Fish Habitat Risk Assessment- Mattamy Richmond Lands Storm Water Management Options

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Submitted To:

Mattamy Homes
123 Huntmar Drive
Ottawa, Ontario

Attention: Susan Murphy

KILGOUR & ASSOCIATES LTD.
1500 Bank Street,
Ottawa, Ontario,
K1H 1B8
Canada
p:613.260.5555
f:613.737.2825
www.kilgourassociates.com
Project Number 0003.6

EXECUTIVE SUMMARY

DSEL and others provided three options for storm water management (SWM) on Mattamy's Richmond properties. These proposals outline the approximate locations of SWM ponds and general indications of where surface water features will be altered. As these surface water features provide both direct and indirect fish habitat, this preliminary study estimates the potential impacts of those alterations on that habitat.

This document assesses the potential for risk of loss of productive potential to fish habitat resulting from the proposed development of the Mattamy Lands and associated stormwater management. This assessment follows the recommended methodology provided by the Ontario Ministry of Transportation and Department of Fisheries and Oceans. The fisheries associated with each of the watercourses are described. Sensitivity of each watercourse to land development is assessed on the basis of: (1) the species known to occur, and their sensitivities to suspended particulate matter and water temperature; (2) rarity of habitats locally and regionally; (3) species' dependence on these watercourses; and (4) habitat resilience. Published pathways of effects diagrams were used to identify likely stressors to watercourses on the developing Mattamy lands. We further identify mitigation measures for these activities, and qualitatively assess the likelihood of significant risk to fish and fish habitat on these lands.

Re-grading of the Mattamy land holdings, and the subsequent construction and operation of the SWM ponds will cause some moderate changes under two options, and a net gain in direct fish habitat in a third option. Fish habitats that would be altered are generally indirect intermittent habitats or are man-made. SWM Option 3 is anticipated to provide a significant and net benefit to direct fish habitat, in association with the following aspects of the proposed design. Sections 6 and 7 of the Moore Branch will be regraded to enhance the conveyance function of the feature. That will result in a change in the status of Sections 7 and 8, which are currently classified as indirect intermittent fish habitat, to direct intermittent fish habitat. Fish will continue to be able to access Section 7 for spawning, while the improved grading is anticipated to allow larvae/fry to migrate out of the system as water levels recede over the course of the spring/summer. A French drain will be incorporated in the SWM pond design to provide cool baseflow to the lower Moore Branch, and maintain the cool-water function of that feature. The outlet channel for SWM Pond 1 will be designed to provide spring fish spawning habitat. Additional riparian plantings along the Moore Branch will enhance its ability to cool surface waters and to provide a naturalized corridor. Riparian plantings along the mainstem of the Arbuckle Drain will provide additional shade and course woody material to that feature. This assessment of the three SWM options suggested that Option 3, with a large SWM pond in the 100-year floodplain of the Arbuckle Drain, would provide net benefits to fish habitat with up to at additional 3,386 m^2 of fish habitat created as a result of the undertaking.

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1.0 INTRODUCTION

Mattamy owns or has options for ownership on ~325 acres of land along the west side of the Village of Richmond (Figure 1). The natural environment features of Mattamy's land holding and adjacent properties are described fully in Kilgour (2010). Briefly, the Mattamy land holding is adjacent to the Jock River which flows in a north-easterly direction south east of the property. Mattamy's land holding is drained primarily by agricultural drains that flow into the Van Gaal Drain (also known as the Arbuckle Drain from Perth Street to the Jock River (Figure 1)). Mattamy's land holdings contain both direct[1] and indirect[2] fish habitat.

Section 35(1) of the federal *Fisheries Act* prohibits the harmful alteration, disruption or destruction (or HADD) of fish habitat. Fisheries and Oceans Canada (DFO) recently developed its *Risk Management Framework for DFO Habitat Management Staff* that outlines a methodology for practitioners to evaluate the risks posed to aquatic habitat by development proposals. The Risk Management Framework is intended to provide a structured approach to decision-making that takes into account the concepts of risk, uncertainty and precaution. Practitioners are encouraged to use this approach to:

- analyze development proposals and apply mitigation to minimize residual effects;
- assess residual effects and characterize the risk they pose to fish and fish habitat;
- use the risk characterization process to support management decisions; and,
- communicate the rationale for their decisions.

The objective of this report is to assess the effects to fish habitat of three potential options for stormwater management for the proposed development of the Mattamy Richmond lands. A summary of existing conditions, with an emphasis on fisheries, is provided in Section 2.0. There are currently three options for storm water management (SWM) on Mattamy's Richmond properties, as described in Section 3.0 below. The impacts of these three options to fish habitat are assessed following the methodology suggested by the Ontario Ministry of Transportation (2006) and are presented in Section 4.0.

[1] Direct Fish Habitat is habitat used by fish for spawning, rearing, feeding or migration
[2] Indirect Fish Habitat is aquatic habitat that is generally not used by fish, but that provides water and food for direct fish habitats

2.0 EXISTING HABITAT CONDITIONS

The drainage fabric for the Mattamy Richmond Land is illustrated in Figure 1. The Van Gaal Drain is the primary drainage feature on the northwest portion of Mattamy's property, with two principal branches: VG-R2-2 from the northwest; VG-R2-3 from the northeast. The mainstem is here denoted VG-R2 upstream of Fortune Street, and VG-R1 downstream of Fortune Street. Drainage on the Mattamy lands on the north side of Ottawa Street currently flows north through a hedgerow, then north-east through a second hedgerow (VG-R3-2) to the Moore Branch (VG-R3, VG-R3-1). The Moore Branch enters the Van Gaal Drain ~ 150 m upstream of Fortune Street.

Drainage on Mattamy's property south of Ottawa Street historically flowed northwest through a culvert under Ottawa Street to the Van Gaal Drain. Drainage on that south side now flows to a drainage ditch (Jock River Estates Drain, or JED-1) and is conveyed south through a constructed berm adjacent to the Jock River.

We describe the general aquatic conditions and fish communities of the major watercourses that will be potentially affected by Mattamy's proposed developments in the Sections below:

- Jock River;
- Van Gaal Drain;
- Moore Branch; and,
- Jock River Estates Drain.

Figure 1. Map of the Mattamy Richmond Land showing watercourses.

2.1 Jock River

2.1.1 Background Information

The Jock River has basic pH (~ 8), with elevated concentrations of nutrients, particularly total phosphorus (> 0.03 mg/L). Summer water temperatures of the Jock River in the vicinity of the Village of Richmond indicate the river is a generally warm-water system. There is evidence, however, of groundwater influences through the village since water temperatures generally decrease by about 2°C from upstream to downstream of the village (Figure 2).

The river contains over 35 species representing a variety of trophic and reproductive guilds (Table 1). The river is dominated by cool and warm-water species, though there are additional cold-water species also present including mottled sculpin, pearl dace and spottail shiner. A number of recreational species are present including pike, muskellunge, brown bullhead, bass (smallmouth, largemouth) and walleye. There are confirmed nursery habitats for pike and other species along the margins of the Jock River in the vicinity of the confluence of the Arbuckle Drain and through the Village of Richmond (Figure 3).

2.1.2 Habitat Classification

For the purposes of this risk assessment, the Jock River is **permanent, direct fish habitat** (Figure 1). The Jock River is considered to be **moderately sensitive** on the basis of the following (from Table 1):

- **Species Sensitivity**: The river contains a highly diverse assemblage of fish including species that are potentially sensitive to land development activities (Table 1).
- **Species Dependence**: The Jock River within the Village of Richmond can be considered to provide habitats for all of the various life stages of fish including spawning habitats, rearing, feeding and over-wintering.
- **Rarity:** None of the shoreline or mid-channel sections of the Jock River have been demonstrated to be unique or unusual habitats. Species within the Jock River can find and use other locales for life processes.
- **Habitat Resilience:** The Jock River is a permanent flowing, large water course. The system is generally warmwater, but does have local areas of coolwater habitat. Groundwater inputs are locally evident from the cooling of the watercourse that apparently occurs as water travels through the Village of Richmond.

There are no species at risk in the Jock River in the vicinity of the Village of Richmond.

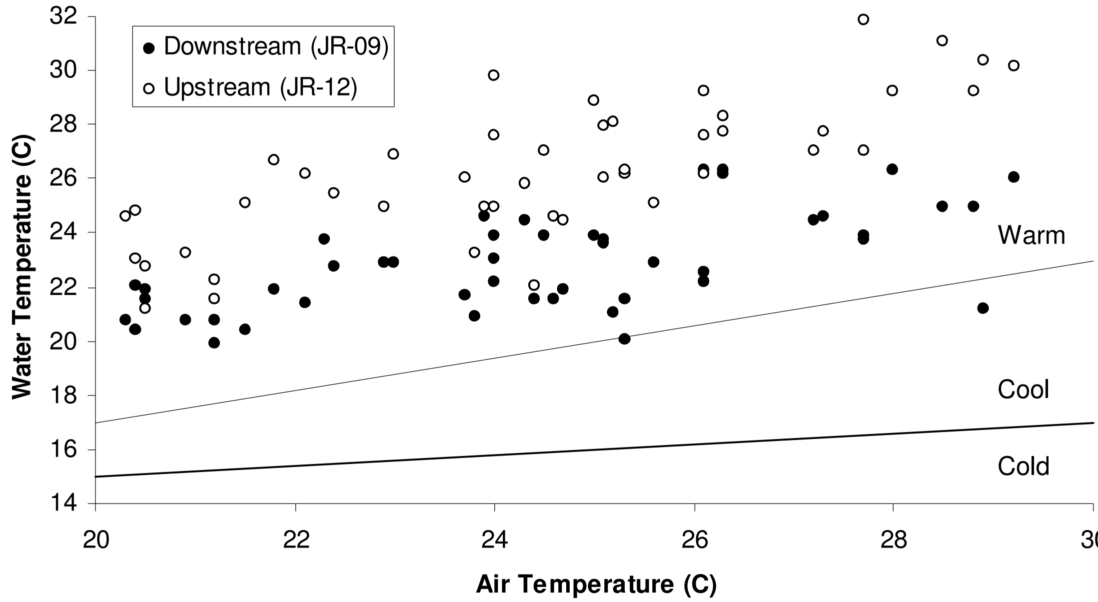


Figure 2. Relationship between air and water temperature in the mainstem Jock River in the vicinity of the Village of Richmond.

Figure Note: Data for the summer of 2004, and provided by the City of Ottawa (Adam Bishow).

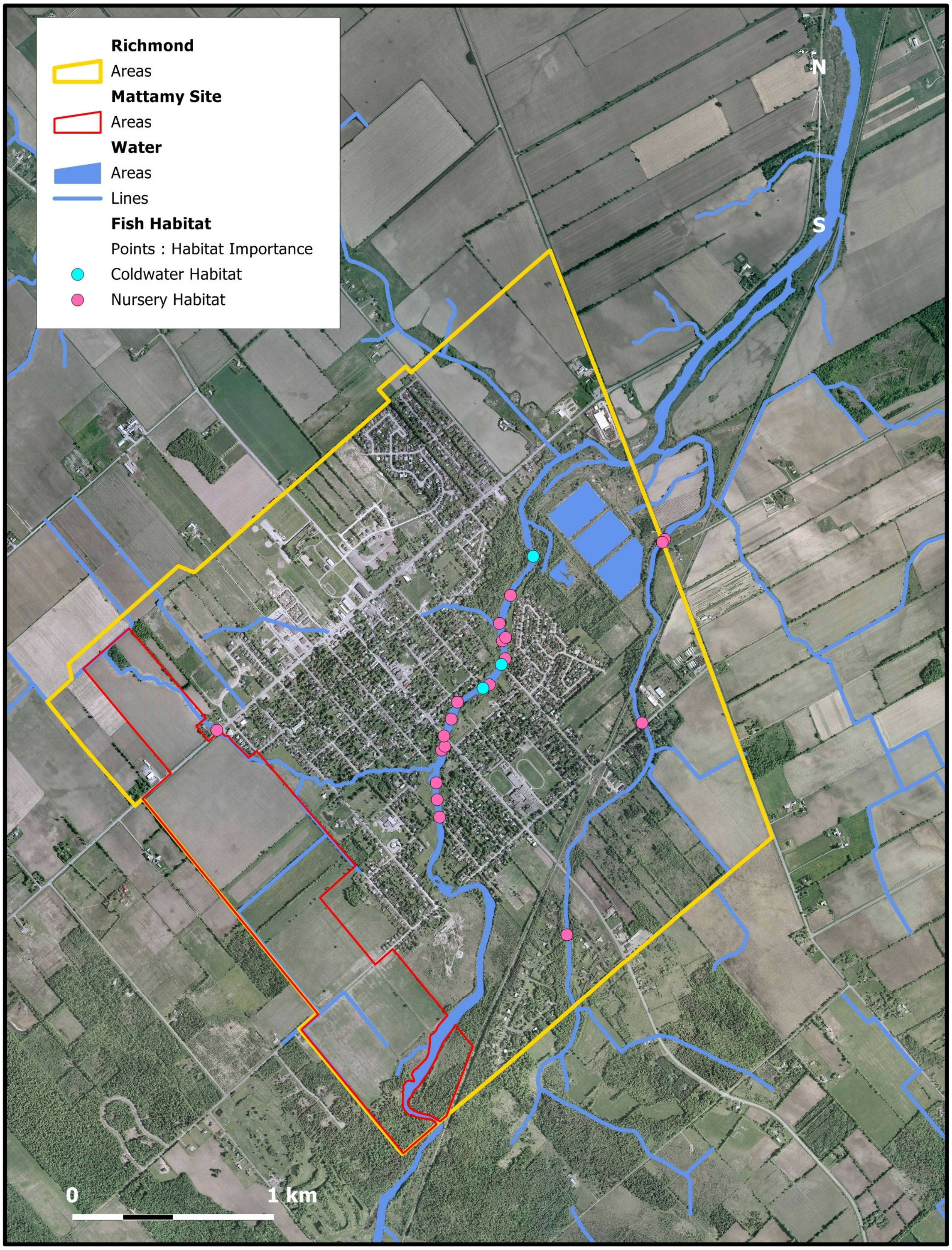


Figure 3. Map of the Study Area Showing Areas of Coldwater Fisheries Habitat and Nursery Habitat.

Figure Note: data from MMM and WESA (2007)

Table 1. List of species reported from Jock River and their ecological sensitivities.

Common Name	Scientific Name	Socio-economic Importance			Status	Trophic Guild[6]	Repro-ductive Guild[7]	Thermal Class	Pref. Temp.	Sensitivity to Sediment/Turbidity[8] (High, Moderate, Low)		
		Rec.	Comm.	Bait						Repro.	Feeding	Resp.
northern pike	*Esox lucius*	x				P	A.1.5	cool	22.5	M	H	L
muskellunge	*Esox masquinongy*	x				P	A.1.5	warm	25.6	M	H	L
central mudminnow	*Umbra limi*			x		I/O	A.1.5	cool/warm		M	M	L
white sucker	*Catostomus commersoni*					I/O	A.1.3	cool	22.4	M	L	H
silver redhorse	*Moxostoma anisurum*					I	A.1.3	cool		M	L	H
greater redhorse	*Moxostoma valenciennesi*					I	A.1.3	cool/warm		M	L	H
northern redbelly dace	*Phoxinus eos*			x		H	A.1.5	cool/warm	25.3	M	L	L
carp	*Cyprinus carpio*	x				O		warm		M	L	
brassy minnow	*Hybognathus hankinsoni*			x	NAR	O/H	A.1.4	cool		M	L	
golden shiner	*Notemigonus crysoleucas*			x		O	A.1.5	cool	23.8	M	M	L
emerald shiner	*Notropis atherinoides*			x		I	A.1.1	cool	22-25	M	L	H
common shiner	*Luxilus cornutus**			x		I	B.2.1	cool	21.9	M	M	
blacknose shiner	*Notropis heterolepis*			x		I	A.1.6	cool/warm		M	M	H
spottail shiner	*Notropis hudsonius*			x		I	A.1.6	cold/cool	14.3	M	M	H
bluntnose minnow	*Pimephales notatus*			x		O	B.2.3	warm	29	M	L	
fathead minnow	*Pimephales promelas*			x		O	B.2.3	warm	29	L	L	
blacknose dace	*Rhinichthys atratulus*			x		I/Ge	A.1.3	cool	24.6	M	M	H
longnose dace	*Rhinichthys cataractae*			x		I	A.1.3	cool	20.6	M	M	H
creek chub	*Semotilus atromaculatus*	x		x		I/Ge	A.2.1	cool	20.8	M	H	H
fallfish	*Semotilus corporalis*	x		x		I	A.2.1	cool		M	H	H
pearl dace	*Margariscus margarita**			x		I	A.1.3	cold/cool	16.2	M	M	H
yellow bullhead	*Ameirus natalis**	x				I	B.2.5	warm	28.3	M	L	
brown bullhead	*Ameirus nebulosus**	x	limited			I	B.2.3	warm	25-27	M	L	L
banded killifish	*Fundulus diaphanus*			x		I	A.1.5	cool	21	M	M	L
brook stickleback	*Culaea inconstans*			x		I	B.2.5	cool	21.3	L	M	
rock bass	*Ambloplites rupestris*					I/P	B.2.1	cool	20.5	L	H	
pumpkinseed	*Lepomis gibbosus*	x				I	B.2.4	warm	26	L	M	
bluegill	*Lepomis macrochirus*	x				I	B.2.1	warm	30.9	L	M	
smallmouth bass	*Micropterus dolomieu **	x	past			I/P	B.2.1	warm	30.3	M	H	
largemouth bass	*Micropterus salmoides*	x	past			I/P	B.2.2	warm	30.2	L	H	H
black crappie	*Pomoxi nigromaculatus*	x				I/P	B.2.2	cool	21.7	L	H	
walleye (yellow pickerel)	*Stizostedion vitreum vitreum*	x				P	A.1.3	cool	22	M	H	H
Johnny darter	*Etheostoma nigrum*			x		I	B.2.3	cool	22.8	M	M	
logperch	*Percina caprodes*			x		I	A.1.6	cool/warm		M	M	H
mottled sculpin	*Cottus bairdi*			x		I	B.2.3	cold	16.6	M	M	

Table Note: Ecological attributes are from MTO (2006) and Coker et al. (2001). See Appendix 1 for definition of reproductive guilds

2.2 Van Gaal Drain

2.2.1 Background Information

The Van Gaal Drain including the mainstem VG-R2, and the two major tributaries VG-R2-1 and VG-R2-2 are permanent watercourses. The mainstem Van Gaal Drain has reasonable water quality with basic pH (~8), high hardness (> 300 mg/L), but with somewhat elevated nutrient concentrations (total phosphorus ~ 0.05 mg/L). Summer water temperatures indicate generally cool conditions, with periods of warm-water (

).

The mainstem reach VG-R2 is slightly sinuous with several straightened areas (Figure 1). The dominant geomorphic process observed in the watercourse was degradation with significant evidence of planform adjustment and channel widening. A rapid geomorphic assessment suggested the reach has low stability, associated with agricultural drains and the poor evidence of scour and deposition features observed. Bankfull widths were between 4 and 10 m with associated depths of 0.6 to 1.5 m. Wetted widths in early June varied between 3.5 and 7 m with associated depths of between 0.2 and 1 m. Wetted widths in August varied up to 4 m, with maximum depths of ~ 0.4 m. The gradient through the reach was low to moderate with a low sinuosity. Sediment in the pools was characterized by sands. Riffles in the lower part of the reach (downstream of Perth Street) were dominated by a sand/pebble mix, while riffles in the upper section of the reach (upstream of Perth Street) had developed as a result of rip rap falling into the channel. . Bank material consisted of clay and silt with some clay exposed at the bank toe. Vegetation through the reach consisted primarily of grasses and herbs with trees in some areas. Minor woody debris was observed at several locations in the reach. A corrugated steel culvert is situated in this reach near fishing location VG-R2f. Spring flows through that culvert approached 1 m/s during the spring melt event (August 16, 2008), posing a potential barrier to upstream migrations by most cyprinids, and potentially pike.

Although this reach contained water for the duration of the study period (April through to October, 2008), this reach had been dry in places upstream of Perth Street in October of 2007 as determined by field investigation (Muncaster, 2008). The Robinson Consultants (2003) report provided the design for the rip rap re-enforcements found in VG-R2, as well as the background documentation for a spawning shelf situated just upstream (right upstream bank) of the Perth Street culvert.

Reach VG-R2-1 had been straightened for agricultural purposes prior to the historical aerial photographs. This sub-reach is aggrading and is considered to have low stability due in large part to the poor scour and deposition features. Bankfull widths were estimated to be between 4 and 4.5 m with associated depths of 0.6 to 1.0 m. Wetted widths at the time of the walks in early June were observed to vary from 2.0 to 4.0 m with associated depths of 0.15 to 0.4 m. The gradient through the reach was observed to be low with no sinuosity. Sediment in the channel was characterized by sands, silt and clay. Bank material consisted of clay and silt. Vegetation through the reach consisted primarily of grasses and herbs. Some in-stream vegetation was observed in the reach.

Reach VG-R2-2 had also been straightened prior to the historical aerial photographs. This reach was also aggrading, and was considered to have low stability because of poor scour and deposition features. Bankfull widths were estimated to be between 2 and 4 m with associated depths of 0.7 to 1.2 m. Wetted widths at the time of the walks in early June were observed to vary from 1.5 to 2.5 m with associated depths of 0.5 to 0.6 m. Wetted widths in August were between 1.5 and3 m, with wetted depths ranging between 0.3 and 1 m. The channel was shallowest at its most western end, and deeper (1 m) prior to its confluence with VG-R1. The gradient through the reach was observed to be low with no sinuosity. Sediment in the reach was characterized by silt and clay. Rip rap at the end of the channel created a minor riffle. Bank material consisted of clay and silt. Vegetation through the reach consisted primarily of grasses and herbs with some shrubs on the south side of the reach. The top of the channel was slightly wider with a more open canopy, while the bottom of the reach was narrower, and the overhanging grasses provided for nearly 100% cover. Minimal woody debris was observed at a few locations in the reach.

Fish species reported from the Van Gaal Drain to date are listed in Appendix 1. Surveys in 2008 documented a variety of coolwater species including central mudminnow, brook stickleback, brassy minnow, and common shiner, as well as species somewhat more sensitive such as Johnny darter. None of the fish species found in the Van Gaal Drain are rare, threatened, or otherwise endangered. A single 15-cm young-of-year northern pike was collected ~250 m downstream of Perth Street at Station VG-R2(2), upstream of the Moore Branch, reflecting successful spawning by adult pike within the Van Gaal drainage, potentially in the vicinity of that same station. Creek chub were about the most dominant species in the drain from the lowest station surveyed to the most upstream station surveyed within VG-R2. Central mudminnow was, however, the most abundant species in the two tributaries to VG-R2 (i.e., VG-R2-1 and VG-R2-2).

The more easterly branch of the Van Gaal Drain (i.e., VG-R2-2) was essentially standing water, with negligible flow in August. The lack of diversity of fish in that tributary suggested degraded conditions, particularly considering the two species present were brook stickleback and central mudminnow.

Mottled sculpin were found throughout the Van Gaal Drain (except the north-east tributary) from the Moore Branch upstream to and including the north-westerly tributary (VG-R2-2). The presence of mottled sculpin implied that the drain is a cool-water system. A relatively large number of fish species collected from the Van Gaal Drain/Arbuckle Drain were also cool-water species including northern pike, central mudminnow, white sucker, northern redbelly dace, Johnny darter and rock bass among others (Table 2). Water temperatures at the Perth Street culvert indicated that the Van Gaal Drain provides is a marginal cool-water stream, with temperatures classifying as both cool and warm.

The presence of the single young-of-year pike in the Van Gaal Drain is significant. Young-of-year pike were previously (1999) found in the drain near the Perth Street culvert according to records provided by the RVCA (Lamoureaux, 2009), which is the precise location where a spawning shelf was later (Robinson Consultants, 2003) constructed. The channel is slightly wider there, and is well vegetated with emergent macrophytes (see photos for sub-reach VG-R2f in Appendix 7 of Kilgour and Parish, 2010). That location provides potential, though limited in terms of area, habitat for pike spawning. A drain outlet provides storm flows to that location from the north-east side of Perth Street.

Pike spawning may also occur near or upstream of the point of capture of the single pike in this study (i.e., in the vicinity of the Moore Branch confluence). Riparian habitat in the vicinity of the confluence of the Moore Branch and the Van Gaal Drain appeared to be relatively suitable for spawning pike with the caveat that water levels were not high for a very long period of time. Pike spawn in flooded grasses and sedges when water temperatures are between 4 and 11°C (Scott and Crossman, 1973). Adhesive eggs require between 12 and 14 days to hatch. Water levels, therefore, need to remain high and flooding vegetation for a period of 2 to 3 weeks. Photographs of the lower reach of the Van Gaal Drain (VG-R2a) and of the Moore Branch (VG-R3) (Appendix 7 of Kilgour and Parish, 2010) show the appropriate water elevations in the Moore Branch on April 10, 2008, but less appropriate elevations on April 17 (i.e., one week later). However, grasses and sedges that line the channel of the lower Moore Branch were flooded on April 17, and may have provided suitable spawning habitat for pike.

The potential for pike to spawn in habitats downstream of the Fortune Street culvert are limited according to Muncaster (2008), who conducted studies on that part of the drain during 2008. There are potentially suitable spawning habitats downstream of the Fortune Street culvert, but like the Moore Branch confluence, water levels did not remain high enough long enough to be fully suitable (Muncaster, 2008).

The potential for pike to spawn upstream of the “spawning shelf” is also considered low. The upper Van Gaal Drain was walked on both April 10 and 17. There were no suitable spawning habitats identified during those investigations, while water levels, like at the Moore Branch confluence dropped significantly over that one-week period. The culvert situated 350 m upstream of Perth Street presents a potential velocity barrier during periods of high spring flows. Velocities at that point were estimated at slightly greater than 1 m/s on April 17, which is marginally passable by pike during spring runoff events. The most likely pike spawning habitat in the Van Gaal Drain, as per the information to date, is in the Moore Branch (Figure 5).

The Arbuckle Drain was inventoried during the spring spawning period in 2010 for possible adult pike or eggs (indicating active spawning). No pike or eggs were observed in the Arbuckle Drain including in the vicinity of the Moore Branch confluence. Grasses and macrophytes in the channel, further, were inundated by flood water for too short a period to provide viable pike spawning habitat in the spring of 2010.

2.2.2 Habitat Classification

For the purposes of this assessment, the Van Gaal Drain (all sub-reaches) is considered to be **Permanent Direct Fish Habitat**. The Van Gaal and Arbuckle Drains are considered to be **moderately sensitive** on the basis of the following:

- **Species Sensitivity**: The river contains a highly diverse assemblage of fish including species that are potentially sensitive to land development activities (Table 2).
- **Species Dependence**: The Jock River within the Village of Richmond can be considered to provide habitats for all of the various life stages of fish including spawning habitats, rearing, feeding and over-wintering.
- **Rarity:** None of the shoreline or mid-channel sections of the Jock River have been demonstrated to be unique or unusual habitats. Species within the Jock River can find and use other locales for life processes.
- **Habitat Resilience:** The Jock River is a permanent flowing, large water course. The system is generally warmwater, but does have local areas of coolwater habitat. Groundwater inputs are locally evident from the cooling of the watercourse that apparently occurs as water travels through the Village of Richmond.

There are no species at risk in the Van Gaal Drain or Arbuckle Drain.

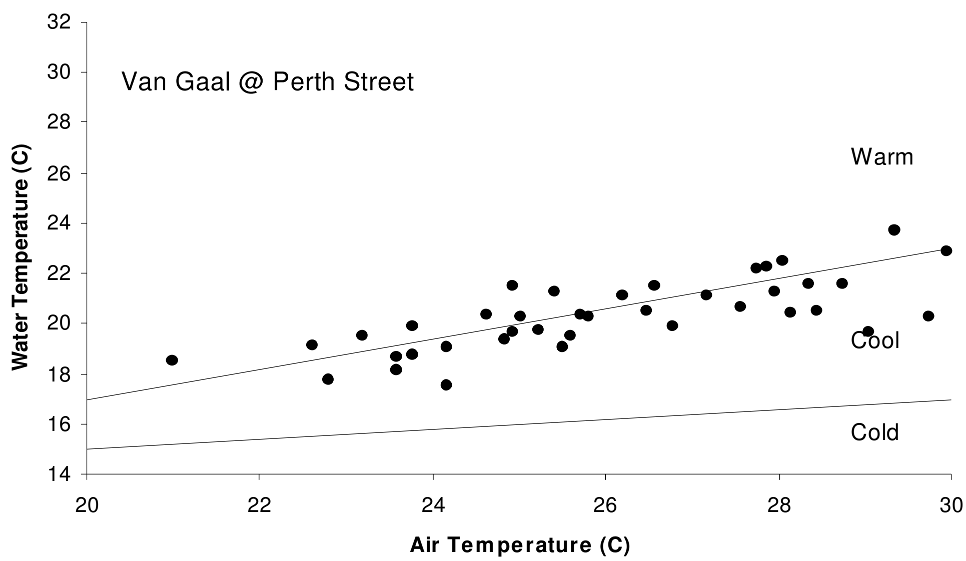


Figure 4. Relationship between air and water temperature in the Van Gaal Drain at Perth Street, summer 2008.

Figure 5. Air photo of the Arbuckle/Moore confluence showing area considered to be sensitive and potential pike spawning/rearing habitat.

Figure Note: Figure provided by Bernie Muncaster.

Table 2. List of species reported from the Van Gaal/Arbuckle Drain and their ecological sensitivities.

Common Name	Scientific Name	Socio-economic Importance			Trophic Guild[6]	Repr. Guild	Thermal Class	Preferred Temp.	Sensitivity to Sediment/Turbidity[8] (High, Moderate, Low)		
		Recr.	Comm.	Bait					Repr.	Feed	Resp.
northern pike	*Esox lucius*	x			P	A.1.5	cool	22.5	M	H	L
central mudminnow	*Umbra limi*			x	I/O	A.1.5	cool/warm		M	M	L
white sucker	*Catostomus commersoni*				I/O	A.1.3	cool	22.4	M	L	H
northern redbelly dace	*Phoxinus eos*			x	H	A.1.5	cool/warm	25.3	M	L	L
brassy minnow	*Hybognathus hankinsoni*			x	O/H	A.1.4	cool		M	L	
common shiner	*Luxilus cornutus**			x	I	B.2.1	cool	21.9	M	M	
spottail shiner	*Notropis hudsonius*			x	I	A.1.6	cold/cool	14.3	M	M	H
bluntnose minnow	*Pimephales notatus*			x	O	B.2.3	warm	29	M	L	
fathead minnow	*Pimephales promelas*			x	O	B.2.3	warm	29	L	L	
blacknose dace	*Rhinichthys atratulus*			x	I/Ge	A.1.3	cool	24.6	M	M	H
creek chub	*Semotilus atromaculatus*	x		x	I/Ge	A.2.1	cool	20.8	M	H	H
brook stickleback	*Culaea inconstans*			x	I	B.2.5	cool	21.3	L	M	
rock bass	*Ambloplites rupestris*				I/P	B.2.1	cool	20.5	L	H	
pumpkinseed	*Lepomis gibbosus*	x			I	B.2.4	warm	26	L	M	
Johnny darter	*Etheostoma nigrum*			x	I	B.2.3	cool	22.8	M	M	
mottled sculpin	*Cottus bairdi*			x	I	B.2.3	cold	16.6	M	M	

Table Note: Ecological attributes are from MTO (2006) and Coker et al. (2001). See Appendix 1 for definition of reproductive guilds

2.3 Moore Branch

2.3.1 Background Information

Flows in the Moore Branch are maintained by cool groundwater seeping from a tile drain at a hedgerow separating Sections 2 and 3 (Figure 1). Water quality is good with basic pH (~ 7.5), high hardness (> 300 mg/L), non-detectable total phosphorus concentrations and low solids (TSS ~ 4 mg/L). Bankfull widths of the Moore Branch were variable (4 to 7 m) with bankfull depths of between 0.6 and 1.0 m. Bank materials consist of clay and silt. Vegetation in the branch consisted of grasses and herbs with more shrubs and trees in the riparian zone further upstream in the reach. Bank-side vegetation provided nearly 100% canopy cover in summer. Minor woody debris was observed at several locations.

The Moore Branch was utilized by 15 fish species during the spring high-flow event in 2008 (Table 3). White sucker, northern redbelly dace and pearl dace were found upstream as far as Ottawa Street along VG-R3-2. The fish community in the lower part of the Moore Branch also included high relative numbers of creek chub and common shiner. Of the 15 species found in the spring, only four were found in the Moore Branch in early August: central mudminnow, creek chub, pearl dace, and brook stickleback. Pike have not been observed in any portions of the Moore Branch, while spawning inventories of 2009 indicated that grasses and macrophytes were not inundated long enough to provide viable spawning habitat for pike (Kilgour & Associates, and Parish Geomorphic, 2010). A single central mudminnow was found in the branch near VG-R3-2(2) (Figure 1) on August 9, 2008. Downstream of that point, the drain was dry, resulting in the mudminnow (and any other fish that were in the upstream reach) being stranded. On August 9, 2008, the drain contained water to depths of approximately 4 to 8 cm, and 1 to 1.5 m wide. There were, however, no other fish observed in the upstream reach on that day. The absence of fish would appear to reflect that the upper drain periodically goes dry or anoxic. The Moore Branch was flowing through to August 9, 2008, the last time the site was visited in 2008, with flows provided by a tile drain.

The upper sections of the drain provide spawning habitat for 15 species of fish, but it is likely that many of those fish become stranded and perish. A high point in VG-R3-2 (i.e., the split between Sections 6 and 7) causes that tributary to dry from the most downstream sections first, effectively stranding fish in the upper reach. Adult cyprinids clearly access this tributary during the spring to spawn. As waters recede, adult fish may move downstream prior to becoming stranded. Young (fry) would be less likely to move downstream because they tend to have greater site fidelity and move passively with currents. Fry stranded by the high point would perish as waters heat up or evaporate. Although the Moore Branch has water temperatures indicating cool-water (Figure 6), it did not produce mottled sculpin, probably because the water was generally too shallow.

2.3.2 Habitat Classification

Aquatic habitat upstream of the high point in VG-R3-2 (i.e., Sections 7 and 8) was classified as **Intermittent Indirect Fish Habitat** after discussions with RVCA (Lamoureaux, 2009). Section 5 is classified as Intermittent Indirect Fish Habitat as a result of a blockage. Sections 1, 2, 3, 4, 6 are classified as Direct Fish Habitat as a result of direct connections to the Arbuckle Drain.

Sections 2 through 8 of the Moore Branch are classified as supporting **low sensitivity** habitats on the basis of the following:

- **Species Sensitivity**: This drain system has a relatively low diversity of fish species that use the drain during the spring, and only one or two species that use the drain during low-flow periods. During low-flow periods, much of the drainage system stagnates and dries. Some of the species that use the drain are potentially sensitive to land development activities (Figure 1).

- **Species Dependence**: The Moore Branch provides principally spawning habitats for species that are able to spawn elsewhere in the Van Gaal/Arbuckle system.

- **Rarity:** None of the sections of the Moore Branch has been demonstrated to be unique or unusual habitats. Species that currently utilize the Moore Branch could find and use other locales for life processes.

- **Habitat Resilience:** The Moore Branch is an intermittent system in sections 4, 5, 7 and 8. The lower section (1, 2, 3) can be classified as coolwater providing groundwater from a tile drain.

There are no species at risk in the Moore Branch.

Section 1 is classified as **moderately sensitive** fish habitat on the basis of the following:

- **Species Sensitivity**: This drain system has a relatively low diversity of fish species that use the lower parts of the drain during the spring, and only one or two species that use the drain during low-flow periods. Some of the species that use the drain are potentially sensitive to land development activities.

- **Species Dependence**: Section 1 of the Moore Branch provides principally spawning habitats for species that are able to spawn elsewhere in the Van Gaal/Arbuckle system. Pike potentially use this lower section of Moore Branch to spawn, but there are other more expansive areas for pike to spawn in the Jock River.

- **Rarity:** This lower section of the Moore Branch is unique for the property, providing a confluence for a minor tributary (Moore Branch) and a moderately sized tributary (Arbuckle). The habitat provided at this confluence is not rare regionally considering the spawning habitats provided in the Jock River.

Habitat Resilience: This Section of the Moore Branch is permanently flowing because of groundwater flows from an upstream tile drain. This section is classified as coolwater on the basis of measured water temperatures.

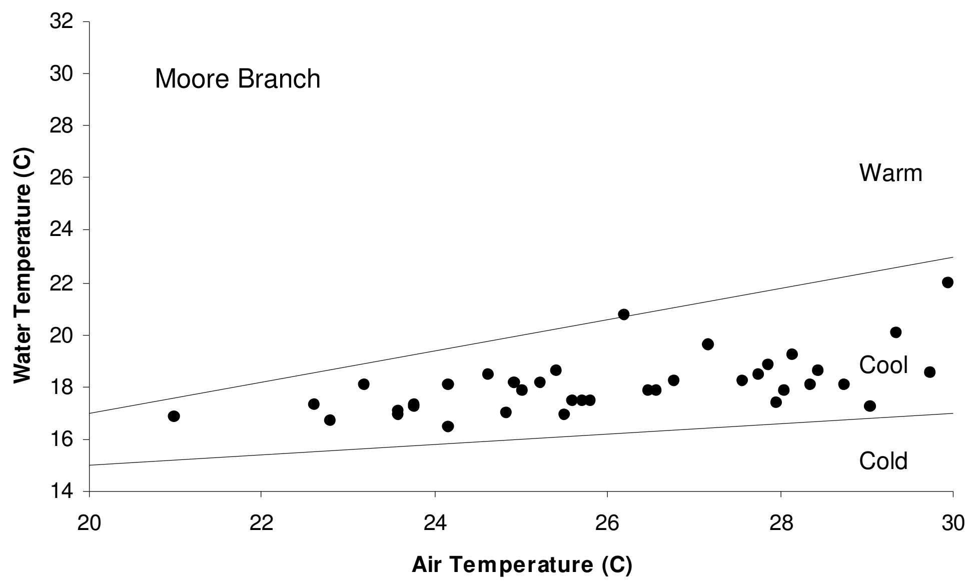


Figure 6. Relationship between air and water temperature in the lower Moore Branch, summer 2008.

Table 3. List of species reported from the Moore Branch and their ecological sensitivities.

Common Name	Scientific Name	Socio-economic Importance			Trophic Guild[6]	Repr. Guild[7]	Thermal Class	Preferred Temp.	Sensitivity to Sediment/Turbidity[8] (High, Moderate, Low)		
		Rec	Comm.	Bait					Repr	Feed	Resp
central mudminnow	*Umbra limi*			x	I/O	A.1.5	cool/warm		M	M	L
white sucker	*Catostomus commersoni*				I/O	A.1.3	cool	22.4	M	L	H
northern redbelly dace	*Phoxinus eos*			x	H	A.1.5	cool/warm	25.3	M	L	L
brassy minnow	*Hybognathus hankinsoni*			x	O/H	A.1.4	cool		M	L	
silvery minnow	*Hybognathus nuchalis*			x	H	A.1.4	cool/warm		M	L	
golden shiner	*Notemigonus crysoleucas*			x	O	A.1.5	cool	23.8	M	M	L
common shiner	*Luxilus cornutus**			x	I	B.2.1	cool	21.9	M	M	
blacknose shiner	*Notropis heterolepis*			x	I	A.1.6	cool/warm		M	M	H
bluntnose minnow	*Pimephales notatus*			x	O	B.2.3	warm	29	M	L	
fathead minnow	*Pimephales promelas*			x	O	B.2.3	warm	29	L	L	
blacknose dace	*Rhinichthys atratulus*			x	I/Ge	A.1.3	cool	24.6	M	M	H
longnose dace	*Rhinichthys cataractae*			x	I	A.1.3	cool	20.6	M	M	H
creek chub	*Semotilus atromaculatus*	x		x	I/Ge	A.2.1	cool	20.8	M	H	H
pearl dace	*Margariscus margarita**			x	I	A.1.3	cold/cool	16.2	M	M	H
brook stickleback	*Culaea inconstans*			x	I	B.2.5	cool	21.3	L	M	

Table Note: Ecological attributes are from MTO (2006) and Coker et al. (2001). See Appendix 1 for definition of reproductive guilds

2.3.3 Jock River Estates Drain

2.3.4 Background Information

The Jock River Estates Drain (Figure 1, JED-1) flows along Ottawa Street, then south-east through a field where it goes through the manmade berm at the Jock River. Water in the drain is basic (pH~8) with high hardness (> 400 mg/L), but has relatively high nutrient concentrations (0.04 mg/L total phosphorus) based on a single sample.

This reach was constructed for the purposes of stormwater management for the adjacent Jock River Estates. The reach is considered to be aggrading, and to have low stability due to poor in-stream habitat features. Bankfull widths were estimated to be between 2 and 3 m with associated depths of 0.4 to 0.7 m. Wetted widths in early June varied from 1 to 1.5 m with associated depths of 0.1 to 0.3 m. The reach had low gradient and was straight (no sinuosity). Sediment in the reach consisted of silt, clay and fine sands. Bank material consisted of clay and silt. Vegetation through the reach consisted primarily of tall grasses with fields on either side, with overhanging grasses (in summer) providing little canopy cover. In-stream vegetation was observed throughout the reach, dominated by cattails and blue-green algae. Channel disturbances consisted of a small, damaged wooden crossing near Ottawa Street, in addition to a rock check dam about half way between Ottawa street and the constructed berm.

During the spring of 2008, the drain contained five species of fish in relatively low abundances. Central mudminnow and fathead minnow were the most dominant fishes in the spring collection. There were no pike or other esocids. The same set of species, but minus the bluntnose minnow, was also collected in the early August inventory. The drain was dry upstream of a rock/rubble check dam that was situated approximately 150 m upstream of the constructed berm. Only the lower ~150 m was permanent aquatic habitat in 2008, and it may go completely dry during drier years. The check dam can also be considered to pose a potential downstream barrier to fish movement post spawning/hatching from upstream habitats: some fish will become stranded behind the check dam and perish upon the water evaporating. This drain would not provide good winter habitat because it is too shallow: fish would likely freeze because of the lack of apparent groundwater flow to the tributary. It is believed that fish gain access to the drain through the berm via the culvert at times of high flow, and assuming that the valve at the downstream end of the culvert stays open during those periods of high flow. There is no other apparent access point for fish to this tributary. As a result of these findings, this tributary is considered to provide artificial fish habitat that did not occur prior to its construction.

2.3.5 Habitat Classification

Despite being a constructed storm conveyance ditch, this feature is considered by RVCA to be **Intermittent Direct Fish Habitat (**Figure 1). This feature is considered to have **low sensitivity** to land development on the basis of the following:

- **Species Sensitivity**: This drain system has a relatively low diversity of fish species that use the drain during the spring. During low-flow periods, much of the drainage system stagnates and dries. Some of the species that use the drain are potentially sensitive to land development activities.

- **Species Dependence**: The Jock River Estates Drain provided principally spawning habitats for species that are able to spawn elsewhere in the Van Gaal/Arbuckle system.

- **Rarity:** The Jock River Estates Drain is a constructed and temporary feature that has been cut through the topsoil and limestone bedrock to route storm flows south in a fashion that did not occur under historical pre-development conditions.

Habitat Resilience: Jock River Estates Drain is an intermittent system. It classifies as warmwater on the basis of measured water temperatures, though it contains coolwater species.

Table 4. List of species reported from the Jock River Estates Drain and their ecological attributes.

Common Name	Scientific Name	Socio-economic Importance			Trophic Guild[6]	Repr. Guild	Thermal Class	Preferred Temp.	Sensitivity to Sediment/Turbidity[8] (High, Moderate, Low)		
		Recr	Comm.	Bait					Repr	Feed	Resp
central mudminnow	*Umbra limi*			x	I/O	A.1.5	cool/warm		M	M	L
bluntnose minnow	*Pimephales notatus*			x	O	B.2.3	warm	29	M	L	
fathead minnow	*Pimephales promelas*			x	O	B.2.3	warm	29	L	L	
creek chub	*Semotilus atromaculatus*	x		x	I/Ge	A.2.1	cool	20.8	M	H	H
brook stickleback	*Culaea inconstans*			x	I	B.2.5	cool	21.3	L	M	

Table Note: Ecological attributes are from MTO (2006) and Coker et al. (2001). See Appendix 1 for definition of reproductive guilds

2.4 Summary of Existing Fish Habitat

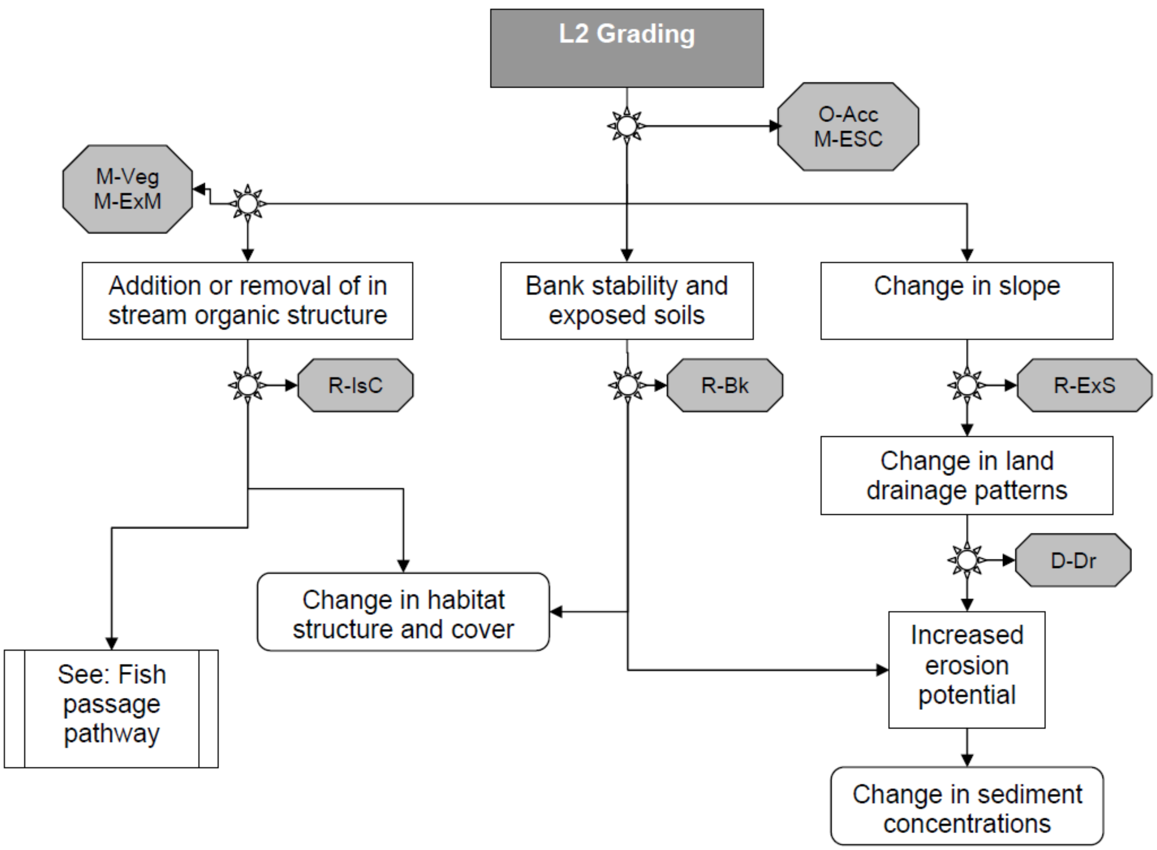
A summary of the existing conditions fisheries habitats is provided in Figure 1, showing the various watercourses and their classification as Direct and Indirect Fish Habitat. Sensitivities are summarized in the table below. The amount (area) of fish habitat potentially influenced in the vicinity of the Mattamy project is also summarized in the table for the Van Gaal/Arbuckle system, the Moore Branch, and for the Jock River Estates Drain. There is ~ 16,526 m^2 of permanent direct fish habitat within the vicinity of the Mattamy lands, as well as an additional ~3,052 m^2 of direct intermittent habitat, and 3,660 m^2 of indirect intermittent fish habitat (Table 5).

Table 5. Summary of amount and sensitivity of fish habitat within the study area.

Watercourse	Reach	Section	Class	Permanence	Length (m)	Bankfull Width (m)	Area (m^2)	Sensitivity
Jock River	at JED outlet		Direct	Permanent				High
	at Arbuckle confluence		Direct	Permanent				High
Arbuckle Drain	VG-R1		Direct	Permanent	639	7.0	4,263	High
Arbuckle/Van Gaal	VG-R2		Direct	Permanent	1406	7.0	9,849	High
Van Gaal Drain	VG-R2-1		Direct	Permanent	178	4.3	757	High
	VG-R2-2		Direct	Permanent	147	3.0	441	Medium
Moore Branch	VG-R3	1	Direct	Permanent	111	5.0	554	Medium
	VG-R3	2	Direct	Permanent	132	5.0	662	Medium
	VG-R3	3	Direct	Intermittent	108	5.0	542	Low
	VG-R3-1	4	Direct	Intermittent	146	3.7	539	Low
	VG-R3-1	5	Indirect	Intermittent	101	3.7	375	Low
	VG-R3-2	6	Direct	Intermittent	259	2.8	726	Low
	VG-R3-2	7	Indirect	Intermittent	333	2.8	934	Low
	VG-R3-2	8	Indirect	Intermittent	635	3.7	2,351	Low
Jock River Estates Drain	JED-1		Direct	Intermittent	415	3.0	1,245	Low
Summary	Direct, Permanent						16,526	
	Direct, Intermittent						3,052	
	Indirect, Intermittent						3,660	
	Total Direct						19,578	

3.0 STORMWATER MANAGEMENT

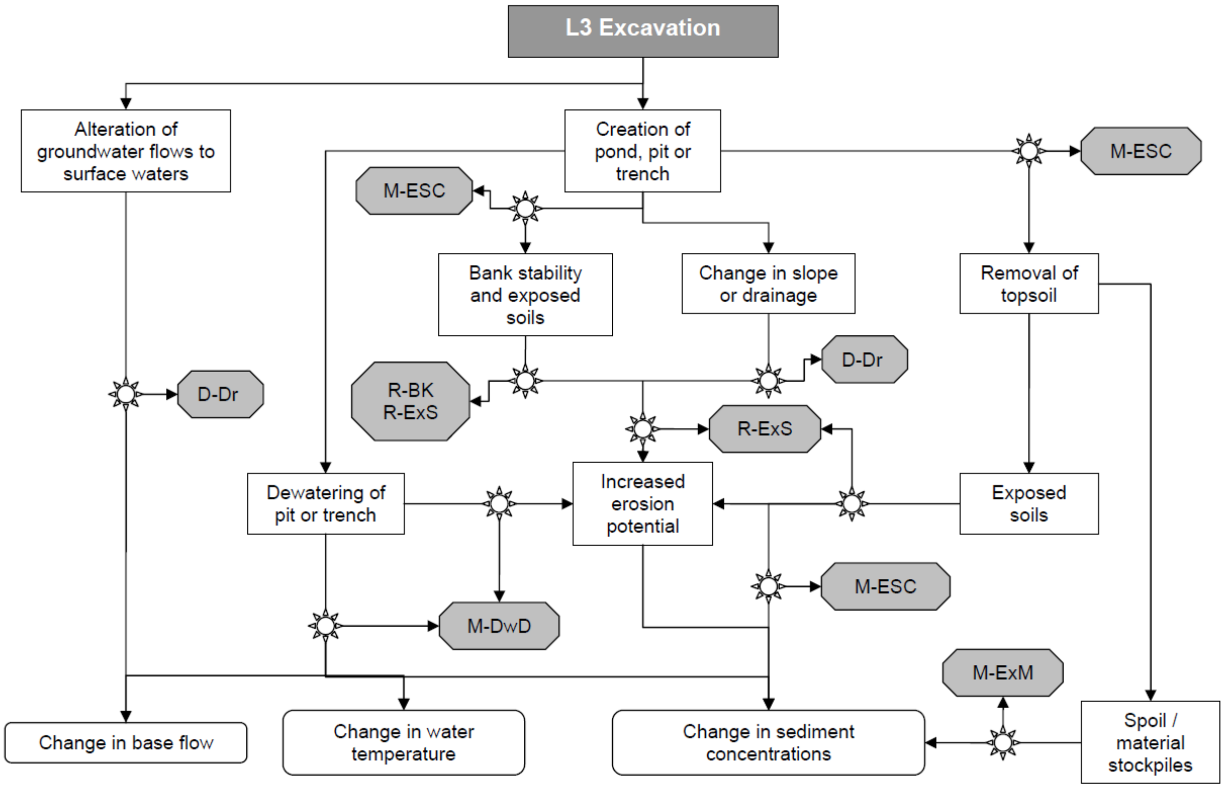
In the sections below we detail each of the three potential options for stormwater management. We explore the anticipated potential impacts to fish habitat following DFO's pathway of effects (PoE) analysis (MTO, 2006), and identify mitigation opportunities for each of those anticipated effects. There are three PoE diagrams that are address unique effects relevant to this assessment (Figure 7, Figure 8, and Figure 9). The PoE diagram for land-based grading (Figure 7) summarizes the potential effects associated with the re-grading the Mattamy land holding (re-grading is necessary for stormwater management). Potential effects associated with excavation of the SWM ponds are illustrated in Figure 8. Potential effects associated with the release of future stormwater to the local surface waters are illustrated in Figure 9. Other pathways (see MTO, 2006) have been considered, but for the purposes of this assessment do not provide unique stressors/effects that are not already considered in by the three pathways presented below.



O-Acc = Operational Constraint for Access; M-ESC = Management of Erosion and Sediment Controls; M-Veg = Management of Vegetation; M-ExM = Management of Excess Material; R-IsC = Rehabilitation of In-Stream Cover; R-Bk = Rehabilitation of Banks; R-ExS = Rehabilitation of Exposed Soils; D-Dr = Design of Drainage System

Figure 7. Pathway of effects diagram for land-based grading.

Figure Note: from MTO (2006)



M-ESC = Management of Erosion and Sediment Controls; M-ExM = Management of Excess Material; R-Bk = Rehabilitation of Banks; R-ExS = Rehabilitation of Exposed Soils; D-Dr = Design of Drainage System; M-DwD = Management of Dewatering Discharge

Figure 8. Pathway of effects diagram for land-based excavation.

Figure Note: from MTO (2006)

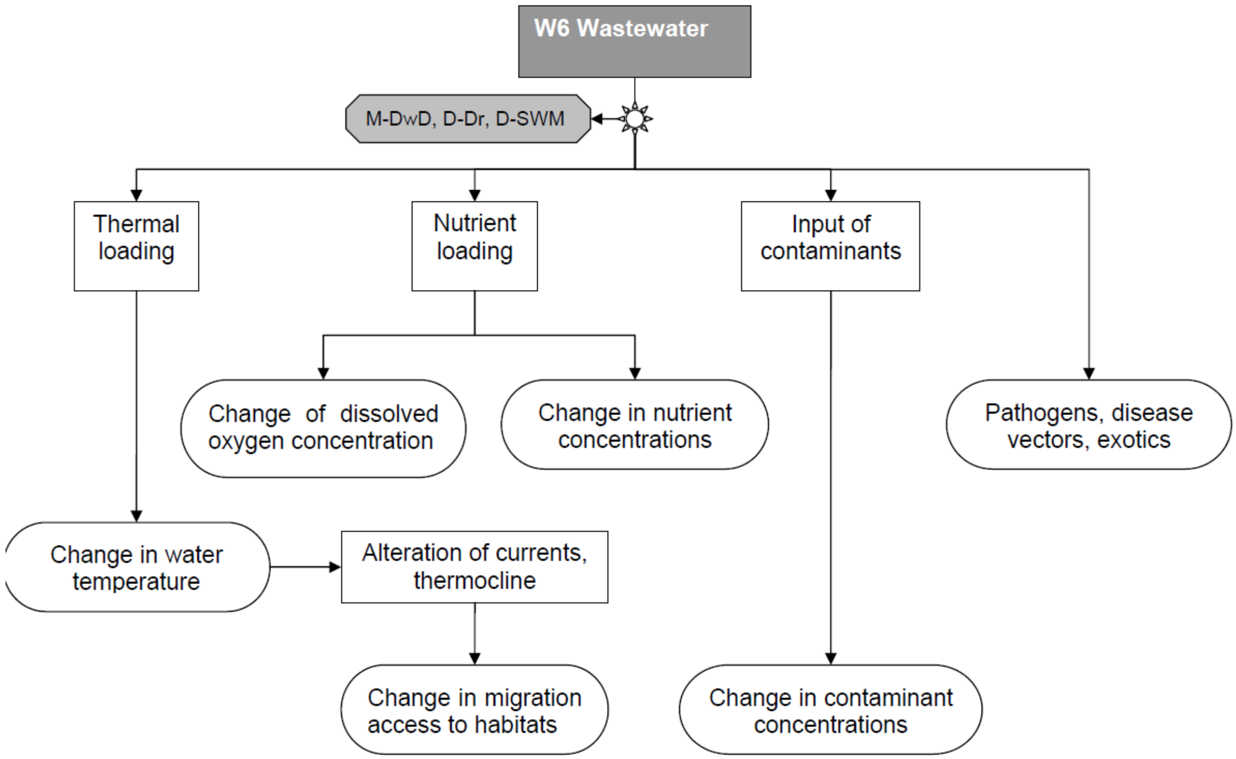


Figure 9. Pathway of effects diagram for wastewater (stormwater) management.

Figure Note: from MTO (2006)

3.1 Option 1

3.1.1 General Description

This option involves the construction of four storm ponds (Figure 10). Three facilities will be a "wet" pond with MOE enhanced TSS removal. Pond 3 will be a dry pond for quantity control and a hydrodynamic separator to provide quality control. External drainage tributary to the subject lands will be conveyed through proposed storm sewers and therefore the existing tributaries identified as VG-R3-2, VG-R3-1 and JED-1 will be enclosed.

Pond 1 will be designed to receive flow from the majority of the area between Perth Street and Ottawa Street, approximately 58 ha. This pond will be designed to attenuate post-development runoff rates to predevelopment levels, while flows up to and including the 2-year event will be attenuated to 330 L/s in accordance with the Geomorphic Study. Base flows will be maintained to the Moore Branch via cooling trenches.

Pond 2 will be designed to receive runoff from approximately 8 ha north of Ottawa and the developable land south of Ottawa Street. Pond 2 has one outlet directing post-development runoff rates to the Jock River via a proposed storm sewer along Ottawa Street. The 100-year release rate from Pond 2 will be restricted to the free flowing capacity of the outlet sewer, approximately 2000L/s.

Pond 3 will be designed to collect and retain runoff from approximately 3 ha north of Perth Street east of the Van Gaal Drain. This pond will be designed to attenuate post-development runoff rates to predevelopment levels, while flows up to and including the 2-year event will be attenuated to 330L/s in accordance with the Geomorphic Study.

Pond 4 will be designed to collect and retain runoff from approximately 28 ha north of Perth Street east of the Van Gaal Drain. This pond will be designed to attenuate post-development runoff rates to predevelopment levels, while flows up to and including the 2-year event will be attenuated to 330L/s in accordance with the Geomorphic Study.

This option requires grading of the landscape (Pathway L2; Figure 7), excavation of ponds (Pathway L3; Figure 8) and release of treated stormwater (Pathway W6; Figure 9).

3.1.2 Pathway of Effects and Mitigation

A summary of the effects pathways and proposed mitigations are presented in Table 6. Pathways and mitigation are further discussed for this Option 1 below

3.1.2.1 Grading

Grading of the Mattamy lands will result in the exposure of soils, with the potential for surface flows to convey suspended particulate materials to the Van Gaal Drain, Arbuckle Drain and Moore Branch. Conventional erosion and sediment controls will be put in place to protect soil stockpiles, and to protect the three watercourses.

The most significant change in surface drainage pattern is the re-routing of water from the Jock River Estates Drain. This drain has for the past few years conveyed stormwater runoff from Jock River Estates development through the drainage easement to the Jock River. In Option 1, that drain will be enclosed outside the floodplain limit and stormwater will be redirected to SWM Pond 1 and subsequently piped to the Jock River via Queen Charlotte Street (~1.2km downstream of the present-day discharge of the Jock River Estates Drain, and 0.7km upstream of the Arbuckle Drain confluence with the Jock River). The Jock River, in the vicinity of the earth dam, is a high quality habitat consisting of pickerel weed and other emergent macrophytes. Water levels in the macrophyte bed are maintained by the Jock River and not by flows from the Jock River Estates Drain. Further, the drainage pattern prior to the construction of the Jock River Estates Drain had surface waters from the property south of Ottawa Street being conveyed north to the Moore Branch. There should, therefore, be no net negative impact resulting from the re-routing of the Jock River Estates Drain on the productivity of fish and fish habitat of the Jock River.

Sections 6, 7 and 8 of the Moore Branch are to be filled in with surface waters being conveyed to Pond 1. There is no mitigation planned for these options at the present time though compensation could be undertaken if required. The residual effect is considered minor considering that this watercourse is ephemeral, and does not provide unique habitat that is not available elsewhere locally or regionally. The ecological functions of Sections 4 and 5 of the Moore Branch (i.e., spring spawning habitat for forage fish) will likewise be lost.

Storm flows will be piped from Ponds 1 and 2 to the Jock River in the vicinity of the Ottawa Street road allowance. Existing flow volumes in the Jock River will buffer and dilute the additional storm-related volumes. Energy dissipation devices will be incorporated into the design of the stormwater outlet at the Jock River. Fish habitat assessment will be undertaken in the vicinity of the proposed storm outlet to ensure that the structure is situated such that is has minimal (to no) impact on existing high-quality and highly sensitive fish habitats.

With the conveyance of storm flows to the Jock River, the Arbuckle and Moore Branch will receive less flow during storm events. These tributaries will, however, continue to receive the equivalent 2 year event. Because it is the 2-year event that is the channel forming flow, the in-stream fish habitat of the Arbuckle and Moore Branch can be expected to be maintained.

3.1.2.2 Excavation

The potential effects of construction of the SWM Ponds will be mitigated using conventional techniques. Water pumped from the dug ponds will be treated (when necessary) as per requirements of the Ontario Ministry of the Environment. Soils exposed by grading or excavation will be covered or contained with geotextiles or silt curtains to minimize the entry of soils/sediment to surface waters Discharge waters released from work areas (ponds) will be released slowly or through or on energy dissipaters to mitigate potential erosion at points of entry to surface waters.

Post construction, soils in the vicinity of SWM Ponds or watercourses will be stabilized with plantings of grasses, sedges, shrubs and trees. Trees that can provide shade to watercourses and SWM ponds will be planted to assist in stabilizing the site, and to maximize shade for ponds and channels.

In the event that baseflows to the Moore Branch are interrupted because the construction of Pond 1, flows to that channel will be augmented artificially to maintain its permanent condition.

3.1.2.3 Stormwater

Maintenance of groundwater flows to the Van Gaal, Arbuckle and Moore watercourses is important as each of these features supports cool and cold-water fish species. Maintenance of groundwater flows will ensure that water in these watercourses remains cold/cool. The overall

SWM design will incorporate infiltration and/or cooling channels to ensure that water provided to these features is cool/cold as appropriate.

The four storm ponds are designed to settle particulates and associated nutrients (phosphorus, nitrogen), generally eliminating potential effects associated with contaminated stormwater (Figure 9; AECOM, 2009). The ponds are also not considered to be sources of diseases for fish or disease vectors for fish. The ponds are anticipated to be warmer during summer periods than water of the Van Gaal/Arbuckle, Moore and Jock Rivers. Warming of the ponds will be mitigated to the extent possible by planting shade trees including a mixture of deciduous and coniferous species. The outlet channel from Pond 1 will also be fully shaded to minimize heating and encourage cooling.

3.1.3 Risks to Fish Habitat

Table 7 provides a summary of the anticipated residual effects to fish habitat assuming the various mitigation measures are undertaken, while Figure 10 illustrates the resulting fish habitats. There will be no residual impacts to fish habitats in the Jock River, Arbuckle Drain, Van Gaal Drain or lower Moore Branch (Sections 1, 2, 3). The Jock River Estates Drain will be filled, but the effect is considered minor because the feature is man made, temporary, and has a fish-exclusion device. The loss of Sections 7 and 8 of the Moore Branch are also considered to be minor because those sections are “sinks” for fish reproduction: adult fish enter these reaches to spawn, and potentially leave during high-flow periods, while their larvae/fry likely remain and perish as water levels recede. The loss of Section 6 of the Moore Branch is a moderate residual effect. The piping of Sections 4 is considered a medium effect on the basis that the ecological function, i.e., spawning habitat for forage fish species, will be lost. The lost habitat, however, is relatively modest in size, while the species that use the area would have no difficulty finding alternative locations to spawn. The piping of Section 5 which under existing conditions is indirect fish habitat, is considered minor.

Option 1 will result in the potential increase in Direct Permanent fish habitat (542 m^2;Table 8) which occurs as a result of permanent flows being provided to Section 3 of the Moore Branch. There is an anticipated loss of some 3,052 m^2 of intermittent direct fish habitat reflecting the loss of the Jock River Estates Drain and Sections 4 and 6 of the Moore Branch. There is an anticipated loss of 3,660 m^2 of indirect fish habitat resulting from the loss of Sections 5, 7 and 8 of the Moore Branch. The total loss of direct fish habitat is some 2,510 m^2.

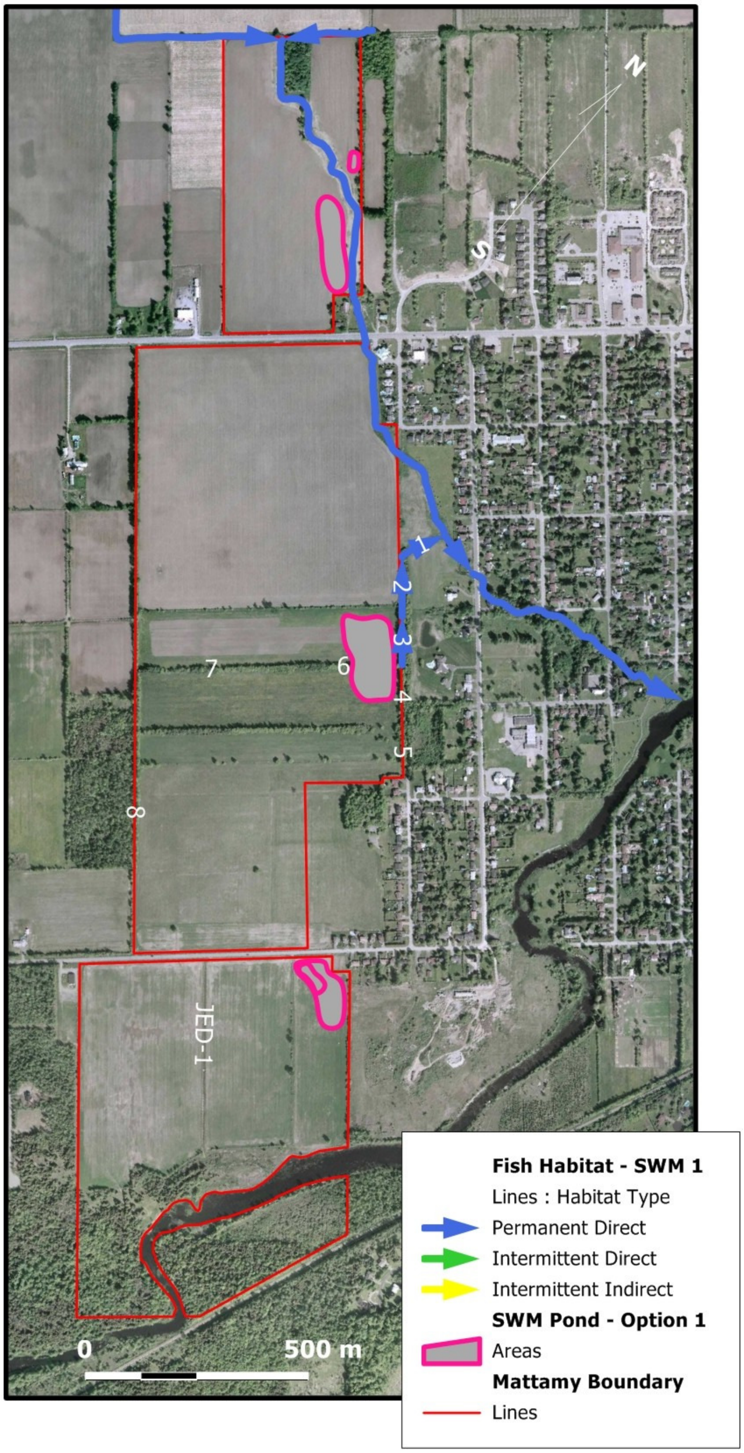


Figure 10. SWM Option 1 and resulting fish habitats.

Table 6. Summary of effects pathways and mitigation for Option 1.

Pathway	Stressor	Effect	Mitigation	Watercourses Potentially Affected	Residual Effect
L2 Grading	Exposed Soils	Various parcels of land within the Mattamy holding may require re-grading to facilitate SWM. Exposed soils, and stockpiled soils have the potential to contribute sediments to surface waters	Appropriate containment of stockpiles including the use of silt curtains. Watercourses will be protected with sediment and erosion control measures including silt curtains and setbacks.	Van Gaal, Arbuckle, Moore (Sections 1, 2 and 3)	None.
	Change in Drainage Pattern	Flows to the Jock River Estates Drain will be rerouted to SWM Pond 2. Flows in Sections 6, 7 and 8 of the Moore Branch will be captured by SWM Pond 1.	None. Jock River estates drain is abandoned and filled in this Option, as are Sections 6, 7 and 8 of the Moore Branch. Sections 4 and 5 are piped.	Jock River Estates Drain, Sections 4, 5, 6, 7 and 8 of Moore Branch	The residual effect is considered moderate. Jock River Estates Drain is a man-made watercourse. Though it is considered to provide Direct Fish Habitat, the only access to that habitat is from the Jock River and up into the channel through a one-way valve. Most of the drain goes dry in summer and is thus ephemeral. Likewise for Sections 7 and 8 of the Moore Branch which are considered Indirect Fish Habitat. The upper Sections go dry in mid summer, likely stranding and killing newly hatched fry. Section 6 is lost in this option, so this is a loss of direct intermittent fish habitat. Sections 4 and 5 are to be piped, thus their ecological function as spawning habitat for forage fish species will be lost..
		High flows are re-routed to Jock River. Loss of extreme flow events in tributaries.	Maintain baseflow and 2-y event flows to tributaries	Moore Branch (Sections 1, 2, 3), Arbuckle Drain	None. Maintenance of the channel-forming 2-year flows will ensure channel structure is maintained in each of the Arbuckle and Moore Branch.
		High flows are re-routed to Jock River. Potential for additional flows in Jock River to cause erosion	Energy dissipaters integrated in design of SWM outfalls.	Jock River	None
L3- Excavation	Exposed Soils	Excavation of ponds will result in the exposure of top soil, and the creation of soil stockpiles	Appropriate containment of stockpiles including the use of silt curtains. Watercourses will be protected with sediment and erosion control measures including silt curtains and setbacks.	Van Gaal, Arbuckle, Moore (Sections 1, 2 and 3)	None.
	Dewatering	Ponds will need to be dewatered during construction at various times, with discharge water released to surface waters.	Discharge water to be of high quality and if necessary treated by filtering through filter bags, etc.	Van Gaal, Arbuckle, Moore, Jock	None
	Change in Baseflow	Construction of the ponds may result in local interception of baseflows.	Flow augmentation to Moore Branch Sections 1, 2, 3 if necessary	Moore Branch Sections 1, 2 and 3.	None.
W8: - Stormwater Management	Thermal loading	Higher temperatures of stormwater has potential to increase temperatures of watercourses during mid summer.	Vegetative plantings adjacent to SWM ponds, and outlet channels. Cooling channels. Infiltration basins.	Jock River, Van Gaal Drain, Moore Branch (Sections 1, 2, 3)	The residual effect is considered minor. Temperature of the Moore Branch is anticipated to be unaffected because cooling channels will be used to convey water from Pond 1 to the tributary.
	Nutrient Loading	Eutrophication	SWM ponds remove phosphorus and other nutrients.		None
	Input of contaminants	Toxicity	SWM ponds settle metals and other contaminants		None
	Pathogens, disease vectors, exotics	Diseases	SWM ponds are not receiving domestic waste.		None
	Discharge of stormwater to watercourse	Potential for erosion at point of discharge.	Energy dissipaters integrated in design of SWM outfalls.	Van Gaal Drain, Moore Branch (S1, S2, S3)	None
	Loss of baseflow	Potential for intermittent habitats to be dry longer	Infiltration to provide water during spring	Moore Branch (S4, S5)	None.

Table 7. Risk classification for each of the watercourses potentially affected by the proposed Mattamy development, SWM Option 1.

Watercourse	Reach	Section	Class	Flow	Length (m)	BFW (m)	Area (m^2)	Sens	SAR	Mitigation Prevents Potential Impacts (yes/no)				Potential Impacts			Category of Risk	Comments
										Footprint	Flow Volumes	Water Temp	Water Quality	Extent	Duration	Intensity		
Jock River	at JED outlet		Direct	P				M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Normal water levels in Jock River will maintain seasonal fish habitats
	at Arbuckle confluence		Direct	P				M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Water temperature increases at Jock River are predicted to be neglible considering volume SWM flows and temperature mitigations.
Arbuckle Drain	VG-R1		Direct	P	609	7	4,263	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	All impacts to lower Arbuckle to be mitigated through appropriate SWM design and conveyance of flows..
Arbuckle/Van Gaal	VG-R2		Direct	P	1407	7.0	9,849	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Van Gaal will be protected from construction activities using conventional mitigations. Cool water temperatures provided by cooling trenches.
Van Gaal Drain	VG-R2-1		Direct	P	178	4.3	757	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R2-2		Direct	P	147	3.0	441	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
Moore Branch	VG-R3	1	Direct	P	111	5.0	554	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Flows to lower Moore Branch will be maintained, and will have same quality and temperature as pre-development.
	VG-R3	2	Direct	P	132	5.0	662	L	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R3	3	Direct	P	108	5.0	542	L	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R3-1	4	Direct	I	146	3.7		L	No	No	No	No	No	Low	High	High	Medium	Ecological function of Sections 4 and 5 lost.
	VG-R3-1	5	Indirect	I	101	3.7		L	No	Yes	No	No	No	Low	High	High	Low	
	VG-R3-2	6	Direct	I				L	No	No	NA	NA	NA	Medium	High	High	Medium	Channels are filled in.
	VG-R3-2	7	Indirect	I				L	No	No	NA	NA	NA	Low	High	High	Low	
	VG-R3-2	8	Indirect	I				L	No	No	NA	NA	NA	Low	High	High	Low	
Jock River Estates Drain	JED-1		Direct	I				L	No	No	NA	NA	NA	Low	High	High	Low	Channel is filled in.
Direct Permanent							17,068											
Direct Intermittent																		
Indirect Intermittent																		
Total Direct							17,068											

Table 8. Summary of fish habitat losses and gains for Option 1.

Habitat Class	Area (m^2)		
	Current Condition	**Option 1**	**Change**
Direct, Permanent	16,526	17,068	+542
Direct, Intermittent	3,052		-3,052
Indirect, Intermittent	3,660		-3,660
Total Direct	19,578	17,068	-2,510

Table Note: detailed numbers presented in Table 7 above.

3.2 Option 2

3.2.1 General Description

This option involves the construction of three storm ponds (Figure 11). Two ponds are "Wet Ponds" with MOE 'Enhanced' TSS removal. Pond 3 is a dry pond for quantity control and a hydrodynamic separator to provide quality control. External drainage tributary to the subject lands will be conveyed through proposed storm sewers and therefore the existing tributaries identified as VG-R3-2 and JED-1 will be enclosed.

Pond 1 will be designed to receive runoff from 45 ha between Ottawa and Perth Streets in addition to 28 ha north of Perth Street on the west side of the Van Gaal Drain. Pond 1 will have two outlets. The first outlet channel will be designed to convey low flows up to and including the 2-year event attenuated to 330 L/s in accordance with the Geomorphic Study. The channel will provide both surface and subsurface conveyance. This channel is anticipated to be ~ 312 m in length, and likely with a bankfull width of ~ 3 m. The channel will be bordered by strategic riparian plantings to provide shade, while the subsurface component will enhance cooling opportunities. This channel will provide direct intermittent fish habitat. Flows provided by this channel, will provide a short segment (76 m) of direct permanent fish habitat. The second pond outlet channel will be designed to convey the treated stormwater runoff from the less frequent storm events generated during the 5 to 100 year return periods. This channel will be ~ 210 m long and ~ 3 m wide. This channel will provide direct intermittent fish habitat, particularly during the spring.

Pond 2 will be designed to receive runoff from 21 ha north of Ottawa and the developable land south of Ottawa Street. Pond 2 has one outlet directing post-development runoff rates to the Jock River via a proposed storm sewer along Ottawa Street. The 100-year release rate from pond 2 will be restricted to the free flowing capacity of the outlet sewer, approximately 2000 L/s.

Pond 3 will be designed to collect and retain runoff from approximately 3 ha north of Perth Street east of the Van Gaal Drain. This pond will be designed to attenuate post-development runoff rates to predevelopment levels, while flows up to and including the 2-year event will be attenuated to 330 L/s in accordance with the Geomorphic Study.

This option requires grading of the landscape (Pathway L2; Figure 7), excavation of ponds (Pathway L3; Figure 8) and release of treated stormwater (Pathway W6; Figure 9).

3.2.2 Pathway of Effects and Mitigation

A summary of the effects pathways and proposed mitigations are presented in Table 9. Pathways and mitigation are further discussed for this Option 2 below.

3.2.2.1 Grading

Grading of the Mattamy lands will result in the exposure of soils, with the potential for surface flows to convey suspended particulate materials to the Van Gaal Drain, Arbuckle Drain and Moore Branch. Conventional erosion and sediment controls will be put in place to protect soil stockpiles, and to protect the three watercourses.

The most significant change in surface drainage pattern is the re-routing of water from the Jock River Estates Drain. That drain has for the past few years provided water to the Jock River in the vicinity of the earth berm. In Option 2, that drain will be enclosed and the stormwater runoff from the estate development will be conveyed by storm sewer to SWM Pond 1 which outlets to the Van Gaal/Arbuckle drains. The Jock River, in the vicinity of the earthen dam is a high quality habitat consisting of pickerel weed and other emergent macrophytes. Water levels in the macrophyte bed are maintained by the Jock River and not by flows from the Jock River Estates Drain. Further, the drainage pattern prior to the construction of the Jock River Estates Drain had surface waters from the property south of Ottawa Street being conveyed north to the Moore Branch. There should, therefore, be no net negative impact resulting from the re-routing of the Jock River Estates Drain on the productivity of fish and fish habitat of the Jock River.

Sections 7 and 8 of the Moore Branch are to be filled in with surface waters being conveyed to Pond 1. There is no mitigation planned for these options at the present time though compensation could be undertaken if required. The residual effect is considered minor considering that this watercourse is ephemeral, and does not provide unique habitat that is not available elsewhere locally or regionally.

Storm flows from Pond 1 will be conveyed to the Van Gaal/Arbuckle Drain. Storm flows from Pond 2 will be conveyed to the Jock River in the vicinity of the Ottawa Street Road allowance. Existing flow volumes in the Jock River will buffer and dilute the additional storm-related volumes. Energy dissipation devices will be incorporated into the design of the stormwater outlet at the Jock River. Fish habitat assessment will be undertaken in the vicinity of the proposed storm outlet to ensure that the structure is situated such that is has minimal (to no) impact on existing high-quality and highly sensitive fish habitats.

With the conveyance of storm flows to the Jock River, the Arbuckle and Moore Branch will receive less flow during storm (> 2-year) events. These tributaries will, however, continue to receive the equivalent 2-year event. Because it is the 2-year event that is the channel forming flow, the in-stream fish habitat of the Arbuckle and Moore Branch can be expected to be maintained.

3.2.2.2 Excavation

The potential effects of construction of the SWM Ponds will be mitigated using conventional techniques. Water pumped from the dug ponds will be treated (when necessary) as per requirements of the Ontario Ministry of the Environment. Soils exposed by grading or excavation will be covered or contained with geotextiles or silt curtains to minimize the entry of soils/sediment to surface waters Discharge waters released from work areas (ponds) will be released slowly or through or on energy dissipaters to mitigate potential erosion at points of entry to surface waters.

Post construction, soils in the vicinity of SWM Ponds or watercourses will be stabilized with plantings of grasses, sedges, shrubs and trees. Trees that can provide shade to watercourses and SWM ponds will be planted to assist in stabilizing the site, and to maximize shade for ponds and channels.

In the event that baseflows to the Moore Branch are interrupted because the construction of Pond 1, flows to that channel will be augmented artificially to maintain its permanent condition.

3.2.2.3 Stormwater

Maintenance of groundwater flows to the Van Gaal, Arbuckle and Moore watercourses is important as each of these features supports cool and cold-water fish species. Maintenance of groundwater flows will ensure that water in these watercourses remains cold/cool. The overall SWM design will incorporate infiltration and/or cooling channels to ensure that water provided to these features is cold/cool as appropriate.

The three storm ponds are designed to settle particulates and associated nutrients (phosphorus, nitrogen), generally eliminating potential effects associated with contaminated stormwater (Figure 9; AECOM, 2009). The ponds are also not considered to be sources of diseases for fish or disease vectors for fish. The ponds are anticipated to be warmer during summer periods than water of the Van Gaal/Arbuckle, Moore and Jock Rivers. Warming of the ponds will be mitigated to the extent possible by planting shade trees including a mixture of deciduous and coniferous species. Outlet channels from Pond 1 will be fully shaded to minimize heating and encourage cooling. Pond 1 will provide base flows to the Moore Branch via a cooling channel.

Outlet channels from Pond 1 will incorporate natural channel design features to maximize their fisheries productive potential.

3.2.3 Risks to Fish Habitat

Table 10 provides a summary of the anticipated residual impacts to fish habitat under Option 2 assuming the various mitigation measures are undertaken. There will be no residual impacts to the Jock River, Arbuckle Drain, Van Gaal Drain or lower Moore Branch (Sections 1, 2, 3). The Jock River Estates Drain will be filled, but the effect is considered minor because the feature is man made, temporary, and has a fish-exclusion device. The loss of Sections 7 and 8 of the Moore Branch are also considered to be minor because those sections are "sinks" for fish reproduction: adult fish enter these reaches to spawn, and potentially leave during high-flow periods, while their larvae/fry likely remain and perish as water levels recede. The loss of Section 6 is a moderate residual effect. Flow reductions to Sections 4 and 5 of the Moore Branch are considered to be a minor as well, since those are existing ephemeral/intermittent habitats.

Option 2 will result in the potential increase in Direct Permanent fish habitat (228 m^2; Table 11) which occurs as a result of flows being provided to Section 3 of the Moore Branch. None of the direct, intermittent habitats are lost as a result of Option 2, though there may be a reduction in total flow volumes drained by Sections 4, 5 and 6 in the Moore Branch. There will be a small gain in direct permanent fish habitat of some 228 m^2 as a result of construction of an outlet channel associated with Pond 1. There is an anticipated loss of some intermittent direct fish habitat reflecting the loss of the Jock River Estates Drain and Section 6 of the Moore Branch (405 m^2). There is an anticipated loss of 3,285 m^2 of indirect fish habitat resulting from the loss of Sections 7 and 8 of the Moore Branch. There is a potential net loss of direct fish habitat of some 177 m^2 under this option.

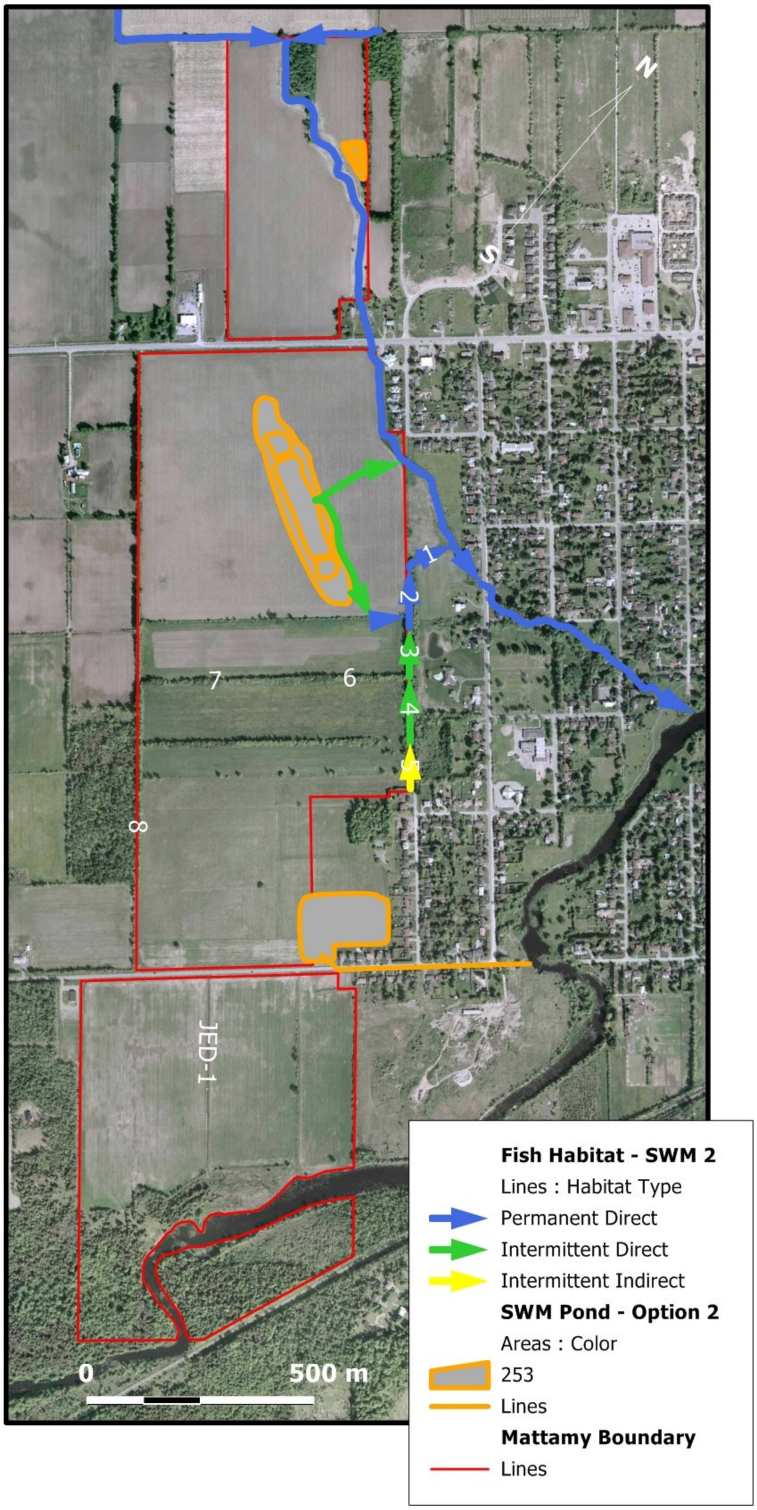


Figure 11. SWM Option 2 and resulting fish habitats.

Table 9. Summary of effects pathways and mitigation for Option 2.

Pathway	Stressor	Effect	Mitigation	Watercourses Potentially Affected	Residual Effect
L2 Grading	Exposed Soils	Various parcels of land within the Mattamy holding may require re-grading to facilitate SWM. Exposed soils, and stockpiled soils have the potential to contribute sediments to surface waters	Appropriate containment of stockpiles including the use of silt curtains. Watercourses will be protected with sediment and erosion control measures including silt curtains and setbacks.	Van Gaal, Arbuckle, Moore (Sections 1, 2 3, 4, 5)	None.
	Change in Drainage Pattern	Flows to the Jock River Estates Drain will be rerouted to SWM Pond 2. Flows in Sections 6, 7 and 8 of the Moore Branch will be captured by SWM Pond 1.	None. Jock River estates drain is abandoned and filled in this Option, as are Sections 6, 7 and 8 of the Moore Branch	Jock River Estates Drain, Sections 4, 5, 6, 7 and 8 of Moore Branch	The residual effect is considered moderate Jock River Estates Drain is a man-made watercourse. Though it is considered to provide Direct Fish Habitat, the only access to that habitat is from the Jock River and up into the channel through a one-way valve. Most of the drain goes dry in summer and is thus ephemeral. Likewise for Sections 7 and 8 of the Moore Branch which is considered Indirect Fish Habitat. The upper Sections go dry in mid summer, likely stranding and killing newly hatched fry. Section 6 of the Moore Branch provides direct intermittent fish habitat and will be lost in this option. Baseflows to Sections 4 and 5 of the Moore Branch may be lower.
		High flows are re-routed to Jock River. Loss of extreme flow events in tributaries.	Maintain baseflow and 2-y event flows to tributaries	Moore Branch (Sections 1, 2, 3), Arbuckle Drain	None. Maintenance of the channel-forming 2-year flows will ensure channel structure is maintained in each of the Arbuckle and Moore Branch.
		High flows are re-routed to Jock River. Potential for additional flows in Jock River to cause erosion	Energy dissipaters integrated in design of SWM outfalls.	Jock River	None
L3- Excavation	Exposed Soils	Excavation of ponds will result in the exposure of top soil, and the creation of soil stockpiles	Appropriate containment of stockpiles including the use of silt curtains. Watercourses will be protected with sediment and erosion control measures including silt curtains and setbacks.	Van Gaal, Arbuckle, Moore (Sections 1, 2 3, 4, 5, 6)	None.
	Dewatering	Ponds will need to be dewatered during construction at various times, with discharge water released to surface waters.	Discharge water to be of high quality and if necessary treated by filtering through filter bags, etc.	Van Gaal, Arbuckle, Moore, Jock	None
	Change in Baseflow	Construction of the ponds may result in local interception of baseflows.	Flow augmentation to Moore Branch Sections 1, 2, 3 if necessary	Moore Branch Sections 1, 2 and 3.	None.
W8: - Stormwater Management	Thermal loading	Higher temperatures of stormwater has potential to increase temperatures of watercourses during mid summer.	Vegetative plantings adjacent to SWM ponds, and outlet channels. Cooling channels. Infiltration basins.	Jock River, Van Gaal Drain, Moore Branch (Sections 1, 2, 3)	The residual effect is considered minor. Moore Branch Sections 1, 2 and 3 may have water temperatures that are somewhat elevated (1 to 2°C) from baseline condition. Impact to the Arbuckle Drain and subsequently to the Jock River is anticipated to be minimal because the volume of those systems is much greater than what will be discharged from SWM ponds.
	Nutrient Loading	Eutrophication	SWM ponds remove phosphorus and other nutrients.		None
	Input of contaminants	Toxicity	SWM ponds settle metals and other contaminants		None
	Pathogens, disease vectors, exotics	Diseases	SWM ponds are not receiving domestic waste.		None
	Discharge of stormwater to watercourse	Potential for erosion at point of discharge.	Energy dissipaters integrated in design of SWM outfalls.	Van Gaal Drain, Moore Branch (Sections 1, 2, 3)	None
	Loss of baseflow	Potential for intermittent habitats to be dry longer	Infiltration to provide water during spring	Moore Branch (Sections 4, 5,)	None.

Table 10. Risk classification for each of the watercourses potentially affected by the proposed Mattamy development, SWM Option 2

Watercourse	Reach	Section	Class	Flow	Length (m)	BFW (m)	Area (m^2)	Sens	SAR	Mitigation Prevents Potential Impacts (yes/no)				Potential Impacts			Category of Risk	Comments
										Footprint	Flow Volumes	Water Temp	Water Quality	Extent	Duration	Intensity		
Jock River	at JED outlet		Direct	P				M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Normal water levels in Jock River will maintain seasonal fish habitats
	at Arbuckle confluence		Direct	P				M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Water temperature increases at Jock River are predicted to be neglible considering volume SWM flows and temperature mitigations.
Arbuckle Drain	VG-R1		Direct	P	609	7	4,263	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	All impacts to lower Arbuckle to be mitigated through appropriate SWM design.
Arbuckle/Van Gaal	VG-R2		Direct	P	1407	7.0	9,849	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Van Gaal will be protected from construction activities using conventional mitigations. SWM ponds will have negligible effect on temperature because of low flow volumes.
Van Gaal Drain	VG-R2-1		Direct	P	178	4.3	757	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R2-2		Direct	P	147	3.0	441	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
Moore Branch	VG-R3	1	Direct	P	111	5.0	554	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Flows to lower Moore Branch will be maintained, and will have same quality and temperature as pre-development.
	VG-R3	2	Direct	P	132	5.0	662	L	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R3	3	Direct	P	108	5.0	542	L	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R3-1	4	Direct	I	146	3.7	539	L	No	Yes	No	No	No	Low	High	Medium	Low	Flows to Sections 4 and 5 will be diminished because of SWM management. Channels will remain.
	VG-R3-1	5	Indirect	I	101	3.7	375	L	No	Yes	No	No	No	Low	High	Medium	Low	
	VG-R3-2	6	Direct	P				L	No	No	NA	NA	NA	Medium	High	High	Medium	Channels are filled in.
	VG-R3-2	7	Indirect	I				L	No	No	NA	NA	NA	Low	High	High	Low	
	VG-R3-2	8	Indirect	I				L	No	No	NA	NA	NA	Low	High	High	Low	
Jock River Estates Drain	JED-1		Direct	I				L	No	No	NA	NA	NA	Low	High	High	Low	Channel is filled in.
SWM Pond 1	Outlet channel		Direct	I	522	3	1,566											
	Outlet channel		Direct	P	76	3	228											Channel created with natural channel design principles, and is a gain of fish habitat. Channel may be > 100 m long.
						Direct Permanent	16,754											
						Direct Intermittent	2,647											
						Indirect Intermittent	375											

Total Direct	19,401											

Table 11. Summary of fish habitat losses and gains for Option 2.

Habitat Class	Area (m^2)		
	Current Condition	Option 2	Change
Direct, Permanent	16,526	16,754	228
Direct, Intermittent	3,052	2,647	-405
Indirect, Intermittent	3,660	375	-3,285
Total Direct	19,578	19,401	-177

Table Note: detailed numbers presented in Table 10 above.

3.3 Option 3

3.3.1 General Description

This option involves the construction of three storm ponds (Figure 12). Two ponds are "Wet Ponds" with MOE 'Enhanced' TSS removal. Pond 3 will be a dry pond for quantity control and a hydrodynamic separator to provide quality control. In this stormwater management option, all portions of the Moore Tributary remain open with external flows being conveyed through the redesigned ditches to the Van Gaal/Arbuckle Drain. The Jock River Estate drain (JED-1) will be enclosed within the development area. The Jock River Estate drainage will be conveyed through a new culvert under Ottawa Street connecting to the Moore tributary.

3.3.1.1 Pond 1 Concept

Pond 1 (Figure 13) will be designed to receive runoff from 45 ha between Ottawa and Perth Streets in addition to 28 ha north of Perth Street on the west side of the Van Gaal Drain. Pond 1 will have two outlets. The first channel will be designed to convey low flows up to and including the 2-year event attenuated to 330 L/s in accordance with the Geomorphic Study. The channel will provide both surface and subsurface conveyance. The channel will be bordered by strategic planting to promote shaded cover, while the subsurface component will enhance cooling opportunities. The channel will be ~ 50 m long to the depression that is the existing tile drain. The tile drain would be enhanced to provide flows for an additional 76 m (total channel length of 390 m) to the Moore Branch. The bankfull width of this channel is predicted to be ~ 3 m. This channel will provide intermittent direct fish habitat during spring, and so will be designed to maximize spring spawning opportunities by fish. The channel provides indirect fish habitat during the summer by providing base flows to the Moore Branch.

The second channel will be designed to convey the treated stormwater runoff from the less frequent storm events generated during the 5 to 100 year return periods. This channel is predicted to be ~ 170 m long, with a bankfull width of 3 m. The channel will provide direct fish habitat in the spring during spawning, and will thus be designed to maximize the spawning potential of fish.

Pond 1 is situated in the 100-year regulatory floodplain, outside the 100-year erosion limit and 100 yr summer flood elevation of the Van Gaal/Arbuckle Drain.

The main features of SWM Pond 1 design are:

- French Drain to Convey Baseflow to Section 3 of the Moore Branch;
- Extension of riparian zone along Section 2 of the Moore Branch
- SWM Pond outlet channel and construction of fish habitat feature; and,
- Vegetating the Arbuckle Drain

These aspects are discussed below.

3.3.1.1.1 French Drain

The upper end of Section 2 of the Moore Branch receives cool baseflow from a tile drain under existing conditions. It is important, from an ecological perspective, to maintain those cool baseflows to the top of Section 2, maintaining cool-water habitat for fish. The proposed pond design includes a French Drain that will convey a continuous and cool “baseflow” from the south-east end of the pond to the top of Section 2 of the Moore Branch. The final design of the French Drain will be based on the notion of maintaining the existing condition.

3.3.1.1.2 Extension of riparian zone along Sections 2 & 3 of the Moore Branch

Section 3 (Figure 13) of the Moore Branch has a well-developed riparian zone with mature Green Ash, Manitoba Maple, and White Elm providing canopy. Section 2 is vegetated along its lower half, but not the upper half. The riparian zone of the upper half of Section 2 will be planted with a mixture of native woody plants through the road allowance to enhance stream shading and add to the leaf litter entering the watercourse. The extended canopy will provide shade where the stream was once fully exposed to sun. The extended riparian corridor will increase the natural corridor/linkage function of the Moore Branch, connecting upper Sections of the Moore Branch to SWM Pond 1 and the Arbuckle Drain.

3.3.1.1.3 SWM Pond outlet channel and construction of fish habitat feature

The proposed outlet channel will be aligned to convey storm flows directly to the Arbuckle Drain, upstream of the proposed pedestrian bridge (Figure 13). This feature will be designed to provide a unique marsh-wetland habitat that could be used by pike and other species for spawning in the spring.

The channel will be ~50 m long with a ~ 1-m wide low-flow channel, graded at a slope of ~0.1 to 0.3% to the Arbuckle Drain. The channel will be sinuous, based on natural channel design principles and respecting the topography, soils and flow volumes that the channel will convey. The channel bottom will be constructed with a variety of habitat features including riffles and pools, with varying substrate, and water depth, to maximize habitat diversity. Pools will be designed with boulders and root wads for cover for fish. Willow will be planted to provide a canopy to the low-flow channel. Side slopes will be graded to between 10:1 and 20:1, with 30 to 40-cm hummocks. Side slopes and hummocks will be planted with sedges *Carex* sp. and meadow grass (*Calamagrostis canadensis*) to the top of the high-flow channel (i.e., the 2-year spring event). Side slopes and hummocks will ensure a variable flooding depth of grasses and sedges, a critical component of design for the provision of fish spawning habitat. Plantings in the side slopes will also contain red osier dogwood and other shrubs to provide local diversity of vegetation and shade for the low-flow channel. In total, the side slopes will provide over 4500 m^2 of spawning fish habitat in the spring.

Pike currently use the Arbuckle Drain for spawning with spawning likely occurring in low-lying areas adjacent to the Van Gaal/Arbuckle Drain. It is anticipated that the outflow channel including the side slopes will provide additional potential spawning habitat for pike and other fishes during spring.

3.3.1.1.4 Vegetating the Arbuckle Drain

Mattamy proposes to provide riparian plantings along the east side of the Arbuckle Drain to provide a natural-environment enhancement as part of the overall SWM Pond design. The plantings will include native shrubs (red osier dogwood) and caliper trees (willow, maple, cedar) planted in a 5-m buffer. The trees and shrubs will provide shading to the channel, reducing channel warming that presently occurs in the reach from Perth Street to the confluence with the Moore Branch. Caliper trees and shrubs will provide additional allochthonous (woody) materials that will become food for invertebrates and fish. This riparian zone will provide a natural corridor/linkage function between the SWM pond and the upper reaches of the Van Gaal Drain (i.e., VG-R2).

3.3.1.1.5 Vegetating the SWM Pond

SWM Pond 1 will be 4.77 ha in size (total area inundated by 100-year event) and will include two forebays. The north and south end of the pond, as well as the east side of the pond will have elevations set such that those areas become wetland/marsh areas. The marshy areas will be ideal habitat for shorebirds, and may also be used by a variety of amphibians (frogs) and reptiles (turtles).

Mattamy proposes to provide riparian plantings along the margin of the proposed SWM Pond including native shrubs and caliper trees. The density of the plantings will minimize access to the pond by people. A trail system is envisioned for the pond margin (Figure 13), with that system connected to the Martin-Street access.

The combination of marsh, open water, and riparian zone with large woody trees will provide habitat diversity that can be utilized by a variety of birds and mammals. SWM Pond 1 and associated plantings will provide an additional natural corridor/linkage function between the Moore Branch and upper Van Gaal Drain, and woodlands further to the north-west.

3.3.1.2 Concepts for Other SWM Ponds

Pond 2 will be designed to receive runoff from 21 ha north of Ottawa and the developable land south of Ottawa Street. Pond 2 has one outlet directing post-development runoff rates to the Jock River via a proposed storm sewer along Ottawa Street. The 100-year release rate from pond 2 will be restricted to the free flowing capacity of the outlet sewer, approximately 2000 L/s.

Pond 3 will be designed to collect and retain runoff from approximately 3 ha north of Perth Street east of the Van Gaal Drain. This pond will be designed to attenuate post-development runoff rates to predevelopment levels, while flows up to and including the 2-year event will be attenuated to 330 L/s in accordance with the Geomorphic Study. Storm flows (i.e., > 2 y event) from this pond would be piped to the Jock River.

3.3.2 Pathway of Effects and Mitigation

This option requires grading of the landscape (Pathway L2; Figure 7), excavation of ponds (Pathway L3; Figure 8) and release of treated stormwater (Pathway W6; Figure 9). A summary of the effects pathways and proposed mitigations are presented in Table 12. Pathways and mitigation are further discussed for this Option 3 below.

3.3.2.1 Grading

Grading of the Mattamy lands will result in the exposure of soils, with the potential for surface flows to convey suspended particulate materials to the Van Gaal Drain, Arbuckle Drain and Moore Branch. Conventional erosion and sediment controls will be put in place to protect soil stockpiles, and to protect the three watercourses.

The most significant change in surface drainage pattern is the re-routing of water from the Jock River Estates Drain. That drain has for the past few years provided water to the Jock River in the vicinity of the earthen berm. In Option 3, that drain will be enclosed within the development area and the stormwater runoff from the estate development will be conveyed to the Moore tributary via a new culvert under Ottawa Street. This drainage will be conveyed through the Moore Tributary and discharged directly into the Van Gaal/Arbuckle Drain. The Jock River, in the vicinity of the earthen dam is a high quality habitat consisting of pickerel weed and other emergent macrophytes. Water levels in the macrophyte bed are maintained by the Jock River and not by flows from the Jock River Estates Drain. Further, the drainage pattern prior to the construction of the Jock River Estates Drain had surface waters from the property south of Ottawa Street being conveyed north to the Moore Branch. There should, therefore, be no net negative impact resulting from the re-routing of the Jock River Estates Drain on the productivity of fish and fish habitat of the Jock River. The lower end of the Jock River Estates Drain, within the flood plain, will remain open and may be used by fish during spring high-water events.

Storm flows will be piped from Pond 2 to the Jock River in the vicinity of the Ottawa Street road allowance, while flow released from SWMPs 1 and 3 will be directed to the Van Gaal Drain. Existing flow volumes in the Jock River will buffer and dilute the additional storm-related volumes. Energy dissipation devices will be incorporated into the design of the stormwater outlets. Fish habitat assessment will be undertaken in the vicinity of the proposed storm outlet to ensure that the structure is situated such that is has minimal (to no) impact on existing high-quality and highly sensitive fish habitats.

With the conveyance of storm flows to the Jock River, the Arbuckle and Moore Branch will receive less flow during storm (> 2-year) events. These tributaries will, however, continue to receive the equivalent 2-year event. Because it is the 2-year event that is the channel forming flow, the in-stream fish habitat of the Arbuckle and Moore Branch can be expected to be maintained.

3.3.2.2 Excavation

The potential effects of construction of the SWM Ponds will be mitigated using conventional techniques. Water pumped from the dug ponds will be treated (when necessary) as per requirements of the Ontario Ministry of the Environment. Soils exposed by grading or excavation will be covered or contained with geotextiles or silt curtains to minimize the entry of soils/sediment to surface waters Discharge waters released from work areas (ponds) will be released slowly or through or on energy dissipaters to mitigate potential erosion at points of entry to surface waters.

Post construction, soils in the vicinity of SWM Ponds or watercourses will be stabilized with plantings of grasses, sedges, shrubs and trees. Trees that can provide shade to watercourses and SWM ponds will be planted to assist in stabilizing the site, and to maximize shade for ponds and channels.

In the event that baseflows to the Moore Branch are interrupted because the construction of Pond 1, flows to that channel will be augmented artificially to maintain its permanent condition.

3.3.2.3 Stormwater

Maintenance of groundwater flows to the Van Gaal, Arbuckle and Moore watercourses is important as each of these features supports cool and cold-water fish species. Maintenance of groundwater flows will ensure that water in these watercourses remains cold/cool. The overall SWM design will incorporate infiltration and/or cooling channels to ensure that water provided to these features is cold/cool as appropriate. Pond 1, for example, will provide base flows via cooling trench to the Moore Branch. The three storm ponds are designed to settle particulates and associated nutrients (phosphorus, nitrogen), generally eliminating potential effects associated with contaminated stormwater (Figure 9; AECOM, 2009). The ponds are also not considered to be sources of diseases for fish or disease vectors for fish. The ponds are anticipated to be warmer during summer periods than water of the Van Gaal/Arbuckle, Moore and Jock Rivers. Warming of the ponds will be mitigated to the extent possible by planting shade trees including a mixture of deciduous and coniferous species. Outlet channels from Pond 1 will also be strategically planted to minimize heating and encourage cooling. The base-flow outlet channels from Pond 1 will be designed as a cooling trench to maintain a cool base flow to the Moore Branch. The outlet channels for Pond 1 will be designed to maximize potential fish spawning.

3.3.3 Risks to Fish Habitat

Table 13 provides a summary of the anticipated risks to fish habitat under Option 3 assuming the various mitigation measures are undertaken (Figure 9). The risks to fish habitat are described for the Jock River, Jock River Estates Drain, Van Gaal Drain, Arbuckle Drain, and Moore Branch in the sections below.

3.3.3.1 Jock River Estates Drain

The overall risk to fish habitat in the Jock River Estates Drain is classified as Low (Table 13). Approximately 300 m of the Jock River Estates Drain will be filled under the proposed stormwater management option (Figure 12). The connection between the lower portion of JED-1 and the Jock River (within the floodplain) will be maintained under the future development plan. The value of that connection maybe limited because it may act as a “blind” alley. Surface flows to that feature will be limited, and it is likely to become stagnant as it fills over time with vegetation and detritus. However it would likely continue to function as fish habitat during periodic high water levels on the Jock River. The Low-Risk classification is justified on the basis that: (1) the feature is man made; (2) the feature presents intermittent fish habitat; (3) the feature has until 2009 had a fish-exclusion flap that minimized the upstream movement of fish from the Jock River into the drain; and (4) the impact is to a relatively small area (i.e., ~ 300 m^2). These impacts are offset by enhancements to the Moore Branch (see below).

3.3.3.2 Arbuckle Drain

The overall risks to fish habitat in the Arbuckle Drain is classified as Low (Table 13). The Arbuckle Drain will receive treated stormwater from SWM Pond 1 via a constructed, meandering and naturalized channel. Flows from the SWM Pond will be low in suspended solids and phosphates, meeting Ontario Ministry of Environment discharge limits. Temperature of the released water will be cooled to the extent possible by riparian plantings around the pond and along both sides of the outlet channel.

Since storm flows > 2-year event will be piped to the Jock River, the Arbuckle Drain will receive smaller storm flows. Flows < 2-year event will flow to the Arbuckle Drain via the newly constructed outlet channel. Because it is the 2-year event that is considered the channel-forming flow, fish habitats in the Arbuckle Drain should be maintained.

AECOM (2009) predicts a reduction in both suspended solids and nutrients in overland runoff, as a result in the conversion of the landscape from agricultural to urban. These changes will benefit fish and invertebrates living in the Arbuckle Drain.

The proposed SWM outlet channel will add ~ 50 m^2 of direct fish habitat, as well as additional low-lying areas that should become flooded in the spring of the year and used by various species for spawning.

3.3.3.3 Van Gaal Drain

The overall risks to fish habitat in the Van Gaal Drain is classified as Low (Table 13). There are no activities that will have a direct impact on fish habitat.

The tractor crossing of the Van Gaal Drain currently causes a localized velocity barrier to upstream fish migrations during high-water events. Upgrading of that crossing for use by cars would involve increasing culvert length. Those losses to fish habitat could be offset locally by an improved conveyance through the culvert. This would be accomplished by increasing the size of the culvert so that it can convey spring and storm flow events at velocities that are less than swimming speeds of local fishes (i.e., < 1 m/s).

The riparian zone of the Van Gaal Drain will be protected by the greater of a 30-m setback, the meander belt (42 m in some places) and floodplain.

AECOM (2009) predicts a reduction in both suspended solids and nutrients in overland runoff, as a result in the conversion of the landscape from agricultural to urban. These changes will benefit fish and invertebrates living in the Van Gaal Drain.

3.3.3.4 Moore Branch

Changes to fish habitat in the Moore Branch are anticipated as a result of the proposed stormwater management plan, with many of the changes producing a net increase in productive fish habitat. The nature of change to each of Section of the Moore Branch is described below.

3.3.3.4.1 Moore Branch - Section 8

<u>Present Configuration</u>

Section 8 currently provides ~2351 m^2 of indirect- intermittent fish habitat. This section retains water and stagnates as a result of a "high" point in the channel where Sections 7 and 6 meet (Figure 12). This Section of the Moore Branch is already known to be used by fish in the spring of the year, presumably for spawning. There is potential for adults, and YOY of these species to become trapped as waters recede.

The existing channel requires a meander-belt corridor of ~ 18 m in order to allow for development of a more natural, sinuous channel (see Kilgour & Associates Ltd. and Parish Geomorphic, 2010).

The field adjacent to the channel is farmed to within 4 to 5 m of the existing channel top of bank. Runoff from the field travels through a thin understory.

Proposed Built-Out Configuration

A preliminary analysis of the potential configuration for Section 8 was completed by JFSA (2010) and DSEL et al. (2010). The channel, through Section 8, could be constructed to convey the 100-year event (Figure 14, 1.5 m^3/s), with at least 40 cm of freeboard. The bankfull channel width is proposed to be 3.6 m, will have a 3-m wide low-flow channel, and 3:1 side slopes to the top of bank. There would be a 5-m setback on the east side of the channel (i.e., Mattamy's side the channel). The total channel corridor on Mattamy's side is thus proposed to be 7.6 m from the normal high water mark. The total corridor dimension would be 18.8 m assuming 8.9 m on both sides.

The 5 m setback from top of bank will be planted with native shrubs and caliper trees to minimize access to the channel by persons, and to provide a natural vegetated riparian zone. The various plantings will also capture water and nutrients (N and P) flowing from adjacent "back" yards to the channel. Fencing will be required along the backyard of properties adjacent to the feature. The setback and channel will be dedicated to the City of Ottawa.

Ecological Benefits of the Re-Configured Channel

This channel will drain more effectively after the site is developed and the channel is reconfigured. The channel will provide ~2287 m^2 of intermittent-direct fish habitat, a small reduction (64 m^2) in total area, but large increase in direct and thus productive fish habitat.

Water quality of the channel can be expected to be of higher quality given that the runoff coefficient for N and P is lower in urbanized catchments than in agricultural catchments (see analysis by AECOM, 2009). The established riparian zone would provide a natural supply of leafy and woody detritus to the stream.

3.3.3.4.2 Moore Branch - Section 7

Present Configuration

Section 7 currently provides ~930 m^2 of intermittent-indirect fish habitat. This section retains water and stagnates as a result of a "high" point at the end of the Section (Figure 1). This Section of the Moore Branch is already known to be used by fish in the spring of the year, presumably for spawning. There is potential for adults, fry and YOY of these species to become trapped as waters recede.

Based on further detailed fluvial geomorphologic assessment carried out in fall 2009, the existing channel requires a meander-belt corridor width of ~ 18 m in order to allow for development of a natural, sinuous channel (see Kilgour & Associates Ltd., and Parish Geomorphic, 2010).

The field adjacent to the channel is farmed to within 4 to 5 m of the existing channel top of bank. Runoff from the field travels through a thin understory.

Proposed Built-Out Configuration

A preliminary analysis of the potential configuration for Section 7 was completed by JFSA (2010) and DSEL et al. (2010). The channel, through Section 7, could be constructed to convey the 100-year event (Figure 14; flows up to 4.8 m^3/s), with at least 40 cm of freeboard. The bankfull channel width is currently proposed to be 4.1 m, including a 3-m wide low-flow channel, and 3:1 side slopes to the top of bank. There would be a 5-m setback on both sides of the channel. The total channel corridor is thus proposed to be 17.3 m, including a setback of 6.6 m from the normal high water mark. This proposed channel and corridor design is slightly less than the corridor that would be required without channel re-configuration as per the analysis in Kilgour & Associates Ltd. and Parish Geomorphic, 2010).

The 5 m setback from top of bank will be planted with native shrubs and caliper trees to re-establish the hedgerows. The various plantings will also capture water and nutrients (N and P) flowing from adjacent “back” yards to the channel.

Ecological Benefits of the Re-Configured Channel

This channel will drain more effectively after the site is developed and the channel is reconfigured. With a 4.1 m bankfull width, the channel will provide ~1367 m^2 of intermittent-direct fish habitat, representing a conversion of indirect to direct habitat of some 930 m^2, and a creation of an additional ~434 m^2.

Water quality of the channel can be expected to be of higher quality given that the runoff coefficient for N and P is lower in urbanized catchments than in agricultural catchments (see analysis by AECOM, 2009).

The various plantings will contribute as much or more allochthonous (terrestrial) food supplies for the channel as the existing condition. Total fish habitat will increase.

The ecological (fisheries) integrity and function of this feature is anticipated to increase post development.

3.3.3.4.3 Moore Branch - Section 6

Present Configuration

Section 6 currently provides ~726 m^2 of direct, intermittent fish habitat. This Section of the Moore Branch is already known to be used by fish in the spring of the year, presumably for spawning.

Based on further detailed fluvial geomorphologic assessment carried out in fall 2009, the existing channel requires a corridor of ~ 18 m in order to allow for development of a more natural, sinuous channel (see Kilgour & Associates Ltd., and Parish Geomorphic, 2010).

The field adjacent to the channel is farmed to within 4 to 5 m of the existing channel top of bank. Runoff from the field travels through a thin understory.

Proposed Built-Out Configuration

Along with Section 7, a preliminary analysis of the potential configuration for Section 7 was completed by JFSA (2010) and DSEL et al. (2010). The channel, through Section 6, could be constructed to convey the 100-year event (Figure 14; up to 4.8 m^3/s), with at least 40 cm of freeboard. The bankfull channel width is proposed to be 4.1 m, will have a 3-m wide low-flow channel, and 3:1 side slopes to the top of bank. There will be a 5-m setback on both sides of the channel. The total channel corridor is thus proposed to be 17.3 m.

The 5 m setback from top of bank will be planted with native shrubs and caliper trees to minimize access to the channel by persons. The various plantings will also capture water and nutrients (N and P) flowing from adjacent "back" yards to the channel.

Ecological Benefits of the Re-Configured Channel

This channel will drain more effectively after the site is developed and the channel is reconfigured. With a 4.1 m bankfull width, the channel will provide ~1064 m^2 of intermittent-direct fish habitat, a direct increase in productive fish habitat of some 337 m^2.

Water quality of the channel can be expected to be of higher quality given that the runoff coefficient for N and P is lower in urbanized catchments than in agricultural catchments (see analysis by AECOM, 2009).

The various plantings will contribute as much or more allochthonous (terrestrial) food supplies for the channel as the existing condition.

The ecological (fisheries) integrity and function of this feature is anticipated to increase post development.

3.3.3.4.4 Moore Branch - Section 5

Present Configuration

Section 5 currently provides ~375 m^2 of intermittent-indirect fish habitat, as a result of a blockage that causes fish stranding during periods of low flow. This Section of the Moore Branch is known to be used by fish in the spring of the year, presumably for spawning.

Based on further detailed fluvial geomorphologic assessment carried out in fall 2009, the existing channel requires a corridor of ~ 19 m in order to allow for development of a more natural, sinuous channel (see Technical Memo from B. Wilkes and J. Parish, January 20, 2010 in Appendix 5).

The field adjacent to the channel is currently farmed to within 4 to 5 m of the existing channel top of bank. Runoff from the field travels through a thin understory.

<u>Proposed Built-Out Configuration</u>

No change to the physical form of the channel is proposed.

Mattamy is proposing a setback of 7.5 m from the channel centerline, to recognize the meander belt width.

The catchment for this feature can be expected to decrease by ~ 1/3^rd^ from its present-day size (see discussion for Section 4 of the Moore Branch).

<u>Ecological Implications of Adjacent Land Development</u>

The change in the size of the catchment poses the only net negative impact to this feature. Presently, the feature conveys water and nutrients to downstream fish habitats. Changes in flow volume (~ 1/3 less flow during 2-y events might produce a small reduction in total area submerged by water, here assumed to be a 20% reduction. This reduction, however, would have no impact to direct fish habitat per se, since Section 5 is classified in the existing and future condition as indirect fish habitat.

Water quality is expected to remain similar or to improve as a result of lower runoff coefficients for N and P associated with the land conversion, which will benefit downstream direct fish habitats.

3.3.3.4.5 Moore Branch - Section 4

<u>Present Configuration</u>

Section 4 currently provides ~539 m^2 of intermittent-direct fish habitat. This Section of the Moore Branch is known to be used by fish in the spring of the year, presumably for spawning.

Based on further detailed fluvial geomorphologic assessment carried out in fall 2009, the existing channel requires a corridor of ~ 19 m in order to allow for development of a more natural, sinuous channel (see Kilgour & Associates Ltd., and Parish Geomorphic, 2010).

The field adjacent to the channel is farmed to within 4 to 5 m of the existing channel top of bank. Runoff from the field travels through a thin understory.

The channel currently drains 2.668 ha, including 0.425 ha of impervious area, and produces ~ 330 L/s during a typical 2-y rainfall event.

Proposed Built-Out Configuration

No change to the physical form of the channel is proposed under the development plan.

Mattamy is proposing a setback of 7.5 m from the channel centerline, to recognize the required meander belt width.

Ecological Benefits of the Re-Configured Channel

The catchment area for this feature, as for Section 5, will decrease from 3.093 ha to 1.972 ha (including 0.415 ha of impervious area) and is anticipated to produce 205 L/s during a typical 2-year rainfall event (Memo from A. Fobert to B. Kilgour, December 18, 2009). If these 2-year events are used as a surrogate for a typical spring melt event, the flows to Section 5 might be reduced by ~ 1/3rd from present-day conditions. As for Section 5, we assume that this might result in a reduction in total wetted area by some 20% for the existing condition, or a loss of some 108 m^2 to 431 m^2.

Water quality is expected to remain similar or to improve as a result of lower runoff coefficients for N and P associated with the land conversion.

3.3.3.4.6 Moore Branch – Section 3

Present Configuration

Section 3 currently provides 542 m^2 of intermittent-direct fish habitat. Based on fluvial geomorphologic assessment carried out in fall 2008, the existing channel requires a meander belt of ~ 30 m in order to protect its natural function.

The field adjacent to the channel is farmed to within 4 to 5 m of the existing channel top of bank. Runoff from the field travels through a thin understory.

Proposed Built-Out Configuration

No change to the physical form of the channel is proposed under the development plan.

Mattamy is proposing a setback of 30 m from the channel centerline in the upper portion of Section 3, to recognize the required meander belt width. The lower portion of Section 3 is within the 100-year Regulatory floodplain, which will be respected by the proposed development, and which provides for a much larger setback.

The quality of runoff to Section 3 can be expected to improve as a result of the conversion of the land from agricultural to urban (AECOM, 2009). No other changes to the channel or its habitat are anticipated.

Ecological Benefits of the Re-Configured Channel

There will be no net negative impact to Section 3 of the Moore Branch. Improvements in water quality may provide for a net benefit.

3.3.3.4.7 Moore Branch – Section 2

Present Configuration

Section 2 currently provides 662 m^2 of permanent-direct fish habitat. Based on fluvial geomorphologic assessment carried out in fall 2008, the existing channel requires a meander belt ~ 30 m in order to protect its natural function.

The field adjacent to the channel is farmed to within 4 to 5 m of the existing channel top of bank. Runoff from the field travels through a thin understory.

Proposed Built-Out Configuration

No change to the physical form of the channel is proposed under the development plan.

Section 2 is within the 100-year Regulatory floodplain, which will be respected by the proposed development and provides a large development setback.

The quality of runoff to Section 2 can be expected to improve as a result of the conversion of the land from agricultural to urban (AECOM, 2009). No other changes to the channel or its habitat are anticipated.

Riparian zone plantings are proposed for Section 2 in areas that are currently devoid of cover, and within the existing road allowance.

A French drain is proposed to provide a permanent flow of cool water from the SWM pond to the head of Section 2.

Ecological Benefits of the Re-Configured Channel

There will be no net negative impact to Section 2 of the Moore Branch. Improvements in water quality may provide for a net benefit. Riparian plantings will help keep the channel cool, and will add leaf litter as a food resource to the channel.

3.3.3.4.8 Moore Branch – Section 1

Present Configuration

Section 1 currently provides 554 m^2 of permanent-direct fish habitat. Based on fluvial geomorphologic assessment carried out in fall 2008, the existing channel requires a meander belt ~ 30 m in order to protect its natural function.

The field adjacent to the channel is currently not farmed.

Proposed Built-Out Configuration

No change to the physical form of the channel is proposed under the development plan.

Section 1 is within the 100-year Regulatory floodplain, which will be respected by the proposed development and provides a large development setback.

The quality of runoff to Section 1 can be expected to improve as a result of the conversion of the land from agricultural to urban (AECOM, 2009). No other changes to the channel or its habitat are anticipated.

Ecological Benefits of the Re-Configured Channel

There will be no net negative impact to Section 1 of the Moore Branch. Improvements in water quality may provide for a net benefit.

3.3.3.4.9 Moore Branch Summary

The re-grading and re-alignment of Sections 6, 7 and 8, will increase the total amount of direct fish habitat by some upwards of 4,000 m^2. Stormwater management will result in Sections 4 and 5 receiving ~1/3 less flow during high-flow events (2 y event). That loss is expected to result in a negligible reduction in direct fish habitat, which is easily offset by the gains resulting from changes to Sections 6, 7, and 8. The proposed built-out condition can be considered to be an enhancement of the natural function of the Moore Branch in terms of its provision of fish habitat. Riparian habitat will be largely unchanged as a result of the built-out design.

The proposed French Drain will provide cool base flow to the top of Section 2 of the Moore Branch, mitigating the potential effects of urban development, and ensuring the long-term sustainability of the cool-water fish assemblage that has developed in the Moore Branch.

The extension of the riparian zone along Section 2 of the Moore Branch will provide shade, keeping the stream cool. The additional riparian area will also provide a new source of leaf litter that will provide substrate for stream invertebrates.

3.3.3.5 Arbuckle/Moore Pike Spawning Area

Flow in the vicinity of the pike spawning area (Figure 5) will be unchanged during spring spawning periods. Flows to that area, via the Moore Branch will be, overall, increased during other times of the year because surface flows from JED-1 are to be re-routed to the SWM pond adjacent to the Moore Branch.

3.3.3.6 Jock River

There will be no residual impacts to the Jock River. The Jock River is the ultimate recipient of all upstream activities including the following:

- Filling of portions of JED-1;
- Re-configuration of various sections of the Moore Branch;
- Proposed riparian plantings along the Moore Branch, Arbuckle Drain,;
- Proposed upgrading of the culvert on the Van Gaal Drain; and,
- Proposed creation of a SWM Pond outlet channel and associated pike spawning habitat.

Apart from the footprint of the SWM outlet at the end of Ottawa Street, there is no physical footprint of any Mattamy-related infrastructure proposed for the Jock River. The proposed development will have indirect influences on the Jock River including changes to flow routing (more storm flows to the Jock River, see DSEL et al., 2010), and changes to runoff water quality (reduced TSS and nutrients; see AECOM 2009). Thus, indirect impacts of the proposed development on the Jock River are anticipated to have no net negative impact.

At detailed design, the stormwater outlet will be designed in consultation with an aquatic and fluvial geomorphology consultant to minimize impacts to the Jock River and associated aquatic habitat. The outlet design will be subject to approval from the City of Ottawa, Rideau Valley Conservation Authority, Ministry of Natural Resources, and Ministry of Environment.

3.3.4 Summary of Net Ecological Benefits

The Mattamy design maintains or enhances major terrestrial features/functions including the following:

- function of the significant woodland adjacent to the Jock River;
- function of the riparian corridor along the Jock River;
- enhanced, minor corridor functions associated with hedgerows situated with the Moore Branch; and,
- enhanced corridor function along the Van Gaal and Arbuckle Drains associated with densification of riparian plantings.

The design also maintains or enhances major aquatic system features/functions, including the following.

The proposed French Drain will provide cool base flow to the top of Section 2 of the Moore Branch, mitigating the potential effects of urban development, and ensuring the long-term sustainability of the cool-water fish assemblage that has developed in the Moore Branch.

The extension of the riparian zone along Section 2 of the Moore Branch will provide shade, keeping the stream cool. The additional riparian area will also provide a new source of leaf litter that will provide substrate for stream invertebrates.

The SWM outlet channel will be designed using natural channel-design principles. The channel, by itself, will provide an additional 150 m^2 of new permanent-direct fish habitat. The channel side slopes are also designed to provide potential pike spawning habitat. The landscape through which the channel drains will be landscaped to ensure flooding during the spring. The side slopes will be planted with a variety of sedges and grasses to match vegetation that typically is found in pike-spawning habitat. Regardless of use of the area by spring-spawning pike, the area will present spawning habitats for a variety of cyprinids and other species that currently use the Van Gaal/Arbuckle Drain. The side slopes are anticipated to provide over 4500 m^2 of spawning habitat in the spring.

Plantings along the mainstem of the Arbuckle Drain will shade that channel, possibly cooling water and providing leaf litter for consumption by invertebrates.

The SWMP pond and associated vegetative plantings will provide a potentially important ecological linkage to the north-west parcels of the Mattamy property, from the corridor provided by the Moore Branch.

Re-grading of the Mattamy land holdings, and the subsequent construction and operation of the SWM ponds will have minimal impact on fish habitat within the Mattamy land holding. The proposed SWM option should produce a net increase in direct fish habitat of some ~3,386 m^2 (Table 15). Outlet channels from Pond 1 under this option could be designed as fish spawning habitats, in particular for pike. A low-flow outlet channel from this pond is proposed to outlet through a cooling trench so that cool base flows are provided to the Moore Branch as per existing conditions.

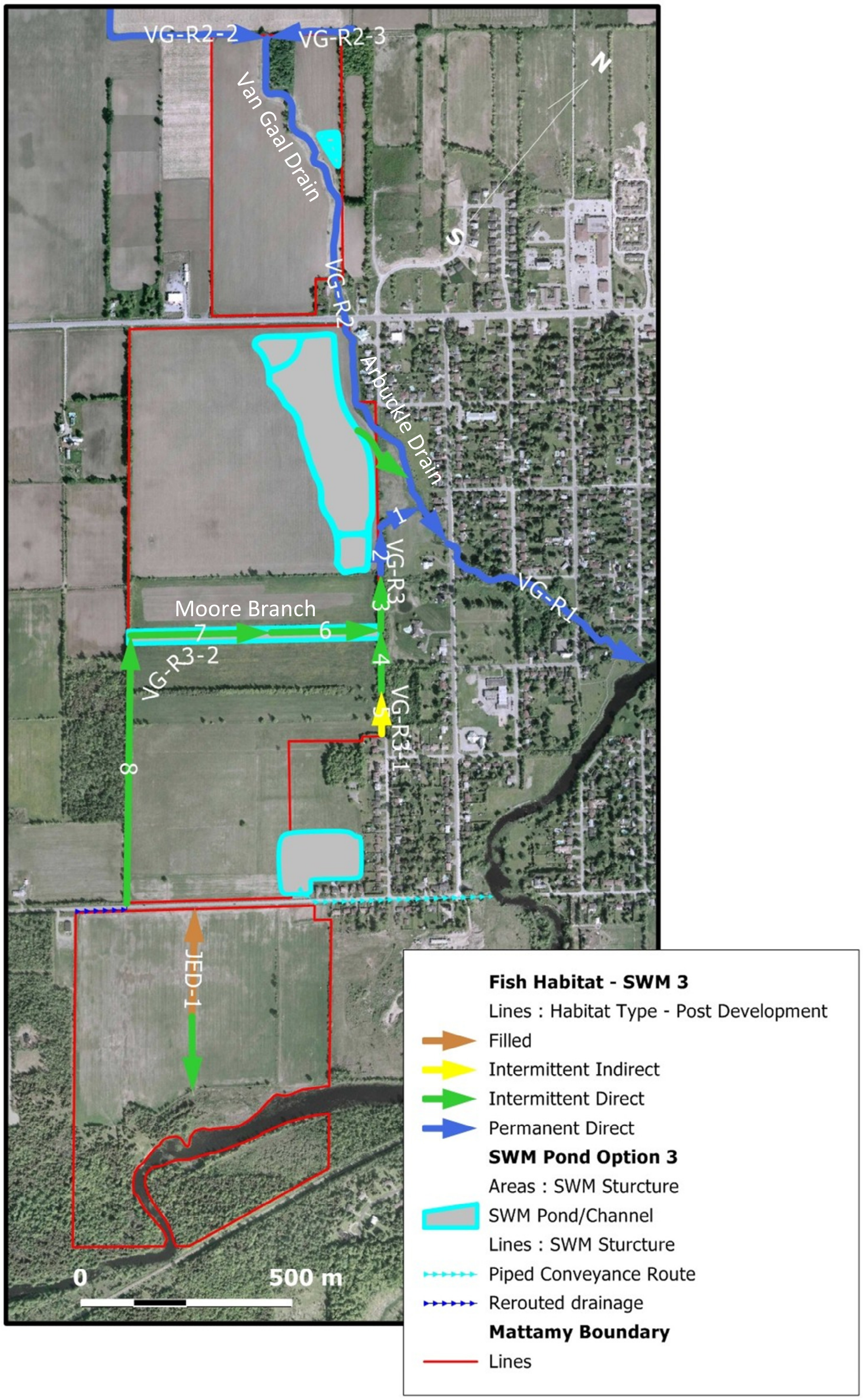


Figure 12. SWM Option 3 and resulting fish habitats.

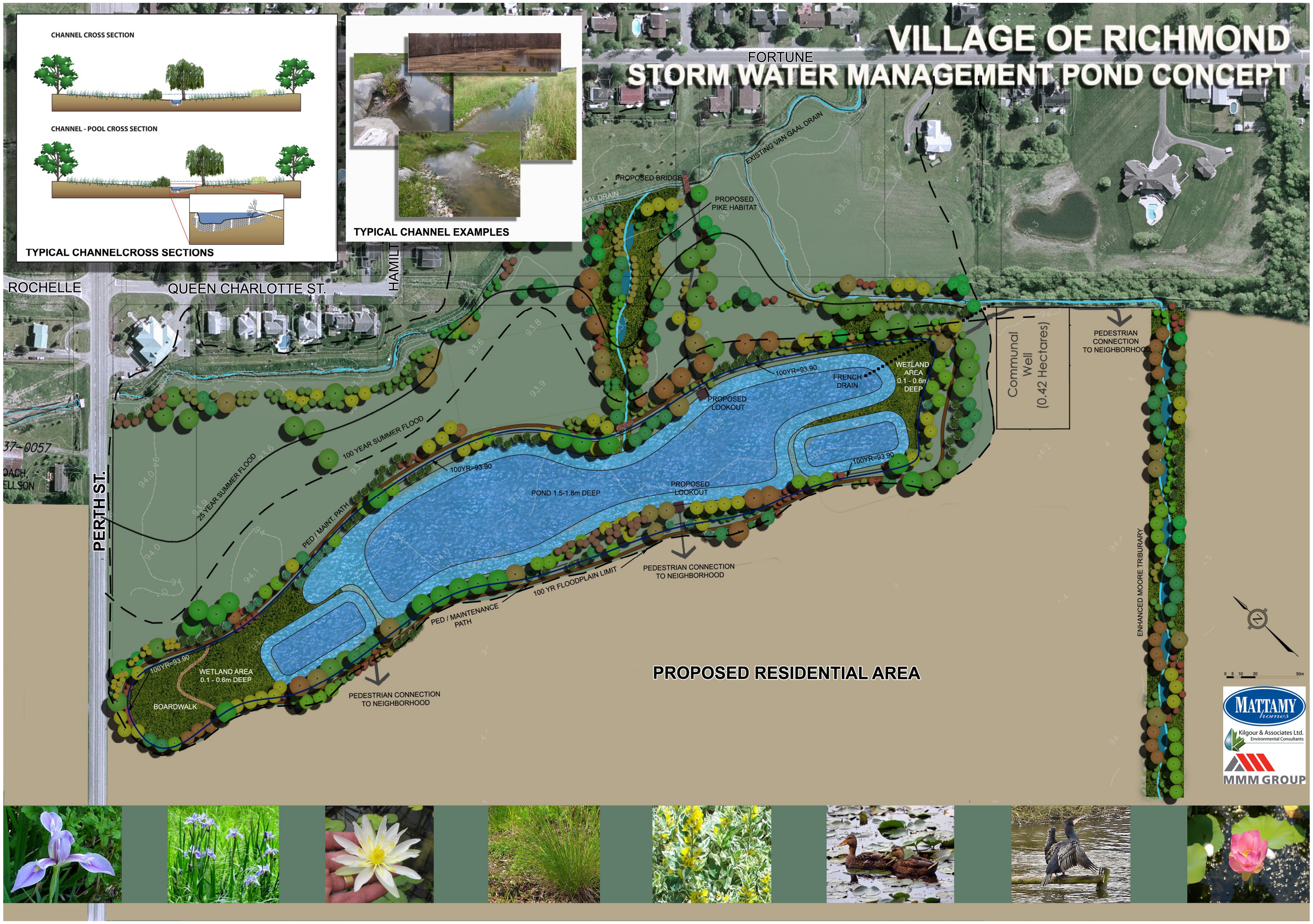


Figure 13. Concept drawing for SWM Pond 1.

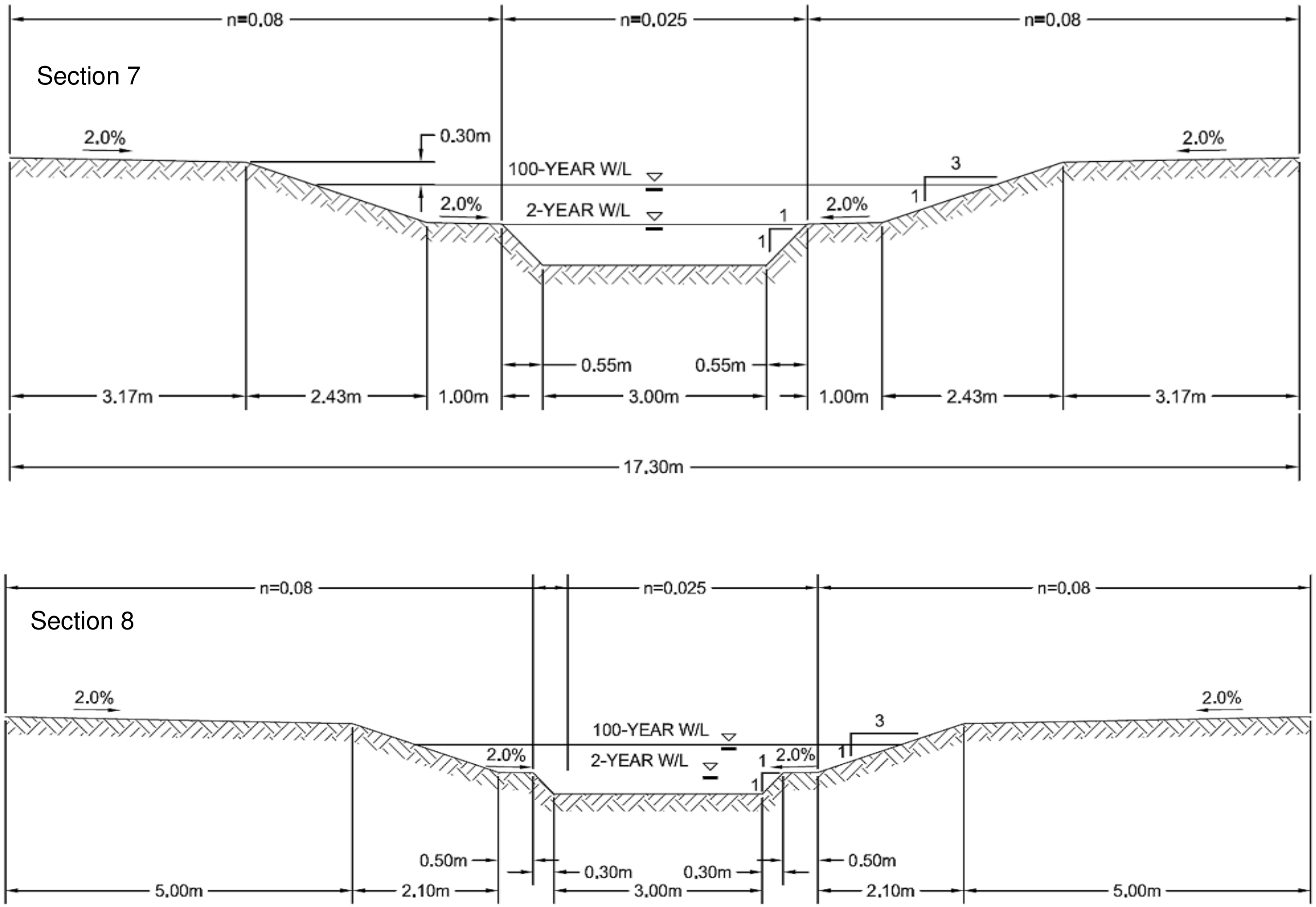


Figure 14. Proposed cross-sections for Sections 7 and 8 of the Moore Tributar

Table 12. Summary of effects pathways and mitigation for Option 3.

Pathway	Stressor	Effect	Mitigation	Watercourses Potentially Affected	Residual Effect
L2 Grading	Exposed Soils	Various parcels of land within the Mattamy holding may require re-grading to facilitate SWM. Exposed soils, and stockpiled soils have the potential to contribute sediments to surface waters	Appropriate containment of stockpiles including the use of silt curtains. Watercourses will be protected with sediment and erosion control measures including silt curtains and setbacks.	Van Gaal, Arbuckle, Moore (Sections 1, 2 3, 4, 5, 6,7)	None.
	Change in Drainage Pattern	Flows to the Jock River Estates Drain will be rerouted to SWM Pond 2. Flows in Section 8 of the Moore Branch will be captured by SWM Pond 1.	None. Jock River estates drain is abandoned and filled in this Option. Flows to Section 8 of the Moore Branch are piped. Sections 6 and 7 stay open with enhancements.	Jock River Estates Drain, Section 4, 5, 8 of Moore Branch	The residual effect is considered minor. Jock River Estates Drain is a man-made watercourse. Though it is considered to provide Direct Fish Habitat, the only access to that habitat is from the Jock River and up into the channel through a one-way valve. Most of the drain goes dry in summer and is thus ephemeral. Likewise for Section 8 of the Moore Branch which is considered Indirect Fish Habitat. The upper Sections go dry in mid summer, likely stranding and killing newly hatched fry. Baseflows to Sections 4 and 5 of the Moore Branch may be lower.
		High flows are re-routed to Jock River. Loss of extreme flow events in tributaries.	Maintain baseflow and 2-y event flows to tributaries	Moore Branch (Sections 1, 2, 3), Arbuckle Drain	None. Maintenance of the channel-forming 2-year flows will ensure channel structure is maintained in each of the Arbuckle and Moore Branch.
		High flows are re-routed to Jock River. Potential for additional flows in Jock River to cause erosion	Energy dissipaters integrated in design of SWM outfalls.	Jock River	None
L3-Excavation	Exposed Soils	Excavation of ponds will result in the exposure of top soil, and the creation of soil stockpiles	Appropriate containment of stockpiles including the use of silt curtains. Watercourses will be protected with sediment and erosion control measures including silt curtains and setbacks.	Van Gaal, Arbuckle, Moore (Sections 1, 2 3, 4, 5, 6, 7)	None.
	Dewatering	Ponds will need to be dewatered during construction at various times, with discharge water released to surface waters.	Discharge water to be of high quality and if necessary treated by filtering through filter bags, etc.	Van Gaal, Arbuckle, Moore, Jock	None
	Change in Baseflow	Construction of the ponds may result in local interception of baseflows.	Flow augmentation to Moore Branch Sections 1, 2, 3 if necessary	Moore Branch Sections 1, 2 and 3.	None.
W8: - Stormwater Managemen t	Thermal loading	Higher temperatures of stormwater has potential to increase temperatures of watercourses during mid summer.	Vegetative plantings adjacent to SWM ponds, and outlet channels. Cooling channels. Infiltration basins.	Jock River, Van Gaal Drain, Moore Branch (Sections 1, 2, 3)	The residual effect is considered minor. Moore Branch Sections 1, 2 and 3 may have water temperatures that are somewhat elevated (1 to 2°C) from baseline condition. Impact to the Arbuckle Drain and subsequently to the Jock River is anticipated to be minimal because the volume of those systems is much greater than what will be discharged from SWM ponds.
	Nutrient Loading	Eutrophication	SWM ponds remove phosphorus and other nutrients.		None
	Input of contaminants	Toxicity	SWM ponds settle metals and other contaminants		None
	Pathogens, disease vectors, exotics	Diseases	SWM ponds are not receiving domestic waste.		None
	Discharge of stormwater to watercourse	Potential for erosion at point of discharge.	Energy dissipaters integrated in design of SWM outfalls.	Van Gaal Drain, Moore Branch (Sections 1, 2, 3)	None
	Loss of baseflow	Potential for intermittent habitats to be dry longer	Infiltration to provide water during spring	Moore Branch (Sections 4, 5, 6, 7)	None.

Table 13. Risk classification for each of the watercourses potentially affected by the proposed Mattamy development, SWM Option 3

Watercourse	Reach	Section	Class	Flow	Length (m)	BFW (m)	Area (m^2)	Sens	SAR	Mitigation Prevents Potential Impacts (yes/no)				Potential Impacts			Category of Risk	Comments
										Footprint	Flow Volumes	Water Temp	Water Quality	Extent	Duration	Intensity		
Jock River	at JED outlet		Direct	P				M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Normal water levels in Jock River will maintain seasonal fish habitats
	at Arbuckle confluence		Direct	P				M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Water temperature increases at Jock River are predicted to be negligible considering volume SWM flows and temperature mitigations.
Arbuckle Drain	VG-R1		Direct	P	609	7	4,263	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	All impacts to lower Arbuckle to be mitigated through appropriate SWM design.
Arbuckle/Van Gaal	VG-R2		Direct	P	1407	7.0	9,849	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Van Gaal will be protected from construction activities using conventional mitigations. SWM ponds will have negligible effect on temperature because of low flow volumes.
Van Gaal Drain	VG-R2-1		Direct	P	178	4.3	757	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R2-2		Direct	P	147	3.0	441	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
Moore Branch	VG-R3	1	Direct	P	111	5.0	554	M	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	Flows to lower Moore Branch will be maintained, and will have same quality and temperature as pre-development.
	VG-R3	2	Direct	P	132	5.0	662	L	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R3	3	Direct	I	108	5.0	542	L	No	Yes	Yes	Yes	Yes	Low	Low	Low	Low	
	VG-R3-1	4	Direct	I	146	3.7	431	L	No	Yes	No	No	No	Low	High	Medium	Low	Flows to Sections 4 and 5 will be diminished because of SWM management. Channels will remain.
	VG-R3-1	5	Indirect	I	101	3.7	300	L	No	Yes	No	No	No	Low	High	Medium	Low	
	VG-R3-2	6	Direct	I	259	2.8	1,064	L	No	No	NA	NA	NA	Low	High	High	Low	Channel enhanced
	VG-R3-2	7	Direct	I	333	2.8	1,367	L	No	No	NA	NA	NA	Low	High	High	Low	Channel enhanced
	VG-R3-2	8	Indirect	I			2,287	L	No	No	NA	NA	NA	Low	High	High	Low	Channel piped.
Jock River Estates Drain	JED-1		Direct	I			597	L	No	No	NA	NA	NA	Low	High	High	Low	Channel is filled in.
SWM Pond 1	Outlet Channel		Direct	P	50	3	150											
Direct Permanent							16,676											
Direct Intermittent							6,288											
Indirect Intermittent							300											
Total Direct							22,964											

Table 14. Summary of fish habitat losses and gains for Option 3.

Habitat Class	Area (m^2)		
	Current Condition	Option 3	Change
Direct, Permanent	16,526	16,676	150
Direct, Intermittent	3,052	6,288	3,236
Indirect, Intermittent	3,660	300	-3,360
Total Direct	19,578	22,964	3,386

Table Note: detailed numbers presented in Table 10 above.

4.0 UNCERTAINTIES AND OTHER CAVEATS

There are some uncertainties associated with some of the conclusions in this risk assessment. In all three options, there are potential impacts to Sections 4 and 5 of the Moore Branch as a reduction of potential losses of baseflow. The magnitude of potential reductions is, at this point, unknown. Some assumptions of the losses were made in relation to SWM Option 3.

The precise location, length and design of outlet channels from the major SWM pond(s) are at this point unknown. Outlet channels represent a means of incorporating fish habitat enhancements in the overall study area. The lengths of outlet channels have been conservatively estimated so as not to provide a potential false expectation of the enhancement opportunities. The bankfull width of these channels can be maximized to recover (gain) direct intermittent fish habitat if required.

Other opportunities for habitat enhancement have not been proposed, because discussions with Ontario Ministry of Natural Resources and Rideau Valley Conservation Authority have not yet broached the notion of fish habitat management goals for the study area. There are opportunities on and off site for the enhancement (potentially creation) of fish habitat that the study team is considering, and would incorporate into the over all design at the appropriate time.

We have not included a potential footprint in the Jock River for a stormwater outlet structure. Any structure built on the shores of the Jock River would, however, be designed to minimize the in-water footprint, and other associated impacts to shoreline fish habitat.

This assessment does not take into account the potential effects associated with residential road crossings on the Mattamy Lands, should they be necessary or should they occur. The culvert currently on the Van Gaal Drain (see Kilgour and Parish, 2010) that is currently used by farm vehicles may stay, though it may also be improved or removed depending on final-design considerations.

5.0 SUMMARY

Re-grading of the Mattamy land holdings, and the subsequent construction and operation of the SWM ponds will variously affect the productive potential of fish habitat (Table 15). Option 1 has the greatest net negative impact on fish habitat (loss of ~2,500 m^2 of direct fish habitat), with Option 2 creating a lesser impact (loss of 177 m^2 of direct fish habitat). SWM option 3 has the least impact, resulting in a net increase in direct fish habitat of some ~3,386 m^2. Outlet channels from Pond 1 under Option 3 could be designed as fish spawning habitats. A low-flow outlet channel from this pond is proposed to outlet through a cooling trench so that cool base flows are provided to the Moore Branch as per existing conditions.

Table 15. Summary of gains and losses of fish habitat under all three SWM options.

Habitat Class	Area (m^2)			
	Current Condition	Option 1	Option 2	Option 3
Direct, Permanent	16,526	17,068	16,754	16,676
Direct, Intermittent	3,052	0	2,647	6,288
Indirect, Intermittent	3,660	0	375	300
Total Direct	19,578	17,068	19,401	22,964
Gains/Losses				
Direct, Permanent		542	228	150
Direct, Intermittent		-3,052	-405	3,236
Indirect, Intermittent		-3,660	-3,285	-3,360
Total Direct		-2,510	-177	3,386

6.0 REFERENCES

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Appendix 1
Definition of Fish Reproductive Guilds

Table 1.1. Classification of reproductive guilds of fish species from the Jock River.

Class			Description	Jock River Species
A. Non-Guarder	A.1 Open Substrate	A.1.1 Pelagophils	Non-adhesive eggs scattered in open water in areas where current direction is favourable to egg distribution and survivial	Emerald shiner
		A.1.2 Litho-Pelagophils	Eggs initially depositive on rocks/gravel bug eggs or embryos are carried away from spawning substrates.	
		A.1.3 Lithophils	Deposits eggs on a rock, rubble or gravel bottom. Embryos are highly photophobic	White sucker, silver redhorse, greater redhorse, pearl dace, blacknose dace, longnose dace, walleye
		A.1.4 Phytolithophils	Deposit eggs in clear water on submerged plants or logs, gravel and rocks. Late Hatching, presence of cement glands.	Brassy minnow,
		A.1.5 Phytophils	Scatter eggs with an adhesive membrane that sticks to submerged, live or dead, aquatic plants, or to recently flooded terrestrial plants. Adapted to low-oxygen environments	Northern pike, muskellunge, central mudminnow, northern redbelly dace, golden shiner, banded killifish
		A.1.6 Psammophils	Eggs scattered directly on sand or near fine roots of plants that hang over the sandy bottom. Eggs adhesive	Blacknose shiner, spottail shiner, logperch
	A.2 Brood Hiders	A.2.1 Lithophils	Hide eggs in natural or specially constructed places. In most cases, hiding places are excavated in gravel, with eggs buried under gravel. Clean gravel or rocks and cold, clean fast flowing water or springs are almost essential to assume some exchange of water around eggs to provide sufficient oxygen.	Creek chub, fallfish,
B. Guarders	B.1 Substratum Choosers	B.1.1 Phytophils	Eggs are scattered onto submerged plants. Male guards and fans eggs.	

Class			**Description**	**Jock River Species**
	B.2 Nest Spawners	B.2.1 Lithophils	Eggs deposited in single layer or multi layer clutchers on cleaned rocks on in pits dug in gravel.	Common shiner, rock bass, bluegill, smallmouth bass
		B.2.2 Phytophils	Nests built on a soft, muddy bottom usually amid algae, plant roots, leaves.	Largemouth bass, black crappie
		B.2.3 Speleophils	Guard spawn in natural hoes and cavities or in specially constructed burrows. Frequently eggs are deposited on a cleaned area of the undersurface of flat stones.	Bluntnose minnow, fathead minnow, brown bullhead, Johnny darter, mottled sculpin
		B.2.4 Polyphils	Fishes that are not particularly in the selection of nest building material and substrate. Usually circular nests with sticks and roots left in place. Often among or next to plants growing in muddy or sandy shallows of slow rivers or lagoons.	Pumpkinseed
		B.2.5 Ariadnophils	Skill nest building and parental care remarkably well developed. Nest materials are bound together by a viscid thread secreted by male.	Yellow bullhead, brook stickleback