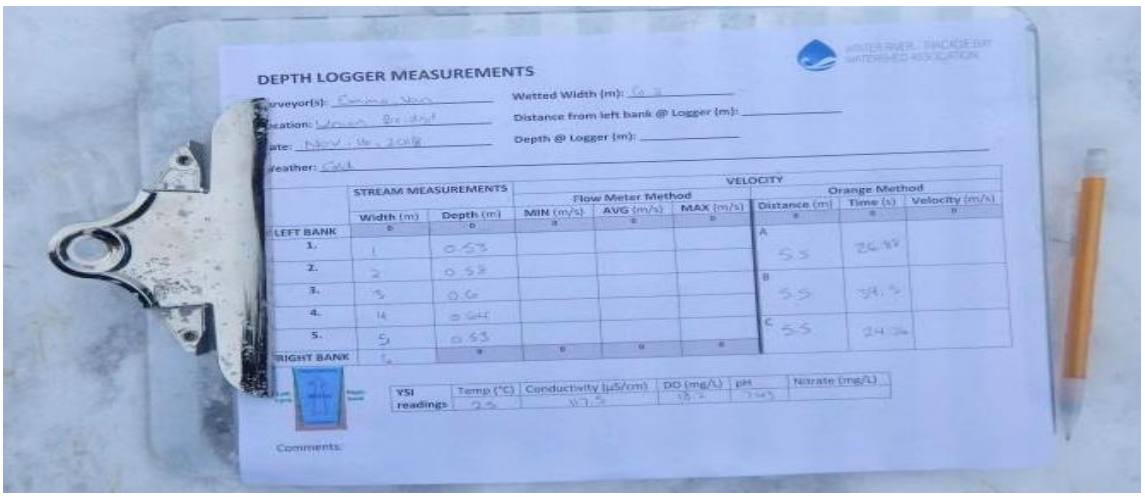


Figure 57. Depth logger collection sheets.

Table 27. 2018 Depth Logger Locations.

Name	**Coordinates**	**Serial Number**	**Notes**
WR @ Union Station	46°18'58.11"N 63° 7'19.10"W	10685266	Below EC station
WR @ Hardy Mill Outlet	46°19'59.82"N 63° 6'48.20"W	10685271	Below Hardy dam
WR @ Officer's Inlet (Apple Orchard)	46°19'50.85"N 63° 5'47.99"W	10685272	Below Apple Orchard
WR @ Tim's Creek Outlet	46°21'7.15"N 63° 4'18.56"W	10685268	Below tributary outlet
WR @ Officer's Outlet	46°19'54.17"N 63° 3'55.49"W	10685267	Below Suffolk dam
Friston Branch	46°22'50.11"N 63° 4'7.99"W	1068526	Above culvert
Beaton's Branch	46°23'8.59" N62° 58'20.87"	10685269	Above culvert

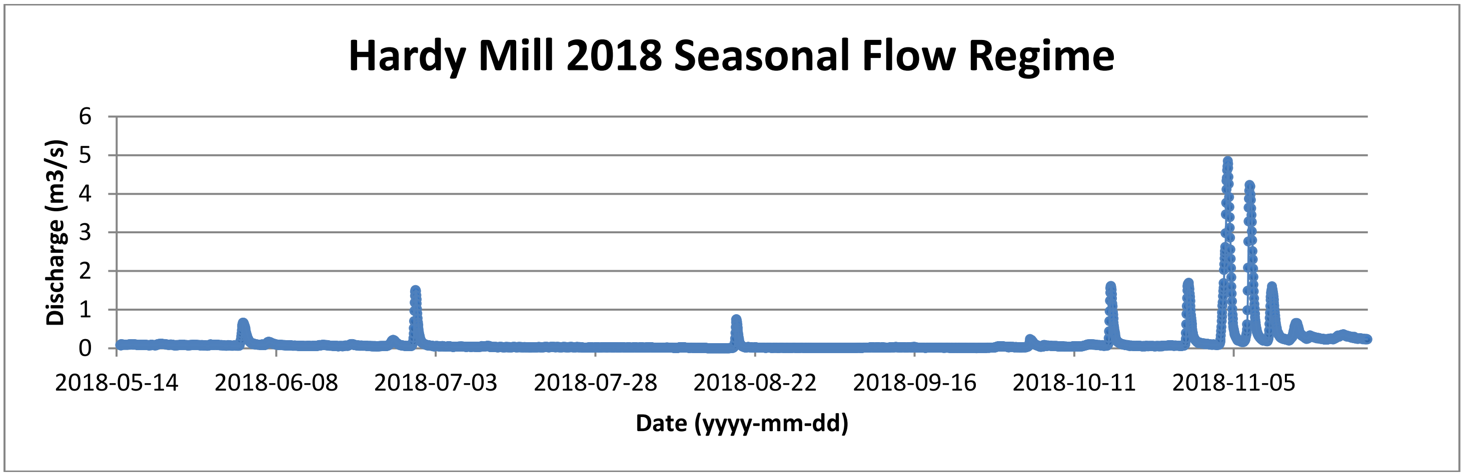


Figure 58. Hardy Mill 2018 seasonal flow regime.

Table 28. Hardy Mill flow regime overview.

	2018			2017		
	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)
Minimum Flow	0.518	0.012	2018-08-14	1.411	0.017	2017-09-22
Median Flow	53.580			55.899		
Maximum Flow	4852.180	1.123	2018-11-04	755.124	0.534	2017-11-23

	2018	2017
R-B Index:	0.681	0.167
Flashiness (# of high flow pulses):	13	13
High flow threshold (L/s):	160.730	167.697
R^2 Value for water level discharge rating curve	0.821	0.591

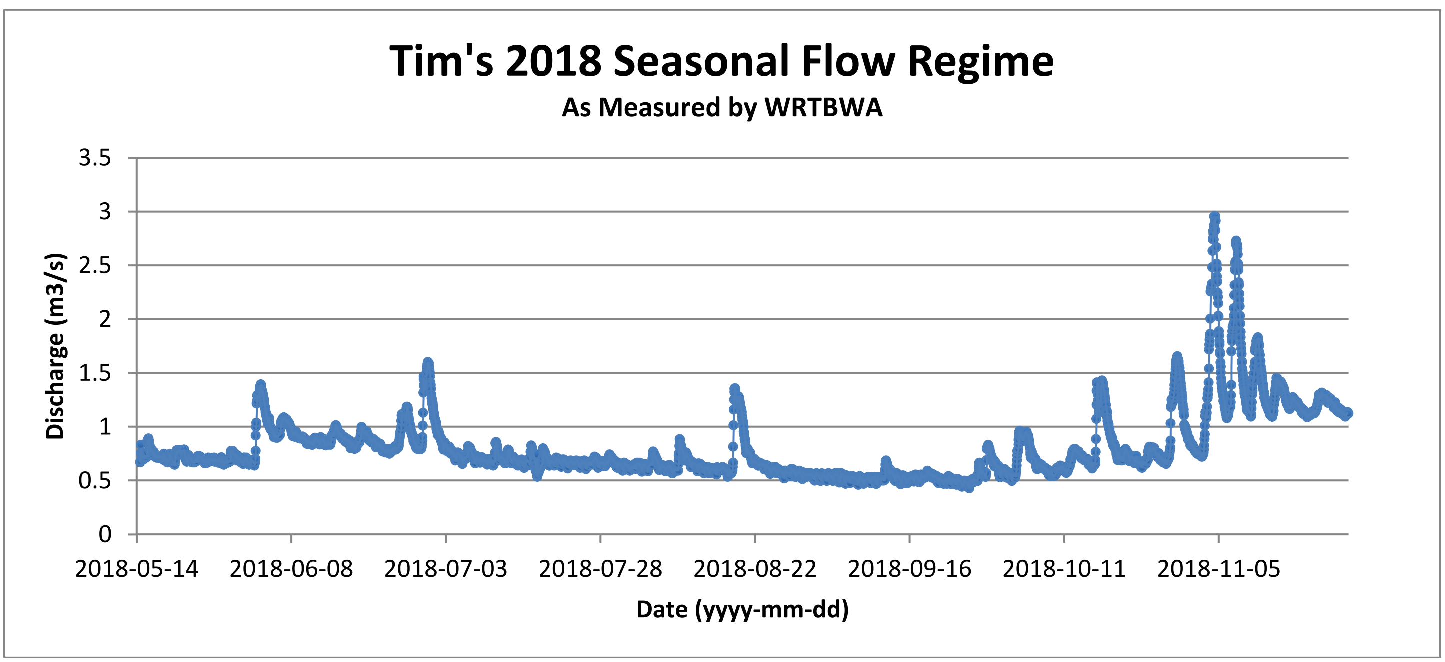


Figure 59. Tim's outlet 2018 seasonal flow regime.

Table 29. Tim's outlet flow regime overview.

	2018			2017		
	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)
Minimum Flow	425.805	0.107	2018-09-25	198.923	0.047	2017-09-12
Median Flow	700.780			320.554		
Maximum Flow	2954.830	0.524	2018-11-04	613.277	0.185	2017-06-24

	2018	2017
R-B Index:	0.118	0.050
Flashiness (# of high flow pulses):	2	0
High flow threshold (L/s):	2102.350	961.663
R^2 Value for water level discharge rating curve	0.524	0.248

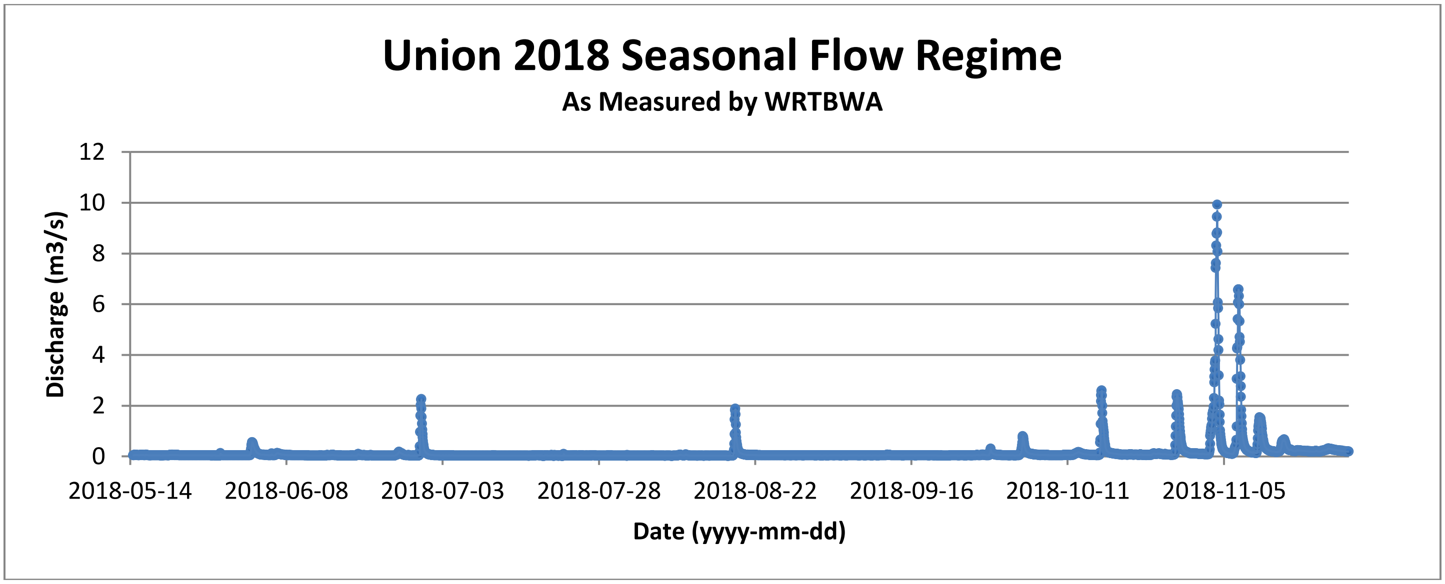


Figure 60. Union Pumping Station 2018 seasonal flow regime.

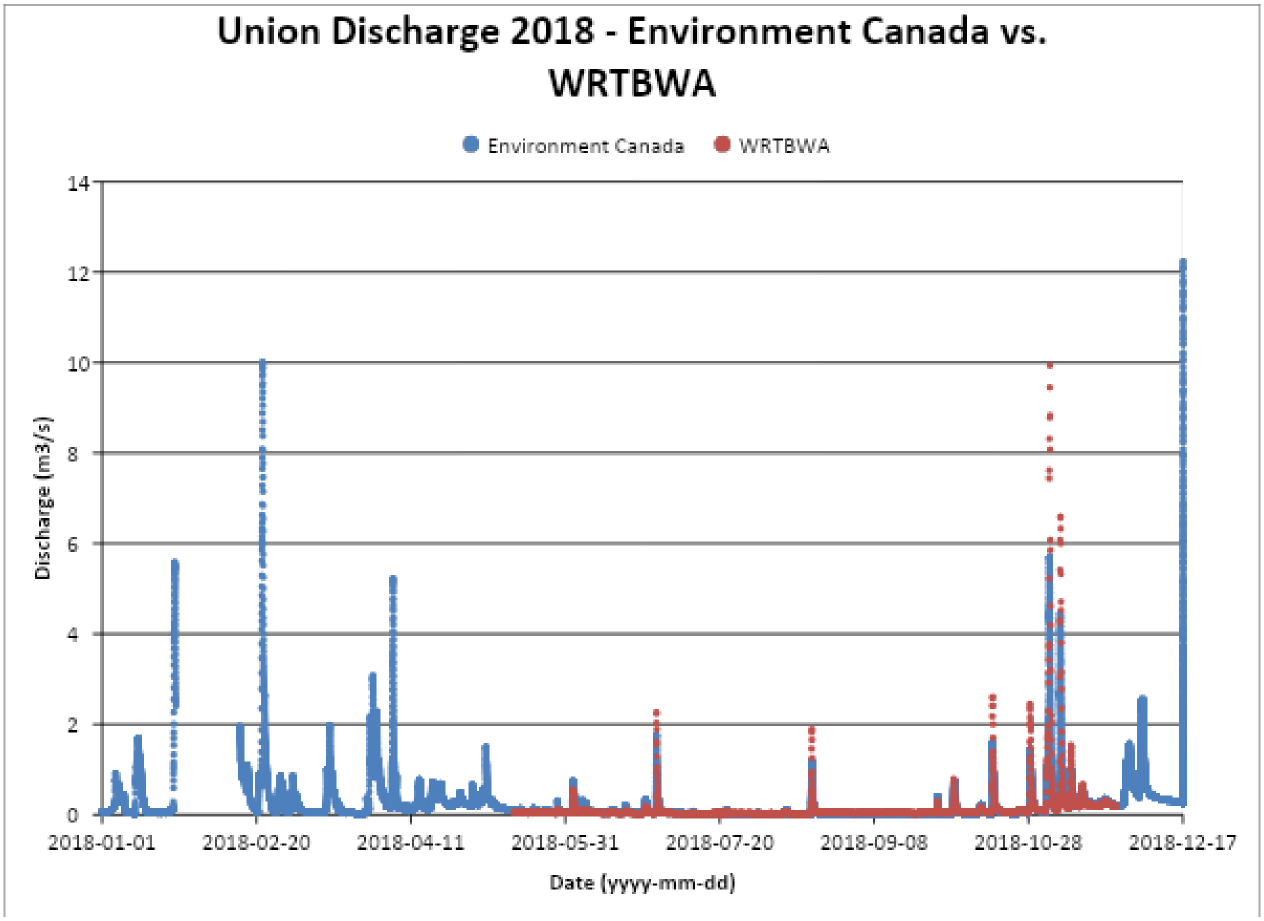


Figure 61. Union Pumping Station discharge 2018 Environment Canada vs. WRTBWA.

Table 30. Union flow regime overview.

	2018			2017		
	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)

Minimum Flow	15.370	0.226	2018-07-19	13.638	0.242	2017-11-17
Median Flow	41.730			21.017		
Maximum Flow	9931.790	1.327	2018-11-03	1022.197	0.899	2017-11-23

	2018	2017
R-B Index:	0.9169	0.333
Flashiness (# of high flow pulses):	15	7
High flow threshold (L/s):	125.200	63.050
R^2 Value for water level discharge rating curve	0.750	0.401

The Friston site was monitored from 2018-05-14 until 2018-08-10, then was relocated to Beaton’s Creek due to issues with landowners’ dogs.

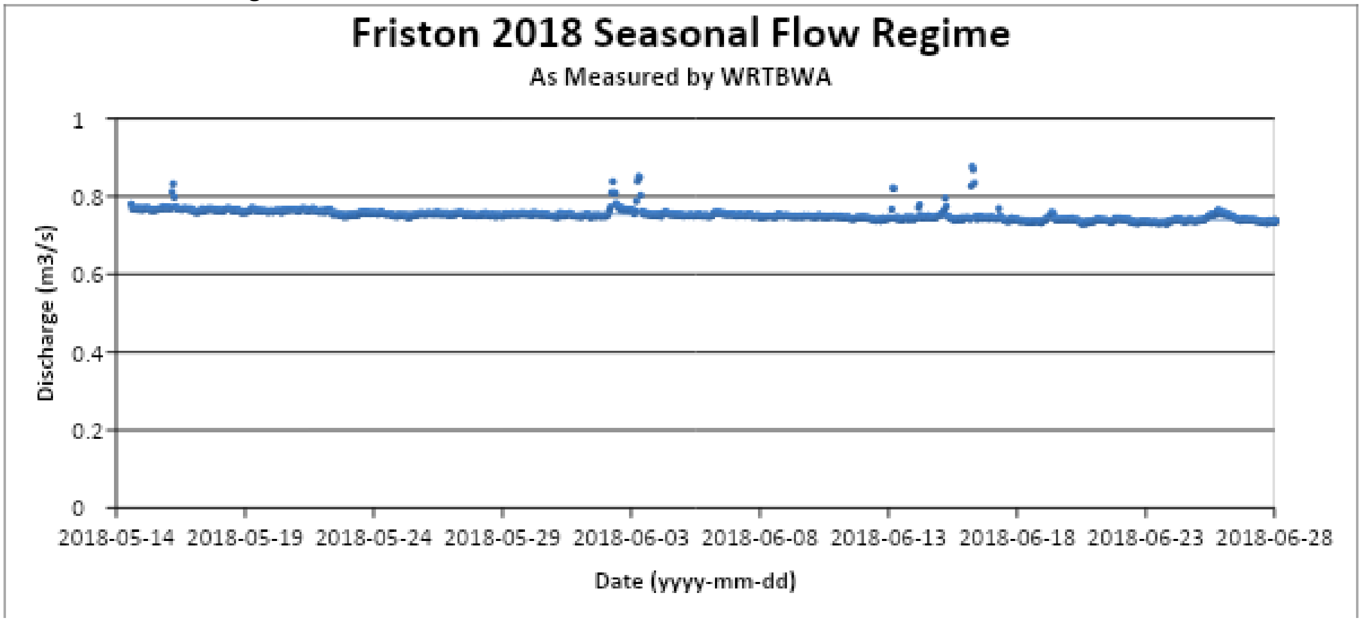


Figure 62. Friston 2018 seasonal flow regime.

Table 31. Friston flow regime overview.

	2018			2017		
	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)
Minimum Flow	728.540	0.168	2018-06-20	97.120	0.149	2017-07-06
Median Flow	751.020			139.458		
Maximum Flow	877.110	0.392	2018-06-16	452.389	0.521	2017-11-17

	2018	2017
R-B Index:	0.007	0.059
Flashiness (# of high flow pulses):	0	1
High flow threshold (L/s):	2253.056	418.373
R^2 Value for water level discharge rating curve	0.125	0.141

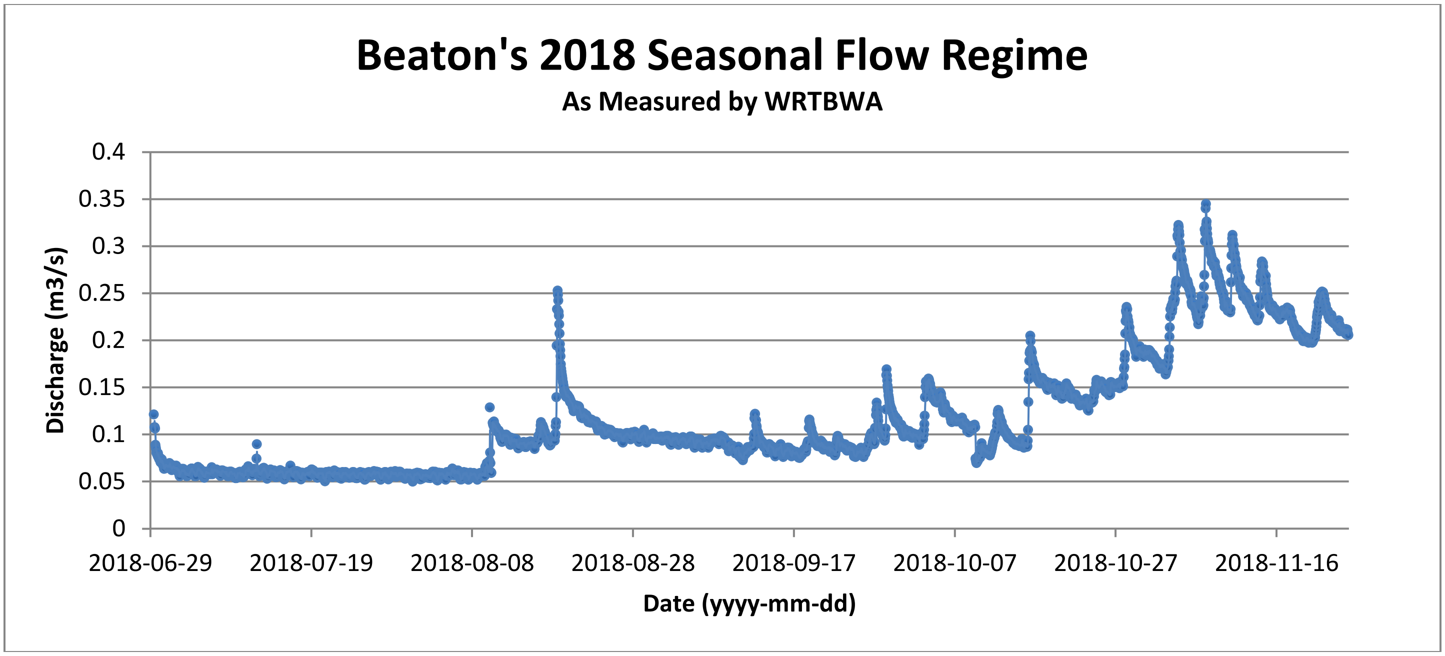


Figure 63. Beaton's Creek 2018 seasonal flow regime.

Table 32. Beaton's Creek flow regime overview.

	2018		
	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)
Minimum Flow	49.710	0.139	2018-07-31
Median Flow	95.150		
Maximum Flow	344.960	0.525	2018-11-07

	2018
R-B Index:	0.014
Flashiness (# of high flow pulses):	4
High flow threshold (L/s):	285.46
R^2 Value for water level discharge rating curve	0.657

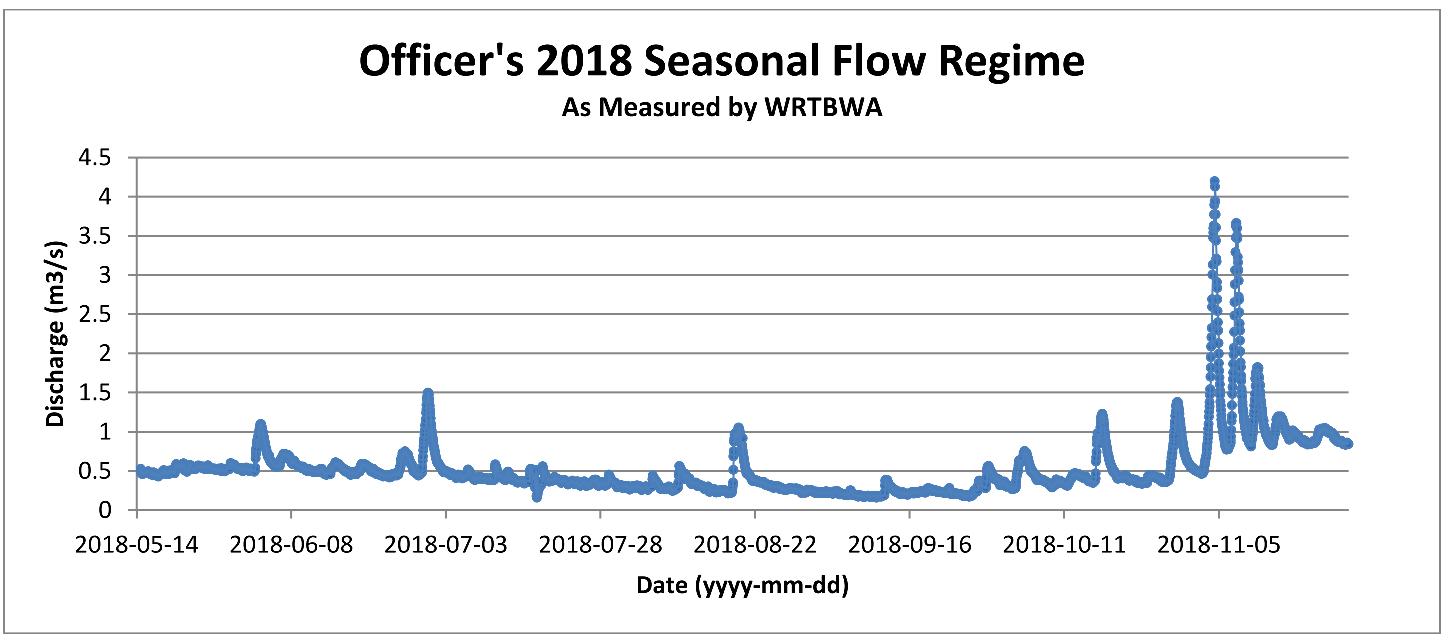


Figure 64. Officer's Pond 2018 seasonal flow regime.

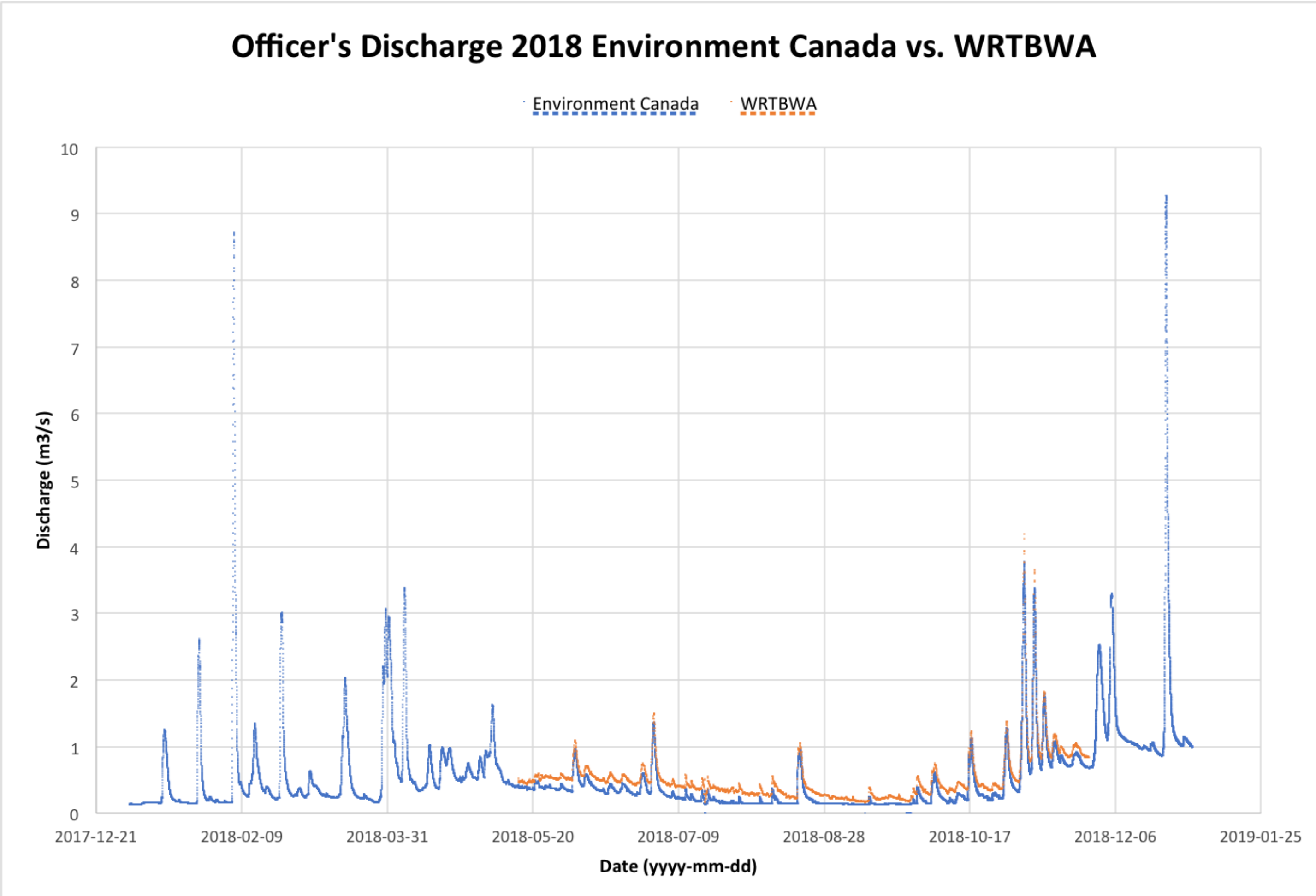


Figure 65. The depth logger at Officer's Pond measures more flow than the Environment Canada Station (the magnitude of the WRTBWA peaks are larger than Environment Canada).

Table 33. Officer's flow regime overview.

	2018			2017		
	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)
Minimum Flow	158.370	0.315	2018-09-10	205.843	0.262	2017-09-12
Median Flow	430.540			293.036		
Maximum Flow	4196.660	0.999	2018-11-04	378.011	0.622	2017-11-24

	2018	2017
R-B Index:	0.216	0.017
Flashiness (# of high flow pulses):	5	0
High flow threshold (L/s):	1291.610	879.107
R^2 Value for water level discharge rating curve	0.642	0.058

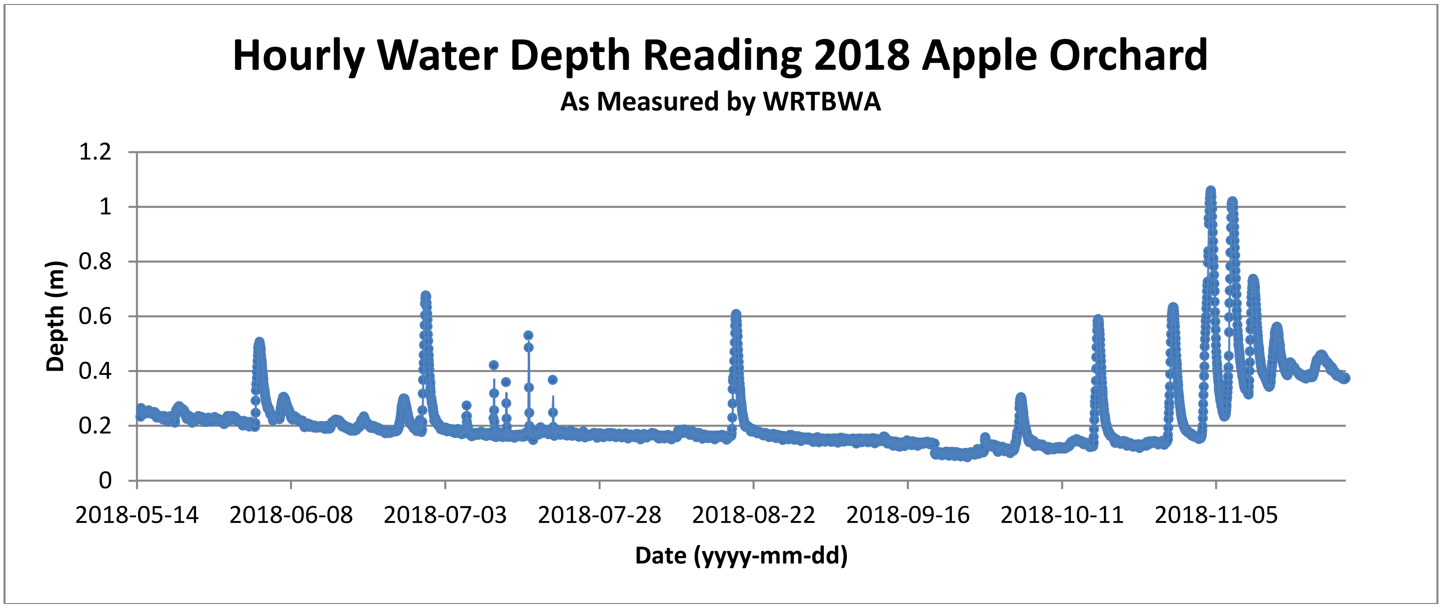


Figure 66. Apple Orchard hourly water depth readings 2018.

Table 34. Apple Orchard flow regime overview.

	2018			2017		
	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)	Discharge (L/s)	Water level (m)	Date (yyyy-mm-dd)
Minimum Flow	41.230	0.085	2018-09-25	79.557	0.126	2017-11-03
Median Flow	106.752			110.082		
Maximum Flow	1202.049	1.059	2018-11-04	170.398	0.549	2017-11-24

	2018	2017
R-B Index:	0.253	0.027
Flashiness (# of high flow pulses):	15	0
High flow threshold (L/s):	320.256	330.247
R^2 Value for water level discharge rating curve	0.721	0.106

Table 35. Summary of flow regime at water-level logger locations.

Location	RB Index	High Flow Threshold (L/s)	# of High Flow Pulses
Union	0.9169	125.200	15
Hardy Mill	0.6810	160.730	13
Apple Orchard	0.2530	320.256	15
Officer’s Outlet	0.2160	1291.610	5
Tim’s Creek	0.1180	2102.350	2
Friston	0.0070	2253.056	0
Beaton’s Creek	0.0140	285.460	4

5.1.3 *Discussion*

There were a few instances of error during the deployment period for the depth loggers. During data analysis for this field season, values that stood out were compared with notes from the field books to try to explain the abnormalities. Details about potential depth logger errors can be found in Appendix 3, section 8.3.

On 2018-08-10 the Friston logger was moved to the Beaton’s Creek location. There was an issue with dogs following the crew along the stream and onto the road. The depth logger was then placed directly by the temperature logger at Beaton’s Creek, upstream from the Blooming Point Road culvert.

On 2018-08-14 around noon there was an upward spike in discharge for the depth logger at Beaton's Creek. When the crew was out checking the loggers, debris was removed from the top of the logger to clean it. Debris on top of a depth logger can alter the pressure readings, and therefore give inaccurate depth data. Due to the sandy bottom of Beaton's Creek, debris would regularly pile up on top of the logger and require maintenance. From the graphs for depth and temperature at Beaton's Creek, it is clear that a large amount of debris must have piled up onto the logger. Once cleared off, the logger was reading much higher temperatures and deeper depths, reflective of the normal conditions at this stream.

This year the bridge at the Union Pumping Station and the culvert on the Brackley branch crossing the driveway to Union Station were replaced with 2 bridges. The water was blocked on either side, with a stream water bypass set up to allow some water flow between the upstream and downstream portions. The blocking of the stream on either side of the bridge created an artificial rise in the depth, and a major slow in the water velocity. After the bridge was installed the depth and flow returned to levels similar to before construction. The new bridges are concrete structures with large arches to allow for high flow events.

Very-high-water events occurred twice this season, once mainly affecting the Union Pumping Station and Hardy Mill Pond sites, and the second time affecting all sites except Beaton's Creek. The first high flow event was on 2018-06-29 and was likely caused by the heavy rain events many consecutive days prior. The Union Pumping Station logger was about 1.2 m deep, while it is usually around 0.2-0.3 m. The velocity was also over 3 times its usual numbers, about 0.3 m/s compared to the usual 0.1 m/s. This gave a 1.601 m^3/s discharge with usual discharge values being recorded around the 0.05-0.15 m^3/s range. The water depth at Hardy Mill was also triple its usual depth and twice the typical velocity. The Apple Orchard site's depth values doubled 2018-06-29, but the velocity was not largely affected. Officer's Pond Outlet had double the normal velocity values that day, but only minor increases in water depth. The effects of the heavy rains may have been dampened by the presence of the dam. The other sites did not appear to have many depth or velocity changes that day.

The second high-water event created much higher water and velocity levels than the first. This event occurred on 2018-11-07. The water levels were impossible to measure at Union Pumping Station, Hardy Mill Pond, and the Apple Orchard due to water levels being significantly over the crew's chest waders. Furthermore, the flow at Hardy Mill was very rapid. Values of velocity at this site usually range from 0.1-0.5 m/s but were measured at about 1.2 m/s when the crew went back out to the sites the next day to try to record values during this event.

There were 2 culverts, 1 at Officer's Pond and 1 at Union Pumping Station, also monitored on 2018-11-08. Many of the depths still could not be recorded, as most were over the meter stick used to measure water depth. The wetted width at all sites (other than Beaton's Creek) had dramatically increased, as the high water levels had flooded the banks on either side of the streams. Hardy Mill had a wetted width double its average, Union had increased by about 1m, the Apple Orchard width increased by about 5m, and the other sites remained similar to average values.

Removal of the beaver dam at the Apple Orchard resulted in initial spikes in the depth of the Apple Orchard logger. After the initial spikes, the data shows that the water level dropped slightly lower until November, when the water rose back up due to heavy rain events.

The summary table of all locations (Table 35) shows that the Union Pumping Station, Apple Orchard and Hardy Mill locations were the most prone to flashiness, or high flow pulses. These locations are all in the upper stream areas of the Winter River. The heavy rain flow events are more likely to affect these than the downstream sections, as by the time the downstream area is reached much of the water has been distributed into the upper flood plain areas. Flashiness numbers were higher in 2018 than in 2017, due to several heavy rain events that occurred over short time periods. These events did not give the stream enough time to disperse the extra water, and in both events the flood plains were severely flooded. Flooding can cause bank destruction, silt to be brought into the stream, and poor water conditions for aquatic life. For these reasons, it is important to monitor high flow events.

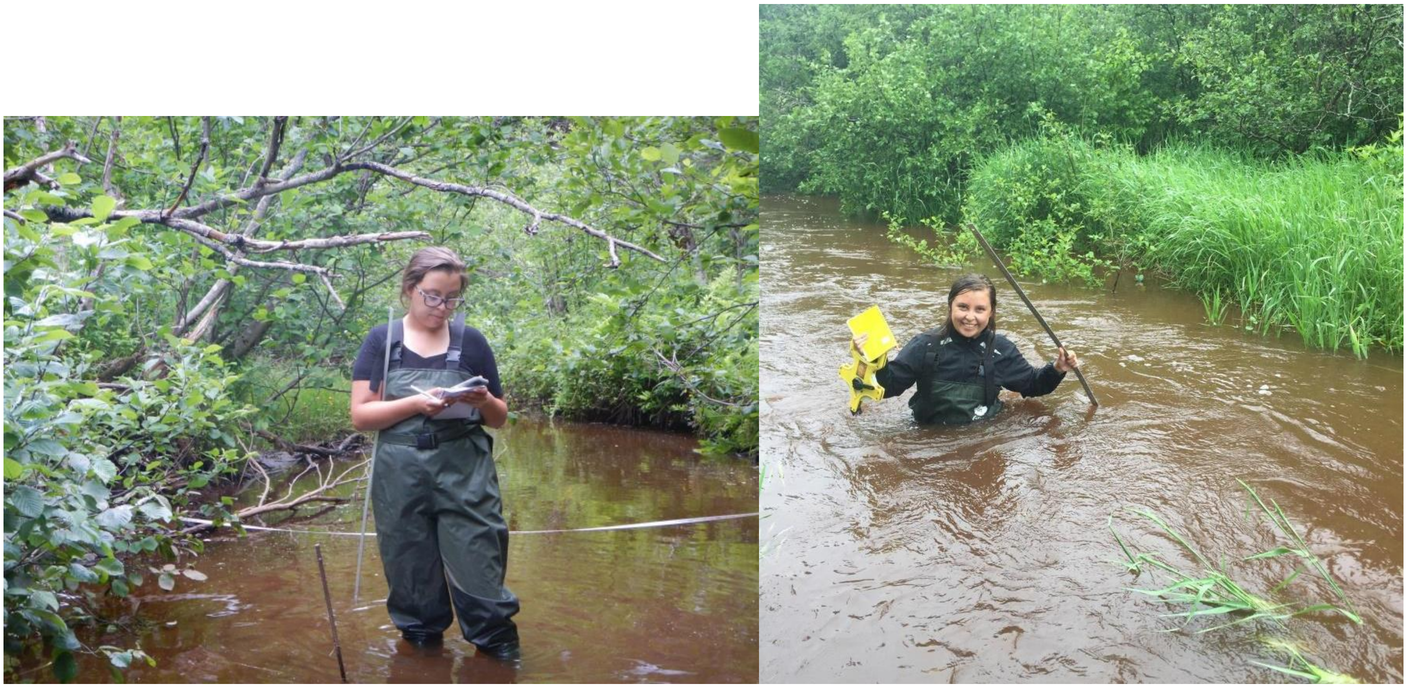


Figure 67. Union Logger being measured (left) and Carley at Union pumping station during June high flow event (right).

Figure 68. New Union Bridge, at normal depth and flow (left) and on November 11th during a high flow event (right).

Figure 69. Upstream of Union Bridge pumping station during November high flow event (left) and Apple Orchard during high flow event in November (right).

Figure 70. Hardy Mill during the high flow event in November (left) and Officer's Pond during the June high flow event (right).

5.2 Temperature Loggers

5.2.1 *Methods*

There were 10 temperature loggers deployed at various locations throughout the Watershed this field season. 7 were successfully retrieved: Officer’s Pond surface, Officer’s Pond bottom, Hardy Mill surface, Piper’s Creek, Tim’s Creek, Beaton’s Creek and Black River. The temperature loggers were deployed in June, and all but 3 were removed on 2018-09-04. These included the logger at the Deroche Pond outlet (it could not be removed due to a beaver dam on top of the logger), the logger at Trout River on Anderson Road (it was unable to be found), and the Hardy Mill Bottom logger (also lost).

The 6 depth loggers recorded temperature in addition to changes in water level. The data from all temperature loggers and depth loggers are graphed together in Figure 72. Both logger types appear to have data that correlates with one another.

Figure 71. Map of the 2018 temperature logger locations.

5.2.2 *Results*

Table 36. Percentage of time spent in each temperature category and longest time period when temperatures were continuously above the stress zone, based on Brook Trout biology at each monitoring site. Beaton's depth logger was moved here mid-season from Friston.

Location	Optimal Growth for Brook Trout (11-18 °C)	Tolerant Brook Trout range (0-20°C)	Stress Zone (>20 °C)	Longest # of hours in Stress Zone
Officer's Pond (Surface)	32.56%	46.94%	53.06%	859
Officer's Pond (Bottom)	54.22%	97.94%	2.06%	40
Officer's Pond Outlet	33.95%	69.96%	30.04%	833
Hardy Mill (Surface)	37.75%	53.31%	46.69%	847
Hardy Mill Outlet	38.84%	74.67%	25.33%	382
Piper's Creek	81.17%	100.00%	0.00%	0
Tim's Creek	1.81%	100.00%	0.00%	0
Below Tim's Creek	57.39%	99.98%	0.02%	1
Beaton's Creek	67.17%	98.61%	1.39%	8
Beaton's Depth Logger	41.45%	99.81%	0.19%	2
Black River	77.95%	100.00%	0.00%	0
Apple Orchard	59.60%	100.00%	0.00%	0
Union Station	46.88%	97.67%	2.33%	15

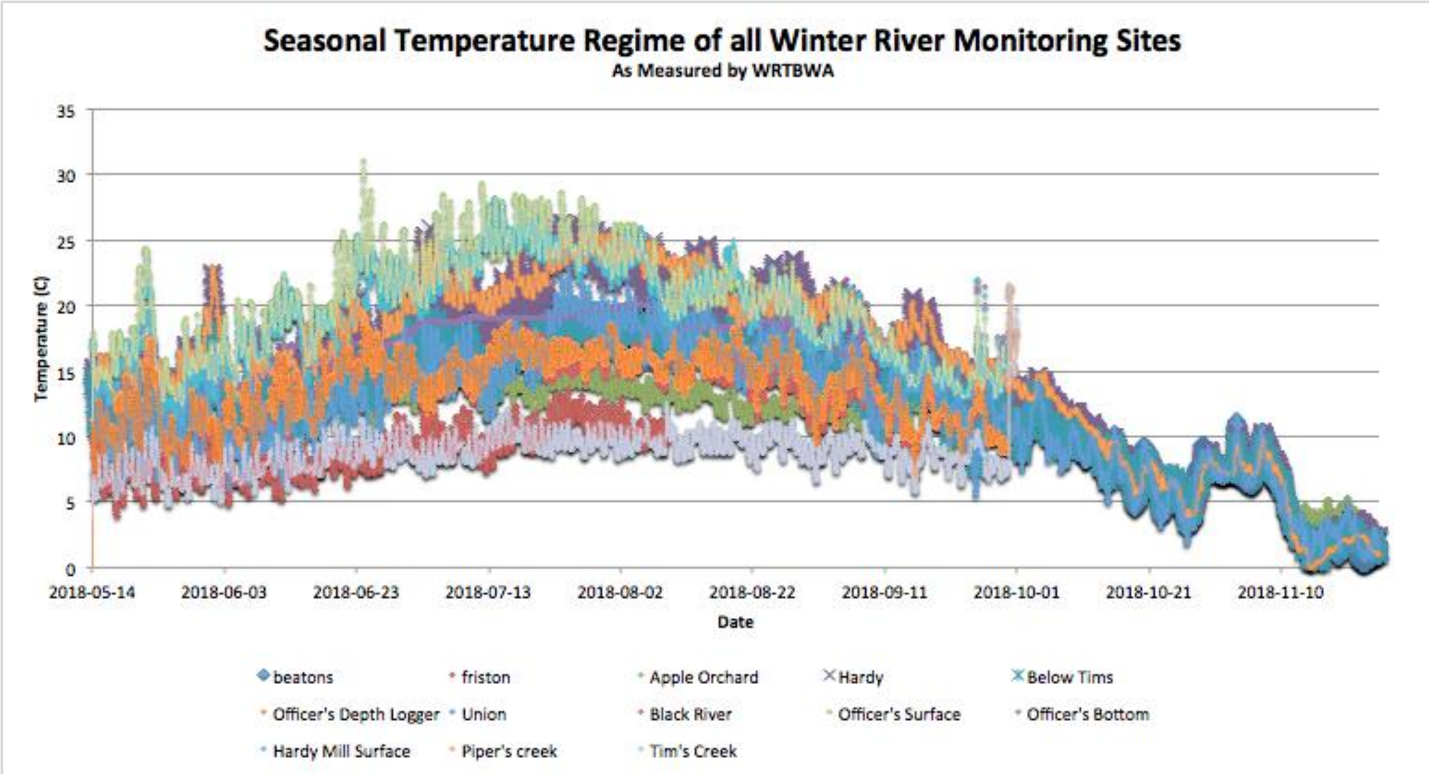


Figure 72. Seasonal temperature regime of all Winter River monitoring sites, with data collected from temperature loggers and depth loggers.

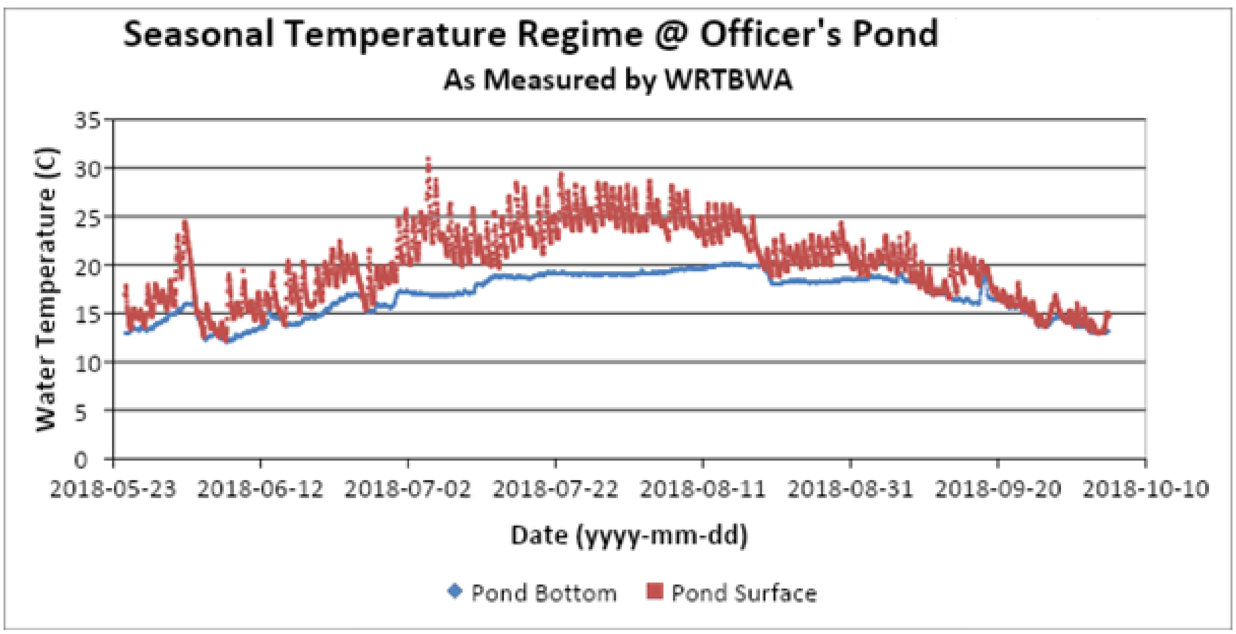


Figure 73. Seasonal temperature regime at Officer's Pond surface and bottom for the 2018 field season.

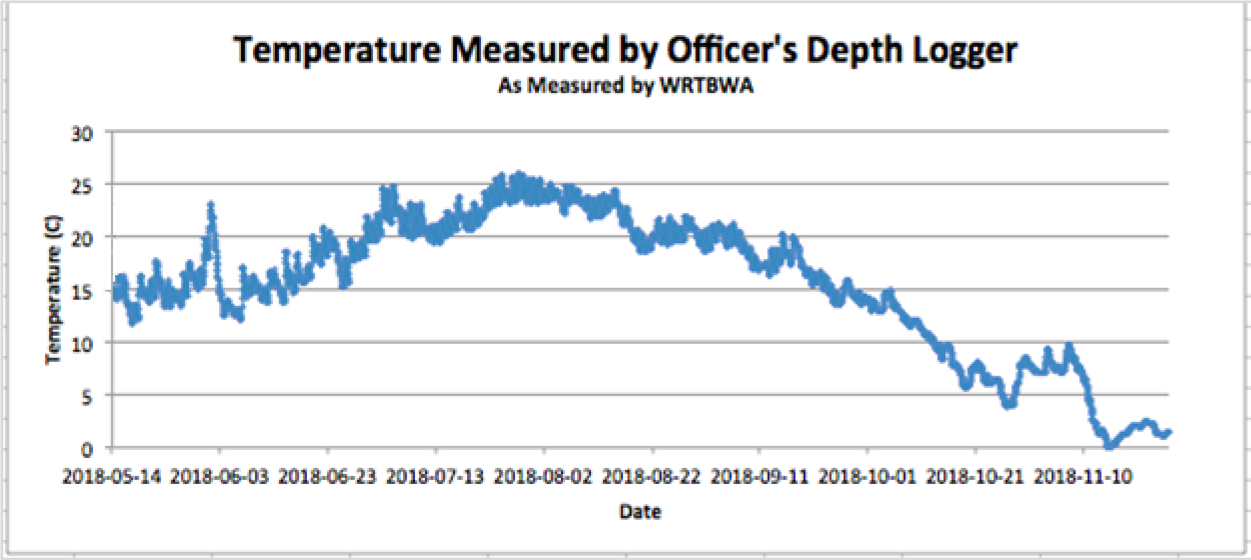


Figure 74. Temperature measured by the depth logger at the outlet of Officer's Pond in 2018.

Table 37. Officer's Pond temperature regime overview at the surface and bottom of the pond for 2018.

	Temperature (°C)		Date (yyyy-mm-dd)	
	Bottom	Surface	Bottom	Surface
Maximum	20.2	31.0	2018-08-18	2018-07-04
Average	16.9	20.2		
Minimum	12.0	12.2	2018-06-07	2018-06-07
			Time Spent in Category	
			Bottom	Surface
Optimal Growth for Brook Trout (11-18°C)			54.22%	32.56%
Tolerant Brook Trout range (0-20°C)			97.94%	46.94%
Stress Zone (>20° C)			2.06%	53.06%
Longest # of Hours in Stress Zone			40	859

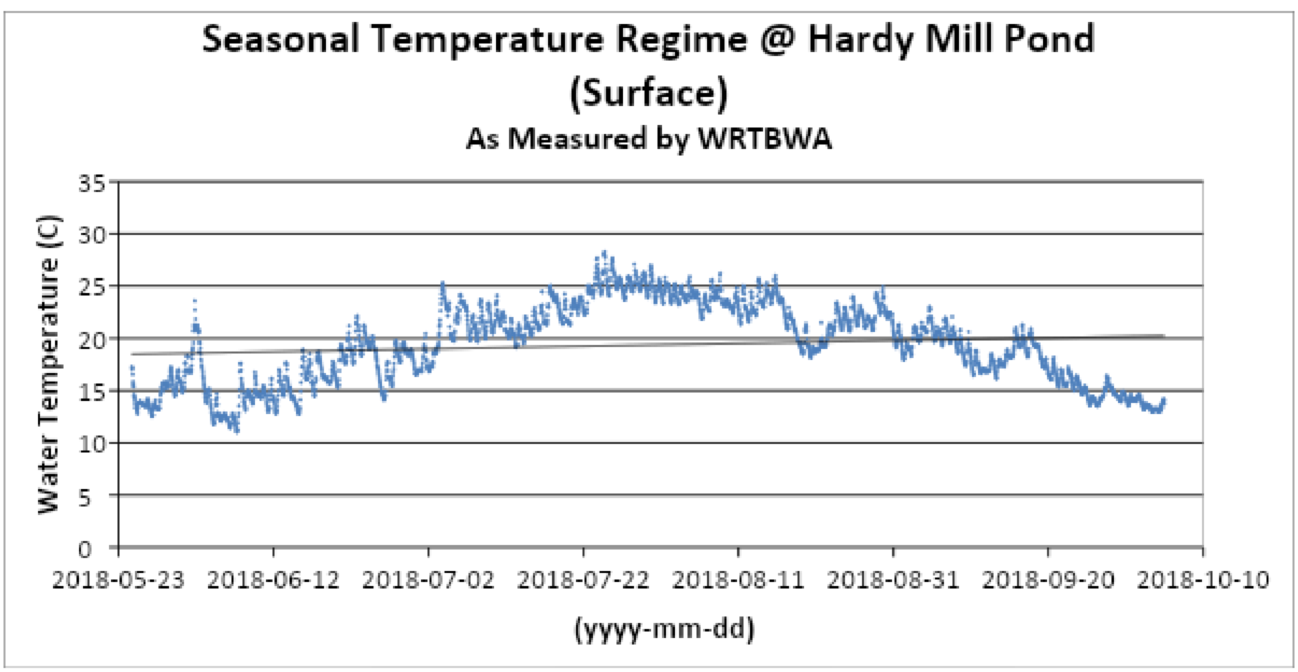


Figure 75. Seasonal temperature regime at the surface of Hardy Mill Pond in 2018.

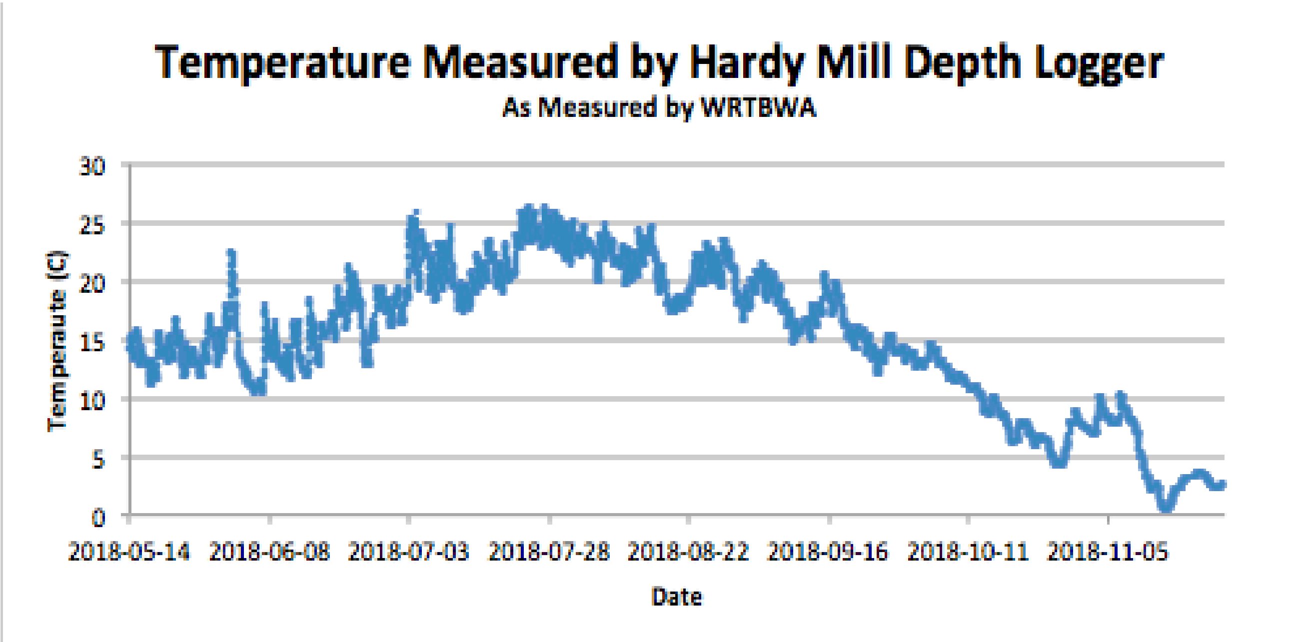


Figure 76. Temperature measured by the depth logger at the outlet of Hardy Mill Pond in 2018.

Table 38. Hardy Mill temperature regime overview for 2018.

	Temperature (°C)	Date (yyyy-mm-dd)
Maximum	28.3	2018-07-24
Average	11.0	
Minimum	19.3	2018-06-07
		Time Spent in Category
Optimal Growth for Brook Trout (11-18°C)		37.75%
Tolerant Brook Trout range (0-20°C)		53.31%
Stress Zone (>20° C)		46.69%
Longest # of Hours in Stress Zone		847

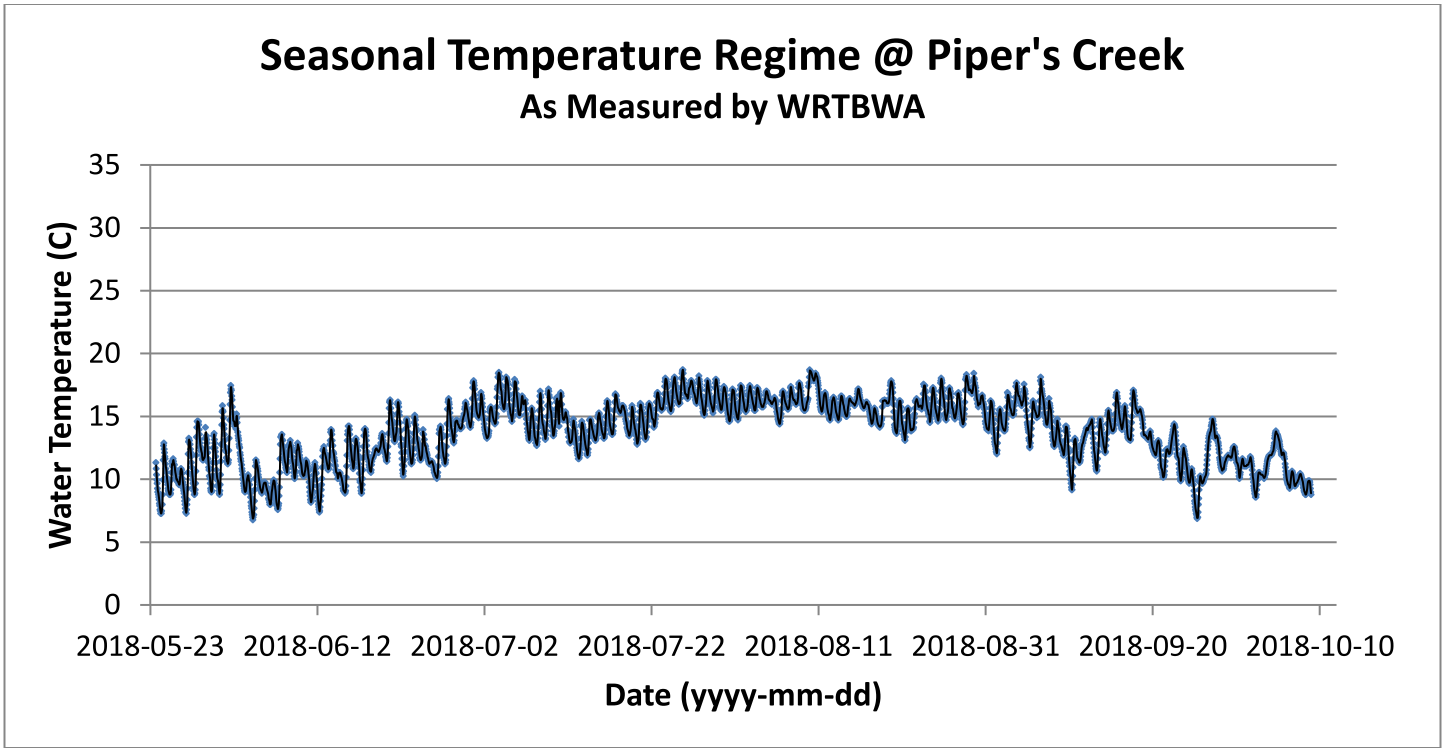


Figure 77. Seasonal temperature regime at Piper's Creek for 2018, measured by a temperature logger.

Table 39. Piper's Creek temperature regime overview.

	Temperature (°C)	Date (yyyy-mm-dd)
Maximum	18.7	2018-07-25
Average	13.8	
Minimum	6.8	2018-06-04
		Time Spent in Category
Optimal Growth for Brook Trout (11-18°C)		81.17%
Tolerant Brook Trout range (0-20°C)		100.00%
Stress Zone (>20° C)		0.00%
Longest # of Hours in Stress Zone		0

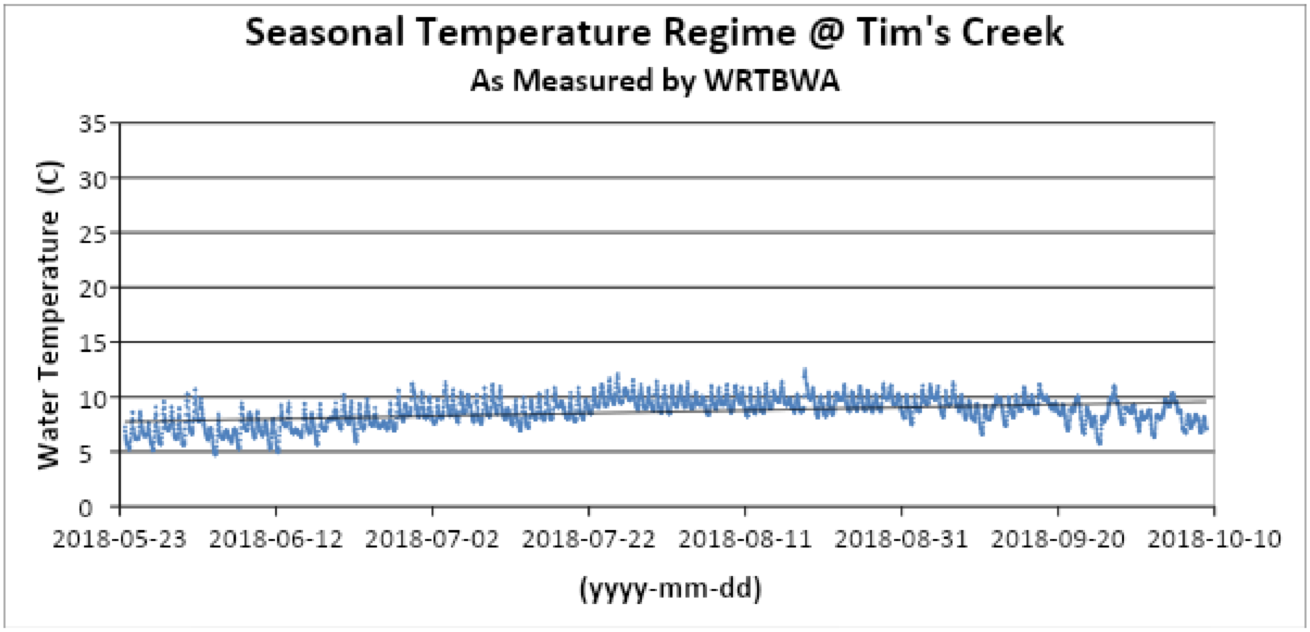


Figure 78. Seasonal temperature regime at Tim's Creek for 2018, measured by a temperature logger.

Table 40. Tim’s Creek temperature regime overview and 2017-2018 comparisons.

	Temperature (°C)	Date (yyyy-mm-dd)	
Maximum	12.5	2018-08-18	
Average	8.6		
Minimum	4.7	2018-06-04	
		Time Spent in Category	
		2018	2017
Optimal Growth for Brook Trout (11-18°C)		1.81%	0.5%
Tolerant Brook Trout range (0-20°C)		100%	100%
Stress Zone (>20° C)		0%	0%
Longest # of Hours in Stress Zone		0	0

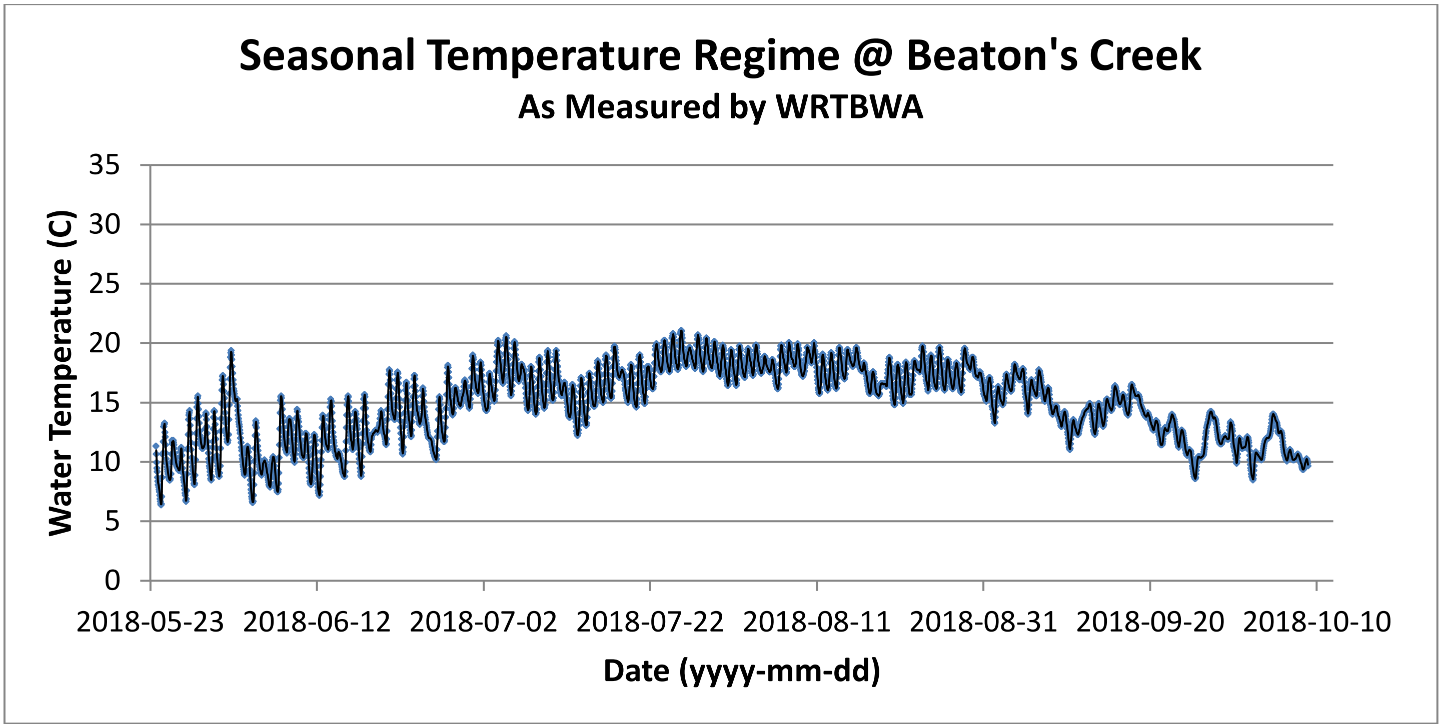


Figure 79. Seasonal temperature regime at Beaton's Creek for 2018, measured by a temperature logger.

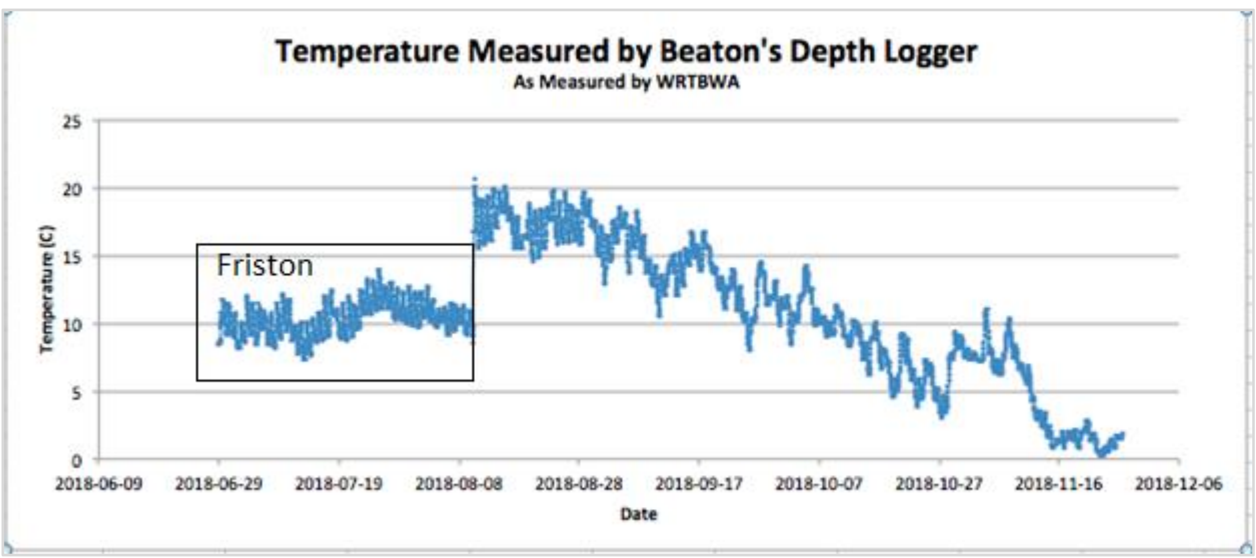


Figure 80. Temperature measured by the Beaton's Creek depth logger in 2018. The logger was moved from the Friston site on 2018-08-09 and logging started at the Beaton's Creek site 2018-08-10.

Table 41. Beaton's Creek temperature regime overview and 2016-2018 comparisons.

	Temperature (°C)	Date (yyyy-mm-dd)	
Maximum	21.1	2018-07-25	
Average	14.9		
Minimum	6.4	2018-05-24	

	Time Spent in Category		
	2018	2017	2016
Optimal Growth for Brook Trout (11-18°C)	67.17%	72.6%	44.9%
Tolerant Brook Trout range (0-20°C)	98.61%	98.6%	77.2%
Stress Zone (>20° C)	1.39%	1.4%	22.8%
Longest # of Hours in Stress Zone	8		91

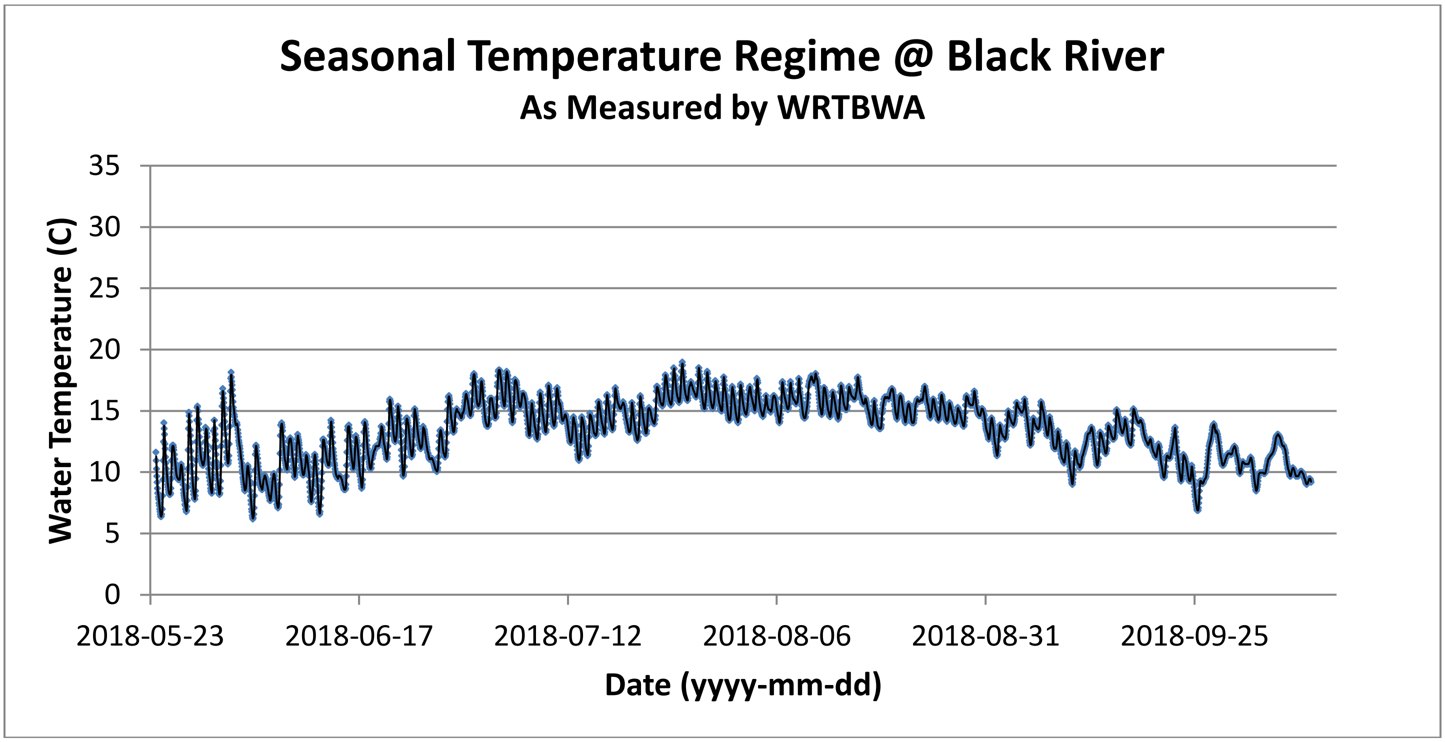


Figure 81. Seasonal temperature regime at Black River in 2018, measured by a temperature logger.

Table 42. Black River temperature regime overview for 2018.

	Temperature (°C)	Date (yyyy-mm-dd)
Maximum	19.0	2018-07-25
Average	13.3	
Minimum	6.2	2018-06-04
		Time Spent in Category
Optimal Growth for Brook Trout (11-18°C)		77.95%
Tolerant Brook Trout range (0-20°C)		100%
Stress Zone (>20° C)		0%
Longest # of Hours in Stress Zone		0

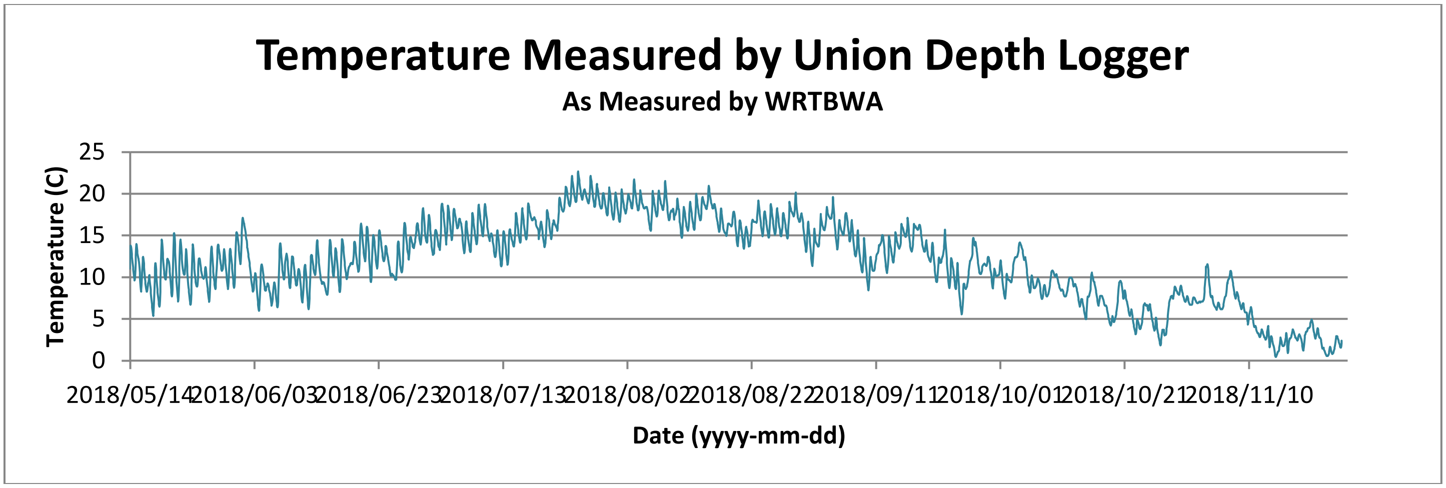


Figure 82. Temperature measured by the depth logger at Union in 2018.

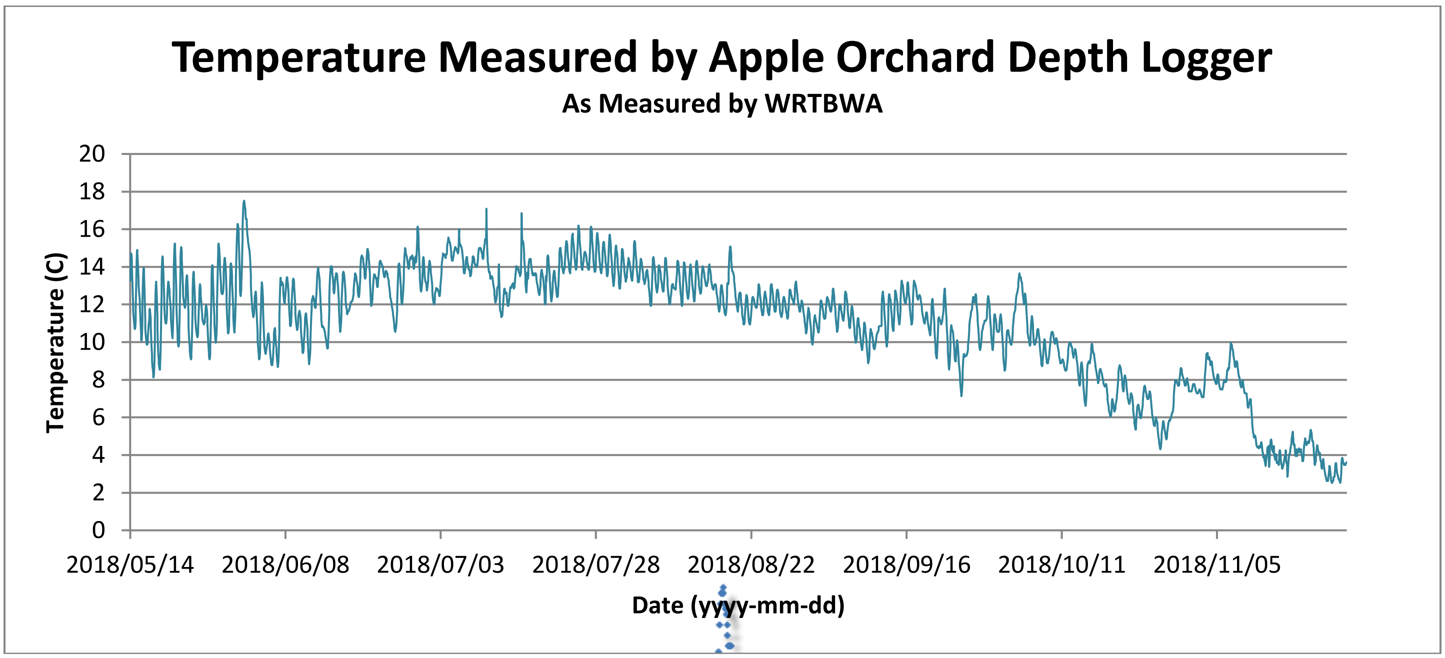


Figure 83. Temperature measured by the depth logger at Apple Orchard in 2018.

5.2.3 *Discussion*

The graph of the seasonal temperature regime of all Winter River monitoring sites (Figure 72) shows the temperatures recorded by the depth loggers and temperature loggers in a single inclusive graph. This shows both similarities due to seasonal variation and differences between sites, largely due to the amount of warming that takes place during summer. When cool weather prevails, water temperatures are mainly influenced by groundwater temperature and air temperature. The dataset for the Beaton's depth logger began in August, after the logger was relocated from Friston.

5.3 V-Notch Weirs

5.3.1 *Methods*

In total, 13 v-notch weirs were monitored in the 2018 field season. YSI readings were taken weekly at each spring to measure water chemistry parameters. The height of the water flowing over the v-notch was measured with a ruler, in centimeters. These height measurements were then correlated to John te Raa's Excel file to determine the flow at each spring in litres per second. Located along the Brackley branch were 5 weirs(numbered 3, 4, 6, 7 & 8), 2 on the Cudmore branch (numbered 3 & 6), 2 at Tim's Creek (upper & lower), 2 at Pleasant Grove (numbered 2 & 5), 1 at Vanco, and 1 at Affleck. The weirs were installed in May 2018 and removed from the springs in December 2018.

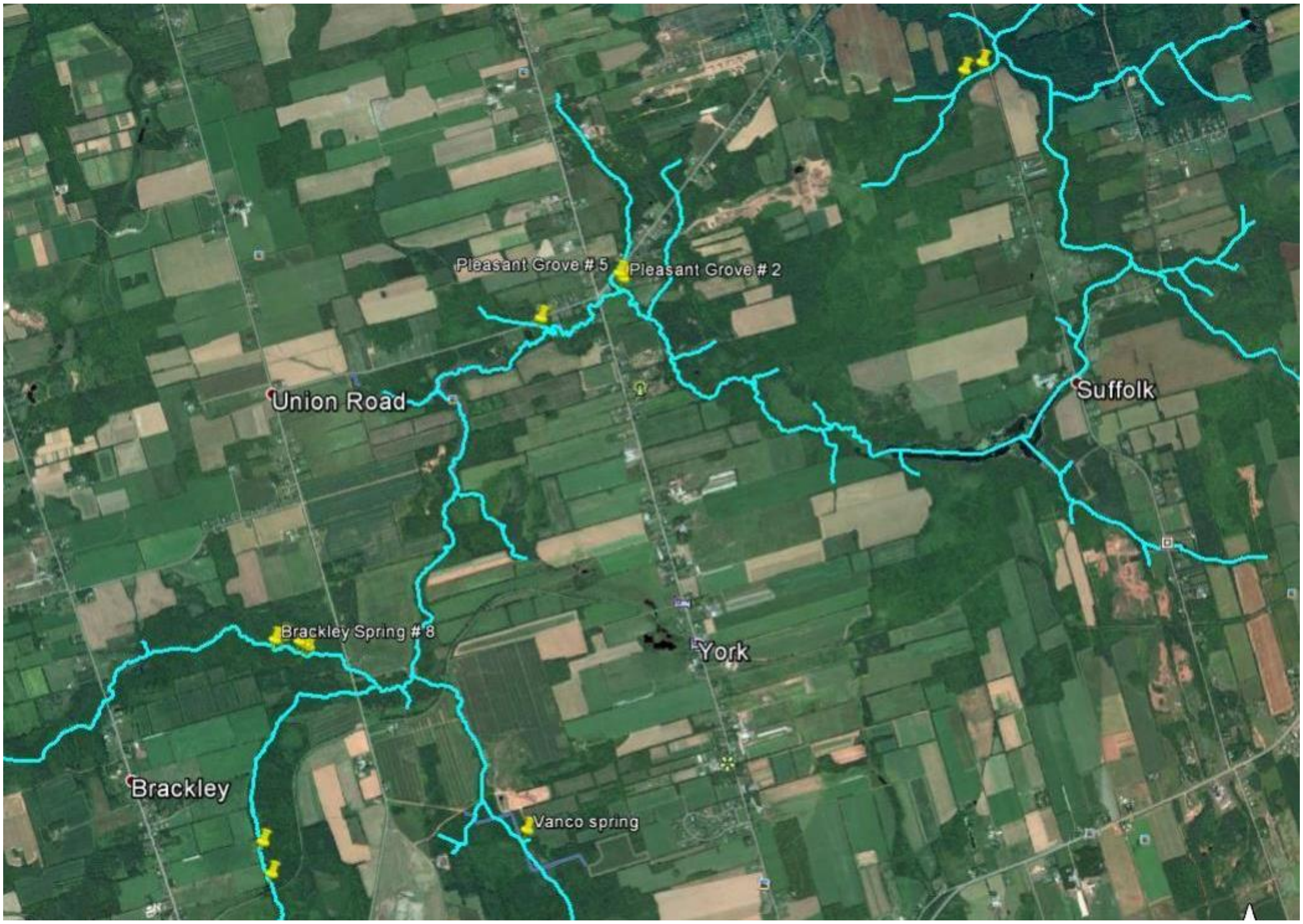


Figure 84. Map of weir locations for the 2018 field season.

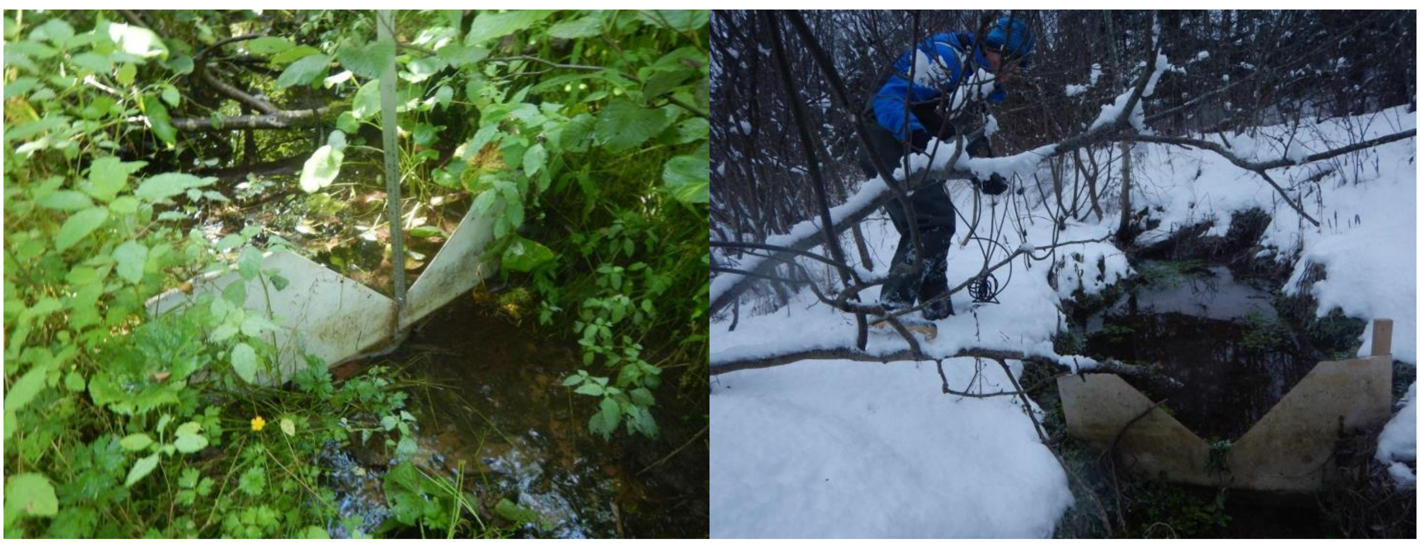


Figure 85. The correct way to measure the depth of v-notch weirs with the ruler (left) and Pleasant Grove #2 weir (right).

Figure 86. Tim's Upper weir (left) and Tim’s Lower weir (right).

Figure 87. Vanco weir (left) and Cudmore #6 weir (right).

Figure 88. Brackley Weir #8 (left) and Brackley Weir #7 when nearly dry.

Figure 89. Removal of one of the Brackley Weirs.

5.3.2 *Results*

The following graphs have a degree of error due to weather conditions, beaver activity and daily evaporation. The unnatural drying up of the Brackley springs directly match up with the time periods of highest water extraction via the Union Pumping Station. The summer months are always the times of highest extraction. The springs began to go dry on 2018-07-07 and all Brackley branch springs were dry by 2018-08-15. The Brackley springs began to recharge in mid-November.

Table 43. Number of dry days at each spring location in 2018.

Spring Location	**Days**		**Spring Location**	**Days**
Brackley #3	131		Cudmore #6	0
Brackley #4	107		Cudmore #3	0
Brackley #6	99		Affleck's Upper	0
Brackley #7	92		Tim's Creek Lower	0
Brackley #8	114		Tim's Creek Upper	0
Vanco	0		Pleasant Grove #2	0
			Pleasant Grove #5	0

Groundwater Spring Monitoring 2018

Spring Location	**Wellfield Distance (m)**	2018-06-11	2018-07-03	2018-07-08	2018-07-07	2018-07-24	2018-07-25	2018-07-31	2018-08-08	2018-08-15	2018-08-23	2018-09-17	2018-10-01	2018-11-01	2018-11-15	2018-11-27	2018-12-06
Brackley #3	698	W	W	W	D	D	X	D	D	D	D	D	D	D	W	W	W
Brackley #4	736	W	L	W	W	W	X	D	D	D	D	D	D	D	W	X	X
Brackley #6	764	X	W	W	W	W	X	W	D	D	D	D	D	D	W	X	X
Brackley #7	871	X	W	X	W	W	X	W	W	D	D	D	D	D	W	X	X
Brackley #8	932	W	W	X	W	D	X	D	D	D	D	D	D	D	W	X	X
Vanco	1386	W	X	W	X	X	W	X	W	W	W	W	W	W	W	W	W
Cudmore #6	1572	W	X	W	X	W	X	W	W	W	W	W	W	W	W	X	W
Cudmore #3	1710	W	X	W	X	W	X	W	W	W	W	W	W	W	W	W	X
Affleck's Upper	2472	W	W	W	X	X	W	W	W	W	W	W	W	W	W	X	X
Tim's Creek Lower	2692	W	X	W	X	X	W	W	W	W	W	W	W	W	W	X	X
Tim's Creek Upper	2696	W	X	X	X	X	W	W	W	W	W	W	W	W	W	W	W
Pleasant Grove #2	2926	X	X	X	X	X	X	W	W	W	W	W	W	W	W	X	X
Pleasant Grove #5	2927	X	X	X	X	X	X	W	W	W	W	W	W	W	W	X	X

W	Water
D	Dry
X	Not monitored

Figure 90. Groundwater Spring monitoring all weirs.

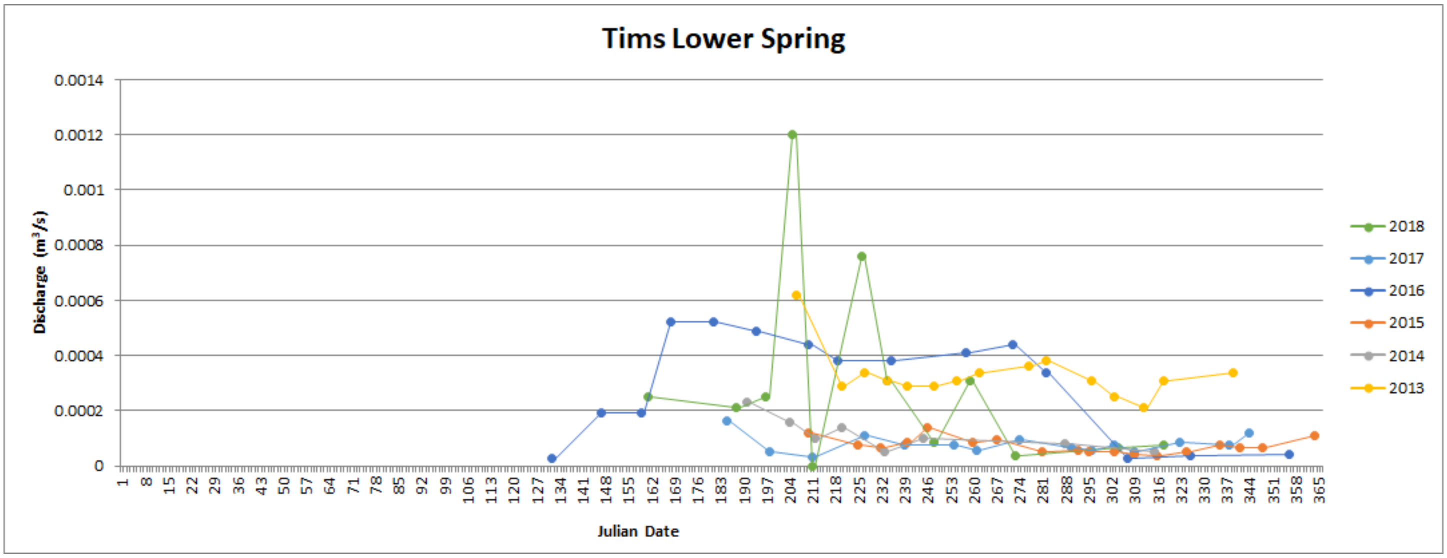


Figure 91. Flow measured all years at Tim's Lower weir.

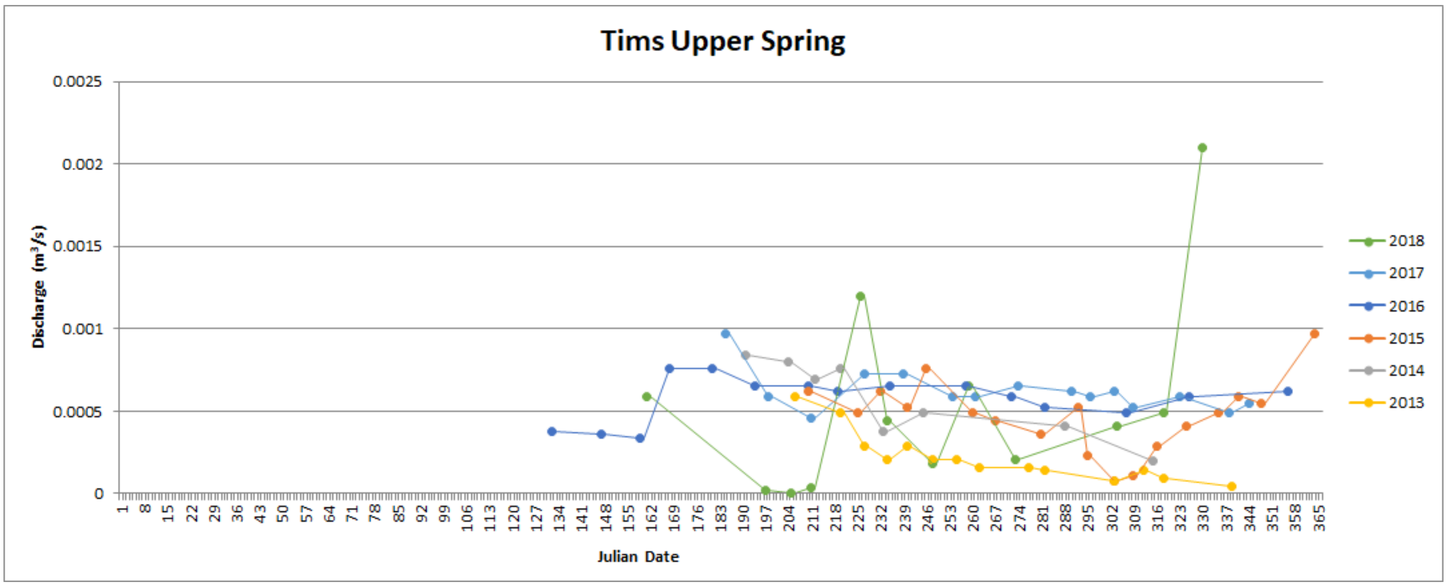


Figure 92. Flow measured all years at Tim's Upper weir.

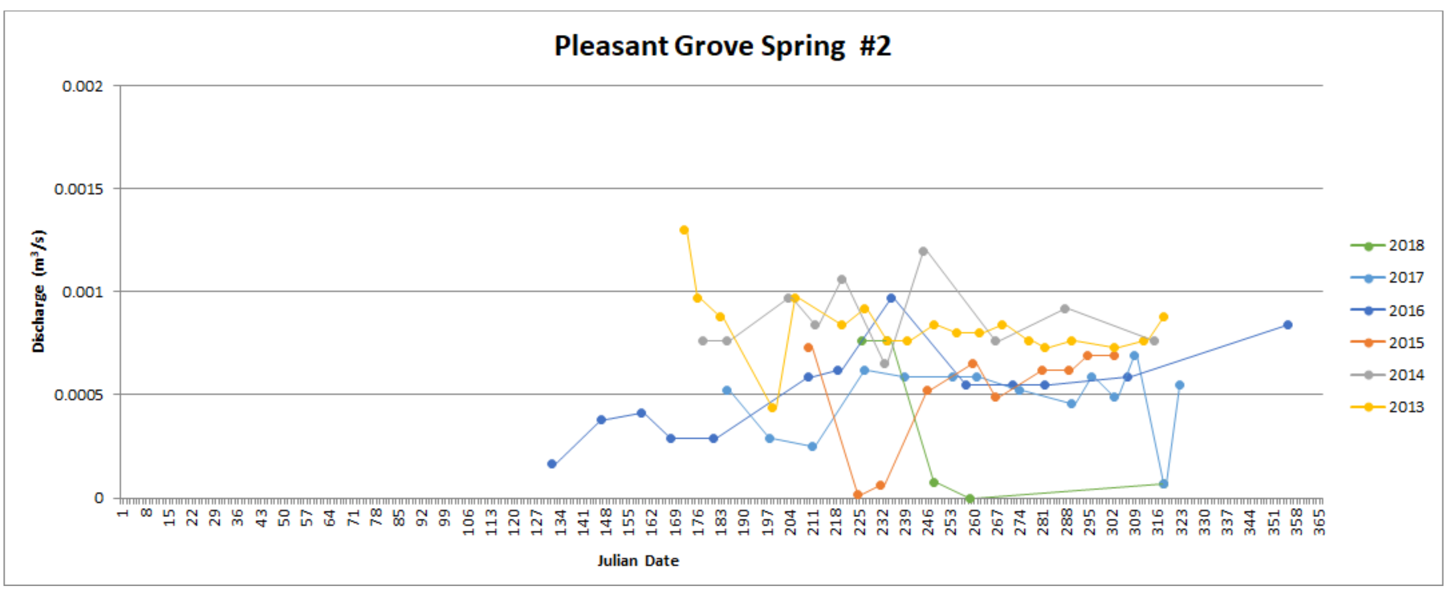


Figure 93. Flow measured all years at Pleasant Grove #2.

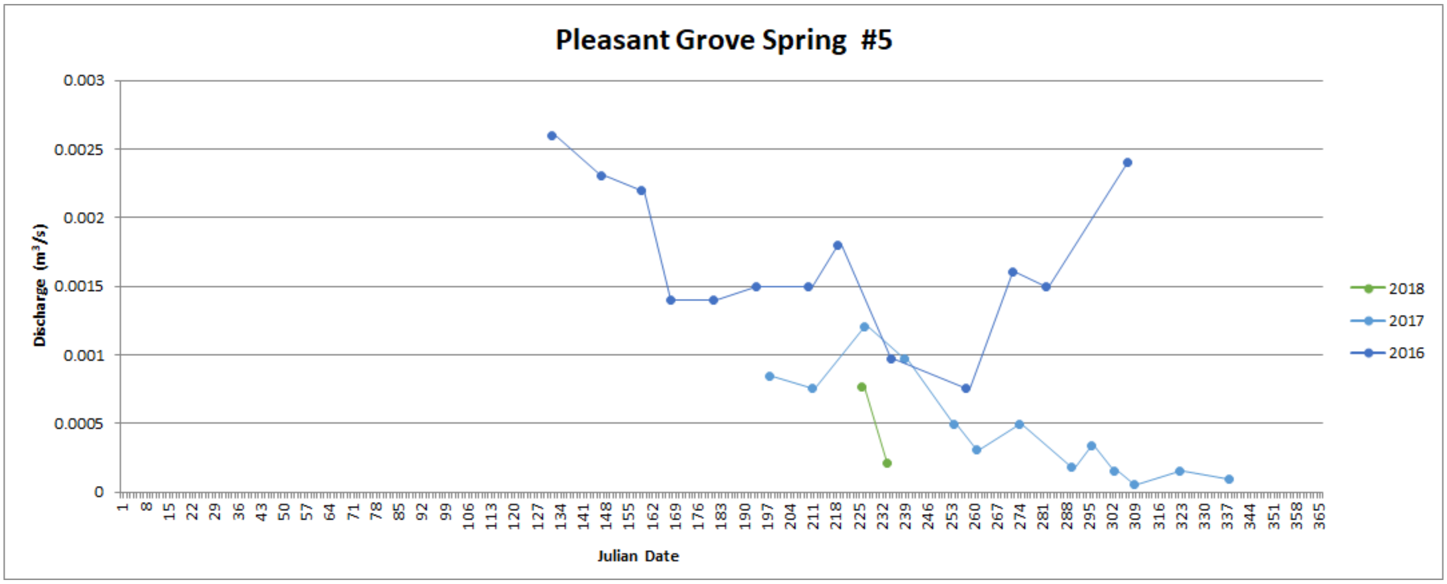


Figure 94: Flow measured all years Pleasant Grove #5.

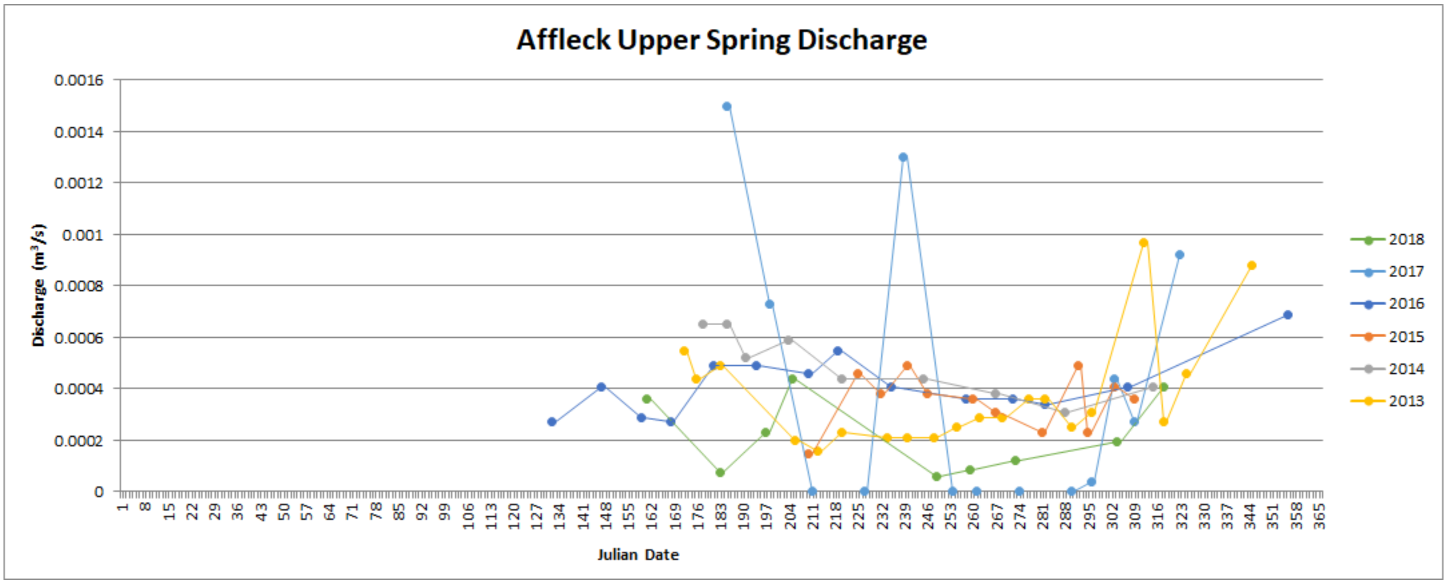


Figure 95. Flow measured all years Affleck Upper weir.

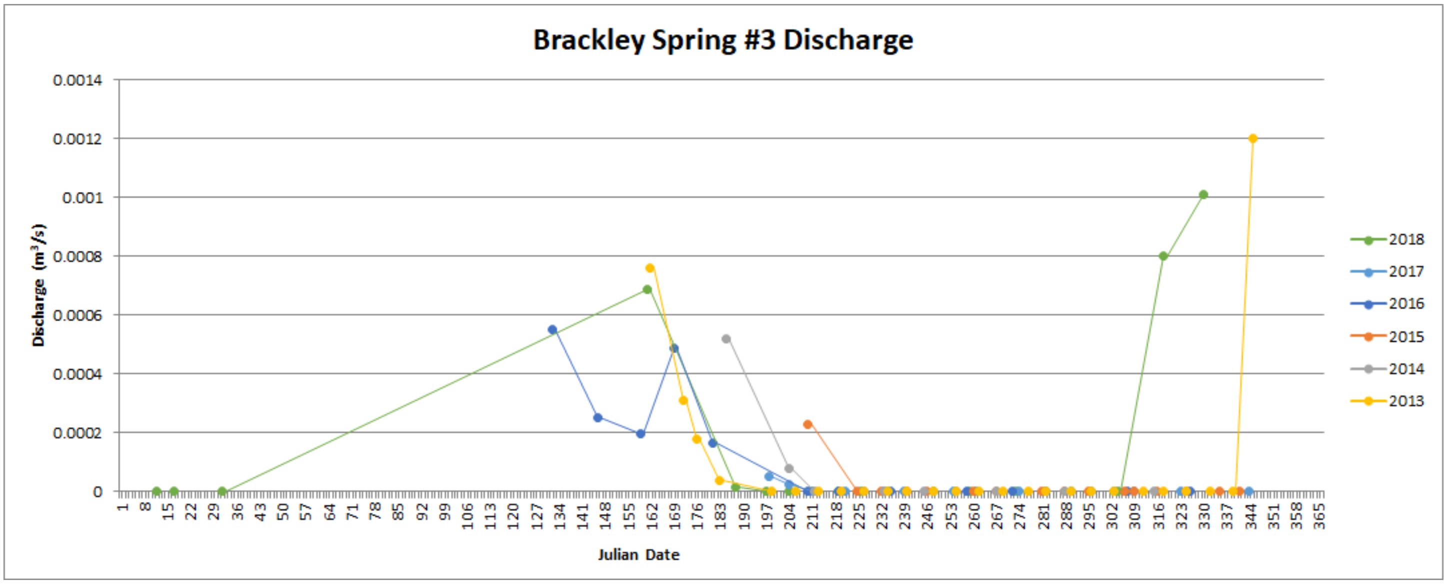


Figure 96. Flow measured all years Brackley #3.

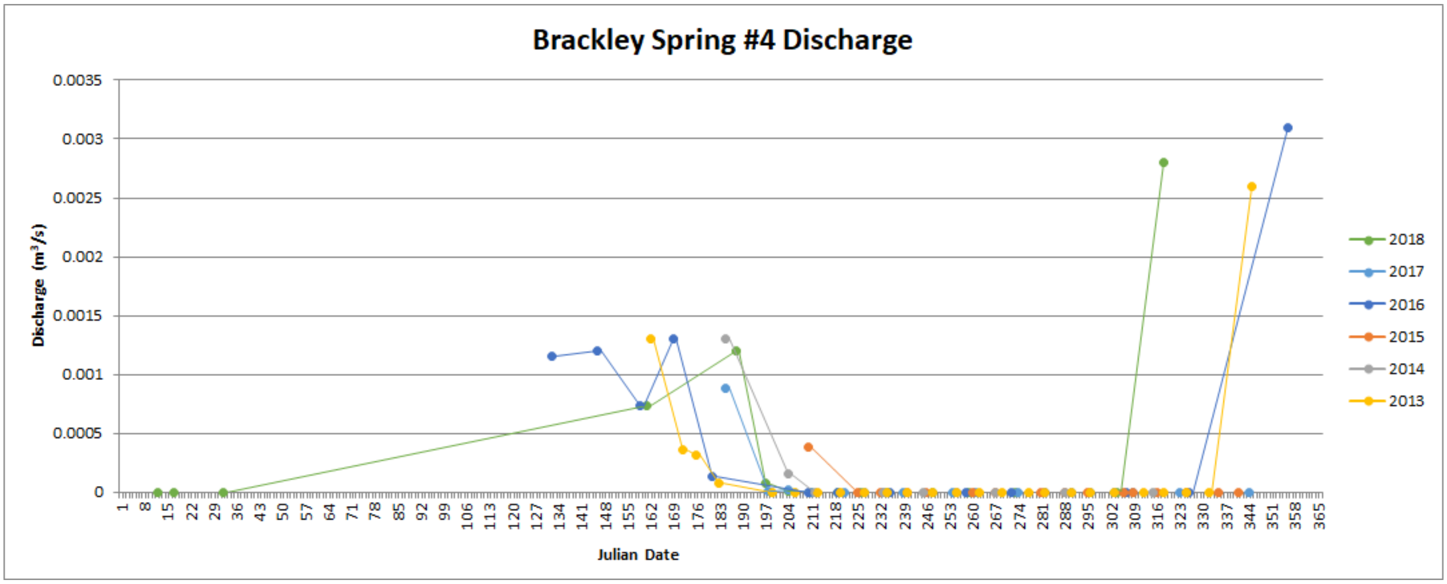


Figure 97. Flow measured all years Brackley #4.

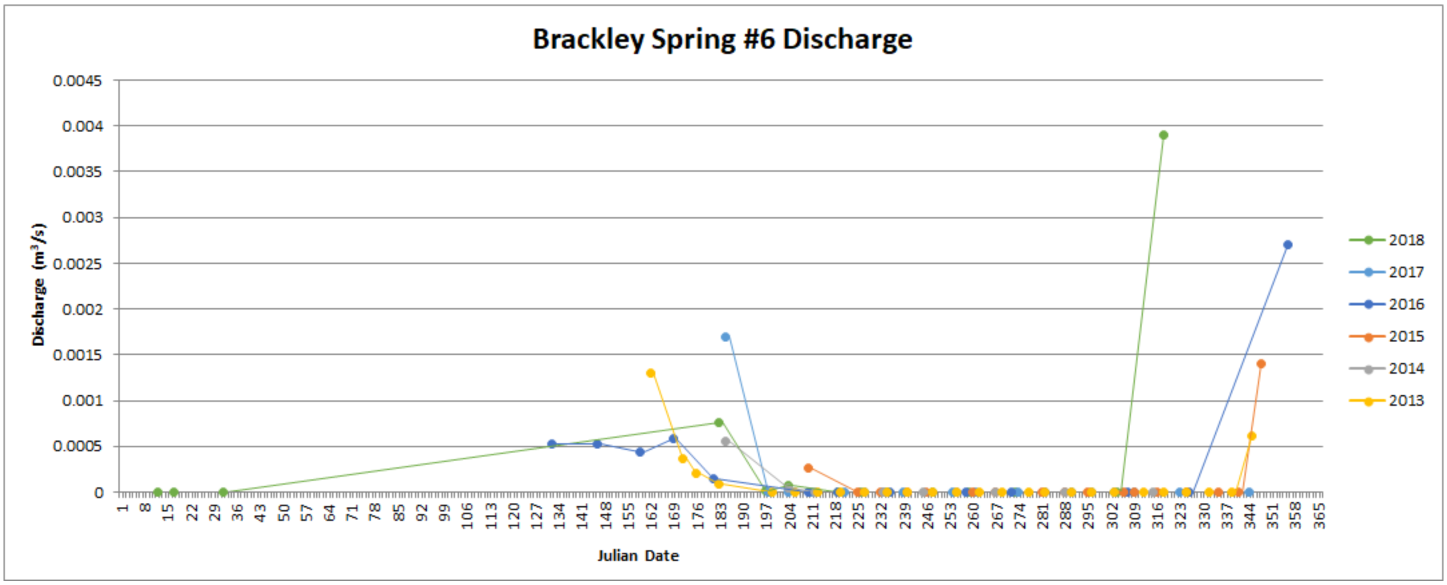


Figure 98. Flow measured all years Brackley #6.

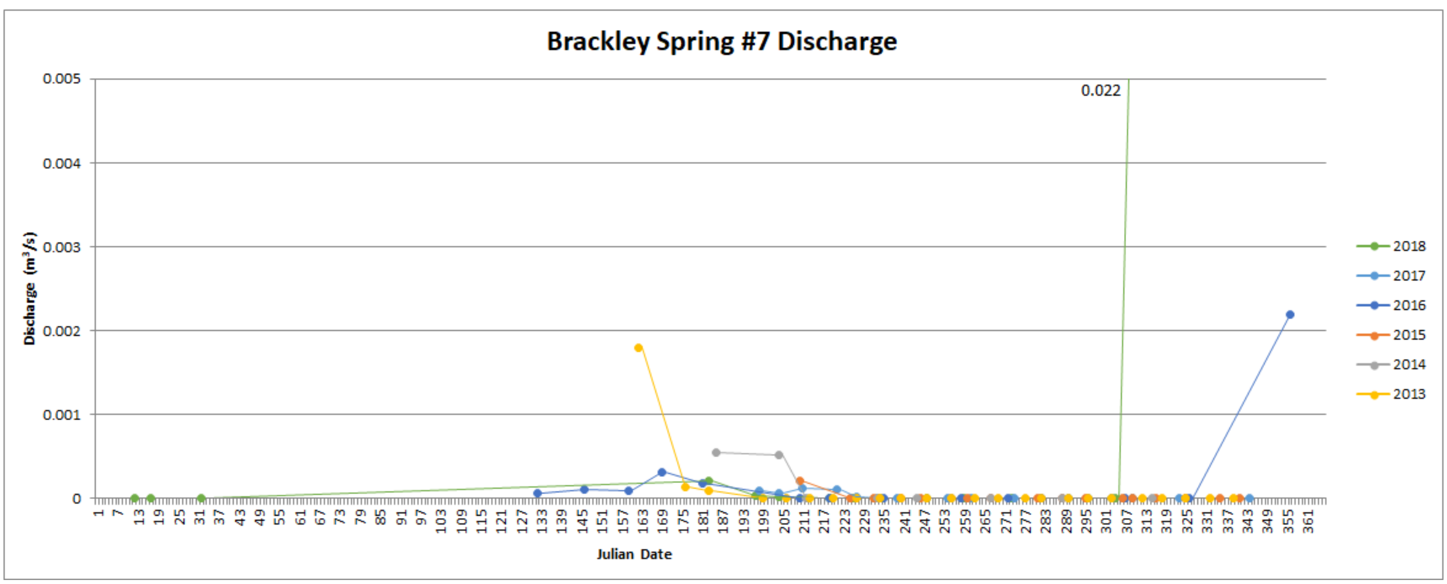


Figure 99. Flow measured all years Brackley #7.

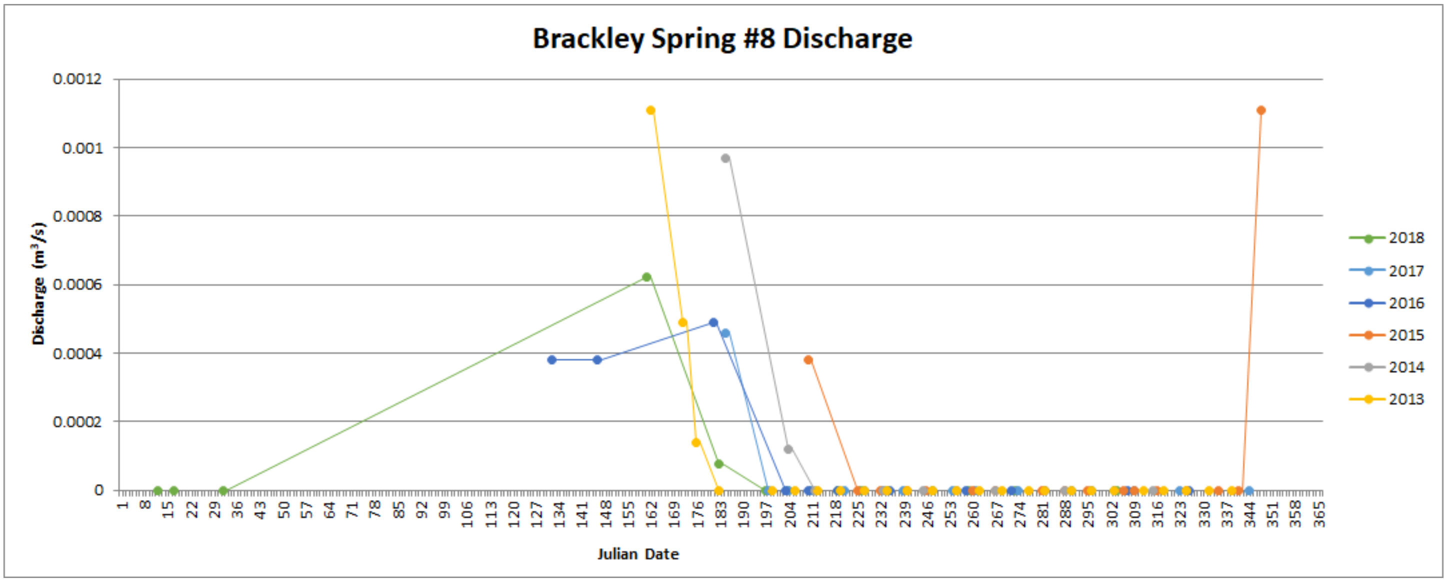


Figure 100. Flow measured all years Brackley #8.

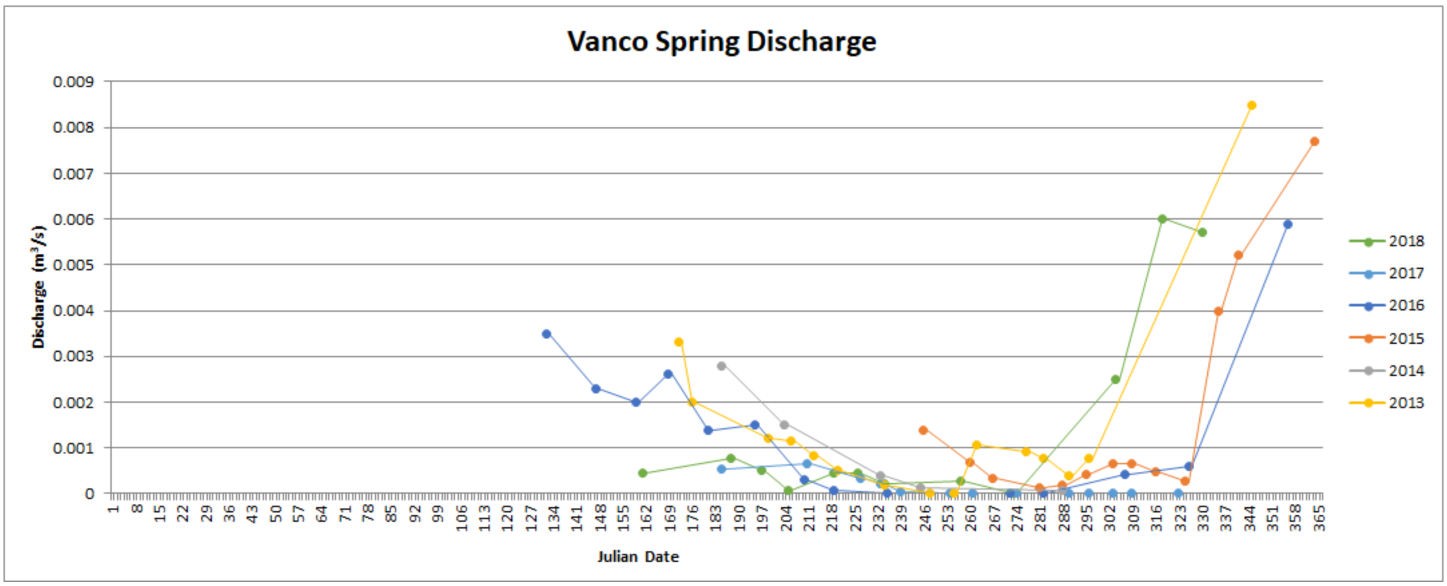


Figure 101. Flow measured 2018 Vanco weir.

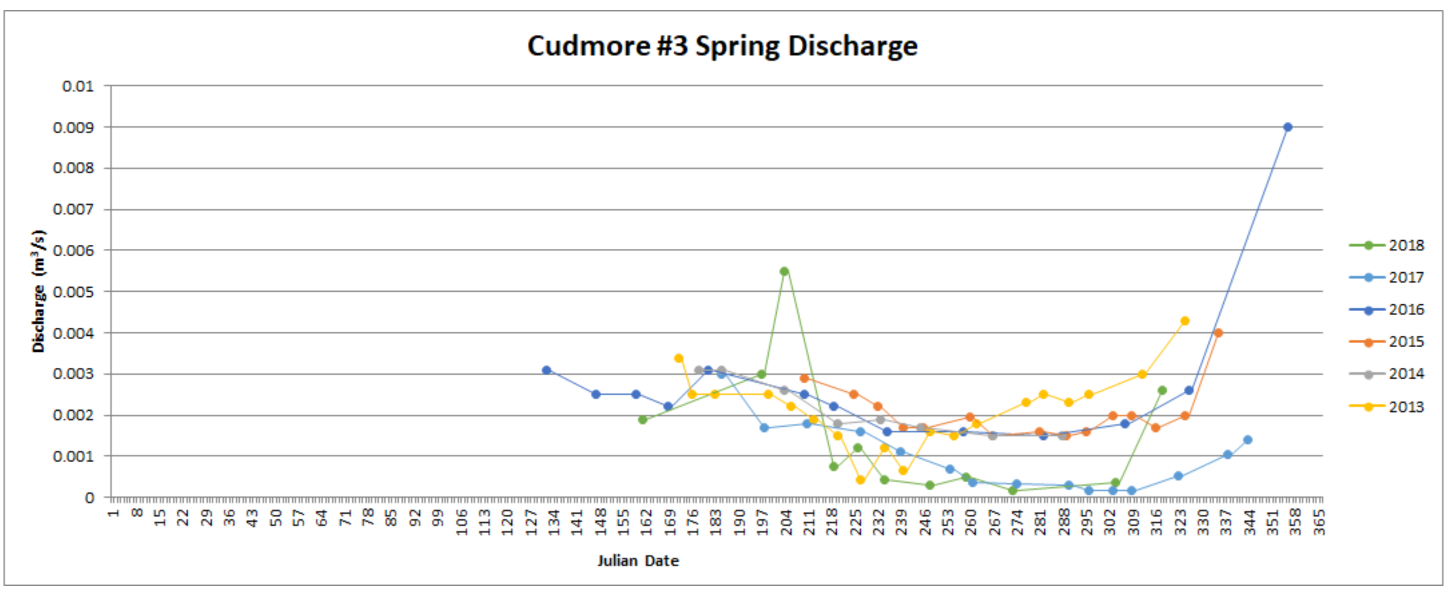


Figure 102. Spring flow measured at Cudmore #3.

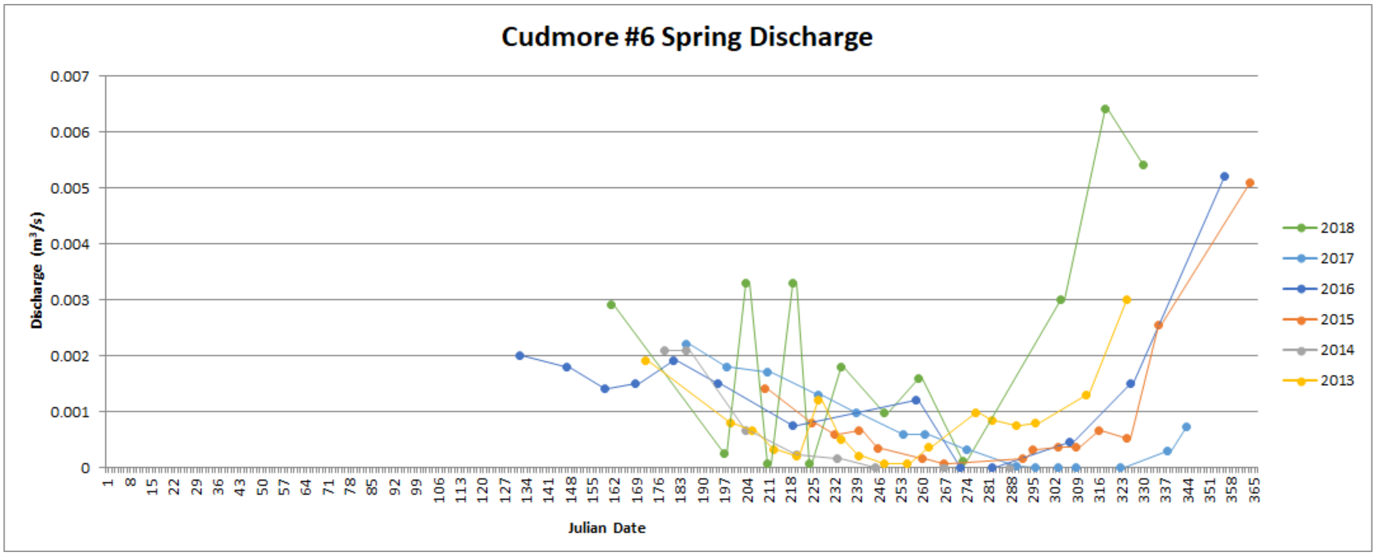


Figure 103. Spring flow measured at Cudmore #6.

5.3.3 *Discussion*

Weirs at Pleasant Grove #5 and Vanco had some issues with leaks throughout the field season. Both Pleasant Grove weirs were also unable to be monitored from June until 2018-07-25 due to a beaver flooding the area. All Brackley springs went dry by 2018-08-15 and resumed flowing by 2018-11-15. Brackley spring #3 was the first to dry up, on 2018-07-07. On 2018-07-24 Brackley #8 also went dry. The last to go dry was Brackley #7, which was the only spring in this branch that still had flow on 2018-08-08. The Brackley springs went dry during the times of lowest groundwater recharge and highest water use in the City of Charlottetown. This year had several periods of heavy rain, which created pools in the Brackley branch, but this water was not supplied via groundwater.

The Pleasant Grove area experienced beaver flooding this year. The beavers built a dam in the area and the stream channel became more of a pond. The 2 nearby weirs, Pleasant Grove #2 and Pleasant Grove #5, were overflowing with water throughout most of the summer season. This made v-notch depth measurements inaccurate and unable to be recorded during this period.

5.4 Dissolved Oxygen Loggers

5.4.1 *Methods*

This season, 3 dissolved oxygen (DO) loggers and 1 conductivity logger were installed. The first 2 dissolved oxygen loggers were installed near the Corran Ban Bridge; the 3rd was installed near the Pleasant Grove boat launch along with the conductivity logger. At the Corran Ban location, 1 logger was installed near the surface, and the other near the bottom of the water column.

The loggers were connected to a concrete anchor to avoid drifting from their location. The anchor was borrowed from the University of Prince Edward Island (UPEI) laboratory of Dr. Michael van den Heuvel. UPEI has access to a large boat to check their DO loggers, while WRTBWA has a canoe, so the design was modified to allow easier retrieval of loggers by staff. A second anchor was constructed, which was modeled after the UPEI version, but was heavier. The anchor was built by inserting a piece of steel rebar into liquid concrete that was poured into a rectangular form. The rebar was supported in place until the concrete set. The top end of the rebar was formed into a loop where a heavy rope was tied. At the other end of the rope a floatation device was attached. UPEI supplied flotation devices made of white Styrofoam, but we opted for orange plastic buoys, onto which we wrote “WRTBWA” with an Allflex tag pen (a super permanent marker commonly used by local farmers for labeling cow ear tags). We also installed signs near each logger to indicate that water-monitoring activities were taking place and to provide a contact number for people to call with any questions.

UPEI used the anchor described above, with the DO logger attached to the metal pole, and their staff would pull the entire anchor up from the seabed in order to download data or to perform maintenance on the logger. Our modification involved sliding a piece of PVC pipe onto the heavy rope and attaching the DO logger to this pipe. A second smaller rope was connected between the float and the PVC pipe. This enabled staff in a canoe to pull up only the PVC pipe and logger, leaving the anchor in place. Staff could then lower the PVC pipe and logger back down along the rope and onto the anchor again after maintenance was completed.

Surface loggers were connected directly to the heavy rope near the buoy, so they would always be submerged, but would not be too deep. The rope had to be long enough to reach between the anchor and the water surface as the water level changed due to tides and storms.

The loggers were deployed on 2018-08-01 and removed on 2018-10-10. After initial installation, the loggers were raised and cleaned on a weekly basis. Each time, readings were taken with a YSI Pro Plus to calibrate the readings from the DO logger. A volunteer retrieved the anchors at one point during the summer using a motorized boat loaned to us. However, this boat was not accessible to us at the end of the field season.

Figure 104. 2018 Dissolved oxygen logger and conductivity logger locations. DO1 at Corran Ban and DO2 at Pleasant Grove.

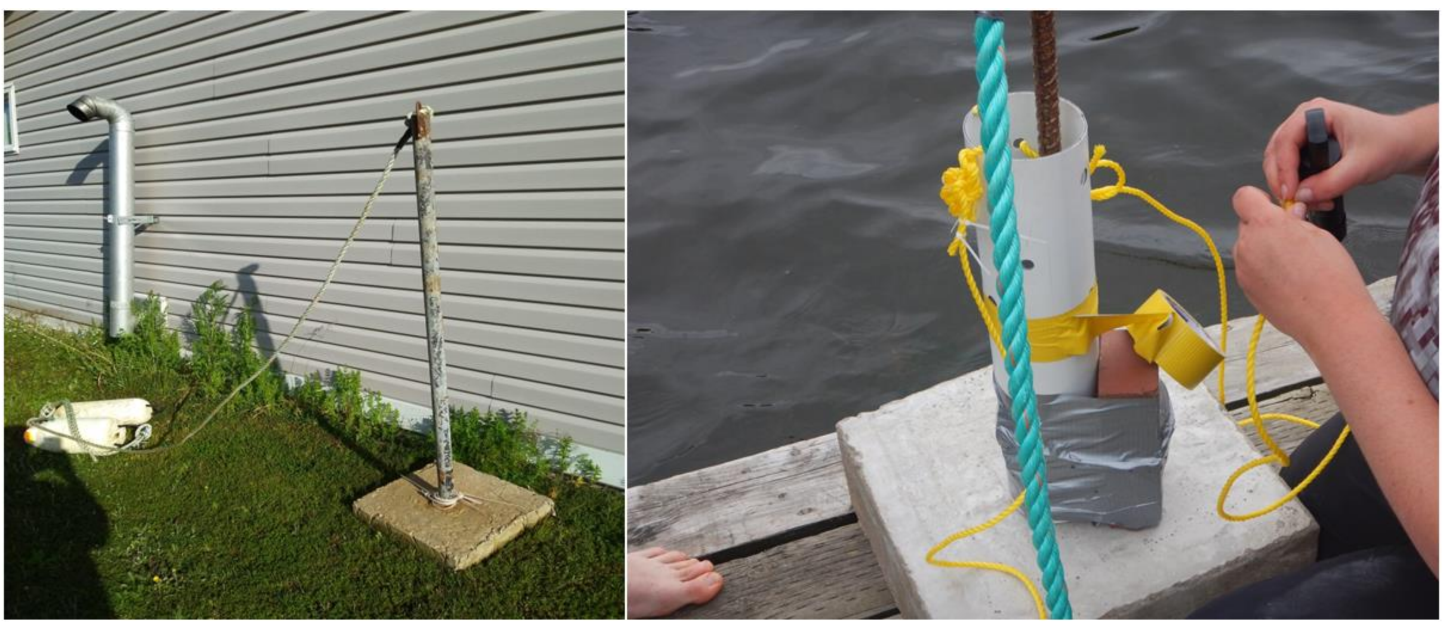


Figure 105. Modifications to the anchor to allow easier retrieval of the logger at the bottom of the water column.

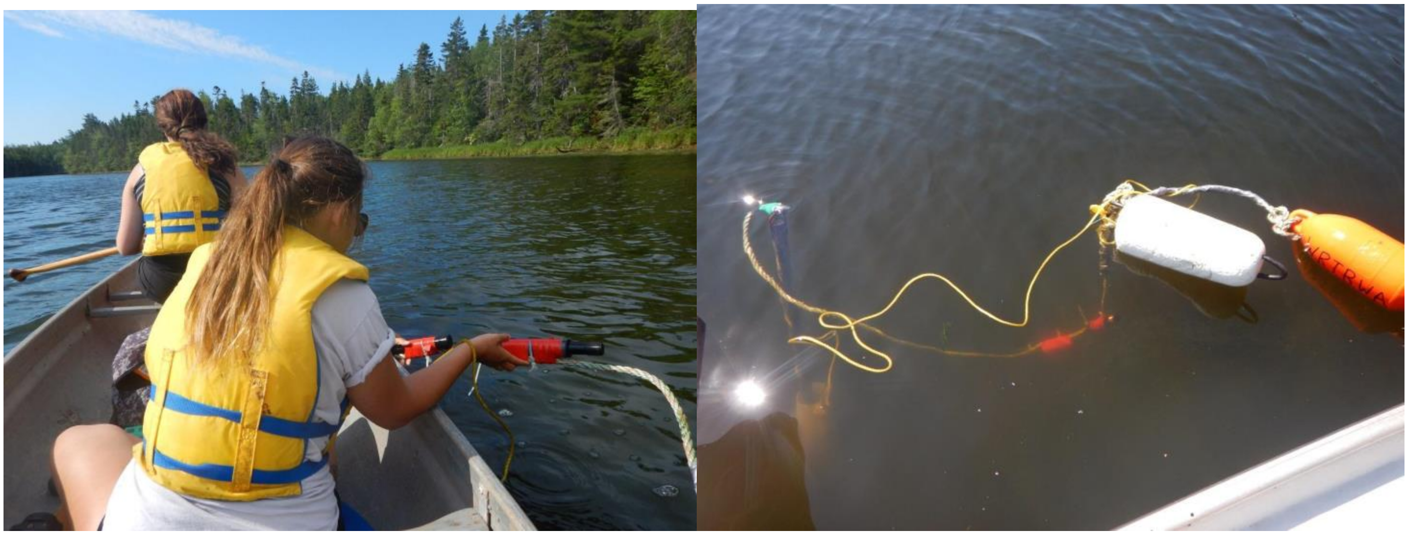


Figure 106. The dissolved oxygen and conductivity logger about to be deployed (left) and once installed (right) at the Pleasant Grove site.

Figure 107. Dissolved oxygen logger being deployed at Corran Ban Bridge. Black/grey logger is attached to a PVC pipe and will slide down the blue rope to the bottom of the water column.

5.4.2 *Results & Discussion*

The results from the loggers showed low accuracy for the DO readings, so they will not be made public. However, the general trends seemed to be accurate. The loggers did show a time frame where the water was anoxic that matched up with when anoxic conditions were observed in the estuary. There were a few issues with the loggers over their deployment periods. There was an issue where the loggers read very high dissolved oxygen values, while the weekly YSI readings never read close to those numbers. The DO logger at the Pleasant Grove site, where conductivity fluctuates with tide levels, must be calibrated with the data recorded on the conductivity logger, and the conductivity logger itself must be calibrated against YSI readings. The conductivity logger seemed to have inaccurate readings, so the DO readings also lacked accuracy. Analyzing the data without factoring in the conductivity changes, due to changes in salinity as tides go in and out, would have also led to lower accuracy. Problems with taking YSI readings also led to low accuracy in our results. Readings were generally only taken at the water surface, not at the depth where the bottom DO logger at Corran Ban was located. As such, the lower Corran Ban logger could only be calibrated against the YSI results from the surface.

The anchor that we constructed was larger than the original provided by UPEI and it proved to be too heavy to easily retrieve in the fall. We ended up needing UPEI staff to bring their boat out to retrieve the last logger at Corran Ban.

5.5 Spring Water Monitoring

5.5.1 *Methods*

Various streams were walked at the beginning of the field season and measurements were taken using a YSI Pro Plus at all sites with springs. Readings of temperature, nitrate, conductivity, pH, and dissolved oxygen were recorded. Nitrate readings were the most important, as they could indicate fertilizer runoff or areas of erosion. The stream was also tested every few hundred meters to provide comparison to the spring readings.

5.5.2 *Results*

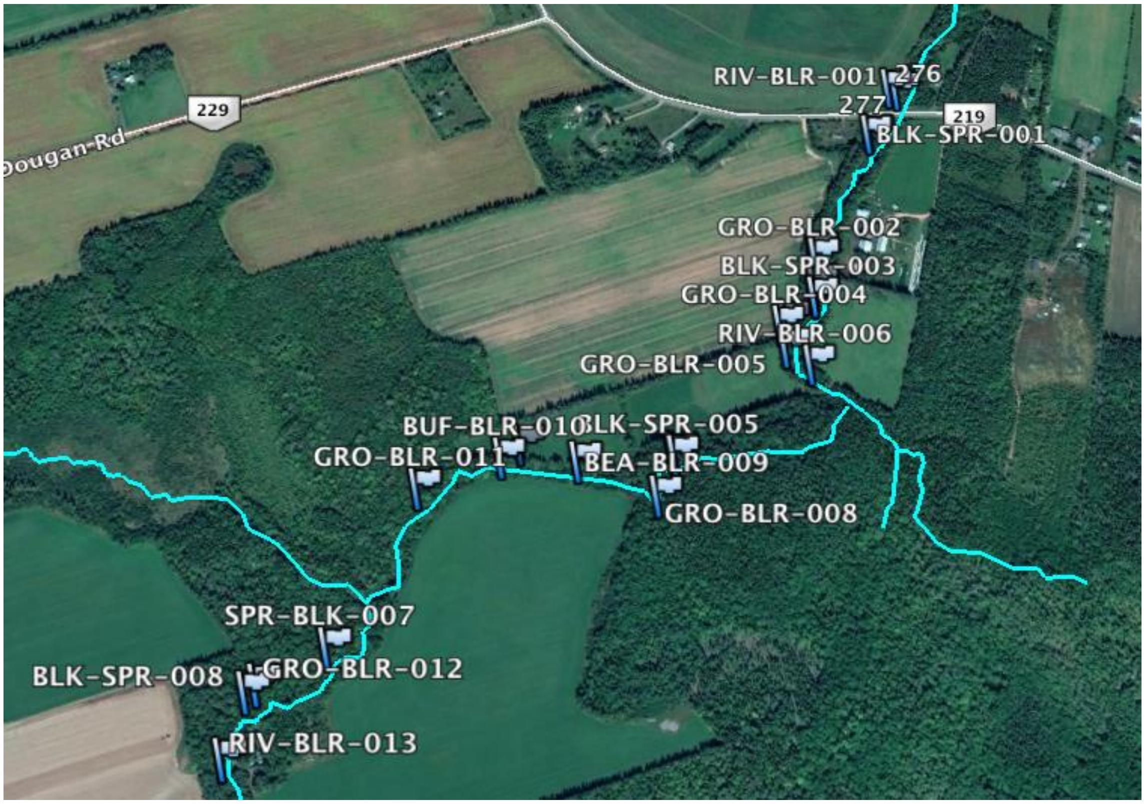


Figure 108. Black River spring water monitoring locations 2018.

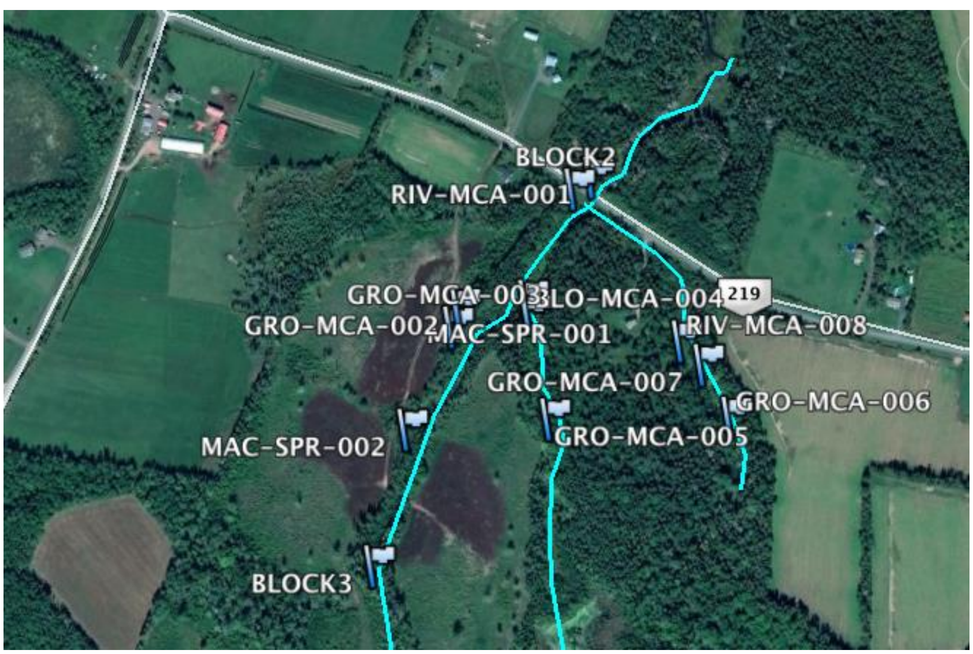


Figure 109. MacAulay's spring water monitoring locations 2018.

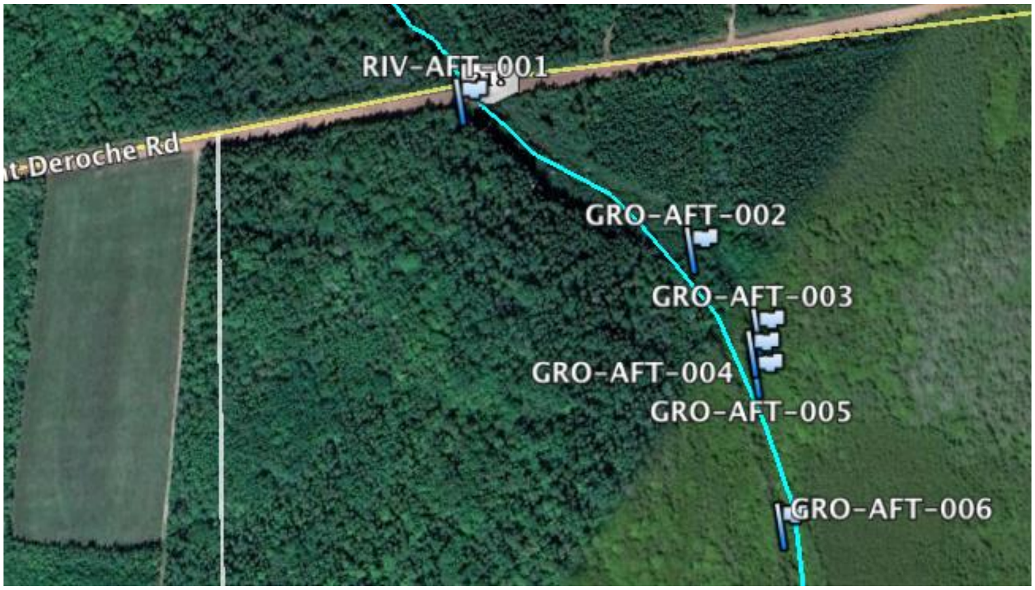


Figure 110. Afton branch spring water monitoring locations 2018.

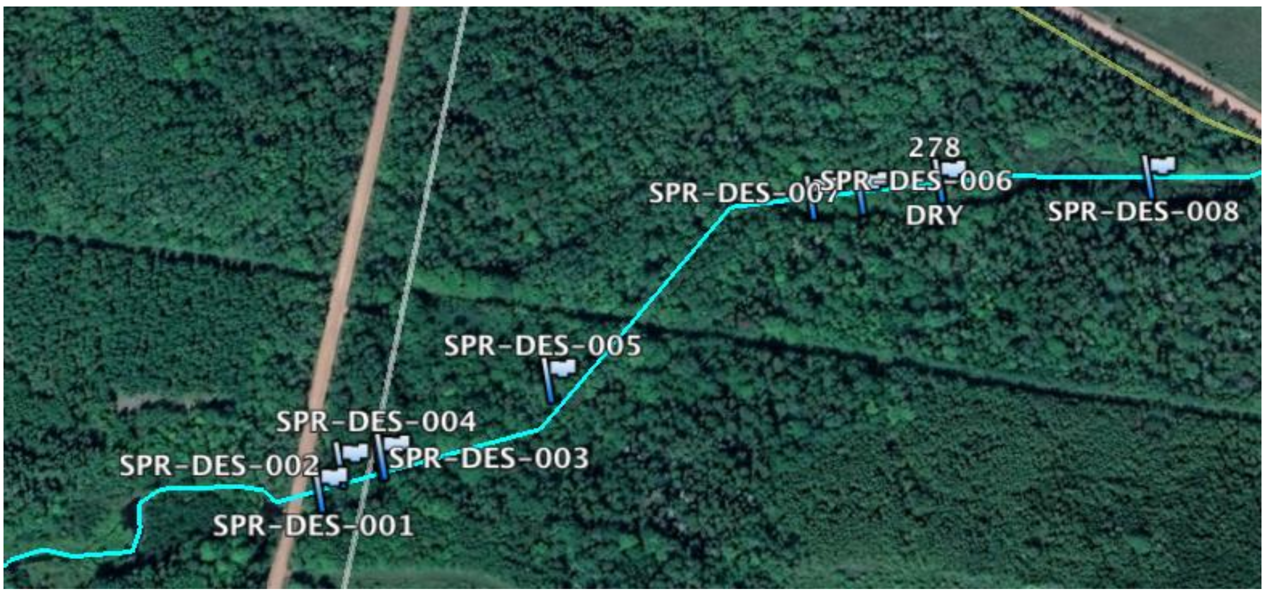


Figure 111. Deroche branch spring water monitoring locations 2018.

Table 44. Spring water monitoring results summary, values are across all sites evaluated in 2018.

	Maximum	**Minimum**	**Average**
Temperature	13.5	6.7	9.7
Dissolved Oxygen	10	1.0	5.47
Conductivity	244.0	89.5	157.6
pH	7.47	6.9	7.13
Nitrates	3.47	1.4	2.11

5.5.3 *Discussion*

Resampling was scheduled to take place in the fall; especially at locations where elevated nitrate levels had been recorded. However, this was not possible. The nitrate probe for the YSI meter malfunctioned and was sent back to the manufacturer on 2018-10-11, while it was still under its warranty period. The returned item still did not function, so it was sent back again on 2018-11-08 for a warranty replacement. Unfortunately, the replacement nitrate probe was not received until late December, so repeat sampling could not take place.

The springs are important to monitor, as they provide much of the water to the stream. The stream is affected by weather and runoff more readily than springs. The stream temperature is also affected by the springs throughout the year. Springs stay at a consistent temperature (around 7℃) year-round, providing cooler water in the summer and warmer water in the winter. Springs also can be an indicator of groundwater conditions. When a high level of groundwater is extracted, such as in the Brackley Branch, the stream may still be full of water, but the springs may be dry. The streams can hold more water and collect rainwater, leaving them to appear healthy for a time after the groundwater extraction has begun causing detrimental effects. The drying up of springs often occurs before the drying of a stream.

The parameters checked with the YSI included temperature, pH, nitrates, dissolved oxygen, and conductivity. Temperature is important as fish can only spawn and survive in certain temperature ranges. Brook Trout, a native species here on PEI, cannot live in temperatures over 20°C. They thrive in the temperature range of 11-18°C. pH is a scale of acidity that ranges from to 14, with 0 being the most acidic and 14 being the most basic. A reading of 7 is considered a neutral pH. PEI streams have an average pH of 7.7. Estuaries have an average pH range of 4.6-9.4, according to the 1999 PEI water quality interpretive report.

Nitrates are one of the parameters we focus on the most, as high nitrate levels can be attributed to fertilizer or pesticide runoff. The PEI government site reports "human activity is responsible for over 90% of the nitrates in many Island waterways." Over abundances of nitrates in the water can cause algal blooms, which will eventually die off, leading to eutrophication. Recording areas of frequent nitrate level spikes can help us determine the point source of the issue. Often the cause is found to be farm fields with insufficient buffer zones.

Dissolved oxygen is required by fish for respiration in the water. Low dissolved oxygen can result in anoxia, leading to the death of aquatic life. Dissolved oxygen is further discussed in section 5.4. Conductivity measures the water's ability to conduct electricity, which is higher when there are more dissolved solids in the water. Conductivity also relates to salinity; higher salinity means higher conductivity. Water with no dissolved solids, such as distilled water would have a very low conductivity reading, freshwater streams would have a higher reading, and salt water would have very high values. This is why the conductivity values are much higher during the estuary survey than the readings we record in the streams. Another factor that alters conductivity is heavy rainfall. Precipitation may cause an increase or decrease to the waterbody's conductivity, due to runoff or dilution, respectively.

5.6 Estuary Watch Survey

5.6.1 *Methods*

The crew surveyed the estuary on a weekly basis during the summer months. 3 crew members would use a canoe to travel upstream from the Corran Ban Bridge, past the Pleasant Grove dock and to the main branch of the Winter River. The Winter Bay estuary was also monitored. YSI readings were taken every 100 meters, where dissolved oxygen, temperature, conductivity, and pH were all recorded. The nitrate probe for the YSI cannot be used in salt water so there were no nitrate readings taken.

Members of the community also aided in reporting times of anoxia by calling the Watershed group and informing of green water conditions or foul smell.

Figure 112. The estuary before any anoxic events. Water is clear and blue. Sign located near dissolved oxygen loggers.

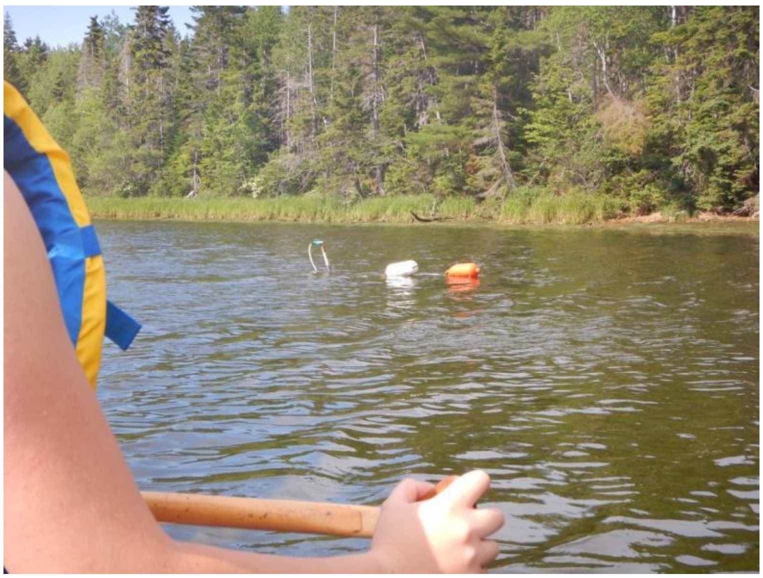


Figure 113. The Pleasant Grove estuary during an anoxic event.

5.6.2 *Results*

Table 45. Estuary results, across all points recorded in the estuary in 2018.

	Maximum	Minimum	Average
Temperature	26.2	13.4	20.4
Dissolved Oxygen	10.0	0.1	5.9
Conductivity	40,682.0	106.5	27,850.0
pH	8.91	6.40	7.98

5.6.3 *Discussion*

According to the Virginia Institute of Marine Science, hypoxia occurs when the dissolved oxygen values read below 2 mg/L and anoxia is considered when there is essentially no dissolved oxygen. Anoxia can also be observed from a foul odor and green, murky water, as presented in Figure 113. The YSI used by WRTBWA is accurate to +/- 0.2 mg/L, so even if a reading of 2.2 is read, the water may still be hypoxic. An estuary is considered unhealthy below 8 mg/L, thus with an average dissolved oxygen reading of 5.9 mg/L during the field season of 2018, the Winter Bay estuary is not an ideal environment for most aquatic life.

The YSI readings showed anoxic conditions on 2018-06-20, 2018-07-10, 2018-08-03, 2018-08-09, 2018-08-10, 2018-08-13, and 2018-08-22.

6 Public Affairs

6.1 Community Involvement

WRTBWA held several events throughout the year to help the community engage with the environment. WRTBWA held the annual Lady Slipper Hike on 2018-06-09 at the trailhead of the Winter River Trail. Several staff from WRTBWA, several board members and 21 guests attended the event. Staff and board members educated guests on tree identification, the history of WRTBWA, and various projects, past and present, that WRTBWA accomplished.

In June, WRTBWA had 3 different groups of students come for field trips to help plant trees and participate in a beach cleanup. Overall, they planted 329 trees at a section of the Glenaladale shorefront and removed many bags of garbage from the shoreline around Glenaladale and nearby beaches.

Figure 114. Students picking up garbage from the Glenaladale shoreline. Boats harvesting mussels are seen in the background, an industry that is responsible for a large portion of the garbage we cleaned up from the shore.

Figure 115. Students planting trees at Glenaladale property by the shore.

6.2 Educational Day

Watershed groups from around the Island were invited to attend an educational day at MacPhail's Woodlot with Gary Schneider. Gary started the day indoors with various slide shows on wildlife and tree identification. Following the slideshow, Gary gave us a tour of his tree nursery, pointing out all the different species of trees and key features for identifying them. He talked about the importance of diversity and how the nursery has Witch Hazel and Beaked Hazelnut growing, which are not common on PEI despite being native species. He also taught the participants how to properly prune trees and had them practice on various trees.

There was also an educational day held in Brookfield by Central Queens Wildlife Federation, where they showed Watershed workers how to build brush mats, plant trees, and make homes for fish with rocks.

Figure 116. Staff member Sam MacSwain receives some tips on tree pruning from Gary Schneider.

6.3 Water Makeover Program

Overall, 71 residences and 4 businesses took part in our Water Makeover Program, which wrapped up in spring 2018. Our program started in 2016 to help the City of Charlottetown reduce their water usage. All the water for the City is currently being extracted from the Winter River. WRTBWA offered water-saving devices such as low-flow toilets, low-flow showerheads, faucet aerators, rain barrels, and shower timers to households for a small fee. We targeted homeowners and small businesses that were using a water meter, so we could determine how much water they saved after switching out some of their devices.

7 References

Andreozzi, H. (2018, January 26). Headwater Streams. Retrieved from https://extension.unh.edu/resource/headwater-streams

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Khodier, M., Tullis, B. (2016). Fish Passage Behavior through Baffled and Nonbaffled Culvert. In B. Crookston & B. Tullis (Eds.), Hydraulic Structures and Water System Management. 6th IAHR International Symposium on Hydraulic Structures, Portland, OR, 27-30 June (pp. 295-301). doi:10.15142/T3110628160853 (ISBN 978-1-884575-75-4).

Matthew C. Kondratieff & Christopher A. Myrick (2006) How High Can Brook Trout Jump? A Laboratory Evaluation of Brook Trout Jumping Performance, Transactions of the American Fisheries Society, 135:2, 361-370, DOI: 10.1577/T04-210.1

8 Appendices

8.1 Appendix 1: Bathymetric map of Officer's Pond from 1994 master's project

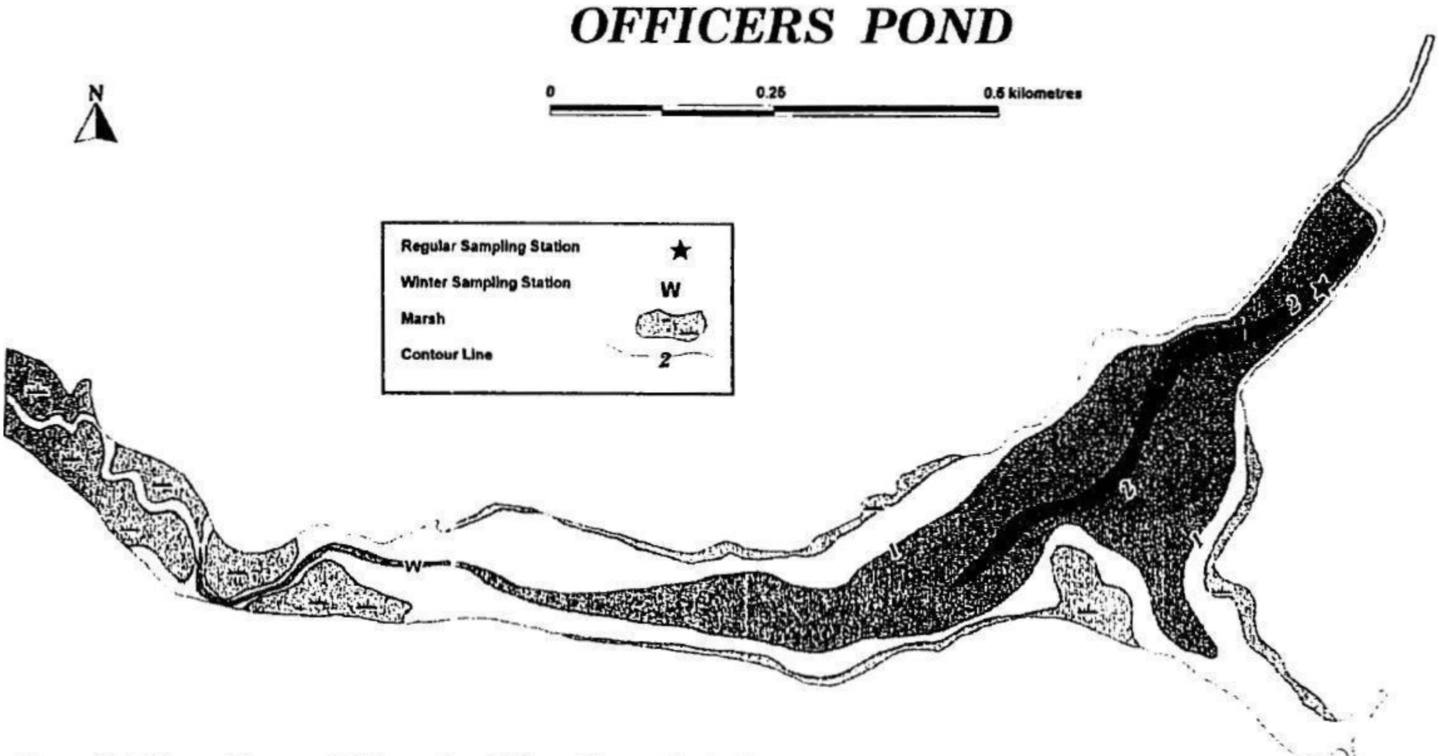
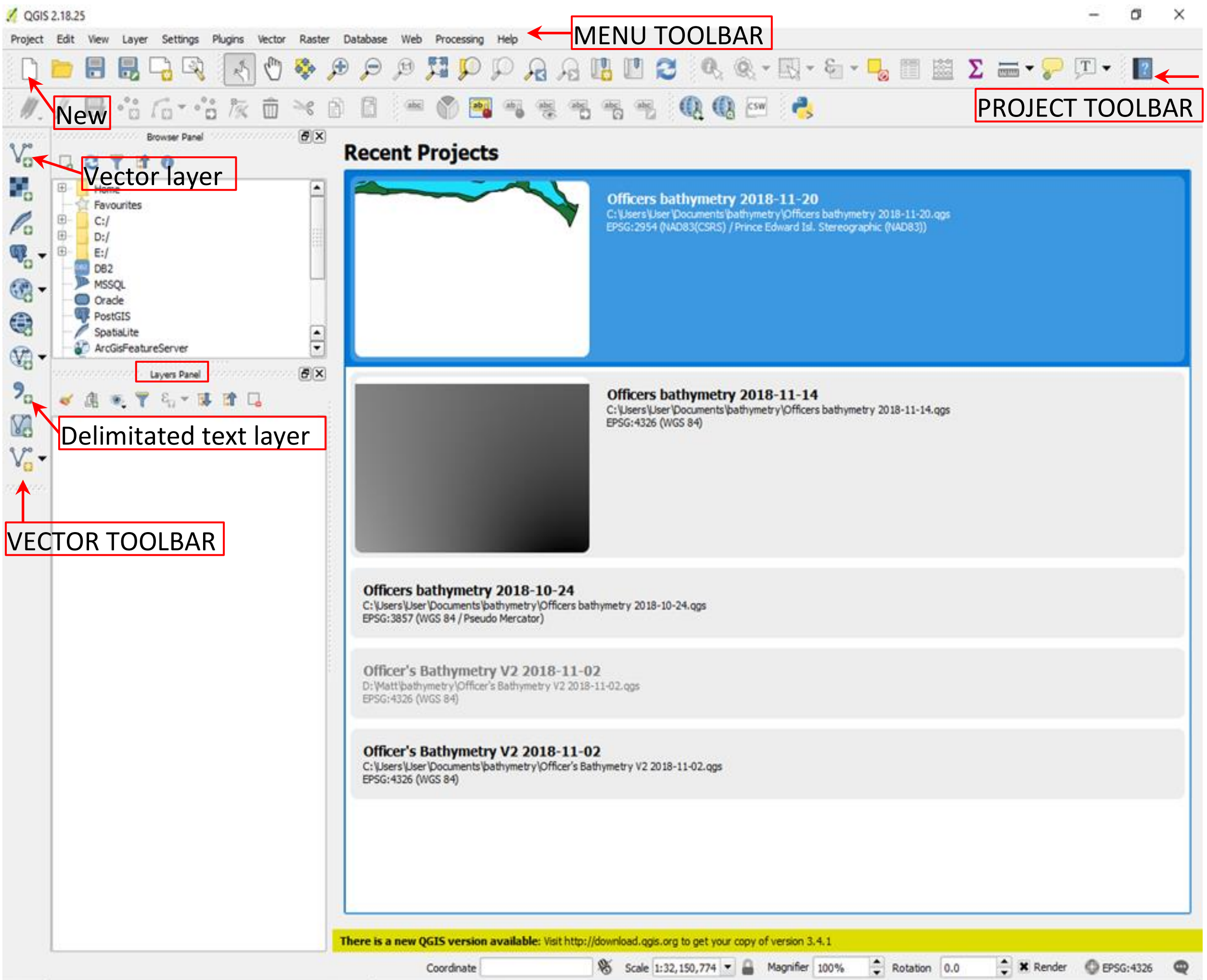


Figure 19. Bathymetric map of Officers Pond, Winter River, with depth contours at 1.0 metre.

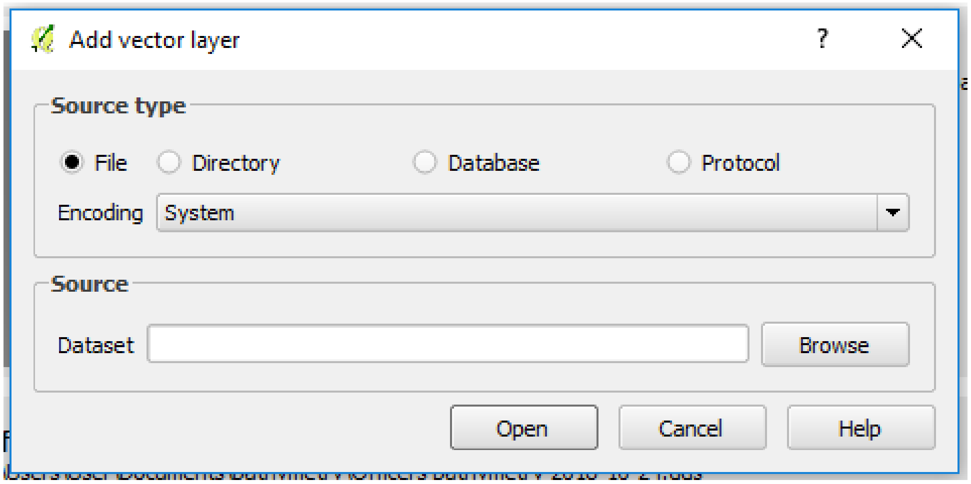
8.2 Appendix 2: Methods for creating a bathymetric map in QGIS

STEPS TO CREATE A BATHYMETRIC MAP USING QGIS 2.18

1. START UP
    a. Using field data entered in Excel, create a new sheet with x (longitudinal values), y (latitudinal values) & z (elevation values) column header, change z values from cm to m, change z values from positive to negative, save as Microsoft Excel Comma Separated Values File (CSV File)
        i. Do not include the zero values of the edges as this will impact interpolation.
    b. In Google Earth, create polygons surrounding the required perimeter (i.e., create separate polygon files for water, vegetation, etc.), save as KMZ File.
    c. Open QGIS 2.18 Desktop with GRASS 7.4
    d. Click *New* (on Project Toolbar)

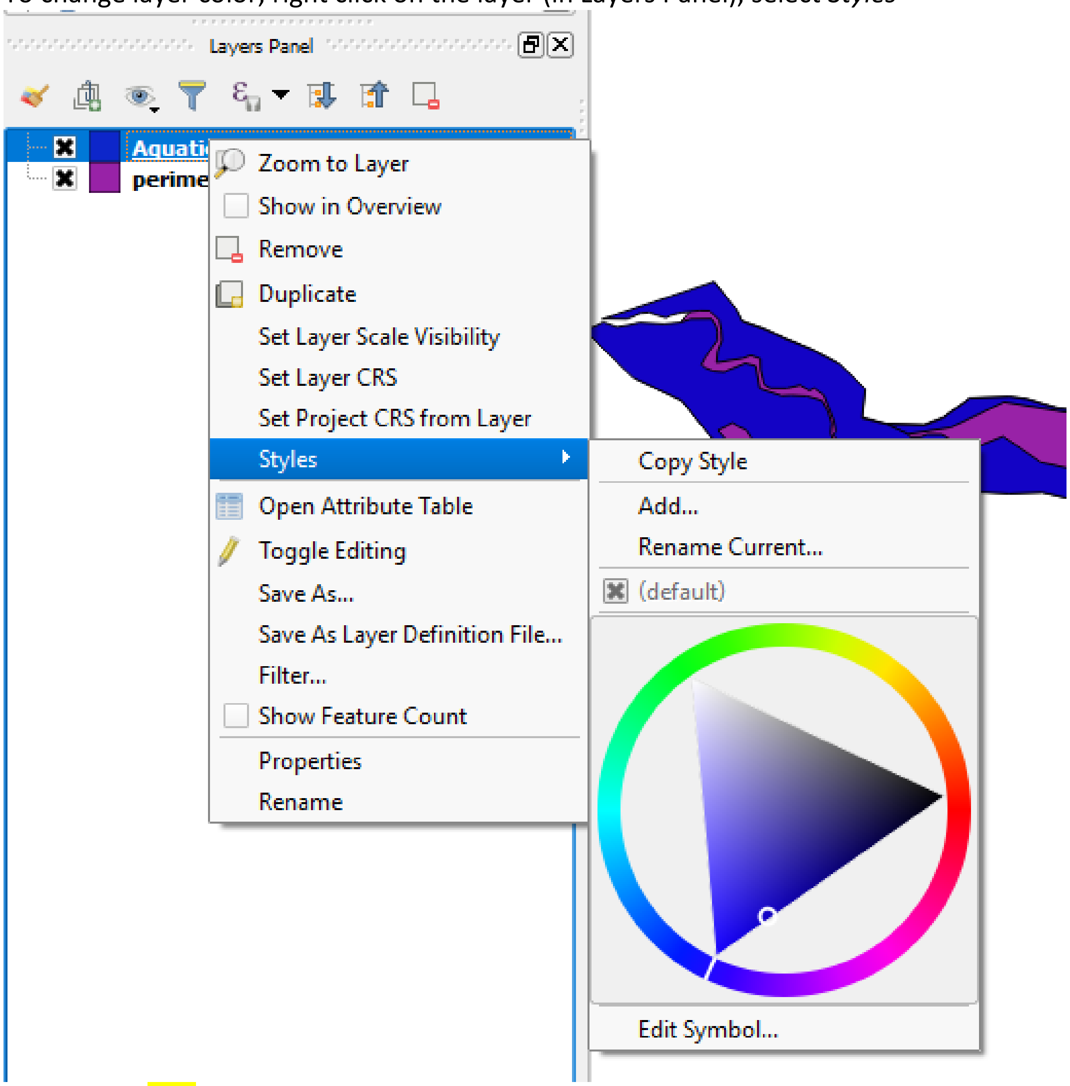


2. ADD LAYERS – VECTOR DATA
    a. Click *Add Vector Layer* (on Vector Toolbar)
    b. In "Add vector layer" window, Click *Browse,* open appropriate KMZ File (water, vegetation, etc.), click *Open.*

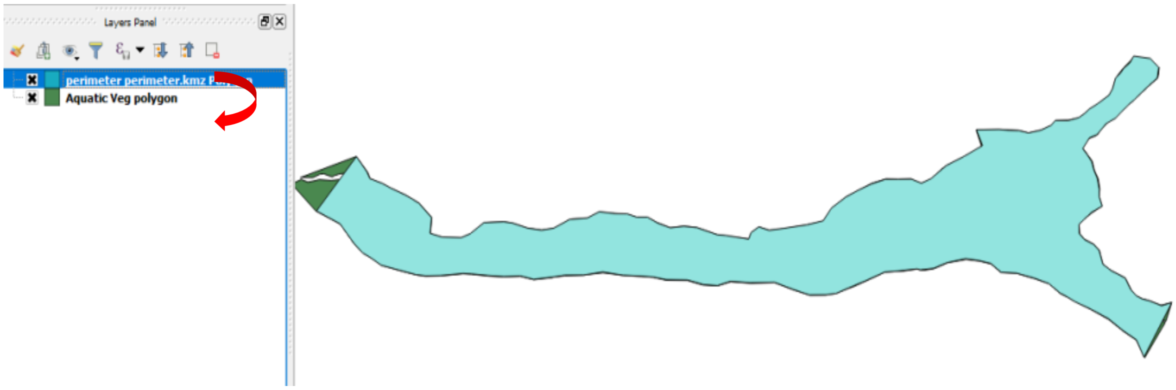


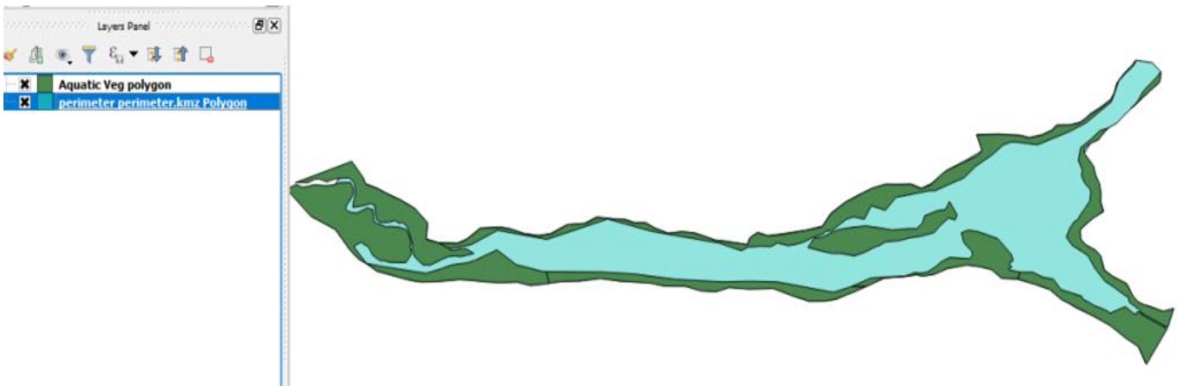
3. STYLE AND SELECT
    a. To position screen view to certain layer, right click on the layer (in Layers Panel), select *Zoom to Layer.*
    b. To rename layers, right click on the layer (in Layers Panel), select *Rename.*

To change layer color, right click on the layer (in Layers Panel), select S*tyles*

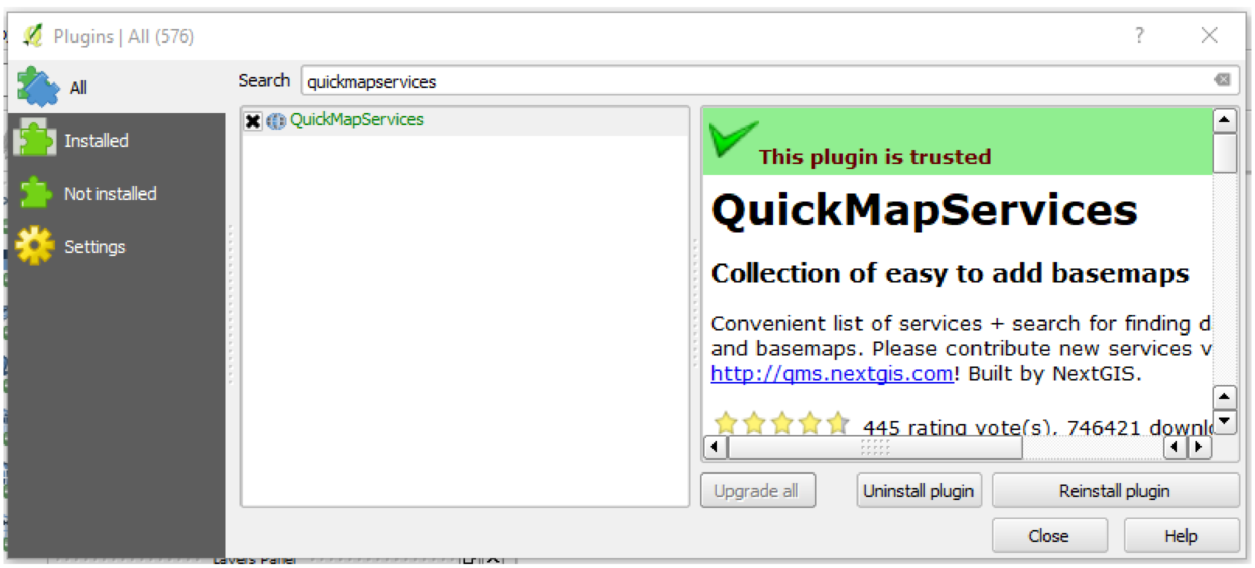


    c. Drag and drop layers within the Layers Panel to change viewing order (that is, to change which layer shows up on top).

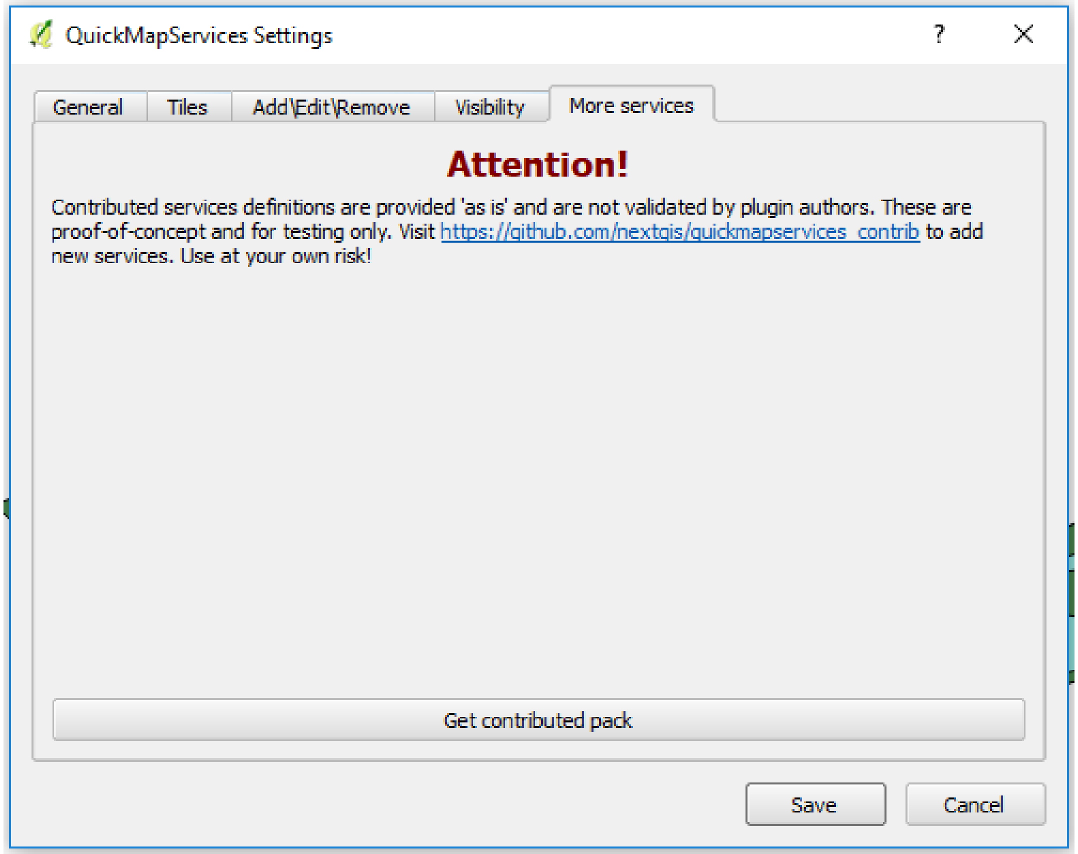




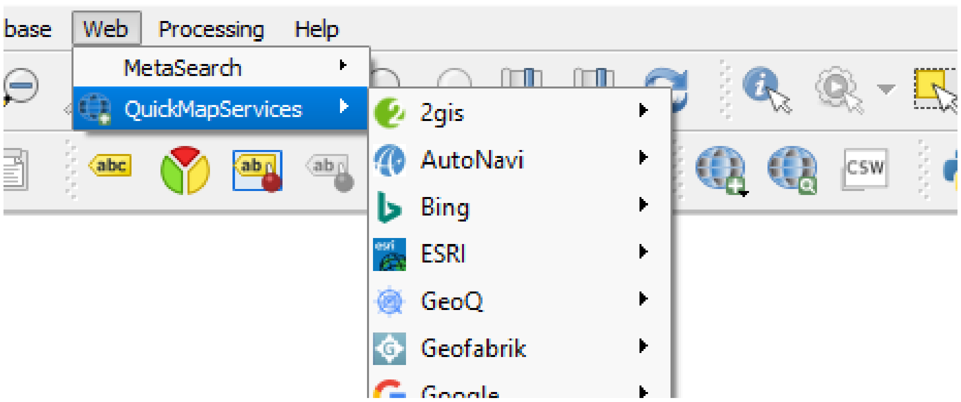
4. ADD BASEMAP – RASTER DATA
   a. Click Plugins (on Menu Toolbar), select Manage and Install Plugins…
   b. In "Plugins" window, search for the QuickMapServices plugin, click *Install plugin*, and click *Close.*



   c. Click *Web* (on Menu Toolbar), select *QuickMapServices*, select *Settings.*
   d. In "QuickMapServices Settings", click *More Services*, select *Get contributed pack*, and click *Save.*



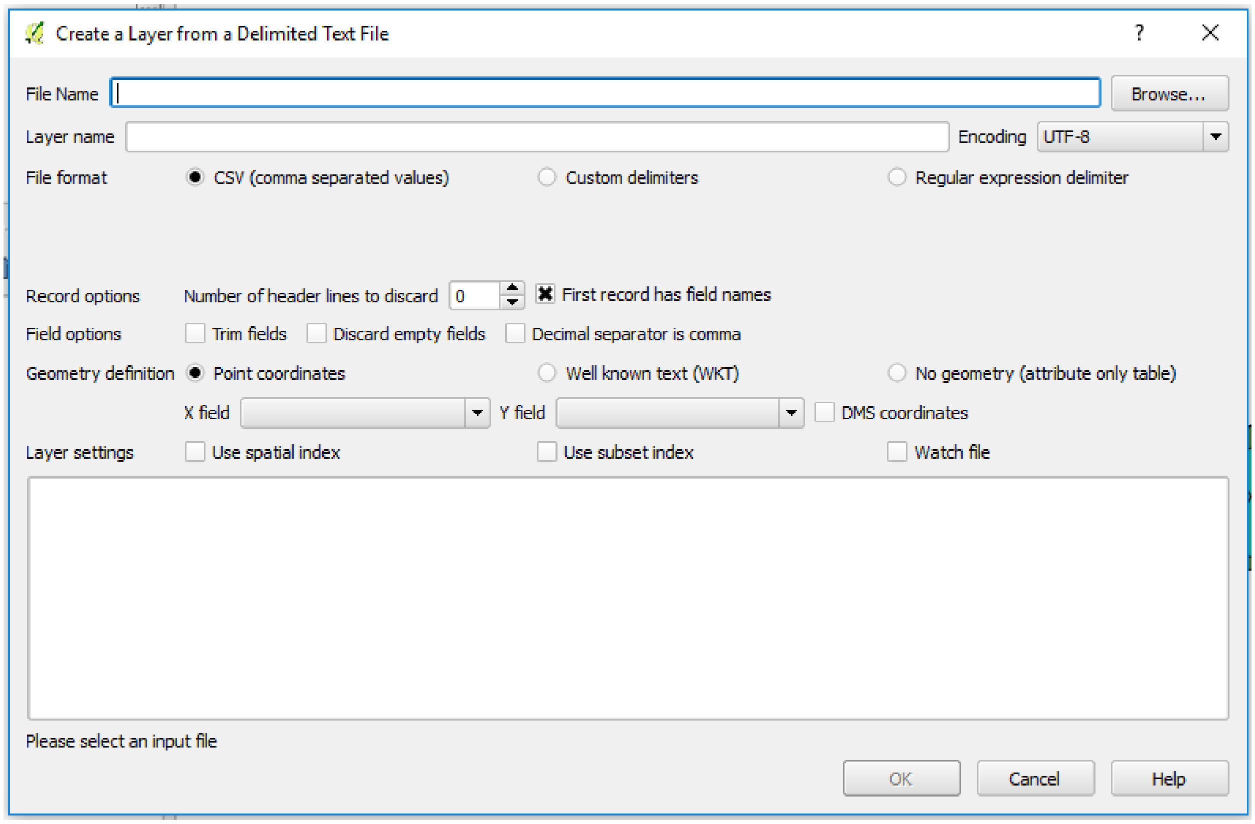
e. Insert base map by clicking *Web*, select *QuickMapServices*, and click on the suitable map (i.e., Select *Google Hybrid* to show the water body's relevance to its surroundings)



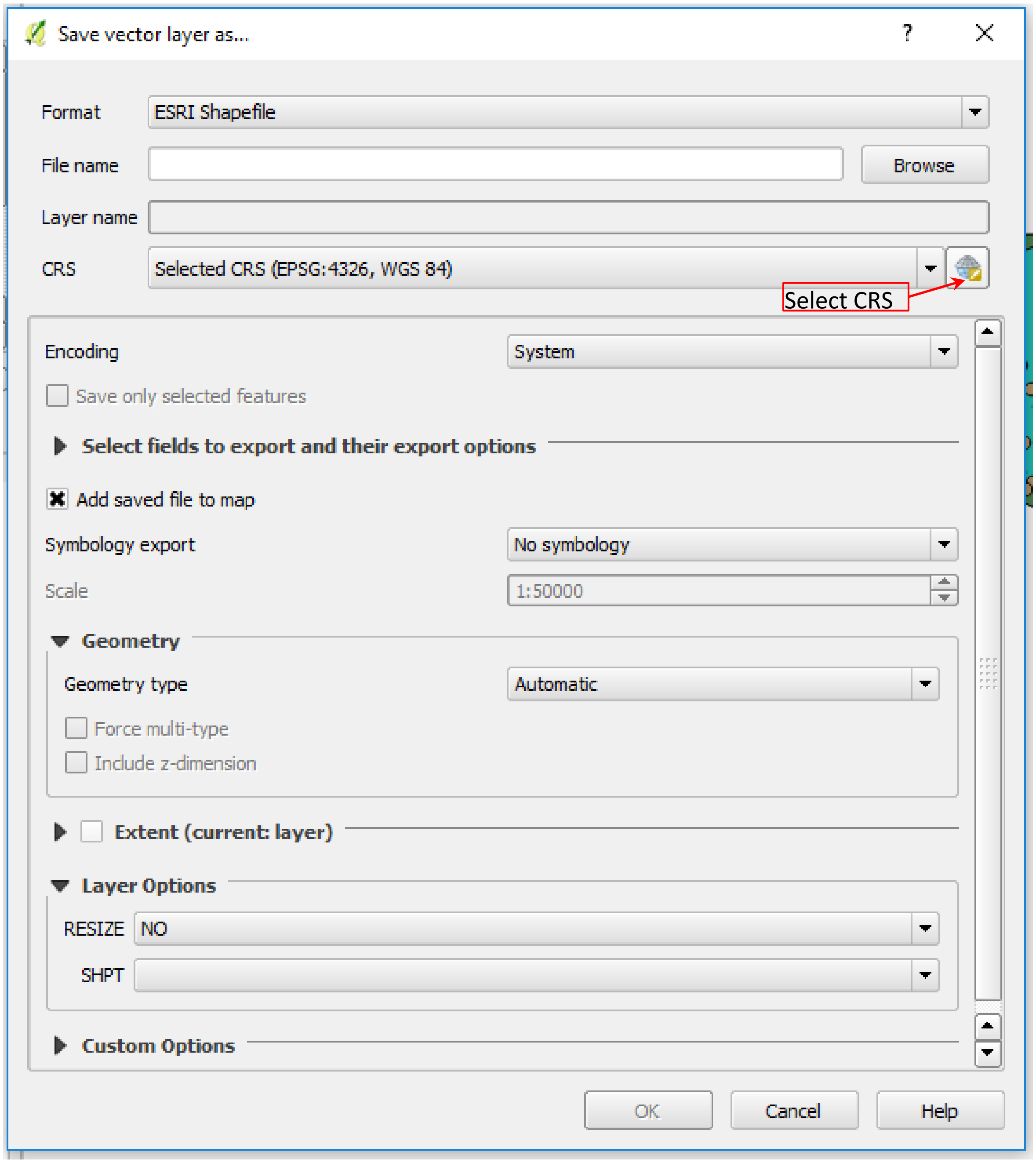
5. ADD COORDINATE REFERENCE SYSTEM

a. Click *Add Delimited Text Layer* (on Vector Toolbar)

b. In "Create a Layer from a Delimited Text File", click *Browse* to open CSV File, click *OK.*

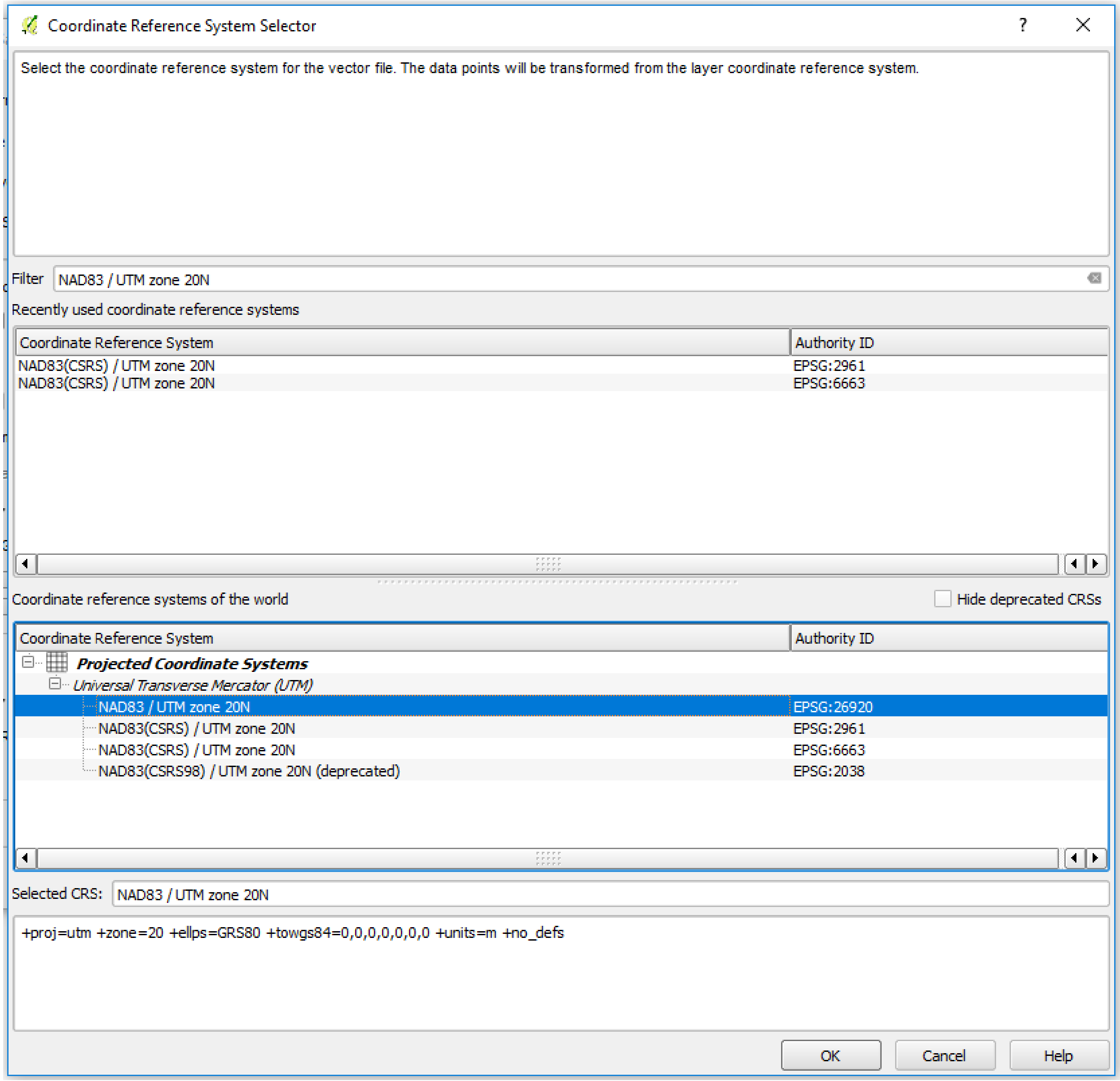


c. Right click CSV File in the Layers Panel, select *Save As*
d. In "Save vector layer as…" window, select *ESRI Shapefile* across from "Format", select *Browse*, name & save as **Shape File.**

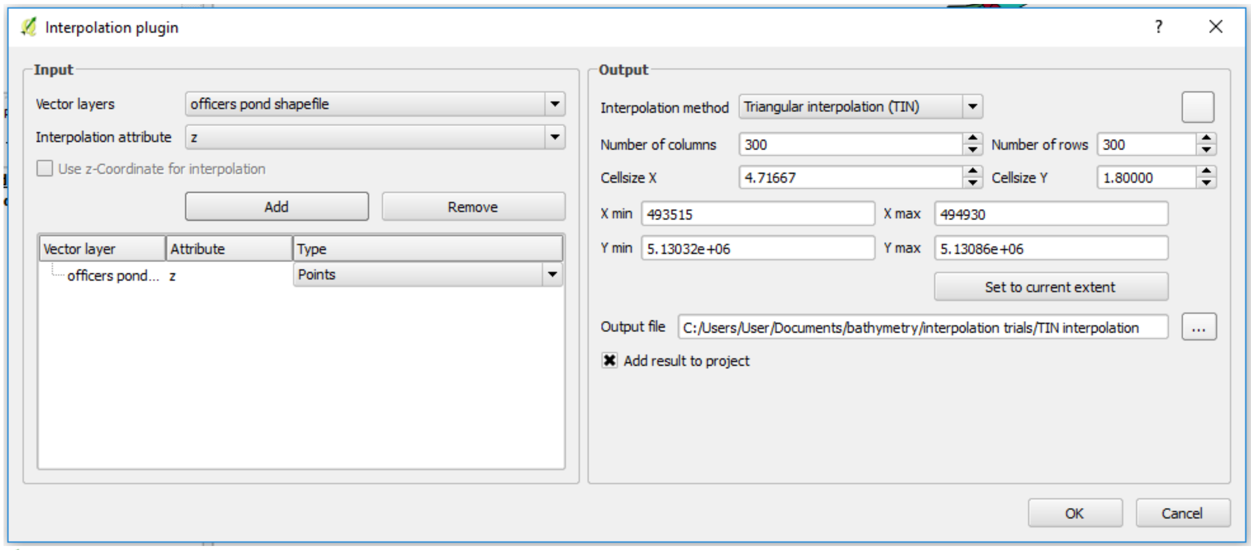


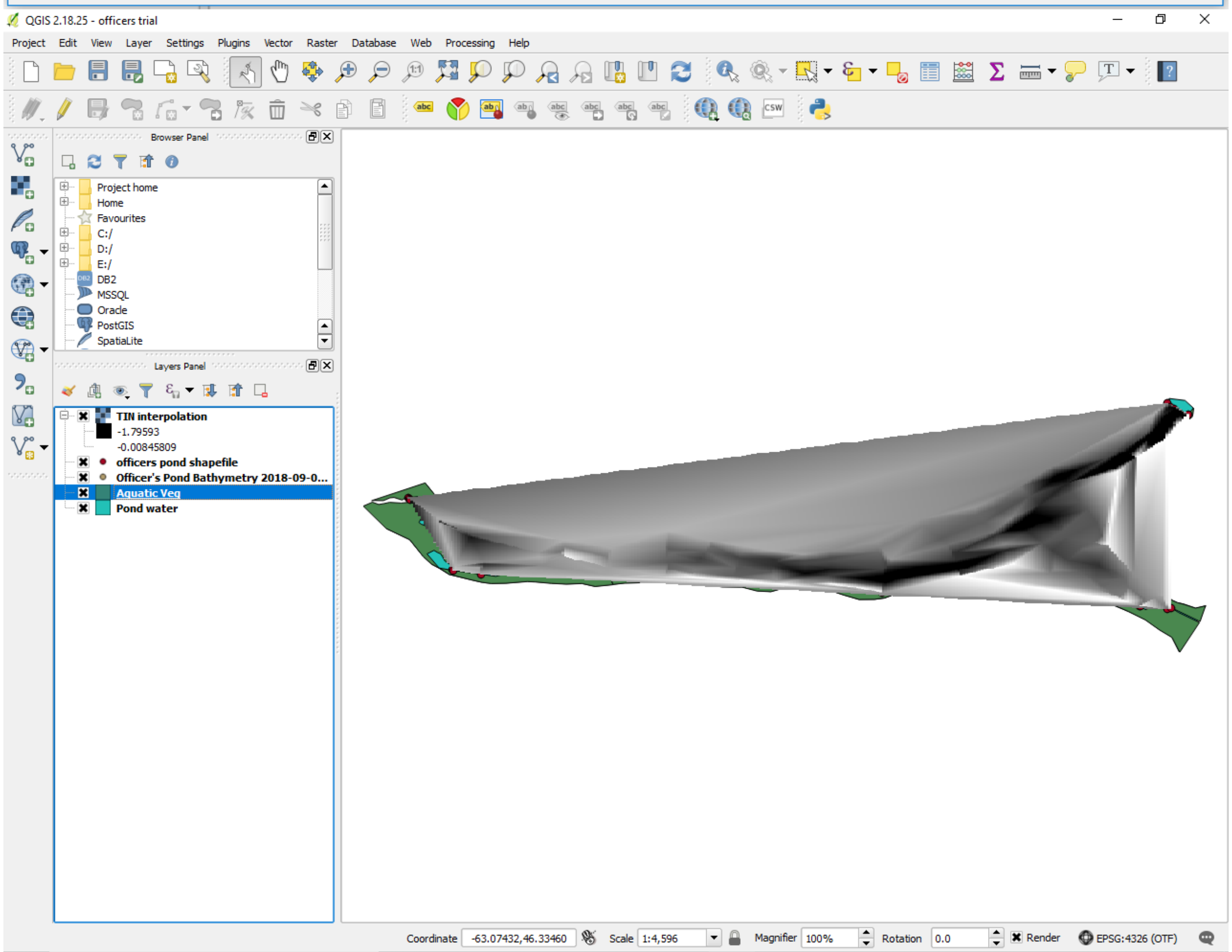
e. Click *Select CRS* button across from "CRS".

f. In "Coordinate Reference System Selector" window, use the "Filter" search bar to type in *NAD83 / UTM zone 20N*, select the first option, *NAD83 / UTM zone* 20N under "Coordinate Reference System" list, click *OK* to finish saving vector layer.



6. INTERPOLATION – TIN METHOD
    a. Click Raster (on Menu Toolbar), click Interpolation, select interpolation again.
    b. In the "Interpolation plugin" window under "Input", select Shape File across from "Vector layers", select *z* across from "Interpolation attribute", then click *Add.*
    c. Under "Output", select *Triangular Interpolation (TIN)* across from "Interpolation method."
    d. Click "*…*" button across from "Output file" to save as Interpolation File in an appropriate location on your computer, and then click *OK.*





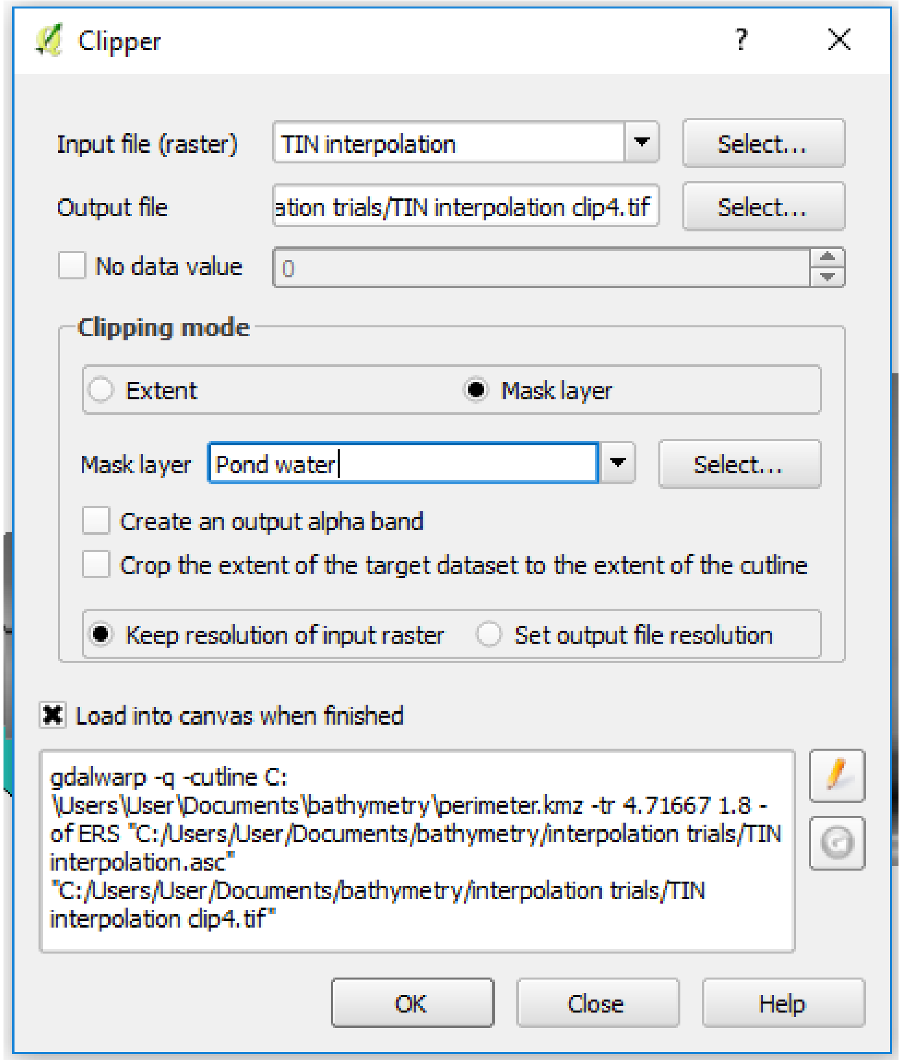
7. EXTRACTION - CLIPPING

   a. Click *Raster* (on Menu Toolbar), click *Extraction*, click *Clipper…*

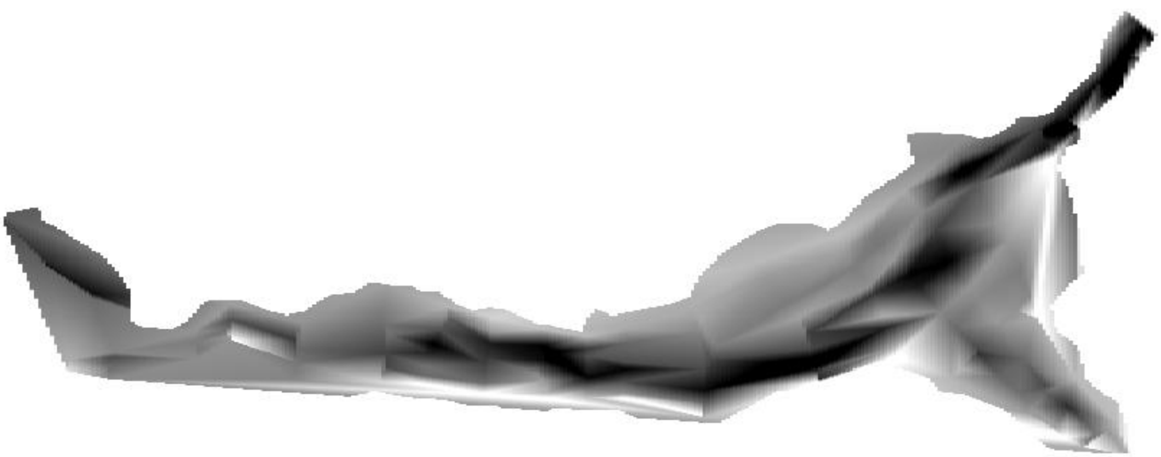
   b. In "Clipper" window, click the drop down across from "Input file (raster)", select **Interpolation File.**

   c. Click *Select…* across from "Output file", name & save **Clip File.**

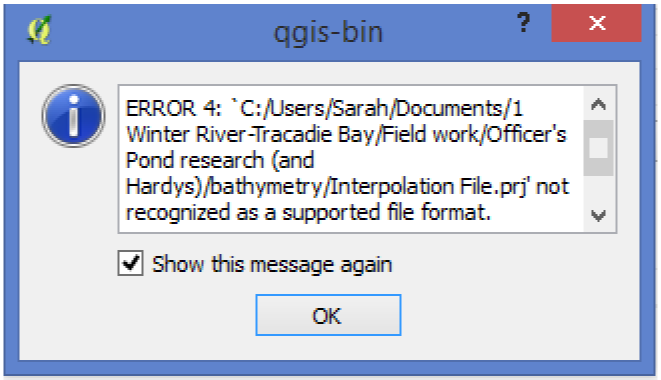
   d. Under "Clipping mode", select *Mask layer*, click *Select…* across from "Mask layer", select **KMZ File** (the file you want the **Interpolation File** to look like i.e., perimeter), Click *OK.*

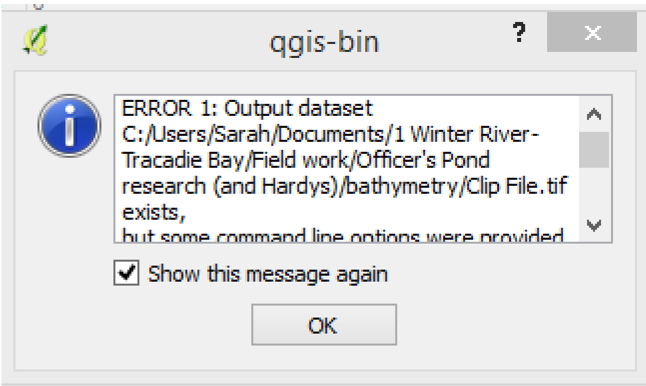


Once processing is complete, click OK to close the Clipper window.



If you see this error message, you selected the wrong file type for the input file.





e. Right click **Clip File** layer, select *Properties*

f. In "Layer Properties" window, on left hand side select S*tyle*, change "Render type" to *Singleband pseudocolor.*

   i. change "Min" to represent the lowest depth "Value" as a whole number (i.e., -2.8 change "Min" to -3), change "Max" to 0 to represent water surface,

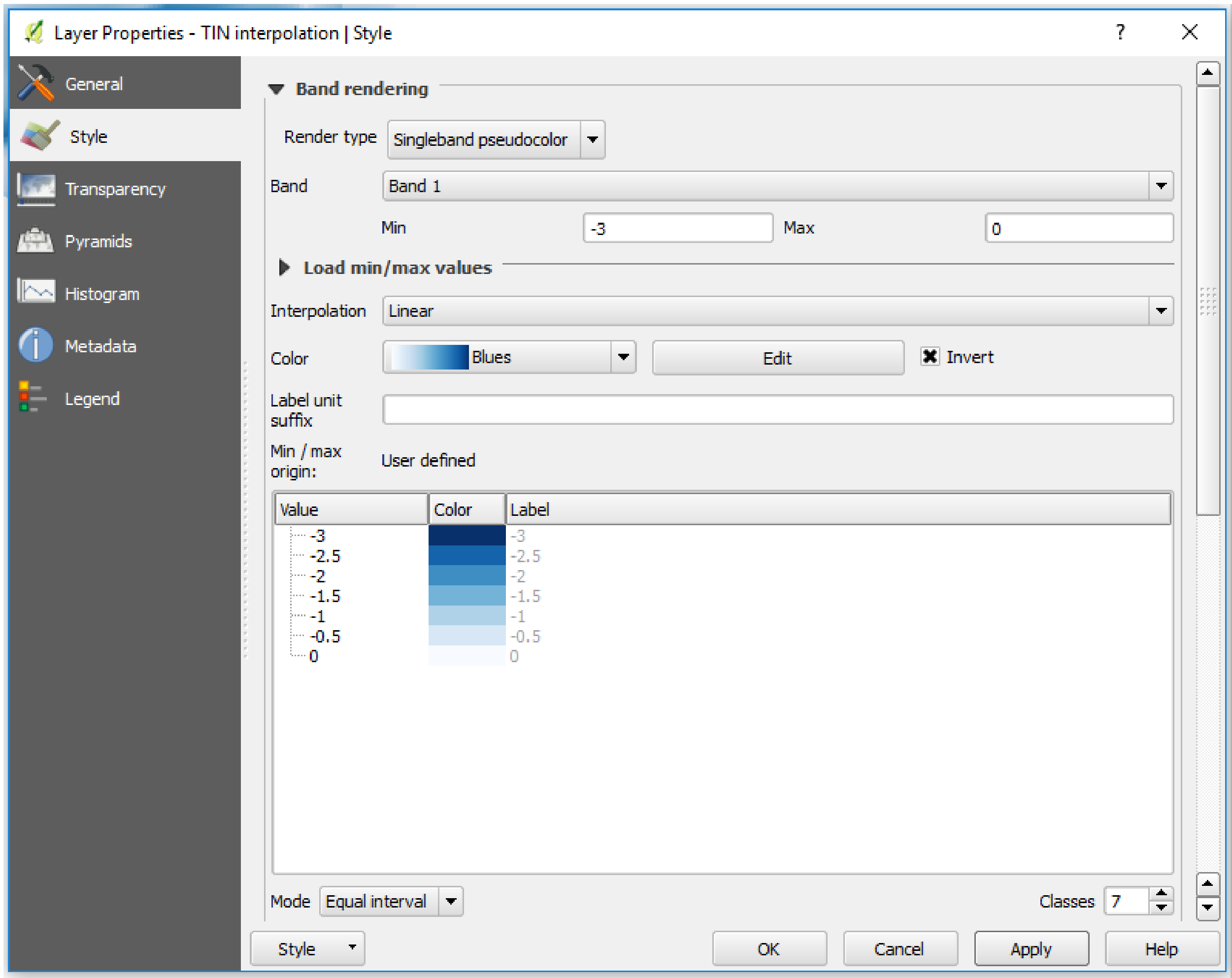
   ii. to change color, select "Color" drop down,

   iii. change "Mode" drop down to *Equal interval,*

   iv. change "Classes" to required number to get the color bands to match the intervals you would prefer.

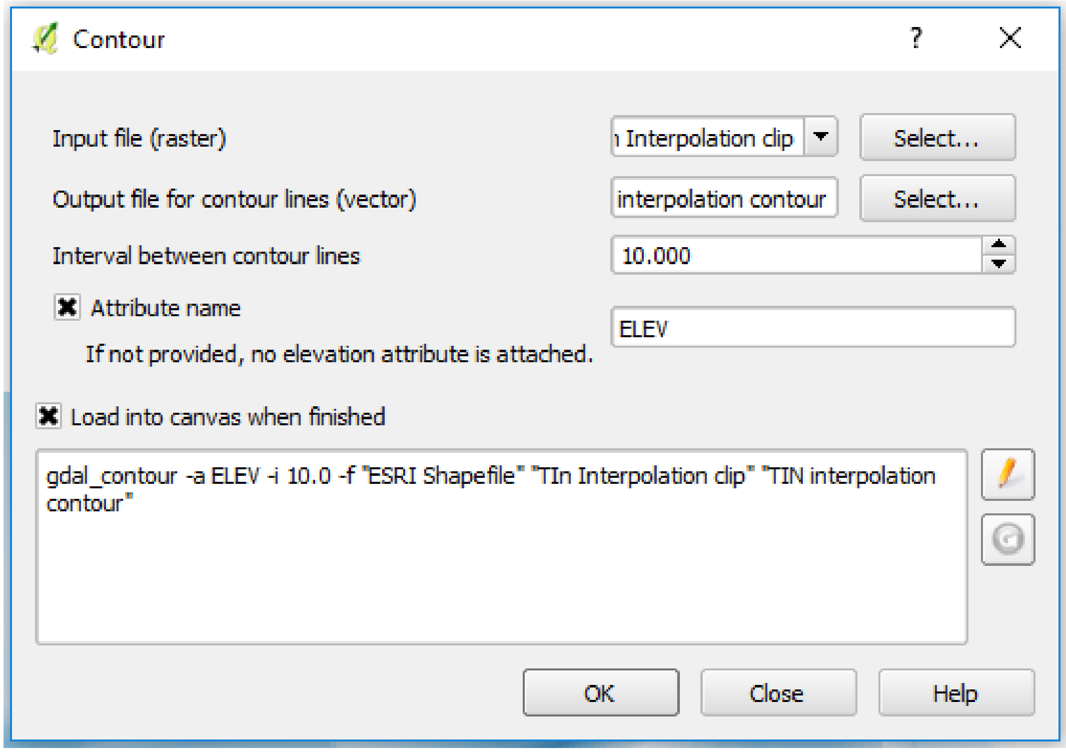
   v. if needed select *invert* (to make deeper areas blue and shallow areas red for example)

   vi. click *Apply,* click *OK.*



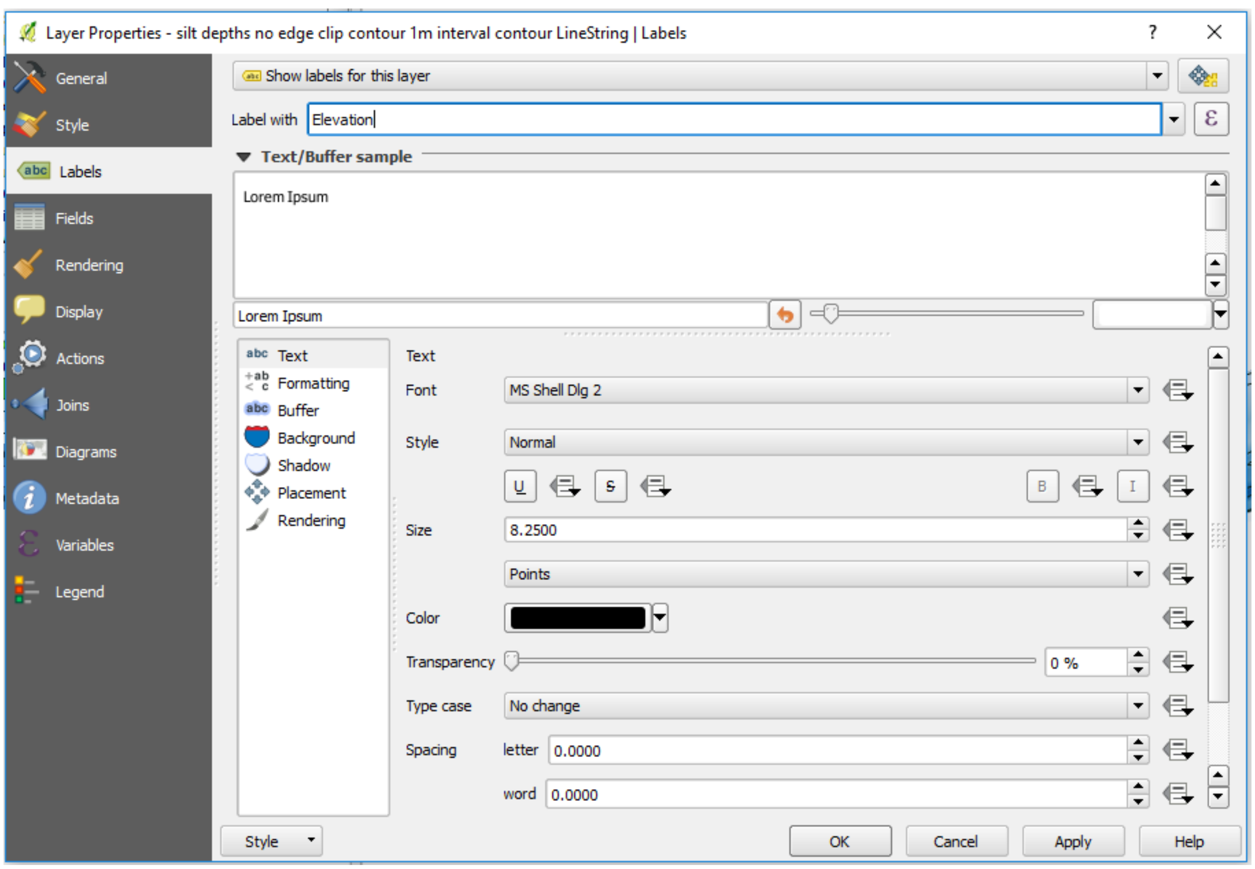
8. EXTRACTION – CONTOUR

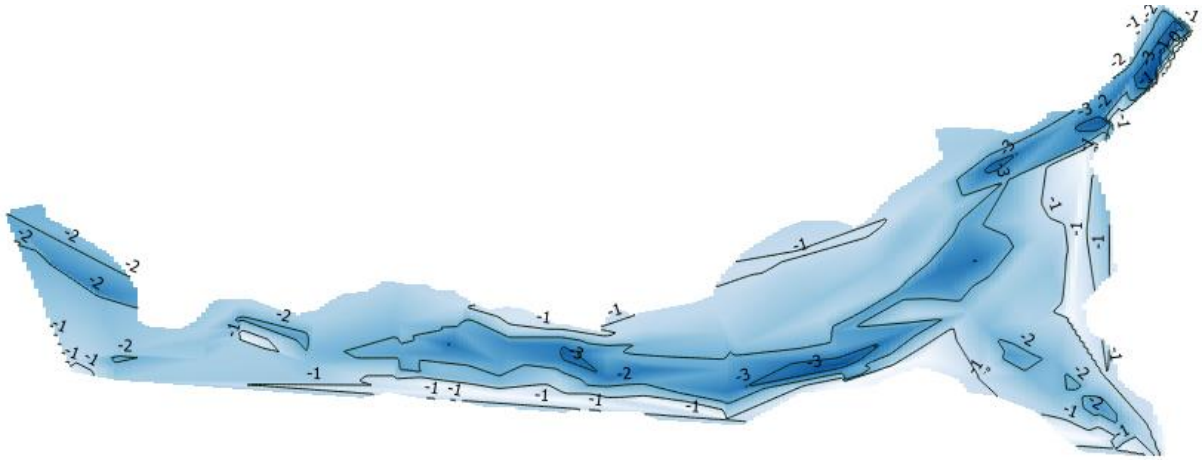
a. Click *Raster* (on Menu Toolbar), click *Extraction*, click *Contour…*
b. In "Contour" window, click drop down across from "Input file (raster)", select **Clip File.**
c. click *Select…* across from "Output file for contour lines (vector)", name & save **Contour File**, select appropriate "Interval between contour lines" (i.e., 0.5 m), click *Attribute name*, rename as **Elevation**, click *OK.*



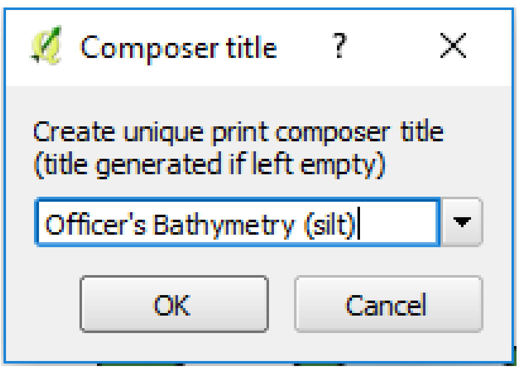
d. Right click **Contour File** vector layer, select *Properties*

e. In "Layer Properties" window, select *Labels* (on left side bar), change top bar to *Show labels for this layer*, change "Label with" drop down bar to **Elevation**, click *Apply*, click *OK.*

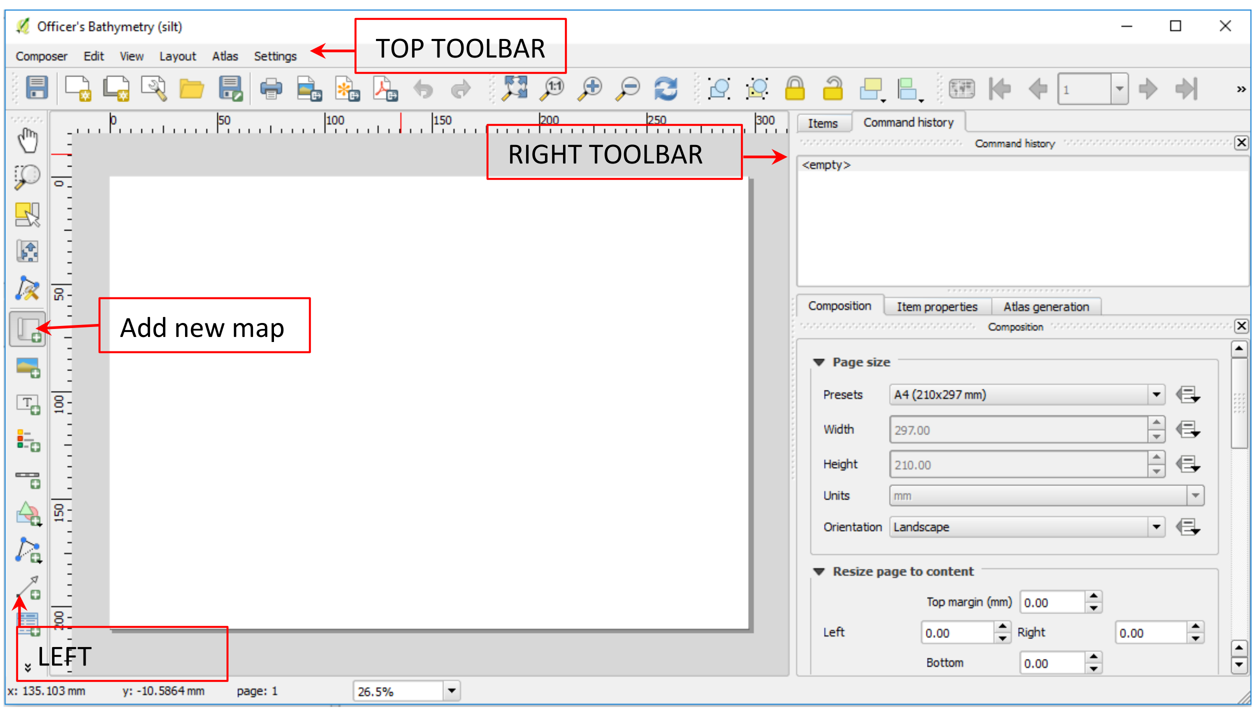




9. PRINT COMPOSER
   a. Click *Project* (on Project Toolbar), select *New Print Composer*
   b. In "Composer title" window, name **Composer Title**, click *OK.*



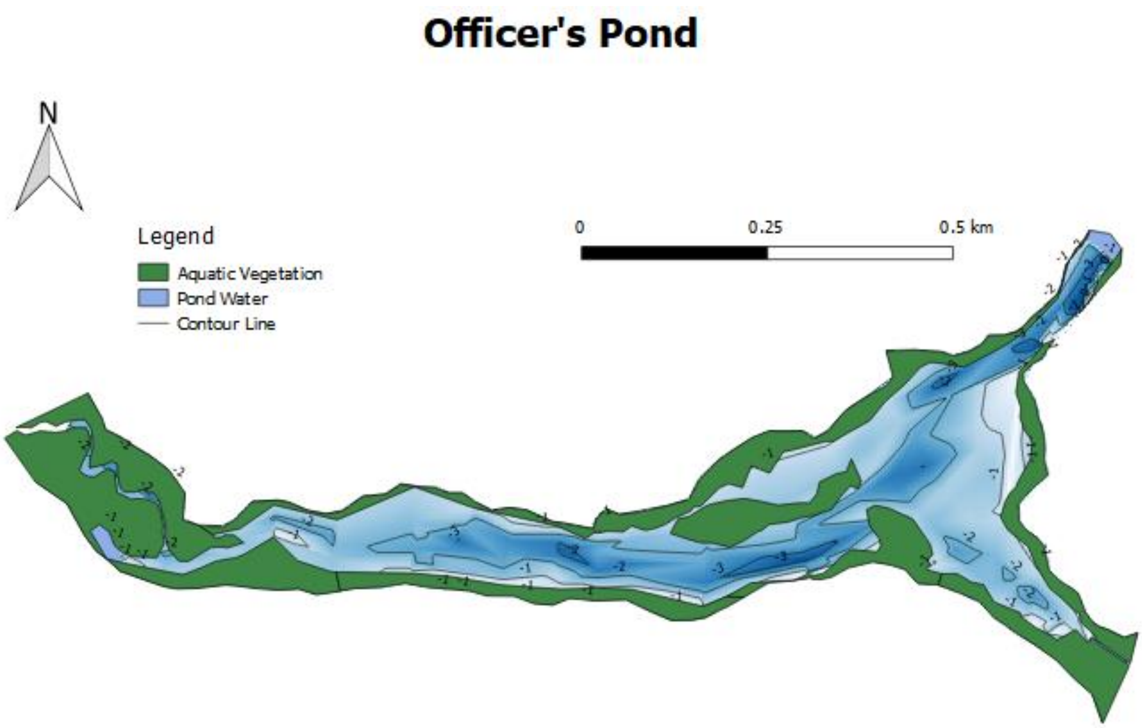
   c. You are greeted with a blank slate.



   d. To change page size: below *Command History* (in Right Toolbar), select *Composition*, under "Page Size" select the preset values for *ANSI A (Letter; 8.5 x 11 in)*
   e. To add map: click *Add New Map* (on Left Toolbar), click and drag curser from one page corner to the opposite corner, release click.

f. To add scalebar: Click *Layout* (in Top Toolbar), click *Add Scalebar*, click on the map in the location where you want to add scale bar, select scale bar, select *Command History* (in Right Toolbar), select *Items properties* to adjust scale bar to preference.
g. To add north arrow: Click *Layout* (in Top Toolbar), click *Add Image*, click and drag to add, select image, select *Command History* (in Right Toolbar), select *Items properties*, click "Search directories" drop down, select north arrow image.
h. To add legend: Click *Layout* (in Top Toolbar), click *Add Legend*, click and drag to add legend, select legend, select *Command History* (in Right Toolbar), select *Items properties* to adjust legend items.
    i. To remove items from Legend, click the minus icon >

i. To add title: Click *Layout* (in Top Toolbar), click *Add Label*, click and drag to add title, select label, select *Command History* (in Right Toolbar), select *Items properties* to adjust title.
j. Click *Composer* (in Top Toolbar), to save file select *Export as...*



8.3 Appendix 3: Potential Depth Logger Errors (for depth and flow values)

Site	Date	Notes
Union	2018-08-01	Isolated spike
	2018-07-19	Isolated spike
	2018-06-11	Isolated spike
	2018-07-20	Isolated spike
	2018-07-22	Isolated spike
	2018-11-03	Highest spike of the season, may be natural but looks suspect
Apple Orchard	2018-05-14	Start date issue?
	2018-07-06	May be natural, looks suspect
	2018-07-10	May be natural, looks suspect
	2018-07-12	May be natural, looks suspect
	2018-07-16	May be natural, looks suspect
	2018-07-20	May be natural, looks suspect
Friston*	2018-05-14	
	2018-05-16	
	2018-06-02	May be natural, looks suspect
	2018-06-03	May be natural, looks suspect
	2018-06-13	May be natural, looks suspect
	2018-06-14	May be natural, looks suspect
	2018-06-15	May be natural, looks suspect
	2018-06-16	May be natural, looks suspect
	2018-06-17	May be natural, looks suspect
Beaton*	2018-06-29	Start date issue?
	2018-07-12	Isolated spike
	2018-08-10	Isolated spike
Officer's	2018-07-17	Sudden drop
	2018-09-27	Fluctuation may be natural, looks suspect
Tim's	2018-05-14	Start date issue?
	2018-07-17	Sudden drop

*Logger moved from Friston to Beaton site midway through the season.