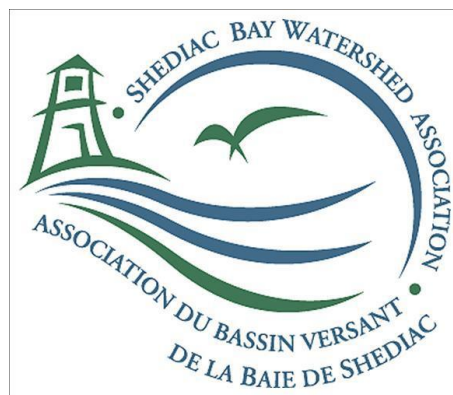


Identifying Habitat of the Brook Floater (*Alasmidonta varicosa*) in the Shediac Bay Watershed



Prepared for:
Habitat Stewardship Program for Species At Risk

Prepared by:
Shediac Bay Watershed Association
Jolyne Hébert



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1. Introduction

The Shediac Bay Watershed Association (SBWA) is a not-for-profit organization located in Shediac, New Brunswick. The SBWA was founded in 1999 as a result of growing concerns among residents from various local communities over the ecological health of the Shediac Bay. A Board of Directors, representing the various communities found within the 420 km² watershed boundaries of the Shediac Bay, oversees its activities. The Association deals with issues related to water quality and habitat integrity.

According to the Canadian Wildlife Federation (CWF), freshwater mussels are now among the most endangered freshwater invertebrates in the world. According to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), 13 out of the 55 species of unionids in Canada are *Endangered*, two are *Threatened* and three are of *Special Concern*. The Brook Floater (*Alasmidonta varicosa*), is a medium-sized freshwater mussel that was found in scattered regions of New Brunswick, Nova Scotia and certain regions of the East Coast of USA. The population of this mussel was not abundant, representing only 1-5% of total freshwater mussel populations in the areas where it was found. In 2009, it was given the status of Special Concern by COSEWIC when the species disappeared from 2 historical sites and approximately half of its known locations in the USA, leaving the Canadian populations to represent the majority of the remaining global populations of the Brook Floater. In 2013, it was added to the *Species At Risk Act*, Schedule 1 (SARA).

The freshwater mussel surveys outlined in this report were conducted in the two main river systems in the Shediac Bay watershed; the Shediac River, Scoudouc River and their tributaries. The Shediac River is divided in two major water arms; the northern water arm is created by the convergence of the McQuade, Weisner and Calhoun Brooks, and the southern water arm is the continuation of the Bateman Brook. The water flow velocity in both rivers is weak due to the gentle regional elevation (Henderson, G. 1999).

In 2005, the SBWA conducted a study on freshwater mussels within the boundaries of its watershed. The main objective was to establish the biodiversity and population status of freshwater mussels in the Shediac Bay watershed.

During the surveys in 2005, a total of 122 brook floaters mussels were reported to have been found throughout the Shediac River, Scoudouc River and their tributaries. In 2014, the SBWA embarked on a new 2-year project containing the following objectives: reconfirm the presence of the brook floater in the watershed; assess the health of the surrounding habitat; work with landowners to create a plan of protection for its habitat. Unfortunately, the rare species was never found in 2014 and 2015, therefore the SBWA continued its work with the same objectives in 2016.

During this past year, the knowledge acquired in the first 2 years of this project was used to prioritize the areas that needed to be surveyed. The high priority sites include the areas that was said to contain brook floater mussels in the 2005 study, as cited in the report Caissie C., D. Audet, 2006¹ “Freshwater mussel inventories in the Shediac and Scoudouc Rivers, NB”, and the areas in

the lower reaches of freshwater habitats of our rivers. In addition to those historical sites, the team expanded their search by visually scanning the riverbed in all suitable habitat for the brook floater that was accessible.

In 2016, the project was modified to conduct surveys at 3 different periods of the year; early spring, summer and fall. These different times of the year is to account for changes in water temperature, changes in the amount of daylight, and other factors that may change the behaviour of the mussel. It is believed by some experts that either the life cycle or the behaviour of this mussel causes it to be burrowed beneath the substrate for a certain amount of time. According to the Management Plan for the Brook Floater prepared by *Species At Risk Act* (SARA) in 2016, the timeline for presence/absence surveys should be conducted on a 2-5 year period.

The present report describes the search surveys result and habitat descriptions of every area of the watershed that was assessed to find this rare Brook Floater freshwater mussel.

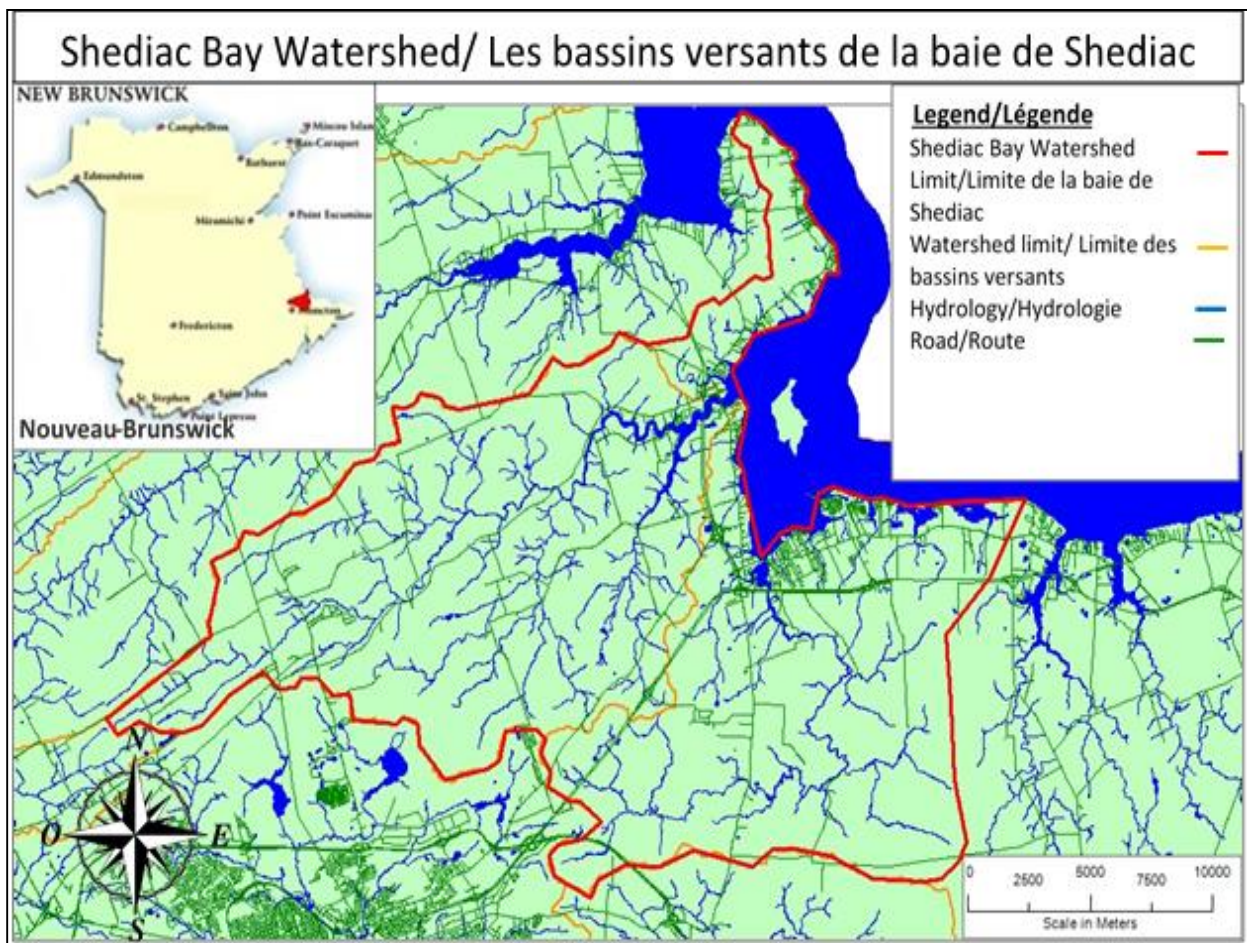


Figure 1: Map of the Shediac Bay Watershed boundaries

2. Material and Method

2.1 Sampling Protocol

The method used for the freshwater mussel inventory is the 4 hour-person Time-Search protocol, as described by Metcalfe-Smith et al. (2000) and Beaudet et al. (2002). This method consists of visually locating and counting all freshwater mussels found in a fixed and standardized amount of time. This time-based count of freshwater mussel was done on the first visit only, any following visits were search-based only.

During the search-based surveys, the field team walked the rivers in search of appropriate brook floater habitat. All habitats deemed suitable were thoroughly searched for the presence of the rare mussel, either by seeing the mussel on the surface of the substrate or by the detection of valves indicating a burrowed mussel.

All areas searched have been recorded using GPS coordinates at the beginning and end of each sweep. The distances covered by either Time-search surveys or by habitat search (no count surveys) for 2016, can be found in section 3.4, Table 7, and also Appendix A.

2.2 Material

The equipment used to conduct the Freshwater Mussel Inventory are listed below:

- Underwater viewers
- Chest Waders
- Field data sheets, maps and clipboards
- GPS
- Digital Camera
- Stopwatch
- Water resistant notepads + pencils
- Water-condition instrument (YSI)
- Survey measuring tape (50m) and metre stick (1m)
- Reference documents (identification key)

3. Results and Observations

3.1 General

During the spring, summer and fall 2016, 8.7 km of habitat was surveyed or searched for the presence of the rare brook floater mussel within the boundaries of the Shediac Bay Watershed. The highest priority areas were searched on multiple occasions during the year.

The sites surveyed and searched in the summer 2016 are based on the knowledge acquired during the freshwater mussel inventories in 2014 and 2015. The information and observations obtained in those previous years helped prioritize which sections of the Shediac and Scoudouc Rivers should be the focus of multiple visits in 2016.

The results of each standardized time-search survey for 2016 can be found in Table 1 and Appendix A. Maps displaying site locations and total search areas for 2016 for the Shediac River and Scoudouc River can be found in Figure 2 and 3 respectively. The survey results for 2015, 2014 and 2005 can also be found in Table 2, Table 3 and Table 4 respectively. During the surveys of 2015 and 2016, juvenile eastern pearlshell mussels (*Margaritifera margaritifera*) were also counted, to help establish the population's viability. Mussels of this species were characterized as juvenile when measured at 6 cm or less in length. Figures displaying the ratios of adults' vs juvenile can be found in Fig.4 (2016) and Fig.6 (2015). A second species prominently found in the Scoudouc River, the Eastern Elliptio (*Elliptio complanata*), was not divided in adult/juvenile category during surveys because the specific size that would classify an elliptio as a juvenile was not known.

In addition to the standardized time-search surveys, the SBWA field team walked various accessible parts of the watershed looking for brook floater mussels in suitable habitats. Those areas were visually scanned for the mussels, and underwater viewers were used as a visual aid tool when needed. Observations and measurements of the habitats were taken: water quality data (temp., DO, pH, salinity); substrate characterization; depths/width/flow speed; signs of erosion; land uses; algae or other vegetation; etc. All habitat data, GPS coordinates, and other information noted on the field sheets can be found in Appendix A. A summary of all areas searched for brook floater habitat over the course of the past 3 years can be found in section 3.4. As requested by the NB Museum, freshwater mussel specimens were collected and submitted to the museum as vouchers. A freshwater mussel collection permit was acquired under Section 52 of the Fishery Regulations for scientific purposes (Licence No. SG-RHQ-16-124).

Determining site ID codes has been based on historical water quality monitoring sites in the Shediac Bay watershed, plus the addition of a numerical or alphabetical value depending on the direction of the survey from the access point. For example, the site ShdG is accessed from the St-Philippe road. If a survey or search is conducted upstream of the bridge, the site will be identified by an alphabetical value; ShdG-A. If the team goes downstream of the access point, the code is given a numerical value; ShdG-1. Subsequent surveys or searches will be identified with the next numerical or alphabetical values.

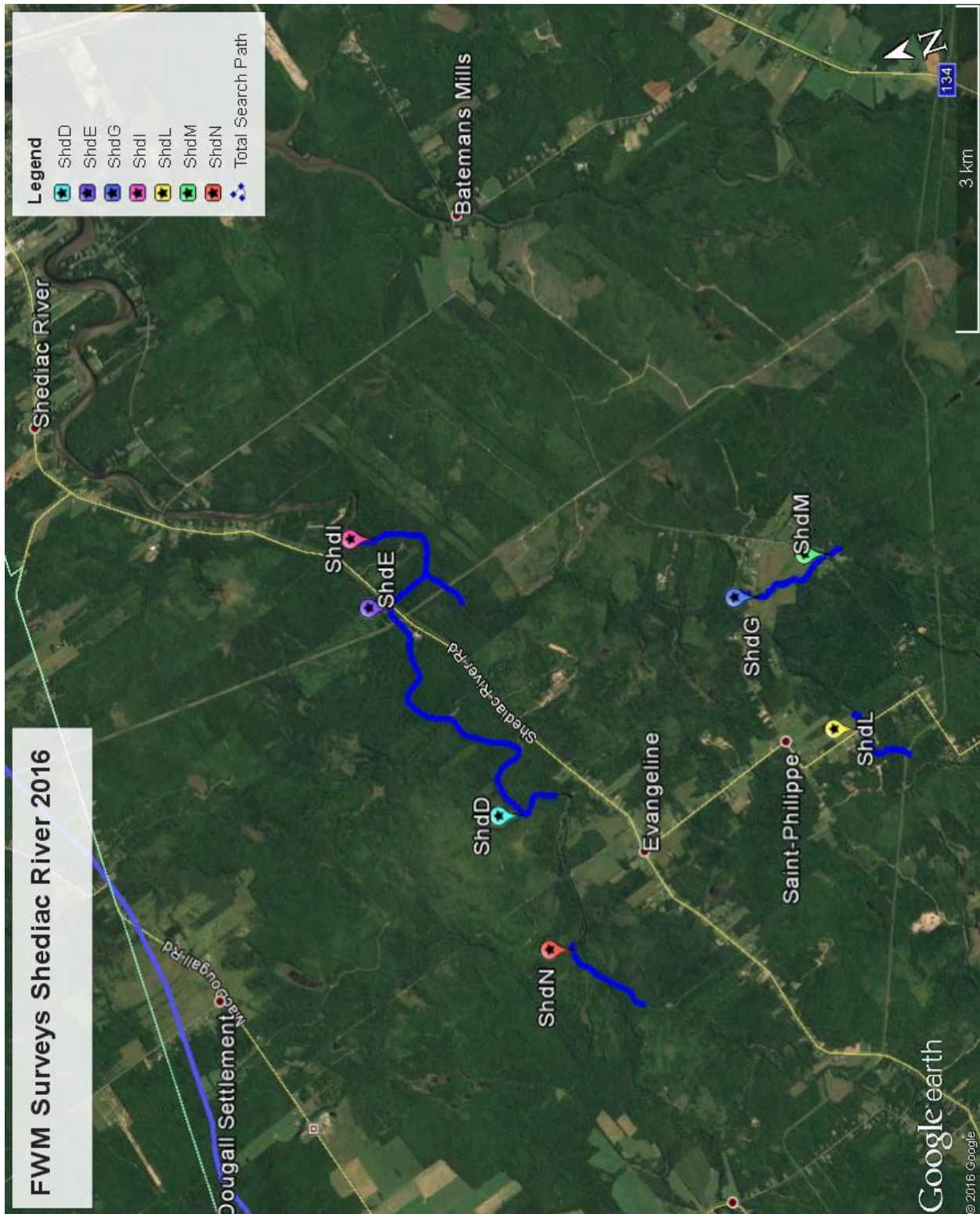


Figure 2: Map of total freshwater mussel surveys in the Shediac River for 2016

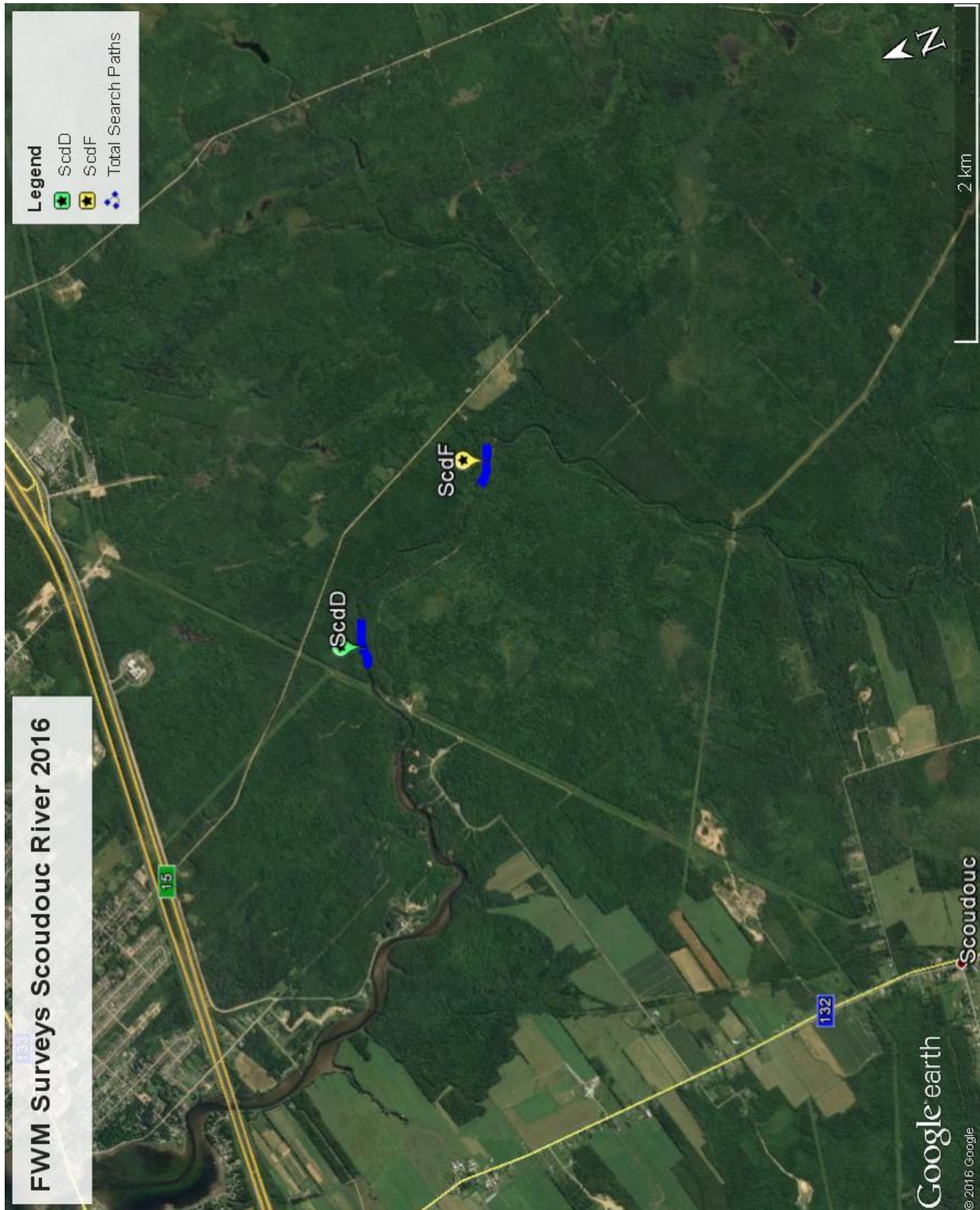


Figure 3 Map of total freshwater mussel surveys in the Scoudouc River for 2016

Table 1: Results of Time-Search freshwater mussels surveys in the Shediac and Scoudouc Rivers, 2016

Site ID	Distance (m)	Time Search (min)	Eastern Pearlshells (<i>Margaritifera margaritifera</i>)	Approximate # juveniles <i>Margaritifera</i> ≥6cm	Eastern Elliptio (<i>Elliptio complanata</i>)
Shediac River					
ShdG-1	80	60	66	0	
ShdG-A	190	40	112	1	
ShdM-1	125	30	21	5	
ShdM-A	160	60	421	25	
ShdN-A	225	60	145	4	
ShdN-B	135	45	543	13	
ShdI-A	135	80	544	29	
ShdI-B	110	60	332	18	
ShdI-C	210	60	8	5	
ShdE-A	210	60	679	34	
ShdE-B	280	80	1069	36	
ShdL-1	200	60	34	6	
ShdL-A	300	120	172	2	
ShdL-B	365	75	132	0	
ShdD-A	175	60	578	4	
ShdD-B	290	80	1998	27	
Total Shediac	3,190 m		6,854	209	0
Scoudouc River					
ScdD-A	85	60	196	2	117
ScdD-B	195	90	608	15	165
ScdF-1	250				
Total Scoudouc	530 m		804	17	282
TOTAL	3,720 m		7,658	226	282

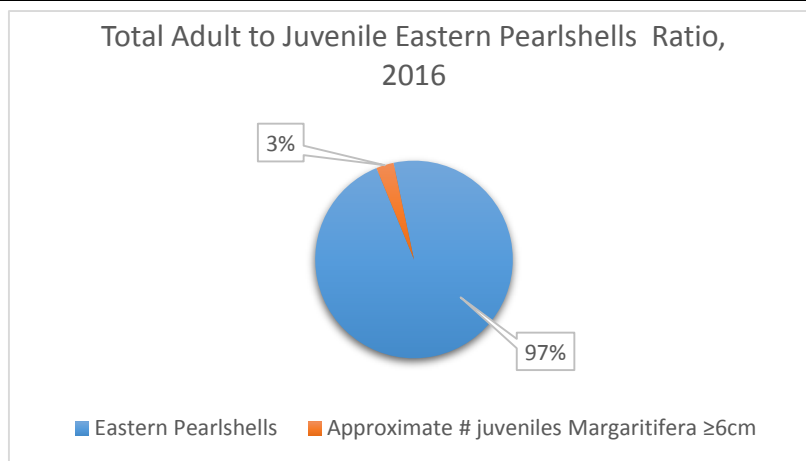


Figure 4: Ratio of adult and juvenile *Margaritifera margaritifera* found in the Shediac and Scoudouc Rivers during 2016 surveys

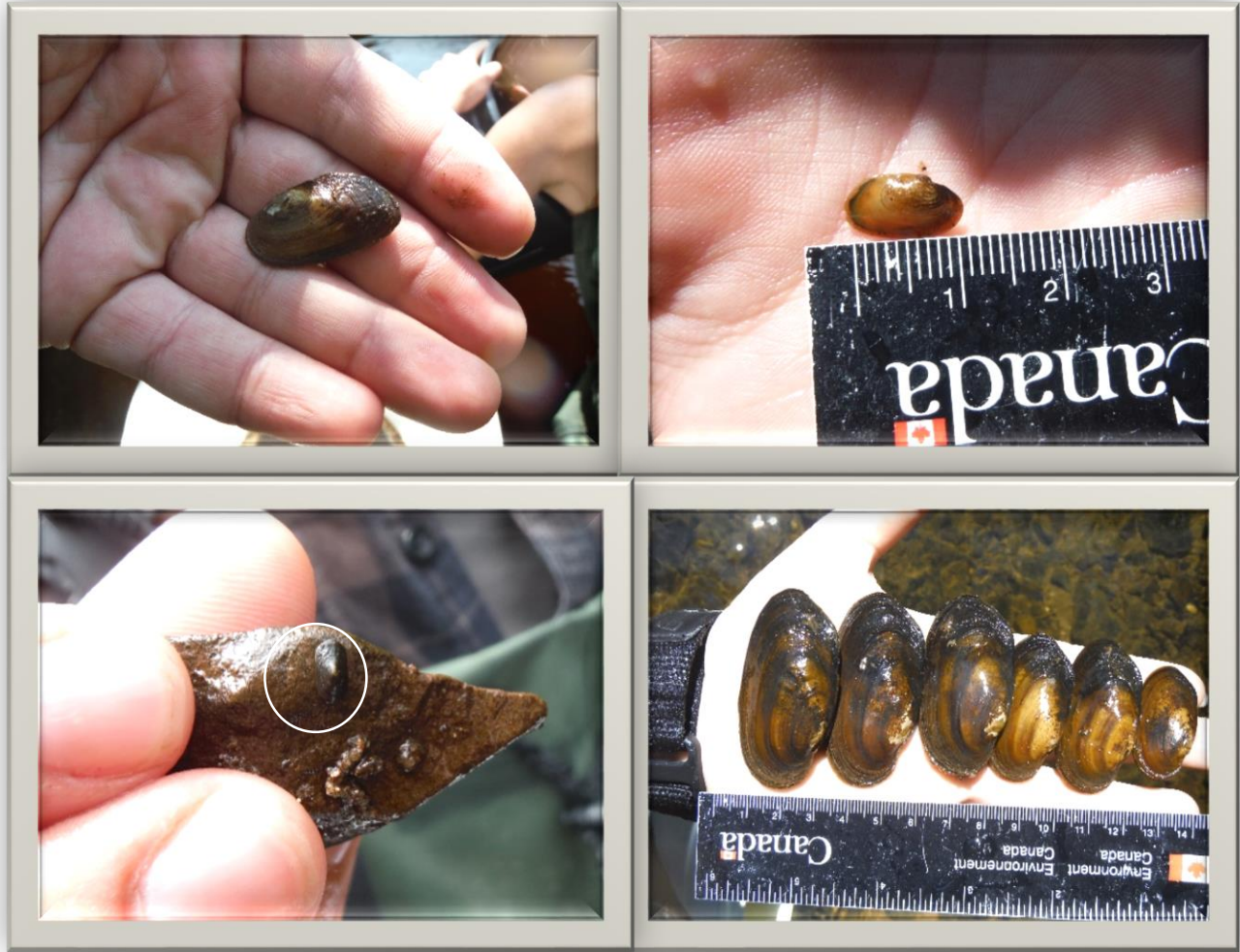


Figure 5: Photos of juvenile Eastern pearlshell mussels (*Margaritifera margaritifera*)

Table 2: Results of freshwater mussel surveys in the Shediac and Scoudouc Rivers, 2015

Site ID	Eastern Pearlshells (<i>Margaritifera margaritifera</i>)	Approximate # juveniles <i>Margaritifera</i> ≥6cm (included in count)	Creeper (<i>Strophitus undulates</i>)	Eastern Elliptio (<i>Elliptio complanata</i>)	Unidentified Mussels
Shediac River					
ShdG-1	347	45			
ShdG-2	622	59			
ShdM-A	620	70			
ShdM-B	528	20			
ShdI-A	1,453	63			
ShdI-B	781	25			
ShdE-1	902	70			
ShdE-2	694	110	1 shell		
ShdE-B	802	(not counted)	1 + 1 shell		
ShdL-1	17	0			
ShdD-1	1,194	30			
ShdD-2	2,659	108	2		1
Total Shediac	10,619		3		1
Scoudouc River					
ScdD-A	480	(not counted)		215	
ScdB-A	977	545		250	
Total Scoudouc	1,457			465	
Total	12,076		2	465	1

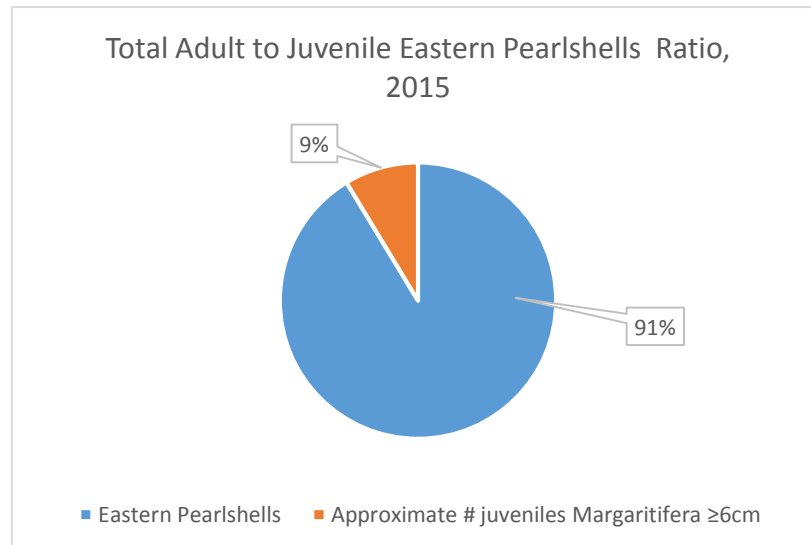


Figure 6: Ratio of adult and juvenile *Margaritifera margaritifera* found in the Shediac and Scoudouc Rivers during 2015 surveys

Table 3: Results of freshwater mussel surveys in the Shediac and Scoudouc Rivers, 2014

Site ID	Eastern Pearlshells (<i>Margaritifera margaritifera</i>)
Shediac River	
Shd G	646
Shd M	495
Shd I	989
Shd E	2 315
Shd L-1	152
Shd N	685
Shd D	3464
Shd C	0
Total Shediac	8,746
Scoudouc River	
Scd I	224
Scd H	0
Scd G	0
Scd A	CANCELED
Scd F-2*	CANCELED
Total Scoudouc	224
Total	8,970

*Site ScdF-1 location was mistaken in 2014. Location as described in 2014 report will now be identified as ScdF-2.

Table 4: Result of freshwater mussel survey of the Shediac and Scoudouc River, New Brunswick 2005, cited from 2006 report¹

Site ID	Eastern Pearlshell (<i>Margaritifera margaritifera</i>)	Eastern Elliptio (<i>Elliptio complanata</i>)	Brook Floater (<i>Alasmidonta varicosa</i>)	Total
Shediac River				
Shd C	0	0	0	0
Shd D	134	46	30	210
Shd E	75	26	0	101
Shd G	37	76	14	127
Shd I	13	5	4	22
Shd L	111	30	2	143
Shd M	95	52	27	174
Shd N	108	24	26	158
Total Shediac	573	259	103	935
Scoudouc River				
Scd I	24	8	1	33
Scd A	245	104	18	367
Scd F-1*	0	1	0	1
Scd G	0	0	0	0
Scd H	0	0	0	0
Total Scoudouc	269	113	19	401
Total	842	372	122	1,336

*Correction of site ID from 2006 report¹, site ScdF is now identified as Scd F-1.

3.2 Freshwater Mussel Inventory in Shediac River 2016- Site Description

In the Shediac River, a total of 16 sites were surveyed in 2016 using to the time-search protocol (Fig.7), and a total of 8.2 km of the river and its tributaries were searched for brook floater mussels (Table 5). All areas surveyed and searched in the Shediac River are described below.

Given that the Shediac River is the most important river where brook floater mussels were reported in the 2006 report¹, the majority of the work was done within the main branch and the tributaries of the Shediac River. All areas where the brook floater mussel was reported to have been found, at six sites in the Shediac River, are considered high priority sites. These high priority sites were thoroughly searched on 2-5 repeated visits in 2016, depending on the accessibility of those areas.

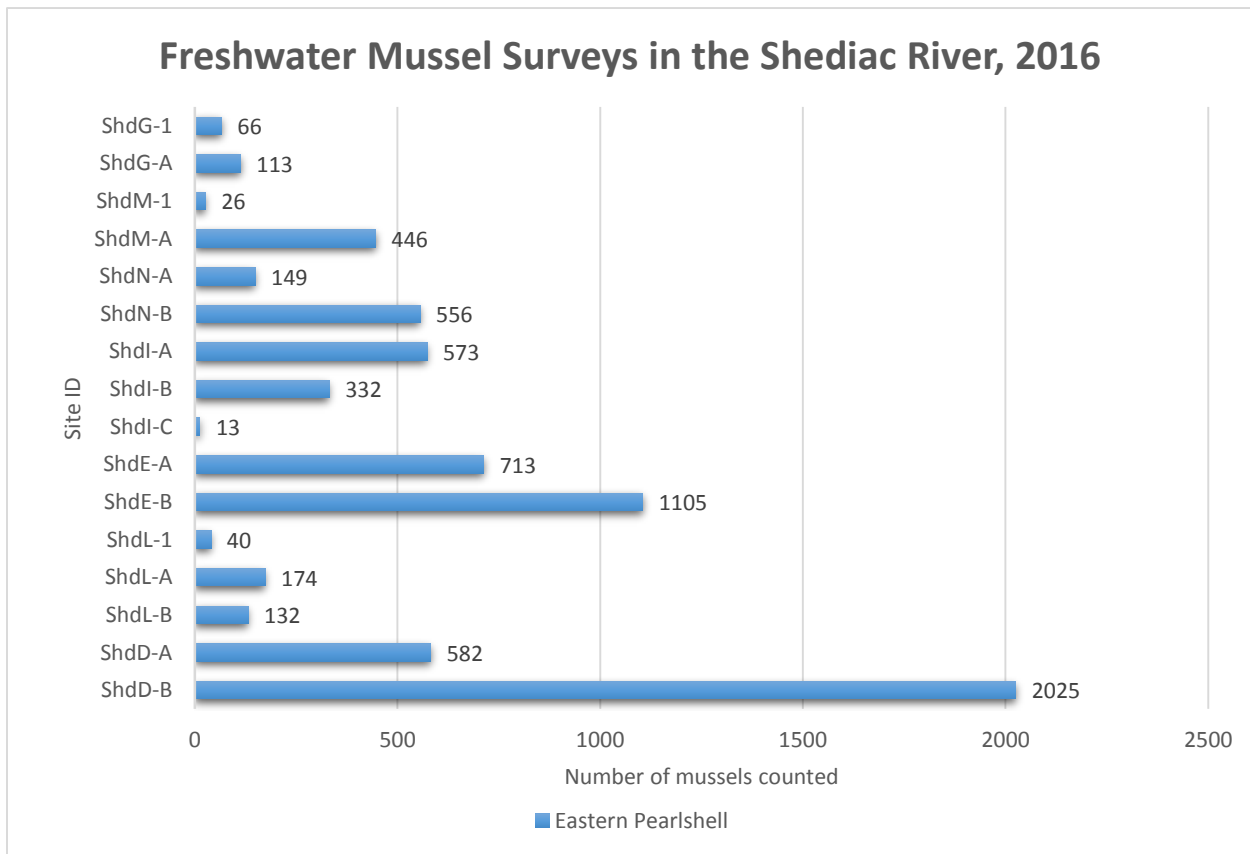


Figure 7: Freshwater Mussel count for each site surveyed in the Shediac River, 2016

Table 5: Total distances of Time-search surveys and of total habitat searched for the Brook Floater mussels in the Shediac River, 2016

Site ID Shediac River	Distances Searched (m)	Site ID Shediac River	Distances Searched (m)
ShdD-A	175	ShdG-A to ShdM-1	560
ShdD-B	290	ShdM-A	160
ShdD-1	575	ShdM-1	125
ShdD-2	590	ShdL-A	300
ShdD-3	575	ShdL-B	365
ShdE-A	210	ShdL-1	200
ShdE-B	280	ShdI-A	135
ShdE-C	590	ShdI-B	110
ShdE-1	155	ShdI-C	210
ShdE-2	240	ShdN-A	225
ShdE-2A	470	ShdN-B	135
ShdE-3	580	ShdN-C	630
ShdG-1	80		
ShdG-A	190		
Total	8,155 m		

3.2.1 Shd G

This site is located at the bridge on St-Philippe Road, in the Weisner Brook (Fig.10). An extensive search was conducted downstream in 2014 and 2015, therefore more attention was given upstream of the bridge. However, a time-search survey was done downstream (ShdG-1), showing only 66 mussels, in approximately the same reach as was done in 2015, where there were 347 mussels. This can be explained by a number of factors; the embeddedness of freshwater mussels and low water flow making them hard to see, their displacement by ice or spring flooding, predation, or other.

The habitat upstream (ShdG-A) has been modified by the presence of a beaver dam, which is located directly underneath the bridge. The habitat upstream (Fig.8) has higher water levels and the substrate contains fine sediments over the substrate, with some rocks. A time-search survey was done, showing that 113 Eastern pearlshell mussels (*Margaritifera margaritifera*) were still present in the modified beaver habitat, on a 190-metre section. An observation was made that most margaritiferas here were relatively of the same size and colour, seeming to be within the same age class.

Following the survey, the entire section of the Weisner Brook (560m) upstream from the St-Philippe road up to the next bridge on Bateman Mill Rd (ShdG-A to ShdM-1), was searched for mussel habitat. There are 6 beaver dams along this brook, making the majority of the stream modified with high water levels and sediment. The substrate in the remaining sections is mostly bedrock, with some rubble and gravel. Only one area contained enough of a gravel substrate to be suitable for brook floater mussels. This area was inspected but only Eastern pearlshell mussels were seen. A shell midden was found (Fig.9) but only contained margaritifera mussel shells.

The total area searched for ShdG is 830m, with average stream width of 4.5 metres (3,735 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.



Figure 8: Site photos of ShdG-A survey site, upstream view (left), downstream view (right), 2016



Figure 9: Photo of a shell midden in freshwater mussel habitat, in the area between ShdG-A and ShdM-1, Weisner Brook 2016

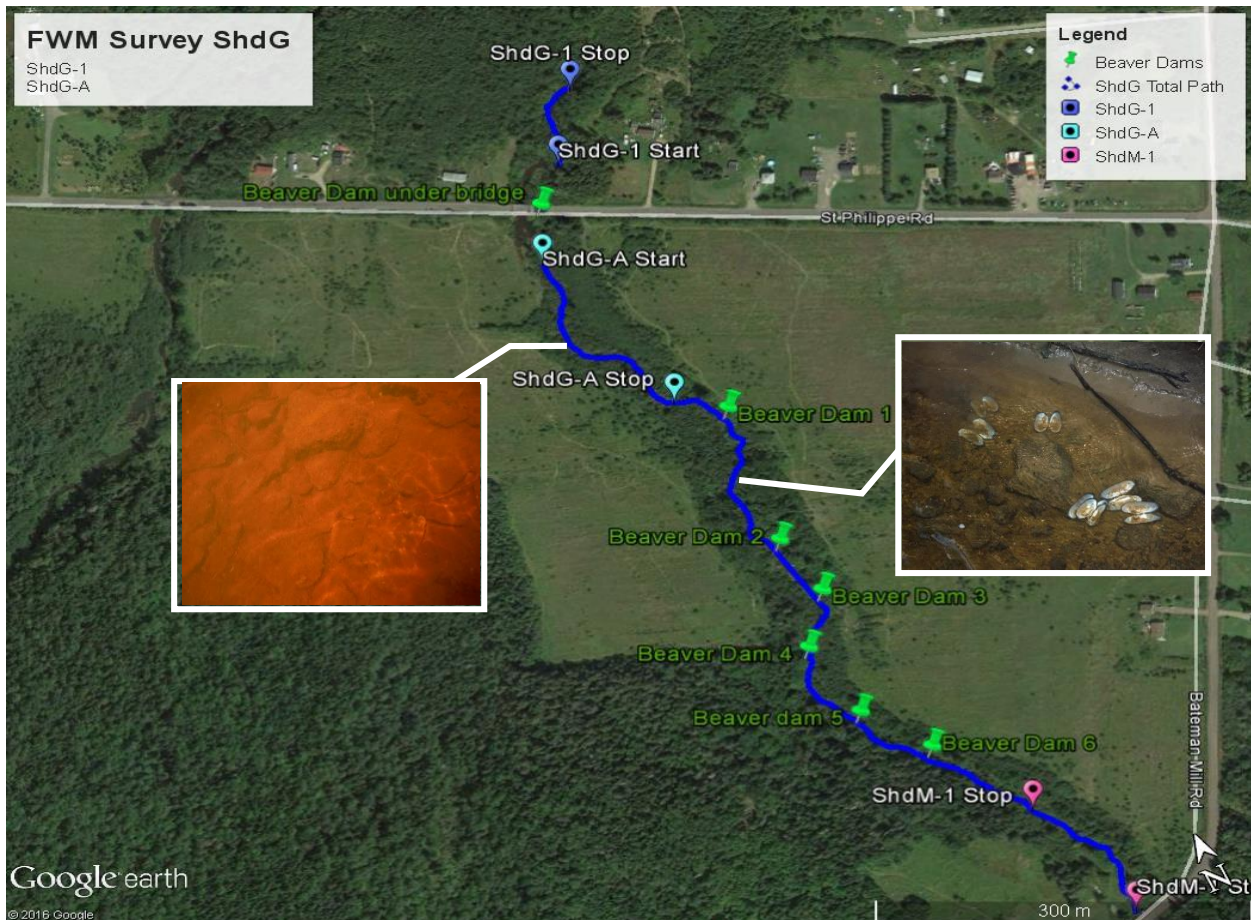


Figure 10: Map of site of the total search area for ShdG, 2016

3.2.2 Shd M

Located on Bateman Mill Rd., at the bridge where the Weisner Brook crosses the road (Fig.13). This area upstream of the bridge (ShdM-A), was high priority as there was 27 Brook Floaters reported in the 2006 report¹ (ShdM-A). The site was thoroughly searched both in 2014 and 2015, but no signs of brook floater mussels were found. In 2016, the area described to have contained brook floaters in the 2006 report¹ was visited on five different occasions. Not all visits here were noted in the raw data, only two field sheets with habitat data was recorded. The other 3 visits were during other projects in this river, where the team took a few minutes to scan the important area for any signs of brook floater mussels.

The habitat upstream (ShdM-A) is in good condition, the substrate composed of mostly rocks and sand with good vegetation cover along the banks (Fig.11). However, there is some erosion nearby on a riverfront property owner's land, due to a lack of vegetation. That area would be a good place to create stewardship with the landowner for erosion control. The important area was searched during different periods of the year, beginning in early May. This was done in the hopes that changes in water temperatures would be more favourable and that burrowed brook floaters would surface. Once again, there were no signs of the rare mussel this year. There are a lot of common mussels here, 445 mussels/160 metres.

The area downstream of the bridge (ShdM-1), is also in good condition, without erosion and healthy riparian zone. However, the substrate is mostly comprised of bedrock, boulders, and some rocks and rubble. This substrate is unfavourable for freshwater mussels, only 26 mussels/125 metres were found in this survey (Fig.12). This area was only checked once.

The total area searched for ShdM is 285m, with average stream width of 5 metres (1,425 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.



Figure 11: Site photos of ShdM-1 survey site, upstream view (left), downstream view (right), 2016



Figure 12: Site photos of ShdM-A survey site, upstream view (left), downstream view (right), 2016

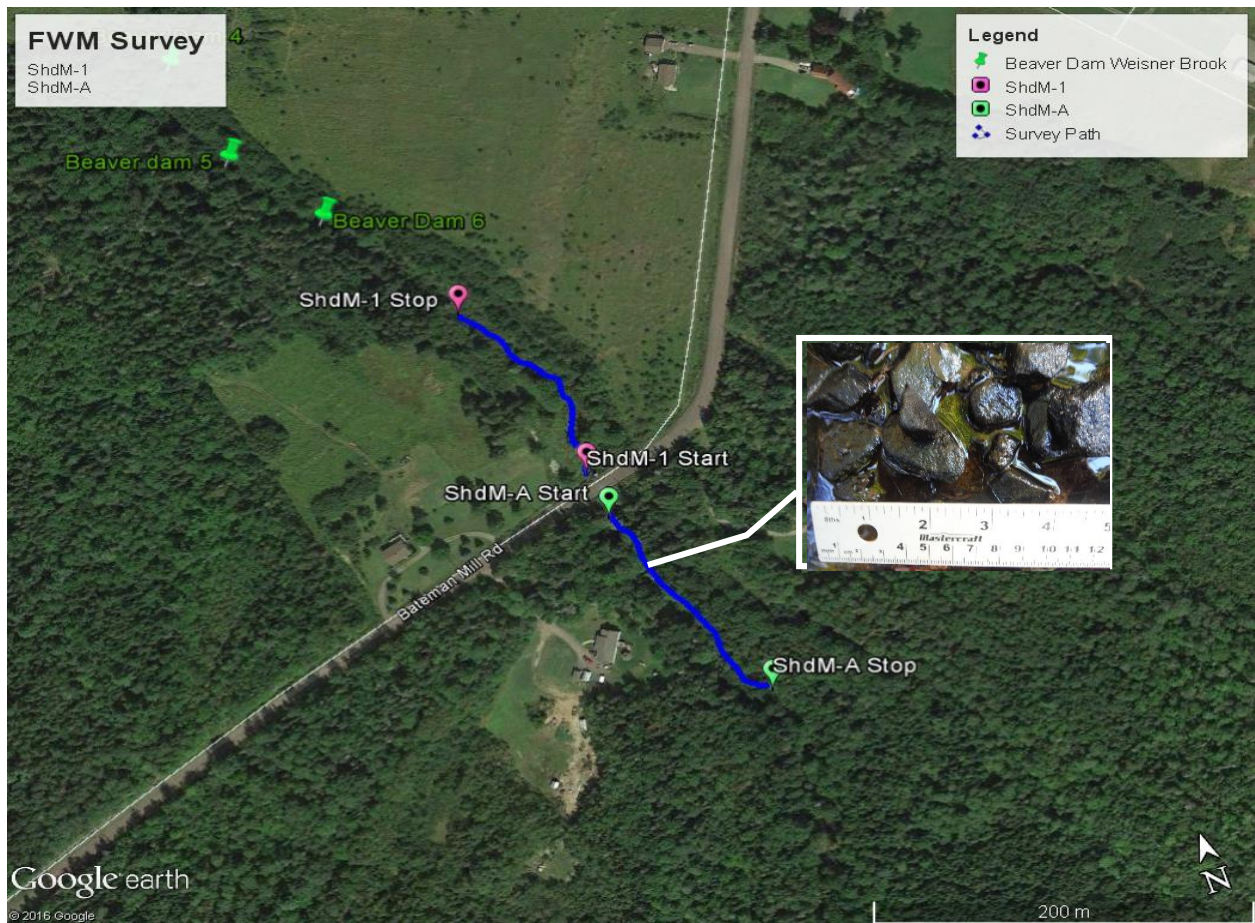


Figure 13: Map of site of the total search area for ShdM, 2016

3.2.3 Shd L

This site is situated in the Calhoun Brook, accessed on Weisner Rd. at the bridge that is nearest to St-Philippe Rd. (Fig.16). This site was of low priority because no brook floater was found here, but the stream was searched upstream and downstream once.

Upstream of the bridge (ShdL-A&B), the beginning of the habitat is in a residential area with very little vegetation in the buffer zone due to lawn mowing close to the stream (Fig 14). There is fine sediment covering the substrate in this area, and sediment loads impacting the area immediately downstream of the bridge. Once past the residential area upstream, the habitat becomes healthier and more favourable to freshwater mussels; a substrate containing rocks, rubble, gravel, and sand, with some sections of bare bedrock. The average width of the stream was approximately 3.5 metres, with water depths ranging from 20-50 cm. There are freshwater mussels here but they were not very abundant; ShdL-A= 174 mussels/300 metres and ShdL-B = 132 mussels/365 metres. There were some areas where erosion was noted, and also some areas that had significant green and brown filamentous algae growth.

Downstream of the bridge (ShdL-1), the habitat in the beginning as mentioned above was modified by thick sediment. This area was checked for freshwater mussels (Fig.15) but the survey only began once the substrate changed to rock, rubble and gravel. Although the substrate contains about 40% rubble, freshwater mussels were not abundant in this site either; 40 mussels/200 metres. The average stream width is approximately 3 metres. The surrounding riparian zones are healthy, with plenty of natural forested area. There are a few fallen trees in one area causing blockages.

The total area searched for ShdL is 865m, with average stream width of 3 metres (2,595 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.

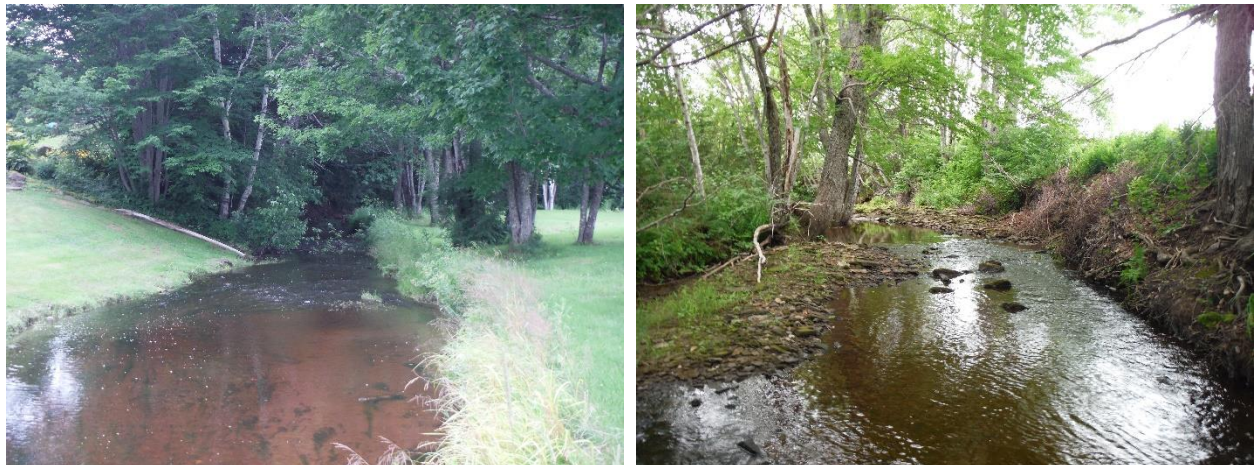


Figure 14: Site photos for ShdL-A, upstream view (left), downstream view (right)



Figure 15: Site photos for ShdL-1, upstream view (left), downstream view (right)

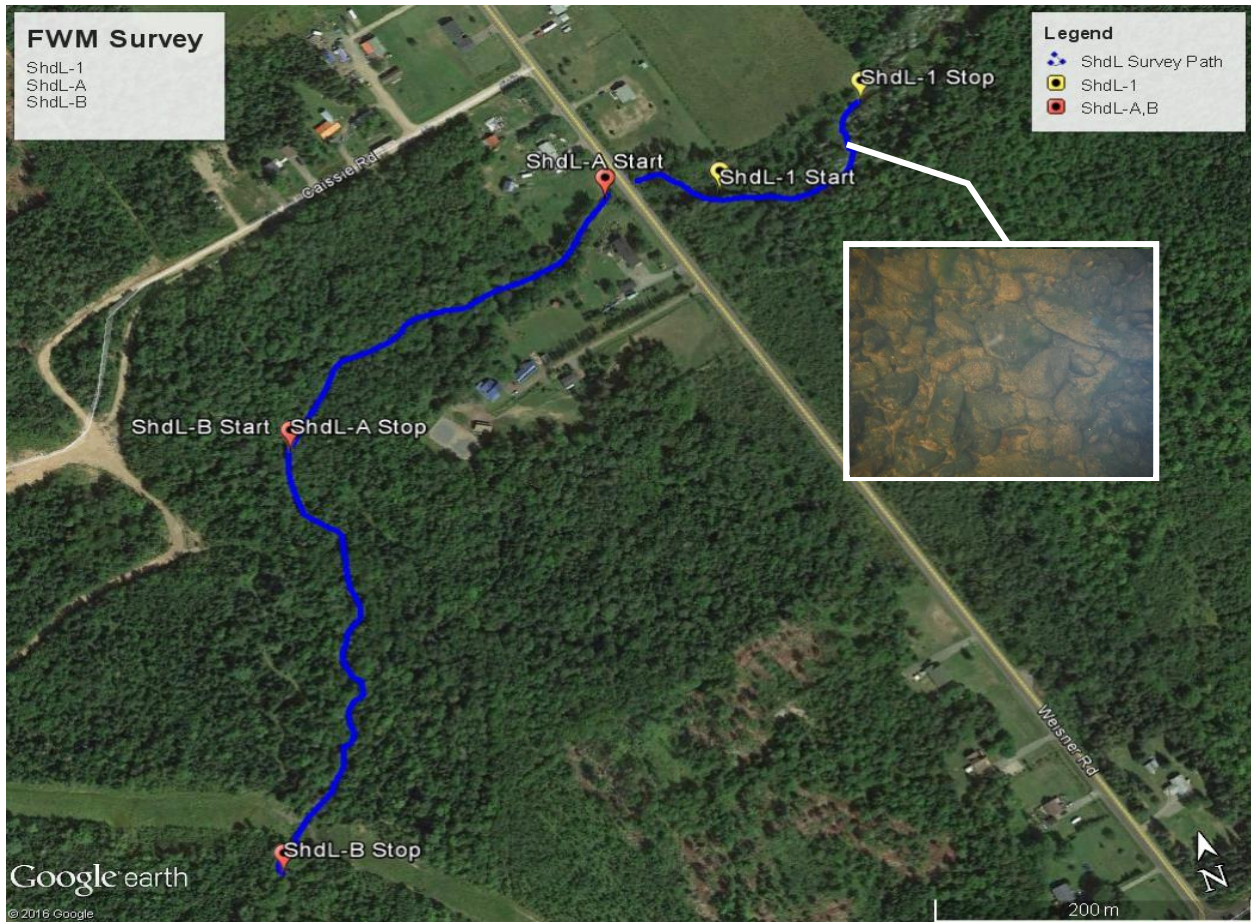


Figure 16: Map of site of the total search area for ShdL, 2016

3.2.4 Shd I

Located directly in the Shediac River, this site can be accessed by walking down an ATV trail (N46°14'55.35" W64°39'17.95") connecting to the Shediac River Rd. (Fig.18). This section of the Shediac River, a short distance from the highest tidal zone, has excellent habitat for freshwater mussels: medium to low water levels, and the substrate consists of rocks, rubble, gravel and sand (Fig.17). This site begins where the habitat transforms from brackish waters to freshwater habitat, and where the common margaritifera mussels begin to appear. This site was visited on 4 occasions during the summer.

This site is the beginning of the high priority area, being the lowest reach of the Shediac River's freshwater habitat. This priority area extends from ShdI to the Covered Bridge and beyond, to ShdD. In addition, the site ShdI-A was reported to have 4 brook floaters mussels in the 2005 surveys¹.

This site is very rich in pearlshell mussels; especially in the first area, ShdI-A (573 mussels/135m). The following sections begin to reduce gradually in ShdI-B (332 mussels/110m), then they become quite scarce near the end of the search in ShdI-C (13 mussels/210m). The riverbanks were also searched for brook floater shells. The total area searched for ShdI is 455m, with average stream width of 13 metres (5,915 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.

There is an area along the site identified as ShdI-B that has significant bank erosion. This area, according to local residents, used to have a wood mill on the edge of the Shediac River. Wooden pillars are becoming more and more visible as the soil surrounding them is eroding away. Those wooden pillars were not seen in 2014, but were discovered in 2015. In 2016, a large portion of the pillars were suddenly visible, indicating that the bank is eroding fast. The pillars can be seen with google earth imagery (Fig.19)



Figure 17: Site photos of ShdI-A survey site, upstream view (left), downstream view (right), 2016

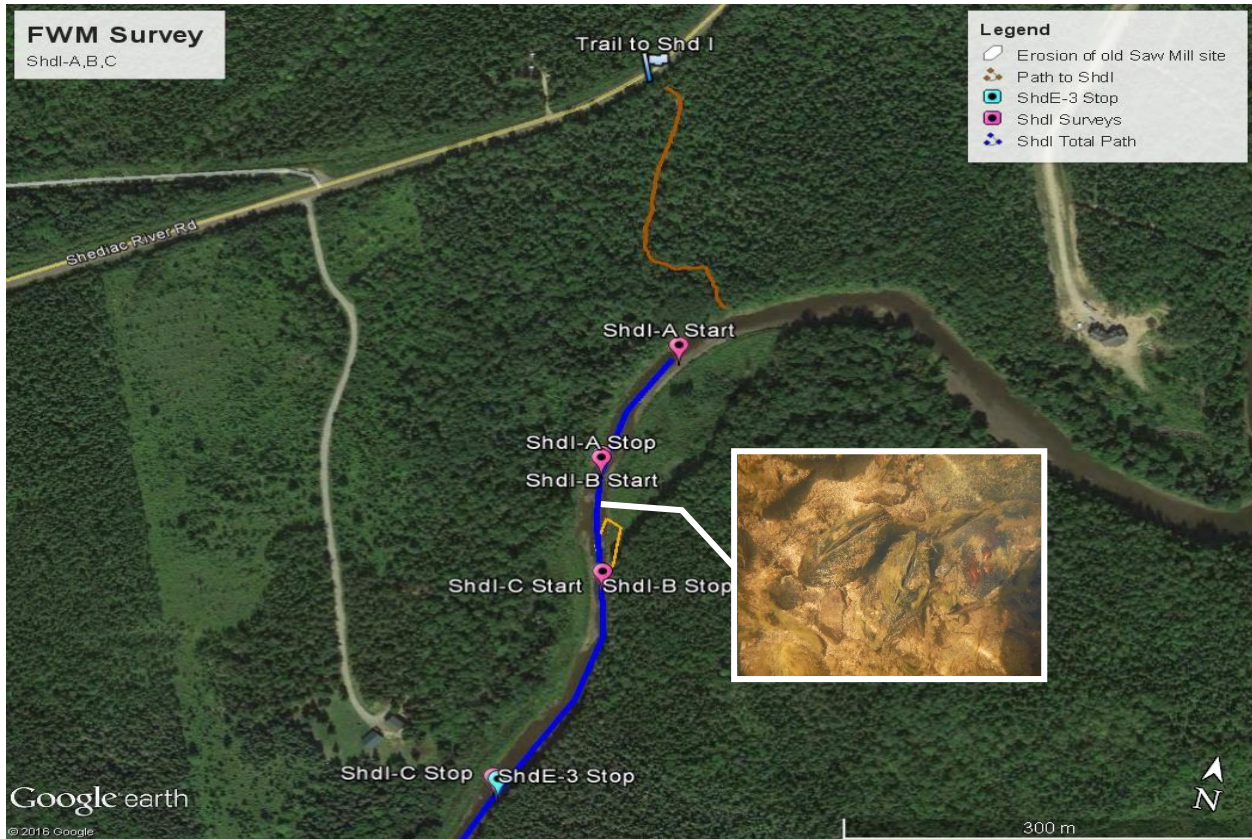


Figure 18: Map of site of the total search area for ShdI, 2016



Figure 19: Photo of eroding bank ShdI-B, historical wood mill site, 2016

3.2.5 Shd E

This site is also in the main branch of the Shediac River, located at the covered bridge on Shediac River Rd (Fig.24). From this access point, upstream from ShdI, the entire habitat has been searched upstream to the end of ShdD-3, and downstream to the end point of ShdI-C. Just as described in the previous section, this area is a high priority because of the substrate and that it is located in the lower reaches of the freshwater habitat of the Shediac River, even though no brook floaters were reported here in the 2006 report¹.

The habitat at the covered bridge going upstream (ShdE-A,B,C) is excellent for freshwater mussels; rubble, gravel and sandy substrate; clear water of an average depth of 35 cm; low water velocity and very wide (average width of 12m). The area ShdE-A (Fig.20) and ShdE-B (Fig.21) was thoroughly searched on 3 repeated visits during the field season, and ShdE-C was reached once. The riverbanks were also searched for brook floater shells during the return trips back to the covered bridge.

The substrate downstream of the covered bridge towards the Shediac River rd. bridge is mainly bedrock and boulders. Therefore, in 2016, the site ShdE-1 (Fig.22) begins downstream of the Shediac River Road's bridge. The substrate at the beginning of ShdE-1 is mostly large flat rocks, and doesn't contain more than a few freshwater mussels. The habitat begins to transform approximately halfway through this site, to more favourable substrate; rubble, gravel and sand. This substrate type remains consistent until about the halfway point of ShdE-3, where there is a long section of bedrock and has no mussels. The end point of ShdE-3 connects with the end point of ShdI-C, to complete the search for brook floater mussels in this section. The points from ShdE-1 to ShdE-2 was swept three times during the year, and the area of ShdE-3 to ShdI-C was covered once. The riverbanks were also searched for brook floater shells.

Along the section of ShdE-2, there is the convergence of the Weisner brook to the Shediac River. This section of the lower Weisner brook was identified as ShdE-2A. This area is densely forested, and has great canopy coverage. The water of this brook is significantly cooler, even in the heights of the summer months. This area is an excellent source of cold water, creating an important habitat for fish looking to migrate to avoid thermal stress. The riparian zones are healthy, with mild natural erosion. Transition power lines cross the brook, and there is a bridge crossing for ATV. The bridge is located approximately 235 metres upstream from the starting point. There was no sign of damage by ATVs along the riverbanks. The substrate along ShdE-2A (Fig.23) varies greatly from start to finish: fine rubble and gravel in the first approximate 100 metres; larger rocks and some sections of bedrock in the following 50 metres; and finally more silty and sandy substrate when approaching the bridge, and continues from then on to the end of the search site. The common freshwater mussel is not prevalent in this site, with only a few mussels seen during the search for the brook floater.

The total area searched for ShdE (A, B, C, 1, 2, 2A and 3) is 2,525m with an average stream width of 12 metres (30,300 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.



Figure 20: Site photos of ShdE-A survey site, upstream view (left), downstream view (right), 2016



Figure 21: Site photos of ShdE-B survey site, upstream view (left), downstream view (right), 2016



Figure 22: Site photos of ShdE-1 survey site, upstream view (left), downstream view (right), 2016

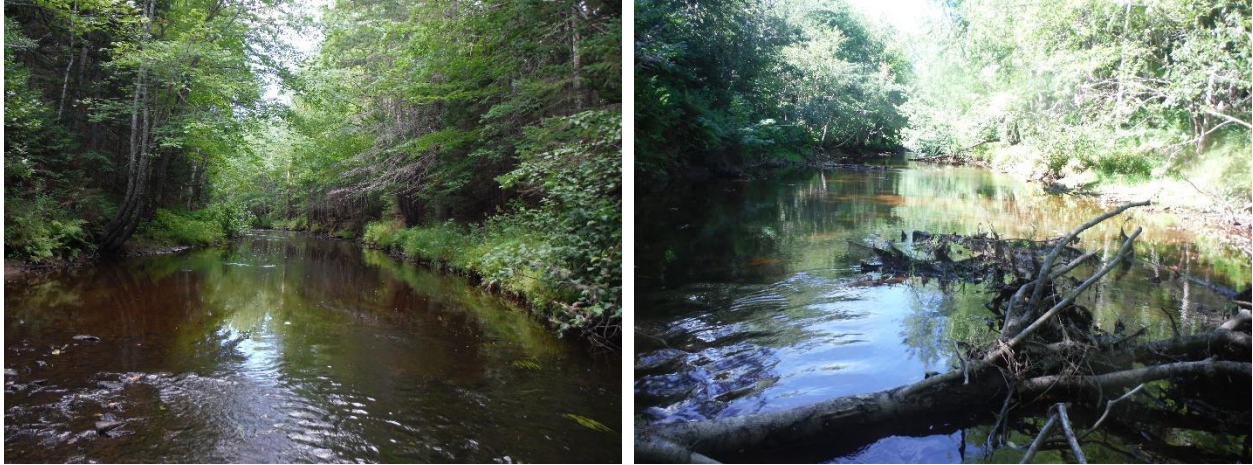


Figure 23: Site photos of ShdE-2A survey site, upstream view (left), downstream view (right), 2016

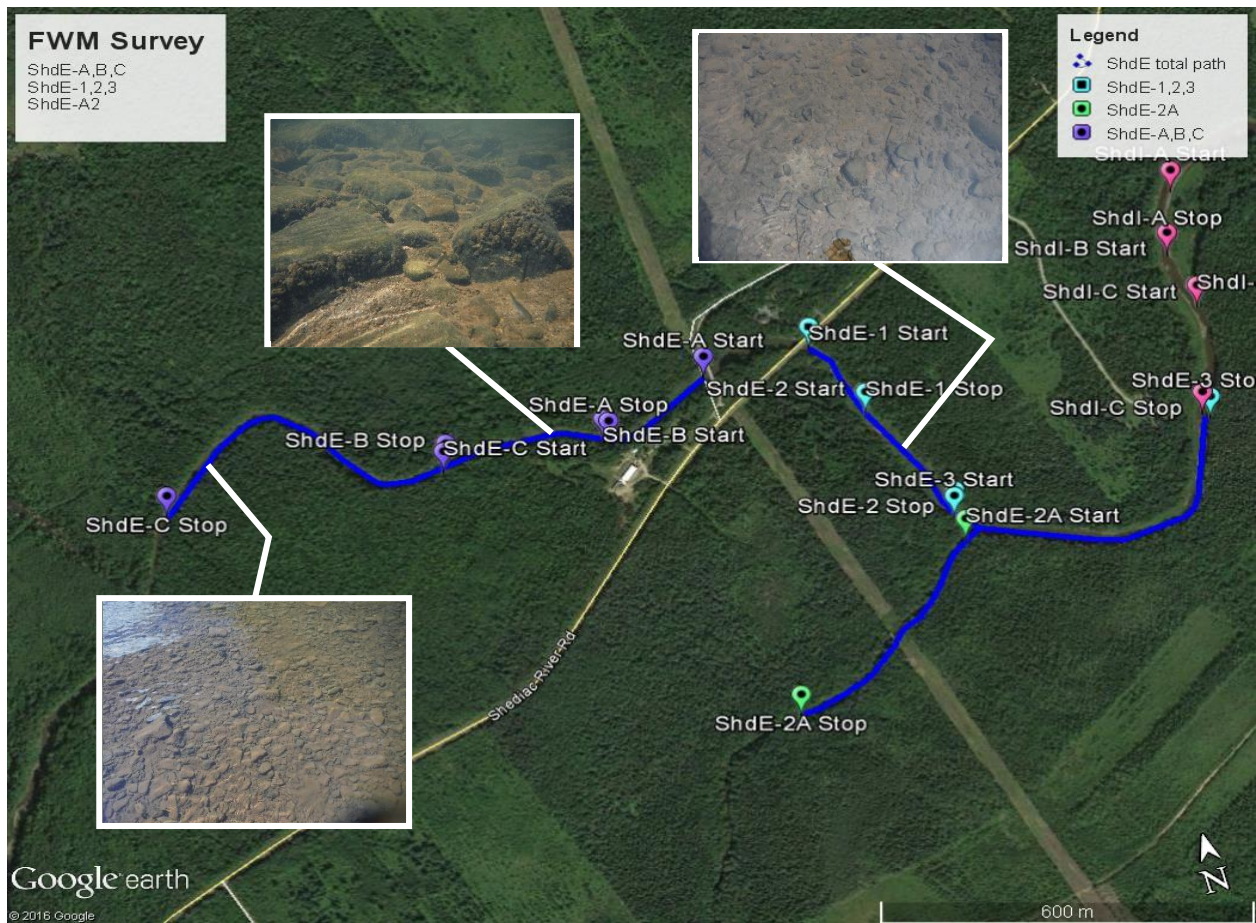


Figure 24: Map of site of the total search area for ShdE, 2016

3.2.6 Shd D

This site was accessed by walking down a trail located behind a private property (968 Shediac River Road), for which we received land owner permission to use (Fig.29). This area can also be accessed via an ATV trail connected to the Shediac River Rd.(N46°13'49.12" W64°41'48.19"), further upstream. ShdD is located upstream from site ShdE; the area searched here connects down to the end point of ShdE-C.

The habitat upstream (ShdD-A&B), is a beautiful site for freshwater mussels; a mix of mostly rubble, gravel and sand (Fig.25&26). Water levels ranged from 25-50 cm in depth, and is perfectly clear giving great visibility of the riverbed. There are multiple sand bars along ShdD-A, and they were carefully inspected for visible valves of burrowed mussels. Some parts of those sand bars were searched by digging in the sand by hand. The habitat is rich in common freshwater mussels; ShdD-A= 582 mussels/175 metres and ShdD-B = 2,025 mussels/290 metres. This area was of high priority; 30 brook floater mussels were reported to have been found in this area in the 2006 report¹. This area was visited twice in the season.

The habitat downstream (ShdD-1, 2&3) had long stretches of bare bedrock. Therefore, there was a lot of walking involved in order to reach habitat that contained a more favourable substrate (Fig.27&28). However, the habitats that were searched contained larger cobble and rocks, and did not have many freshwater mussels. No counts were taken, the purpose of this sweep was a search for freshwater mussel habitat and for the brook floater mussel. This area was visited once in the season.

The total area searched for ShdD is 2,205m, with average stream width of 10 metres (22,050 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.



Figure 25: Site photos of ShdD-A survey site, upstream view (left), downstream view (right), 2016



Figure 26: Site photos of ShdD-B survey site, upstream view (left), downstream view (right), 2016



Figure 27: Site photos of ShdD-1 survey site, upstream view (left), downstream view (right), 2016



Figure 28: Site photos of ShdD-2 survey site, upstream view (left), downstream view (right), 2016

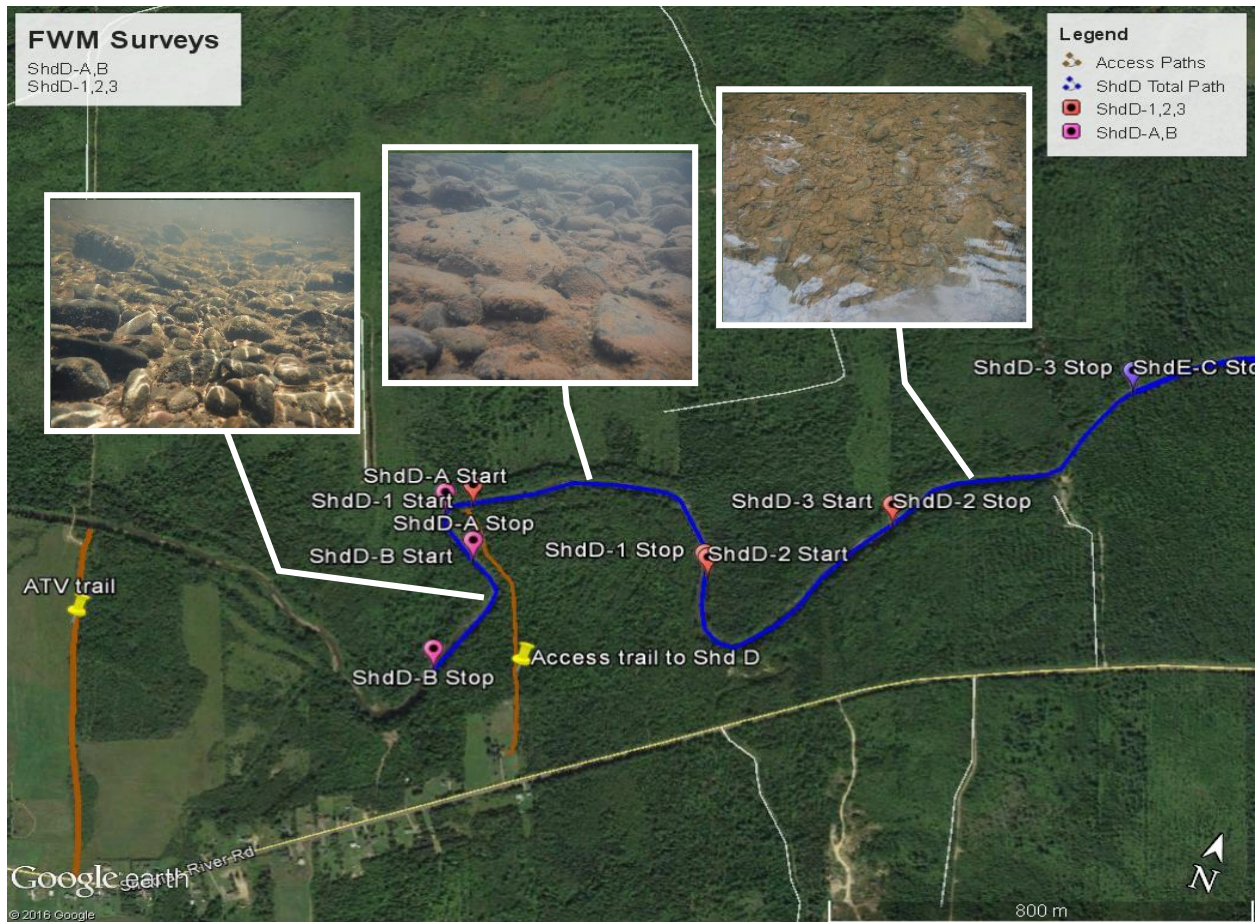


Figure 29: Map of site of the total search area for ShdD, 2016

3.2.7 Shd N

This site is further upstream of site Shd D, and it is a more difficult place to access due to the lack of roads nearby. In previous years, the site was accessed by walking down the ATV trail depicted on the site map (Fig.33). In 2016, a new path was discovered on a private property, and landowners gave their permission to park in their driveway and use the path to the river (846 Shediac River rd.). This site was visited twice during the field season. The habitat along ShdN-A, B, C, varies along the way.

The site ShdN-A (Fig.30) has larger rocks with a little of rubble, gravel and sand, and has long stretches of bedrock. The very beginning of the site has severe erosion along the meandering bank, in addition to some more erosion after the turn. This area did not have many pearlshell mussels, with only 149 mussels on 225 metres.

The site ShdN-B (Fig.31) has better substrate; more rubble and gravel with sand, and a little bedrock. This site was also noted to have some severe erosion in some places with fallen trees in the river. This area was more concentrated in freshwater mussels; 556 mussels on 135 metres.

The site ShdN-C (Fig.32) has an excellent substrate for freshwater mussels; the majority being rubble and gravel. No erosion was noticed in this area. This zone is the area believed to have contained brook floater mussels during the surveys of 2005¹. There was no count of freshwater mussels on this stretch of 630 metres, instead the time was spent carefully inspecting the riverbed for brook floater mussels. The riverbanks were also searched for brook floater shells.

The total area searched for ShdN is 990m, with average stream width of 10 metres (9,900 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.



Figure 30: Site photos of ShdN-A survey site, upstream view (left), downstream view (right), 2016



Figure 31: Site photos of ShdN-B survey site, upstream view (left), downstream view (right), 2016



Figure 32: Site photos of ShdN-C survey site, upstream view (left), downstream view (right), 2016

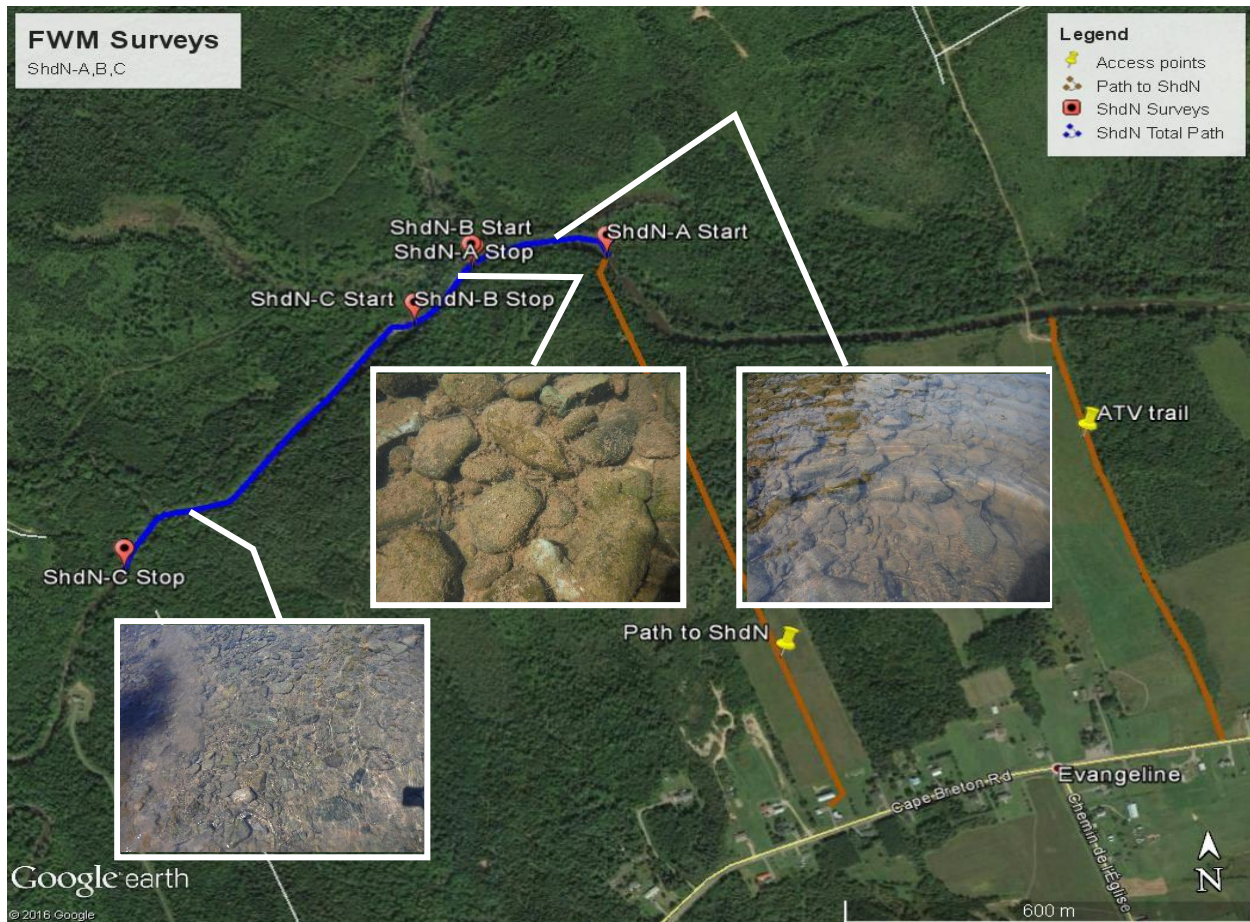


Figure 33: Map of site of the total search area for ShdN, 2016

3.3 Freshwater Mussel Inventory in Scoudouc River 2016 – Site Description

In the Scoudouc River, 2 sites were surveyed in 2016 using the time-search protocol (Fig.34), giving a total of 530 m of the river that was searched for brook floater mussels (Table 6). The areas surveyed in the Scoudouc River are described below.

The Scoudouc River is of lower priority for the brook floater mussel; only 19 brook floaters were reported to have been found in 2005, in a higher section of the river (ScdI=1 BF and ScdA=18 BF). Those sites are difficult to access, requiring an ATV to get there. In 2014 and 2015, the site ScdI was thoroughly searched, and the site ScdA, a small tributary adjacent to ScdI, was discovered to be very difficult to survey. It was determined that the site was modified, possibly impacted by the beaver dams observed, by using site photos from the 2006 report¹ along with habitat descriptions. The team attempted to search the brook for freshwater mussels, but had great difficulty. The water was concentrated in red tannins making the visibility of the riverbed extremely poor. Fine sediments covered the substrate, creating clouds of sediment obstructing the visibility with every step. Also, the brook had an abundance of large aquatic plants that were hiding freshwater mussels. It is possible that in 2005, the brook was in much better condition for freshwater mussels surveying, and they were able to discover the 18 brook floaters. Due to the current conditions of the habitat, the team did not attempt to return in 2016.

Another problem with the Scoudouc River is a lack of access points to suitable freshwater mussel habitat. Therefore, the team focused their efforts in the lower reaches of the river, where there are some access points to freshwater mussel habitat, and may have better luck finding brook floaters that would have moved downstream.

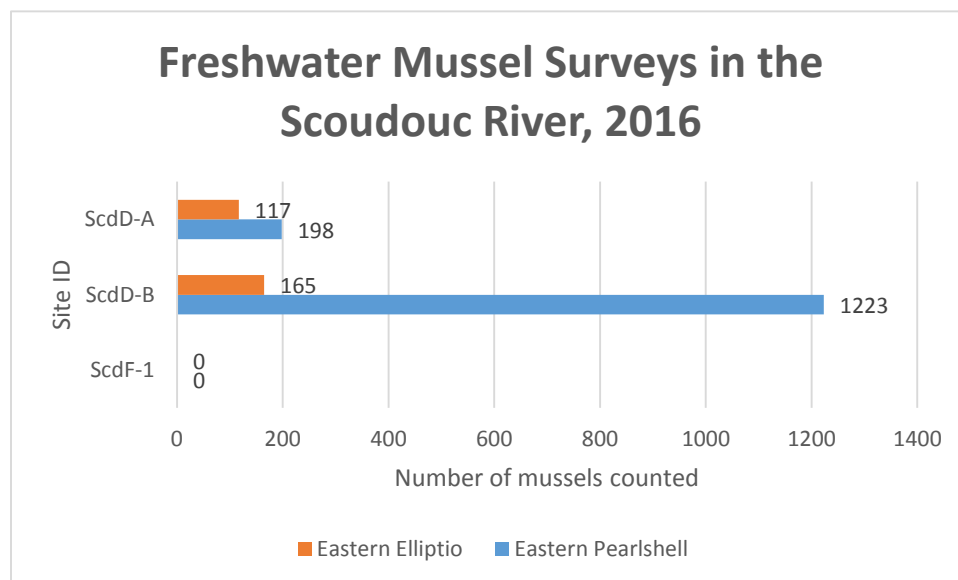


Figure 34: Freshwater Mussel count for each site surveyed in the Scoudouc River, 2016

Table 6: Total distances of habitat searched for the Brook Floater in the Scoudouc River, 2016

Site ID Scoudouc River	Distances Searched (m)
ScdD-A	85
ScdD-B	195
ScdF-1	250
Total Scoudouc	530m



Figure 35: Photos of Eastern elliptio (*Elliptio complanata*) found in the Scoudouc River, from left to right: frontal view, lateral view, view of the beak, juvenile elliptio.

3.3.1 Scd D

This site is located where freshwater habitat begins in the Scoudouc River. It was accessed by Red Bridge Road (Fig.38) off route 132 (Scoudouc Road). Once at the end of the paved road, it transitions to a dirt road that follows the power lines down to the river.

The habitat suitable for freshwater mussels begins a short distance away from the access point. The substrate is comprised of a mix of rocks, rubble, and sand, with some sections of bedrock. The riparian zone is healthy without any signs of erosion, and has good mixed forest vegetation on both sides. In addition to the common Eastern pearlshell mussel (*Maragaritifera margaritifera*), there is a second species commonly found in the Scoudouc River; the Eastern elliptio mussel (*Elliptio complanata*) (Fig.35).

The reason why the two sites (ScdD-A&B) are very short in distance is because the stream is very wide and was very rich with 2 species of freshwater mussels. Therefore, a lot of time was spent picking up each mussel so that they were properly identified, as the two species looks very similar.

The site ScdD-A (Fig.36) was only 85 metres in length, and contained 198 Eastern pearlshell and 117 Eastern elliptio. The site ScdD-B (Fig.37) was 195 metres in length, and had 1,223 pearlshell mussels and 165 elliptio mussels. Considering the average stream width of the river (16m), the area covered for ScdD-A and ScdD-B is 1,360 m² and 3,120 m² respectively.

Despite having two species prominently found in the Scoudouc River, no other species have been found during the surveys of 2014, 2015 and 2016.

The total area searched for ScdD is 280m, with average stream width of 16 metres (4,480 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.



Figure 36: Site photos of ScdD-A survey site, upstream view (left), downstream view (right), 2016



Figure 37: Site photos of ScdD-B survey site, upstream view (left), downstream view (right), 2016

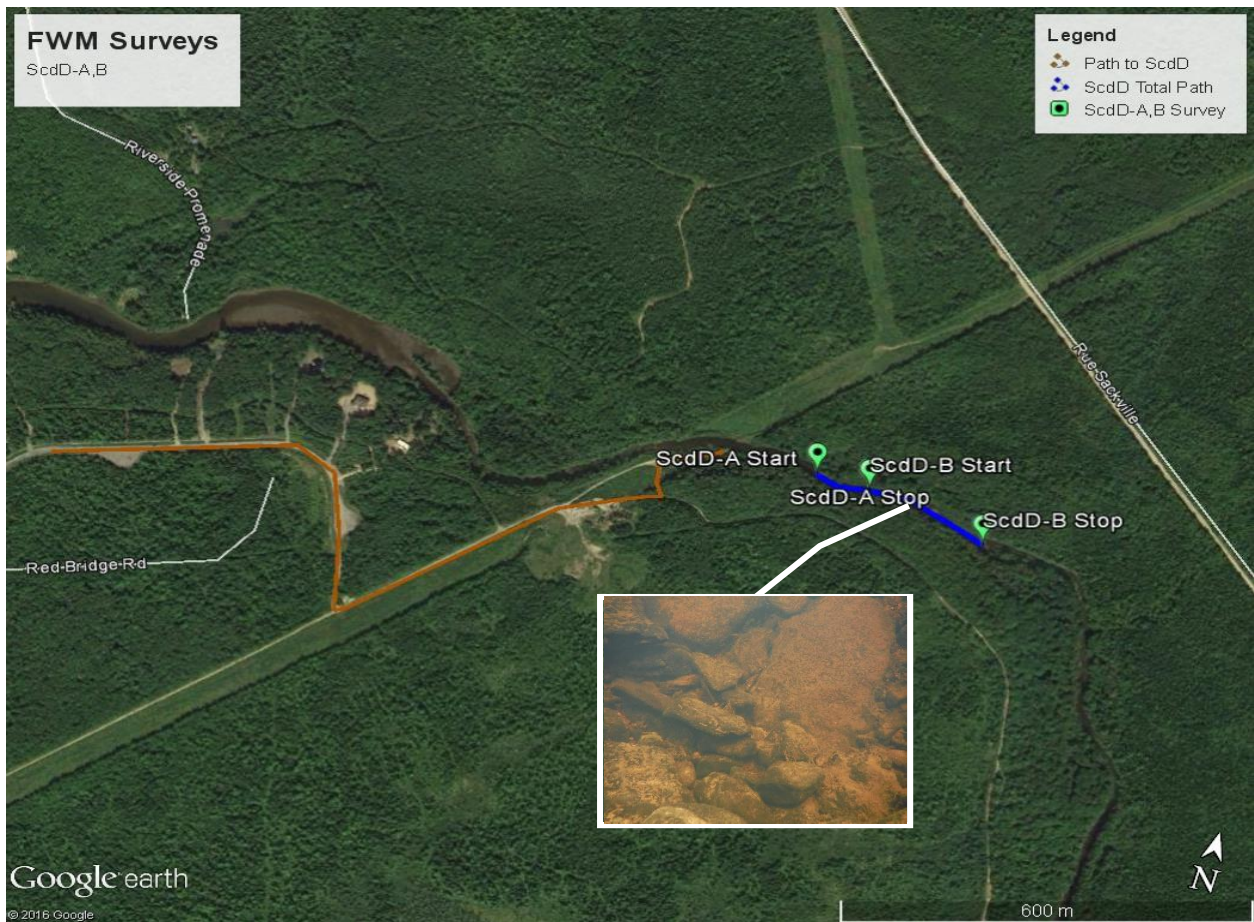


Figure 38: Map of site of the total search area for ScdD, 2016

3.3.2 ScdF

This site is located upstream of ScdD in the main branch of the Scoudouc River. It was accessed by taking Pellerin Rd., a dirt road off Lino rd. in Shediac. On google maps, this road is labelled as Sackville rd. Approximately 15 min down this road, there is an ATV trail (N46°11'5.02" W64°30'27.83") that goes down to the river, which is about a 5 min walk (Fig.41).

The habitat here, going downstream (ScdF-1) is not suitable for freshwater mussels; the substrate is comprised mostly of large flat rocks and boulders. There were no mussels seen during this survey, but a few empty shells of pearlshell mussels and 1 half of an elliptio shell were found on the riverbanks. The habitat upstream of the access site was not attempted due to the water depths (>1m), making it impossible to see the riverbed. The high water levels also created unsafe conditions for wading.

The total area searched for ScdF-1 (Fig.39&40) was 250 metres in length, with an average stream width of 13 m (3,250 m²). For more information on freshwater mussel surveys refer to Table 1, and for all field sheet data refer to Appendix A.

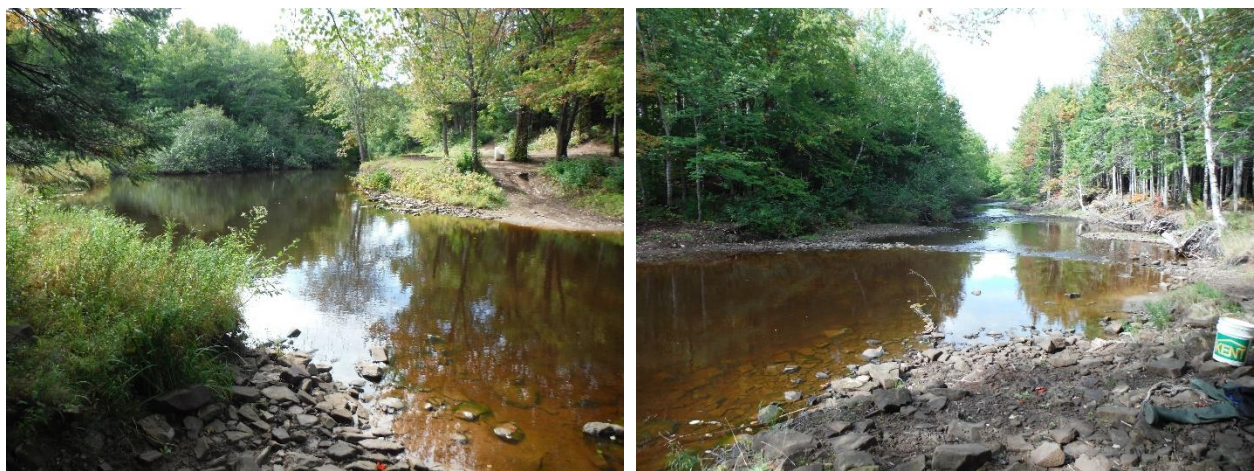


Figure 39: Site photos of access site ScdF survey site, upstream view (left), downstream view (right), 2016



Figure 40: Site photos of ScdF-1 survey site, upstream view (left), downstream view (right), 2016



Figure 41: Map of site of the total search area for ScdF, 2016

3.4 Project Summary

The following table (Table 7) will summarize total distances searched for the brook floater mussel and its habitat over the 2016 field sessions, adding up to approximately 8.7 km. Most of those sites were visited multiple times during the season, at various periods of the year (from May to September 2016).

The following maps summarize all areas searched since the beginning of the search for the brook floater mussel in 2014. Figures 42 to 51 illustrate maps with paths drawn to represent all areas where the SBWA searched during the 2014 (green), 2015 (red) and 2016 (blue) field seasons.

Table 7: Total search distances for the Shediac and Scoudouc River in 2016

Site ID	Distances Searched (m)	Site ID	Distances Searched (m)
ShdD-A	175	ShdM-A	160
ShdD-B	290	ShdM-1	125
ShdD-1	575	ShdL-A	300
ShdD-2	590	ShdL-B	365
ShdD-3	575	ShdL-1	200
ShdE-A	210	ShdI-A	135
ShdE-B	280	ShdI-B	110
ShdE-C	590	ShdI-C	210
ShdE-1	155	ShdN-A	225
ShdE-2	240	ShdN-B	135
ShdE-2A	470	ShdN-C	630
ShdE-3	580	ScdD-A	85
ShdG-1	80	ScdD-B	195
ShdG-A	190	ScdF-1	250
ShdG-A to ShdM-1	560		
Total	8,685 m		

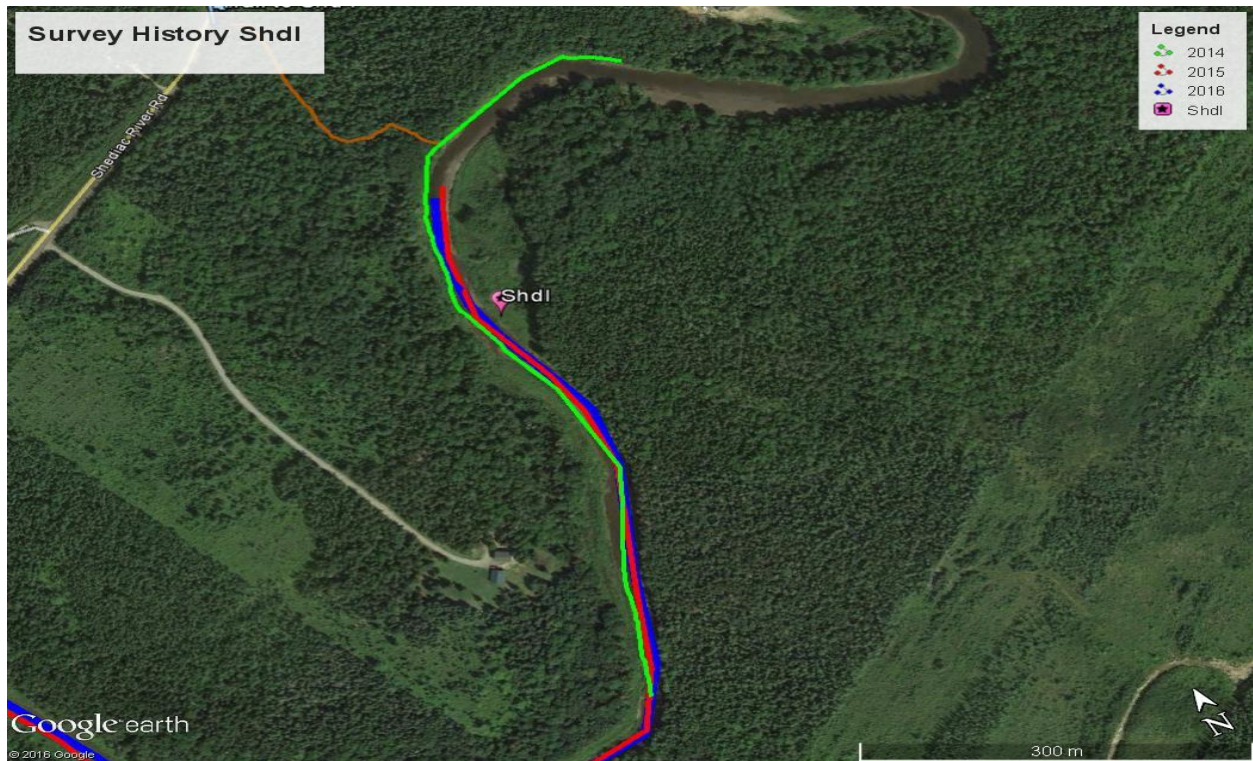


Figure 42: Historical freshwater mussel survey/habitat search at ShdI

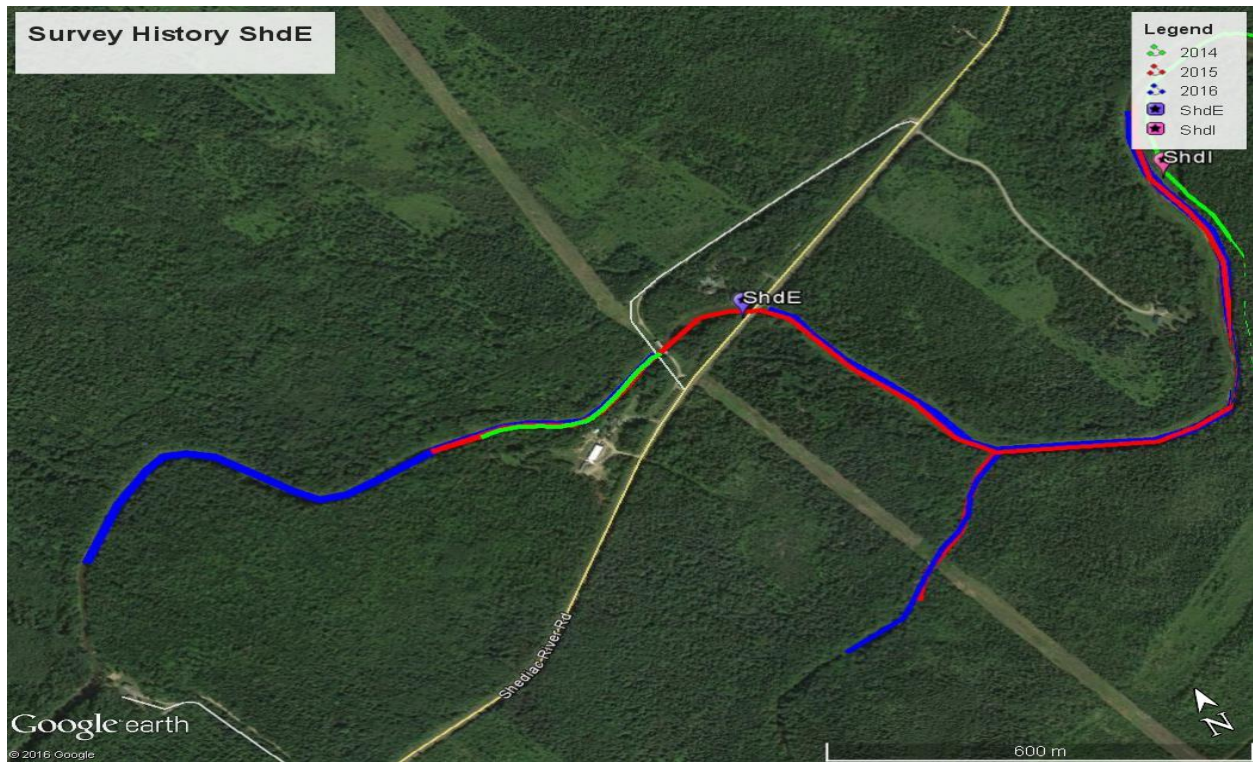


Figure 43: Historical freshwater mussel survey/habitat search at ShdE

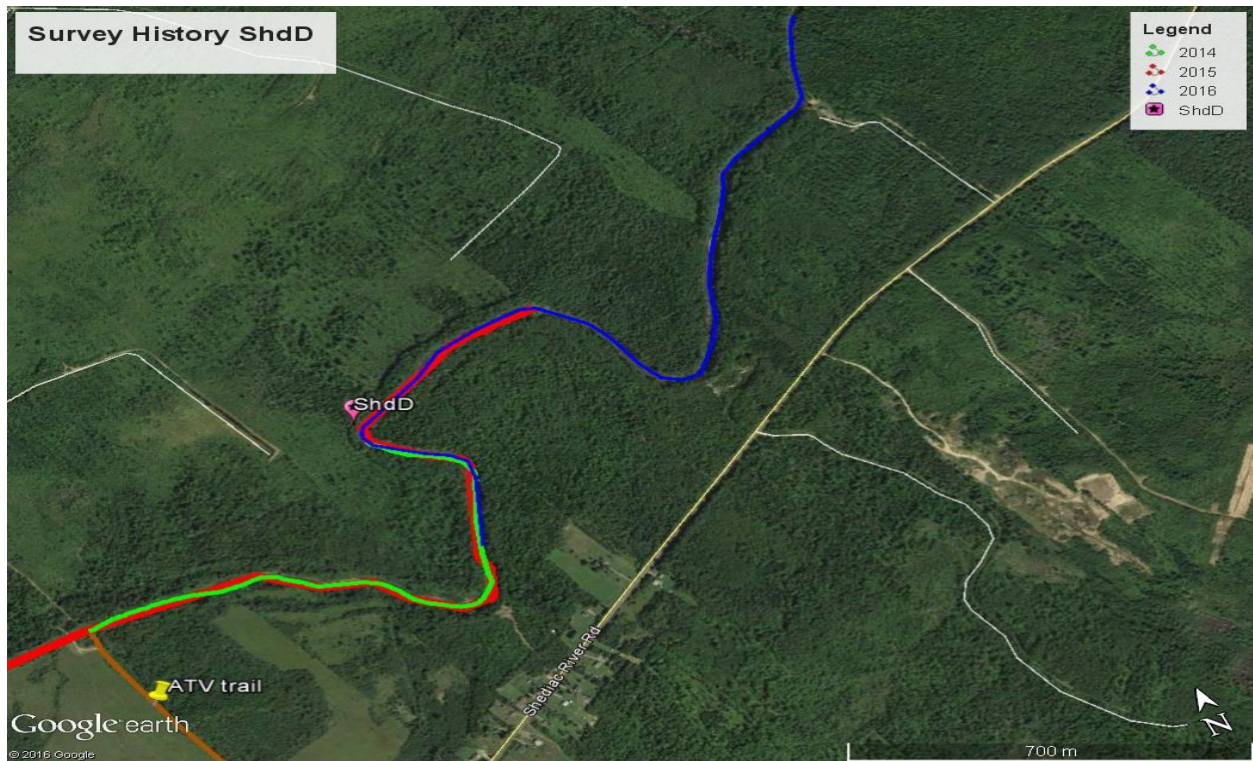


Figure 44: Historical freshwater mussel survey/habitat search at ShdD

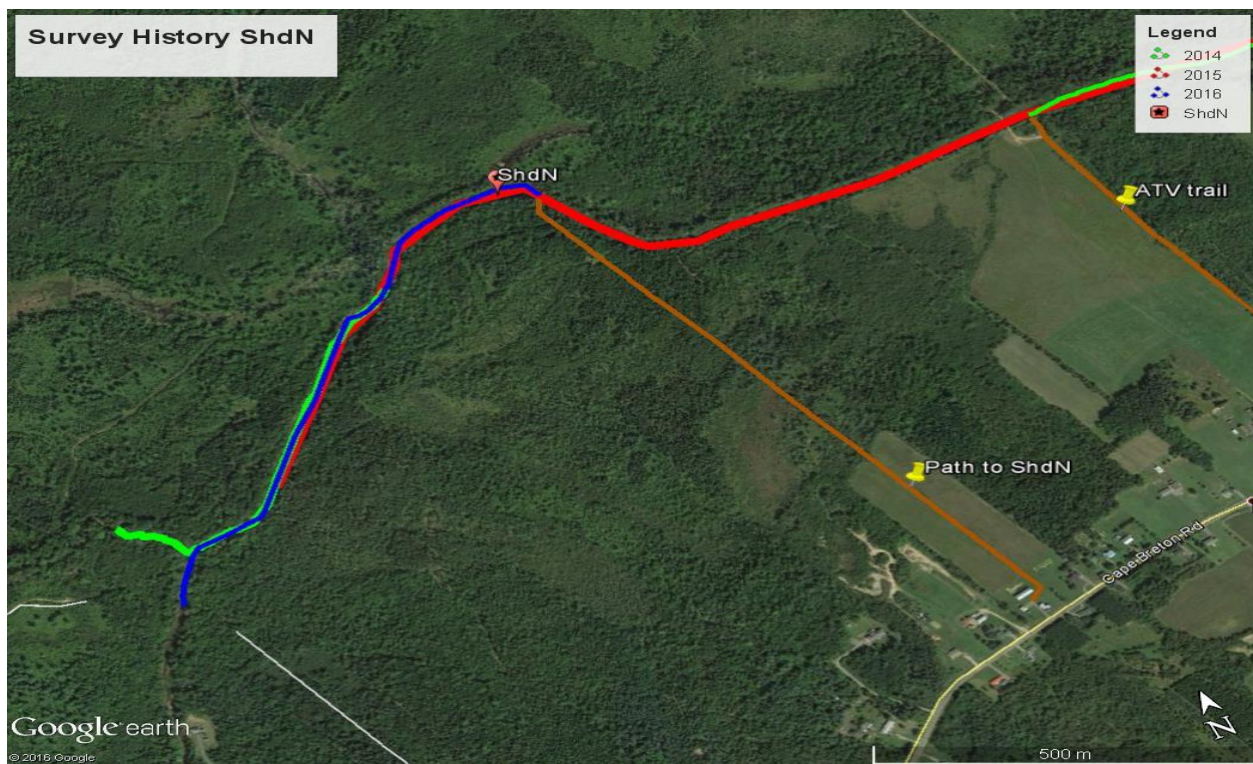


Figure 45: Historical freshwater mussel survey/habitat search at ShdN

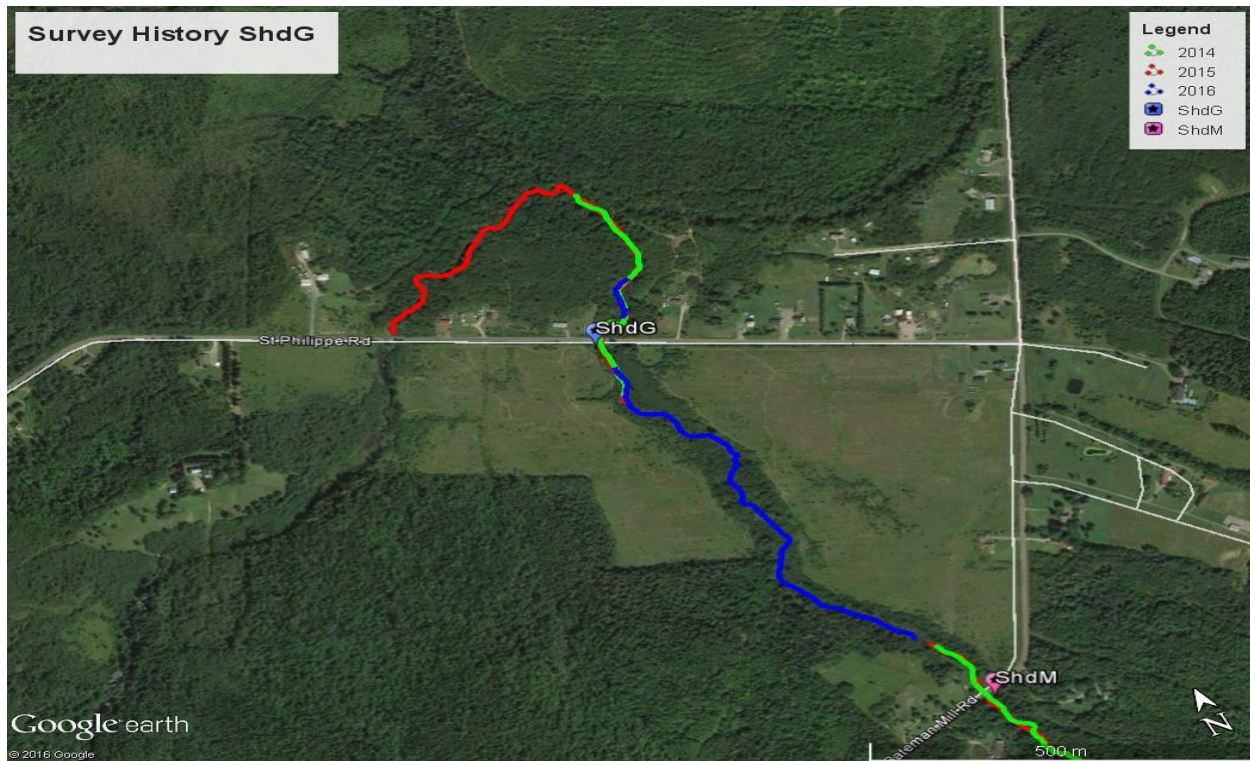


Figure 46: Historical freshwater mussel survey/habitat search at ShdG

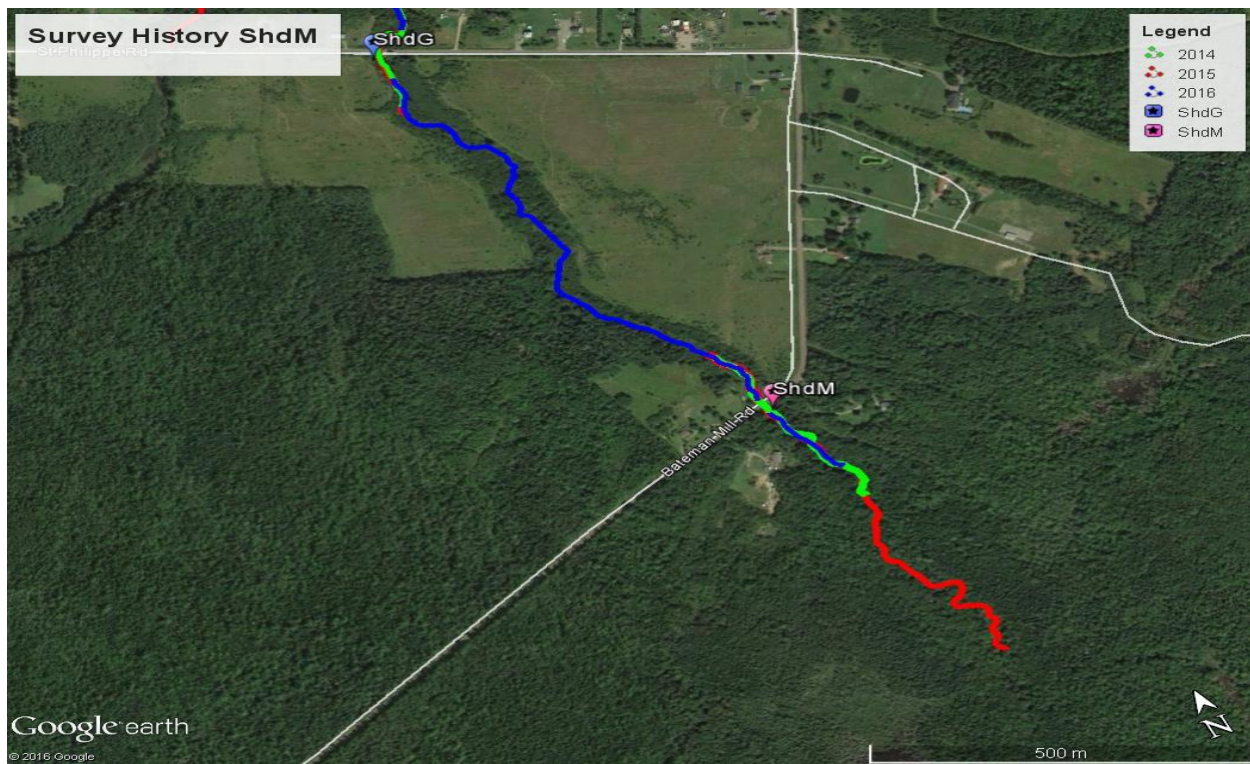


Figure 47: Historical freshwater mussel survey/habitat search at ShdM

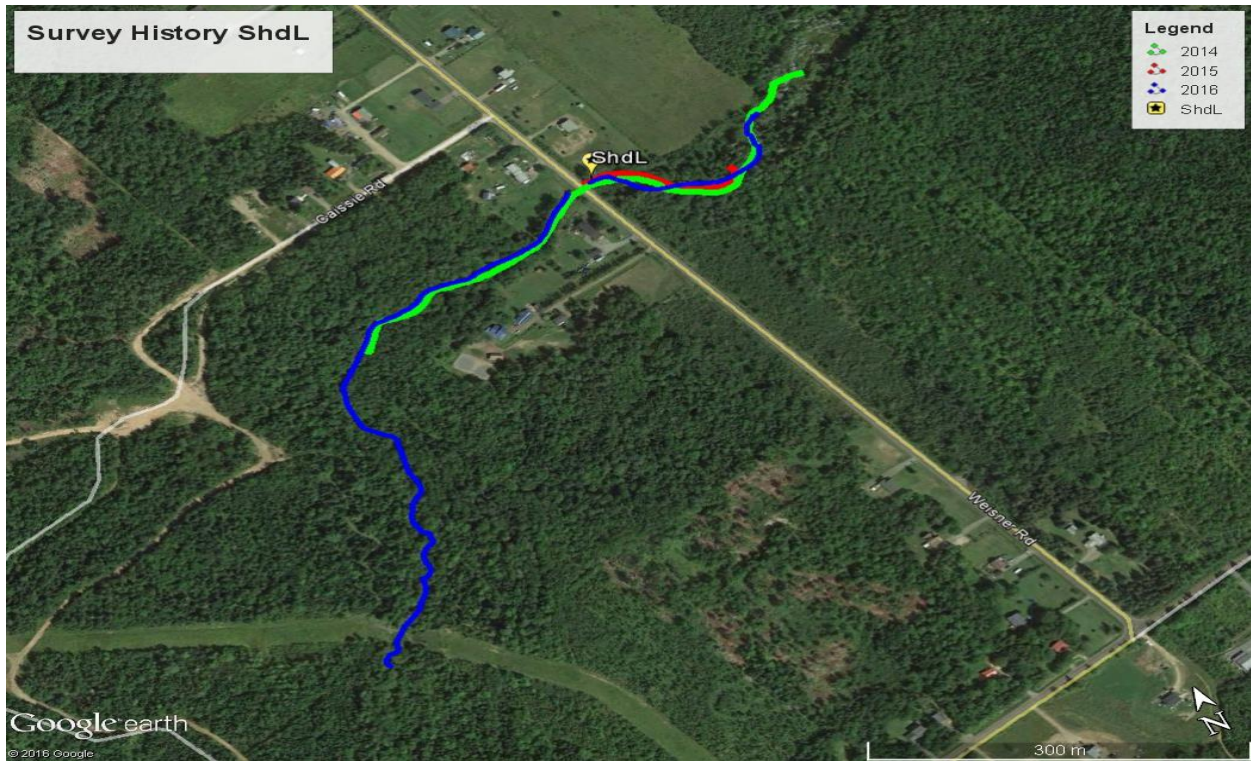


Figure 48: Historical freshwater mussel survey/habitat search at ShdL



Figure 49: Historical freshwater mussel survey/habitat search at ScdD and ScdF

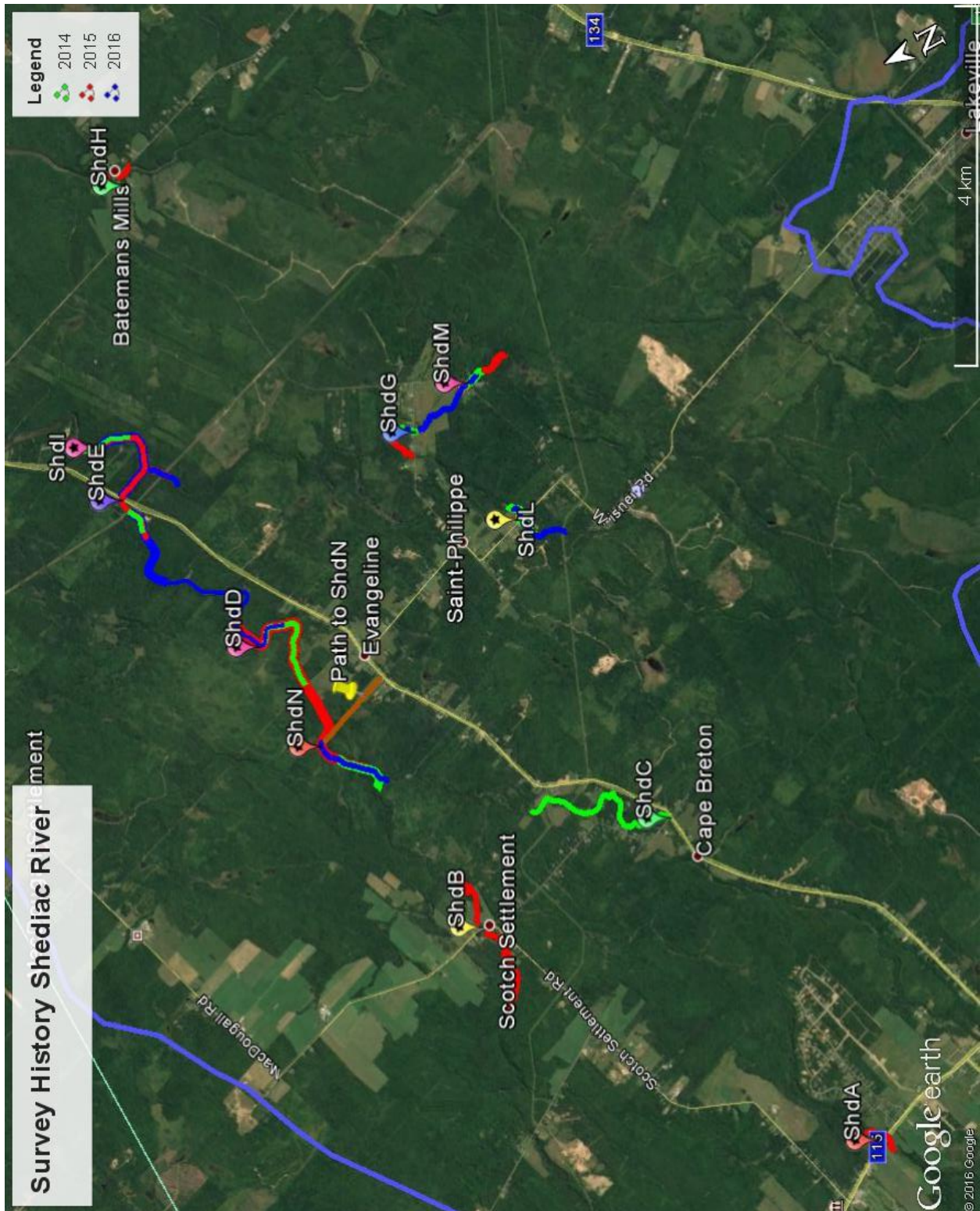


Figure 50: Historical freshwater mussel survey/habitat search in the Shediac River

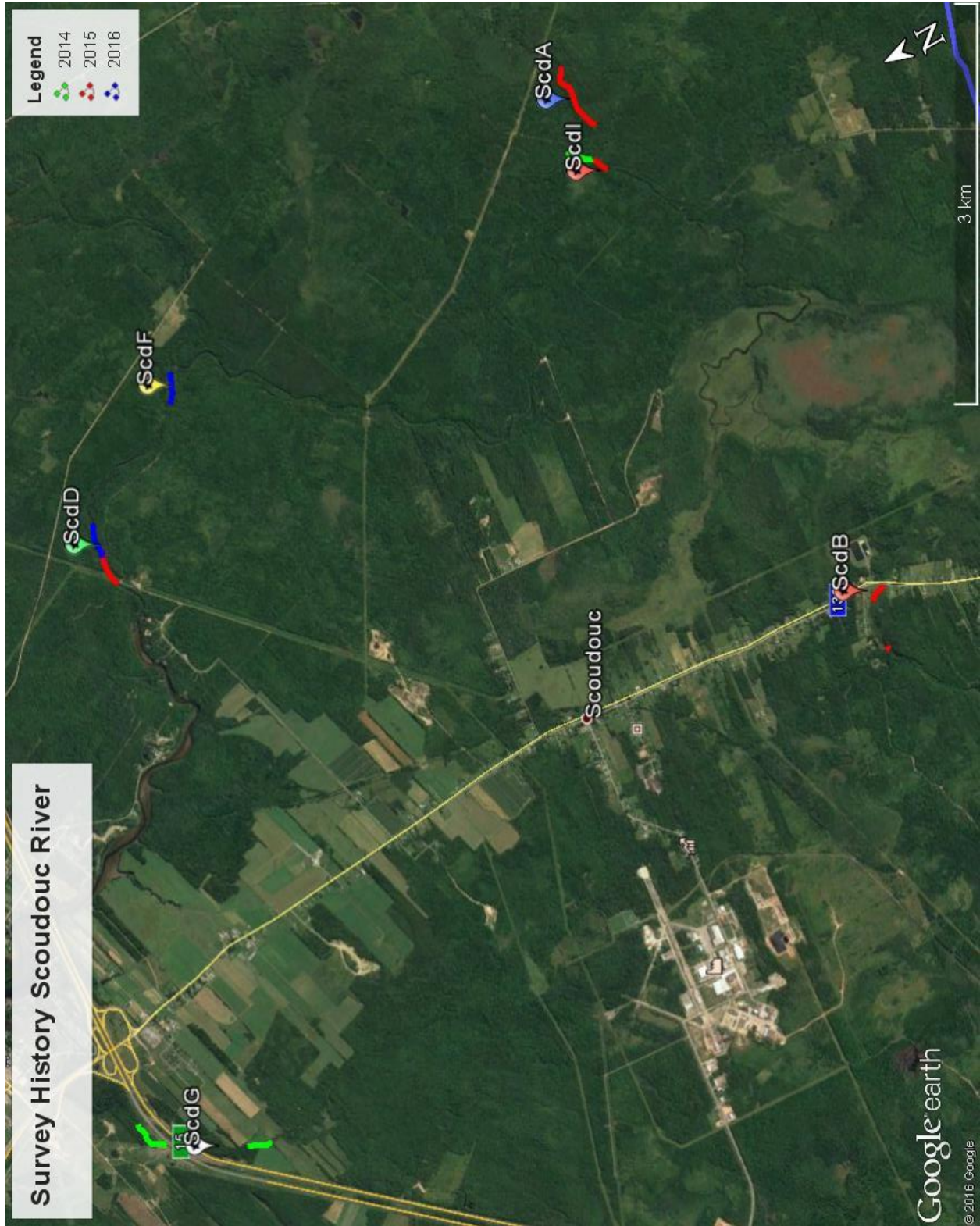


Figure 51: Historical freshwater mussel survey/habitat search in the Scoudouc River

4. Discussion

A separate report was prepared this year “*Le plan d’intendance pour la protection et la restauration de l’habitat de l’Alasmidonta renflé dans les bassins versants de Shediac et Scoudouc, 2016*”. This report describes the general characteristics of the Shediac Bay Watershed, the specifications of the anatomy and habitat of the brook floater, the threats to the brook floater in our watershed, and on a stewardship plan for the protection of this rare and endangered freshwater mussels. This report has been made available on the SBWA website and can be sent upon request by contacting our office. This report is currently only available in French.

As previously mentioned, the purpose of this project was to re-confirm the presence of Brook Floater (*Alasmidonta varicosa*) in the Shediac Bay watershed, based on the finding of the report *Freshwater Mussel Inventory in the Shediac and Scoudouc Rivers, New Brunswick* (Caissie C., and D. Audet 2006). After thoroughly searching all sites where the rare brook floater mussel was reported to be found in 2005, on multiple occasion during these past 3 years of reproducing the project, no brook floater mussels nor shells of the species were found in the Shediac Bay Watershed.

When adding up the distances searched from all the sites in the Shediac and Scoudouc Rivers in 2016, we get an approximate of 8.7 km of watercourse. The total distances of riverbed both surveyed with the time-search protocol or searched for suitable habitat during the past 3 years is approximately 19.2 km. All high priority areas, which are based on habitat characteristics and whether or not the brook floater was reported there in the 2006 report¹, were visited multiple times during different seasons in the past 3 years. These visits during the changing seasons are to account for varying factors that may cause burrowed mussels to rise to the surface of the substrate, where they could finally be spotted. According to recent studies, as much as 30-80% of freshwater mussels may be buried (COSEWIC 2009). Schwalb and Pusch (2007) found that up to 75% of a mussel population that is buried varies with discharge volumes of the river, day length, water temperature and possibly the mussel’s reproductive cycle. This is also the reason why the SBWA has been encouraged to embark on a multi-year project to confirm the presence of the brook floater mussel in our watershed. The timeline for undertaking presence/absence surveys is 2-5 years (*Management Plan for the Brook Floater in Canada, SARA 2016*).

Most of the work in the past 3 years was conducted in the Shediac River for two main reasons: the large majority of the brook floater mussels in the 2006 report¹ were found in the Shediac River; there is more suitable freshwater mussel habitat and more access points to those suitable habitats than in the Scoudouc River. The Scoudouc River proved to be difficult to access, requiring the use of an ATV or landowner permission of access though their properties. The Shediac River had a total 103 brook floater mussels found during the 2005 surveys¹, in the mid to lower reaches of the river. The Scoudouc River has a total of 19 individuals found in the higher reaches of the river.

In the Assessment and Status Report on the Brook Floater in Canada (COSEWIC 2009), the population assessment of the brook floater in the Shediac River was estimated at 6,100, based on the findings of these 103 mussels. This population estimate would classify the Shediac River as

one of the most important rivers for the species in New Brunswick. However, the same report describes the sources of errors of the population estimates. One source of error is that the populations are being *overestimated*, because the assumption was made that the brook floater would be continuously distributed throughout the occupied reaches of the river, when in fact they are patchily distributed in suitable habitats of sand or sandy gravel in areas of moderate flow. Although, another source of error describes that populations may be *underestimated* because surveys rely primarily on visual searches for mussels occurring at the surface of the substrate, when as mentioned above, as much as 30-80% of mussels may be buried. Another reason why populations may be *underestimated* is because the Time-Search protocol, which is commonly used in freshwater mussel surveys, does not locate all mussels present in a site or suitable habitat, they only locate those found during the allotted amount of search time. That being said, it is extremely difficult to determine the population dynamics of the brook floater in the Shediac Bay Watershed.

Another cause for concern is regarding whether or not the brook floater mussels reported in the 2006 report¹ were properly identified as *Alasmidonta varicosa*. No vouchers specimens were ever submitted to the NB Museum for positive identification. Very few photos from 2005 were found in the archives of the SBWA, and the only photos on a disk named “Brook Floater 2005” that were not blurry were sent to two experts (Dwayne Sabine of DFO and Dr. Donald McAlpine, curator of the NB Museum). The two photos, showing frontal and lateral view of the mussel, were inspected by Dr. McAlpine and M. Sabine. Although identification of freshwater mussels cannot be definitive by analyzing them through photographs, both their opinions were that the lateral view of the mussel confirmed that it was not a brook floater, but resemble the Triangle floater (*Alasmidonta undulata*).

In addition, the only other known survey in the Shediac River that reports brook floaters being found is in 2002 by Kate Bredin, as cited in the report “Assessment and status report on the Brook Floater (*Alasmidonta varicosa*) in Canada, COSEWIC. 2009.” The information in this report saying that Bredin found 2 brook floaters in the Shediac River in 2002 is also likely a mistake. The ACCDC (Atlantic Canada Conservation Data Centre) was contacted during the winter 2014-2015 for the raw data of this 2002 survey. The data received indicated that 2 mussels *resembling* the brook floater were found, and they were noted as “Unidentified floaters”. Yet those two *unidentified floaters* were taken as proof of the existence of the brook floater population in the Shediac River. Not only is there the possibility of misidentification of brook floater mussels in the 2006 report¹, it is also likely that the mention of Eastern Elliptio (*Elliptio complanata*) in the Shediac River is wrong. The Eastern pearlshell and Eastern elliptio are two very similar looking mussels, frequently described as confusing species. During the surveys from 2014, 2015 and 2016, only the Scoudouc River was found to contain a population of elliptio. The only species found in the Shediac River during those years are: the Eastern pearshell (*Margaritifera margaritifera*), the Creeper mussel (*Strophitus undulatus*), and one other unidentified mussels, a possible triangle floater (*Alasmidonta undulata*) or a shell variation of a Creeper mussel. Taking all this information and misinformation into account, there is reason to believe that some freshwater mussels were misidentified in previous years, and we should consider the possibility that the brook floater was never actually present in the Shediac bay watershed.

5. Conclusion

To conclude, after 3 years of field surveys and habitat searches, the SBWA team was unable to confirm the presence of the elusive brook floater mussel. However, the knowledge that the behaviour of this mussel can change, causing it to burrow itself within the substrate for long periods of time, gives hope that the population may exist in the Shediac Bay Watershed.

Even though the fulfillment of this project did not show any signs of the brook floater population, this project is still of great value as it gives us much needed information on the state of the habitats and current freshwater mussel populations throughout the Shediac Bay watershed. This information will be used as part of future endeavours to find this species of special concern and to integrate our findings in the community awareness mission of the SBWA. The educational part of this project was successful, in that many residents were made aware of the existence of freshwater mussels. The subject comes as a surprise to many people, possibly due to the fact that freshwater mussels are not consumed like their saltwater cousins. Many riverfront property owners were also informed of the existence of a rare freshwater mussel that could possibly be found in their own backyard. The topic seemed to interest most property owners, and discussions were always in a positive note. If the search for this rare freshwater mussel can continue in future years, a stewardship program with riverfront property owners will be officially implemented.

The Shediac Bay Watershed Association is confident in the works performed throughout this project. The realization of this project has allowed us to better understand the composition of the freshwater mussel populations and the state of their habitats in the Shediac bay watershed. .



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7. APPENDIX A: Field Sheet Data 2016

Table 8: Site data for 2016 field season; watercourse name, access points and direction

Date	Site ID	River	Access	Upstream/ Downstream from Access
05/04/2016	ShdM-A	Weisner Brook/Shediac	Bateman Mill Rd.	U/S
05/25/2016	ShdI-A	Shediac	ATV trail of Shediac Rd.	U/S
06/02/2016	ShdI-B	Shediac	ATV trail of Shediac Rd.	U/S
06/02/2016	ShdI-C	Shediac	ATV trail of Shediac Rd.	U/S
06/07/2016	ShdG-1	Weisner Brook/Shediac	St-Phillipe Rd.	D/S
06/20/2016	ShdD-A	Shediac	968 Shediac River Rd (driveway), walk down old path in the woods to the end	U/S
06/20/2016	ShdD-B	Shediac	Same as ShdD-A	U/S
06/21/2016	ShdG-A	Weisner Brook/Shediac	Bridge on St-Philippe Rd.	U/S
06/24/2016	ShdL-A	Calhoun/Shediac	Upstream of culvert in St. Philippe	U/S
06/27/2016	ShdE-A	Shediac	Covered Bridge	U/S
06/27/2016	ShdE-B	Shediac	Covered Bridge	U/S
07/05/2016	ShdN-A	Shediac	846 Cape Breton Rd, St-Philippe, Path down to River (1 km, 15 mins walk)	U/S
07/05/2016	ShdN-B	Shediac	Same as ShdN-A	U/S
07/05/2016	ShdN-C	Shediac	Same as ShdN-A	U/S
07/14/2016	ShdM-A	Shediac	Bateman Mill Rd., St-Philippe	U/S
07/15/2016	ShdI-A	Shediac	ATV trail of Shediac Rd.	U/S
07/19/2016	ShdM-1	Shediac	Bateman Mill Rd., St-Philippe	D/S
07/20/2016	ShdL-B	Calhoun/Shediac	Upstream of culvert in St. Philippe	U/S
07/20/2016	ShdL-1	Calhoun/Shediac	Upstream of culvert in St. Philippe	D/S
07/21/2016	ScdD-A	Scoudouc	Red Bridge rd. Down the powerline	U/S
07/21/2016	ScdD-B	Scoudouc	Red Bridge rd. Down the powerline	U/S
07/28/2016	ShdE-1	Shediac	Downstream of covered bridge	D/S
07/28/2016	ShdE-2	Shediac	Downstream of covered bridge	D/S
08/03/2016	ShdI-B	Shediac	ATV trail of Shediac Rd.	U/S
08/10/2016	ShdN	Shediac	Walked from Mcquade Brook	U/S
08/23/2016	ShdE-1&2	Shediac	D/S covered bridge	D/S
08/23/2016	ShdE-2A	Shediac	D/S covered bridge	D/S
09/08/2016	ShdE-C	Shediac	U/S Covered bridge	U/S
09/14/2016	ShdD-1	Shediac	986 Shediac River Rd	D/S
09/14/2016	ShdD-2	Shediac	986 Shediac River Rd	D/S
09/16/2016	ShdD-3	Shediac	U/S Covered bridge	U/S
09/29/2016	ScdF-01	Scoudouc	ATV trail D/S WQ site Scd F	D/S

Table 9: Site data for 2016 field season; GPS coordinates of start and end points of each survey with distance (m)

Date	Site ID	Start		End		Distance (m)
		Latitude	Longitude	Latitude	Longitude	
05/04/2016	ShdM-A	N46°12'27.56"	N64°40'21.21"	N46°12'23"	W64°40'19"	160
05/25/2016	ShdI-A	N46° 14' 47.1"	W64° 39' 14.8"	N46°14'43.5"	W64°39'16.5"	120
06/02/2016	ShdI-B	N46°14'43.5"	W64°39'16.5"	N 46°14'40.00"	W 64°39'15.50"	110
06/02/2016	ShdI-C	N 46°14'40.00"	W 64°39'15.50"	N 46°14'33.70"	W64°39'17.60"	205
06/07/2016	ShdG-1	N46°12'54.59"	W64°40'27.47"	N46°12'56.50"	W64°40'25.70"	80
06/20/2016	ShdD-A	N46°14'20.50"	W46°14'20.50"	N46°14'17.84"	W64°41'25.37"	120
06/20/2016	ShdD-B	N46°14'17.84"	W64°41'25.37"	N46°14'9.85"	W64°41'25.14"	290
06/21/2016	ShdG-A	N46°12'52.1"	W64°40'29.8"	N46°12'46.90"	W64°40'27.87"	190
06/24/2016	ShdL-A	N46°12'35"	W64°41'38"	N46°12'27"	W64°41'50"	335
06/27/2016	ShdE-A	N46°14'42.7"	W64°39'53.32"	N46°14'40.25"	W64°40'1.75"	200
06/27/2016	ShdE-B	N46°14'40.25"	W64°40'1.75"	N46°14'41.2"	W64°40'14.2"	270
07/05/2016	ShdN-A	N46°14'16.9"	W64°42'28.8"	N46°14'16.16"	W64°42'38"	225
07/05/2016	ShdN-B	N46°14'16.7"	W64°42'38.2"	N46°14'13.6"	W64°42'42.3"	135
07/05/2016	ShdN-C	N46°14'13.6"	W64°42'42.3"	N46°14'16.6"	W64°43'38"	660
07/14/2016	ShdM-A	N46°12'27.56"	N64°40'21.21"	N46°12'23"	W64°40'19"	160
07/15/2016	ShdI-A	N46°14'47.10"	N64°39'14.80"	N46°14'43.4"	W64°39'16.5"	125
07/19/2016	ShdM-1	N46°12'27.9"	N64°40'21.5"	N46°12'31.6"	W64°40'22.5"	125
07/20/2016	ShdL-B	N46°12'29.2"	N64°41'49.8"	N46°12'19.6"	W64°41'54.3"	360
07/20/2016	ShdL-1	N46°12'32.5"	N64°41'34.8"	N46°12'33.7"	W64°41'29.8"	140
07/21/2016	ScdD-A	N46°11'39.2"	N64°31'24.8"	N46°11'39.0"	W64°31'21"	85
07/21/2016	ScdD-B	N46°11'39.0"	N64°31'21"	N46°11'37.5"	W64°31'12.4"	195
07/28/2016	ShdE-1	N46°14'42.98"	W 64°39'44.91"	N 46°14'38.38"	W 64°39'42.26"	135
07/28/2016	ShdE-2	N 46°14'38.38"	W 64°39'42.26"	N46°14'31.40"	W 64°39'38.00"	245
08/03/2016	ShdI-B	N46°14'43.2"	N64°39'16.3"	N46°14'33.7"	W64°39'17.6"	305
08/10/2016	ShdN	N46°14'3.52"	N64°43'1.00"	N46°13'53.04"	W64°43'8.13"	355
08/23/2016	ShdE-1&2	N46°14'42.98"	W 64°39'44.91"	N46°14'31.40"	W 64°39'38.00"	380
08/23/2016	ShdE-2A	N 46°14'29.93"	W64°39'37.08"	N46°14'21.62"	W64°39'53.9"	460
09/08/2016	ShdE-C	N46°14'41.2"	W64°40'14.2"	N46°14'42.0"	W64°40'35.8"	600
09/14/2016	ShdD-1	N46°14'21.52"	W64°41'27.15"	N46°14'21.5"	W64°41'5.6"	575
09/14/2016	ShdD-2	N46°14'21.28"	W64°41'5.21"	N46°14'28.41"	W64°40'51.50"	590
09/16/2016	ShdD-3	N46°14'28.41"	W64°40'51.5"	N46°14'42.0"	W64°40'35.8"	575
09/29/2016	ScdF-01	N46°11'1.4"	W64°30'37.7."	N46°11'05.7"	W64°30'49.1"	250

Table 10: Site data for 2016 field season; freshwater mussel survey (time-searched, specie found, and counts)

Date	Site ID	Distance (m)	Time surveyed (min)	Freshwater Mussel Species	Count	Juveniles (≥ 6 cm)	Voucher collected?
05/04/2016	ShdM-A	160	80	M. margaritifera	207	10	No
05/25/2016	ShdI-A	120	80	M. margaritifera	544	29	Yes
06/02/2016	ShdI-B	110	60	M. margaritifera	332	18	Yes
06/02/2016	ShdI-C	205	60	M. margaritifera	8	5	No
06/07/2016	ShdG-1	80	60	M. margaritifera	66	0	Yes
06/20/2016	ShdD-A	120	60	M. margaritifera	578	4	Yes
06/20/2016	ShdD-B	290	80	M. margaritifera	1998	27	Yes
06/21/2016	ShdG-A	190	40	M. margaritifera	112	1	Yes
06/24/2016	ShdL-A	335	120	M. margaritifera	172	2	Yes
06/27/2016	ShdE-A	200	60	M. margaritifera	679	34	Yes
06/27/2016	ShdE-B	270	80	M. margaritifera	1069	36	Yes
07/05/2016	ShdN-A	225	60	M. margaritifera	145	4	Yes
07/05/2016	ShdN-B	135	45	M. margaritifera	543	13	Yes
07/05/2016	ShdN-C	660	N/A	M. margaritifera	No count	No count	No
07/14/2016	ShdM-A	160	60	M. margaritifera	421	25	Yes
07/15/2016	ShdI-A	125	60	M. margaritifera	No count	No count	No
07/19/2016	ShdM-1	125	30	M. margaritifera	21	5	No
07/20/2016	ShdL-B	360	75	M. margaritifera	132	0	No
07/20/2016	ShdL-1	140	60	M. margaritifera	34	6	Yes
07/21/2016	ScdD-A	85	60	M. margaritifera	196	2	Yes
				Eastern Elliptio	117	0	Yes
07/21/2016	ScdD-B	195	90	M. margaritifera	608	15	No
				Eastern Elliptio	158	7	No
07/28/2016	ShdE-1	135	60	M. margaritifera	No count	No count	No
07/28/2016	ShdE-2	245	90	M. margaritifera	No count	No count	No
08/03/2016	ShdI-B	305	90	M. margaritifera	No count	No count	No
08/10/2016	ShdN	355	50	M. margaritifera	No count	No count	Yes
08/23/2016	ShdE-1&2	380	60	M. margaritifera	No count	No count	No
08/23/2016	ShdE-2A	460	90	M. margaritifera	No count	No count	No
09/08/2016	ShdE-C	600	90	M. margaritifera	No count	No count	No
09/14/2016	ShdD-1	575	60	M. margaritifera	No count	No count	No
09/14/2016	ShdD-2	590	60	M. margaritifera	No count	No count	No
09/16/2016	ShdD-3	575	30	M. margaritifera	No count	No count	No
09/29/2016	ScdF-01	250	30	None	No count	No count	No

Table 11: Site data for 2016 field season; water quality data

Date	Site ID	Water Temp. (°C)	D.O. (mg/L)	pH	Salinity (ppm)	Depth (cm)	Width (m)	Flow
05/04/2016	ShdM-A	7.3	-	-	0.04	45		slow/moderate
05/25/2016	ShdI-A	20.2	10.88	-	0.06	30-45		Moderate
06/02/2016	ShdI-B	16.2	11.36	7.75	0.05	35-50		Moderate
06/02/2016	ShdI-C	16.2	11.36	7.75	0.05	45-60		Moderate
06/07/2016	ShdG-1	16	10.04	7.77	0.04	25-35		Moderate/fast
06/20/2016	ShdD-A	19.8	11.6	8.24	0.06	35-50		Slow
06/20/2016	ShdD-B	19.8	11.6	8.24	0.06	10-15		Slow
06/21/2016	ShdG-A	14.8	10.15	7.67	0.04	80		Slow
06/24/2016	ShdL-A	14.5	9.7	8.13	0.5	20-50		slow/moderate
06/27/2016	ShdE-A	22.6	9.73	8.07	0.08	17-41		Slow
06/27/2016	ShdE-B	22.6	9.73	8.07	0.08	35-55		Slow
07/05/2016	ShdN-A	21.6	10.3	8.23	0.09	30-40		Slow
07/05/2016	ShdN-B	21.6	10.3	8.23	0.09	15-30		Slow
07/05/2016	ShdN-C	21.6	10.3	8.23	0.09	15		slow/moderate
07/14/2016	ShdM-A	DND	DND	DND	DND	DND		DND
07/15/2016	ShdI-A	25.9	9.81	8.29	0.05	30-55		Moderate
07/19/2016	ShdM-1	DND	DND	DND	DND	30-40	3	slow/moderate
07/20/2016	ShdL-B	15.5	10.15	7.95	0.05	10-50	3	Moderate
07/20/2016	ShdL-1	15.5	10.15	7.95	0.05	30-45	3	Moderate
07/21/2016	ScdD-A	20.5	9.1	8.00	0.05	15-60	16.5	slow
07/21/2016	ScdD-B	20.5	9.1	8.00	0.05	30-65	16	Moderate
07/28/2016	ShdE-1	24.2	10.87	8.19	0.09	15	10	Moderate
07/28/2016	ShdE-2	24.2	10.87	8.19	0.09	15-25	10	Moderate
08/03/2016	ShdI-B	19.3	10.27	8.14	0.08	15-40	DND	Slow
08/10/2016	ShdN	DND	DND	DND	DND	DND	DND	DND
08/23/2016	ShdE-1&2	20.8	9.57	8.05	0.08	8-20	11	Moderate
08/23/2016	ShdE-2A	17	9.26	7.91	0.05	10-35	10	Moderate
09/08/2016	ShdE-C	-	-	-	-	-	-	Moderate
09/14/2016	ShdD-1	20	11.79	8.18	0.1	10-40	8	Moderate
09/14/2016	ShdD-2	-	-	-	-	-	-	Moderate
09/16/2016	ShdD-3	11.9	12.65	7.86	0.1	25-40	13	Moderate
09/29/2016	ScdF-01	11.9	10.2	7.92	0.05	20-40	13	Moderate

Table 12: Site data for 2016 field season; substrate characteristics

Date	Site ID	Substrate type (100%)							Substrate comments
		Bedrock (ledge)	Boulder (>460mm)	Rock (180 to 460mm)	Rubble (54 to 179mm)	Gravel (2.6 to 53mm)	Sand (0.06 to 2.5mm)	Fines (0.0005 to 0.05mm)	
05/04/2016	ShdM-A	0	0	30	0	20	50	0	
05/25/2016	ShdI-A	0	0	10	50	40	0	0	Rocks with some gravel bars
06/02/2016	ShdI-B	50	10	20	10	0	10	0	
06/02/2016	ShdI-C	75	10	10	0	0	5	0	
06/07/2016	ShdG-1	0	10	30	30	20	10	0	
06/20/2016	ShdD-A	0	5	15	35	15	30	0	
06/20/2016	ShdD-B	0	5	0	35	35	25	0	
06/21/2016	ShdG-A	0	0	10	10	0	10	70	
06/24/2016	ShdL-A	15	0	5	5	70	5	0	
06/27/2016	ShdE-A	20	15	30	15	0	20	0	
06/27/2016	ShdE-B	15	15	40	15	0	15	0	
07/05/2016	ShdN-A	15	15	30	10	10	20	0	
07/05/2016	ShdN-B	5	5	10	35	35	10	0	
07/05/2016	ShdN-C	0	0	20	50	20	10	0	
07/14/2016	ShdM-A	DND	DND	DND	DND	DND	DND	DND	
07/15/2016	ShdI-A	0	30	20	20	10	5	5	
07/19/2016	ShdM-1	50	30	10	10	0	0	0	
07/20/2016	ShdL-B	20	15	15	20	15	10	5	
07/20/2016	ShdL-1	15	5	15	40	15	0	10	
07/21/2016	ScdD-A	15	5	20	20	10	20	10	
07/21/2016	ScdD-B	15	25	30	10	5	5	10	
07/28/2016	ShdE-1	0	0	15	40	30	15	0	
07/28/2016	ShdE-2	5	25	40	15	15	0	0	
08/03/2016	ShdI-B	20	15	25	25	5	10	0	
08/10/2016	ShdN	DND	DND	DND	DND	DND	DND	DND	
08/23/2016	ShdE-1&2	5	5	30	20	20	10	0	
08/23/2016	ShdE-2A	5	0	15	35	30	15	0	
09/08/2016	ShdE-C	DND	DND	DND	DND	DND	DND	DND	
09/14/2016	ShdD-1	DND	DND	DND	DND	DND	DND	DND	start with rubble and rocks then Long stretch of bedrock, ends with sand and gravel
09/14/2016	ShdD-2	DND	DND	DND	DND	DND	DND	DND	
09/16/2016	ShdD-3	60	5	0	5	25	5	0	
09/29/2016	ScdF-01	0	10	60	20	10	0	0	

Table 13: Site data for 2016 field season; other general information

Date	Site ID	Bank Erosion?	Sand or Gravel Bars?	Surrounding Land Use	Fish (dead or alive?)	Algae?	Personnel	Comments
05/04/2016	ShdM-A	Yes (right)	Sand	Forest/some residences	-	No	JH, RD	FWM survey, and Brook floater habitat search
05/25/2016	ShdI-A	Some	Both	Forest	Plenty alive	Abundant brown and green	JH, RD	FWM survey, and Brook floater habitat search
06/02/2016	ShdI-B	Yes severe (left)	Both	Forest	Both	small amount brown algae	JH, MT	FWM survey, and Brook floater habitat search (Severe erosion on left bank), (water turbid, difficulty seeing bottom in some areas)
06/02/2016	ShdI-C	severe on both banks	Both	Forest/ Residential	Alive	small amount brown algae	JH, MT	FWM survey, and Brook floater habitat search (Severe erosion on left bank), (water turbid, difficulty seeing bottom in some areas)
06/07/2016	ShdG-1	No	No	Forest/ Residential/ 1 camp	Plenty of live fish (Blacknose dace, trout)	Slippery rocks	JH, AC	FWM survey, and Brook floater habitat search
06/20/2016	ShdD-A	No	Sand	Forest	Plenty alive	No	JH, AC, ML	FWM survey, and Brook floater habitat search
06/20/2016	ShdD-B	No	Both	Forest	Plenty alive, 3 dead	No	JH, AC, ML	FWM survey, and Brook floater habitat search
06/21/2016	ShdG-A	No	No	Field/ Residential	Live fish	No	JH, AC, ML	FWM survey, and Brook floater habitat search
06/24/2016	ShdL-A	Some	Both	Forest/ Residential	Both	Some	RD, MT, ML	FWM survey, Brook floaters and Brook floater habitat
06/27/2016	ShdE-A	Minimal	Sand	Forest	Plenty alive, 1 dead	No	JH, ML, JC	FWM survey, and Brook floater habitat search
06/27/2016	ShdE-B	No	Gravel	Forest	Plenty alive, 2 dead	No	JH, ML, JC	FWM survey, and Brook floater habitat search
07/05/2016	ShdN-A	Yes severe	Both	Forest	Plenty alive, 3 dead	Green and brown on rocks, few macrophytes	JH, MT, ML, JC	FWM survey, and Brook floater habitat search
07/05/2016	ShdN-B	Yes severe	Both	Forest	Plenty alive	Brown on rocks, some green filamentous on mussels	JH, MT, ML, JC	FWM survey, and Brook floater habitat search
07/05/2016	ShdN-C	No	Gravel	Forest	2 dead lampreys	Some brown and green, and macrophytes	JH, MT, ML, JC	Brook floater search only

07/14/2016	ShdM-A	Light	Both	Forest/some residences	Alive	Some at end	RD, ML, JC	FWM survey, and Brook floater habitat search
07/15/2016	ShdI-A	Not in site but U/S	Gravel	Forest	1 dead, lots alive	Brown and green on rocks	JH, MT, ML	Brook floater search only
07/19/2016	ShdM-1	No	Rock bars	Forest/some residences	Lots of live fish	Green filamentous on rocks	JH, ML, JC	FWM survey, and Brook floater habitat search
07/20/2016	ShdL-B	Light	Both	Forest	Alive	Brown and green filamentous, macrophytes	MT, ML	FWM survey, and Brook floater habitat search
07/20/2016	ShdL-1	No	No	Forest/some residences	Lots alive, 1 dead	Some green filamentous	JH, JC	FWM survey, and Brook floater habitat search
07/21/2016	ScdD-A	No	1 Gravel bar	Forest/powerline	Alive, 1 dead	Macrophytes	JH, ML, AC, JC	FWM survey, and Brook floater habitat search
07/21/2016	ScdD-B	No	No	Forest	Live fish, 7 dead	Macrophytes	JH, ML, AC, JC	FWM survey, and Brook floater habitat search
07/28/2016	ShdE-1	No	No	Road, Forest	4 dead fish		JH, ML, JC	Brook floater habitat search
07/28/2016	ShdE-2	Yes left bank	Gravel	Forest	dead white sucker, plenty live fish		JH, ML, JC	Brook floater habitat search
08/03/2016	ShdI-B	Yes both sides	Gravel and sand	Forest	lots alive	Green and brown fuzzy	JH, ML, JC	Brook floater habitat, (water level low, as low as 5 cm some pools are as deep as 70 cm)
08/10/2016	ShdN	Yes	Yes	Forest	Some fish	DND	RD, ML, AC, JC	Brook floater habitat search
08/23/2016	ShdE-1&2	Yes, Severe	Gravel	Forest, road	1 dead, lots live	No	JH, ML, JC	Brook floater habitat search
08/23/2016	ShdE-2A	No	No	Forest ATV Bridge	Lots live, 1 large trout	lots brown fuzzy	JH, ML, JC	Brook floater habitat search (Approx. 75% of FWM are young or juveniles, no large FWM, great vegetation cover)
09/08/2016	ShdE-C						JH, JR	Brook floater habitat search
09/14/2016	ShdD-1	severe left side	rubble and gravel	Forest	alive and 5 dead	slippery rocks, brown fuzzy and some macrophytes	JH, MT, JR	Brook floater habitat search
09/14/2016	ShdD-2							
09/16/2016	ShdD-3	Erosion on both sides	multiple both	Forest	lots alive, 10 dead	Slippery rocks, brown slimy on rocks	JH, MT, JR	Brook floater habitat search
09/29/2016	ScdF-01	Both sides, severe on left side	Rock bars	ATV Crossing/Forest	some alive	Macrophytes U/S of site only	JH, MT	FWM survey (No mussel found) some margaritifera shells and possibly one elliptio shell.

