THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

FISH HABITAT CHARACTERIZATION IN THE VAUDREUIL CANAL - DOWNSTREAM END OF TASCHEREAU BRIDGE

JCCBI CONTRACT: 62114

MARCH 2015

WSP

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The Jacques Cartier and Champlain Bridges Incorporated

Final Report

Project N^{o}: 141-24230-00
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1 INTRODUCTION

1.1 CONTEXT

The Jacques Cartier and Champlain Bridges Incorporated (JCCBI) in conjunction with Infrastructure Canada (IC) are seeking development projects to compensate for habitat losses generated by both the eventual work on the Champlain Bridge and the construction of the New Bridge for the St. Lawrence River (NBSL). In this context, JCCBI mandated WSP Canada Inc. (WSP) to first characterize the aquatic habitat present in the Vaudreuil Rapids sector, and secondly to establish the potential for developing spawning habitat for three target species, namely: Smallmouth Bass (*Micropterus dolomieu*), Walleye (*Sander vitreus*) and Lake Sturgeon (*Acipenser fulvescens*).

1.2 OBJECTIVES

The present study's objectives are to:

- Present the baseline conditions regarding aquatic habitats around the Taschereau Bridge;
- Identify potential compensatory habitat sites for species such as lake sturgeon, Walleye and Smallmouth Bass;
- Identify the area to be restored under the Taschereau Bridge following work carried out on the bridge in 2002.

2 METHODOLOGY

2.1 FIELD SURVEYS

2.1.1 BATHYMETRY

Bathymetric surveys were conducted in the study area on November 11 and 12, 2014 (Map 1). These were completed using an echosounder (Odom Hydrotrac and a Leica GS-15 real-time GPS-RTK system) installed on a shallow-draft motorboat. The watercourse cross-sections measured are spaced 50 m apart for the section between the upstream end of the railway bridge and Île aux Pins, and 250 m apart downstream from Île aux Pins. Survey lines along the flow direction were added to form a complete grid of the study area. Despite average water levels, some areas were not navigable due to the presence of shoals, notably just below and downstream from Taschereau Bridge, as well as the sector upstream from Île aux Pins.

An additional bathymetric survey was conducted on December 8, 2014 on the shoal downstream from the Taschereau Bridge, to establish the presence of the remnants of an old jetty used during the refurbishment of the bridge (Map 1). This survey covers some 85 m from the downstream limit of the bridge, excluding the emergent grass bed in the middle of the river. An ADCP TRDI RiverRay 600 KHz type apparatus was used for this survey. The flow speed and the free surface's elevation were also surveyed.

A survey of the position of the Taschereau Bridge's piers, using a GPS RTK, from the bridge deck, completed the bathymetric surveys.

During the November survey, water levels in Lake Deux-Montagnes and Lake Saint-Louis remained relatively stable, fluctuating between 22.17 and 22.21 m at Vaudreuil (station 02OA107) and between 21.29 and 21.33 m at Pointe-des-Cascades (station 02MC005). During the December 8 survey, water levels in Lake des Deux-Montagnes and Lake Saint-Louis fluctuated between 22.19 and 22.21 m at Vaudreuil, and between 21.19 and 21.20 m at Pointe-des-Cascades.

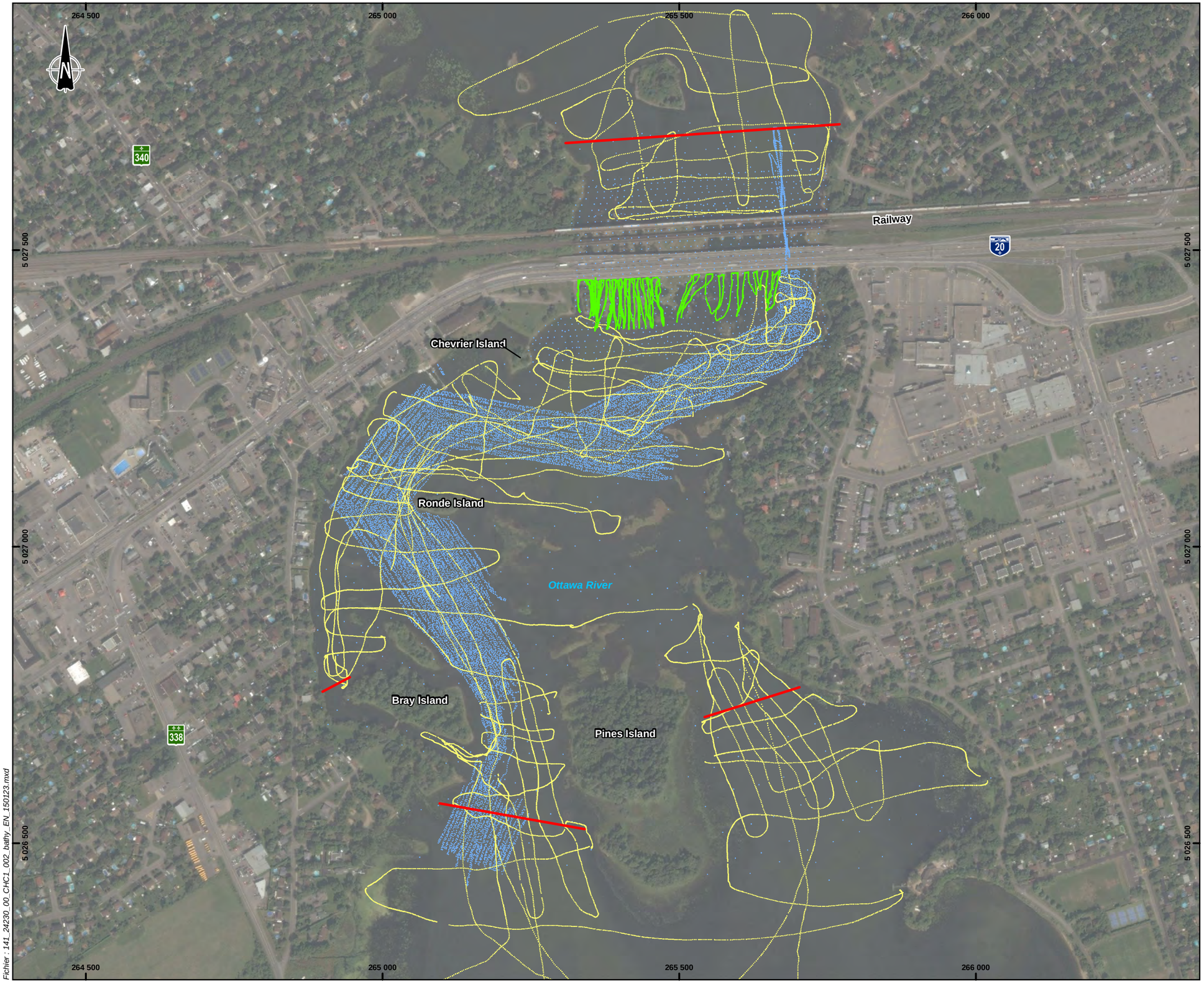
Finally, elevation data produced in September 2000 by the Canadian Hydrographic Service (CHS) was acquired to complete the data gathered during these surveys.

2.1.2 HYDROMETRY

Water levels were measured simultaneously at each bathymetric survey point used for the November 11-12, 2014 survey campaign. This provided a complete portrait of the water surface elevation for the area of study. These level where equivalent to levels recorded at nearby hydrometric stations.

Flow measurements were also taken during this campaign, at different spots (Map 1), using a ADCP TRDI RiverRay 600 KHz. The flow measured was 445 m^3/s upstream from Taschereau Bridge, 412 m^3/s downstream from Île aux Pins, and respectively 204 and 218 m^3/s east and west of Île aux Pins. The canal's flow during the measurements is evaluated at 430 m^3/s for modelling purposes.

Photos were taken and visual observations made so as to characterize the area's flow.



Gauging section

Bathymetric surveys

- SHC (sept 2000)
- WSP (Nov 2014)
- WSP (Dec 2014)

Water level during surveys:

Between 22,17 m and 22,21 m at Vaudreuil (station 02OA107)
Between 21,19 m and 21,33 m at Pointe-des-Cascades (station 02MC005)

0 62,5 125 250 m

1 : 6 250

Projection : NAD83, MTM fuseau 8

THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

OTTAWA RIVER AQUATIC HABITATS CHARACTERISATION

Downstream of Taschereau Bridge, Dorion, Quebec

Map 1

Localisation of gauging, bathymetric surveys and CHS data

Sources :
Satellite image : ESRI World Imagery, DigitalGlobe (2010-03-07)
Maps: - BNDT, RNCan, 1 : 250 000, 31G et 31H
- ESRI World topographic Map
Limits of municipalities : SDA20K, 2010-01

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2.1.3 SUBSTRATE CHARACTERIZATION

The substrate was characterized on November 11, 12, 13 and 18, 2014 by two biologists from WSP. At the time of these surveys, the river's flow fluctuated around 410 m^3/s. This characterization was carried out from an anchored craft using a MarCum™ underwater camera attached to a 2.75-m long copper pipe (see Figure 1). In order to estimate the size of particles, a marked line was attached to the end of the pipe. Hitting the bottom with this pipe was used to find any fine particles present and to crudely characterize the substrate when macrophyte coverage was too great. The initial focus of this characterization was on the areas initially identified by Dessau et Cima (2013), that is immediately downstream from the bridges, around Île Ronde and between Île aux Pins and Bray Ouest. More spaced out stations were also measured throughout the study area. Table 1 presents the grain classes used to describe the substrate, based on Wentworth-Udden modified by Boudreault (1984).

Table 1 Grain Classes used in the Description of the Substrate

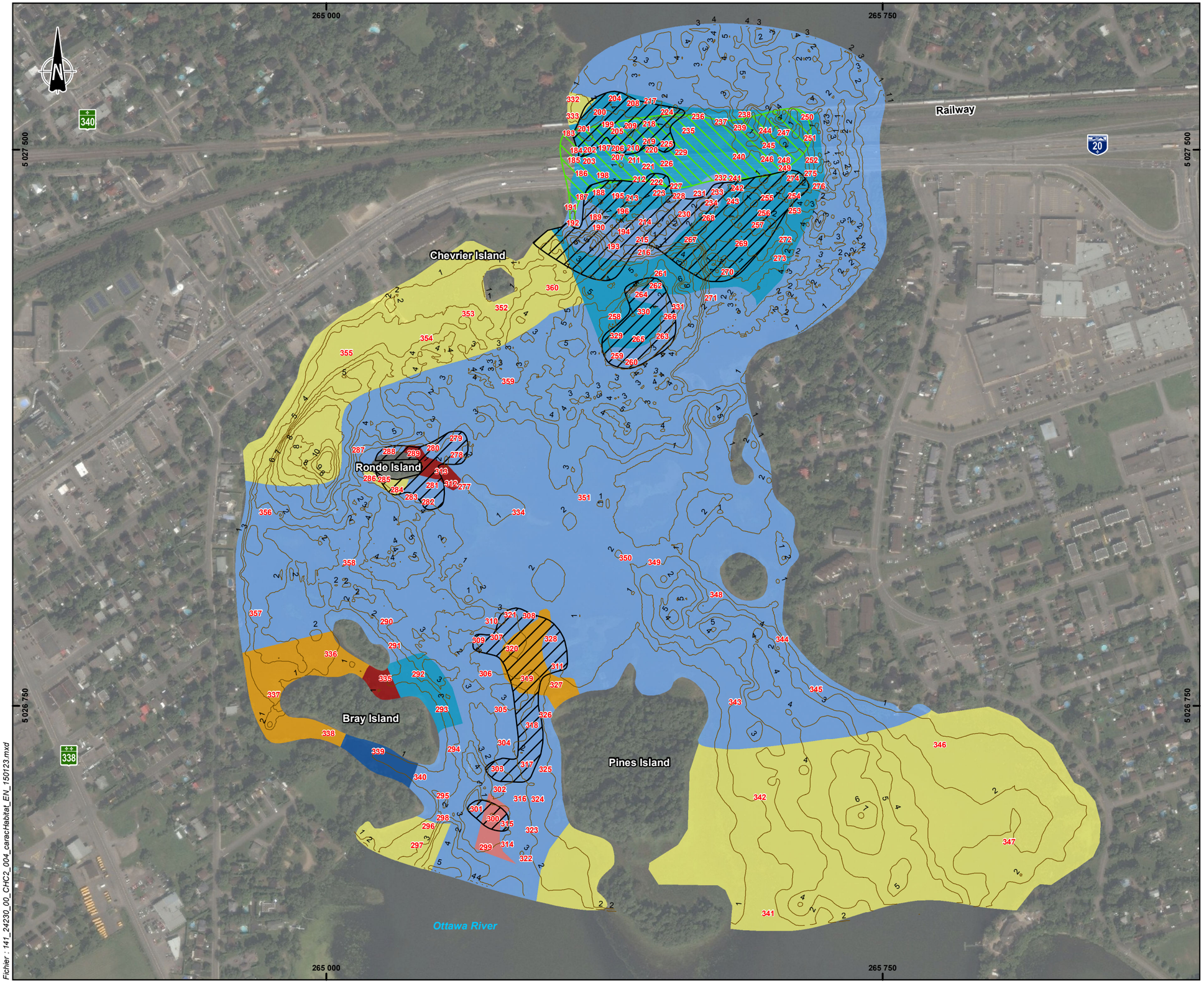
CLASS	DIAMETER (MM)
Fine particles	< 1
Sand	> 1 - < 2
Gravel	2 - 15
Pebble	16 - 63
Cobble	64 - 256
Boulder	> 256

The Ottawa River's high turbidity made it difficult to characterize the substrate at depths of more than 2.5 m. Further, the shallow water at the rapids under the bridges restricted navigation in this sector.

In all, the substrate was characterized at 272 stations within the study area. A video was recorded for the substrate at each station. All of these recordings are contained on a DVD included with this report. Map 2 shows the locations of each of these stations. The raw results are for their part presented in Appendix A.

Numerous photographs were taken during the field surveys; they are on the DVD included with this report.

Figure 1 Equipment used for the Substrate Characterization



183 — Number and substrate characterisation station location

2 — Depth contour line (m) (discharge of 455 m³/s)

Backfill zone

Presence of aquatic vegetation

Observation of threadfoot

Historical CDPNQ threadfoot occurence

Homogenous substrate sub-areas

	Dominant substrate	*Subdominant substrate*
	Boulder	Boulder
	Cobble	Pebble
	Cobble	Cobble
	Cobble	Gravel
	Boulder	Cobble
	Sand	Fine
	Sand	Cobble

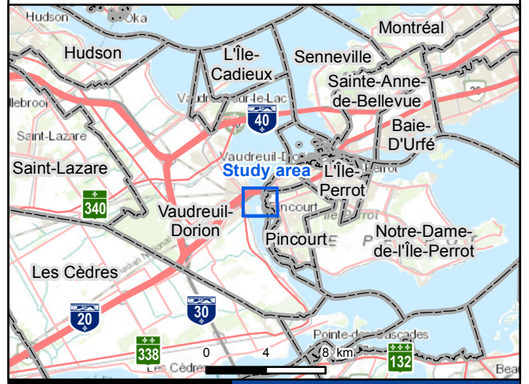
Water level during surveys:

Between 22,17 m and 22,21 m at Vaudreuil (station 02OA107)
Between 21,19 m and 21,33 m at Pointe-des-Cascades (station 02MC005)

0 50 100 200 m

1 : 5 000

Projection : NAD83, MTM fuseau 8



THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

OTTAWA RIVER AQUATIC HABITATS CHARACTERISATION

Downstream of Taschereau Bridge, Dorion, Quebec

Map 2

Habitat characterisation

Sources :

Satellite image : ESRI World Imagery, DigitalGlobe (2010-03-07)
Maps: - BNDT, RNCan, 1 : 250 000, 31G et 31H
- ESRI World topographic Map
Limits of municipalities : SDA20K, 2010-01

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2.2 2D HYDRODYNAMIC MODELLING

2.2.1 DESCRIPTION OF THE MODEL

LOCATION AND HYDROGRAPHIC NETWORK

The area targeted for development is located in the Vaudreuil Canal, which constitutes an outlet of Lake des Deux-Montagnes towards Lake Saint-Louis. This site is at the heart of the Montréal Archipelago, which has a relatively complex hydrography. Lake des Deux-Montagnes, which is upstream from Montréal, is fed by the Ottawa River and has four outlets to the St. Lawrence, namely: the Mille Îles River, the Des Prairies River, the Sainte-Anne Canal and the Vaudreuil Canal. The distribution of flows from the Ottawa River between these four outlets depends on the flow and level of the St. Lawrence. The flow passing through the Vaudreuil Canal is controlled by the Vaudreuil Rapids at the Taschereau Bridge and by the level of the St. Lawrence au Lake Saint-Louis.

HYDRODYNAMIC MODELLING

A 2D hydraulic model was run to assess the flow speeds and depths in the Vaudreuil Canal downstream from the Taschereau Bridge, for the periods targeted. TELEMAC 2D is used to digitally simulate the flows.

TELEMAC 2D, a software program developed by the Laboratoire National d'Hydraulique et Environnement d'Électricité of France, solves shallow-water equation in two dimensions. This calculation software is based on the finite element method. The application of TELEMAC 2D requires that the study area be geometrically scanned to form a set of interrelated triangular elements forming an irregular grid. It enables the depth-averaged speed to be evaluated, as well as the flow depth at each grid node.

MODEL DOMAIN

The model domain is 6 km long, and the area of interest is approximately in the centre of the domain. The downstream limit is at Pointe Pincourt, 4 km upstream from Pointe-des-Cascades. The upstream limit is located approximately in the centre of Vaudreuil Bay.

DIGITAL TERRAIN MODEL

The digital terrain model is based on the bathymetric data gathered in November 2014. Added to these data are the Canadian Hydrographic Service's (CHS) field sheets, as well as the interpretation of satellite images taken during high-water periods in areas difficult to navigate.

The model includes the piers of the Taschereau Bridge's two spans, as well as those of the two rail line spans which pass just upstream from the bridge. All of the islands are also included.

The grid density, that is the space between the computing nodes, was adjusted so as to properly define the area of interest, while obtaining reasonable computing times. The spaces vary from 20 m and the upstream and downstream areas to 2 m in the central area, between the Taschereau Bridge and Île aux Pins. They go down to 1 m around the bridge piers.

BOUNDARY CONDITIONS

The conditions established at the hydraulic model's boundary are an upstream inflow and a downstream water level.

The flow rate in the Vaudreuil Canal is determined by water levels in both Lake des Deux-Montagnes and Lake Saint-Louis. Long data series are available for these two waterbodies at the Sainte-Anne-de-Bellevue (02OA013) and Pointe-des-Cascades (02MC005) hydrometric stations. A relationship was developed (communication from Pierre Dupuis, senior hydraulic engineer with WSP to Claudine Breton, on November 24, 2014) to establish the connection between the water levels at these two hydrometric stations and the flow rate in the Vaudreuil Canal. In the event that the water level is higher in Lake des Deux-Montagnes than in Lake Saint-Louis, and that the latter's water level exceeds 20.987 m, the relationship is as follows:

$$0.2218 \times 300 \times (VAUD - 20.987) \times \sqrt{(2 * 9{,}81)} \times (VAUD - 20.987)^{0{,}7396} \times \left(1 - \left[\frac{PCAS - 20.987}{VAUD - 20.987}\right]^{4.6001}\right)^{0.9543}$$

and

$$VAUD = SADB - 0.0187 \times \left(\sin\left[{}^{(Jourjulien\ -\ 153)}/_{366}\right] \times 2\pi\right) + 0.0247$$

Where:

PCAS = Water level at the Pointe-des-Cascades hydrometric station;

SADB = Water level at the Sainte-Anne-de-Bellevue hydrometric station;

VAUD = Water level at Vaudreuil.

Therefore, in order to simulate the hydrodynamic conditions associated with a given date or period, establish the water levels at the two reference stations for the dates and apply the above equation. The water level corresponding to this flow, at the model's downstream end, is the water level at Pointe-des-Cascades.

2.2.2 MODEL CALIBRATION

The hydraulic model was calibrated using conditions measured during the November 11-12, 2014 survey campaign. During that campaign water levels were measured all along the model domain and flow measurements were taken in the domain's upstream and downstream parts as well as either side of Île aux Pins. The Vaudreuil Canal's flow speed is evaluated at 430 m³/s while the downstream level was 21.32 m.

The parameters used for the 2D model calibration are essentially the bottom friction coefficients (Manning coefficient: n) and the improvement in the definition of singularities in the bathymetry (sills, shoals and canals). The friction coefficients are firstly set following the usual values found in areas characterized by fast, medium or slow flow speeds. These values are then adjusted, downstream to upstream, in an iterative process until the modelled water level corresponds with the measured water levels. The values used are as follows:

- 0.025 upstream from Taschereau Bridge;
- 0.033 to 0.035 in the rapids immediately downstream from the bridge;
- 0.025 to 0.027 in the area of islands upstream from Île aux Pins;

- 0.035 in the arm to the right of Île aux Pins;
- 0.033 in the arm to the left of Île aux Pins;
- 0.025 downstream from Île aux Pins.

There is no more than a 7-cm gap between the measured and simulated water levels, evaluated along two lines on the left and right sides of the watercourse. The largest gaps are in the rapids directly downstream from Taschereau Bridge. The flow apportionment gap between the two arms of Île aux Pins is 8 %.

2.3 MODELLED SCENARIOS

Table 2 shows the evaluated flows and water levels for different analysis periods, covering the spring spawning period. It should be noted that average water levels for this period are evaluated using an average of the daily values recorded from 1972 to 2011. Pre-1972 data was discarded due to changes in flood management following the construction of various structures on the St. Lawrence in the 1960s.

Flows are greater at the beginning of spring, with downstream water levels also being higher at this time.

Table 2 Modelled Hydrological Scenarios

ANALYSIS PERIOD	WATER LEVEL AT SAINTE-ANNE-DE-BELLEVUE (M)	WATER LEVEL AT POINTE-DES-CASCADES (M)	VAUDREUIL CANAL FLOW SPEED (M^3/S)
April 15 to June 15 (full period)	22.51	21.75	610
April 15 to May 15 (first half of the period)	22.75	21.86	792
May 15 to June 15 (second half of the period)	22.28	21.65	455

2.4 SELECTED HABITAT CRITERIA FOR TARGET SPECIES

As part of this project, three species were targeted when establishing the development criteria, namely Smallmouth Bass, Walleye and Lake Sturgeon. There is a large amount of scientific literature available regarding the physical characteristics of these species' spawning sites, especially regarding Walleye and Lake Sturgeon. A detailed summary of the literature available for these two species of fish (taken from Courteille, 2008) is presented in table form in Appendix B. Table 3 summarizes the sites' physical characteristics as well as the three species' spawning period.

Table 3 Spawning Period and Summary of Physical Characteristics of the Three Target Species' Spawning Sites

Species	Spawning Period	Flow (m^3/s)	Depth (m)	Current Speed (m/s)	Calibre of the Substrate
Flowing water					
Walleye	April 15 - May 15	793	Optimal: 0.4 – 1 Extended: 0.2 – 2	Optimal: 0.4 – 1 Extended: 0.3 à 1.5	2-256 mm Cobbles with pebbles and boulders
Lake sturgeon	May 15 -June 15	455	Optimal: 0.4 – 1.25 Extended: 0.2 to 13	Optimal: 0.2 – 1.1 Extended: 0.1 to 1.7	3.0 – 256.0 mm Large rocks (shelter) Clean substrate, no silt, sand, organic particles or vegetation
Calm water					
Smallmouth Bass	May 1st - July 15	455	Optimal: 0.5 – 0.7 Extended: 0.3 – 2.5	Optimal: 0 to 0.3 Extended: 0 to 0.6	Sand, gravel or pebbles

As the Lake Sturgeon and Walleye requirements are generally similar, it was decided to group them together under a single type, that is flowing water spawning grounds, with the Smallmouth Bass' selection criteria corresponding to calm water spawning grounds. The depth criteria for each of these two types were selected so as to take into account the flow variations and the establishment of a layer of spawning substrate (0.5 m thick in flowing water and 0.3 m thick in calm water). In other words, this criterion allows for the selection of a slightly higher range of depths to take into account the placement of new substrate and reaching the desired range. Finally, the speed and depth criteria are wider to encompass various flow conditions. Table 4 presents the flowing water and calm water spawning ground selection criteria.

Table 4 Flowing Water and Calm Water Spawning Ground Selection Criteria

SPECIES	DEPTH (M)	CURRENT SPEED (M/S)
Flowing water spawning grounds	0.9 to 2.5	0.4 to 1.5
Calm water spawning grounds	0.5 to 1.5	< 0.3

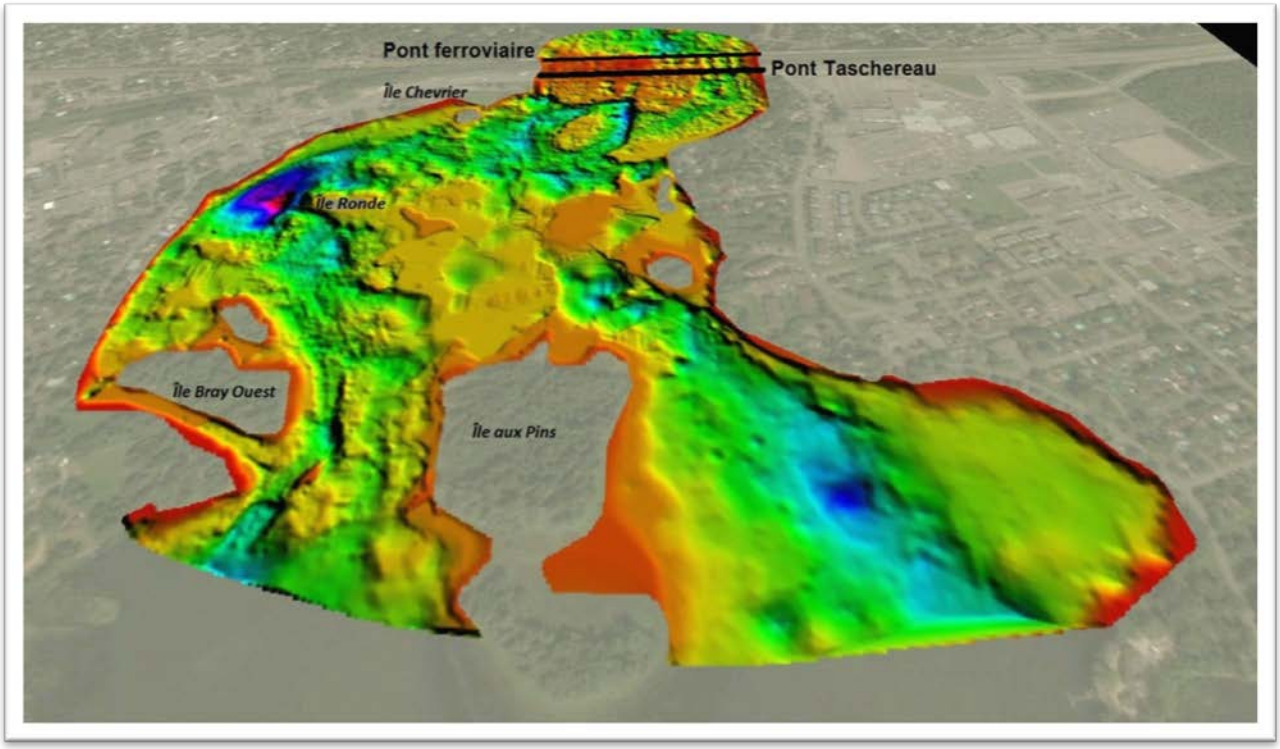
3 BASELINE CONDITIONS

3.1 BATHYMETRY

At the Vaudreuil Rapids, the elevation varies between 20.5 and 21.5 m. There is a deeper channel on the left bank (Île Perrot) where the elevation at the bottom of the navigation channel varies between 19 and 19.5 m. Immediately at the foot of the plateau, where the rapids flow, there is a trench (between 18.0 and 18.5 m) surrounding a shoal (20.5 m). The flow section between Île Bray Ouest and Île aux Pins consists of two separate channels separated by a shoal where the elevation reaches between 20 and 20.5 m. The channel running along Île Bray Ouest is narrower and deeper (19.0 m) while the channel running along Île aux Pins is wider and shallower (19.5 m). The central portion of the study area, upstream from Île aux Pins, consists of a shoal where the topography varies between 19.5 and over 20.5 m. Finally, there is a pit with a central elevation of less than 12 m is directly west of Île Ronde.

During the November 2014 surveys, under flow conditions of 410 m^3/s, the depths on the plateau downstream from Taschereau Bridge varied between 0.5 and 2 m. The maximum depth at the centre of the trench located to the west of Île Ronde was less than 11 m. Figure 2 shows a 3D view of the study area's topography.

Figure 2 3D View of the Study Area's Topography



3.2 SUBSTRATE AND VEGETATION

The substrate characterization allowed the division of the study area into areas of uniform substrate. It should be noted that emphasis was put on areas targeted in the Dessau-Cima study (2013). Outside of these areas, the areas of substrate were defined for the entire study area from spot observation stations.

Over the majority of the study area, the substrate consists of coarse particles. The most commonly found type of substrate is the cobble-pebble combination. At the bridges, the substrate is mainly made up of cobbles. Throughout the study area, pockets of boulders, rock and cobbles-gravel can be found. Within the bays where the flow slows down, the substrate is more dominated by sand with fine particles.

At the time of the inventories, the substrate in certain sectors of the study area was still covered with aquatic vegetation. In some areas, especially at the rapids, in the area immediately downstream from the Taschereau Bridge, the vegetation totally covers the substrate. At the rapids, the majority of this vegetation consists of a moss (*Fontinalis sphagnifolia)*. It is important to mention that a few threadfoot (*Podostemum ceratophyllum*) specimens were also seen at this rapid (see photos - DVD). The locations of these observations are shown on Map 2. This plant is considered likely to be designated as threatened or vulnerable in the province of Québec. An historical occurrence dating from 1981 of this plant, surveyed by the Centre de données sur le patrimoine naturel du Québec (CDPNQ) is located on the edge of Île aux Pins (Map 2). The list of species likely to be designated as threatened or vulnerable plays a preventative role. It officialises the precarious situation of the so designated species and provides direction for the stabilisation and improvement of their situation. Finally, the species on this list may be the subject of programs and activities designed to assess their situation, and thus adjust their status, to either threatened or vulnerable.

It will be important to evaluate the density of the aquatic vegetation cover during breeding season, that is right after the ice recedes, to determine whether the presence of aquatic vegetation could reduce the site's spawning potential.

At the rapid, in the area under the Taschereau Bridge and the Canadian National Bridge, quarry stone was seen at several stations. This material could have come from a jetty used during the refurbishment of the Taschereau Bridge in 2002.

Map 2 shows the distribution of substrate types encountered, the position of grass beds as well as the backfill area under the Taschereau Bridge.

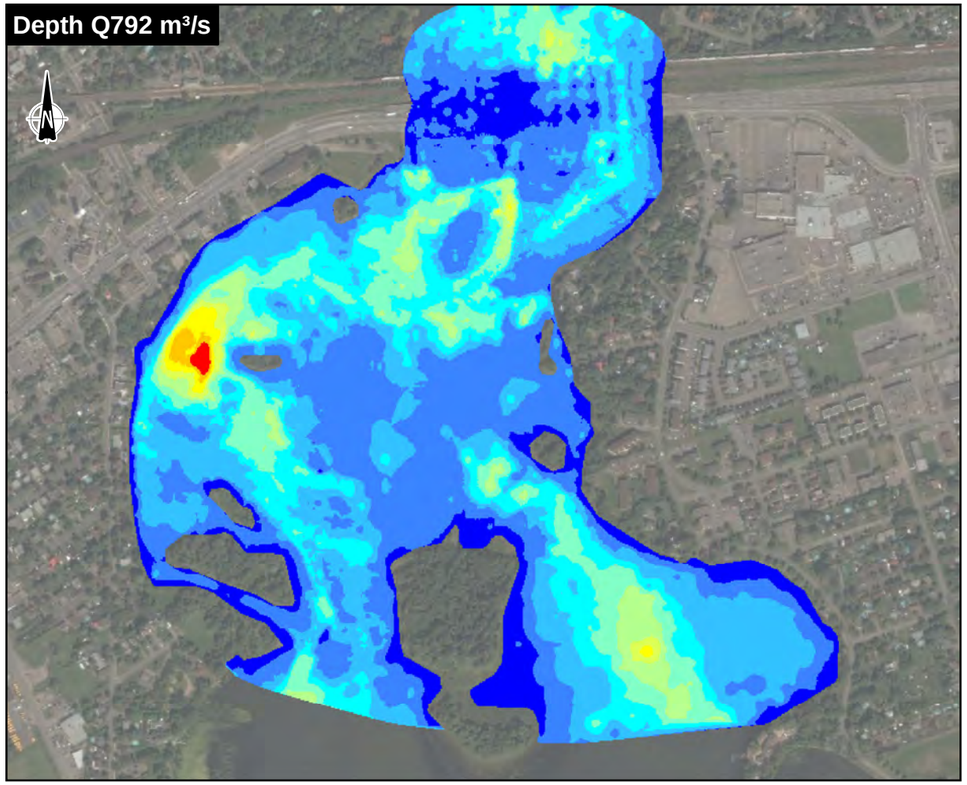
3.3 HYDRODYNAMIC CONDITIONS

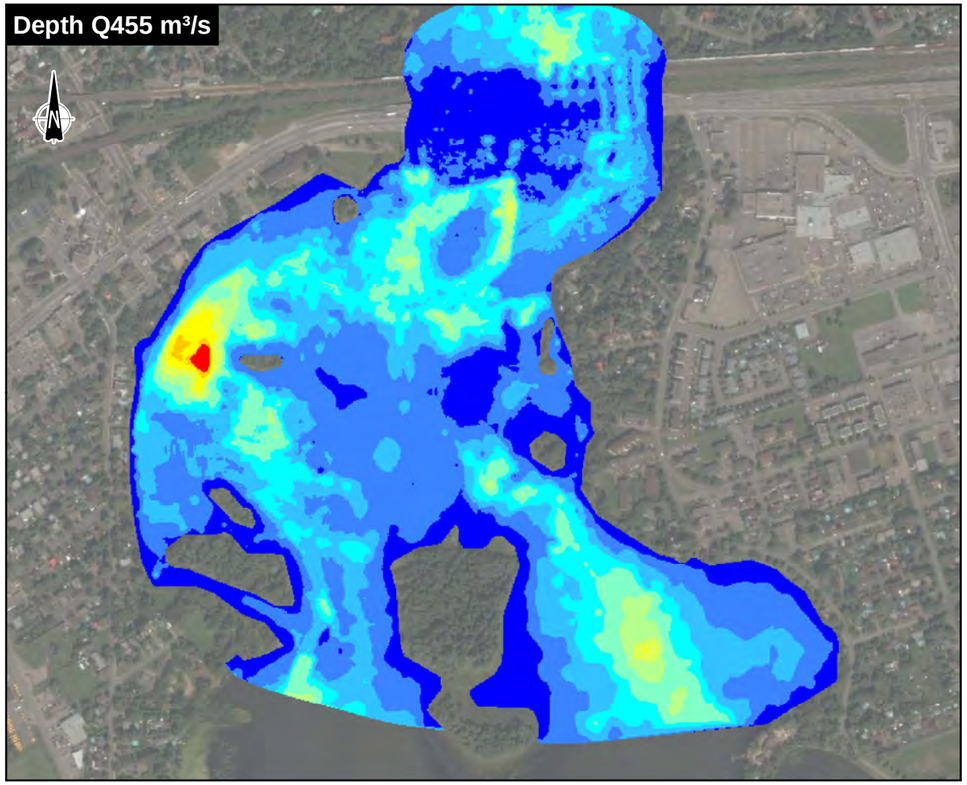
3.3.1 FLOW SPEED

Under 793 m^3/s flow conditions, flow speeds vary between 0 and 2.9 m/s with an average of 0.6 (standard deviation of 0.48 m/s). Under 455 m^3/s flow conditions, flow speeds vary between 0 and 2.5 m/s with an average of 0.4 (standard deviation of 0.36 m/s). For both scenarios, the fastest speeds are found at the rapids. The modelling results are presented in Map 3.

3.3.2 DEPTH

Under 793 m^3/s flow conditions, the maximum depth is 11.2 m and the average is 2.5 m (standard deviation of 1.44 m). Under 455 m^3/s flow conditions, the maximum depth is 10.8 m and the average is 2.2 m (standard deviation of 1.43 m). The modelling results are presented in Map 3.





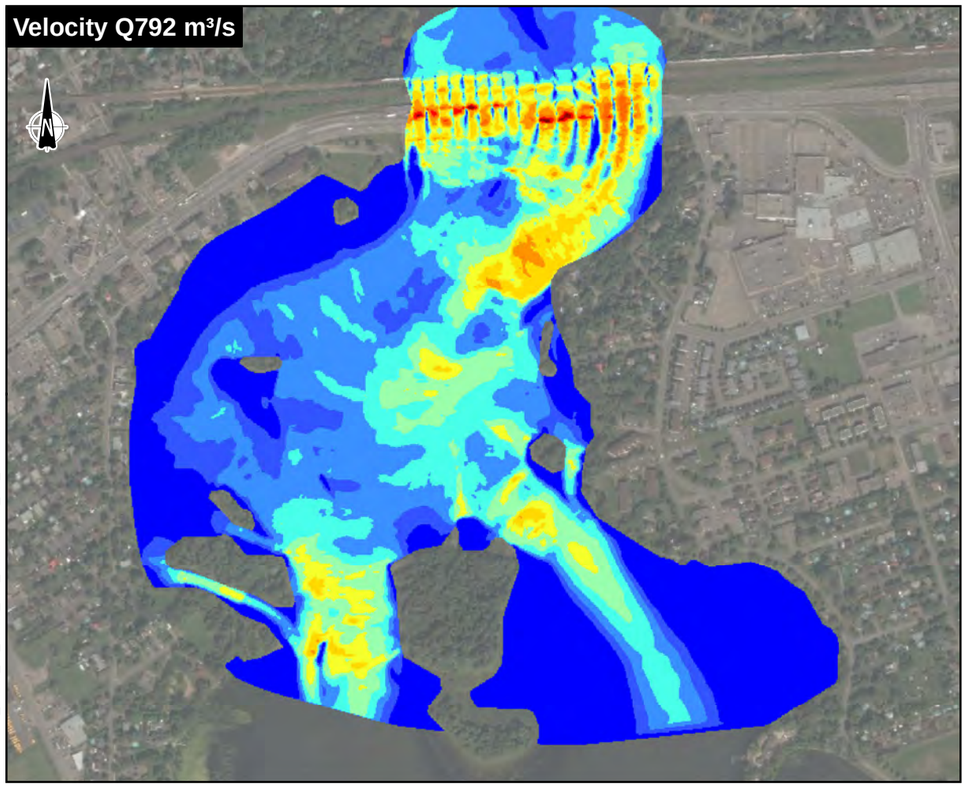
Depth (m)

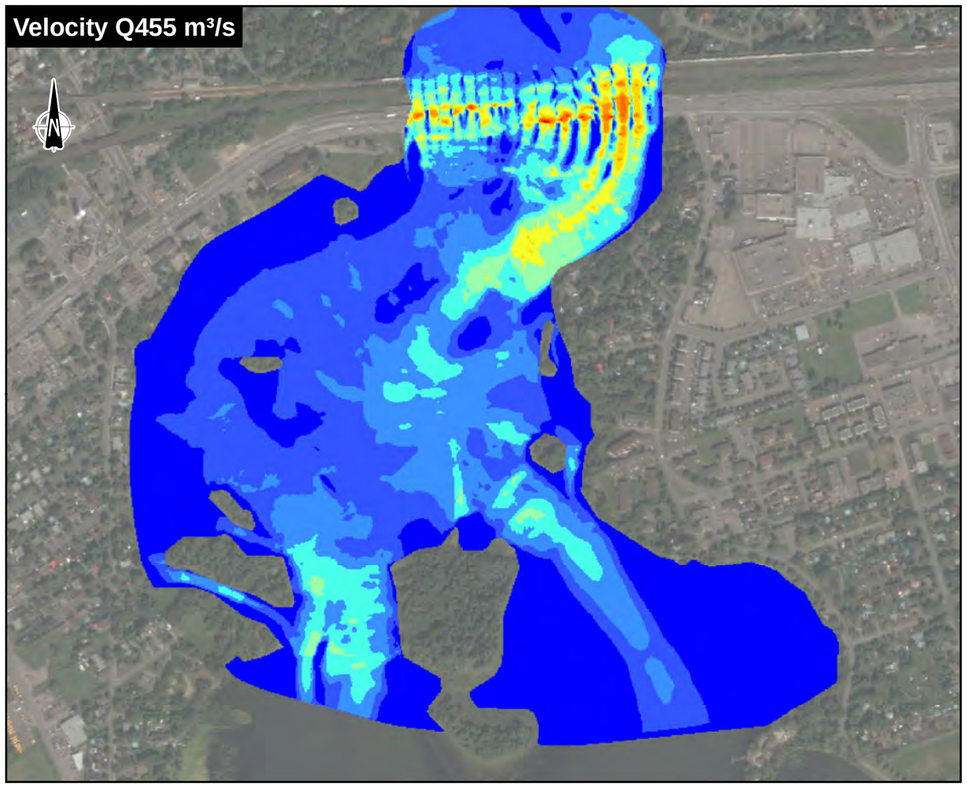
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 12

Velocity (m/s)

- 0,00 - 0,25
- 0,25 - 0,50
- 0,50 - 0,75
- 0,75 - 1,00
- 1,00 - 1,25
- 1,25 - 1,50
- 1,50 - 1,75
- 1,75 - 2,00
- 2,00 - 2,25
- 2,25 - 2,50
- 2,50 - 2,75
- 2,50 - 2,75

Analysis period	Water level at Ste-Anne-de-Bellevue (m)	Water level at Pointe-des-Casacades (m)	Vaudreuil Channel discharge (m³/s)
April 15 to June 15	22,51	21,75	610
April 15 to May 15	22,75	21,86	792
May 15 to June 15	22,28	21,65	455





THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

OTTAWA RIVER AQUATIC HABITATS CHARACTERISATION

Downstream of Taschereau Bridge, Dorion, Quebec

Map 3

Simulated flow velocities and depth (discharge:455 m³/s and 792 m³/s)

Sources :

Satellite image : ESRI World Imagery, DigitalGlobe (2010-03-07)
Maps: - BNDT, RNCan, 1 : 250 000, 31G et 31H
- ESRI World topographic Map
Limits of municipalities : SDA20K, 2010-01

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3.4 SPAWNING GROUND HABITAT POTENTIAL FOR TARGET SPECIES WITHIN THE STUDY AREA

The modelling results for the flows corresponding to the target species' spawning periods were used to identify the sectors with spawning ground potential for these species. These sectors were identified using the criteria presented in Table 3. The flow and depth matrices were reclassified according to the optimal and extended ranges for each species. Then, arbitrary values were attributed to the two ranges: the optimal range = 2 and the extended range = 1. Finally, the two matrices thus created per target species (flow and depth) were multiplied. The results of these calculations for the three species are presented in Appendix C.

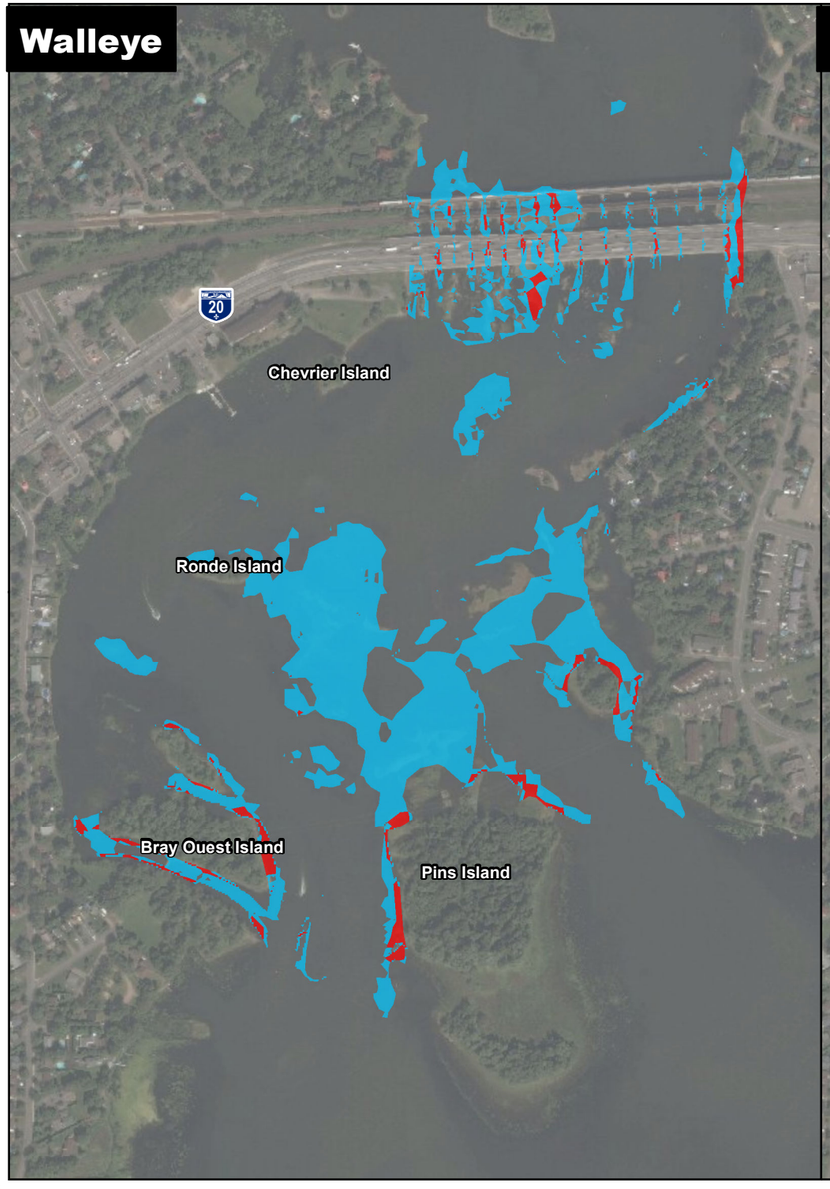
Map 4 was produced using the flow model-based calculations, the results of which are presented in Appendix C. This map presents the spawning potential for the three target species under the flow conditions corresponding to each one's spawning period. For the three species, the areas of mixed potential (blue) correspond to sectors where one of the parameters (depth or speed) is within the optimal range and the second is within the extended range. The areas of optimal potential (red) correspond to sectors where both parameters are within the optimal range.

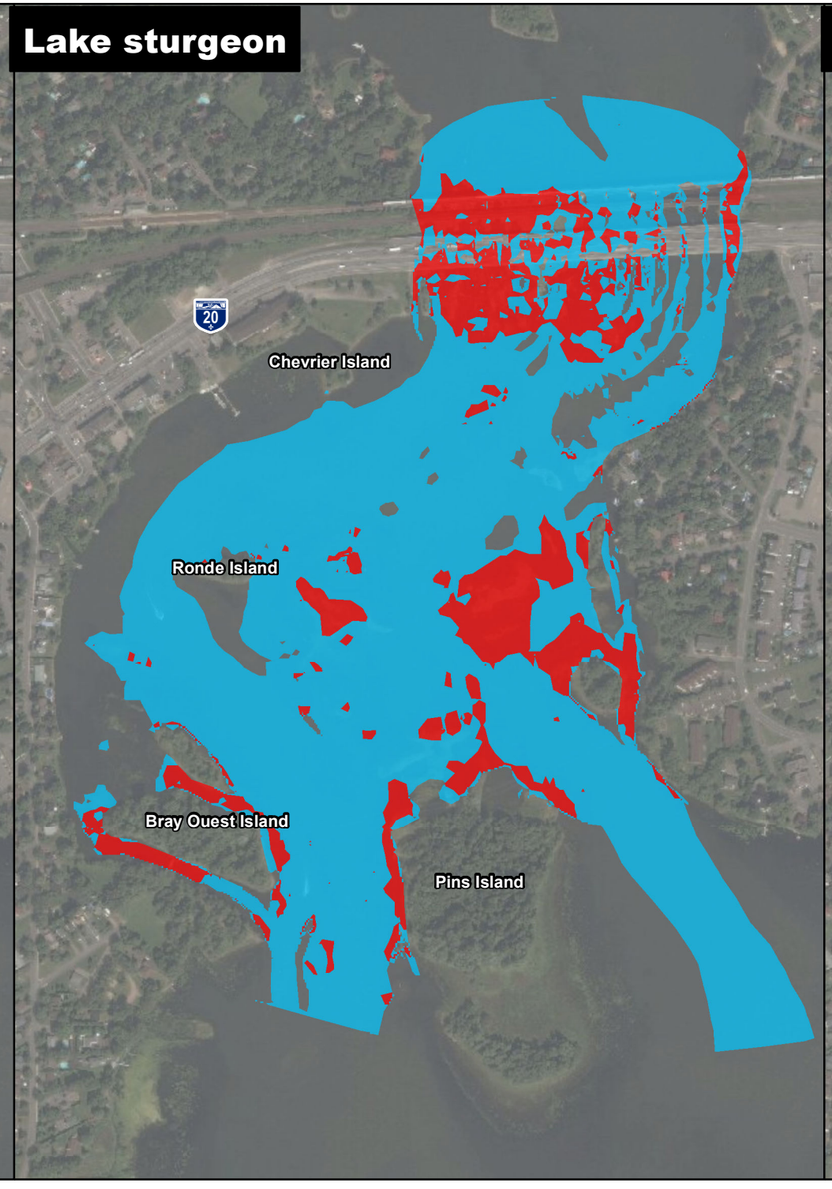
In the case of Walleye, for a flow rate of 793 m^3/s, the sector downstream from Taschereau Bridge provides mixed speed and depth ranges in certain portions; the speeds are either in the extended or optimal range, while depths are mainly in the extended range (between 1.2 and 1.8 m). There are a few pockets within the optimal range downstream from Taschereau Bridge, at Île Bray Ouest, Île aux Pins and around a small island near the shores of Île Perrot around 5e Avenue.

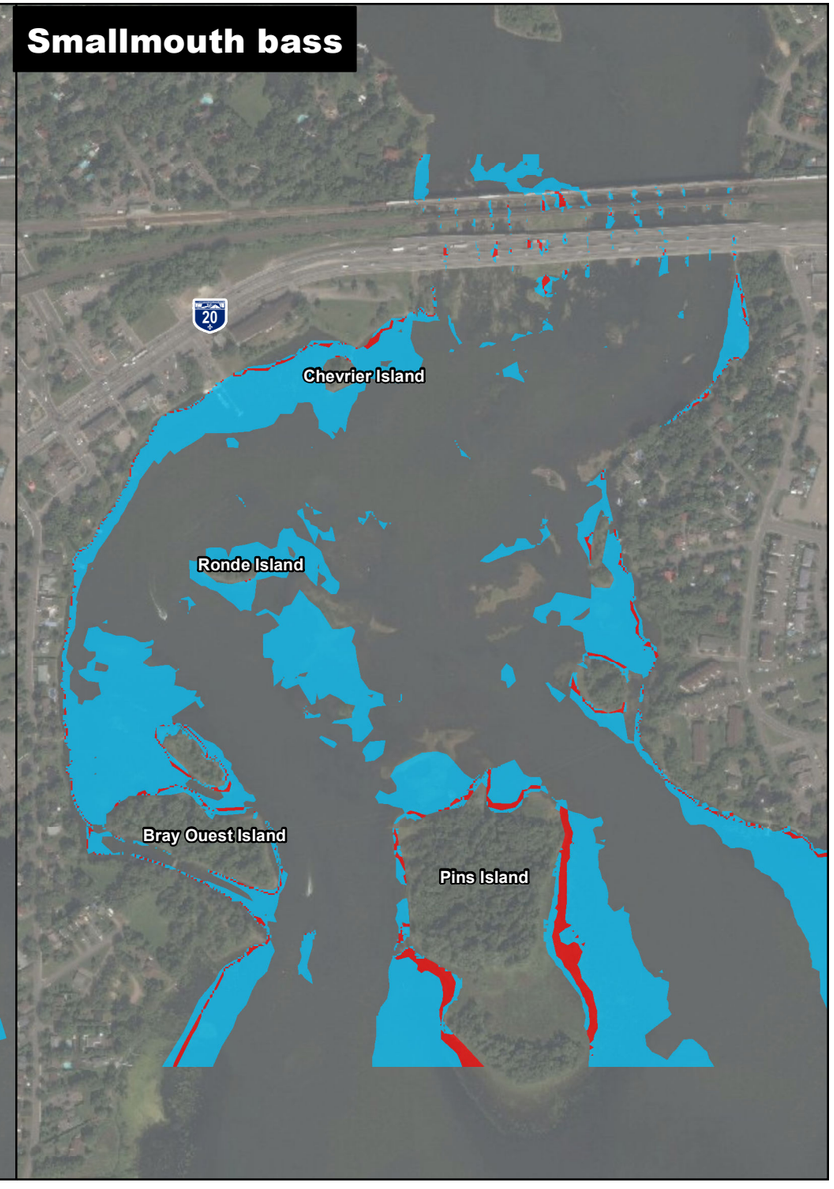
For Lake Sturgeon, under 455 m^3/s flow conditions, numerous sectors provide speed and depth conditions within the optimal range for this species both in the portion downstream from Taschereau Bridge, the Îles Bray Ouest and aux Pins as well as the shores of Île Perrot. However the majority of the study area provides mixed speed and depth ranges.

Finally, for Smallmouth Bass, under 455 m^3/s flow conditions, the optimal conditions for this species can be found along a narrow strip along the banks of the study area.

Within most of the study area, the substrate is dominated by large cobbles with occasionally pebbles. There is however a decided lack of large boulders able to provide shelter. Also, there is generally no gravel. Thus, the substrate is coarse and very homogeneous. It could improve the spawning habitat available for the target species to add smaller material as well as large boulders.







Potentiel de fraie

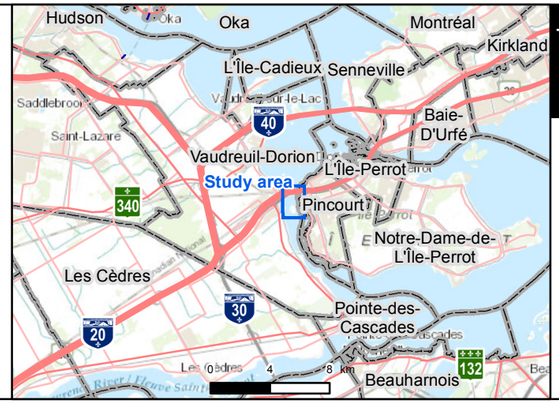
- Mixed potential
- Optimal potential

Species	Spawning Period	Flow (m^3/s)	Depth (m)	Current Speed (m/s)	Calibre of the Substrate
Flowing water					
Walleye	April 15 - May 15	793	Optimal: 0.4 – 1 Extended: 0.2 – 2	Optimal: 0.4 – 1 Extended: 0.3 à 1.5	2-256 mm Cobbles with pebbles and boulders
Lake sturgeon	May 15 -June 15	455	Optimal: 0.4 – 1.25 Extended: 0.2 to 13	Optimal: 0.2 – 1.1 Extended: 0.1 to 1.7	3.0 – 256.0 mm Large rocks (shelter) Clean substrate, no silt, sand, organic particles or vegetation
Calm water					
Smallmouth bass	May 1st - July 15	455	Optimal: 0.5 – 0.7 Extended: 0.3 – 2.5	Optimal: 0 to 0.3 Extended: 0 to 0.6	Sand, gravel or pebbles

0 75 150 300 m

1:7 500

Projection : NAD83, MTM fuseau 8



THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

OTTAWA RIVER AQUATIC HABITATS CHARACTERISATION

Downstream of Taschereau Bridge, Dorion, Quebec

Map 4

Spawning ground potential in the study area for the three target species

Sources :

Satellite image : ESRI World Imagery, DigitalGlobe (2010-03-07)
Maps: - BNDT, RNCan, 1 : 250 000, 31G et 31H
- ESRI World topographic Map
Limits of municipalities : SDA20K, 2010-01

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March 30, 2015 141-24230-00

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4 POTENTIAL DEVELOPMENT SITES AND IDENTIFICATION OF SITES NEEDING RESTORATION

4.1 POTENTIAL DEVELOPMENT SITES

The study area's spawning potential for the three target species having been demonstrated, we can now proceed with analyzing the potential development sites.

As presented in Section 2.4, in order to efficiently identify potential development sites, the spawning site selection parameters for the three target species were grouped together under two selection criteria types, that is flowing water spawning grounds and calm water spawning grounds. The selection criteria for these two types of habitats are presented in Table 4

Then, a second, subjective, selection was made so as to prioritize areas with the greatest potential for attracting spawners and providing access for any eventual work. Indeed, certain species of fish, including Lake Sturgeon and Walleye, gather at points (perpendicular to the flow) or other areas where the flow narrows. This second selection also took into account technical considerations, such as the ability of machinery to access the site. The results of the full potential development site selection process are presented on Map 5.

4.1.1 FLOWING WATER SPAWNING GROUNDS

Map 5 shows the flowing water spawning ground development sectors. According to this selection, a little over 90,000 m^2 could be developed for use between April 15 and June 15 by flowing water-spawning fish species, including Walleye and Lake Sturgeon.

These zones were determined by superposing zones corresponding to flowing water spawning habitat selection criteria (Table 4) under the two flow conditions (455 and 793 m^3/s). The results of this superposition are presented in Appendix D. It is proposed that a substrate be put in place in these areas made up of 80-to-250-mm stone with larger boulders providing downstream resting areas. A typical cross-section of this is presented in Figure 3.

The area of rapids immediately under the bridges was excluded from the selection, despite providing good development potential, as the numerous piers along the riverbank make accessing the area with machinery difficult. However, the portion of rapids downstream from the bridges could still be developed.

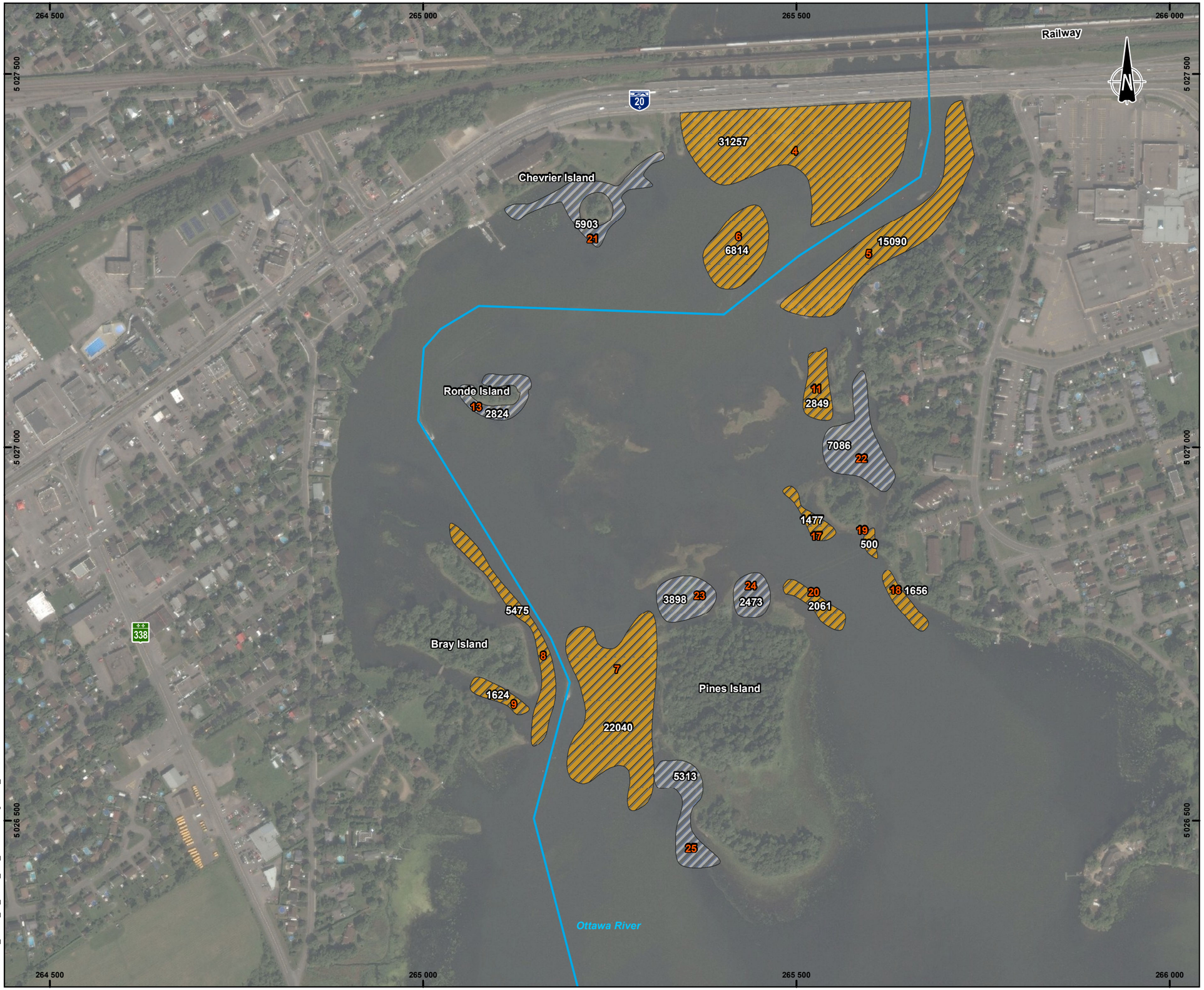
Appendix E contains a table detailing the surface areas within each development sector with spawning potential for the two target species.

4.1.2 CALM WATER SPAWNING GROUNDS

There is a total of a little over 27,000 m^2 with calm water spawning ground development potential (Map 5). These development sectors were selected using zones corresponding to calm water spawning habitat selection criteria (Table 4 and Appendix D).

The proposed development includes the installation of submerged rocky islets made up of boulders and gravel providing areas for Smallmouth Bass to nest during spawning season. These rocky islets will be placed at regular intervals (±10 m) within the target areas. A cross-section of this is presented in Figure 4.

Appendix E contains a table detailing the surface areas within each development sector with spawning potential for Smallmouth Bass.



Navigation channel

Potential development areas

Flowing water spawning site (90 845 m²)

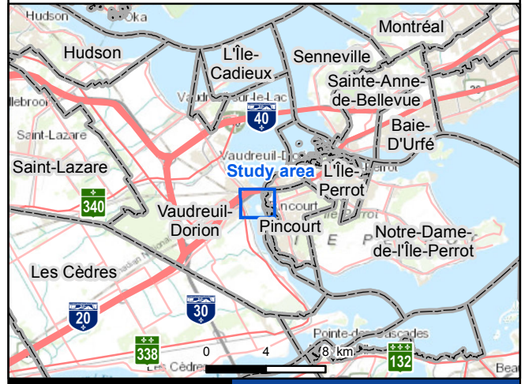
Calm water spawning site (27 497 m²)

Specie	Range
Flowing water	
Depth	0,9 to 2,5 m
Velocity	0,4 to 1,5 m/s
Calm water	
Depth	0,5 to 1,5 m
Velocity	< 0,3 m/s

0 50 100 200 m

1 : 5 000

Projection : NAD83, MTM fuseau 8



THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

OTTAWA RIVER AQUATIC HABITATS CHARACTERISATION

Downstream of Taschereau Bridge, Dorion, Quebec

Map 5

Potential Development Areas

Sources :

Satellite image : ESRI World Imagery, DigitalGlobe (2010-03-07)
Maps: - BNDT, RNCan, 1 : 250 000, 31G et 31H
- ESRI World topographic Map
Limits of municipalities : SDA20K, 2010-01

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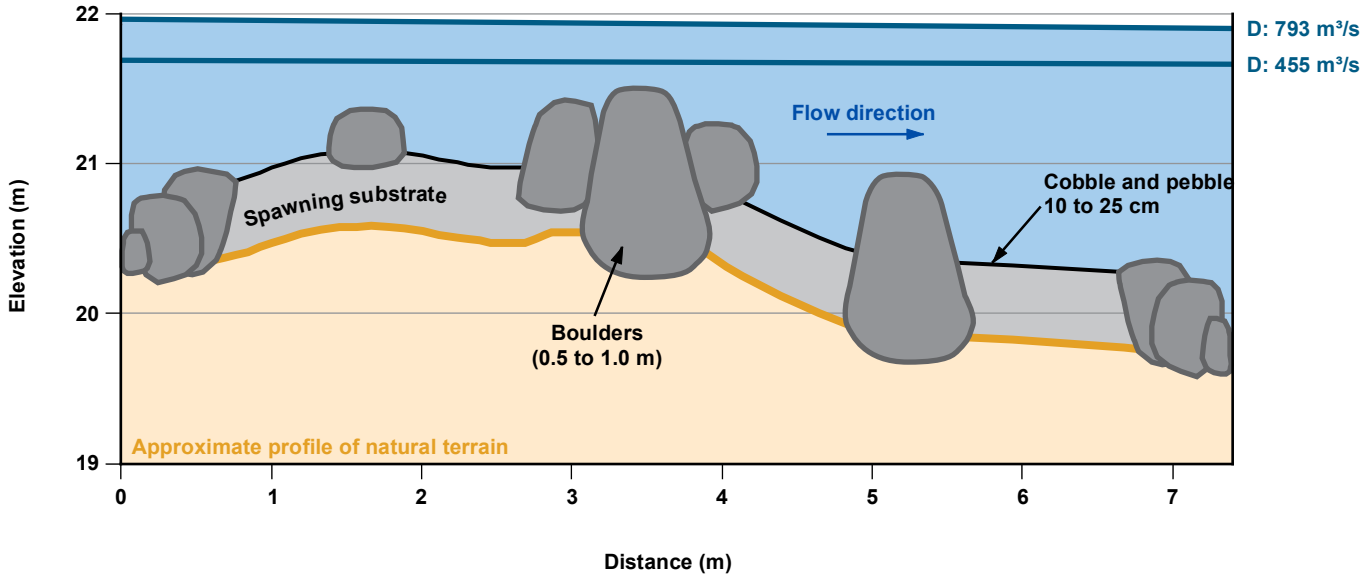

D: discharge corresponding to water level

THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

OTTAWA RIVER AQUATIC HABITATS CHARACTERISATION

Downstream of Taschereau Bridge, Dorion, Quebec

Figure 3

Potential spawning ground cross-sectional view Flowing water spawning site

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Approuved : P. Lafrance

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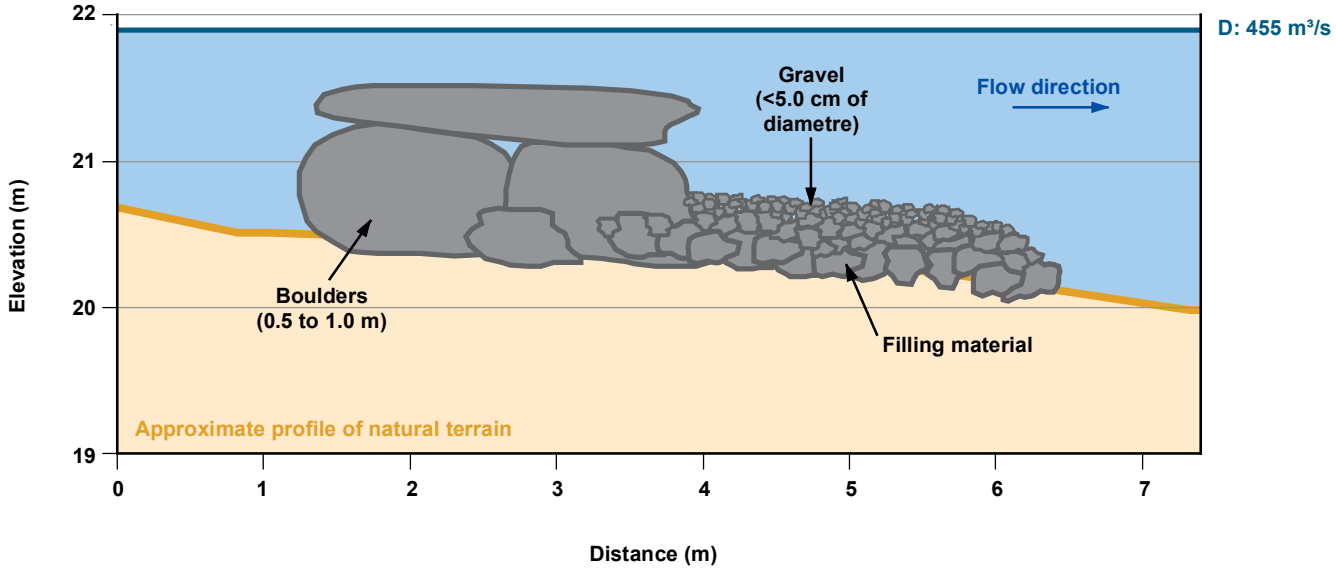

D: discharge corresponding to water level

THE JACQUES CARTIER AND CHAMPLAIN BRIDGES INCORPORATED

OTTAWA RIVER AQUATIC HABITATS CHARACTERISATION

Downstream of Taschereau Bridge, Dorion, Quebec

Figure 4
Potential spawning ground
cross-sectional view
Calm water spawning site

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Approuved : P. Lafrance

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4.2 SITE TO BE RESTORED

A Walleye spawning ground extending from the CN bridge to 60 m downstream from the Taschereau Bridge was identified during the Archipel Project Work in 1984. At the time, this spawning ground consisted of a series of trenches and small rocky plateaux. However, according to an outfitter active in this section of the Ottawa River, the Taschereau Bridge refurbishment work carried out in 2002 significantly changed the environment (S.-E. Picard DFO, pers. comm.). According to this witness, the materials used for a temporary jetty were left in place, thus filling in the trenches and raising the plateaux. Therefore, the spawning ground has lost its attraction since this work was carried out. During low spring floods, certain portions are exposed and only a small section of the original spawning ground on the right bank is used by Walleye (DESSAU-CIMA+ 2013).

Following the characterization work carried out for the current mandate, the following observations can be made regarding this area:

- The area infilled seems limited to the sectors immediately under the bridges, as demonstrated by visual observations made during the substrate characterization (Map 2);
- Despite the additional bathymetric survey conducted immediately downstream from Taschereau Bridge compared to the 2000 survey, no trace of a significant amount of fill material was found.

However, while no traces of fill were clearly identified downstream from the bridge as part of this study, the sector could be developed so as to optimize spawning conditions for flowing water species such as Walleye and Lake Sturgeon. However, this would not be a restoration, but rather an improvement of an existing spawning ground.

5 NEXT STEPS AND TIMETABLE

The implementation of such a project requires the steps set forth in Table 5. It should be noted that no work can be carried out in water during the fish spawning protection period. This period shall be defined by the relevant authorities, but could extend between April 1st and July 15.

Table 5 Completion Stages and Timetable

STAGE	DESCRIPTION	DATE
Development of the overall design	→ Development of a detailed design for the entire study area → Assessment of the impact of development on hydraulic conditions in the studied area. Evaluation of the development's resistance to floods, the effects of ice and of substrate clogging. → Production of plans → Strategy for development construction	Spring and Summer 2015
Spring field validation	→ Evaluate the density of moss, *Fontinalis sphagnifolia*, cover in the spring just before the beginning of spawning; → Evaluate the use of each target species' different potential development sites during spawning season, to optimize the development designs to take into account existing spawning grounds.	Spring 2015
Tender process		Fall-Winter 2015
Construction phase 1		Summer-Fall 2016
Construction phase 2		Summer-Fall 206

Finally, once the development has been completed, their integrity and effectiveness shall be monitored over a period of time yet to be determined. The aspects monitored will include physical characteristics, stability, the use of sites by spawners and signs of spawning.

6 CONCLUSION

The characterization conducted as part of this mandate provided a detailed portrait of the spawning potential within the study area. This exercise highlighted several sectors with strong development potential within the study area.

Several sites provide the right conditions for developing calm water spawning grounds according to a flow scenario corresponding to May 1st to July 15, thus could benefit, among others, Smallmouth Bass. In the case of flowing water spawning grounds, the locations were selected so as to take into account the target species' (Lake Sturgeon and Walleye) physical characteristics as well as two flow scenarios covering April 15 to June 15. By applying these more flexible selection parameters, these developed areas could be used under different flow conditions as well as by several species (suckers and redhorse) in addition to those targeted.

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Appendix A

RAW DATA – SUBSTRATE CHARACTERIZATION

Caractérisation du substrat: Rapides de Vaudreuil date:

id_station	date	id_enregistrement	prof	Courant	Roc	Bloc	Galet	Caillou	Gravier	Sable	Fines	Trace Fine	Végé	Pierre net	Commentaire	Substrat dominant	Substrat Codominant
183	2014-11-10	10:59 / 11:00	0,8	<1		90	10							1		Bloc	Galet
184	2014-11-10	11:06	0,5	>1		100							50	1		Bloc	
185	2014-11-10	11:11	0,5	>1		10	40	50						0		Caillou	Galet
186	2014-11-10	11:30	0,6	<0,5	90	5	5					1		1		Roc	Bloc
187	2014-11-10	11:46	0,5	1		10	45	45				1		1		Galet	Galet
188	2014-11-10	11:57	0,6	>1		1	1						100	2		Bloc	Bloc
189	2014-11-10	12:06	0,7	>1		5	50	10	35				30	0		Galet	Gravier
190	2014-11-10	12:16	0,5	>1			60	40					10	0		Galet	Caillou
191	2014-11-10	12:53	0,5	1		20	35	25	15	5				1		Galet	Caillou
192	2014-11-10	13:09	1,1	0,5			75	25						1		Galet	Caillou
193	2014-11-10	13:07	0,7	>0,5			25	75					10	0		Caillou	Galet
194	2014-11-10	13:14	0,8	1			40	30	30				10	0		Galet	Caillou
195	2014-11-10	13:22	0,6	>1			1						100	2		Galet	
196	2014-11-10	13:27	0,6	>1			1						100	2		Galet	
197	2014-11-10	13:38/13:36	0,9	>1,5		30	70							1		Galet	Bloc
198	2014-11-10	13:41	1	>1,5			100							1		Galet	
199	2014-11-10	13:51	0,5	>1			100						10	0		Galet	
200	2014-11-10	13:56	1	<0,5			50	50				1	10	0		Galet	Galet
201	2014-11-10	14:01	0,6	1		25	75						10	1		Galet	Bloc
202	2014-11-10	14:04	1	>0,5			1						100	2		Galet	
203	2014-11-10	14:09	0,7	>1,5			85	15						1		Galet	Caillou
204	2014-11-10	14:22	1,1	<0,5			50	50				1	10	0		Galet	Galet
205	2014-11-10	14:28	1	>1,5			1						100	2		Galet	
206	2014-11-10	14:32	0,9	>1,5			1						100	2		Galet	
207	2014-11-10	14:35	0,7	>1,5			100							1		Galet	
208	2014-11-10	14:41	1,6	0,5		5	75	20				1	10	0		Galet	Caillou
209	2014-11-10	14:47/14:49	9	>1			1			1			50	2		Galet	Galet
210	2014-11-10	14:52	0,7	>1			1						100	2		Galet	
211	2014-11-10	14:57	0,8	>1,5			100							1		Galet	
212	2014-11-10	15:05	0,6	>1,5			75	25				1		1		Galet	Caillou
213	2014-11-10	15:08	0,8	1			1						100	2		Galet	
214	2014-11-11	10:04/10:05	0,6	>1			75	25					50	0		Galet	Caillou
215	2014-11-11	10:11	0,4	>1			50	50				1	10	0		Galet	Galet
216	2014-11-11	10:14	1,3	>1			50	25	25			1		0		Galet	Caillou
217	2014-11-11	10:25	1,9	<0,5		40	40	10	10			1		0		Bloc	Bloc
218	2014-11-11	10:29/10:31/10:32	0,9	>1,5			1	1					100	2		Galet	Galet
219	2014-11-11	10:36	0,7	>1,5			1						100	1		Galet	
220	2014-11-11	10:42	0,8	>1		50	50							1		Bloc	Bloc
221	2014-11-11	10:51	0,7	>1			95	5						0		Galet	Caillou
222	2014-11-11	10:55	0,5	>1			1	1					100	2		Galet	Galet
223	2014-11-11	10:58/11:00	0,3	>1,5			1	1					100	2	probablement pierre naturelle	Galet	Galet
224	2014-11-11	11:09	1,8	>0,5			50	50				1	10	0		Galet	Galet
225	2014-11-11	11:15	0,7	>2			1						100	1		Galet	
226	2014-11-11	11:19	0,7	>1,5			50	50						1		Galet	Galet
227	2014-11-11	11:22	0,7	>1,5			50	50						1		Galet	Galet
228	2014-11-11	11:30	0,7	>1,5			50	25	25					0		Galet	Caillou

Caractérisation du substrat: Rapides de Vaudreuil

date:

id_station	date	id_enregistrement	prof	Courant	Roc	Bloc	Galet	Caillou	Gravier	Sable	Fines	Trace Fine	Végé	Pierre net	Commentaire	Substrat dominant	Substrat Codominant
229	2014-11-11	11:36	0,4	1			100					1		1		Galet	Fine
230	2014-11-11	11:41	0,6	<0,5			75	25					10	0		Galet	Caillou
231	2014-11-11	11:50	0,8	<0,5				30		70		1		0		Sable	Caillou
232	2014-11-11	12:16	0,3	>1			70	30						1		Galet	Caillou
233	2014-11-11	12:19	0,7	>1,5			1						100	2		Galet	
234	2014-11-11	12:23	1,4	>1			60	30	10				50	0		Galet	Caillou
235	2014-11-11	12:38	0,6	<0,5			50	50						1		Galet	Galet
236	2014-11-11	12:41	0,4	<0,5			50	50						1		Galet	Galet
237	2014-11-11	12:47	1	<0,5			100					1		1		Galet	Fine
238	2014-11-11		5,4	<0,5										2	pas assez de lumière	Roc	
239	2014-11-11	13:23	1,6	>1,5			1						100	2		Galet	
240	2014-11-11	13:34	1	>1,5			100							1		Galet	
241	2014-11-11	13:38/13:40	1	>1,5		50	50							1		Bloc	Bloc
242	2014-11-11	13:50	0,6	>2			1						100	2		Galet	
243	2014-11-11		0,7	>2			1						100	2	pas d'enregistrement problème cable	Galet	
244	2014-11-11		2,4	<1			100							1		Galet	
245	2014-11-11		1,4	>1,5		10	60	30						1		Galet	Caillou
246	2014-11-11		1,3	>1,5			50	50				1		1		Galet	Galet
247	2014-11-11		3	>1			100							1		Galet	
248	2014-11-11		1,8	>1,5			100							1		Galet	
249	2014-11-11		1,9	>1,5			100							1		Galet	
250	2014-11-11		3,1	>1		100								1		Bloc	
251	2014-11-11		2,5	>1,5			100							1		Galet	
252	2014-11-11		2,2	>2											trop de courant pas possible avec downrigger	Roc	
253	2014-11-11														pas d'observation	Roc	
254	2014-11-11		2	>1,5			1	1					75	0		Galet	Galet
255	2014-11-11		1,8	>1			1	1	1				100	2		Galet	Galet
256	2014-11-11		1,1	>1			1	1	1				100	2		Galet	Galet
257	2014-11-11		1,6	>1			1	1					100	2		Galet	Galet
258	2014-11-12	10:20	2	0,5		50	50							0		Bloc	Bloc
259	2014-11-12	10:25	1,1	0,5			75	25				1	10	0		Galet	Caillou
260	2014-11-12	10:30	1,9	1			75	25				1	10	0		Galet	Caillou
261	2014-11-12	10:39	2,4	0,5			100							0		Galet	
262	2014-11-12	10:43	1,5	>0,5			50	50				1	10	0		Galet	Galet
263	2014-11-12	10:47	2,1	0,5			75	25				1	10	0		Galet	Caillou
264	2014-11-12	10:53	0,5	>0,5			75	25				1	50	0		Galet	Caillou
265	2014-11-12	10:57	1,1	1			95			5		1	10	0		Galet	Sable
266	2014-11-12	11:03	1,4	0,5			90	10				1	10	0		Galet	Caillou
267	2014-11-12	11:18	0,5	1				2		1		1	100	0		Caillou	Sable
268	2014-11-12	11:22	1,5	1			100						10	0		Galet	
269	2014-11-12	11:37	1,6	>1			20	45	35			1	10	0		Caillou	Gravier
270	2014-11-12	11:43	0,9	>1			1		1				100	2		Galet	Galet
271	2014-11-12	11:57	2	>1			90	10				1		0		Galet	Caillou
272	2014-11-12	12:02	2,5	>1			20		80			1		0		Gravier	Galet
273	2014-11-12	12:05	2,5	>1			100							0		Galet	
274	2014-11-12	12:11	1,3	>1,5			1		1				100	2		Galet	Galet

Caractérisation du substrat: Rapides de Vaudreuil date:

id_station	date	id_enregistrement	prof	Courant	Roc	Bloc	Galet	Caillou	Gravier	Sable	Fines	Trace Fine	Végé	Pierre net	Commentaire	Substrat dominant	Substrat Codominant
275	2014-11-12	12:18	2,4	>2			100							0		Galet	
276	2014-11-12	12:22	1,8	>1,5			80	20	1					0		Galet	Caillou
277	2014-11-12	12:57	0,5	<0,5			75	25				1	10	0		Galet	Caillou
278	2014-11-12	13:00	1,5	<0,5			75	25				1	10	0		Galet	Caillou
279	2014-11-12	13:03	1,4	<0,5			75	25				1	10	0		Galet	Caillou
280	2014-11-12	13:06	2,2	<0,5			75	25				1	10	0		Galet	Caillou
281	2014-11-12	13:09	1,4	<0,5			75	25				1	10	0		Galet	Caillou
282	2014-11-12	13:12	2,1	<0,5			50	20	30				10	0		Galet	Gravier
283	2014-11-12	13:16	1,5	<0,5			40	60				1		0		Caillou	Galet
284	2014-11-12	13:19	1	<0,5							100		10	0		Fine	
285	2014-11-12	13:24	0,8	<0,5							100		10	0		Fine	
286	2014-11-12	13:26	1,5	<0,5		40	20	10		30		1		0		Bloc	Sable
287	2014-11-12	13:31	2,5	<0,5			70	30						0		Galet	Caillou
288	2014-11-12	13:33	1	<0,5			10	10		80		1	10	0		Sable	Galet
289	2014-11-12	13:41		<0,5		10	40	40		10		1	10	0		Galet	Galet
290	2014-11-12	13:54	0,7	0,5			50	50				1		0		Galet	Galet
291	2014-11-12	13:45	1	0,5			60	40				1		0		Galet	Caillou
292	2014-11-12	13:48	1,8	0,5			45	45		10		1	10	0		Galet	Galet
293	2014-11-12	13:54	0,7	0,5			50	50				1	10	0		Galet	Galet
294	2014-11-12	13:58	1,6	>1			70	30						0		Galet	Caillou
295	2014-11-12	14:01	1,8	0,5			50	25	25			1		0		Galet	Caillou
296	2014-11-12	14:06	0,7	<0,5			50			50		1		0		Galet	Galet
297	2014-11-12	14:11	1	<0,5			10				90			0		Fine	Galet
298	2014-11-12	14:18	2,5	1			50	25	25			1		0		Galet	Caillou
299	2014-11-12	14:22	1,5	1			50	15	35					0		Galet	Gravier
300	2014-11-12	14:26	0,8	1			50	15	35			1	10	0		Galet	Gravier
301	2014-11-12	14:29	1,3	>1			40	60				1	10	0		Caillou	Galet
302	2014-11-12	14:33	1,8	>1			90	10				1		0		Galet	Caillou
303	2014-11-12	14:37	1,2	>1			50	50				1	10	0		Galet	Galet
304	2014-11-12	14:41	2,3	>0,5		5	45	50				1		0		Caillou	Galet
305	2014-11-12	14:45	2,1	>0,5			70	30						0		Galet	Caillou
306	2014-11-12	14:50	2	>0,5			70	30						0		Galet	Caillou
307	2014-11-12	14:53	1	0,5		5	65	30				1	10	0		Galet	Caillou
308	2014-11-12	14:57	1,7	>0,5			70	30				1	10	0		Galet	Caillou
309	2014-11-12	15:01	1,7	0,5			100					1	10	0		Galet	Fine
310	2014-11-12	15:05	2,2	<0,5			70	30				1		0		Galet	Caillou
311	2014-11-12	15:09	0,8				50			50		1	10	0		Galet	Galet
312	2014-11-19	10:49	1,2	<0,5			50	50				1		0		Galet	Galet
313	2014-11-19	10:52	1,2	<0,5			50	50				1		0		Galet	Galet
314	2014-11-19	11:00	2,3	<1			75	25						0		Galet	Caillou
315	2014-11-19	11:03	1,5	<1,5			75	25				1	10	0		Galet	Caillou
316	2014-11-19	11:09	2,5	<1,5			75	25						0		Galet	Caillou
317	2014-11-19	11:12	1,2	<1,5			95	5				1	10	0		Galet	Caillou
318	2014-11-19	11:15	1,2	<1		10	80	10				1	10	0		Galet	Bloc
319	2014-11-19	11:18	2,4	0,5			20	20	20	40		1	10	0		Sable	Galet
320	2014-11-19	11:21	0,7	<1			20	20	20	40		1	10	0		Sable	Galet

Caractérisation du substrat: Rapides de Vaudreuil

date:

id_station	date	id_enregistrement	prof	Courant	Roc	Bloc	Galet	Caillou	Gravier	Sable	Fines	Trace Fine	Végé	Pierre net	Commentaire	Substrat dominant	Substrat Codominant
321	2014-11-19	11:24	2	0						100		1	10	0		Sable	Fine
322	2014-11-19	11:33	2,3	<1			75	25				1		0		Galet	Caillou
323	2014-11-19	11:38	2	<1			75	25				1		0		Galet	Caillou
324	2014-11-19	11:41	0,9	1			75	25				1		0		Galet	Caillou
325	2014-11-19	11:43	1,5	1		15	75	10				1		0		Galet	Bloc
326	2014-11-19	11:47	0,5	0,5			75	25				1		0		Galet	Caillou
327	2014-11-19	11:51	0,6	0				30	30	40		1		0		Sable	Caillou
328	2014-11-19	11:55	0,6	0			5	15	40	40		1	10	0		Gravier	Gravier
329	2014-11-19	12:33	0,5	>0,5			1						100	2		Galet	
330	2014-11-19	12:36	0,5	>1			1		1	1			100	2		Galet	Galet
331	2014-11-19	12:44	2	>1			85	15				1		0		Galet	Caillou
332	2014-11-19	12:51	2	0							100			0		Fine	
333	2014-11-19	12:53	2,4	<0,5							100			0		Fine	
334	2014-11-19	13:01	0,4	0,5			100							0		Galet	
335	2014-11-19	13:08	0,8	0,5		50	50							0		Bloc	Bloc
336	2014-11-19	13:11	1,2	>0,5			5			95		1		0		Sable	Galet
337	2014-11-19	13:15	0,7	0			5			95		1	10	0		Sable	Galet
338	2014-11-19	13:18	0,8	<0,5			10	40		50		1		0		Sable	Caillou
339	2014-11-19	13:22	0,9	>0,5	85		10		5					0		Roc	Galet
340	2014-11-19	13:27	0,7	0,5			75	25				1		0		Galet	Caillou
341	2014-11-19	13:35	1,2	0						50	50			0		Sable	Sable
342	2014-11-19	13:38	1,4	0						50	50			0		Sable	Sable
343	2014-11-19	13:42	1,2	<0,5			75	25						0		Galet	Caillou
344	2014-11-19	13:45				10	60	30				1		0		Galet	Caillou
345	2014-11-19	13:49	1,7	0,5			70	20		10		1		0		Galet	Caillou
346	2014-11-19	13:52	1,4	0						50	50			0		Sable	Sable
347	2014-11-19	13:55	1,5	0						50	50			0		Sable	Sable
348	2014-11-19	14:03	1,1	0,5		5	70	15	5	5		1		0		Galet	Caillou
349	2014-11-19	14:08	1,3	1			70	25	5					0		Galet	Caillou
350	2014-11-19	14:12	2,5	>1			70	25	5			1		0		Galet	Caillou
351	2014-11-19	14:15	1,8	1			70	25	5			1		0		Galet	Caillou
352	2014-11-19	14:20	1,8	0,5						50	50			0		Sable	Sable
353	2014-11-19	14:22	2,3	0						50	50			0		Sable	Sable
354	2014-11-19	14:25	2,6	0						50	50			0		Sable	Sable
355	2014-11-19	14:32	1,9	0						50	50			0		Sable	Sable
356	2014-11-19	14:32	1,8	0		5	50			45		1		0		Galet	Sable
357	2014-11-19	14:35	1,8	0			33	33		33		1		0		Galet	Galet
358	2014-11-19	14:40	3	0,5			75	25						0		Galet	Caillou
359	2014-11-19	14:46	2,7	0,5		5	70	25						0		Galet	Caillou
360	2014-11-19	14:50	1,7	0,5						50	50			0		Sable	Sable

Appendix B

LITERATURE REVIEW – WALLEYE AND LAKE STURGEON SPAWNING

Literature Review on the Physical Characteristics of Natural Lake Sturgeon (Acipenser fulvescens) Spawning Grounds

Reference	Location	Type of Study	Depth (m)	Current Speed (m/s)	Substrate Characteristics	Remarks
Peterson et *al.*, 2007		General	0.1-2	0.5-1.3	- Gravel or cobbles	- Temperature: 10-15°C - Spawning on lake strand rocks (only a few populations)
Caswell et *al.*, 2004	Detroit River, Michigan, USA	Observation: 1 spawning ground	10-11	0.35-0.73	- Coal cinders (1-4 cm), scattered gravel (20-60 mm) and cobbles (7-20 mm) - Clean, without sand, nor silt or partially covered in periphyton and silt	- Temperature: 14-15°C - Secchi depth: 2.4-2.5 m - Detroit River: - Average current speed: 0.1-1.8 m/s, - Average flow: 5,300 m^3/s
La Haye et *al.*, 2004	Upstream section of the Lachine Rapids, St. Lawrence River, QC, Canada	Observation : 1 spawning ground Monitoring 2002-2003	1.15-6	Rapid flow conditions: 1-2	- Rocks and large rocks (shelter) à gravel fin à coarse, free of periphyton and aquatic plants	- Surface area: 2.3-3.6 ha - 163 eggs gathered (using concrete blocks) and 108 eggs and 5 larvae gathered over 2,419 of drift (in 2002)
Environnement Illimité Inc., Déc. 2003	Eastmain, Opinaca and Rupert rivers, QC, Canada	Observation: 17 spawning grounds	Optimal (high yield of eggs): 0.4-1.25 Maximum (presence of eggs): 0.2-4.0	Optimal (high yield of eggs): 0.2-1.1 Maximum (presence of eggs): 0.1-1.7	- Heterogeneous substrate en propositions variables, sans silt, sand or organic particles: Boulders: 20 à 70% Cobbles: 25 à 60% Pebbles <30% Gravel <5%	- Temperature: 11.1-14.5°C
Nichols et *al.*, 2003	St. Clair River, Michigan, USA	Observation: 2 spawning grounds Monitoring 1998-1999	6-13	1-3	- Irregularly-shaped 0.5-12 cm coal cinders - Thickness: 2 m	- Initial egg density: 2,521 eggs/m^2 - Egg density at the end of spawning: 337 eggs/m^2 - <1% of laid eggs survive to hatch - Round gobies are major Lake Sturgeon egg predators, among others
Auer et Baker, 2002	Sturgeon River, Michigan, USA	Observation: 5 spawning grounds Monitoring 1992-2000	1.27-1.85	0.21-0.73	- Clean sandstone rock	- Temperature: 10-18°C
Bruch et Binkowski, 2002	Wolf and Fox rivers, Winnebago System, east-central Wisconsin, USA	Observation: 30 spawning grounds Monitoring 1987-2002		>0.5	- Clean rocks or cobbles	- Temperature: 11.5–16.0°C (no spawning above 21.1°C)
Manny et Kennedy, 2002	Detroit River, Lake St. Clair and St. Clair River, Michigan, USA	Observation: 3 spawning grounds	9.1-12.2	0.33-0.98	- Rounded glacial cobbles (10-40 mm) and coarse gravel (20-80 mm) or human-generated coal cinders (5-120 mm) - Thickness: 0,3-2,0 m	- Temperature: 8.5-20.3°C - Surface area: 2,500 m^2, 15,000 m^2, 160,000 m^2 - Secchi depth: 2.5-6.5 m - Light surface reaching the bottom: 0.05-8.7% - Current speed (m/s): - Surface: 0.33-0.98 - Bottom: 0.36-0.98 - Oxygen concentration in the water: 6.5-11.2 mg/L - Detroit River, Lake St. Clair and St. Clair River: 5,121-5,200 m^3/s
McKinley et *al.*, 1998	Groundhog and Mattagami rivers, northern Ontario, Canada	Observation: 2 spawning grounds	<2.5	>0.5		- Temperature: 3-18°C
Dubuc et *al.*, 1996	Rivière des Prairies, QC, Canada	Observation: 1 spawning ground	0.5-4.1	0.23-1.66	- Homogeneous substrate: rocks (65.0-255.9 mm)	- Temperature: 10,5-18,4°C - Period: May 17 –June 10 (maximum: May 21-23) - Larvae downstream migration: June 6-12 (maximum: June 9) - 95% of larvae drift at night (maximum 9pm-midnight) - 1,295,000 larvae are purported to have drifted from spawning ground in 1996, for a drifting larvae/egg survival rate 0.46-0.62%
Environnement Illimité Inc., Juin 1994a		General (Khoroshko et Vlasenko, 1970; Folz et Meyers,1985; La Haye, 1992)	0.5-2.0	0.6-1.2	- Heterogeneous substrate: rocks (65-255 mm) and gravel (17-65 mm)	

Reference	Location	Type of Study	Depth (m)	Current Speed (m/s)	Substrate Characteristics	Remarks
La Haye et Gendron, 1994; La Haye et Fortin, 1990	QC, Canada	General: Quebec literature review (13 articles)	0.25-3.0	0.25-1.7	- Hard substrate: fine (= 3 mm), medium (3.0-16.9 mm) to coarse (17-64.9 mm) gravel, interspersed with smooth and fractured rocks (65.0-255.9 mm) (for 12 authors who characterized the substrate in 7 spawning grounds) - Particle size classes (+ mentioned): 17.0-64.9 mm; 65.0-254.9 mm (9 and 8 authors respectively) - Large rocks (1-2 m) placed at various spots in the spawning ground to create shelter from the current for spawners	- Spawning temperature according to the longitudinal gradient (range frequently mentioned: 11-15°C)
G.D.G Environnement, 1990	St.-Maurice River ~125 m downstream from the La Gabelle generating station, QC, Canada	Observation: 1 spawning ground	2.0-3.15 (during highest floods)	0.15-0.64	- Boulders with gravel in the gaps	- Very turbulent water - 111 lake sturgeons captured in the spawning ground
Ménard, 1983	Projet Archipel, QC, Canada	General	0.60-3.50	0.60-3.50	- Sand, gravel, rocks et boulders - No vegetation	
Provost et *al.*, 1982	Rivière-des-Prairies, QC, Canada	Observation	0.60-3.50	0.60-3.50	- Bottom consisting of sand, gravel, rocks and boulders	- Temperature: 8-15°C

Literature Review on the Physical Characteristics of Natural Walleye (Sander vitreus) Spawning Grounds

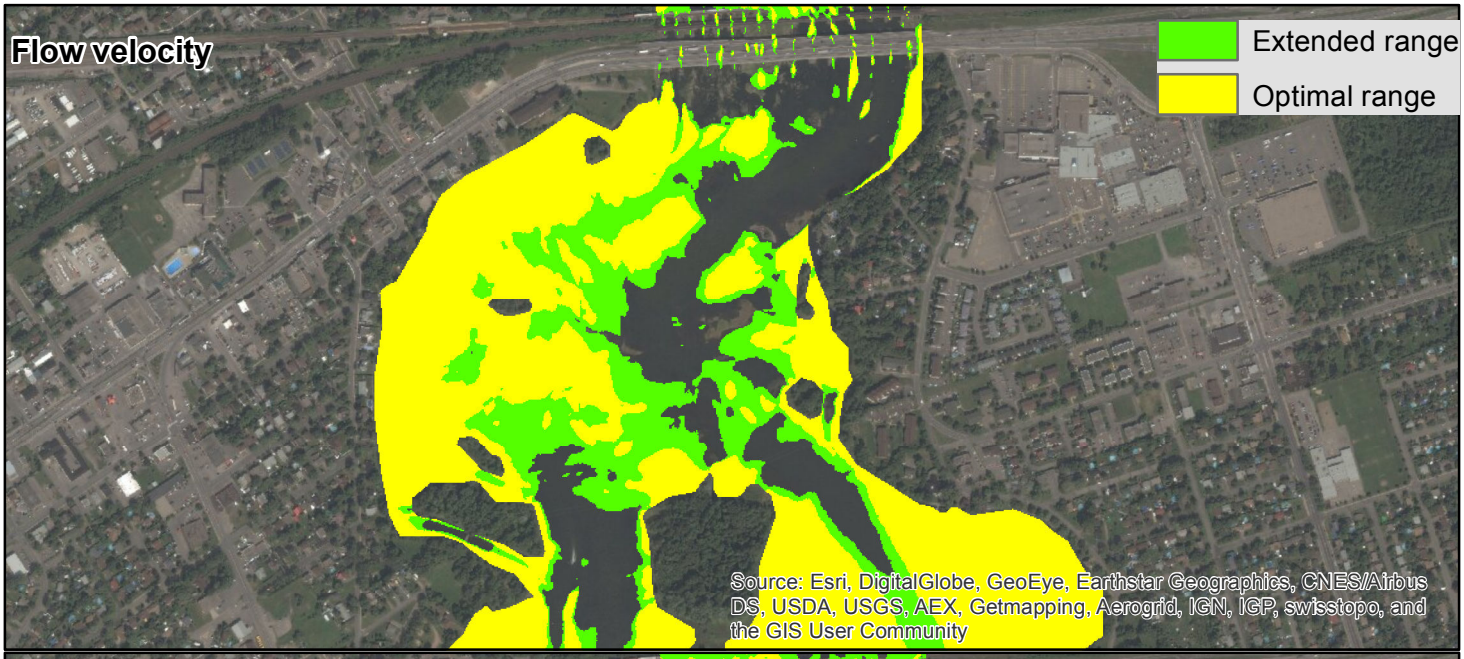
Reference	Location	Type of Study	Depth (m)	Current Speed (m/s)	Substrate Characteristics	Remarks
Génivar, July 2008	Upstream for the spawning ground developed downstream (500 m) from the Rapides-des-Quinze generating station, Ottawa River, QC, Canada	Observation: 1 spawning ground	0.4-1.7 0.32 (for hatching)	0.4-1 0.4-0.49 (for hatching)	- Cobbles	
GENIVAR, April 2008c		General	<2	0.3-1.5	- Rocky substrate mainly made up of cobbles and pebbles	
	Territory of the Eastmain-1-A and Rupert diversion project, QC, Canada	Observation	0.72 (±0.32)	0.60 (±0.32)	- Substrate is dominated by cobbles, with pebbles and boulders	
Alliance Environnement, Feb. 2007		General	0.2-1.5 (Machniak, 1975; Harzel et Fortin, 1986; Hartley et Kelso, 1991)	0.14-1.87 (Hartley et Kelso, 1991) 0.5-1.5 (FFQ, 1996)	- Best egg and embryo survival rates are obtained on gravel, pebbles and cobbles (2-250 mm) (McMahon et al., 1984) - Preferred substrate made up of pebbles and cobbles (50-200 mm) (FFQ, 1996)	
Foust et Haynes, 2007	Honeoye ¨Lake, west-central New York state, USA	Observation	2.8			- No eggs were collected in Lake Honeoye during 2002 and 2003 - Spawning doesn't seem to occur in the lake (non-favourable conditions) but rather in the tributaries
Alliance Environnement, April 2006		General	0.2-1.5 (Machniak, 1975; Hazel et Fortin, 1986; Hartley et Kelso, 1991)	Extended: 0.14-1.87 (Hartley et Kelso, 1991) Preferred: 0.5-1.5 (FFQ, 1996)	- Size: 50-200 mm (FFQ, 1996)	- Spawning can begin when the water's temperature reaches 7°C - Optimal temperature for fertilization: 9-12°C
Environnement Illimité Inc., April 2006	Rupert forebays and tailbays, QC, Canada	General and observation: literature review [a] + 130 sampling stations spread across numerous spawning grounds (GENIVAR, 2004b; 2003a)	<3 [a] 0.72 (±0.35)	0.60 (±0.32)	- Rocky substrate made up of cobbles and pebbles [a] - Substrate dominated by cobbles (43.1%) and boulders (21.95%)	- Temperature: >6°C (pic à 8°C) [a] - Spawning in the river and sometimes in the lake near the shore [a]
GENIVAR, Dec. 2004	Eastmain-1-A powerhouse and Rupert diversion, QC, Canada	Observation: sucker and Walleye spawning grounds	0.725	0.6	- Cobbles dominant, with mainly pebbles and boulders	- Strong similarity of the physical characteristics of sucker and Walleye spawning grounds
Naturam Environnement, August 2000	Lake Duhamel, Manouane River, QC, Canada	Observation: 6 sites (presence of eggs)	0.31-0.79 0.553	Average speed of the water column: 0.10-0.91 0.44 Speed near the bottom: 0.08-0.83	- Dominance of cobbles and pebbles and large presence of gravel and boulders	- Confirmed spawning grounds generally found at spots with 3 characteristics present: 1) a rapid 2) a sill 3) a trench - Spawning grounds often found at the foot of a waterfall, a dam or a rapid (FFQ, 1996) - Spawning temperature: 6-11°C (FFQ, 1996) - Low egg density in spawning grounds and small number of adults suggests that there are relatively few Walleye in the Manouane River's ecosystem (numerous causes but it is unlikely that the number and quality of spawning grounds is a limiting factor)
GDG Environnement, August 1994		General	0.2-1.5 (Machniak, 1975; Hazel et Fortin, 1986, Hartley et Kelso, 1991)	0.14-1.87 (in river, Hartley et Kelso, 1991)	- Rocky surfaces and other types of substrate when these are not available (Machniak, 1975; Colby et al., 1979) - On rocky surfaces, the top egg and embryo survival rates are obtained on gravel, pebbles and cobbles (2.0-250.0 mm) (Johnson, 1961; McMahon et al., 1984)	

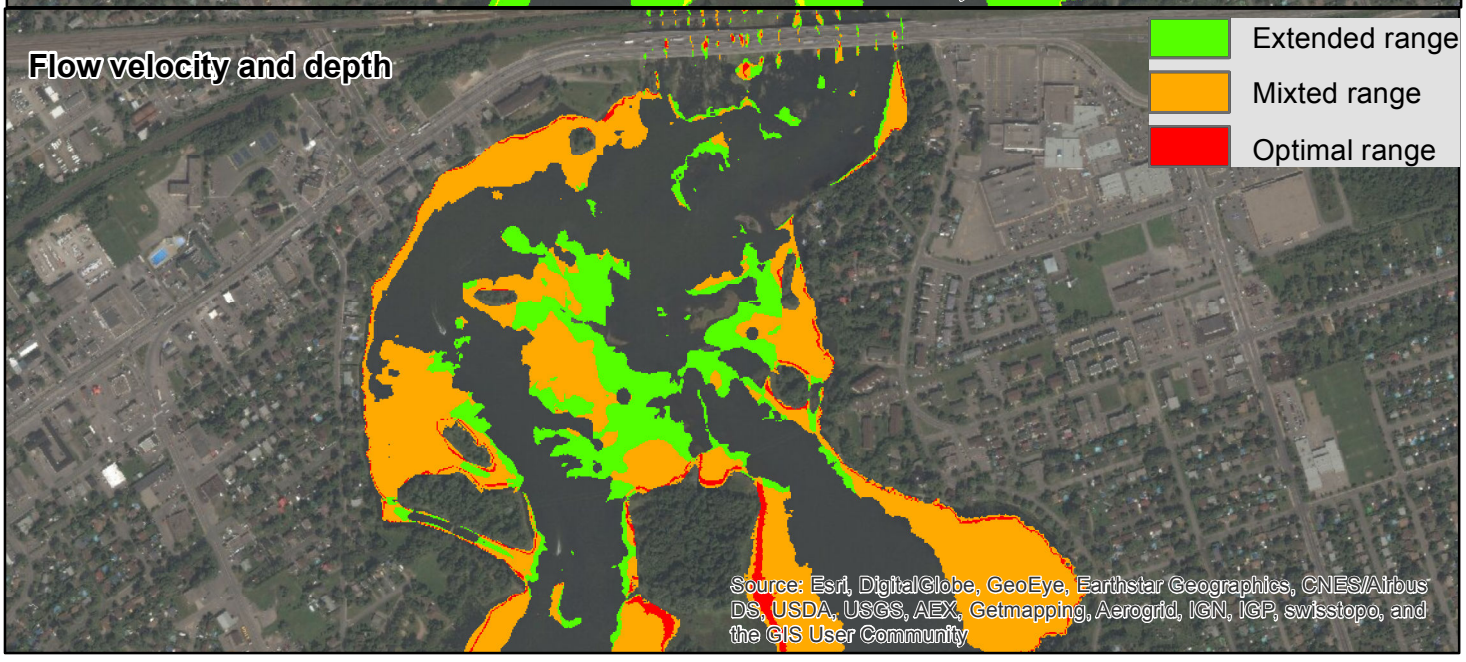
Reference	Location	Type of Study	Depth (m)	Current Speed (m/s)	Substrate Characteristics	Remarks
GDG Environnement, 1990		General: Quebec literature review (Mailhot & Scrosati, 1984; Couillard & al., 1985; Villemure, 1977; Mailhot & Scrosati, 1984.; Hazel & Fortin, 1986; Gendron, 1988)	<3	0.06-0.23 (Batiscan River) >1.0 (Ste-Anne-de-Bellevue Rapids) 0.6-0.7 (Gendron. 1988)	- Rocky bed - Variably-sized rocks such as cobbles and boulders, with gravel and sand in the gaps - Near-absence of aquatic vegetation	- In flowing water, often at the foot of a rapid or a waterfall - Temperature: 5-11°C
	Downstream from the La Gabelle generating station, QC, Canada	Observation: 2 spawning grounds		0.05-0.78	- Rocks, a few boulders and gravel	- 63 fish and 11 eggs
Ménard, 1983		General	0.20-1.50	0.40	- Sand, gravel and rocks - No vegetation	
Provost et *al.*, 1982	Rivière-des Prairies, QC, Canada	Observation	3.0	0.12-2.14	- Base of medium-sized rocks	- Temperature: 7-11°C - Spawning in a lake, or upstream/downstream from fast-flowing watercourses - Strong currents
Colby et al., 1979 (in Foust et Haynes, 2007)			<1	Sufficient speed for adequate oxygenation and minimal sedimentation	- Gravel and cobbles	
Scott et Crossman, 1973	Great Lakes region, Canada					- In rocky rivers or pebbly lakeshores - Temperature: 5.6-11.1°C - Night spawning, in clusters
Johnson, 1961 (in Foust et Haynes, 2007)						- Egg survival rate when substrate is covered by organic matter: 0.6-4.6%
Eschmeyer, 1950 (in Foust et Haynes, 2007)		General: review of 15 studies			- Spawning on lotic and lentic substrate	- Steep sloped areas near the shore are not used for spawning

Appendix C

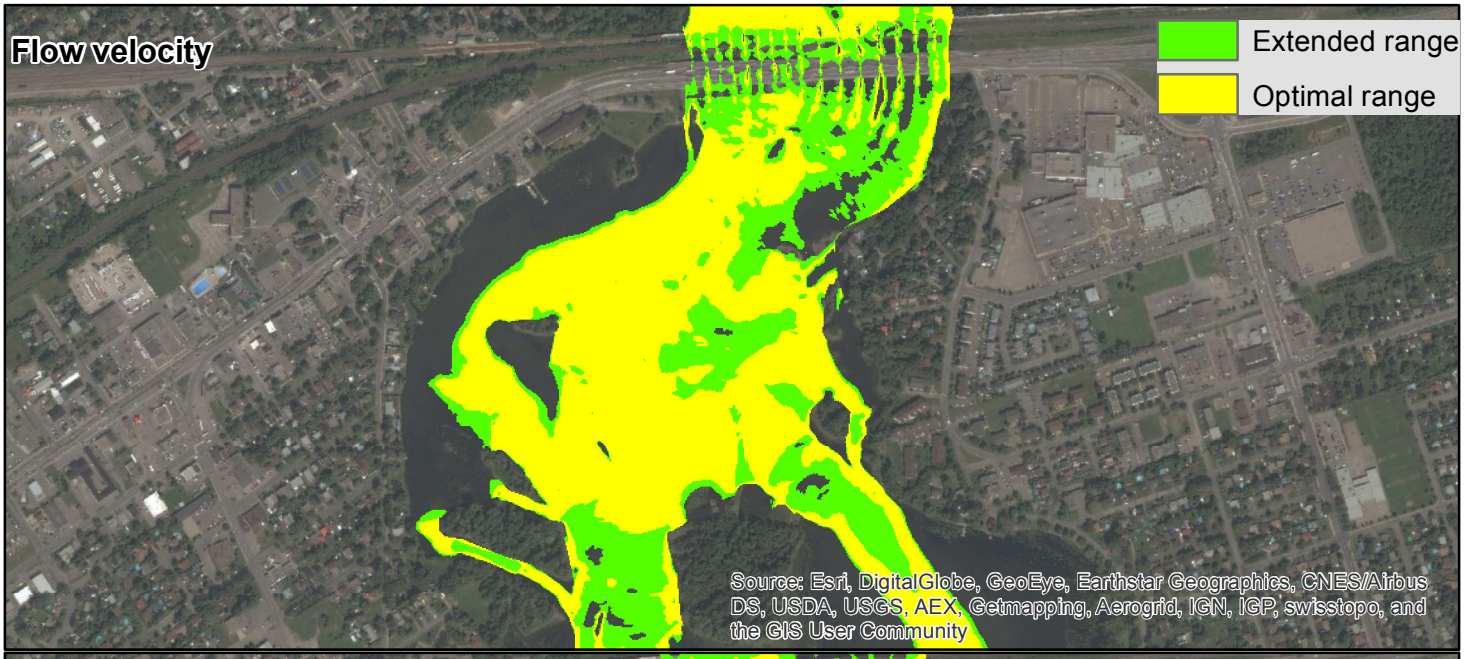
SPAWNING GROUND POTENTIAL IN THE STUDY AREA

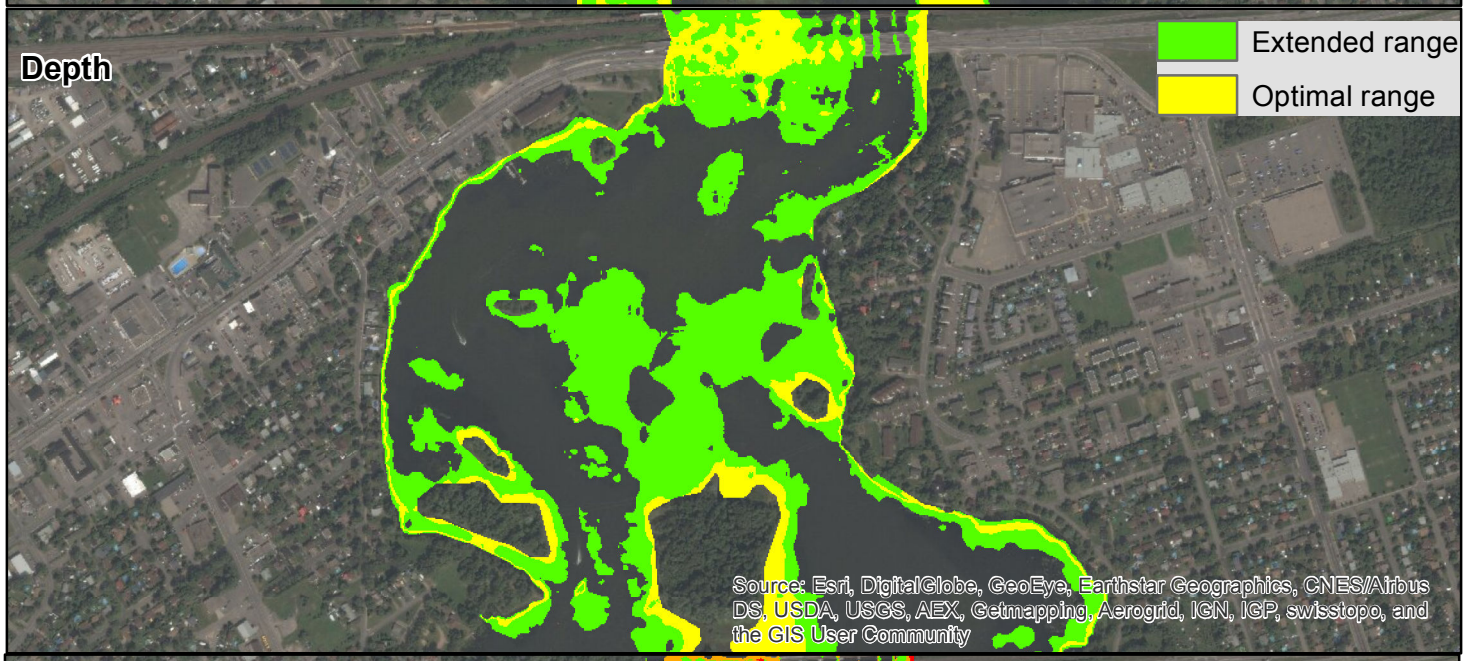
Spawning ground potential for smallmouth bass-455 m³/s

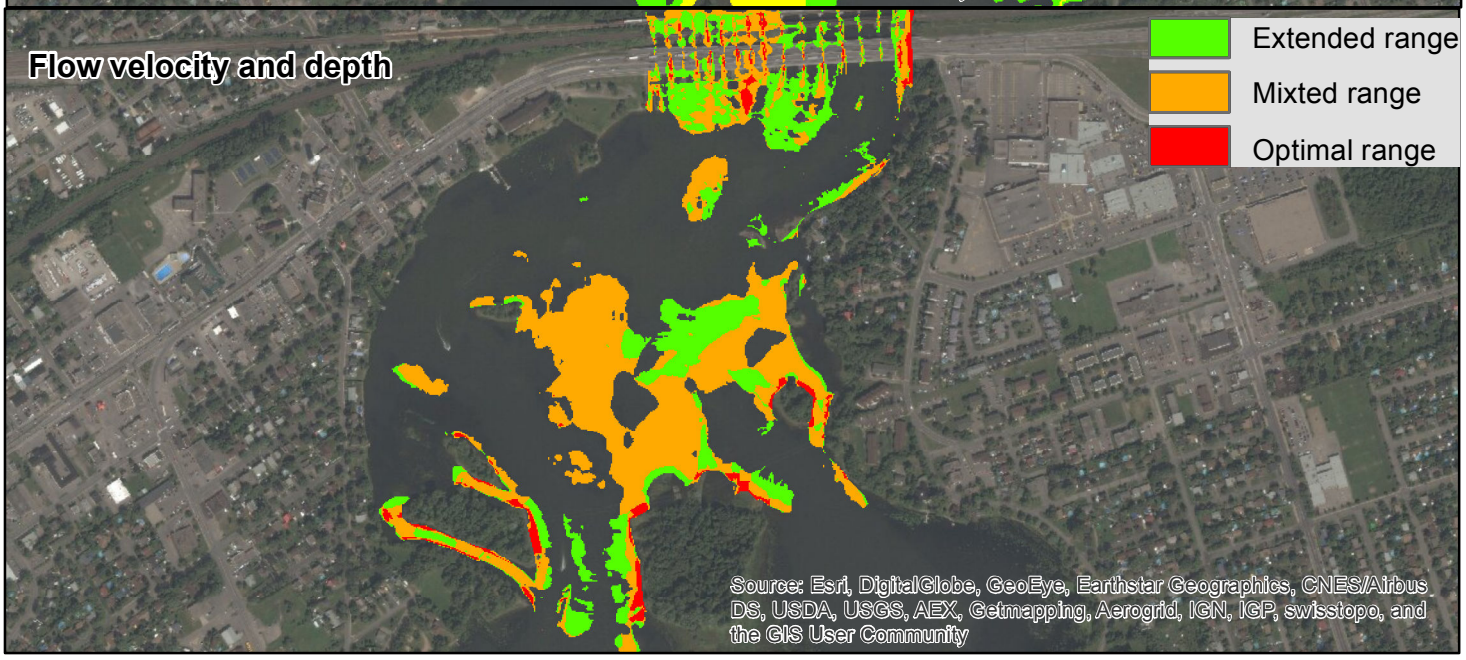




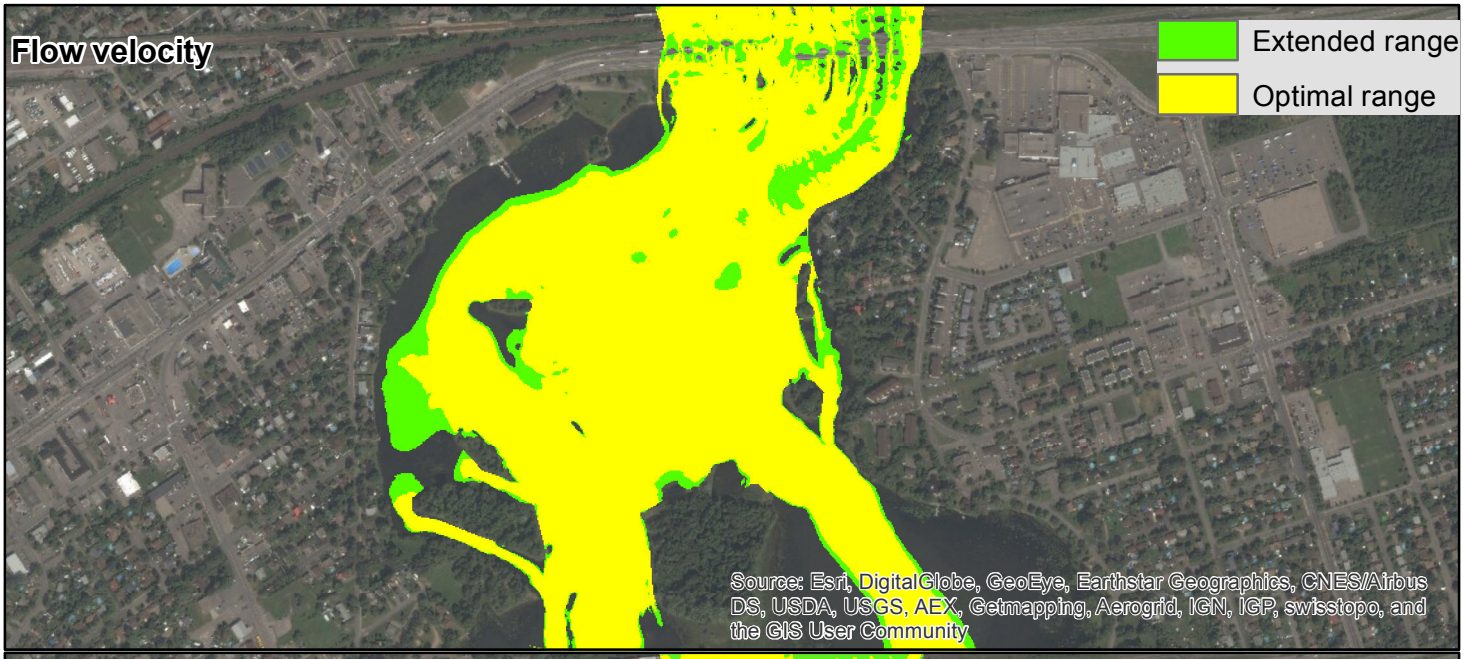
Spawning ground potential for walleye-793 m³/s

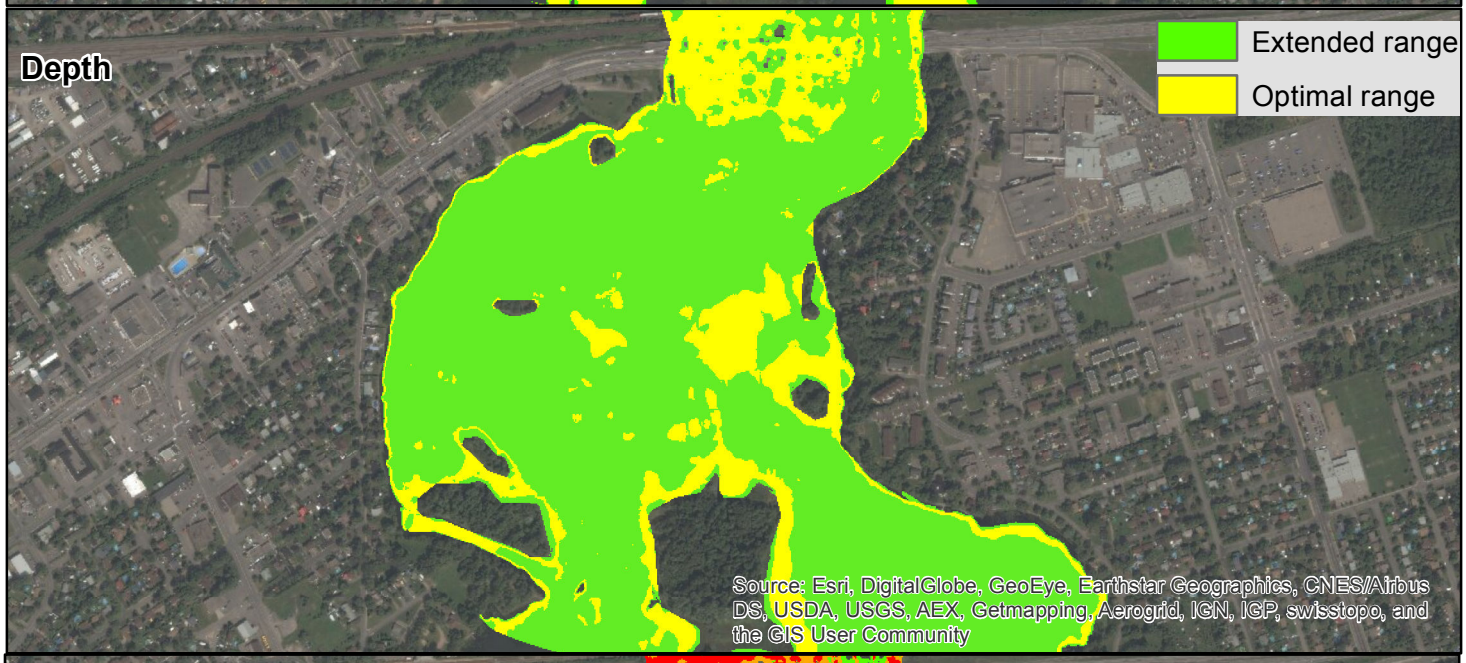


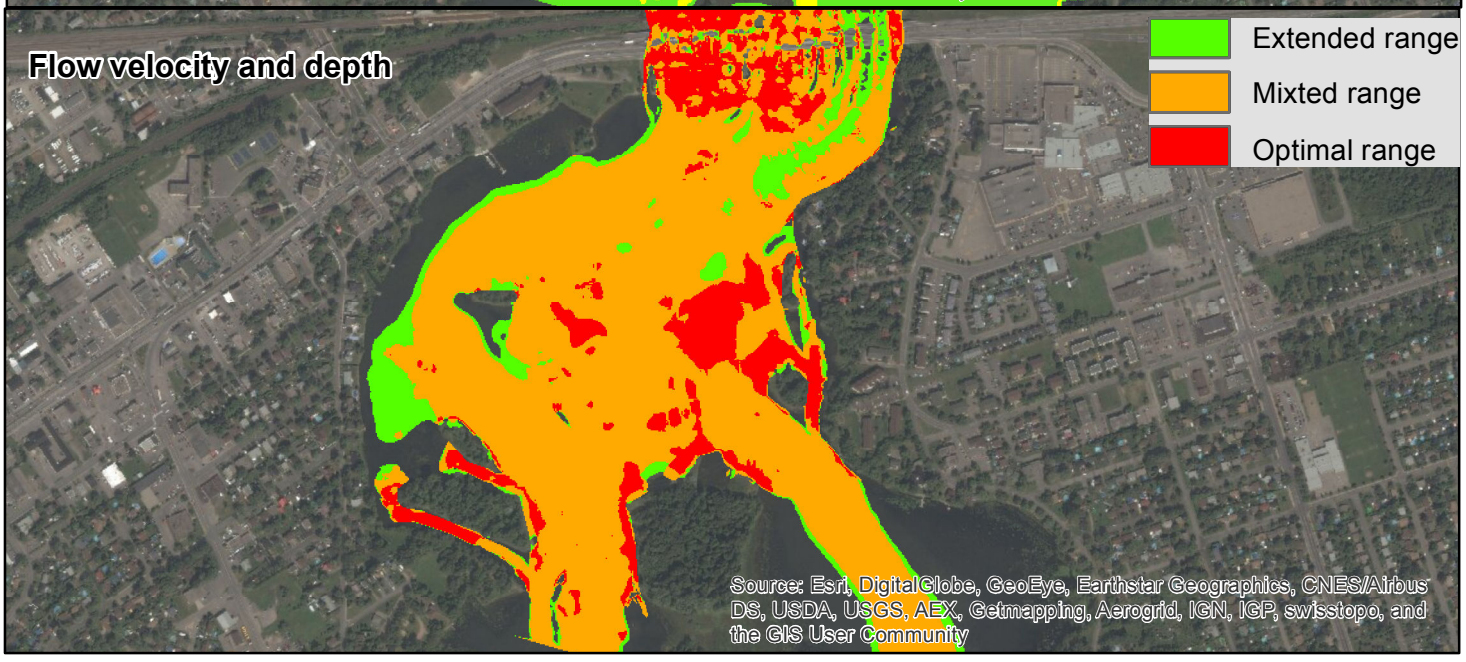




Spawning ground potential for lake sturgeon-455 m³/s



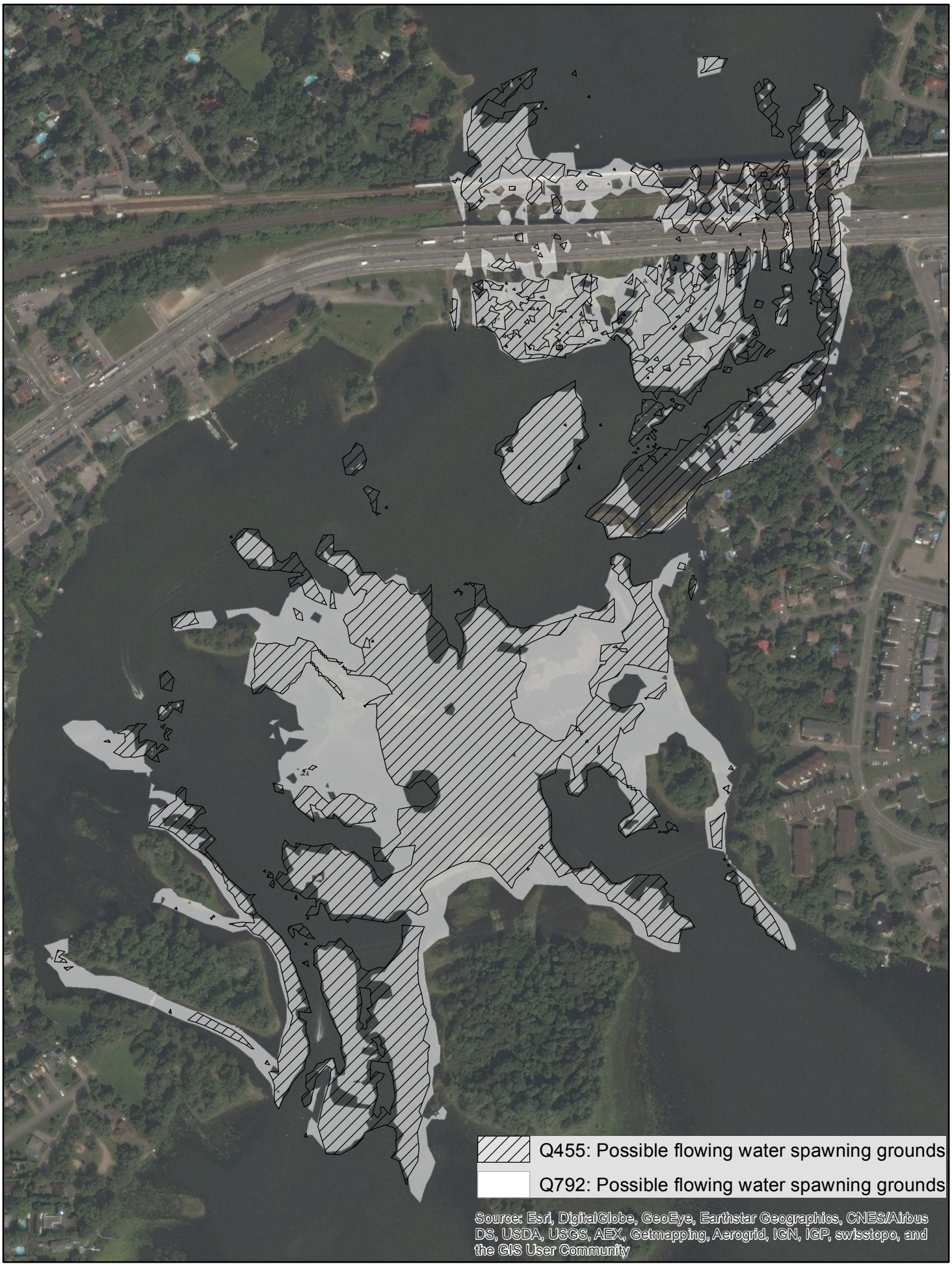




Appendix D

POSSIBLE AREAS FOR DEVELOPMENT OF FLOWING WATER AND CALM WATER SPAWNING GROUNDS

Possible areas for development of flowing water spawning grounds- 455 and 793 m³/s



Possible areas for development of calm water spawning grounds- 455 m³/s

Appendix E

TABLES DETAILING AREAS PROVIDING SPAWNING POTENTIAL FOR THE THREE TARGET SPECIES BY DEVELOPMENT SECTOR

Breakdown of areas with spawning potential for Walleye and Lake Sturgeon by proposed development sector

Development Sector	4	5	6	7	8	9	11	17	18	19	20
Total surface area of the proposed development area (m²)	31,257	15,090	6,814	22,040	5,475	1,624	2,849	1,477	1,656	500	2,061
Walleye											
Mixed spawning potential (m²)	7,056	974	3,553	3,010	1,970	1,263	2,664	385	865	398	415
Optimal spawning potential (m²)	813	13		399	121	51			0	1	
Total surface area with spawning potential (m²)	7,869	987	3,553	3,409	2,092	1,315	2,664	385	865	398	415
Lake sturgeon											
Mixed spawning potential (m²)	12,556	12,370	6,122	18,571	3,997	1,287	1,843	1,387	1,521	179	1,727
Optimal spawning potential (m²)	16,579	287	682	2,728	1,396	33	999	88	112	317	331
Total surface area with spawning potential (m²)	29,135	12,656	6,804	21,299	5,393	1,320	2,841	1,475	1,633	496	2,057

Breakdown of areas with spawning potential for Smallmouth Bass by proposed development sector

Development Sector	13	21	22	23	24	25
Total surface area of the proposed development area (m²)	2,824	5,903	7,086	3,898	2,473	5,313
Mixed spawning potential (m²)	2,567	5,324	6,453	3,775	1,926	3,698
Optimal spawning potential (m²)	41	524	319	113	469	1,106
Total surface area with spawning potential (m²)	2,608	5,848	6,772	3,888	2,395	4,804