WOLASTOQEY NATION IN NEW BRUNSWICK

Matawaskiye • Neqotkuk • Wotstak • Pilick • Sitansisk • Welamoktok

Wolastoq Watershed barrier analysis

Executive summary

Fragmentation of stream networks by anthropogenic structures such as road culverts can affect the health of a catchment by negatively affecting the ecosystem's biota, their movements, abundances, and species richness within the Wolastoq/Wəlastəkw Watershed. The challenge for resource managers is the prohibitive costs of locating, evaluating, and remediating problem structures at landscape-scales. There is a need for a framework to perform a desktop, landscape-scale evaluation and prioritization process using existing data that allows managers to identify high-impact and/or cost-effective restoration projects". decisions. The Wolastoqey Nation in New Brunswick presents a framework using publicly available LiDAR and orthophotography to locate and identify road crossings and evaluate fragmentation and passability for various fish species at the landscape-scale. Within the Wolastoq Watershed, 8,340 crossings were found. Of those crossings, 79% were culverts, 7% were bridges, 7% were fords, 6% are impoundments, and 1% are false detections. Of the 8,340 crossings, approximately 26% of them are considered barriers and approximately 2,300 linear kilometers being inaccessible. Approximately 1,500 linear kilometers were inaccessible due to barriers greater than stream order 3. The approach provides a valuable and cost-effective means of identifying potential stream crossing issues for multiple management objectives, e.g., fish passage, and thus the approach is an important step in the prioritization of options for restoration decisions.

Methods

Study Area

The Wolastoq/Wəlastəkw/ drainage, otherwise known as the Saint John River, has a total drainage area is approximately 55,000 square kilometers, approximately 28,000 square kilometers resides in New Brunswick and will be the study area for this study. The main stem of the Wolastoq/Wəlastəkw/ runs for approximately 700 km, with its headwaters in Maine and Quebec. The Wolastoqiyik/Wəlastəkokewiyik are the people who have lived here thousands of years before Europeans arrived (Valk, 2009). In 2020 the Wolastoqiyik/Wəlastəkokewiyik filed an Aboriginal Title claim that includes the portions of the Wolastoq/Wəlastəkw within the province of New Brunswick.

Figure 1. Range and sample area of the Wolastoq Watershed, New Brunswick portion of the Restigouche catchment, New Brunswick, Canada.

For the Wolastoq/Wəlastəkw drainage crossing analysis, we chose to use the stream network provided by Service New Brunswick (SNB) for two reasons. 1) We want to use the data that is free and publicly available and 2) The portion of the Wolastoq Watershed in New Brunswick is over 28,000 square kilometers, delineating a stream network from DEM would be time intensive and produce a similar result to the SNB data. Additionally, the analysis did not include industrial freehold areas, due to the data not being available through SNB.

Workflow

A similar workflow to Arsenault et al. (2022) was used for this study. The framework developed for this study follows 5 steps. In step 1, the road and stream network obtained from SNB were intersected to find potential road-stream crossings. In steps 2 and 3, culverts are visually identified and classified using high resolution (1 m) 3-band (Red-Green-Blue) aerial image, and elevation is extracted from the DEM upstream and downstream of the culvert, respectively. In steps 4 and 5, slope and length are calculated at the site, and the site is tested for species specific passability. An illustration of the workflow is provided in Figure 2.

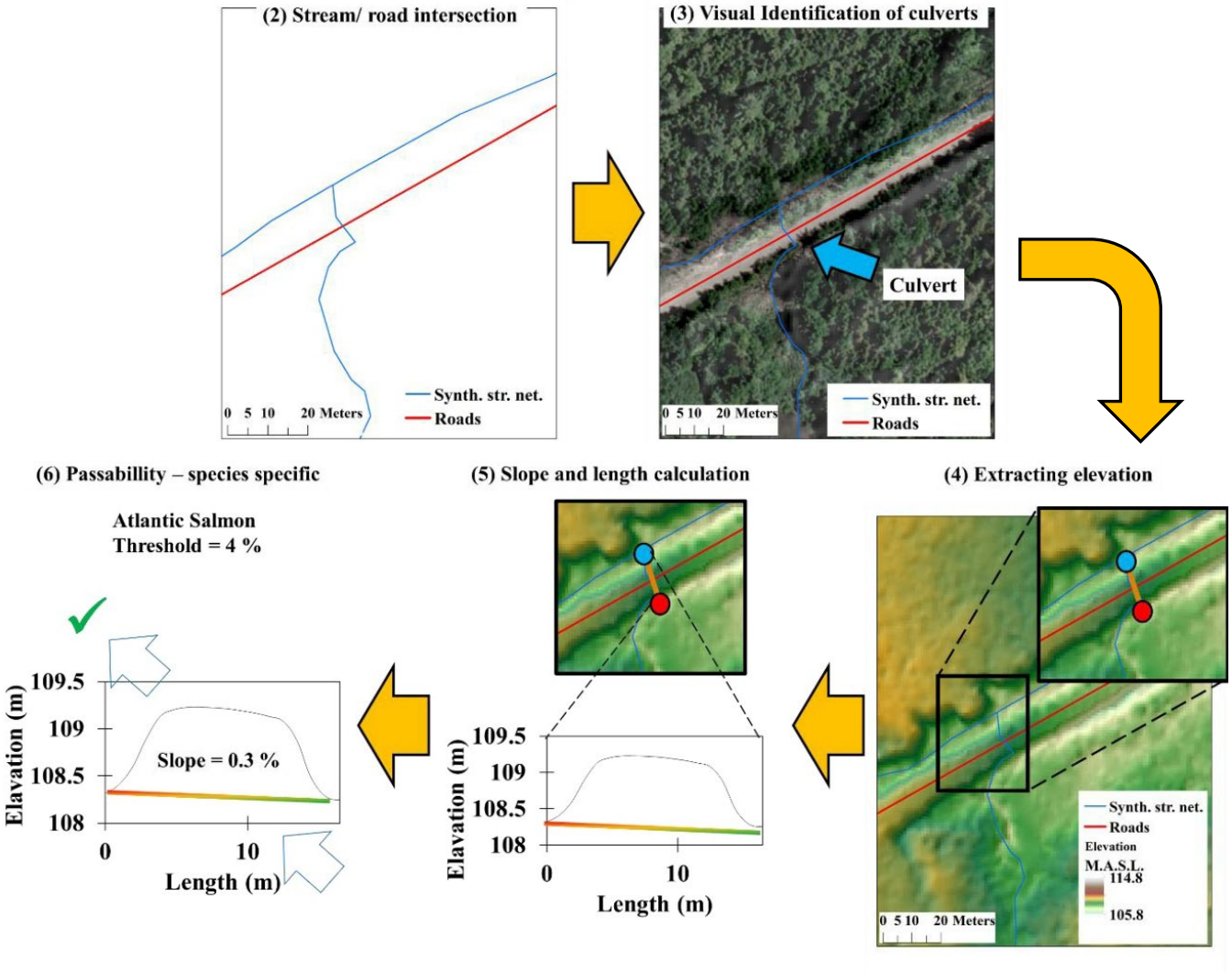

Figure 2. The 5-step framework for (1) determine stream crossing locations; (2) classifying the crossing; (3) extracting elevation data from LiDAR DEM; (4) extracting elevation data from LiDAR DEM; (5) calculating slope and length of culverts; (6) export slopes to determine fish passability. Figure reproduced with permission from Arsenault et al. (2022).

Classification

There were two methods that were used to classify each crossing. The first being manually where the user would visually identify landscape characteristics from the DEM to determine what it is. The second being an automated method in which a proprietary algorithm would use surrounding landscape features, patterns, and DEM transformation to classify the crossing.

Culverts could be identified by visually observing the stream channel becoming more restricted and passing the road on the DEM. If the culvert is large enough, it was apparent on the orthophotography, and some culvert ends were visible on the DEM.

Various combination of these layers can help the user to identify where the road crossed a stream, i.e., the layers are interchanged to represent the crossing and emphasize topographical features. For example, if a crossing was thought to be a culvert, the 1-m resolution DEM with the hillshade was overlaid. This would make the channel and the embankment of the road more apparent. In some cases, culverts or other crossings were identified directly from the 1 m orthophotography layer if there are no trees or structures obscuring the view.

Passability

Morphological and physiological characteristics of the fish can limit passability for each species based on swim speed, water velocity, and the length of time the fish can maintain that speed. Best practice is to design structures for the weakest swimmers to maximize the diversity between the up and downstream structures (Bourne et al., 2011). We selected four common stream fish species to examine passability based on available information in the literature: Burbot (*Lota lota);* Lake Chub (*Couesius plumbeus*); Atlantic Salmon (*Salmo salar*), and Brook Trout (*Salvelinus fontinalis*). Passable conditions for each of the fish species were defined by slope thresholds from previous studies, see MacPherson et al. (2012) – Burbot and Lake Chub; Bourne et al. (2011) – Atlantic Salmon; Burford et al. (2009) – Brook Trout where strong swimmers couldn't pass. Prioritizing barriers for remediation will vary greatly based on management goals; increasing connectivity for weak swimmers could differ from the barriers that would increase connectivity for diadromous fish (O'Hanley & Toberlin, 2005).

Table 1. Thresholds of passability, determined by slope, for four species. Sourced from Arsenault et al., (2022).

Species	Slope threshold (%)
Burbot [1]	2%
Lake Chub [1]	2%
Atlantic Salmon [2]	4%
Brook Trout [3]	4.5%

Results

Crossings Analysis

Table 2. Number of stream crossings by Strahler stream order based on provincial data (Service New Brunswick (SNB) 2016–2018) and the classification for crossings.

Stream Order	Culvert	Bridge	Ford	False Detection	Impoundment
1	3899	60	356	7	376
2	1865	65	135	1	110
3	591	96	89	0	36
4	233	218	2	0	4
5	31	77	0	0	9
6	0	46	0	0	2
7	0	14	0	0	1
8	1	14	0	0	2

Of the 8,340 crossings, a majority (56%) of all crossings were located on first order streams. Second order streams made up 25%, third order was 10%, fourth order was 5%, fifth order was 1%, sixth order was 1%, seventh order was 1%, and eight order was 1% (Table 2). Within the

Table 3. Table 5. Thresholds of passability, determined by slope, for four species, followed by the number of barriers impeding each species as a function of slope and as a percentage of total culverts in the study.

Species	Slope threshold (%)	Number of barriers due to culvert slope (% of total)	Restricted stream in km
Burbot[1]	2%	860 (13%)	2,388
Lake Chub[1]	2%	860 (13%)	2,388
Atlantic Salmon[2]	4%	462 (7%)	1665
Brook Trout[3]	4.50%	421 (6%)	1351

Of the 6,620 culverts, 860 were barriers to all four index species (Table 3). Burbot and Lake Chub had 860 barriers, which restricted 2,388 linear stream kilometers. There were 462 barriers to Atlantic Salmon which restricted 1,665 linear stream kilometers. Lastly, there were 421 barriers to Brook Trout which restricted 1,351 linear stream kilometers (Table 3).

Remediation targets

After identifying the barriers to fish passage based on the parameters presented in this paper, we chose higher order (stream order 3 or higher) targets to identify the barriers that restricted the most habitat. Each table presented in this paper will have the following:

1) Crossing #
2) Coordinates
3) County
4) Crossing type

5) Length of barrier
6) Slope of barrier
7) Upstream kilometers restricted.
8) Notes on the barrier
9) Two remote images of the barrier Orthophotography (Left) and LiDAR Digital Elevation Model (Right).

The purpose of this format is it to be easily read by any audience; to allow the information to be accessible to anyone who has interest or concern. Additionally, the coordinates are in decimal degrees, which the user can copy and paste directly into applications like Google Maps to see the barrier themselves or report additional information to groups interested in remediation.

Discussion

The goal of this project was to identify stream crossings within the Wolastoq/Wəlastəkw drainage that could be potential barriers to fish passage using a desktop, GIS-based method. We chose 100 crossings that restricted the highest number of stream kilometers and a breakdown of the characteristics, which resulted in the Wolastoqey Nation identifying over 1,500 linear kilometers of stream that is being restricted by there barriers.

Duty to consult

Within Canada, the Crown owes the duty to consult the First Nation communities on any action that could affect Aboriginal or Treaty rights. An example of this is projects that require a Fisheries Act Authorization (FAA). The federal government requires projects to be approved if the project, that could carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal fishery, or to fish that support such

a fishery. This can include death of fish, permanent alteration to fish habitat, or destruction of fish habitat.

Offset

Often with offsets from either Fisheries Act Authorizations or Environmental Impact Assessments (EIA), the proponent will present the offset project for consultation's offset is often suggested by an organization that is not a First Nation. We see proponents remediating these projects for offset credits from banking projects; using these offset credits in an economic framework to fit the interests of them and their partners (Monosky & Keeling, 2021; Spash, 2015). An example of this could be the proponent identifying an offset area that has less than habitable conditions and a culvert that needs baffles installed. It is a low cost for a high payout (i.e., offset credits for cheap). The issue is that there is no guarantee or often pre-post monitoring to ever determine if the remediation would achieve its purpose (Gardner et al., 2013).

This can be due to uncertainties from the habitat not being properly evaluated, time lag, or pre-monitoring not being conducted to measure these impacts (Clarke and Bradford, 2014). An evaluation by Minns (2006) showed that minimum offset ratios should be 2:1, while some projects may require as much as an 8:1 ratio. While the 2019 amendment restored the harmful alteration, disruption, or destruction (HADD) was restored from the 2012 Fisheries Act, this is not enough to reach that 2:1 ratio (Imhof et al., 2021). Imhof et al. (2021) outlines that baseline data is the top priority to begin to understand what is needed for an offset ratio.

The interactions of our ecosystem are too complicated to reduce to a common currency (Greenhalgh et al., 2010). When a proponent approaches the First Nations to purpose an offset, they are looking through the lens of the offset being another solvable issue that has no ethical

weight, only a monetary value (Spash, 2015; Juniper, 2012). While the First Nations and others who have to live on the land impacted have concerns of human-nature relationships, treatment of the biological value, and being able to carry out their cultural rights, on their land, without the uncertainty of if an offset will be a net gain or not. An Elder within the Wolastoqey Nation, Elder Spike (Donald) from Neqotkuk echoed these concerns: "He was pointing to Wolastoq River where significant bank erosion was occurring. The erosion is a source of anxiety for people living in the homes along the road that runs adjacent to the river" (CRI, 2011). This sentiment carries over to other aspects of the watershed (i.e., fish populations, water quality).

Conclusion

One of the most important aspects of the project is putting the power of choice and planning back into the First Nations' hands. By providing these data to the communities, it will be the first step towards having a more balanced the regulators must assess whether that offset will provide a net benefit to fish and fish habitat and, by extension, their Aboriginal and Treaty Rights. Samaqan Nuhkmoss (Water Grandmother) of the Wolastoqiyik explains this well "This cycle of mistrust can be fixed by including Wolastoqiyik in finding solutions. Relationships need to be mended and new ones need to be made. The foundation of that relationship could be the shared interest of the scientific community and the First Nations in environmental concerns. Cooperation through the inclusion of First Nations, in finding solutions, would be a great starting point" (CRI, 2011).

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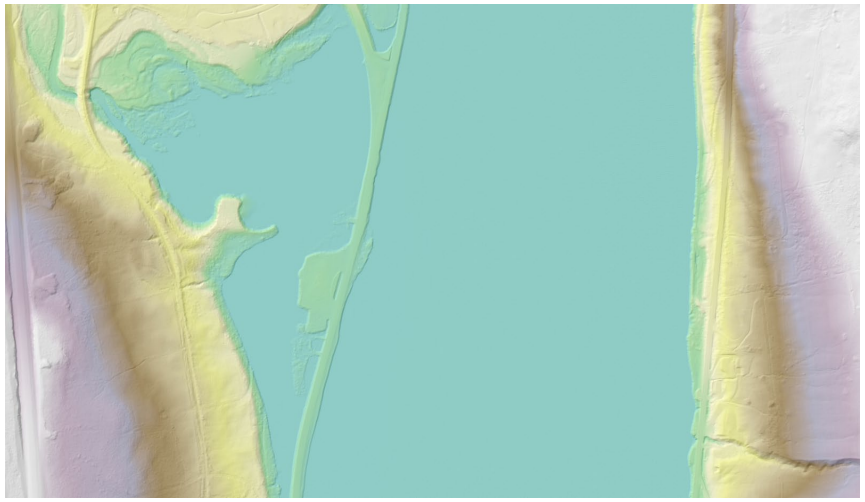
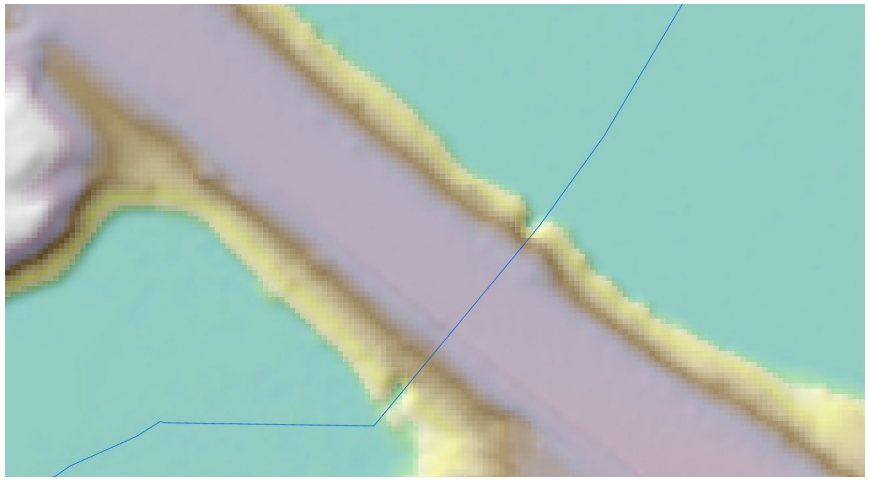
Crossing 1



Coordinates	67.5605430°W, 46.0838734°N
County	Carleton
Crossing type	Impoundment
Length of barrier	36 m
Slope %	0.5%
Upstream kilometers restricted	115 km

Notes	Impoundment length is 1km in length with no visible crossing structure. If there is a crossing structure present, it would be too small for a in-stream structure for such a long impoundment. An open bottom culvert installed at the highest velocity point in the thalweg would open passage through and reduce erosion on the embankment of the impoundment.

Crossing 2



Coordinates	67.7025144°W, 46.5531401°N	**Notes**	Bottom lip of the culvert is visible in Orthophotography. Slope of the culvert when measured from the culvert is below threshold but, elevation difference increases from the lip of the culvert to downstream, indicating it is a hanging culvert. Replacement is recommended because the upstream and downstream side of the culvert are not channelized stream, they are wide river, reducing the options of remediation.
County	Carleton		
Crossing type	Culvert		
Length of barrier	45 m		
Slope %	0.2%		
Upstream kilometers restricted	69 km		

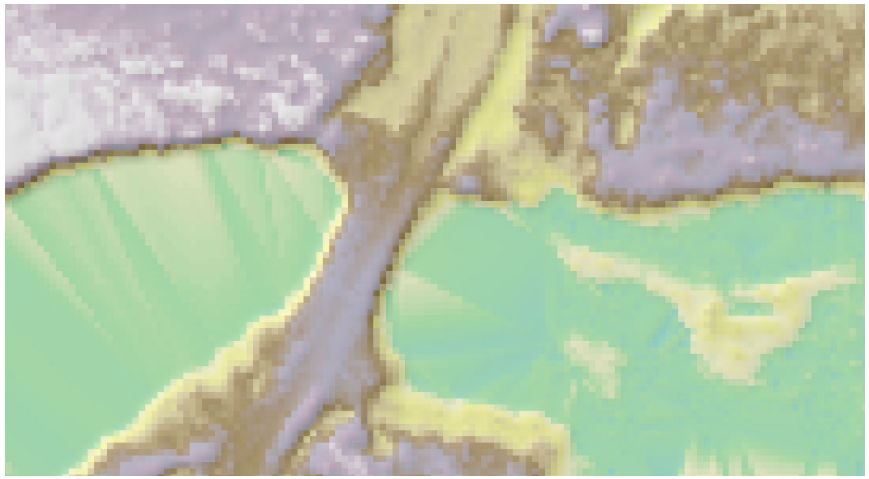
Crossing 3

Coordinates	67.6859913°W, 46.3370867°N	**Notes**	Structure appears to be a weir from orthophotography, large elevation changes over the 3-meter-wide structure from the LiDAR DEM confirms that it is. While weirs can provide fish passage during high flow events when the structure is not retaining water, the high slope, channelization of 80% results in high velocity flows with a steep slope would not allow fish passage at any point. Solution could be complete removal of the structure. If it is needed for water retention, a fish ladder could be installed.
County	Carleton		
Crossing type	Weir		
Length of barrier	3 m		
Slope %	21%		
Upstream kilometers restricted	80 km		

Crossing 4

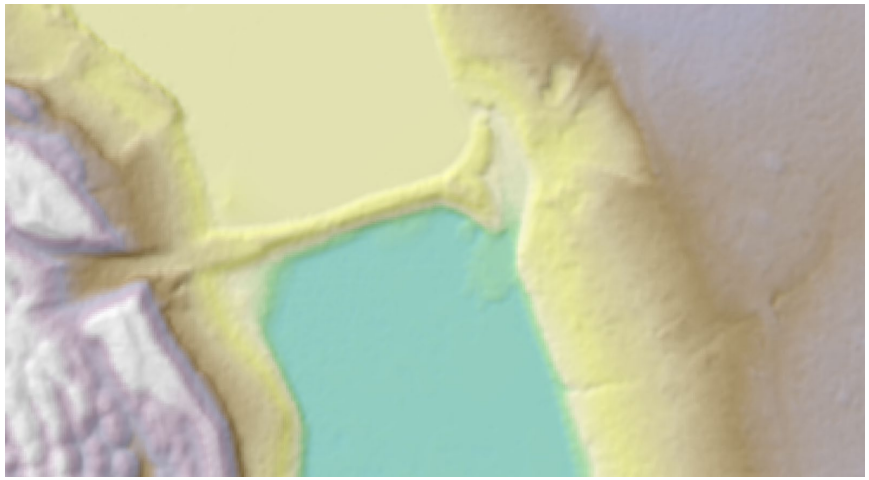
Coordinates	66.4414438°W, 45.7154392°N	**Notes**	The ford lacks any natural or artificial bank reinforcement. This could result in increased erosion and sedimentation. Evidence of erosion is already present, increased stream width at crossing. Bank reinforcement to maintain the average stream width and prevent erosion would result in water depth increase, protecting downstream habitat from sedimentation.
County	Sunbury		
Crossing type	Ford		
Length of barrier	-		
Slope %	-		
Upstream kilometers restricted	-		

Crossing 5



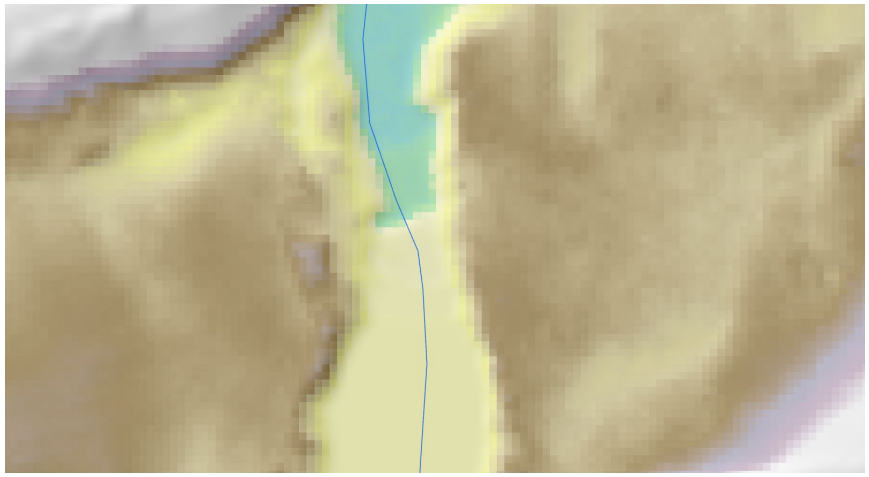
Coordinates	66.4278025°W, 45.8988082°N	**Notes**	Impoundment has no structure. The road appears to be an old forestry road that was not properly decommissioned. Solution would be to remove the impoundment fully and reinforce the underlying substrate to prevent erosion.
County	Sunbury		
Crossing type	Impoundment		
Length of barrier	12 m		
Slope %	0.25%		
Upstream kilometers restricted	130 km		

Crossing 6



Coordinates	65.9485715°W, 46.1407914°N	**Notes**	Impoundment has no crossing structure installed, the only viable crossing passage is to the East edge where there appears to be a natural spillway. The slope of the spillway averages 8% slope, making it impassable to any fish species present in New Brunswick. Solution is to either remove the impoundment and restore natural passage or if that's not viable, remediate the spillway to the East at a maximum slope of 2% to ensure all fish can pass upstream.
County	Queens		
Crossing type	Impoundment		
Length of barrier	9 m		
Slope %	17.9%		
Upstream kilometers restricted	63 km		

Crossing 7

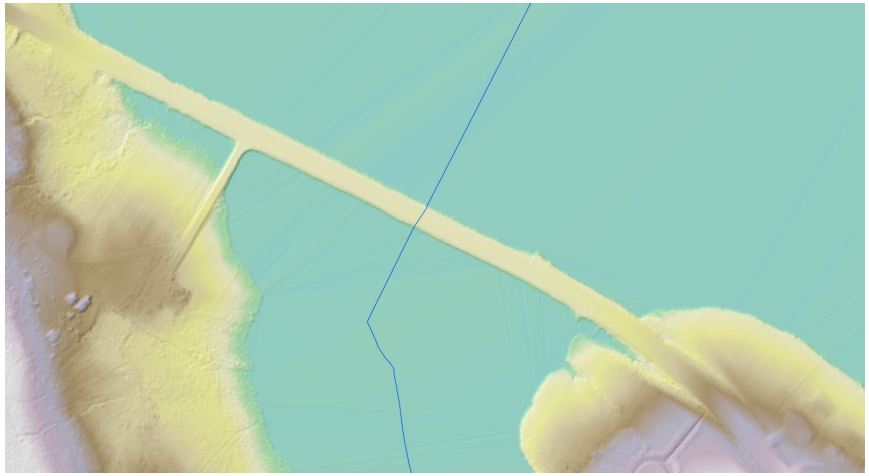


Coordinates	65.5676446°W, 45.7087957°N	**Notes**	From remotely accessed data, there is no evidence to identify what structure the impoundment is. From the LiDAR DEM, it shows a sharp level of elevation gain, (0.8 meters) over a 1 meter distance. There is a culvert upstream and this could be installed to raise the water level on the downstream end of the culvert; upstream side of the impoundment. Further investigation is needed to have a conclusive solution.
County	Kings		
Crossing type	Impoundment		
Length of barrier	1 m		
Slope %	46%		
Upstream kilometers restricted	62 km		

Crossing 8

Coordinates	67.5077527°W, 46.6137278°N	**Notes**	Culvert slope exceeds slope threshold. Need to remove two barriers: There is a bridge on another branch of the stream that allows upstream passage. Can be low priority if habitat is not adequate for target species.
County	Carleton		
Crossing type	Culvert		
Length of barrier	9 m		
Slope %	12.6%		
Upstream kilometers restricted	5 km		

Crossing 9

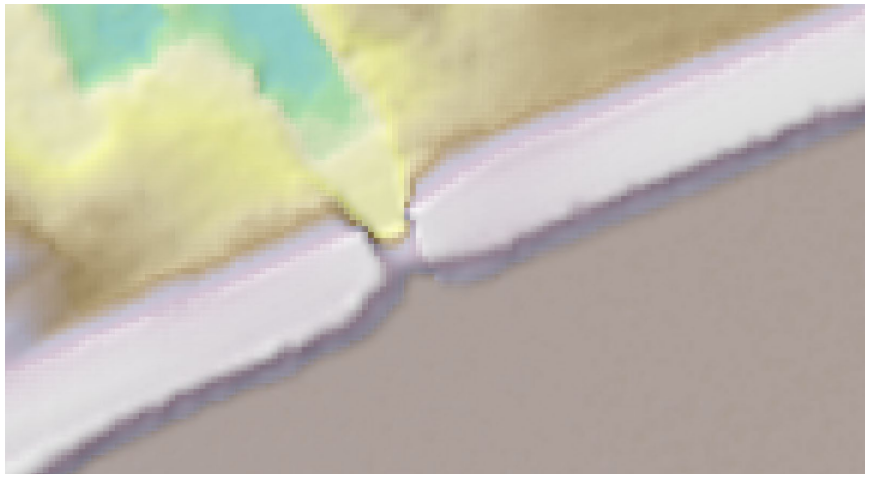


Coordinates	67.0204065°W, 45.9005610°N
County	York
Crossing type	Impoundment
Length of barrier	28 m
Slope %	-
Upstream kilometers restricted	45 km

Notes

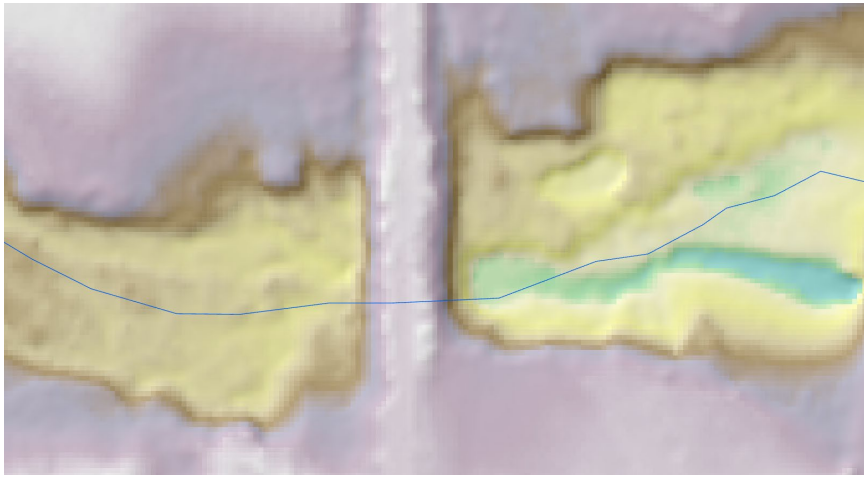
Impoundment length is 700m in length with no visible crossing structure. If there is a crossing structure present, it would be too small for a in-stream structure for such a long impoundment. An open bottom culvert installed at the highest velocity point in the thalweg would open passage through and reduce erosion on the embankment of the impoundment.

Crossing 10



Coordinates	66.9229512°W, 47.0600975°N	**Notes**	Crossing appears to be a bridge with a water retention/artificial riffle structure. DEM and LiDAR confirm that the water characteristics and water level dramatically change over the 8m barrier and again at the riffle structure 15m downstream. Elevation drops by 4 meters under the bridge, indicating there might be a structure below. The elevation drops by another 0.5m of the riffle structure. The elevation values in the DEM could be altered depending on the method used to remove the pits. Regardless the slope from the upstream bridge side to the downstream end of the riffle structure (18m in length) still has a slope of 24.4%, which fish cannot pass. Due to the intricate nature of the structure, the crossing should be modified within the existing structure; install natural boulder habitat to create a series of pool/riffle habitat at low slope.
County	Victoria		
Crossing type	Bridge-Weir		
Length of barrier	8 m		
Slope %	51.56%		
Upstream kilometers restricted	170 km		

Crossing 11



Coordinates	68.6033280°W, 47.2553542°N	**Notes**	Slope exceeds 4% slope threshold. There is uncertainty on whether this crossing has any modifications like culvert baffles that could help overcome slope. The culvert upstream has baffles installed (see left side of picture 1), so there could be a possibility of baffles present in the culvert downstream; not requiring remediation if baffles are already present. If there are no baffles in place, they should be installed or the culvert replaced to maintain slopes below 2%.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	24 m		
Slope %	6.5%		
Upstream kilometers restricted	15 km		

Crossing 12

Coordinates	67.6221808°W, 47.0681112°N	**Notes**	Culvert slope exceeds threshold. The culvert being directly downstream of a head pond could have a water retention structure to maintain water level, but it is not fish passable from DEM elevation data. Should be replaced with fish passable spillway or fish ladder structure if replacement is not viable.
County	Victoria		
Crossing type	Culvert		
Length of barrier	6 m		
Slope %	24.3%		
Upstream kilometers restricted	9 km		

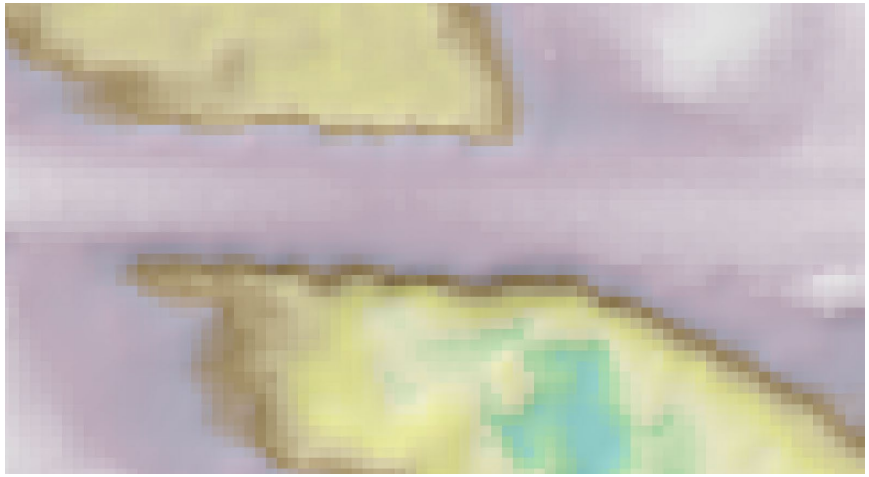
Crossing 13

Coordinates	68.2577561°W, 47.3873344°N	**Notes**	Culvert slope exceeds threshold. Ortho shows it could be a square concrete slab culvert. The culvert should be replaced or installed baffles.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	22 m		
Slope %	7.86%		
Upstream kilometers restricted	13 km		

Crossing 14

Coordinates	67.5858298°W, 46.9945398°N	**Notes**	Old forestry road that has degraded to the point where there are multiple points of crossings and become less channelized. The road should be removed and replaced with a ford to allow natural flow to reoccur.
County	Victoria		
Crossing type	Culvert and Ford		
Length of barrier	8 m		
Slope %	10%		
Upstream kilometers restricted	12 km		

Crossing 15



Coordinates	67.6117368°W, 46.8140493°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	18 m		
Slope %	4.7%		
Upstream kilometers restricted	7 km		

Crossing 16

Coordinates	67.3016939°W, 47.0290785°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	24 m		
Slope %	4.8%		
Upstream kilometers restricted	14 km		

Crossing 17

Coordinates	68.4117716°W, 47.2902511°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	30 m		
Slope %	5.3%		
Upstream kilometers restricted	5.5 km		

Crossing 18

Coordinates	67.5638751°W, 47.0556402°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	7%		
Upstream kilometers restricted	17 km		

Crossing 19

Coordinates	68.5860539°W, 47.2911587°N	**Notes**	Crossing appears to be a bridge culvert, it is assumed to not have a concrete bottom due to the design. The slope exceeds the threshold. If the slope is naturally of a higher slope or it is a DEM error due to pit removal methods, then no remediation should take place unless its anthropogenic or was a result of intervention.
County	Madawaska		
Crossing type	Bridge Culvert		
Length of barrier	10 m		
Slope %	5.3%		
Upstream kilometers restricted	45 km		

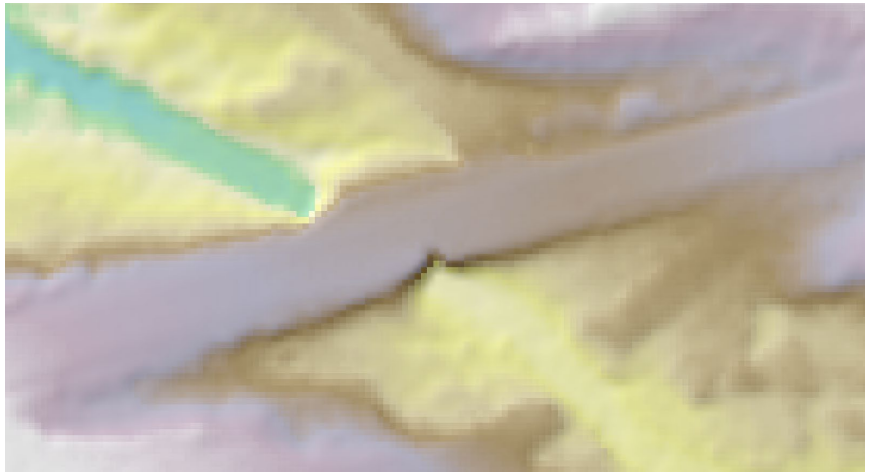
Crossing 20

Coordinates	68.5037588°W, 47.4001740°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Bridge Culvert		
Length of barrier	10 m		
Slope %	6.4%		
Upstream kilometers restricted	13.5 km		

Crossing 21

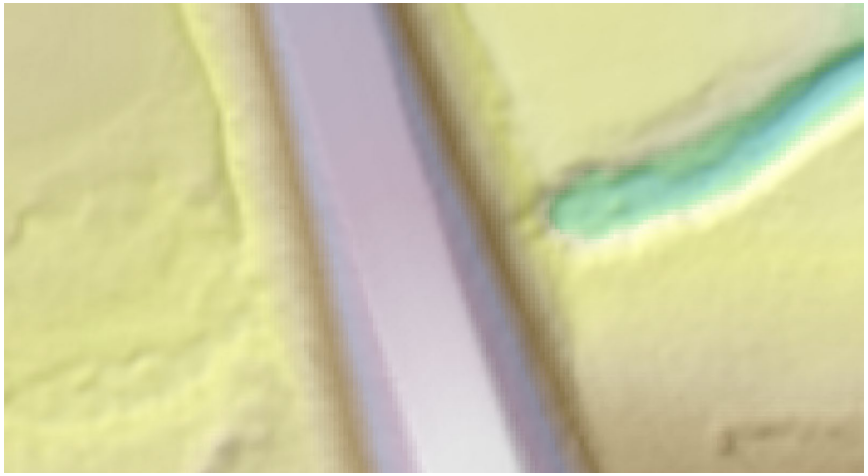
Coordinates	67.6265032°W, 46.9321716°N	**Notes**	The impoundment seems to be a result of beaver activity or logging. Typically, log jams are hard to identify due to the temporal nature of LiDAR/Ortho/Sat data, but the log jam was identified in Ortho data from 2018, satellite data from 2021, and LiDAR from 2020. This gives strong enough evidence to further investigate the barrier. Removal of the log jam is recommended, if fresh beaver activity is observed, other measures like beaver exclusion devices are recommended.
County	Victoria		
Crossing type	Impoundment		
Length of barrier	3 m		
Slope %	16.6%		
Upstream kilometers restricted	13 km		

Crossing 22



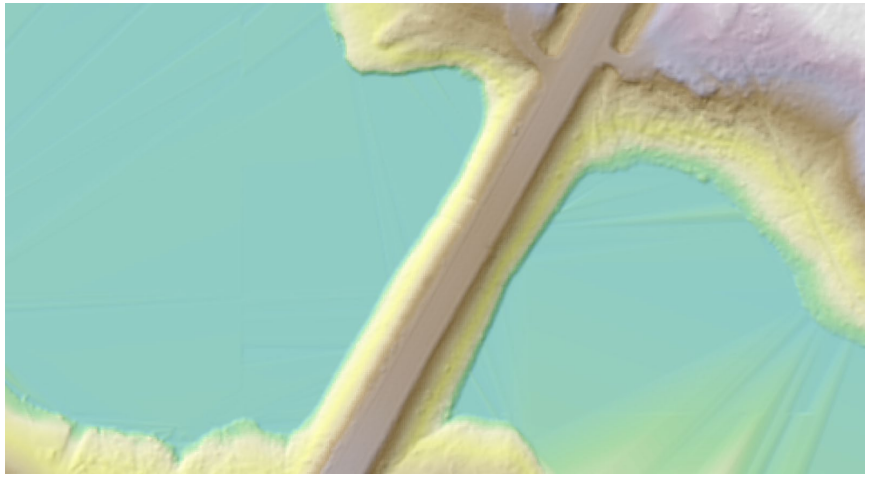
Coordinates	68.1872518°W, 47.4758987°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	21 m		
Slope %	4.6%		
Upstream kilometers restricted	26.5 km		

Crossing 23



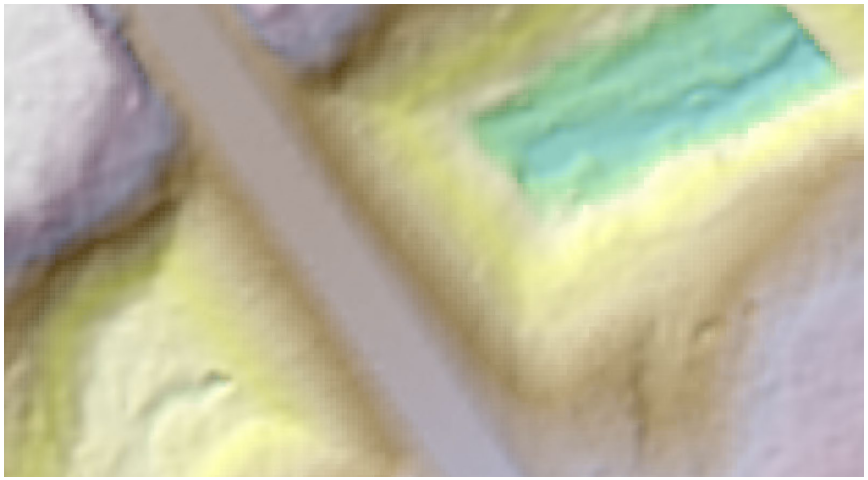
Coordinates	67.7550231°W, 47.0082618°N	**Notes**	Culvert slope exceeds slope threshold. Culvert needs to be replaced. Replacing the culvert would require significant funds since the structure is over 65m long and under an embankment almost 20 meters deep which is on a 3 lane highway. Modifying the existing structure would be the most viable and cost-effective approach.
County	Victoria		
Crossing type	Culvert		
Length of barrier	65 m		
Slope %	6.5%		
Upstream kilometers restricted	8 km		

Crossing 24



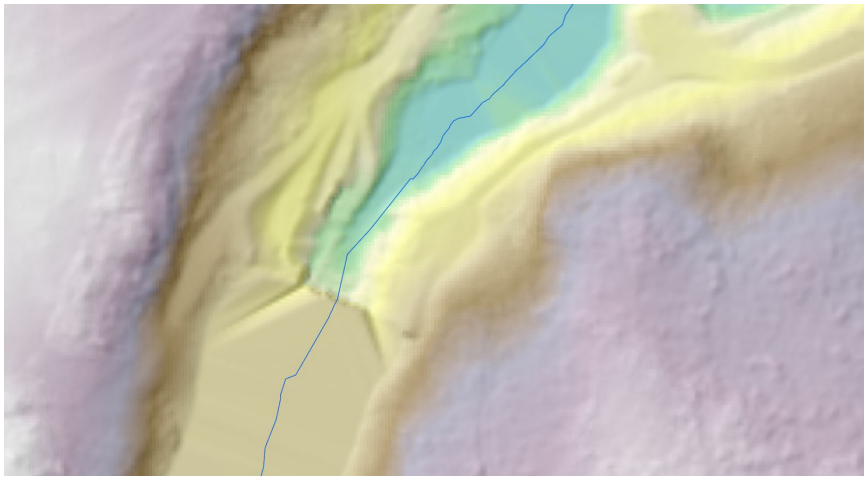
Coordinates	66.8852474°W, 45.9152209°N	**Notes**	Embankment shows no evidence of a structure being present. There would be some discoloration in the water around the outlet of the culvert due to the contrast between the color of the waters on the upstream and downstream mixing in the ortho. Additionally, there is no evidence of channeling to a structure via elevation discrepancies along the embankment. It is recommended to install an open bottom culvert or bridge.
County	York		
Crossing type	Impoundment		
Length of barrier	60 m		
Slope %	-		
Upstream kilometers restricted	20 km		

Crossing 25



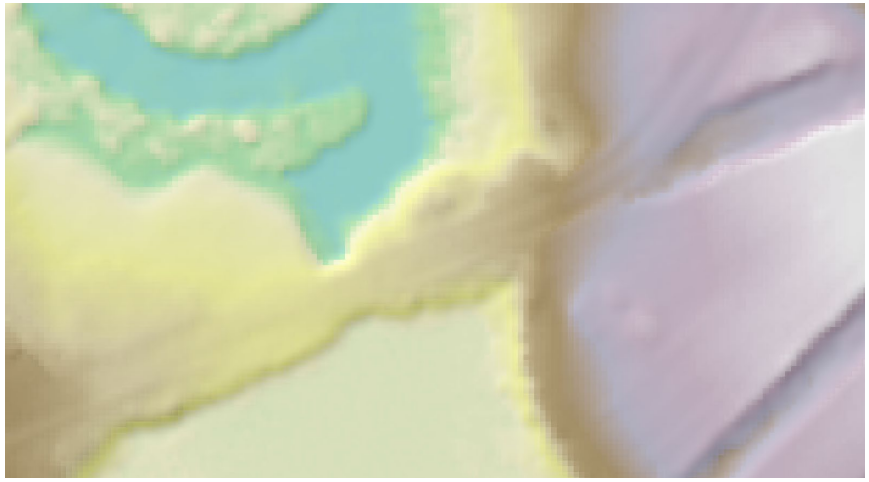
Coordinates	66.9763319°W, 45.8679668°N	**Notes**	Culvert slope exceeds slope threshold. Culvert needs to be replaced. Replacing the culvert would require significant funds since the structure is 65m long and under an embankment almost 14 meters deep. Modifying the existing structure would be the most viable and cost-effective approach. Need to remove two barriers: The barrier downstream (Crossing 26) would need to be removed for the upstream kilometers to be restored.
County	York		
Crossing type	Culvert		
Length of barrier	65 m		
Slope %	4.2%		
Upstream kilometers restricted	13 km		

Crossing 26



Coordinates	66.9749724°W, 45.8753000°N	**Notes**	Unknown structure, it could be a grain mill or some water diversion system for the nearby fields. The removal of this structure would be optimal, but if it is vital to existing infrastructure, a fish ladder can be installed or a fishway. The height of the dam is estimated to be 6.5 meters based on LiDAR DEM values. Need to remove two barriers: The barrier upstream (Crossing 25) would need to be removed for the upstream kilometers to be restored.
County	York		
Crossing type	Dam		
Length of barrier	2.5 m		
Slope %	-		
Upstream kilometers restricted	14 km		

Crossing 27



Coordinates	67.5788892°W, 46.2707830°N	**Notes**	Culvert slope exceeds slope threshold.
County	Carleton		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	6.3%		
Upstream kilometers restricted	5 km		

Crossing 28

Coordinates	67.7611115°W, 46.4333473°N	**Notes**	Culvert slope exceeds slope threshold.
County	Carleton		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	5%		
Upstream kilometers restricted	12 km		

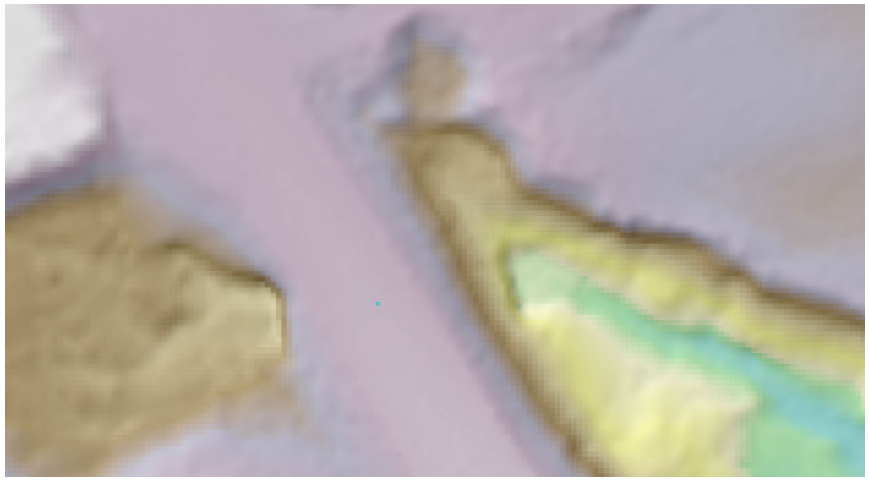
Crossing 29

Coordinates	67.7382398°W, 46.5172512°N
County	Carleton
Crossing type	Culvert
Length of barrier	12 m
Slope %	5%
Upstream kilometers restricted	8 km

Notes

Culvert slope exceeds slope threshold. There is another culvert 100m away on the same road, but is not part of the main channel, it appears to be a wetland or a culvert for ephemeral flow. The culvert should be replaced.

Crossing 30



Coordinates	67.5439559°W, 46.0304338°N	**Notes**	Ortho shows evidence that the structure is an arch culvert. Baffles would be the easiest approach to help fish passage, if replacement with an open bottom culvert is not viable.
County	Carleton		
Crossing type	Arch Culvert		
Length of barrier	40 m		
Slope %	12%		
Upstream kilometers restricted	10.5 km		

Crossing 31

Coordinates	67.7264555°W, 46.9731048°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	55 m		
Slope %	5%		
Upstream kilometers restricted	23 km		

Crossing 32

Coordinates	67.7003661°W, 46.9340917°N	**Notes**	Culvert slope exceeds slope threshold. Need to remove two barriers: Crossing 32 (located 100m downstream) will need to be remediated as well to restore the upstream kilometers.
County	Victoria		
Crossing type	Culvert		
Length of barrier	5 m		
Slope %	15%		
Upstream kilometers restricted	5 km		

Crossing 33

Coordinates	67.7000302°W, 46.9338908°N	**Notes**	Bridge culvert slope exceeds slope threshold. Ortho shows minor channel constriction during normal flow periods, high flows could cause increased velocity reducing fish passage. The structure should be widened to accommodate high flows. The slope is too steep where baffles would not be effective so a redesign or full replacement is necessary. Need to remove two barriers: Crossing 32 (located 100m upstream) will need to be remediated as well to restore the upstream kilometers.
County	Victoria		
Crossing type	Bridge Culvert		
Length of barrier	10 m		
Slope %	14.6%		
Upstream kilometers restricted	5 km		

Crossing 34

Coordinates	66.9303433°W, 45.8564641°N	**Notes**	Culvert exceeds slope threshold. Baffles could be an option; replacement would be a better option since there is slight channelization that the Ortho shows.
County	York		
Crossing type	Open bottom/concrete slab culvert		
Length of barrier	30 m		
Slope %	5.6%		
Upstream kilometers restricted	12 km		

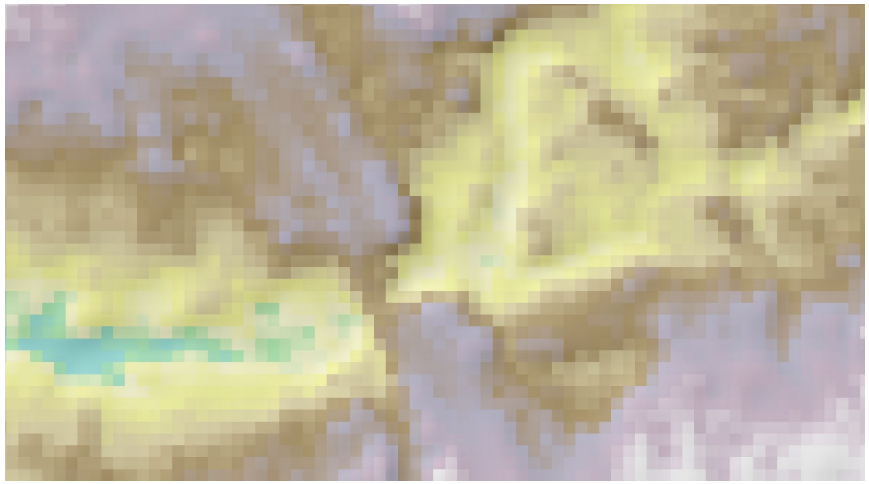
Crossing 35

Coordinates	66.5960094°W, 45.7370292°N	**Notes**	Culvert slope exceeds slope threshold.
County	Sunbury		
Crossing type	Culvert		
Length of barrier	8 m		
Slope %	18.8%		
Upstream kilometers restricted	12 km		

Crossing 36

Coordinates	67.6864184°W, 46.4221726°N	**Notes**	Culvert slope exceeds slope threshold.
County	Carleton		
Crossing type	Culvert		
Length of barrier	21 m		
Slope %	11.3%		
Upstream kilometers restricted	23.5 km		

Crossing 37

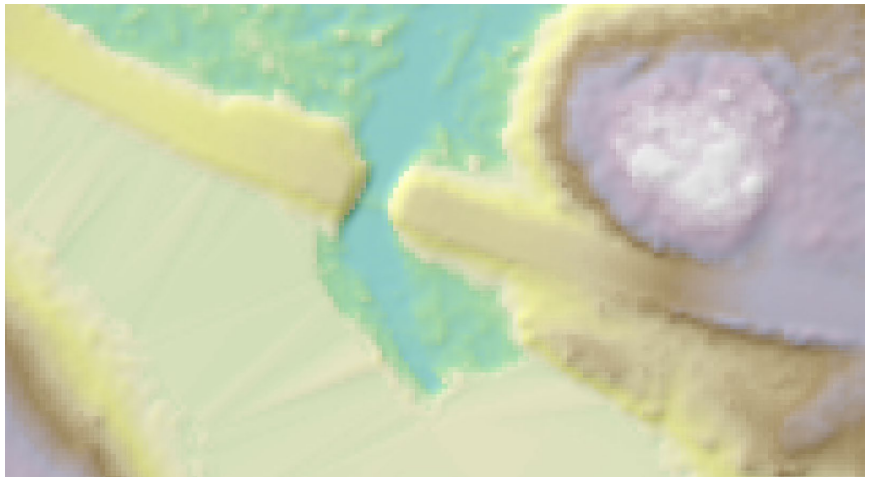


Coordinates	66.5071838°W, 45.6349616°N	**Notes**	The road has degraded; lost over 75% of the width of the road at crossing point. Recommendation is to properly decommission the road, reinforce the embankments and underlying stream bed to create a ford and restore natural flow.
County	Sunbury		
Crossing type	Culvert		
Length of barrier	8 m		
Slope %	4%		
Upstream kilometers restricted	4 km		

Crossing 38

Coordinates	66.3408822°W, 45.5836366°N	**Notes**	Since the structure is open bottom, the slope is calculated from the natural stream bed. Further investigation is needed to determine if the slope was from anthropogenic impacts altering the stream slope or it has maintained natural stream state throughout construction.
County	Queens		
Crossing type	Open Bottom Culvert		
Length of barrier	35 m		
Slope %	4.8%		
Upstream kilometers restricted	8 km		

Crossing 39



Coordinates	66.1723001°W, 45.5717696°N	**Notes**	Downstream of the bridge is a breakwater, unsure if it is natural or installed during bridge construction. There is evidence from the Ortho and DEM that the impoundment is a complete barrier and is 1.5m berm separating the up and downstream ends. It should be breached if still present.
County	Queens		
Crossing type	Impoundment		
Length of barrier	3 m		
Slope %	-		
Upstream kilometers restricted	11 km		

Crossing 40

Coordinates	67.2912440°W, 46.2225714°N	**Notes**	Since the structure is open bottom, the slope is calculated from the natural stream bed. Further investigation is needed to determine if the slope was from anthropogenic impacts altering the stream slope or it has maintained natural stream state throughout construction.
County	York		
Crossing type	Open Bottom Culvert		
Length of barrier	18 m		
Slope %	4.9%		
Upstream kilometers restricted	10 km		

Crossing 41

Coordinates	65.2913929°W, 46.0117647°N	**Notes**	Culvert slope exceeds slope threshold. Need to remove two barriers: Crossing 42 (located 1km upstream) will need to be remediated as well to restore the upstream kilometers.
County	Westmorland		
Crossing type	Culvert		
Length of barrier	14 m		
Slope %	11%		
Upstream kilometers restricted	5 km		

Crossing 42

Coordinates	65.2855161°W, 46.0104251°N	**Notes**	Culvert slope exceeds slope threshold. Need to remove two barriers: Crossing 41 (located 1km downstream) will need to be remediated as well to restore the upstream kilometers.
County	Westmorland		
Crossing type	Culvert		
Length of barrier	25 m		
Slope %	14.1%		
Upstream kilometers restricted	4 km		

Crossing 43

Coordinates	65.2534161°W, 46.5435251°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	6.7%		
Upstream kilometers restricted	8 km		

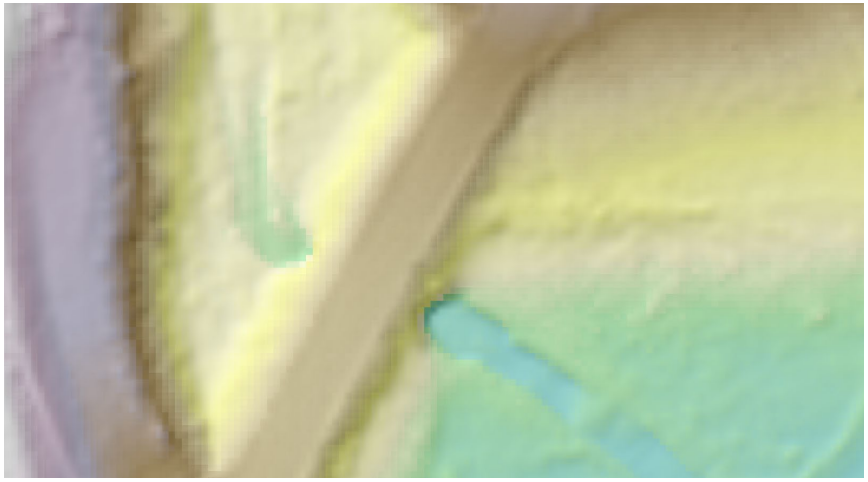
Crossing 44

Coordinates	65.9212526°W, 45.7039002°N	**Notes**	Culvert slope exceeds slope threshold.
County	Queens		
Crossing type	Bridge Culvert		
Length of barrier	15 m		
Slope %	6.5%		
Upstream kilometers restricted	12 km		

Crossing 45

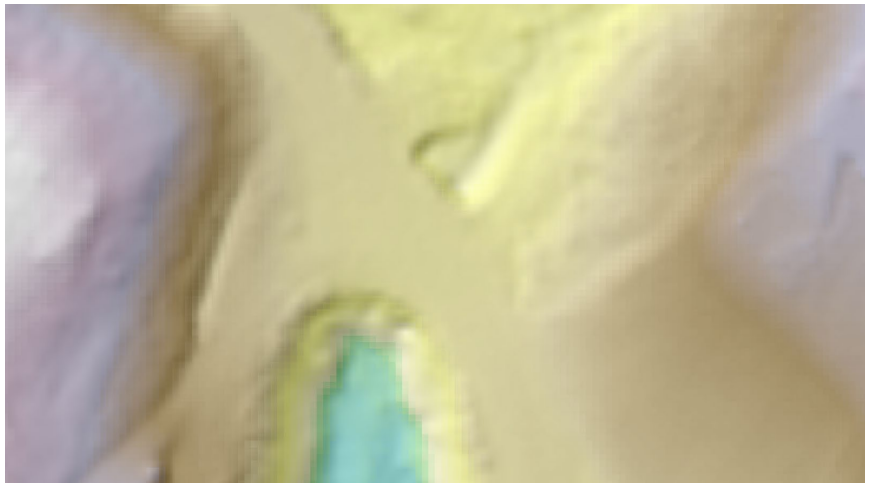
Coordinates	65.3444217°W, 45.7218550°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	10%		
Upstream kilometers restricted	5 km		

Crossing 46



Coordinates	65.8822266°W, 45.6401328°N	**Notes**	Culvert slope exceeds slope threshold. Need to remove two barriers: Crossing 47 (located 100 m upstream) will need to be remediated as well to restore the upstream kilometers.
County	Kings		
Crossing type	Culvert		
Length of barrier	20 m		
Slope %	4.3%		
Upstream kilometers restricted	6 km		

Crossing 47



Coordinates	65.8824408°W, 45.6412808°N	**Notes**	Culvert slope exceeds slope threshold. Evidence from Ortho and DEM show that it could be a hanging culvert. Need to remove two barriers: Crossing 46 (located 100 m downstream) will need to be remediated as well to restore the upstream kilometers.
County	Kings		
Crossing type	Culvert		
Length of barrier	22 m		
Slope %	7.3%		
Upstream kilometers restricted	6 km		

Crossing 48

Coordinates	65.4904891°W, 45.6501638°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	20 m		
Slope %	6.8%		
Upstream kilometers restricted	6 km		

Crossing 49

Coordinates	65.9144018°W, 45.5929071°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Single barrel culvert		
Length of barrier	28 m		
Slope %	6.7 %		
Upstream kilometers restricted	7 km		

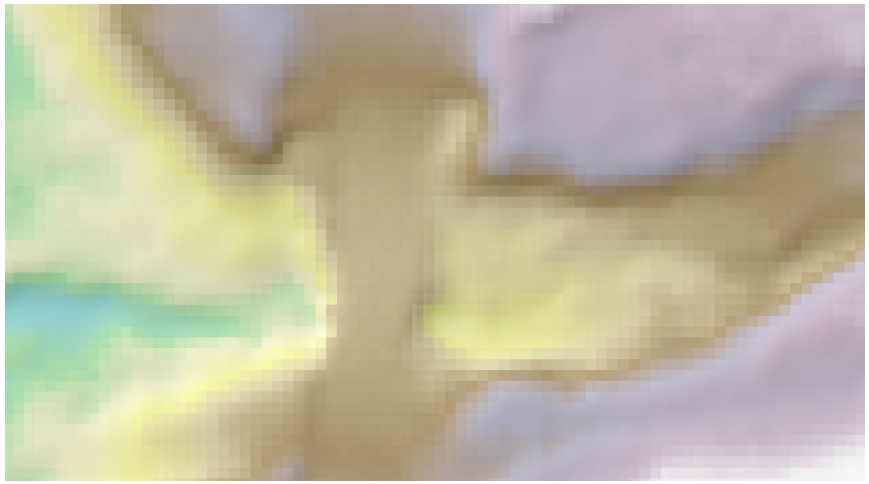
Crossing 50

Coordinates	65.4591384°W, 45.6798873°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	24 m		
Slope %	15.5%		
Upstream kilometers restricted	14 km		

Crossing 51

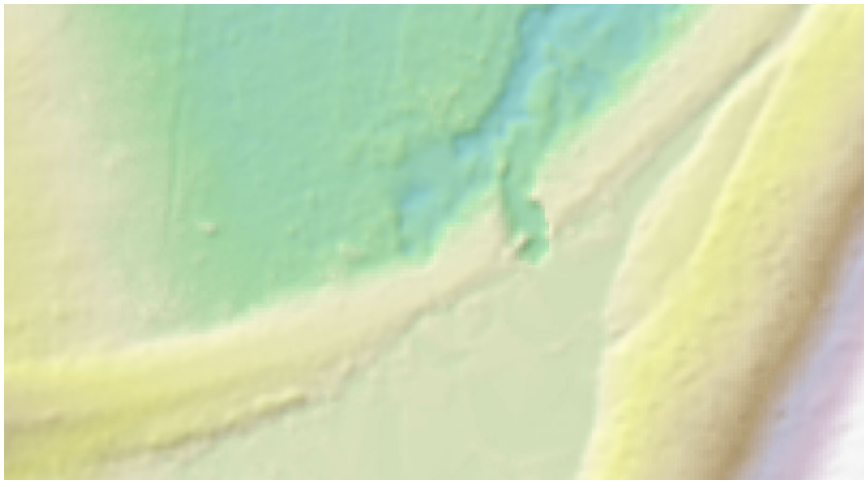
Coordinates	68.6989288°W, 47.2442763°N	**Notes**	Ortho shows evidence of a decommissioned dam or water retaining structure. Further investigation is needed to determine if the steep slope is a result of the deconstruction or it being natural rapids.
County	Madawaska		
Crossing type	Impoundment		
Length of barrier	10 m		
Slope %	22%		
Upstream kilometers restricted	23 km		

Crossing 52



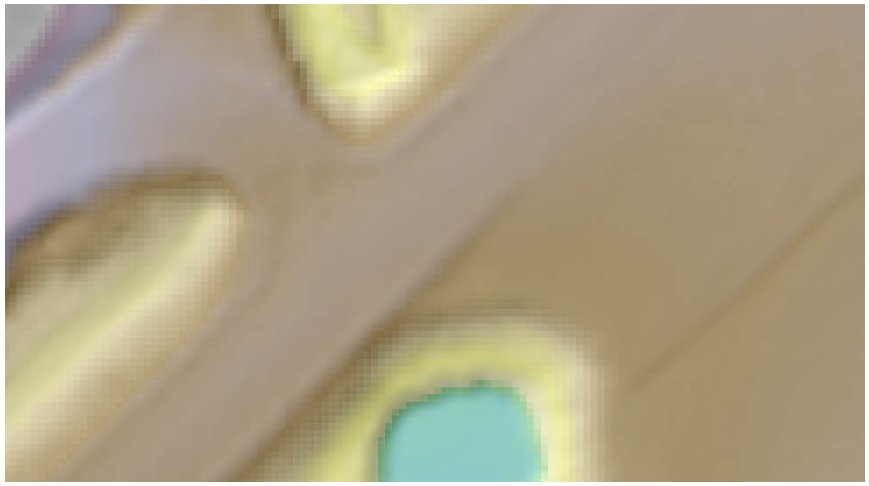
Coordinates	68.2472987°W, 47.7317075°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	8 m		
Slope %	10%		
Upstream kilometers restricted	4.8 km		

Crossing 53



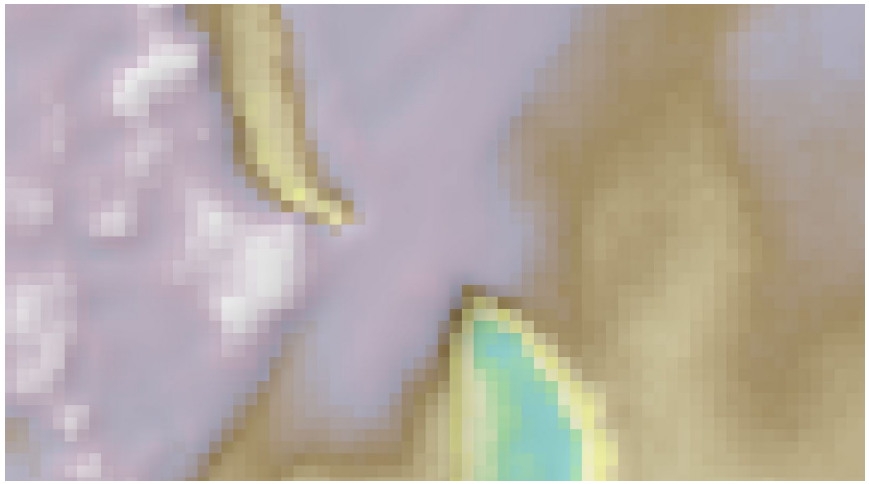
Coordinates	66.0418888°W, 45.8435568°N	**Notes**	The main channel of the stream has breached an unmaintained forest road and created a ford. Without remediation through bank reinforcement, erosion will continue and could cause increased sedimentation and creating embankments downstream which could create further barriers.
County	Queens		
Crossing type	Ford		
Length of barrier	18 m		
Slope %	-		
Upstream kilometers restricted	-		

Crossing 54



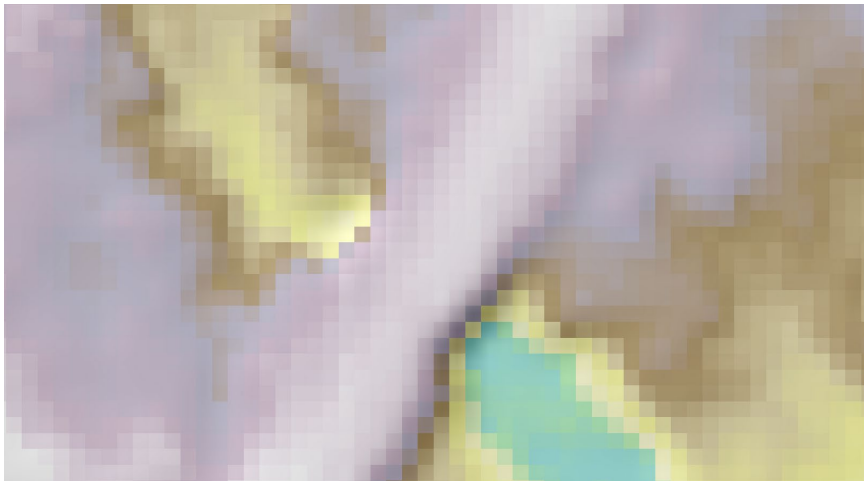
Coordinates	67.9473784°W, 46.4668055°N	**Notes**	Culvert slope exceeds slope threshold. Significant channelization (75%) to the point where concrete wings were installed to prevent scouring. No modifications should be made to the culvert, because of numerous design problems. It should be replaced with an open bottom culvert where flow will not be impeded in any flow event.
County	Carleton		
Crossing type	Culvert		
Length of barrier	45 m		
Slope %	5.5%		
Upstream kilometers restricted	29 km		

Crossing 55



Coordinates	68.1954018°W, 47.3546768°N	**Notes**	Culvert slope exceeds slope threshold. Need to remove two barriers: Crossing 56 (located 700 m upstream) will need to be remediated as well to restore the upstream kilometers
County	Madawaska		
Crossing type	Culvert		
Length of barrier	14 m		
Slope %	7%		
Upstream kilometers restricted	12 km		

Crossing 56



Coordinates	68.1997066°W, 47.3594587°N	**Notes**	Culvert slope exceeds slope threshold. Need to remove two barriers: Crossing 55 (located 700 m downstream) will need to be remediated as well to restore the upstream kilometers
County	Madawaska		
Crossing type	Culvert		
Length of barrier	10 m		
Slope %	5%		
Upstream kilometers restricted	11 km		

Crossing 57

Coordinates	67.7055345°W, 46.8307689°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	10 m		
Slope %	9.7%		
Upstream kilometers restricted	3 km		

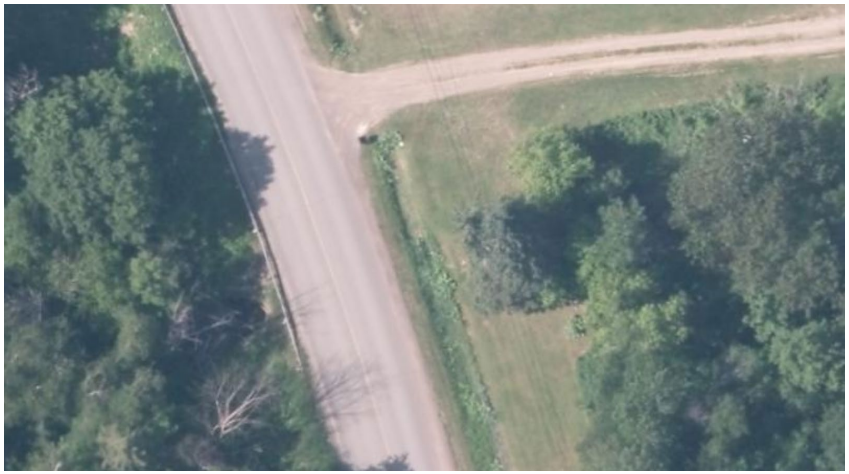
Crossing 58

Coordinates	67.706539°W, 46.98114800°N	**Notes**	Ortho shows heavy sedimentation and erosion prone substrate. In Ortho from 2018, one of the two barrel culverts was completely blocked by sand/silt. Bank reinforcement and a culvert design that can encompass the width of the stream is needed.
County	Victoria		
Crossing type	Dual barrel culvert		
Length of barrier	65 m		
Slope %	5%		
Upstream kilometers restricted	25 km		

Crossing 59

Coordinates	67.5762056°W, 46.4957055°N	**Notes**	Culvert slope exceeds slope threshold.
County	Carleton		
Crossing type	Culvert		
Length of barrier	35 m		
Slope %	9.6%		
Upstream kilometers restricted	8 km		

Crossing 60



Coordinates	67.7155876°W, 46.6594798°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	28 m		
Slope %	8.3%		
Upstream kilometers restricted	5 km		

Crossing 61

Coordinates	67.6430403°W, 46.6821694°N
County	Victoria
Crossing type	Culvert
Length of barrier	12 m
Slope %	4.5%
Upstream kilometers restricted	5 km

Notes	Culvert slope exceeds slope threshold.

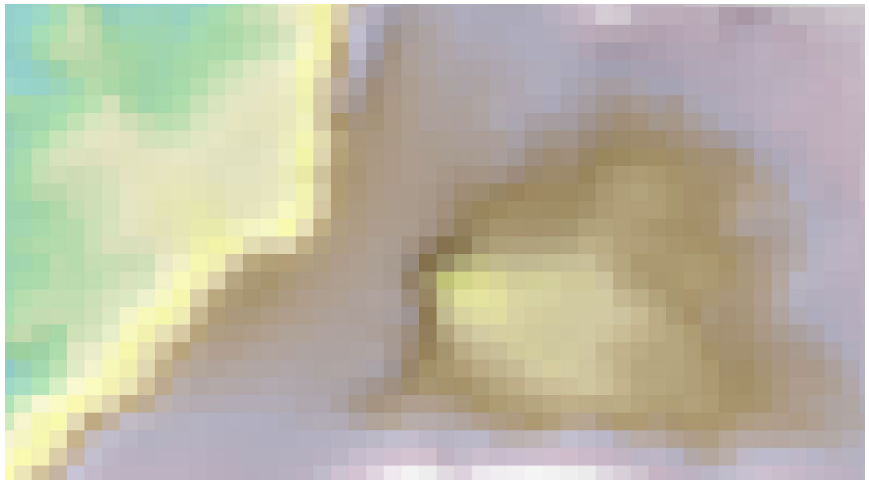
Crossing 62

Coordinates	67.6499599°W, 46.6724106°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Box Culvert		
Length of barrier	13 m		
Slope %	6.8%		
Upstream kilometers restricted	7 km		

Crossing 63

Coordinates	67.4954369°W, 46.6118343°N	**Notes**	Culvert slope exceeds slope threshold.
County	Carleton		
Crossing type	Culvert		
Length of barrier	8 m		
Slope %	7%		
Upstream kilometers restricted	4 km		

Crossing 64

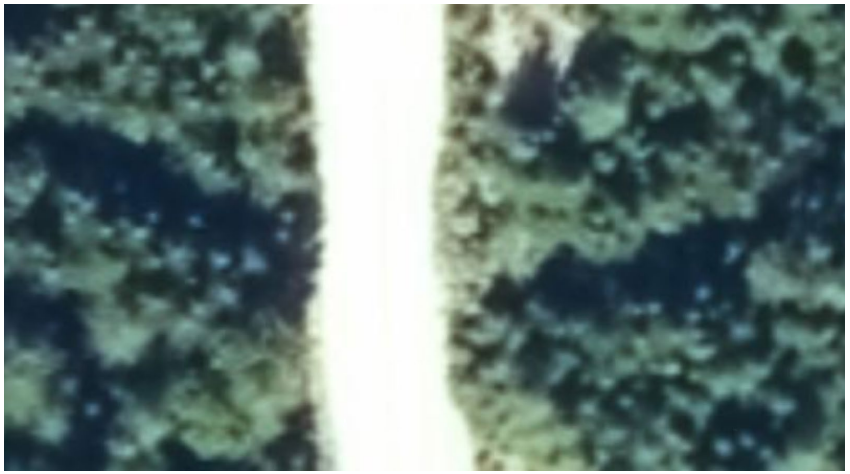


Coordinates	67.5062534°W, 46.6138827°N	**Notes**	Culvert slope exceeds slope threshold.
County	Carleton		
Crossing type	Culvert		
Length of barrier	10 m		
Slope %	5%		
Upstream kilometers restricted	5 km		

Crossing 65

Coordinates	67.5882924°W, 46.6856340°N	**Notes**	Culvert slope exceeds slope threshold. Upstream side of culvert appears to have concrete wings from the Ortho. Slow moving, wetted land, with no evidence of a channel. Downstream is more channelized due to the slope of the culvert increasing the velocity of water resulting in scouring downstream. The upstream wetted land should be investigated to see if the stream morphology is natural or anthropogenic from the road. The crossing should be removed for a larger diameter culvert to prevent pooling on the upstream side and establish a channel.
County	Victoria		
Crossing type	Concrete wing culvert		
Length of barrier	12 m		
Slope %	12.5%		
Upstream kilometers restricted	7 km		

Crossing 66



Coordinates	66.815595°W, 47.1059359°N	**Notes**	Culvert slope exceeds slope threshold.
County	Northumberland		
Crossing type	Culvert		
Length of barrier	16 m		
Slope %	9.2%		
Upstream kilometers restricted	11 km		

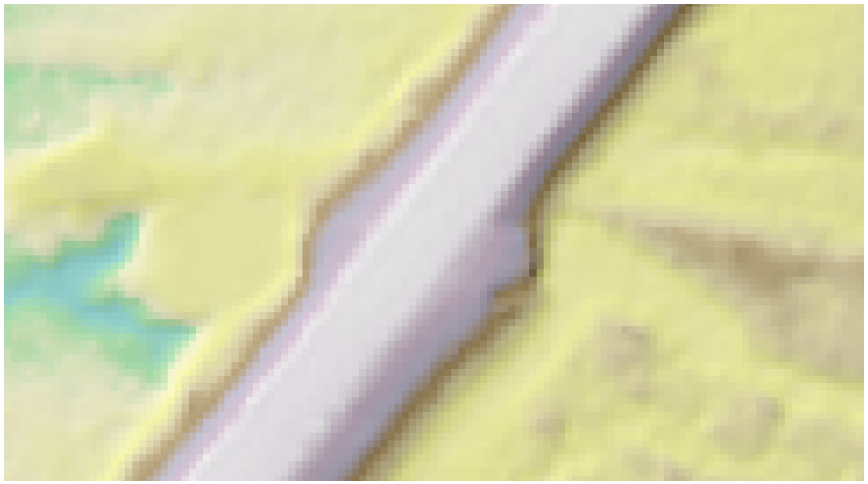
Crossing 67

Coordinates	67.1768676°W, 47.2867639°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Box culvert		
Length of barrier	12 m		
Slope %	8.3%		
Upstream kilometers restricted	15.5 km		

Crossing 68

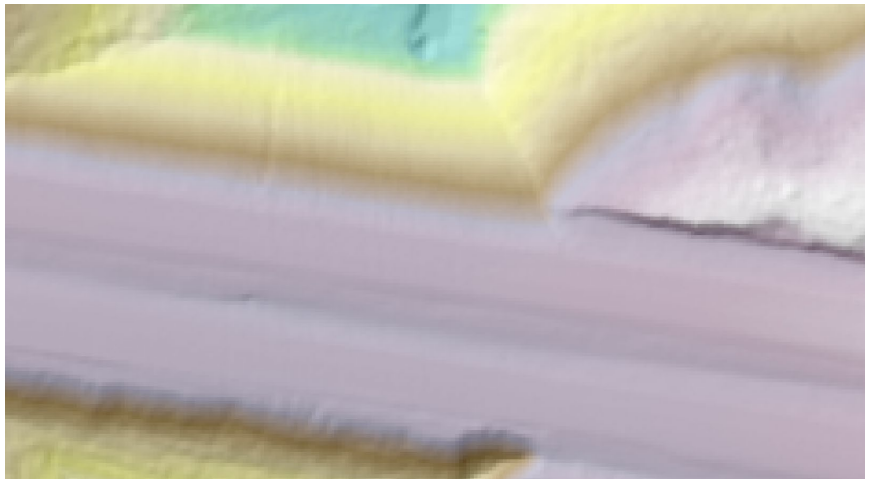
Coordinates	67.6545964°W, 46.6375832°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	6.3%		
Upstream kilometers restricted	8.5 km		

Crossing 69



Coordinates	67.0276874°W, 47.3153825°N	**Notes**	Significant pooling on the upstream side of the culvert, indicating water is slow moving and not channelized. 20 meters downstream either fresh beaver or logging activity that has allowed a large pool to form. More channelization is needed on the upstream side and for the downstream side to be free of structures to allow fish passage
County	Victoria		
Crossing type	Culvert		
Length of barrier	35 m		
Slope %	1.5%		
Upstream kilometers restricted	8 km		

Crossing 70

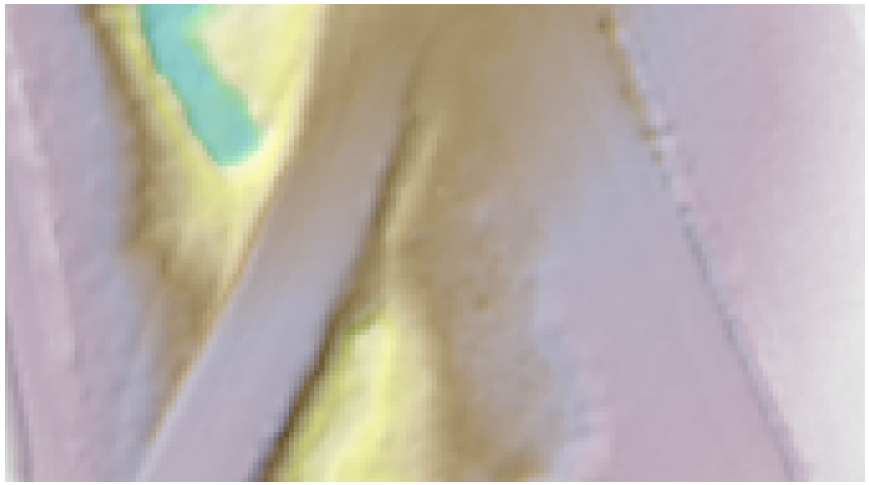


Coordinates	67.6436100°W, 46.159610°N	**Notes**	While culvert slope does not exceed the 4% threshold for strong swimming fish, the length of the culvert at a 2.5% slope could pose a problem for burst swimmers. Additionally, this would be a barrier for any non-trout species that could inhabit the area. Due to the culvert being below 20 meters of road embankment, modifying the existing structure would be most viable. From LiDAR and Ortho measurements, the diameter (taken from the outside shell of the culvert) is roughly 4 m. This could provide enough space to place baffles and resting pools within the culvert, given the water level can be high enough. Another concern is that the stream is being restricted by about 50% on the lead up to the culvert causing further increases in velocity which would make it even more unlikely to pass weaker swimmers.
County	Carleton		
Crossing type	Concrete wing culvert		
Length of barrier	150 m		
Slope %	2.5%		
Upstream kilometers restricted	15 km		

Crossing 71

Coordinates	66.7800439°W, 45.9674094°N	**Notes**	Culvert slope exceeds slope threshold.
County	York		
Crossing type	Arch Culvert		
Length of barrier	45 m		
Slope %	4.8%		
Upstream kilometers restricted	15 km		

Crossing 72



Coordinates	66.6188212°W, 45.9238103°N	**Notes**	Culvert slope exceeds slope threshold.
County	York		
Crossing type	Double Culvert		
Length of barrier	42 m		
Slope %	4.1%		
Upstream kilometers restricted	10.5 km		

Crossing 73

Coordinates	67.3890064°W, 46.9185546°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	18 m		
Slope %	4.3%		
Upstream kilometers restricted	5 km		

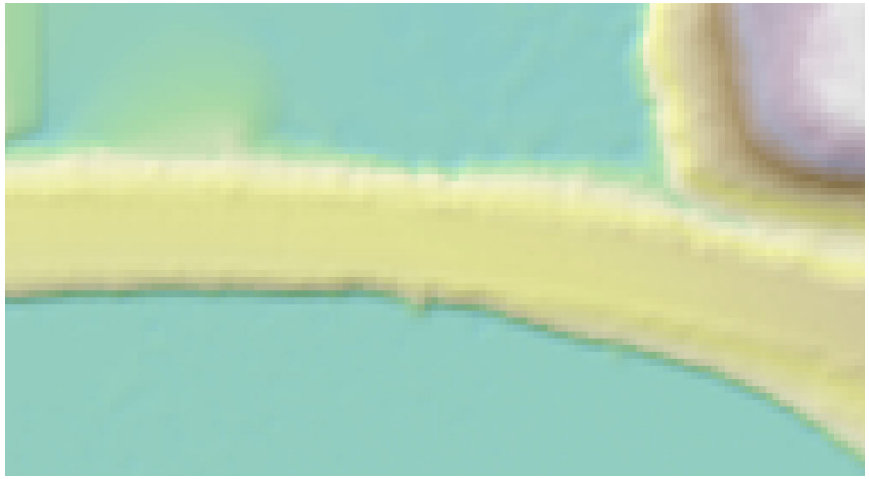
Crossing 74

Coordinates	67.6907237°W, 46.7841622°N	**Notes**	Culvert slope exceeds slope threshold.
County	Victoria		
Crossing type	Culvert		
Length of barrier	9 m		
Slope %	7.9%		
Upstream kilometers restricted	7 km		

Crossing 75

Coordinates	65.9294419°W, 45.3216751°N	**Notes**	While the culvert is passable based on slope, the design of using a triple culvert is questionable. Standard practice would not space culverts that close together. By having culverts so closely spaced, the soil between them is not compact and is prone to scouring and will lead to a culvert failure. By splitting the flow between the three structures, the water level could be dramatically reduced. During Summer seasons, depending on the depth of the water, could be unpassable. A better design that would allow year-round passage is to use an open bottom arch culvert that would allow natural flow under the road embankment.
County	Saint John		
Crossing type	Triple Culvert		
Length of barrier	15 m		
Slope %	1.3%		
Upstream kilometers restricted	20 km		

Crossing 76

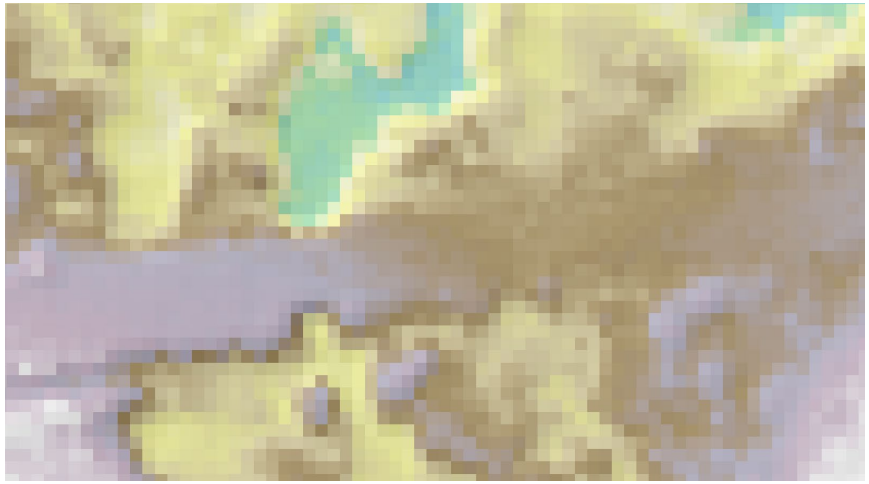


Coordinates	67.4493717°W, 45.9994730°N	**Notes**	While the culvert is passable, a single 3-m diameter culvert off the main stem of the river will result in a failure or the velocity of the water being too great due to the sheer volume from upstream. A bridge culvert would allow more upstream volume to flow into the main stem and help regulate flooding.
County	York		
Crossing type	Culvert		
Length of barrier	24 m		
Slope %	0.3%		
Upstream kilometers restricted	38 km		

Crossing 77

Coordinates	66.7293031°W, 45.5532472°N	**Notes**	Culvert slope exceeds slope threshold.
County	Sunbury		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	8.3%		
Upstream kilometers restricted	7 km		

Crossing 78



Coordinates	66.7468757°W, 45.7858299°N
County	Sunbury
Crossing type	Culvert
Length of barrier	8 m
Slope %	4.2%
Upstream kilometers restricted	6.5 km

Notes	Culvert slope exceeds slope threshold.

Crossing 79

Coordinates	66.6858961°W, 45.6981587°N	**Notes**	Culvert slope exceeds slope threshold.
County	Sunbury		
Crossing type	Concrete winged culvert		
Length of barrier	8 m		
Slope %	15.1%		
Upstream kilometers restricted	7.5 km		

Crossing 80

Coordinates	68.2529868°W, 47.3628336°N	**Notes**	Culvert slope exceeds slope threshold. The downstream side has too many boulders where there is no unimpeded flow to the actual downstream end. 1 km upstream (Crossing 81 or 82) need to be removed to restore upstream habitat.
County	Madawaska		
Crossing type	Arch culvert (Right)		
Length of barrier	80 m		
Slope %	4.8%		
Upstream kilometers restricted	19 km		

Crossing 81

Coordinates	68.2529868°W, 47.3628336°N	**Notes**	Culvert slope exceeds slope threshold. 1 km upstream (Crossing 80 or 82) need to be removed to restore upstream habitat.
County	Madawaska		
Crossing type	Arch culvert (Left)		
Length of barrier	110		
Slope %	4%		
Upstream kilometers restricted	19 km		

Crossing 82

Coordinates	67.6319020°W, 46.9936756°N	**Notes**	Culvert slope exceeds slope threshold. Downstream end appears to be hanging based on Ortho. Need to remove two barriers: 1 km downstream (Crossing 80 or 81) need to be removed to restore upstream habitat.
County	Victoria		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	4%		
Upstream kilometers restricted	20 km		

Crossing 83

Coordinates	66.0085262°W, 45.3187327°N	**Notes**	Since the structure is open bottom, the slope is calculated from the natural stream bed. Further investigation is needed to determine if the slope was from anthropogenic impacts altering the stream slope or it has maintained natural stream state throughout construction.
County	Saint John		
Crossing type	Bridge culvert		
Length of barrier	10 m		
Slope %	3.9%		
Upstream kilometers restricted	19 km		

Crossing 84

Coordinates	68.6064814°W, 47.3353702°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	18 m		
Slope %	6.7%		
Upstream kilometers restricted	3 km		

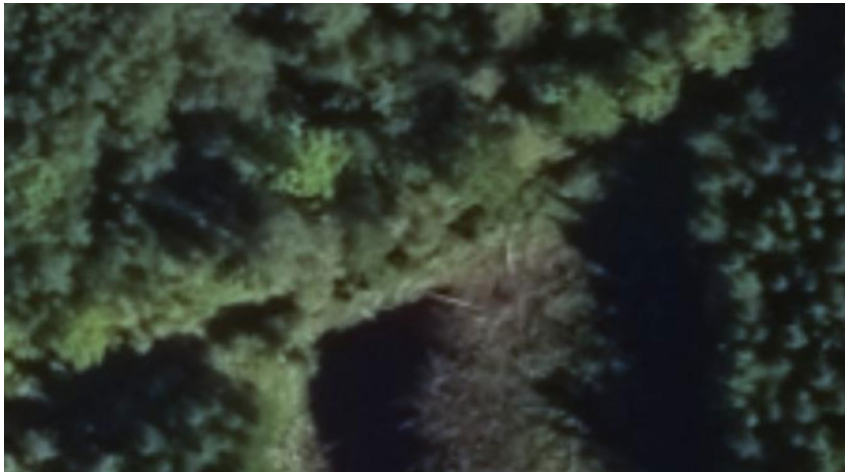
Crossing 85

Coordinates	68.4140582°W, 47.3556283°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	5%		
Upstream kilometers restricted	4 km		

Crossing 86

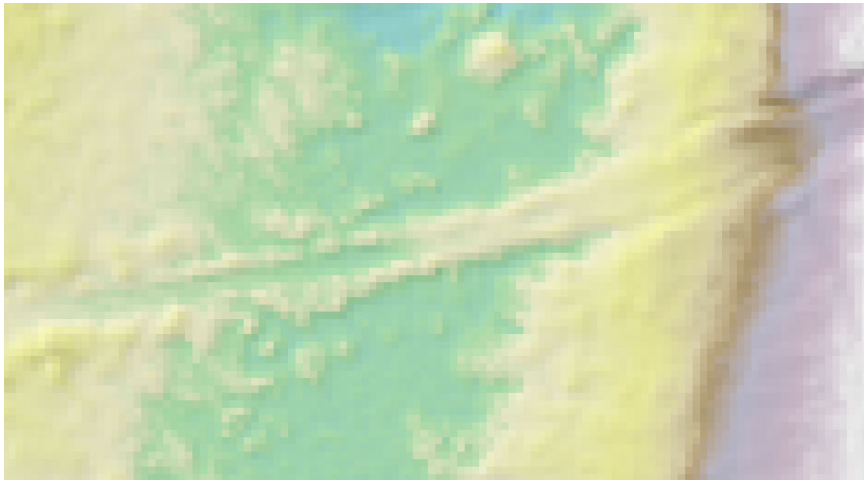
Coordinates	68.4756997°W, 47.3724718°N	**Notes**	Culvert slope exceeds slope threshold.
County	Madawaska		
Crossing type	Culvert		
Length of barrier	12 m		
Slope %	6.6%		
Upstream kilometers restricted	4 km		

Crossing 87



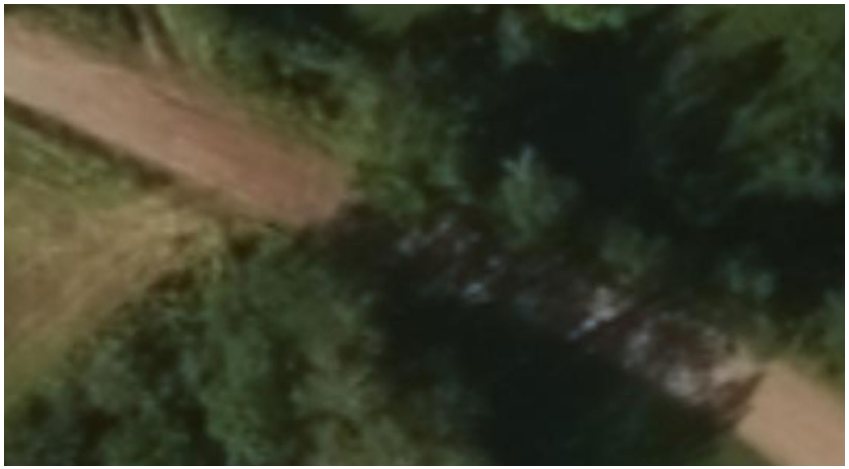
Coordinates	65.7018551°W, 45.9633343°N	**Notes**	Culvert slope exceeds slope threshold.
County	Queens		
Crossing type	Culvert		
Length of barrier	8 m		
Slope %	5.5%		
Upstream kilometers restricted	4 km		

Crossing 88



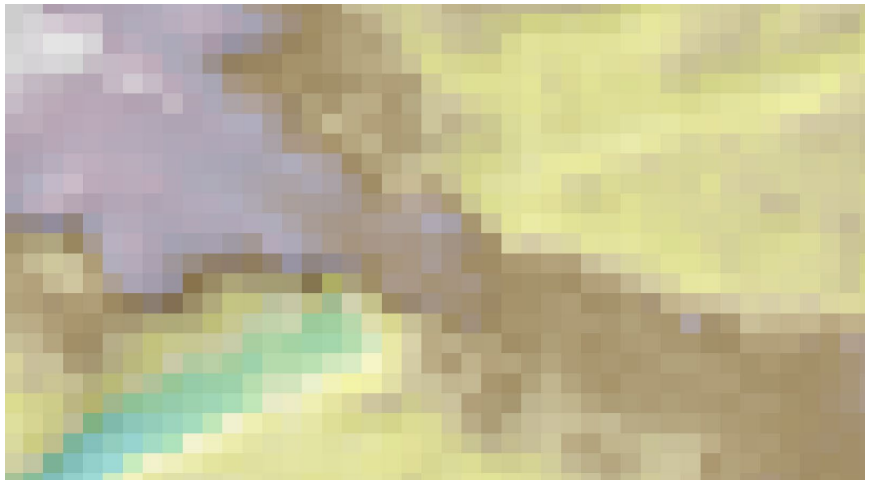
Coordinates	65.7132069°W, 45.9583234°N	**Notes**	Old forest road that was not maintained or decommissioned. Multiple breaches across the road embankment, with no clear main channel. The road should be breached and install a ford to prevent further road failure which could further restrict upstream access.
County	Queens		
Crossing type	Ford		
Length of barrier	8 m		
Slope %	-		
Upstream kilometers restricted	2.5 km		

Crossing 89



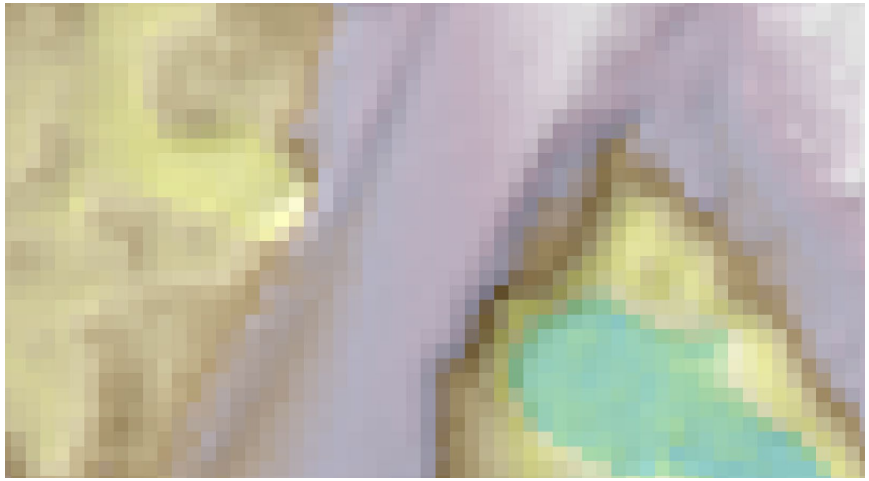
Coordinates	65.5178905°W, 45.6447376°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	15 m		
Slope %	4.9%		
Upstream kilometers restricted	3.5 km		

Crossing 90



Coordinates	65.6847531°W, 45.7814214°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	9 m		
Slope %	5.5%		
Upstream kilometers restricted	6 km		

Crossing 91



Coordinates	66.0789023°W, 45.3850063°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	18 m		
Slope %	4%		
Upstream kilometers restricted	3.5 km		

Crossing 92

Coordinates	66.0657481°W, 45.3918538°N
County	Kings
Crossing type	Culvert
Length of barrier	15 m
Slope %	6%
Upstream kilometers restricted	3.5 km

Notes	Culvert slope exceeds slope threshold.

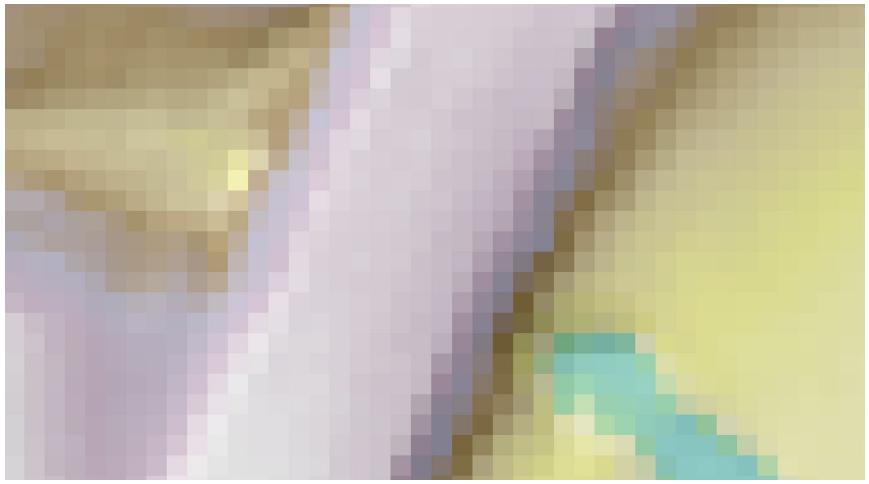
Crossing 93

Coordinates	66.1750893°W, 45.3909969°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Box culvert		
Length of barrier	18 m		
Slope %	6.4%		
Upstream kilometers restricted	8 km		

Crossing 94

Coordinates	65.9841253°W, 45.4587568°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	16 m		
Slope %	5.1%		
Upstream kilometers restricted	12.5 km		

Crossing 95



Coordinates	65.8087248°W, 45.6431503°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	18		
Slope %	8.8%		
Upstream kilometers restricted	5 km		

Crossing 96

Coordinates	65.6929005°W, 45.6862085°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	18 m		
Slope %	8.8%		
Upstream kilometers restricted	4.5 km		

Crossing 97

Coordinates	65.6916103°W, 45.7032218°N	**Notes**	Culvert slope exceeds slope threshold. High slope threshold would indicate a failed road embankment.
County	Kings		
Crossing type	Culvert		
Length of barrier	8 m		
Slope %	26.75%		
Upstream kilometers restricted	3 km		

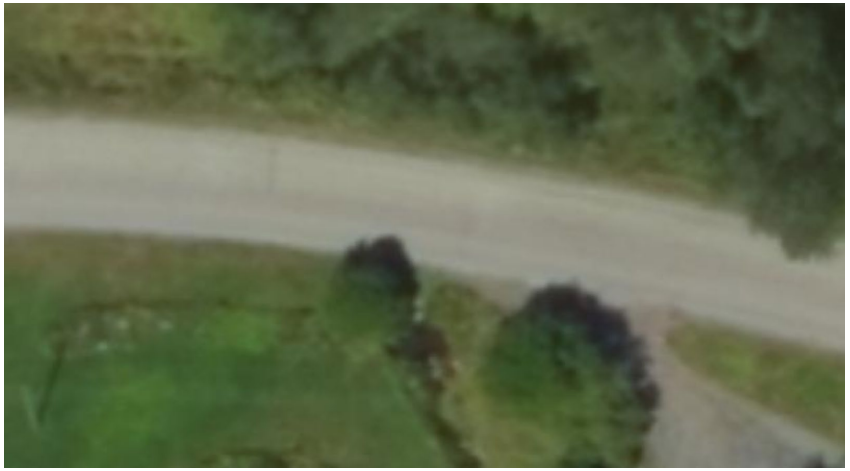
Crossing 98

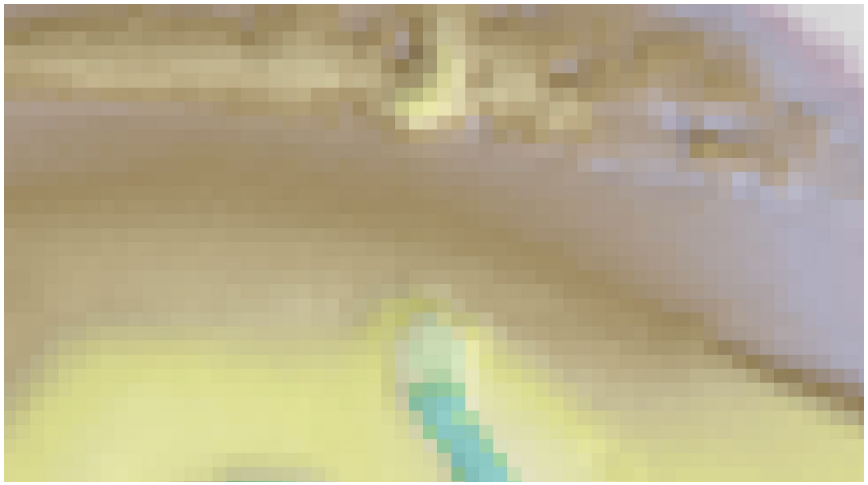
Coordinates	65.7142991°W, 45.6904984°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	16 m		
Slope %	4.7%		
Upstream kilometers restricted	3 km		

Crossing 99

Coordinates	65.9689026°W, 45.6950132°N	**Notes**	Culvert slope exceeds slope threshold.
County	Queens		
Crossing type	Culvert		
Length of barrier	16 m		
Slope %	6%		
Upstream kilometers restricted	15 km		

Crossing 100





Coordinates	65.6868364°W, 45.5399354°N	**Notes**	Culvert slope exceeds slope threshold.
County	Kings		
Crossing type	Culvert		
Length of barrier	14 m		
Slope %	5%		
Upstream kilometers restricted	3 km		

Additional information and resources

Recommendations for remediating these stream crossings are not absolute; they are quick notes that should never be used as a substitute for further investigation. Looking forward, I like to keep the 10 rules of thumb for culvert crossings by Christopher M. Crowley when I am deciding what would be the best remediation strategy:

1. Use a pipe no smaller than 18-in diameter with 18 in of clean, compacted cover.
2. Measure the cross-sectional area of the culvert crossing to obtain the area of flow for the Spring storm.
3. Place multiple culverts at least one culvert diameter apart.
4. Compact clean soil tightly in and around culverts and the cover material.
5. Construct the road section low or allow for overtopping to one side.
6. Use maximum slide slopes of 2:1 (H: V) and a road surface width of at least 12 ft. to calculate pipe length.
7. Consult a professional when working with special use pipes.
8. Add riprap protection to the upstream and downstream approaches to culverts.
9. Check the condition of the crossings frequently and clear the openings of debris.
10. Know your limitations.

The stream smart road crossing pocket guide by the State of Maine Aquatic Resources Management Strategy Forum is a great resource for quick reference on what best practices for site assessment and implementation.

Additionally, the Watercourse and Wetland Alteration Technical Guidelines manual provides the guiding principles and permissible alterations that will help decide if the remediation project is viable for a particular group or project.