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Contract No 62453

CHAMPLAIN BRIDGE, CONSULTANCY SERVICES, FEASIBILITY STUDY ON THE DECONSTRUCTION OF THE EXISTING CHAMPLAIN BRIDGE (2016-2017)

Feasibility Study - Final Report

February 2017

Parsons
Tetra Tech
Amec Foster Wheeler

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Final report

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Parsons
Tetra Tech
Amec Foster Wheeler

List of Revisions

REVISION	DATE	DESCRIPTION
0	January 27, 2017	Final
1	February 16, 2017	Final - Revision 1

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

On April 27, 2016, **The Jacques Cartier and Champlain Bridges Incorporated** (JCCBI) awarded Contract No. 62453 – Champlain Bridge, Consultancy Services, Feasbility Study on the Deconstruction of the Existing Champlain Bridge (2016-2017) to the **Parsons / Tetra Tech / Amec Foster Wheeler** (PTA) Consortium for a feasibility study on the deconstruction of the existing Champlain Bridge in accordance with sustainable development principles, as well as an environmental impact assessment of the project once the deconstruction method has been determined.

This report was prepared by Bertrand Voutaz, Eng., (deconstruction), Alain Robitaille, Eng. (materials transportation), [redacted] M. Env. (materials recovery) and Sylvain Gariépy, Urb. (asset enhancement) and verified by Sylvain Montminy, Eng. The following people also participated in the writing of the report: [redacted], Eng., PE, and [redacted] Eng., M.Eng., for the deconstruction section [redacted] Eng., and [redacted], M.Sc., for the materials transportation section ; [redacted] Eng., and [redacted] Geo., for the materials recovery section ; as well as Josée Labelle, landscape architect, [redacted], landscape architect [redacted] urban planner and [redacted] urban planning intern, for the asset enhancement section.

The report first presents the project background, followed by the evaluation criteria in Chapter 3. Chapters 4 to 7 cover the four fields of the study: deconstruction, materials transportation, materials recovery and asset enhancement. Chapter 8 deals with the influence of the stakeholders, while Chapter 9 covers project delivery methods. Chapters 10 and 11 respectively deal with project estimation and schedule. Chapter 12 presents the conclusion, and Chapter 13 lists the study's recommendations.

1.2 DESCRIPTION OF MANDATE

The aim of the feasibility study is to present various scenarios and recommend the optimal scenario for the deconstruction of the existing Champlain Bridge. The deconstruction represents a sizeable challenge, since it is one of the only projects of this scale not only in Quebec but in all of Canada. The devised scenarios must allow JCCBI to come to a definitive conclusion and ensure adequate transition for the execution of the project.

This study examines not only the deconstruction of the bridge, but also the transportation of materials off the site, the disposal of waste and site rehabilitation, from the standpoint of sustainable development, in accordance with JCCBI's mission and vision[1] :

> MISSION : *Use systemic management and a sustainable development approach to ensure the safety and longevity of the major infrastructure under its responsibility.*
>
> VISION : *Become a leader in major infrastructure management as an innovative expert, a mobility leader and a social and urban contributor.*

Furthermore, the study must take into account the various major projects in the Greater Montreal Area, including the construction of the new Champlain Bridge Corridor, the development of the north end of Nuns' Island, the upgrading of the Bonaventure Expressway, the Turcot Interchange, the electric light-rail train network (Réseau électrique métropolitain - REM) of the Caisse de dépôt et de placement du Québec (CDPQ) and various other JCCBI, City of Montreal and Ministère des Transports, de la Mobilité durable et de l'Électrification des transports du Québec (MTMDET) projects).

The study must review various methods and options for each of the four following fields of study:

- Deconstruction work ;
- Materials transportation ;

[1] http://jacquescartierchamplain.ca/our-corporation/a-propos/?lang=en

- Materials recovery ;
- Asset enhancement.

For each field of study, options or methods must be reviewed and compared based on a set of evaluation criteria related to the following dimensions:

- Technical feasibility ;
- Economic viability and benefits ;
- Environmental impacts ;
- Social acceptability.

Lastly, the optimal scenario must reflect, insofar as possible, the needs, constraints and concerns of the host environment. The process of including and consulting the stakeholders is therefore an essential part of the deconstruction of the existing Champlain Bridge. The definition of stakeholder retained for this project is the most commonly used to define the concept, i.e., “any group or person that may affect or be affected by an organization’s objectives.” The notion of stakeholder therefore includes both groups and individuals actively involved in decision-making and implementation processes, as well as any group or individual potentially affected by the deconstruction of the existing Champlain Bridge. However, for certain fields of study, this definition has been expanded to include other stakeholders or expertise related to the study.

2 PROJECT BACKGROUND

The existing Champlain Bridge has reached the end of its useful life, and, in 2011, it was announced that a new bridge would be built to replace it. The Government of Canada launched a call for tenders for the construction of the new Champlain Bridge, the new Nuns' Island Bridge and the federal section of Highway 15. The new bridge is expected to be open to traffic in December 2018. Once traffic has been rerouted to the new bridge, the deconstruction of the existing Champlain Bridge can begin. The deconstruction of the bridge is necessary since it can no longer be used for transportation purposes due to its condition.

The new bridge is located downstream of the existing bridge and no construction phasing has to be considered: the existing bridge will remain fully operational until traffic has been rerouted to the new bridge.

The new bridge is being built under a public-private partnership agreement, and Signature on the Saint Lawrence Group (SSL) will be responsible for the bridge for 30 years.

2.1 CURRENT AND UPCOMING MAJOR URBAN STRUCTURING PROJECTS

The Greater Montreal Area is experiencing a very active period with regard to large-scale infrastructure projects. Ground has been broken on a number of major projects. In particular, the following projects are currently under way:

- Reconstruction of the Turcot Interchange ;
- Upgrading of the Bonaventure expressway (municipal section) ;
- New Champlain Bridge Corridor ;
- CDPQ-Infra electric light-rail train network ;
- Repairs to the Honoré-Mercier Bridge ;
- Repairs to the Louis-Hyppolite-Lafontaine Tunnel ;
- Port of Montreal / Contrecœur Terminal (owned by Port of Montreal) ;
- Alexandra jetty ;
- Ville-Marie Expressway / Champ-de-Mars area.

These multiple projects, which are being carried out at virtually the same time, require considerable coordination. Maintaining the flow of traffic is a major concern that requires significant efforts to reduce the impact on users.

The large number of construction sites definitely provides an opportunity to develop new techniques and refine construction and deconstruction methods, but this may limit the availability of resources and equipment for performing delicate operations.

2.2 LOCATION

The existing Champlain Bridge is a critical thoroughfare for the Montreal area and one of the busiest bridges in Canada. Opened to traffic in 1962, the Champlain Bridge is 3,440 m long and 24.08 m wide, and has six traffic lanes, three in each direction. It allows motorists to cross the St. Lawrence River and the St. Lawrence Seaway, linking Nuns' Island to the City of Brossard (Figure 1).

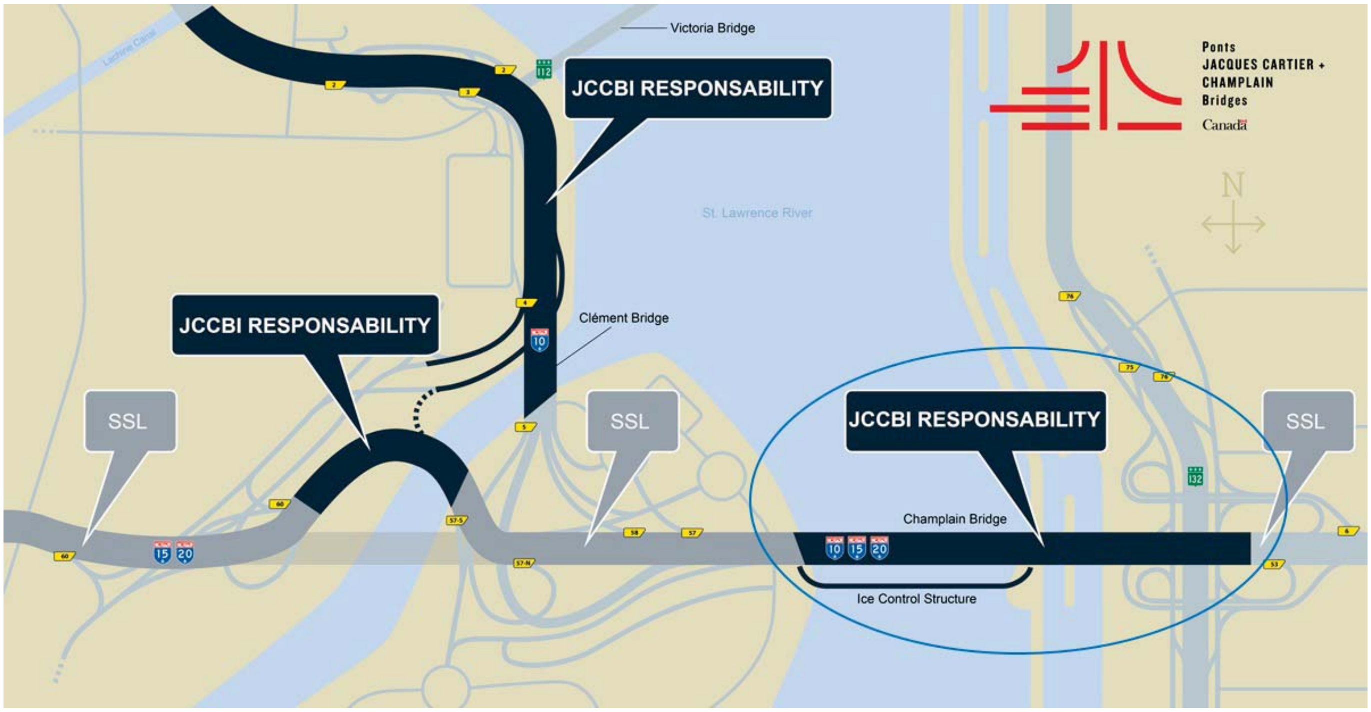


Figure 1 – Champlain Bridge (source: pjcci.ca)

2.3 DESCRIPTION OF THE STRUCTURE

The Champlain Bridge is divided into three sections (Figure 2):

- Section 5: between Nuns' Island and the Seaway (±2,150 m) ;
- Section 6: crossing over the Seaway (±763.45 m) ;
- Section 7: between the Seaway and the City of Brossard (±528.07 m).

The bridge has two main structural systems. The approach spans are made of prestress girders (sections 5 and 7 – 50 spans), while the spans over the Seaway are made of steel trusses (section 6).

The Ice Control Structure is also discussed. Although this structure will not be deconstructed, it plays a key role in the project.

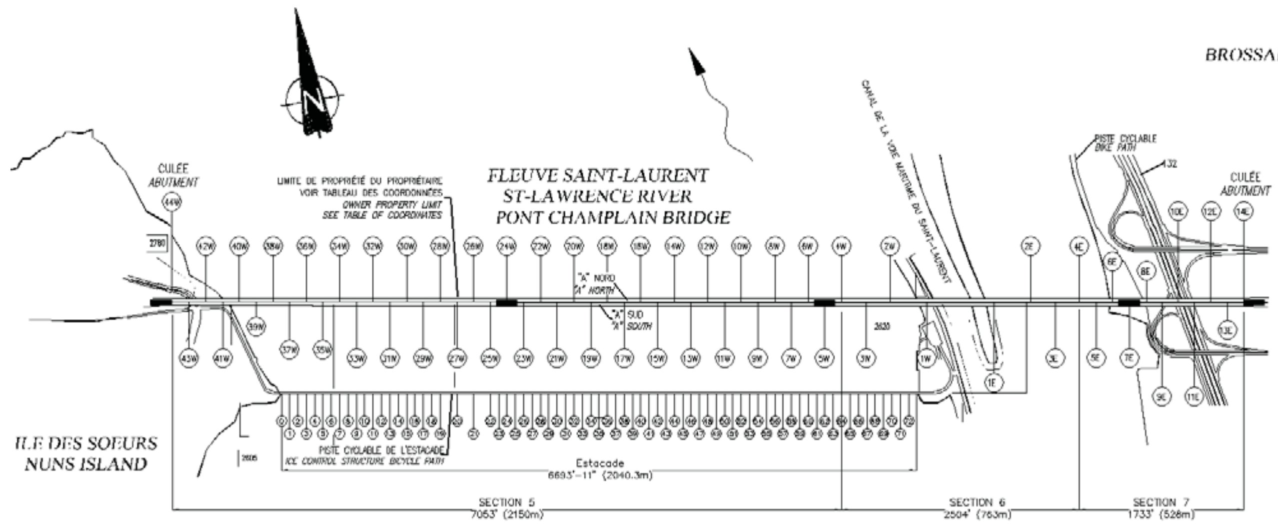


Figure 2 – Sections of the Champlain Bridge

2.3.1 SECTION 5

Section 5, which links Nuns' Island to the Seaway, is the longest section of the Champlain Bridge. It is comprised of 40 spans each measuring 53.75 m (total length: 2,150 m) and extends from axis 44W (abutment) to axis 4W. The spans between axes 44W and 41W are over land while the others are over the river. Span 43W-42W extends over Boulevard René-Lévesque on Nuns' Island.

The functional cross-section has the following configuration:

- 2 reinforced concrete barriers ;
- 1 reinforced concrete median barrier ;
- 3 traffic lanes in each direction ;
- Average cross slope of 1.32%.

The deck is composed of seven precast prestressed post-tensioned girders (Figure 3) spaced at 3.721 m. The concrete spans have a particular structural system, since the girders are not topped with a reinforced concrete slab, as is usually the case, but instead, the slab is an infill strip between the girders. The 216 mm cast-in place slab is connected to the girders by transverse post-tensioning.

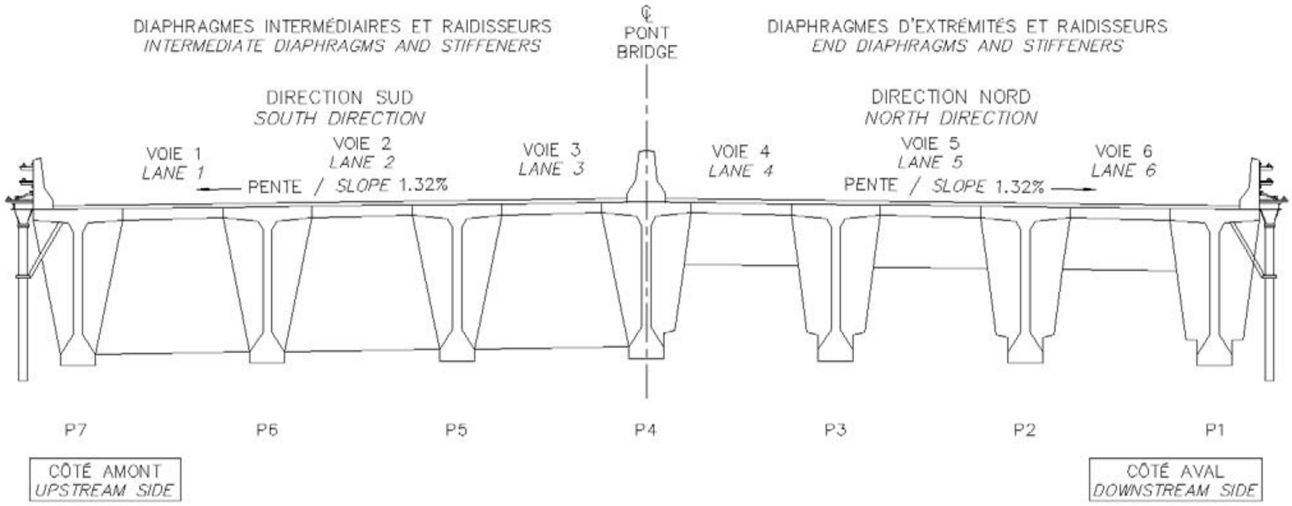


Figure 3 – Cross-section – Section 5

The main characteristics of section 5 are presented in Table 1.

Table 1 – Section 5

	SECTION 5
Overall width	24,08 m
Number of spans	40
Span length	53,75 m (176' 4'')
Girder length	53,65 m (176')
Number of girders/span	7
Girder height	3,07 m
Girder spacing	3,721 m
Intermediate diaphragms	2
Reinforced concrete slab thickness	216 mm
Number of prestressing tendons	24 tendons: 12 7-mm strands/tendon
Type of prestressing	Freyssinet (STUP)
Type	Simple spans
Total length	2 150 m

The girders sit on reinforced concrete hammerhead piers (Figure 4). The footings rest on the bedrock. Pier height ranges from 4.5 to 28 m.

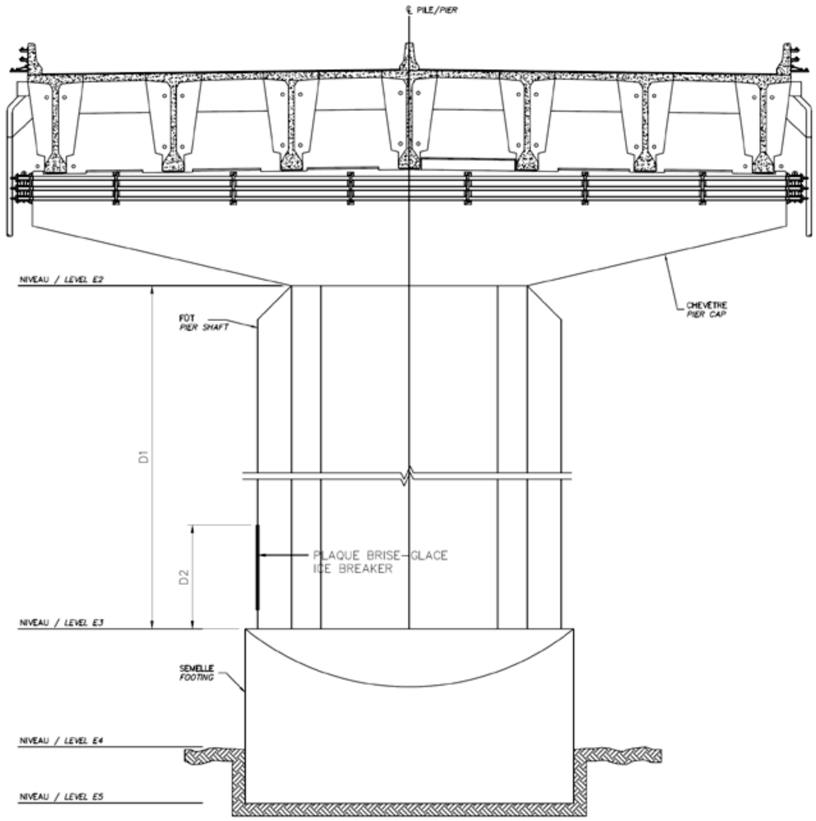


Figure 4 – Typical pier – Section 5

2.3.2 SECTION 6

Section 6 crosses over the Seaway and its deck is composed of steel trusses. This section extends from axis 4W to axis 4E and has a total length of 763.45 m (Figure 5). The vertical clearance over the St. Lawrence Seaway is 36 m above the high water level.

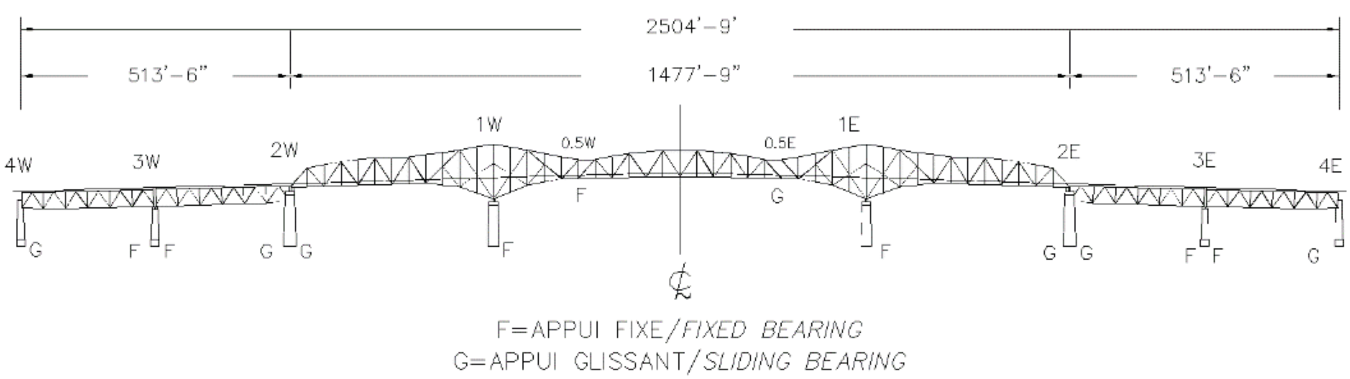


Figure 5 – Section 6 – Elevation

Spans 4W-3W, 3W-2W, 2E-3E and 3E-4E consist of four deck-trusses (Figure 6), while the main span is a cantilever span with a suspended central span composed of three trusses (Figure 7). For this entire section, the original deck was replaced with an orthotropic steel deck installed between 1990 and 1993.

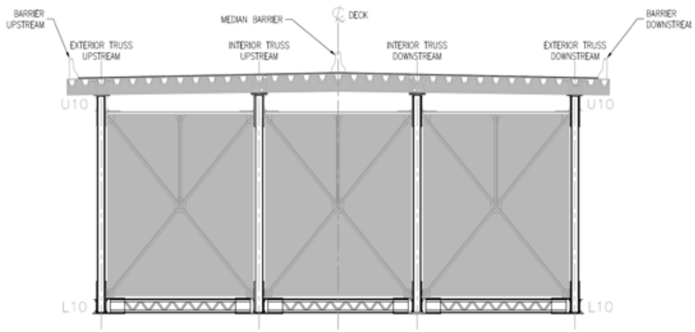


Figure 6 – Typical cross-section of spans 4W-2W/2E-4E – Section 6 (source: JCCBI nomenclature drawings)

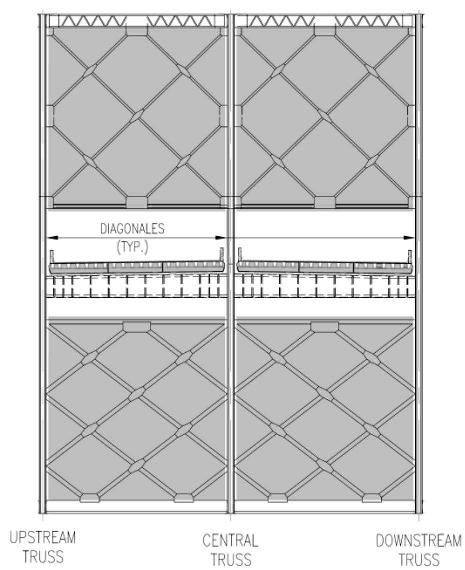


Figure 7 – Cross-section of spans 2W-2E – Section 6 (source: JCCBI nomenclature drawings)

The functional cross-section has the following configuration:

- 2 reinforced concrete barriers for spans 4W-2W and 2E-4E ;
- 4 side steel railings for spans 2W to 2E ;
- 1 reinforced concrete median barrier for spans 4W-2W and 2E-4E ;
- 3 traffic lanes for each direction.

The main characteristics of section 6 are presented in Table 2.

Table 2 – Section 6

	SECTION 6 SPANS 4W-3W AND 3E-4E	SECTION 6 SPANS 3W-2W AND 2E-3E	SECTION 6 SUSPENDED SPAN 0.5W-05E	SECTION 6 ANCHOR SPANS 2W-1W AND 1E-2E	SECTION 6 CANTILEVER SPAN 1W-05.W AND 0.5E-1E
Width	24.08 m (overall width)	24.08 m (overall width)	22.10 m (c-c of edge trusses)	22.10 m (c-c of edge trusses)	22.10 m (c-c of edge trusses)
Number of spans	2	2	1	2	2
Span length	78 m (256')	78.5 m (257' 6")	117.50 m (385' 6")	117.50 m (385' 6")	48.9506 m (160' 7 ½")
Number of girders/span	4	4	3	3	3
Girder height (c-c of chords)	9.14 m (30')	9.14 m (30')	15.19 m (49' 10 1/16" max)	31.70 m (104' max)	31.70 m (104' max)
Girder spacing	7.11 m (23' 4")	7.11 m (23' 4")	13.25 m (43' 6")	13.25 m (43' 6")	13.25 m (43' 6")
Slab	Orthotropic	Orthotropic	Orthotropic	Orthotropic	Orthotropic
Type	Simple spans	Simple spans	Continuous spans	Continuous spans	Continuous spans
Total length	763.45 m (2,504' 9")				

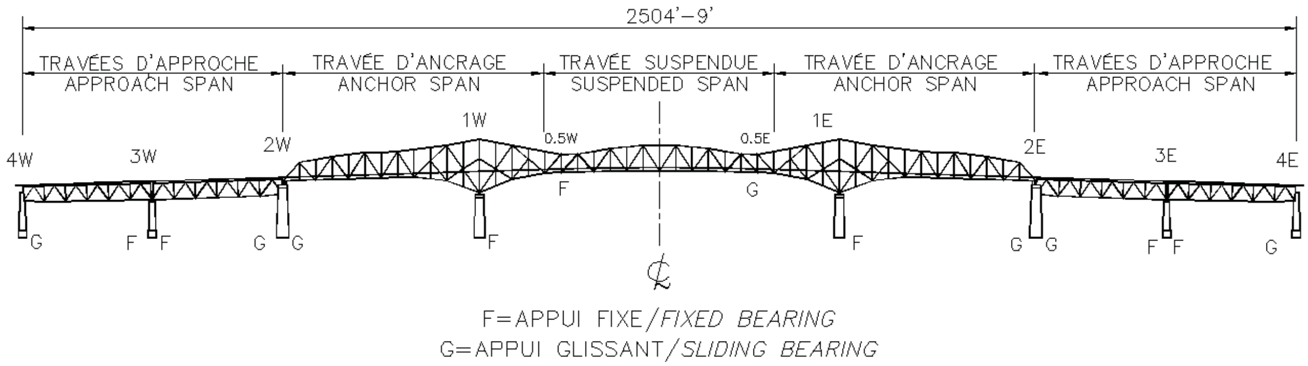


Figure 8 – Section 6 – Type of spans

2.3.3 SECTION 7

Section 7 links the Seaway to the City of Brossard. As for section 5, The deck is composed of seven precast prestressed post-tensioned girders (Figure 9) spaced at 3.721 m. The concrete spans have a particular structural system, since the girders are not topped with a reinforced concrete slab, as is usually the case, but instead, the slab is an infill strip between the girders. The 216 mm cast-in place slab is connected to the girders by transverse post-tensioning.

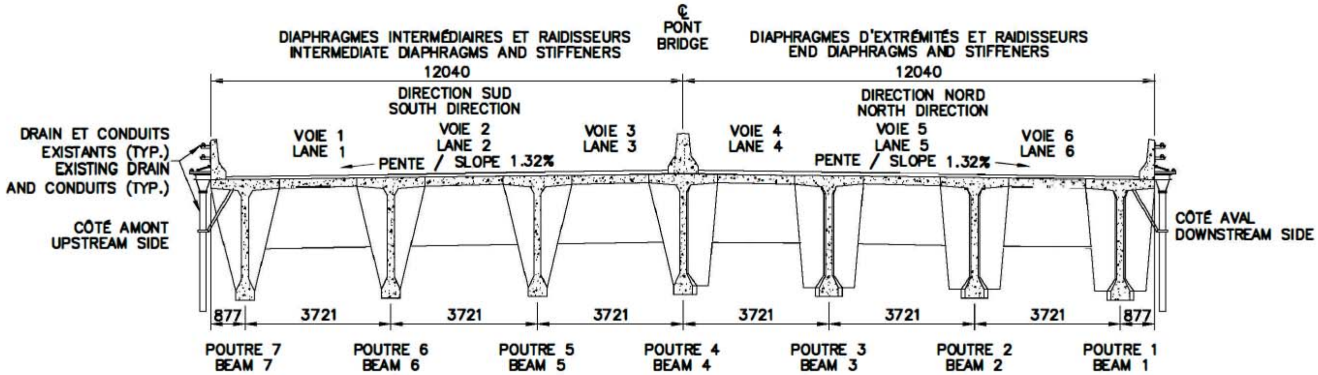


Figure 9 – Typical cross section – Section 7B

Section 7 consists of 10 spans with lengths ranging from 53.75 m to 51.41 m (total length of 528.07 m) and extends from axis 4E to axis 14E (abutment). Section 7 is subdivided into sections: section 7A between axes 4E and 10E has the same characteristics as section 5, except for spans 8E-9E and 9E-10E, which are slightly shorter in length, and section 7B which has slightly shorter spans and a different prestressing system, made up of SEEE 12 T13 tendons.

Only axes 4E and 5E are located over the St. Lawrence. Span 10E-11E crosses Route 132 in the City of Brossard. The longitudinal slope is significant, close to 3%.

The functional cross-section has the following configuration:

- 2 reinforced concrete side barriers ;
- 1 reinforced concrete median barrier ;
- 3 traffic lanes in each direction ;
- Average transverse slope of 1.32%.

The main characteristics of section 7 are presented in Table 3.

Table 3 – Section 7

	SECTION 7A	SECTION 7A	SECTION 7B	SECTION 7B
Spans	4E to 8E	8E to 10E	10E to 13E	13E-14E
Overall width	24.08 m	24.08 m	24.08 m	24.08 m
Number of spans	4	2	3	1
Span length	53.75 m (176' 4")	51.41 m (168' 8")	52.53 m (172' 4")	52.68 m (172' 10")
Girder length	53.65 m (176')	51.308 m (168' 4")	52.451 m (172' 1")	52.451 m (172' 1")
Number of girders/span	7	7	7	7
Girder height	3.07 m	3.07 m	3.07 m	3.07 m
Girder spacing	3.721 m	3.721 m	3.721 m	3.721 m
Intermediate diaphragms	2	2	5	5
Reinforced concrete slab thickness	216 mm	216 mm	216 mm	216 mm
Type	Simple spans	Simple spans	Simple spans	Simple spans
Number of prestressing tendons	24 tendons: 12 7-mm strands/tendon	24 tendons: 12 7-mm strands/tendon	19 tendons 22 (10E-11E)	19 tendons
Type of prestressing	Freyssinet (STUP)	Freyssinet (STUP)	GTM (SEEE system)	GTM (SEEE system)
Total length	528.07 m (1732' 6")			

The girders sit on reinforced concrete hammerhead piers. The footings rest on the bedrock. Pier height ranges from 9 to 26 m. As it is the case for the deck, two types of piers are present, those within section 7A have the same shape as those of section 5 while the piers of section 7B have a different shape ((Figure 10).

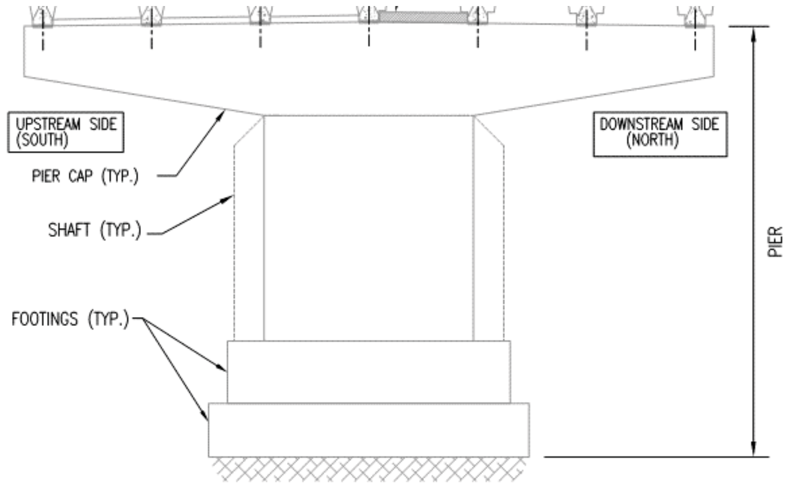


Figure 10 – Piers – Section 7 (source: JCCBI nomenclature drawings)

2.3.4 STRENGTHENING AND MAJOR REPAIRS

Over time, strengthening and repairs were needed to ensure the safety of users and the integrity of the structure. The prestressed concrete spans, and the edge girders in particular, are the components that have deteriorated the most and therefore have been subjected to most repairs or strengthening.

The main types of repairs and reinforcements are described below. The following tables summarize the number of reinforcements carried out or planned before the deconstruction according to the information available as of June 8 2016. Other strengthening or repairs could be added before the deconstruction, depending on the evolution of the structure.

Table 4 – Reinforcements – Girders – Sections 5 and 7

	NUMBER OF EDGE GIRDERS	WEIGHT OF THE REINFORCEMENT PER GIRDER (CONCRETE COMPONENT OF THE REINFORCEMENT)	WEIGHT OF THE REINFORCEMENT PER GIRDER (STEEL COMPONENT OF THE REINFORCEMENT)
Type 1 external post-tensioning (EPT1)	100	6 t	1 t
Type 2 external post-tensioning (EPT2)	63 and 26 internal girders	S. O.	5 t
Type 1 Queen-posts (QP1)	26	39 t	20 t
Type 2 Queen-posts (QP2)	14	20 t	7 t
Carbon Fibre Reinforced Polymer (CFRP)	72 and 27 internal girders	Not applicable	Not applicable
Strengthening under the span with posts	6	Not applicable	130 t per span
Modular trusses	90	Not applicable	50 t (QP1) or 32 t
Auxiliary girders	4	Not applicable	Not available

Table 5 – Reinforcements – Slab – Sections 5 and 7

	NUMBER OF SPANS	WEIGHT OF THE REINFORCEMENT PER SPAN (CONCRETE COMPONENT OF THE REINFORCEMENT)	WEIGHT OF THE REINFORCEMENT PER SPAN (STEEL COMPONENT OF THE REINFORCEMENT)
Slab – PT	27	1 t	0,70 t
Slab – passive	6	Not applicable	3,25 t

Table 6 – Reinforcements – Foundations – Sections 5 and 7

	NUMBER OF AXES	WEIGHT OF THE REINFORCEMENT PER PIER (STEEL COMPONENT OF THE REINFORCEMENT)
Steel lining for pier shafts (average)	22	9,40 t
Pier caps – PT (internal or external)	48	1,15 t

2.3.4.1 External post-tensioning (EPT)

One of the first reinforcements consisted of adding external post-tensioning (EPT) to the edge girders (Figure 11). First, post-tensioning was added at the bottom flanges. Next, additional prestressing was needed for certain girders, and a second level of prestressing was added, this time at the bottom of the girder web (Figure 12).

Figure 11 – Concrete girders – Type 1 additional post-tensioning reinforcement (EPT1) (source: ct 62419)

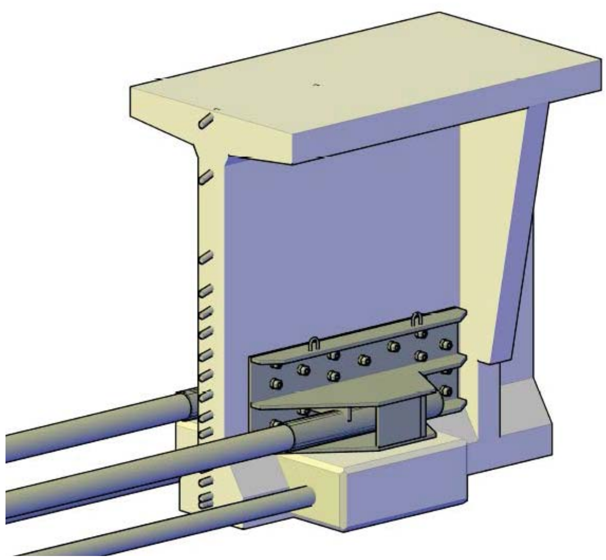


Figure 12 – Concrete girders – Type 2 additional post-tensioning reinforcement (EPT2) (source: JCCBI nomenclature drawings)

26 internal girders were also reinforced using external post-tensioning.

2.3.4.2 Queen-posts (QP1)

Queen posts (QP1) are reinforcements that are basically made of prestressing bars placed under the edge girders. The prestressing bar anchor blocks are located along the web of the prestressed girders.

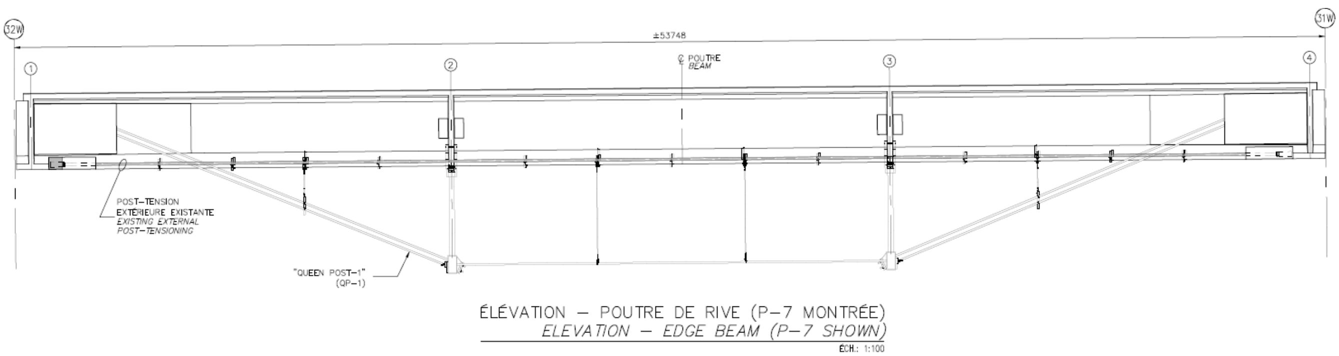


Figure 13 – Concrete girders – QP1 reinforcement (source: ct 62419)

Figure 14 – Concrete girders – QP1 reinforcement – Cross section (source: ct 61315)

2.3.4.3 Deflected greased-sheathed single strands (QP2)

The deflected greased-sheathed single strand system (QP2) was developed for spans with a vertical clearance above the road that does not allow installing queen-posts (QP1). The system consists of adding prestressing through single strands whose anchor block is connected to the web of the prestressed girders. There are at least two types of QP2: one with 16 strands and one with 8 strands.

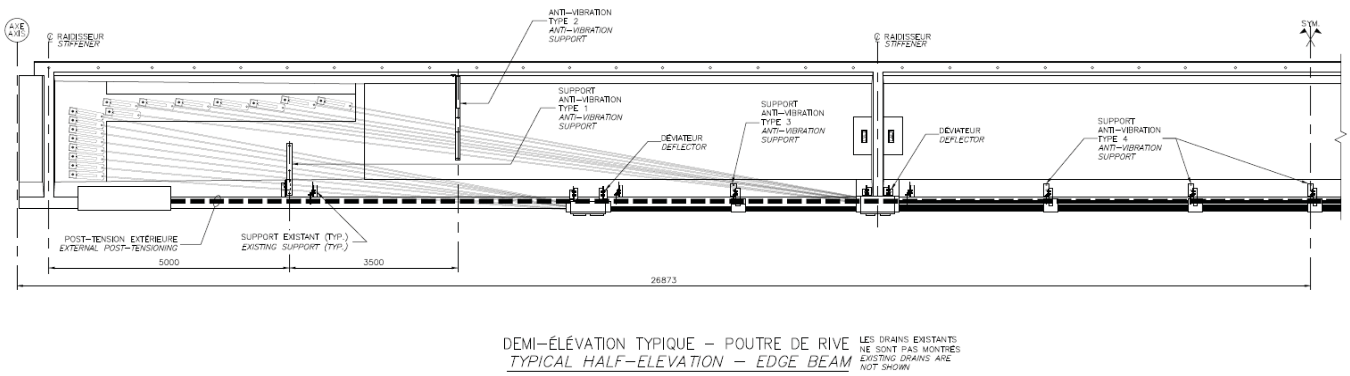


Figure 15 – Concrete girders – QP2 reinforcement – 16 strands (source: ct 62419)

Figure 16 – Concrete girders – QP2 reinforcement – 8 strands (source: ct 61692)

2.3.4.4 Carbon Fibre Reinforced Polymer (CFRP)

Strips of carbon fibre reinforced polymer (CFRP) were generally installed over the two thirds of the girder's length, at the ends of the girders to restore their shear capacity. 27 internal girders were also reinforced.

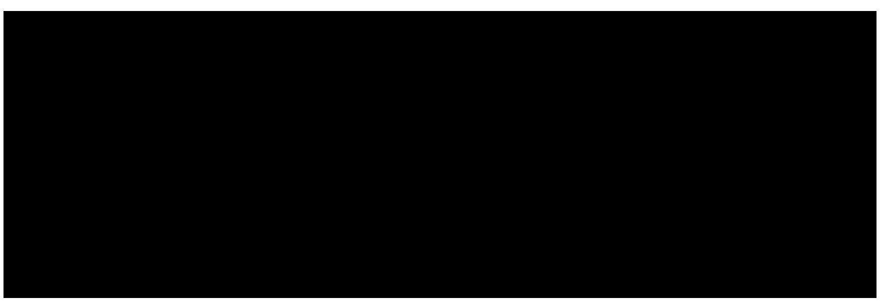


Figure 17 – Concrete girders – CFRP reinforcement (source: ct 62419)

2.3.4.5 Strengthening under the span with posts

This kind of system was installed for spans where posts could be placed under the girders. The system consists of steel columns that support the girders. The steel pillars sit on reinforced concrete surface footings. The strengthening under the span with posts was also used in combination with QP2.

Figure 18 – Concrete girders – strengthening under the span with posts
(source: ct 62419)

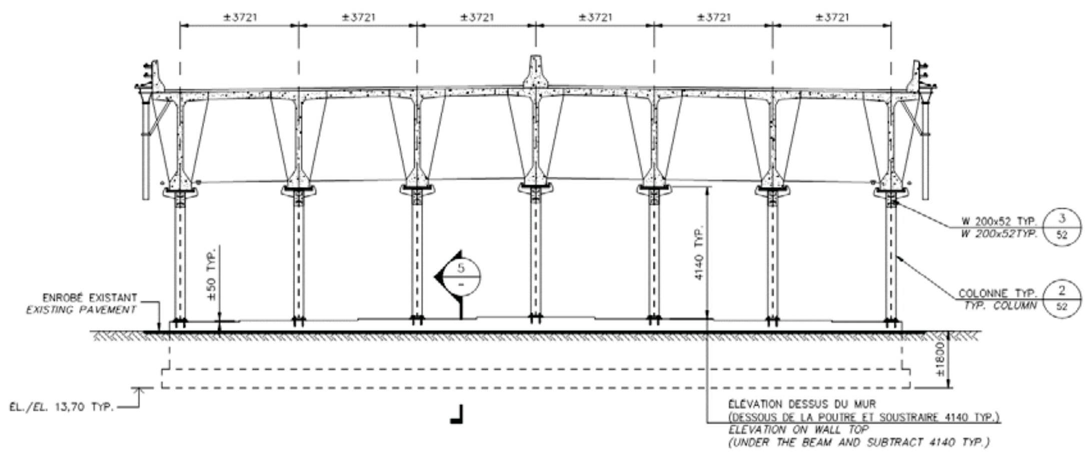


Figure 19 – Concrete girders – strengthening under the span with posts – Cross-section
(source: ct 62419)

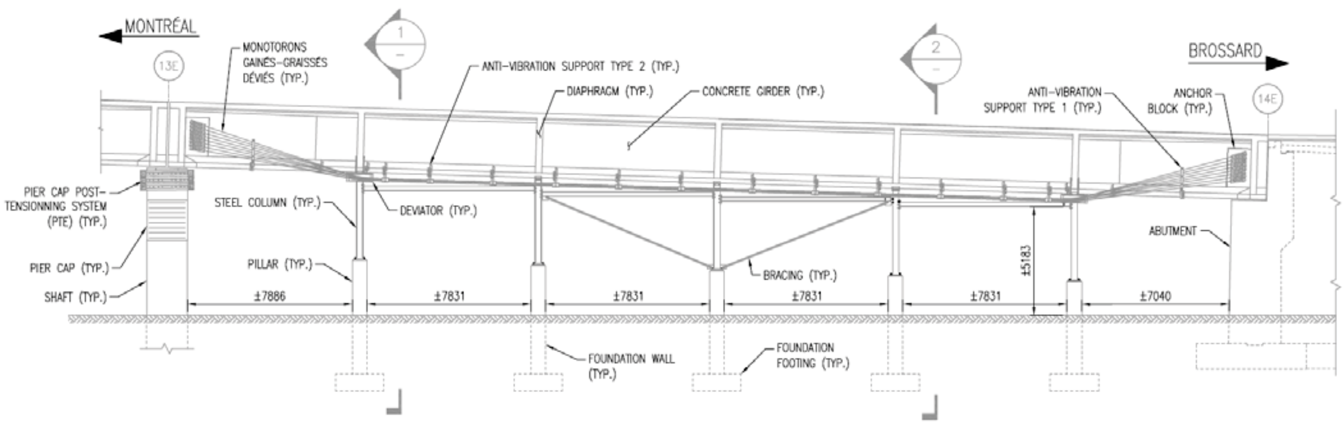


Figure 20 – Concrete girders – strengthening under the span with posts and QP2
(source: JCCBI nomenclature drawings)

2.3.4.6 Modular trusses

Modular trusses are steel trusses installed under the girders that are designed to take up the entire load of the edge girder, if necessary. Several types of modular trusses have been developed to be combined with the other reinforcements in place: standard trusses, trusses for QP1, and trusses for QP2

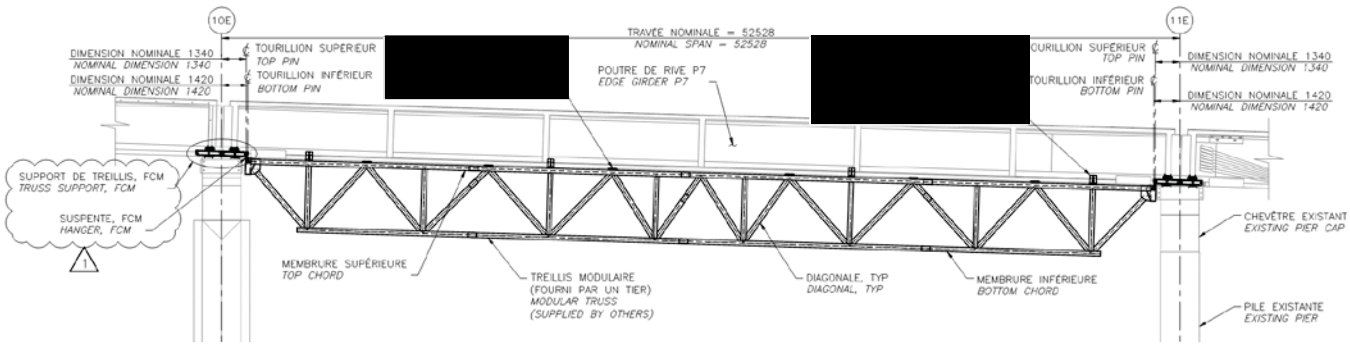


Figure 21 – Concrete girders – Reinforcement using modular trusses (source: ct 62419)

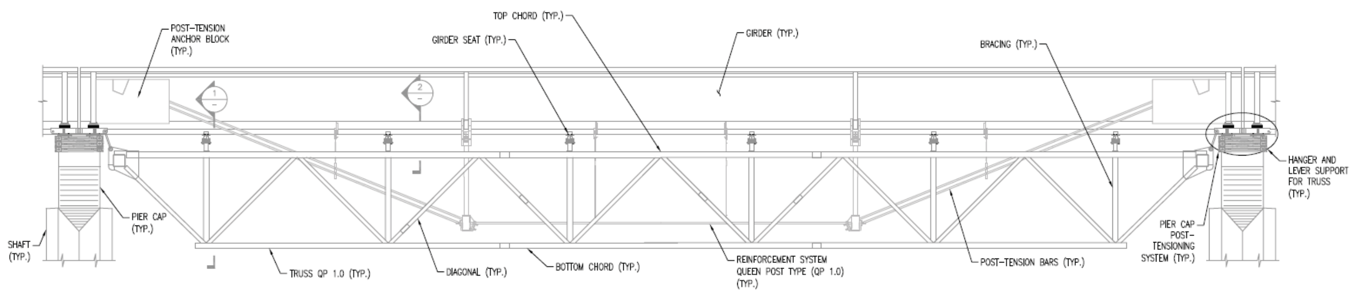


Figure 22 – Concrete girders – Reinforcement using modular trusses for QP1 (source: JCCBI nomenclature drawings)

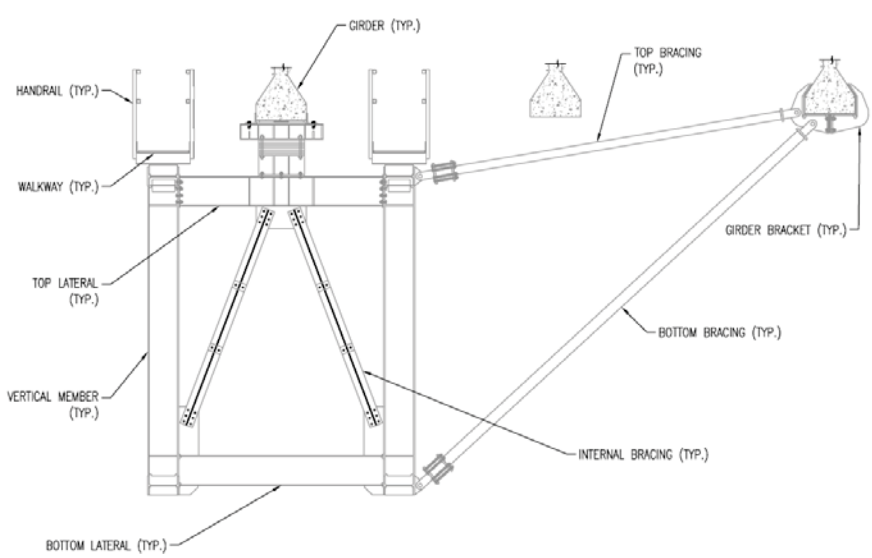


Figure 23 – Concrete girders – Reinforcement using modular trusses for QP1 (QP1 not shown) – cross-section (source: JCCBI nomenclature drawings)

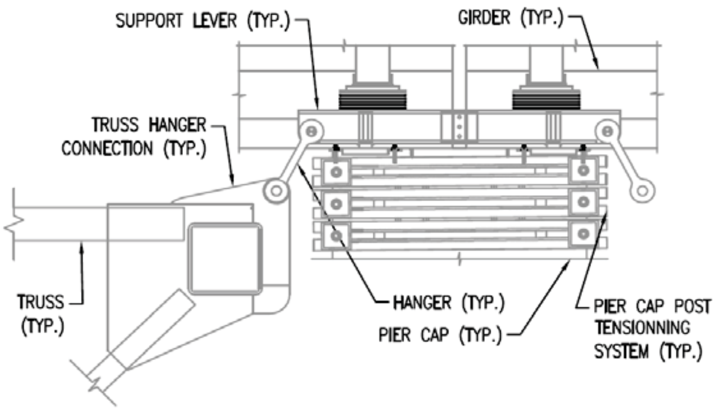


Figure 24 – Concrete girders – Reinforcement using modular trusses – support at pier caps (source: JCCBI nomenclature drawings)

2.3.4.7 Auxiliary girders

When the available vertical clearance prevents the use of modular trusses and that post cannot be placed under the girders, auxiliary girders are used. The system comprises two steel girders installed along the edge girders linked with transversal post-tensioning.

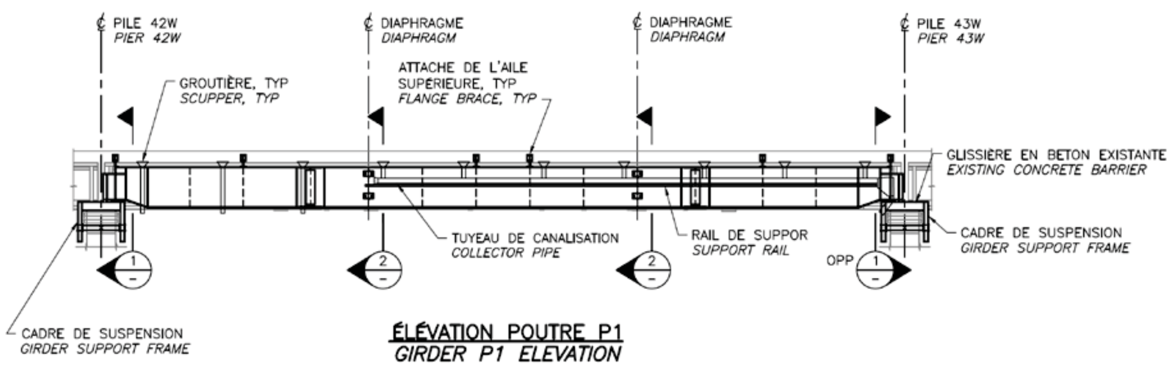


Figure 25 – Concrete girders – Reinforcement using auxiliary girders (source : ct 62414-125814-1004)

2.3.4.8 Diaphragms

The use of additional post-tensioning combined with the deterioration of the concrete and prestressing tendons required the reinforcement of the intermediate diaphragms. New prestressing tendons were added or CFRP strips were installed.

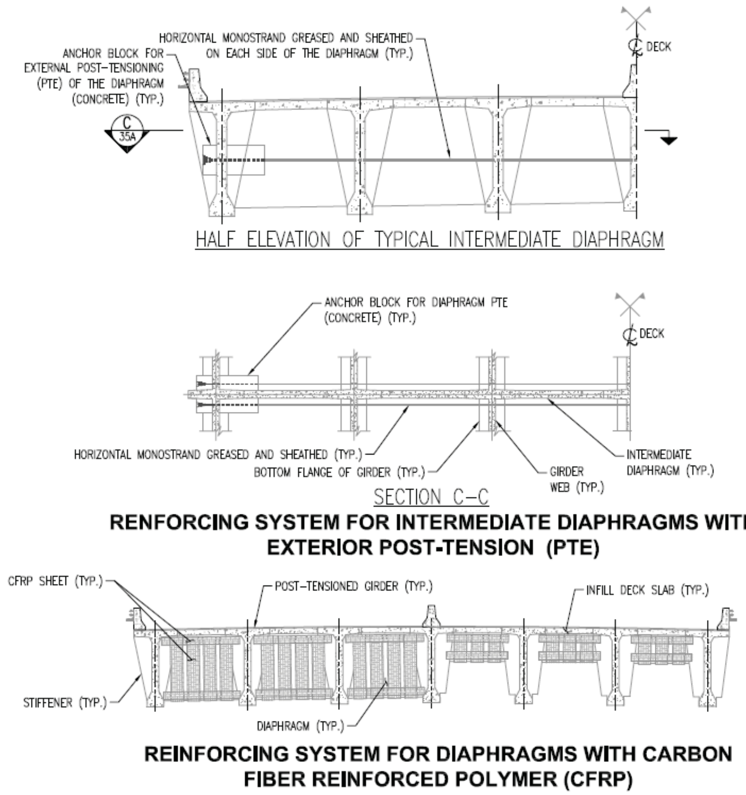


Figure 26 – Concrete girders – Diaphragm reinforcement (source: JCCBI nomenclature drawings)

2.3.4.9 Active and passive slab supports

The infill slabs are interconnected with prestressing tendons. Like the girders, these components have been damaged, and two systems were proposed to repair them: passive slab support, essentially consisting of a steel girder between the girders to support the slab, and an active system, which consists of installing prestressing under the slab. The active system is installed over the entire width of the bridge, while passive support can only be installed between two girders.

[redacted]

Figure 27 – Slab – Passive reinforcement

[redacted]

Figure 28 – Slab – Active reinforcement – with deflectors

[redacted]

Figure 29 – Slab – Active reinforcement – without deflectors

2.3.4.10 Pier cap prestressing

All concrete spans pier caps have been reinforced by the addition of post-tensioning. Three systems were installed: internal post-tensioning (extra thickness of concrete added), unsheathed external post-tensioning and sheathed external post-tensioning

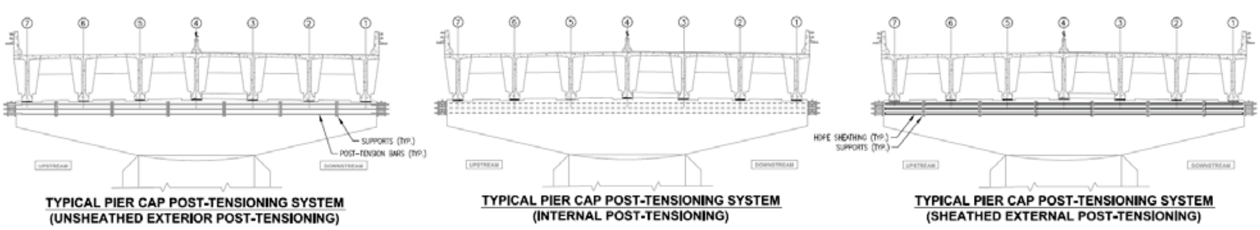


Figure 30 – Pier caps – Prestressing (source: JCCBI nomenclature drawings)

2.3.4.11 Steel lining of the piers

Steel lining was added to the shafts of several piers in sections 5 and 7.

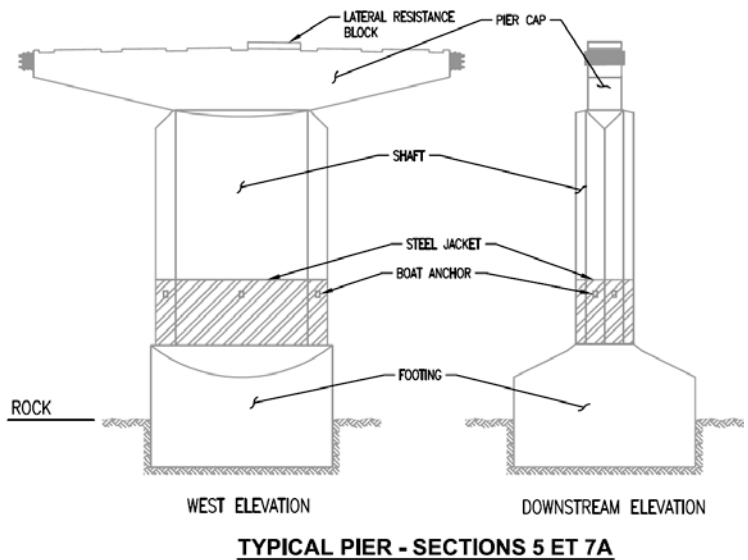


Figure 31 – Piers – Steel lining (source: JCCBI nomenclature drawings)

2.3.4.12 Steel spans

Steel spans underwent only one major transformation, the replacement of the original deck with an orthotropic deck. The original deck was made of steel crossbeams and steel stringers supporting a concrete slab. The deck was replaced in the early 1990's.

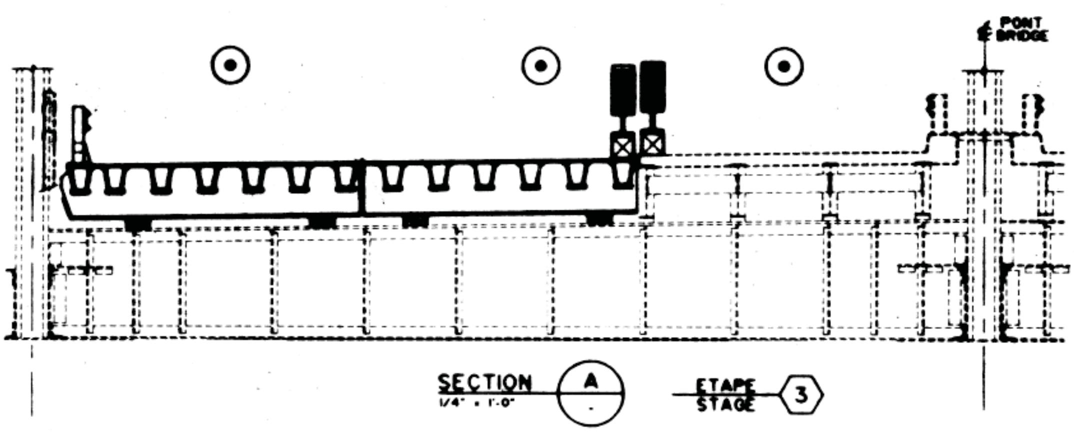


Figure 32 – Section 6 – Deck replacement (source: drawing 121036)

The pier caps of axes 2E and 2W in section 6 were reinforced using internal prestressing. Rock anchors were added to the footings of axes 1E, 1W, 3E and 3W. A steel lining was added to the piers at axes 1W and 1E.

Figure 33 – Section 6 – Pier 1E (source: dessin 125657-06)

Figure 34 – Section 6 – Pier 1E – Steel lining

2.3.5 SCOPE OF WORK (QUANTITIES)

The unit weight used corresponds to the values in Table 3.4 of Standard S6-14: 24.5 kN/m³ for prestressed concrete, 24.0 kN/m³ for reinforced concrete, 23.5 kN/m³ for the bituminous wearing surface. The quantities presented below are values appropriate for a feasibility study and do not constitute data that can be used for drawings and specifications or calls for tenders.

2.3.5.1 Sections 5 and 7 – Concrete spans

The estimated quantities for the deck and foundations of sections 5 and 7 are respectively presented in Table 7 and Table 8.

Table 7 – Quantities overview – Deck

	SECTION 5 & 7A	SECTION 7B	TOTAL
Number of spans	44	6	50
Number of girders	308	42	350
Weight of girders and diaph. per span	1,210 t	1,030 t	59,420 t
Slab weight per span	345 t	335 t	17,190 t
Barrier weight per span	130 t	125 t	6,470 t
Weight of reinforcements (concrete component)			1,925 t
TOTAL - Concrete			**85,005 t**
Total volume of concrete			34,037 m³
Weight of reinforcements (steel component)			4,795 t
Weight of asphalt per span (65 mm)	190 t	185 t	9,470 t

Table 8 – Quantities overview – Foundations

	SECTION 5	SECTION 7	TOTAL
Number of piers	39	9	48
Weight of pier cap	365 t	365 t	17,520 t
Mean height of pier shaft	16.90 m	15.10 m	
Mean weight of pier shaft	935 t	840 t	44,025 t
TOTAL			**61,545 t**
Total volume of concrete for pier cap/pier shaft			25,157 m³
Min. height of pier shaft	3.30 m	9.30 m	
Max. height of pier shaft	26.15 m	22.85 m	
Mean weight of footings	920 t	920 t	**44,745 t**
Total volume of concrete footings			18,290 m³
Weight of reinforcements (steel - lining and PT pier caps)			**270 t**

2.3.5.2 Section 6 – Steel spans

The estimated quantities for the deck and foundations of section 6 are respectively presented in Table 9 and Table 10.

Table 9 – Quantities overview – Deck

	SECTION 6 SPANS 4W-3W AND 3E-4E	SECTION 6 SPANS 3W-2W AND 2E-3E	SECTION 6 SPAN 2W-2E	TOTAL
Number of edge trusses	4	4	2	
Number of internal trusses	4	4	1	
Weight of edge trusses	434 t	441 t	1,896 t	2,771 t
Weight of internal trusses	508 t	513 t	1,639 t	2,660 t
Weight of bracing	156 t	151 t	943 t	1,250 t
Weight of steel deck	990 t	996 t	3,276 t	5,262 t
Weight of steel railings	N/A	N/A	559 t	559 t
TOTAL – Steel				**12,502 t**
Concrete barriers	341 t	343 t	N/A	
TOTAL – Concrete				**684 t**
Asphalt weight	445 t	458 t	1,391 t	**2,294 t**

Table 10 – Quantities overview – Foundations

	SECTION 6
Number of piers	8
Min. height of pier shaft	37.37 m
Max. height of pier shaft	25.71 m
Mean height of pier shaft	30.61 m
Weight of pier shafts	34,765 t
Weight of footings	26,287 t
Total weight	**61,052 t**
Total volume	24,955 m³

2.3.5.3 Summary

Table 11 provides a summary of the quantities.

Table 11 – Quantities overview – Global

	SECTIONS 5, 6 AND 7
Concrete	253 031 t
Steel	17 567 t
Asphalt	11 764 t

2.3.6 ICE CONTROL STRUCTURE

The Ice Control Structure, located upstream of the Champlain Bridge, was built in 1965, mainly for ice control in the La Prairie Basin and to reduce the erosion of the islands near Montreal, especially those created for Expo 67.

The 2,040-m-long structure comprises 73 spans: 70 concrete (precast prestressed concrete girders) measuring 26,87 m each and three 53,34 m steel spans. This structure provides access to the Seaway dike, mobilization areas and dock located near pier 1W on the Champlain Bridge. This road access reduces the number of bridge closures.

The Ice Control Structure deck was recently rehabilitated and, according to Stantec's study[2], is able to withstand legal loads. In the absence of an evaluation of the icebreaker piers, it is assumed that they have at least the same capacity. The Ice Control Structure is critical to the deconstruction project: it will provide access to the work area and serve as an essential link for the supply of materials to the work site and the removal of materials.

The approaches to the Ice Control Structure, both on Nuns' Island and at the Seaway dike, are currently being upgraded. The purpose of this work is to improve the layout and setup of control and monitoring equipment

Figure 35 – Ice Control Structure

2.4 CONSTRAINTS OF THE HOST ENVIRONMENT

Prior to the assessment of the options being considered based on technical, environmental, social and cost criteria, the PTA consortium adopted a precautionary approach from the very beginning, by advising all members of the study team of the study zone constraints, to avoid assessing alternatives that conflict with these constraints.

The study area corresponds to the area defined for the environmental assessment involving the new Champlain Bridge (Dessau-Cima+, 2013[3]). This study, conducted in 2013 for Transport Canada, also included the deconstruction of the existing Champlain Bridge. The study area is presented in Drawing 101 in Appendix 1.

The environmental constraints were established based on the following environmental components of the host environment:

1. Physical environment
    a. Soil and sediment quality
    b. Groundwater quality
    c. Surface water quality
    d. Hydrology
    e. Air quality
2. Biological environment
    a. Terrestrial and aquatic vegetation, including wetlands
    b. Fish and habitats
    c. Reptiles/amphibians and habitats
    d. Birds and habitats
    e. Mammals and habitats
    f. Special-status species and habitats

[2] Stantec, 16 décembre 2015. Acceptation des travaux de renforcement du tablier de l'Estacade du pont Champlain, Ct. 62094-Ct. Construc. 62402/N° projet Stantec 159010053.
[3] Dessau-Cima+ 2013. Évaluation environnementale du Nouveau pont pour le Saint-Laurent. © Her Majesty the Queen in Right of Canada.

3. Human environment
    a. Sound environment
    b. Existing infrastructures (e.g., new Champlain Bridge)
    c. Land and buildings
    d. Shipping and recreational boating (e.g., St. Lawrence Seaway Management Corporation (SLSMC))
    e. Recreational and tourism activities
    f. Archaeology and heritage
    g. Landscape
    h. Traditional use of land and resources

The host environment for the study area was defined following a review of the documents provided by the client and a consultation of public data regarding the City of Montreal and City of Brossard land use plans, as well as the environmental assessment of the construction of a temporary bypass bridge at Nuns' Island (Génivar, 2013[4]).

Following the literature review, environmental constraints were identified on a preliminary basis. These mainly affect three areas of study for the deconstruction of the existing Champlain Bridge, namely, deconstruction, materials transportation and asset enhancement. Table 12 and Drawings 102 and 103 (Appendix 1) present the environmental constraints and their approximate locations.

[4] Génivar 2013. *Aménagement d'un pont-jetée temporaire en vue du remplacement du pont de l'île-des-Sœurs: Rapport d'évaluation environnementale du projet.* Summary prepared for the Jacques-Cartier and Champlain Bridges Inc. 53 pages and appendix.

Table 12 – Constraints

ENVIRONMENTAL COMPONENT	ENVIRONMENTAL CONSTRAINT	LOCATION
Physical environment	Contaminated sediment	St. Lawrence Seaway (Small La Prairie Basin)
	Sensitive areas for air quality	South-West and Verdun Borough, Nuns' Island, Brossard
	Surface water quality (drinking water intake, fish habitats, recreation and tourism activities)	St. Lawrence River, St. Lawrence Seaway
Biological environment	Fish spawning and aquatic grass areas of interest	Northern tip of Nuns' Island, St. Lawrence Seaway
	Waterfowl gathering area	Off shore from Nuns' Island
	Migratory bird sanctuary	Couvée Island
	Nesting sites for the peregrine falcon (vulnerable species) and cliff swallow	Existing Champlain Bridge, Ice Control Structure
	Special-status plant and animal species: rough water-horehound and St. Lawrence water-horehound, peregrine falcon, chimney swift, brown snake, American eel, chain pickerel, lake sturgeon, rosyface shiner, and American shad.	See Drawings 102 and 103 (Appendix 1). Note that fish fauna was not mapped.
	Restricted period for work in water	–
	Restricted disruption period in the migratory bird sanctuary	–
Human environment	Areas sensitive to noise	South-West and Verdun Borough, Nuns' Island, Brossard
	New Champlain Bridge	St. Lawrence River, St. Lawrence Seaway, Nuns' Island, City of Brossard
	St. Lawrence Seaway	Small La Prairie Basin
	Archaeological site	Northeastern tip of Nuns' Island
	Residential areas	Nuns' Island and South Shore
	Areas with "Park," "Recreation and protection" and "Conservation" zoning	Nuns' Island, South Shore, dyke of the St. Lawrence Seaway
	Recreational and tourism activities associated with the St. Lawrence River (recreational boating, recreational fishing, windsurfing) or alongside the river (e.g., bike path, walking trails, parks)	St. Lawrence River, St. Lawrence Seaway, Nuns' Island, City of Brossard

3 EVALUATION CRITERIA

The purpose of this process is to identify several alternatives in each area of study. An optimal combination of the above alternatives must be selected to move on to the next planning stages for the deconstruction of the existing Champlain Bridge. To facilitate the selection, each alternative will be assessed based on technical evaluation criteria and sustainable development evaluation criteria (economic, environmental and social).

For the technical evaluation of the options, the evaluation criteria are closely linked to the technical feasibility and constraints specific to each area of study. Thus, sections 4, 5, 6 and 7 each list the technical evaluation criteria specific to these areas of study.

For the environmental, social and economic evaluation criteria, it was decided to use the same criteria to assess the options of all four areas of study. To begin, a large quantity of possible criteria was identified from which the most relevant evaluation criteria were selected (see sections 3.1 to 3.3). To keep the efforts involved in assessing the options to a reasonable level, it was proposed to choose five evaluation criteria for each sustainable development facet. Subsequent to a proposal made by PTA, a set of definitive criteria was retained by JCCBI based on its mission, and government and taxpayer interests.

3.1 ECONOMIC CRITERIA

The identification of economic evaluation criteria, from the standpoint of sustainable development, differs from the traditional cost/benefit analysis in that a broader view of the economic variants is involved. An analysis of the economic evaluation criteria that were identified led to the selection of the five criteria highlighted in the table below. The “Procurement method” criterion was withdrawn following an internal review conducted by JCCBI, as this aspect of the study is part of a separate analysis. The “Origin of labour” criterion was chosen instead, at JCCBI’s request.

For the “Direct jobs” criterion, we determined that the number of jobs created is directly proportional to the value of the capital expenditures. To validate this hypothesis, we asked the Institut de la statistique du Québec to conduct a study on the economic impact for Quebec of the capital expenditures associated with the deconstruction of the Champlain Bridge. This study is provided in Appendix 2.

The Institut de la statistique du Québec uses a Quebec intersectoral model to measure the economic impact of a spending initiative on the Quebec economy. Based on different types of expenditures, the model assesses the impact on labour, added value, indirect taxes and leaks (imports and other productions). It also allows government tax revenues to be estimated, as well as the incidental taxes paid by employees and the employer. For the purposes of the project, the simulation was done using an average expenditure structure for transportation-related engineering work. However, caution should be exercised when interpreting the results since the models are based on construction work and not on deconstruction work.

Table 13 – Economic criteria

	CRITERION	DESCRIPTION	SELECTED	JUSTIFICATION
1	Direct costs	Cost of work, including the cost of disposing of the materials – Quantitative / Moderate accuracy	Yes	
2	Indirect costs	Related costs: road wear, greenhouse gas compensation, fish habitat compensation, financial penalties, etc. – Quantitative / Low accuracy	No	Indirect costs usually associated with the direct costs. Non-discriminating.
3	Operating costs	Cost of operating the structures and installations resulting from the project – Quantitative / Moderate accuracy	No	Mainly applicable to asset development options (technical criterion).
4	Procurement method	Compatibility of options with proposed methods of financing – Qualitative / High accuracy	No	Criterion withdrawn by JCCBI due to the specific handling of this issue at the end of this report.
5	Lifespan	Lifespan of structures and installations resulting from the project (depreciation) – Quantitative / High accuracy	No	Pertains only to asset development options (technical criterion).
6	Direct jobs	Number of employees directly assigned to the project (e.g., client, consultants, contractors, subcontractors, suppliers) – Quantitative / Moderate accuracy	Yes	Criterion expanded to include direct and indirect jobs.
7	Indirect jobs	Number of jobs supported by the project's economic activity – Quantitative / Moderate accuracy	No	Indirect jobs usually associated with direct jobs. Non-discriminating.
8	Origin of labour	Identify the possible origin of the required labour (on a national and international scale) – Qualitative / Moderate accuracy	Yes	Criterion retained by JCCBI since it is at the core of the federal government mandate (note: local jobs = in Canada).
9	Origin of contractors and subcontractors	Identify the possible origin of the required contractors (on a local, regional and national scale) – Qualitative / Moderate accuracy	No	Criterion similar to 8 (jobs).
10	Origin of suppliers	Identify the possible origin of the required suppliers (on a local, regional and national scale) – Qualitative / Moderate accuracy	No	Criterion similar to 8 (jobs).
11	Origin of consultants	Identify the possible origin of the required consultants (on a local, regional and national scale) – Qualitative / High accuracy	No	Criterion similar to 8 (jobs).
12	Risk of delays to the project schedule.	Assess the possibility of complications that could cause delays – Qualitative / Moderate accuracy	Yes	
13	Commercial navigation	Negotiations required for work on the Seaway and associated costs/lead times – Qualitative / High accuracy	Yes	
14	Tourism and leisure	Effect on the area's tourist appeal and on available recreational/leisure activities – Qualitative / Moderate accuracy	No	Mainly pertains to asset development options (technical criterion).
15	Real-estate development	Creation of areas suitable for real-estate projects, increase in land value, land value capture – Quantitative / Moderate accuracy	No	Pertains only to asset development options, but is not retained as a technical criterion.
16	Ecological services	Preservation or enhancement of productive habitats (e.g., filtering marshes, shade islands, carbon sinks, spawning grounds, nesting sites) – Qualitative / High accuracy	No	Criterion included in the environmental evaluation criteria.
17	Vulnerability to climate change	Assess the vulnerability of the structures and installations resulting from the project to an increase in water levels or extreme climate events – Qualitative / Low accuracy	No	Mainly pertains to asset development options (technical criterion).

3.2 ENVIRONMENTAL CRITERIA

Two major sources of information for identifying environmental evaluation criteria are the environmental impact study conducted for the construction of the new Champlain Bridge and the constraints of the natural environments found in section 2.4. An analysis of the environmental evaluation criteria that were identified led to the selection of the five criteria highlighted in Table 14.

Table 14 – Environmental criteria

	CRITERION	DESCRIPTION	SELECTED	JUSTIFICATION
1	Water quality	Impact during and after work on the river water (e.g., sedimentation, spill) – Qualitative / High accuracy	Yes	
2	Air quality	Impact on ambient air quality during and after the work – Qualitative / Moderate accuracy	No	Included in social evaluation criteria (nuisances).
3	Greenhouse gas emissions	Carbon footprint of the various options – Quantitative / Moderate accuracy	Yes	
4	Fish habitats	Loss of habitat during and after the work – Quantitative / High accuracy	No	Included in criterion 10.
5	Nesting birds	Loss of nesting sites – Quantitative / High accuracy	No	Included in criterion 10.
6	Migratory birds	Bycatch (disturbance) and loss of space in a waterfowl gathering area – Quantitative / High accuracy	No	Included in criterion 10.
7	Reptile/amphibian habitat	Loss of habitat during and after the work – Quantitative / High accuracy	No	Included in criterion 10.
8	Endangered plant species	Loss of individuals and habitat during and after the work – Quantitative / High accuracy	No	Included in criterion 10.
9	Wetlands	Loss of surface area during and after the work – Quantitative / High accuracy	No	Included in criterion 10.
10	Biodiversity	Habitat losses reducing biodiversity and scale of the losses (local/regional) – Quantitative / Moderate accuracy	Yes	
11	Biomass	Loss or gain in biomass during and after the work – Quantitative / High accuracy	No	Included in criterion 10.
12	Contaminated soil and sediment	Disturbance of contaminated soil or sediment, or production of new contamination – Qualitative / Moderate accuracy	Yes	
13	Consumption of resources/Residual materials	Use of resources and production of additional residual materials – Quantitative / Moderate accuracy	Yes	Criterion mainly oriented toward the consumption of raw materials.
14	Materials reclamation	Influence of the option on materials reclamation capacity – Qualitative / High accuracy	No	Criterion covered during the cross-evaluation of the areas of study (section 12).

3.3 SOCIAL CRITERIA

Here as well, the environmental impact study conducted for the construction of the new Champlain Bridge and the constraints of the natural environments found in section 2.4 are major sources of information. An analysis of the social evaluation criteria that were identified led to the selection of the five criteria highlighted in Table 15.

Table 15 – Social criteria

	CRITERION	DESCRIPTION	SELECTED	JUSTIFICATION
1	Recreational navigation / Coast Guard	Effect on recreational navigation – Qualitative / High accuracy	Yes	
2	Road traffic	Effect on road traffic during and after the work – Qualitative / High accuracy	Yes	Criterion expanded to include the notion of "nuisances."
3	Active mobility	Effect on active mobility during and after the work – Qualitative / High accuracy	No	Included in criterion 2.
4	Cleanliness of public roads	Possibility of soiling public roads – Qualitative / High accuracy	No	Included in criterion 2.
5	Sound environment	Effect on sound environment during and after the work – Quantitative / Moderate accuracy	No	Included in criterion 2.
6	Dust/odours	Possibility of emitting dust or odours – Qualitative / Moderate accuracy	No	Included in criterion 2.
7	Access to shoreline (public spaces)	Effect on access to riverbanks and shores – Qualitative / High accuracy	No	Included in criterion 15.
8	Access to ice control structures	Effect on access to ice control structures – Qualitative / High accuracy	No	Included in criterion 15.
9	Duration of work	Duration of the option considered (duration of disruption) – Quantitative / High accuracy	No	Included in criterion 15.
10	Fishing and water sports	Effect on fishing and water sports – Qualitative / Moderate accuracy	No	Included in criterion 15.
11	Archeology	Conflict with a documented or potential archeological resource – Qualitative / Low accuracy	No	Unconfirmed potential on the South Shore.
12	Historical/cultural reminder	Possibility of historical or cultural reminder – Qualitative / Moderate accuracy	No	Mainly pertains to asset development options (technical criterion).
13	Landscape/Enhancement of area	Level of integration into the immediate landscape and enhancement of the area – Qualitative / Moderate accuracy	No	Included in criterion 15.
14	Project visibility	Favourable project image – Qualitative / Low accuracy	No	Included in criterion 15.
15	Public support	Strong character of the option, likely to limit opposition to the project – Qualitative / Low accuracy	Yes	
16	Health and safety	Possible risk to the health and safety of workers and users during and after the work – Qualitative / Moderate accuracy	Yes	
17	Knowledge/Innovation	New techniques or know-how provided by the option being considered – Qualitative / Moderate accuracy	Yes	

3.3.1 HEALTH AND SAFETY

Table 16 presents the general risks and associated impacts for the health and safety criterion. The health and safety risks specific to the techniques and tasks retained in this study will be covered throughout the report in each respective section. These apply to all the work sites.

Table 16 – Health and safety – General physical and/or environmental risks

RISKS	EFFECTS	
Hot work environment (heat)	• Headaches • Vomiting • Heatstroke	• Burns • Death
Cold work environment	• Falls • Sprains • Strains • Fractures	• Frostbite • Burns • Hypothermia, death
Extreme temperatures (including rain, downpours, storms, snow and ice)	• Cold/flu • Falls • Sprain	• Strain • Fractures
Noise	• Decreased hearing acuity • Loss of balance	• Hearing loss
Vibrations	• Fatigue, stress, reduced alertness • Loss of sensitivity	• Loss of grip strength • Bone cysts
Biological (fauna and flora)	• Cold/flu • Infections • Hepatitis (A, B, C)	• Rabies, tetanus, AIDS

In according with laws and regulations, the principal contractor is entirely responsible for the prevention of work site accidents. However, each contractor must ensure the health, safety and physical wellbeing of its employees, its subcontractors' employees, and any person assigned to the work site along with those present at the work site, in accordance with federal and provincial laws and regulations as well as other applicable legislation, including, without being limited to, the Safety Code for the Construction Industry, the OHSR, CSA standards (e.g., S350-(R2003), Z150-11, Z460-13, Z1600-14, Z195 and Z94.3). They are also responsible for ensuring that all their equipment meets federal, provincial and other applicable standards. In the event of confusion or a conflict among the standards, the document that is most favourable to JCCBI shall prevail. In addition, contractors must draw up a specific prevention program for the work carried out under the project. It must integrate into this accident prevention program required by the CNESST any special practices related to risks specific to the areas in general and to the type of work that will be performed using the selected deconstruction methods. These must include all the information required to meet health and safety standards, regulations and requirements as well as training of their employees with regard to occupational health and safety related to the target risks and control their enforcement.

3.4 RETAINED CRITERIA AND PROPOSED WEIGHTING

Despite the rigorous process already performed to select the five most relevant criteria for the economic, environmental and social aspects of the options evaluation, further consideration is required to determine the relative weight of each criterion in the evaluation of the options. Table 17 presents the criteria that were retained and offers a weighting between 1 and 4 for the purpose of attributing a higher relative weight to the criteria that are the most selective in choosing the options. This process must also be done with the technical evaluation criteria for each area of study.

The final weighting is the outcome of an initial proposal made by PTA in the 60% report and from an internal JCCBI review completed in mid-September 2016.

Table 17 – Retained criteria and proposed weighting

	CRITERION	CATEGORY	WEIGHTING	JUSTIFICATION
1	Direct costs	Economic	[redacted]	The higher weighting reflects the importance of the sound management of public funds.
2	Jobs	Economic	[redacted]	The high weighting reflects the federal investments objective of supporting economic activity.
3	Origin of jobs	Economic	[redacted]	The higher weighting reflects the support for Canadian jobs, which is at the core of the federal government's mission.
4	Risk of delays to the project schedule.	Economic	[redacted]	Additional delays may affect project credibility and increase costs. An average weighting is retained given the various possible mitigation measures.
5	Commercial navigation	Economic	[redacted]	A low weighting is allocated given that the SLSMC requires detailed memoranda of understanding and the risk of losses is thus minimized.
6	Water quality	Environmental	[redacted]	The high weighting reflects the sensitivity of the water resource, which is valued on a regional scale.
7	Greenhouse gas effects	Environmental	[redacted]	The anticipated regional effects are considered relatively minimal and periodic, thus the low weighting.
8	Biodiversity	Environmental	[redacted]	The high weighting reflects action taken in high-value and high-biodiversity environments.
9	Soil/sediment contamination	Environmental	[redacted]	The average weighting reflects the periodic local and regional effect of contaminated-sediment management.
10	Residual materials/Resources	Environmental	[redacted]	A low weighting is allocated given that most of the materials must be reclaimed.
11	Recreational navigation/Coast Guard	Social	[redacted]	A low weighting is allocated given that mitigation measures have already been identified for the new bridge.
12	Nuisances	Social	[redacted]	The higher weighting reflects the high sensitivity of neighbouring residents already affected by the construction of the new bridge (e.g., noise, dust, road traffic, disruptions).
13	Public support	Social	[redacted]	Opposition to the project may complicate its execution. A high weighting is therefore allocated.
14	Health and safety	Social	[redacted]	The higher weighting reflects the inherent risk of the specific work environment (over water) and the unusual nature of the project.
15	Innovation	Social	[redacted]	The higher weighting reflects the significant leverage provided by innovation to ensure the sustainability of the infrastructures.
16	To be determined in the grid for each area of study (see sections 4, 5, 6, 7)	Technical	[redacted]	To be determined in the grid for each area of study (see sections 4, 5, 6, 7)
17		Technical	[redacted]	
18		Technical	[redacted]	
19		Technical	[redacted]	
20		Technical	[redacted]	

3.5 EVALUATION METHOD

For each area of study, a grid containing the criteria selected in sections see sections 3.1 to 3.3 and the technical criteria retained will be used to rate each option considered for each of the evaluation criteria. To do so, a rating scale of 1 to 5 (with 1 being the least favourable and 5 the most favourable) is proposed, and decision-making guidelines are provided in Appendix 3. This rating is then multiplied by the weight in Table 17. Lastly, the total points obtained for each aspect of sustainable development (technical, economic, environmental, social) are calculated for each option. Table 18 provides a partial example of the evaluation grid.

Table 18 – Example of option evaluation grid

ANALYSIS GRID PART X: *AREA OF STUDY*																		
SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS / *AREA OF STUDY* SCENARIOS																JUSTIFICATION / COMMENTS
		WEIGHTING	Option 1			Option 2			Option 3			Option 4			Option 5			
			Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	
TECHNICAL	Criterion 1	2	3	6			0			0			0			0		
	Criterion 2	4	2	8			0			0			0			0		
	Criterion 3	1	5	5	30		0			0			0			0		
	Criterion 4	2	1	2			0			0			0			0		
	Criterion 5	3	3	9			0			0			0			0		
ECONOMIC	Costs	4	4	16			0			0			0			0		
	Jobs	3	3	9			0			0			0			0		
	Origin of labour	4	3	15	53		0			0			0			0		
	Risk of overstepping project deadline	2	5	10			0			0			0			0		
	Commercial navigation	1	3	3			0			0			0			0		
ENVIRONMENTAL	Water quality	3	3	9			0			0			0			0		
	Greenhouse gas emissions	2	5	10			0			0			0			0		
	Biodiversity	3	5	15	44		0			0			0			0		
	Contaminated soil and sediment	2	4	8			0			0			0			0		
	Consumption of resources/Residual materials	1	2	2			0			0			0			0		
SOCIAL	Recreational navigation	1	4	4			0			0			0			0		
	Nuisances	4	5	20			0			0			0			0		
	Public support	3	2	6	70		0			0			0			0		
	Health and safety	4	5	20			0			0			0			0		
	Knowledge/Innovation	4	5	20			0			0			0			0		
Total **points obtained** *			OPTION 1		**197**	OPTION 2		**0**	OPTION 3		**0**	OPTION 4		**0**	OPTION 5		**0**	

* See the graphical representation of results for visualization by component

Example

To represent the results based on the four components under study, a four-axis graphical representation is proposed to facilitate the viewing of the results (see Figure 36). This representation of the results allows for a quick comparison of the options with respect to the technical, environmental, social and economic criteria, as a relatively balanced figure is considered as being best able to meet sustainability objectives. In the following example, for instance, the T-Solution 1 option has the most balanced ratio, despite a weakness on the environment front.

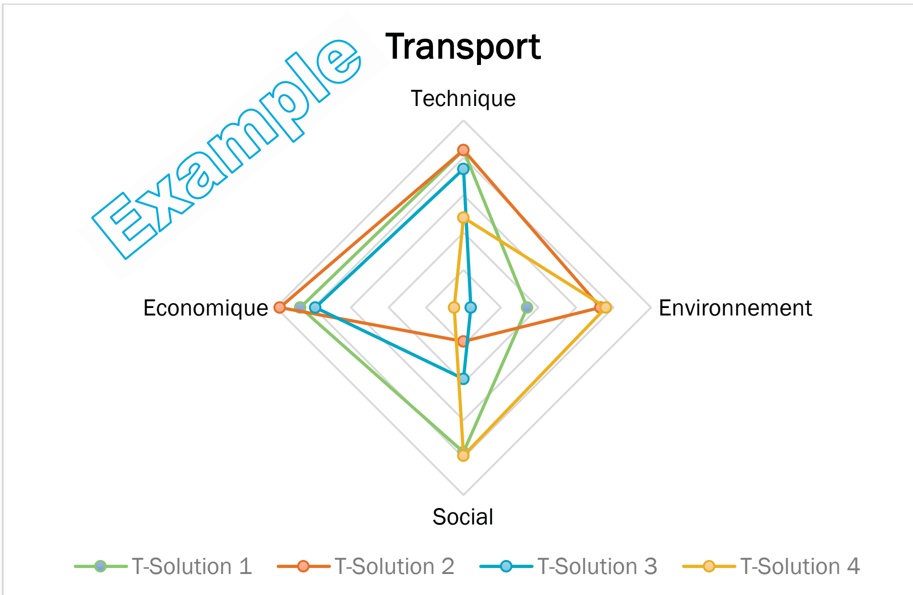


Figure 36 – Example of a qualitative analysis of the options

Subsequent to this process, the options for each of the areas of study can be classified in decreasing order of sustainability. The optimal combination of deconstruction, materials transport, materials reclamation and asset development options will be determined based on a cross-evaluation, which is presented in section 12 of the report.

Note that this multi-criteria approach is a decision-making tool for the option or combination of options that will be selected for each of the four areas of study. Other considerations (e.g., contextual or environmental) could supplement the contents of the study and thus influence the results.

4 DECONSTRUCTION WORK

4.1 BACKGROUND OF AREA OF STUDY

This area of study focuses on the methods and techniques required for the deconstruction of the bridge structure. The methods to dismantle the precast prestressed concrete girders, steel trusses, pier caps, pier shafts and foundation footings are all covered. The presence of numerous external strengthening components, in particular on the edge girders of all the concrete spans, is an unusual factor that requires special attention and that may greatly influence, or even limit, the applicable techniques.

The deconstruction of a structure can be very similar to building a new structure. The way the Champlain Bridge was originally erected will affect the methods being proposed. In addition, the construction and commissioning of the new Champlain Bridge, only a few metres away from the existing bridge in some locations, is a factor that will also have to be taken into account.

4.2 STAKEHOLDERS

Stakeholders were initially identified on the basis of the documentation made available to the Consortium. JCCBI had also already identified some stakeholders in the request for proposals document. For this field of study, however, the definition of stakeholder was broadened to identify participants who could offer pertinent information or expertise to clarify certain issues or constraints specific to the deconstruction work.

Stakeholders were grouped into five broad categories: *Governance* (governments, band councils, municipalities, elected officials, etc.), *Community* (local residents, community groups, environmental organizations, etc.), *Users* (car drivers, fishermen, pleasure boaters, etc.), *Economic Partners* (SLSMC, suppliers, subcontractors, workers) and *Experts* (industry associations, research centres, laboratories, etc.). Table 19 below provides an overview of the stakeholders applicable to deconstruction work. No stakeholders in the User and Expert resources categories have been identified in this section.

Table 19 – Stakeholders – Deconstruction

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

Section 8 of this report contains an assessment of stakeholders' influence, along with the outcome of approaches made to the most influential among them.

In addition to approaching influential stakeholders, certain experts were contacted to obtain information relevant to the project. A summary of the discussions was prepared in each case to record the information. The summaries can be found in Appendix 4.

4.3 OPTIONS CONSIDERED

4.3.1 COMMON TECHNIQUES – CONCRETE

The next sections describe common techniques for the deconstruction of concrete components such as the girders in Sections 5 and 7 and their bearings and foundations. This is a qualitative review of the options that are available from a broad and general perspective in order to identify the possible options. Not all the techniques mentioned are necessarily applicable to the Champlain Bridge, given both the bridge's specific characteristics and its current condition.

Note: This section does not cover the removal of materials from the site.

4.3.1.1 Standard concrete deconstruction

Standard techniques for the deconstruction of concrete structures are based on the concept of breaking down the structure into pieces that can be easily handled at the site with existing construction equipment. The dismantled components of manageable size must be collected and removed from the site. This operation does not require any special means or specific precautions. Simple excavators and loaders will generally be used to recover the materials, and trucks or barges will be used for transport.

The surfaces under and around the structures being deconstructed are used to receive the dismantled components. Depending on the location of the structure, the surface may be firm ground, another structure that will remain in service after deconstruction (such as a road), a body of water, floating barges or the iced-over surface of a body of water in the winter. Depending on the surface intended to receive the debris, various protection measures will be required. When another structure is involved, the protection often consists of a layer of backfill or sand spread out over the structure before the deconstruction work is done, but other methods are also possible, such as protective netting or steel plates. If the structure to be deconstructed is above water, the dismantled components can be placed on a surface which is out of the water, such as floating barges or a temporary jetty. In other cases, the dismantled components end up at the bottom of the water and barge equipment is used to haul them away, or they are used as fill material for the voids left by the deconstructed foundations.

Figure 37 – Standard barge method used for the deconstruction of the Long Island Bridge in Boston Harbour (source: Walsh Construction 2016)

One disadvantage of several of these methods is the dust generated by the deconstruction work. Dust containment and control methods must generally be used. Dust is generally contained by spraying water over the structure being deconstructed. In such cases, the waterway can be protected by containment barges that collect the resulting contaminated water.

There are several methods for breaking up the structure into pieces that are easy to handle at the site with existing construction equipment. Possible methods include:

- Hydraulic and pneumatic hammers
- Concrete crusher with shear jaws
- Sawing and cutting
- Hydrodemolition
- Splitting
- Demolition wrecking ball and crane
- Thermal cutting and drilling

Deconstruction with explosives, which follows the same basic principle as the methods outlined above (breaking down the structure into pieces), is covered in a separate section of this report.

4.3.1.1.1 Hydraulic and pneumatic hammers

Hydraulic and pneumatic hammers are often used for partial or complete concrete deconstruction, generally in conjunction with other equipment to cut the reinforcing steel in the structure. These hammers are categorized based on their energy impact, and a wide range of hammers are commercially available for various types of work. The choice of the class of hammer depends on the component to be deconstructed, the adjacent components to be protected, the target production rates and the available equipment. The operating method depends on the class of hammer. Hydraulic hammers mounted on excavators are much more powerful than hand-held hydraulic hammers. They can be mounted on telescopic-arm excavators. The telescopic arms can be more than 20 metres high, but these heights are less common for this type of equipment.

Work with hydraulic and pneumatic hammers can have a relatively good production rate, but also negative impacts. They generate noise, dust and vibrations. Their use in sensitive areas requires mitigation measures.

4.3.1.1.2 Concrete crusher with shear jaws

Concrete crushers with shear jaws use opposing forces to break the concrete or cut the steel. They can be mounted on telescopic-arm excavators. The telescopic arms can be more than 20 metres high, but these heights are less common for this type of equipment. They can also be mounted on cranes, which allows areas to be accessed that would otherwise be difficult to reach. There are several types of jaws with different functions. Some pulverize concrete, allowing it to be separated from the steel so the materials can be processed separately. Others have jaws that cut the concrete and steel or that break and remove large pieces of concrete.

Concrete crushers with shear jaws have the advantage of limiting nuisances such as dust and vibration, as well as being efficient for separating the concrete from the reinforcing steel. They also cut the reinforcing steel relatively quickly and safely by working a certain distance from the structure being deconstructed. The prestressing steel can also be cut, at a pace that depends on the quantity in question.

Figure 38 – Concrete crusher with shear jaws mounted on a telescopic-arm excavator (source: Marubeni-Komatsu, 2016)

Figure 39 – Deconstruction of bridge deck using a concrete crusher with shear jaws

4.3.1.1.3 Sawing and cutting

Sawing and cutting are used to cut concrete and steel elements. This can be done using a blade or diamond wire saw. Sawing and cutting have the advantage of creating a straight cut, limiting the production of dust when used in combination with water, and limiting vibrations, thus protecting the structure's remaining components. These deconstruction methods can be used for certain deconstruction stages or for partial deconstructions.

Table 20 – Advantages/Disadvantages – Standard concrete deconstruction

ADVANTAGES	DISADVANTAGES
Hydraulic and pneumatic hammers	
DCA1 – Hydraulic and pneumatic hammers are commonly used in deconstruction work, for both construction and civil engineering. This equipment is therefore readily available. DCA2 – Hydraulic and pneumatic hammers have a relatively extensive power range. Therefore, they can be used on a modest (pneumatic equipment) or large scale (hydraulic equipment). DCA3 – The deconstruction pace is fairly fast.	DCD1 – The height of the structure being deconstructed may present a problem. The work height can naturally be increased using longer arms, within certain limits. DCD2 – Deconstruction is relatively noisy. It generates dust, which can be reduced by spraying, but the higher the object being deconstructed, the more difficult this is. The noise may disturb breeding and migratory birds. DCD3 – The height also requires precautions to be taken to ensure the safety of the machinery operator and workers (falling rubble). DCD4 – In general, the reinforcing steel in the structure must be cut using other means (e.g., shearing, blow torch). DCD5 – The removal of modular trusses for future reuse should be done first using other methods (in principle, hoisting). DCD6 – Creation of a temporary jetty to access the area where the water depths does not allow the use of a barge generates additional residual materials. DCD7 – Temporary loss of fish habitat (temporary jetties).
Concrete crusher with shear jaws	
DCA4 – This type of equipment is generally used in combination with hydraulic hammers. It crushes concrete components and cuts reinforcing steel.	DCD8 – With the exception of noise, which is more limited, and the cutting of the reinforcing steel, as long as the concentration is not too high, this method presents disadvantages similar to those of hydraulic hammers.

ADVANTAGES	DISADVANTAGES
Sawing and cutting	
DCA5 – These methods allow a structure or part of a structure to be cut into smaller parts, making it easier to handle or deconstruct. They are highly suited to high-density reinforcing steel and can even be used to cut steel parts. DCA6 – Sawing is suitable for parts that are less thick, such as slabs, and chain cutting for large parts. DCA7 – The work pace is fast. Cutting speed ranges from 0.15 m/min to 1 m/min, depending on the cutting thickness. The speed for chain cutting is about 1 m^2/hour.	DCD9 – Sawing or cutting operations are relatively noisy. DCD10 – They must be combined with other techniques, at the very least with hoisting and transportation equipment to haul away the cut components. DCD11 – Temporary supports to hold the part in place during cutting are generally required. DCD12 – The blades must be properly lubricated during sawing. The need for water makes their use difficult in the winter.

4.3.1.1.4 Hydrodemolition

Hydrodemolition consists of using high pressure water, with or without abrasives, to tear down the concrete. Hydrodemolition allows the concrete to be broken without damaging the steel in the structure or to do highly targeted deconstruction. It tends to be used for repairs where the deconstruction involves limited quantities of material. This method is very costly and has a relatively low output. It also requires large quantities of water to be subsequently processed to remove the deconstruction materials. For instance, an output of 10 m^3/day can be expected for a lance mounted on a robot at pressures of 110 MPa to 120 MPa and using between 150 l/min and 250 l/min (70 m^3 to 120 m^3) of water a day.

4.3.1.1.5 Chemical and mechanical splitting

Concrete deconstruction using splitting consists of inducing loads that place the concrete in tension at specific locations in order to crack it and cause it to collapse or break up into pieces. For mechanical splitting, holes are drilled in the concrete and jacks are inserted. The jacks are pressurized with controlled pressure inside the holes, causing the concrete component to crack. For chemical splitting, chemicals that expand when mixed together are inserted into the boreholes, exerting pressure which creates tension inside the concrete.

Splitting has the advantage of minimizing vibration and dust, but generally requires the use of other methods to cut and separate the reinforcing steel.

4.3.1.1.6 Wrecking ball and crane

This type of deconstruction consists of a large wrecking ball operated by a crane that strikes the structure to break it down. The work is relatively safe for workers since they are some distance away from the structure being deconstructed. However, there is less control, the noise level is high and a lot of dust is generated.

4.3.1.1.7 Thermal cutting and drilling

Thermal cutting and drilling techniques involve the application of high temperature to the concrete. This temperature can be created using flames, laser, plasma or an electrical current in the reinforcing steel, which requires substantial energy. Potential applications are mainly for the partial deconstruction of concrete structures.

4.3.1.2 Unlaunching

This method stems directly from the method used to build the current bridge structure, as well as for many works of this type, by “inverting” the construction process using a metal frame known as a “launching gantry.”

The principle consists of separating the girders, such as by sawing the middle slab and diaphragms, before they are picked up by the launching gantry. Launching gantries are divided into two major groups: traditional launching gantries and lateral launching gantries.

4.3.1.2.1 Traditionnal launching gantries

With traditional launching gantries, once the girders have been separated, they are taken away toward the rear, to the adjacent span, where they are placed in a transport vehicle. These launching gantries are generally made up of two main interwoven steel trusses (Figure 40). Their total length is close to twice the span to be crossed. For easier manoeuvring, the main trusses are generally equipped with upstream and downstream launching noses.

Figure 40 – Launching gantry

The weight of the launching gantry may constitute a disadvantage since it must be supported by the structure. However, the standard designs avoid having the launching gantry rest on the deck when in motion and, naturally, when handling girders. As shown in Figure 41, the launching gantry stands on two or three pedestals, depending on the project phase, and is supported directly on the piers.

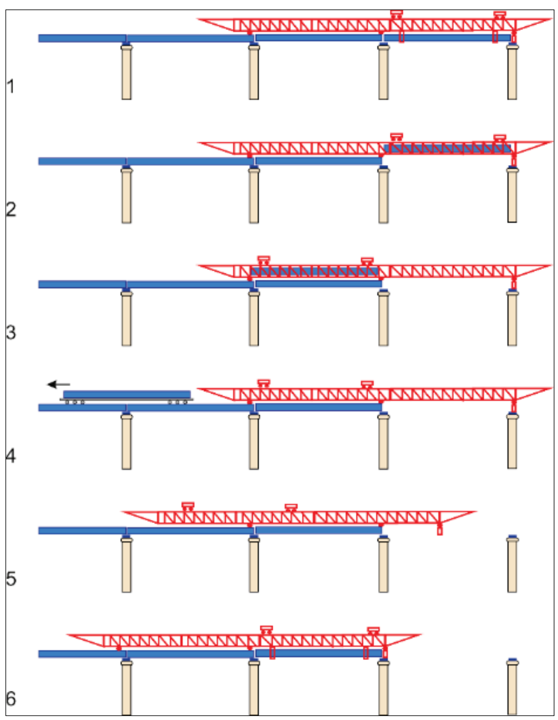


Figure 41 – Unlaunching

The deck is therefore never subjected to both the weight of the launching gantry and a component being handled. It must, however, be capable of supporting the weight of the girder and the vehicle removing it from the work site. Likewise, the piers must naturally have sufficient resistance.

This method therefore generally requires that access to the structure be maintained in order to remove the girders from the site. Given their height (slightly more than 3 metres) added to that of the transport vehicle, it would be preferable to maintain access from each shore. This would also allow deconstruction work to be performed at a faster pace by working on both concrete sections, and to be separate from the deconstruction work on the steel truss spans.

Otherwise, instead of taking the girders away toward the rear, the launching gantry could lower them to a floating wharf for disposal. This solution is only feasible at locations with sufficient clearance for barge access. It also has the disadvantage of combining two techniques, with the corresponding costs.

Lastly, it is possible to combine these two options, with the transport vehicle carrying the girders to a specific area where they are transferred to transport barges. This option would streamline and optimize the various operations.

4.3.1.2.2 Latreal launching gantry

In some cases, instead of take the girders away toward the rear, the launching gantry moves them laterally beyond the edge of the deck, where they are lowered to a transport vehicle. With lateral launching gantries, heavy loads, such as girders and self-propelled modular trailers, do not need to travel over the deck, but greater anchoring is needed on the piers to ensure deck stability when heavier girders are involved. These launching gantries are therefore used more frequently for bridge structures with small spans (Figure 42).

Figure 42 – Lateral launching gantry

With a lateral launching gantry, instead of taking the girders away toward the rear, the launching gantry could lower them and place them in a specially designed area on the ground, such as a jetty or a floating wharf. This solution, however, is only feasible at locations with sufficient clearance for barge access. If a jetty is used, it must provide a sufficiently high-quality surface for heavy transport vehicles. This solution also has the disadvantage of combining two techniques, with the corresponding costs.

Table 21 – Advantages/Disadvantages – Unlaunching

ADVANTAGES	DISADVANTAGES
DLA1 – The use of a launching gantry allows work to be done from the deck, thus avoiding any interaction with the surrounding area. This is a non-invasive method that significantly minimizes the environmental impact. DLA2 – Worker safety is protected since the work is done from the deck. DLA3 – The work proceeds at a faster pace, with the removal of one or two girders per day. DLA4 – Girder deconstruction takes place in designated, specially designed areas, which makes it easier to mechanize the process and implement environmental protection measures (e.g., noise, dust). DLA5 – The modular trusses can be removed easily and carefully by the launching gantry once the girders have been removed. DLA6 – These advantages foster strong public support for the method.	DLD1 – The availability of a suitable launching gantry may be problematic, but the costs of having one specially made could be amortized due to the magnitude of the work site. DLD2 – Use of a launching gantry requires qualified personnel, especially when moving it from one span to another. DLD3 – Mechanisms may be required to ensure the stability of a reinforced girder before it is handled by the launching gantry. DLD4 – Transporting girders requires the use of relatively heavy transport vehicles on the deck. DLD5 – The deconstruction areas must allow for sufficient storage to accommodate the pace of removal and deconstruction.

4.3.1.3 Removal by crane

Cranes are commonly used to handle girders, but they are more often used for steel structures than concrete ones. Concrete structures are in fact heavier and therefore require more powerful hoisting equipment. In the case of the Champlain Bridge, the weight of the girders is definitely considerable, but it should not require unconventional hoisting mechanisms. This solution can also be used for the bearings.

The method basically consists of breaking up the component, by sawing, for example, which will be picked up by the crane(s) (e.g., girder, group of girders, section of pier caps, pier shafts and footings).

These methods of hoisting can consist of floating derricks or standard cranes mounted on floating barges. The basic difference between the two types of equipment is their hoisting capacity. Derricks are designed to lift very heavy loads, but they are probably not a feasible solution given their size in the context of the Champlain Bridge. As a crane is an integral part of a derrick, access to the site will be difficult given the dimensions and the required clearances.

In all cases, the use of nautical means requires a minimal clearance so that the machinery can be operated and work can progress. Naturally, the more powerful the hoisting equipment, the greater the draught or the surface dimensions of the watercraft. As a result, this option will likely not be feasible near the shores at Section 5 or for Section 7 during a short period of the year. Other solutions will have to be devised for these areas, such as a jetty, boom or floating wharf.

Once picked up by the hoisting equipment, the portion of the structure is placed on a barge and removed from the work site.

Figure 43 – Derrick

In areas with a shallow draught, three solutions can be considered to access the work site:

- An earth jetty, similar to the one used for the construction of the new Champlain Bridge: depending on its position, it would be interesting to study whether it can be reused
- A temporary work bridge, which would limit the environmental impacts on the St. Lawrence
- A floating bridge, which would also limit the environmental impacts.

Table 22 – Advantages/Disadvantages - Removal by crane

ADVANTAGES	DISADVANTAGES
DGA1 – Cranes are commonly used to install structural components. DGA2 – Sufficiently powerful cranes could be used to lift two or three girders at a time. In addition to a decrease in the number of operations, a distribution of forces among the girders that remain connected can be anticipated and therefore an improvement in overall resistance. DGA3 – The modular trusses can be removed easily and carefully by the crane once the girders have been removed.	DGD1 – The height of certain spans increases the capacity of the cranes to be used. The corollary to this is that the higher the mast, the more the operations may be affected by the wind. DGD2 – The higher capacity the cranes, the less common and therefore more costly. The same is true for their weight with regard to the size of the barges carrying them. DGD3 – The hoisting of large pieces is impacted (restriction) more easily by weather conditions such as heavy winds.

4.3.1.4 Deconstruction using explosives

Blasting is generally the least costly and fastest method for deconstructing civil engineering structures.

Explosives such as dynamite generate a shock wave that cracks the material, followed by expanding gas that breaks it up. This action is used to destroy very thick concrete components such as bridge piers and foundations with maximum efficiency.

The deconstructed components must then be picked up in order to be removed from the site. This operation does not require any special means or specific precautions. Simple excavators or loaders are generally used to recover the materials, and trucks or barges are used for transport.

However, this deconstruction method requires in-depth know-how, considerable structural knowledge and the utmost rigour to ensure that the operation is carried out properly. This type of deconstruction can be adapted to the urban and environmental setting of the structures in question and its surroundings.

Figure 44 – Explosives – Concrete

Table 23 – Advantages/Disadvantages – Deconstruction using explosives – Concrete

ADVANTAGES	DISADVANTAGES
DEA1 – This is a quick and low-cost method. DEA2 – The fragmenting of materials can be controlled and therefore tailored to the hauling operations. DEA3 – The actual deconstruction occurs in a few moments, thus limiting nuisances for local residents. DEA4 – Simple application and required existing equipment.	DED1 – The preparation for the procedure – the shot blasting pattern – requires highly qualified personnel. DED2 – The explosion produces a large amount of dust. However, dust dispersion can be minimized by containing the structure. DED3 – Special measures must be taken for work in or near water. DED4 – This method is not perceived favourably by the public. DED5 – For the deck, this technique is considered unacceptable by the DFO due to the major impacts on fish and fish habitat. DED6 – Temporary deterioration of water quality caused by the inflow of a large quantity of suspended matter/sediment when the debris falls into the water. DED7– The health and safety risks associated with explosive methods can be mitigated. DED8 – Given the large number of pies and the safety radius to be observed, recreational boating will be affected.

4.3.1.5 Removal of full span

With this method, the barges are equipped with provisional platforms. The height of the platforms is set to just below the span to be removed. The platforms must therefore be adjusted, possibly in groups, based on the area involved when the height of the deck above the waterway is not consistent, as is the case here. To allow the operations to be carried out, the barges are ballasted with water, with the height of the platforms naturally taking into account the draught of the barges with the ballast.

Figure 45 – Full span

The operations consist of the following:

- The barges equipped with these platforms position themselves under the span. They are then progressively deballasted and rise up. The platforms come into contact with the deck and lift it, as Archimedean buoyancy transforms the barge/platform system into a type of jacking system. This operation releases the deck from its bearings on the piers.
- Once the deck is resting on the platforms, the barges back up in order to move away from the piers. The deck can then be lowered, using cables or a jacking system, for example. This operation is recommended to improve the stability of the barge supporting the deck when it is fairly high (e.g., over 10 m).
- Once the deck has been lowered to a reasonable height, the barge and its load leave the site to go to an unloading area. The deck is then dismantled, using a traditional deconstruction method. This solution allows stationary hoisting equipment to be concentrated, optimizing and organizing it in a more industrial way, for better performance and safety.

Table 24 – Advantages/Disadvantages – Removal of full span – Concrete

ADVANTAGES	DISADVANTAGES
DTA1 – By keeping the span whole, this method decreases variations in the resistance of the various components. The resistance of the span is not changed from what it is when in place on the structure. Even if the reinforcements are removed, this is theoretically compensated by the lack of traffic loads and the removal of equipment.	DTD1 – Given the weight of a span, very large barges with large capacities will be needed. DTD2 – The height of certain spans will require very high temporary bents capable of withstanding the heavy load of the span. DTD3 – The span must be lowered to the barge to avoid any risk of instability during transportation. This is a relatively slow and delicate procedure. DTD4 – The modular trusses must first be removed using other means. DTD5 – Navigation constraints are compounded by the size of the part being transported (53 m x 21 m), but are not theoretically prohibitive.

4.3.2 COMMON TECHNIQUES – TRUSSES

The following sections describe several options that exist for removal of the steel span superstructure (Section 6). This is intended to primarily be a qualitative review of potential removal options ; however, some methods have been reviewed with preliminary consideration given to the capacity of the structure to resist loads associated with the removal methods. This section describes removal of the steel superstructure only and does not address removal of the substructure or the transportation of the materials offsite.

4.3.2.1 Deconstruction by explosives

Deconstruction by explosives may be an economical and efficient removal method. Explosive charges are placed at preplanned locations and are activated to separate the bridge into manageable sections of truss for removal from the site. The bridge sections fall to either water or grade and are hoisted by crane and loaded onto a barge for disposal. Preplanning for this operation is important ensuring that each section of bridge is manageable in size and adequately stable to be hoisted as a single unit.

This method requires knowledge and experience with explosives and also presents several environmental risks that need to be considered. The structure may have lead paint which can contaminate the water or soils under and adjacent to the bridge. The explosives would also release significant amounts of dust which may have environmental impact. Dropping the structure into the water could have an adverse effect on wildlife. Also, while the operation can include careful planning for the removal of debris from the water, there are risks of fugitive debris remaining in the water after removal.

Figure 46 – Jamestown Bridge Deconstruction(source: www.graengs.com)

Figure 47 – Explosive Deconstruction of Old Ledbetter Bridge (source: www.courierpress.com)

Table 25 – Advantages/Disadvantages – Deconstruction by explosives – Steel spans

ADVANTAGES	DISADVANTAGES
DEaA1 –- This is a fast and economical method. DEaA2 – The operation can be controlled in such a way that working personnel and the public are away from the structure during the highest risk events.	DEaD1 – The operation requires highly trained contractors. DEaD2 – The explosive operation produces a large amount of dust. DEaD3 – If lead is present on the structure, the explosive operation will likely release lead into the air and water. DEaD4 – For the structure over the Seaway, it may take 3 to 5 days to clear the structure from the channel for clear passage. DEaD5 – The removal operation may not capture all of the bridge pieces and small amounts of fugitive debris may remain in the water or the river/channel bottom. DEaD6 – Not perceived favourably by the public. DEaD7 – This technique is considered unacceptable by the DFO due to the major impacts on fish and fish habitats. DEaD8 – Temporary deterioration of water quality caused by the inflow of a large quantity of suspended matter and the suspension of contaminated sediments when debris falls into the water.

4.3.2.2 Reverse Erection

The reverse erection method attempts to reverse the original construction sequence used to erect the steel truss spans including the deck truss approach spans and the cantilever truss main span.

The original erection of the approach spans was completed using piece-by-piece assembly starting at piers 2W and 4E and working toward piers 4W and 2E, respectively. The steel erection used equipment on the bridge structure requiring three temporary support towers in each span to support the truss vertical load as erection progressed. Reverse erection would substantially reverse this sequence utilizing piece-by-piece dismantling and temporary support towers as required. The size and capacity of temporary supports can be adjusted to accommodate either the dead load of the bridge structure only or to accommodate the bridge structure with equipment operating on the bridge deck.

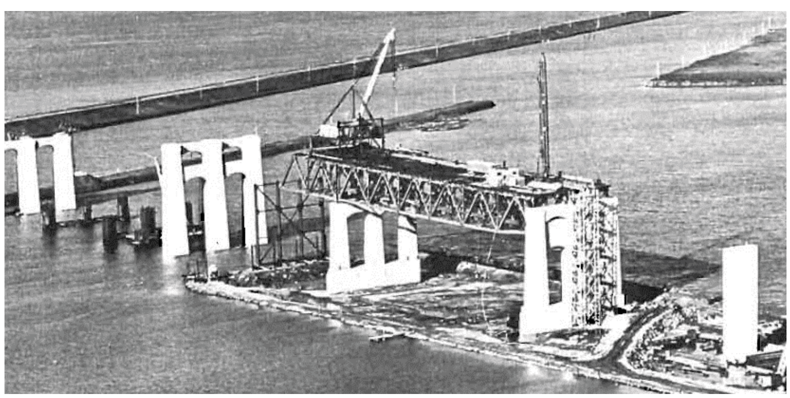


Figure 48 – Erection of Champlain Bridge Approach Span (source: The Champlain Bridge: A Photographic Story by Hans Van Der Aa)

The original erection of the main span was also completed using piece-by-piece assembly starting from the anchor span piers (2W and 2E) and working toward midspan. Three temporary support towers were used in each anchor span of the main span structure to support the truss as it was erected out to piers 1W and 1E and into the cantilever span. The truss continued to be constructed out to midspan of the suspended span of the main span structure with two long cantilevers meeting in the middle. Jacking operations were used to “swing” the suspended span of the main span structure, freeing it from the cantilever span of the main span structure such that it simply hangs from the hangers at each end of the cantilever span of the main span structure. Once the main span truss structure was complete, concrete deck was added along the length. It should be noted that a later bridge retrofit replaced the concrete deck and stringers with a lighter steel orthotropic deck. Reverse erection for the main span would involve piece-by-piece dismantling and substantially reverse the original erection sequence utilizing a jacking operation to re-engage the suspended span and temporary supports in the anchor spans as required.

The design of the anchor span temporary supports offers some level of adjustment to accommodate the dead load of the bridge structure with or without equipment operating on the bridge deck. However, the anchor span temporary supports have limited impact on improving the ability of the cantilever section to support equipment. Based on a preliminary structural review of the main span, completing the removal operation in a reverse erection manner would require removal of the steel orthotropic deck or require the retrofit of highly stressed bridge members. It is likely that even with these accommodations, bridge removal would need to be completed using lighter bridge mounted derrick cranes or equipment operating below the structure from the water or a temporary jetty.

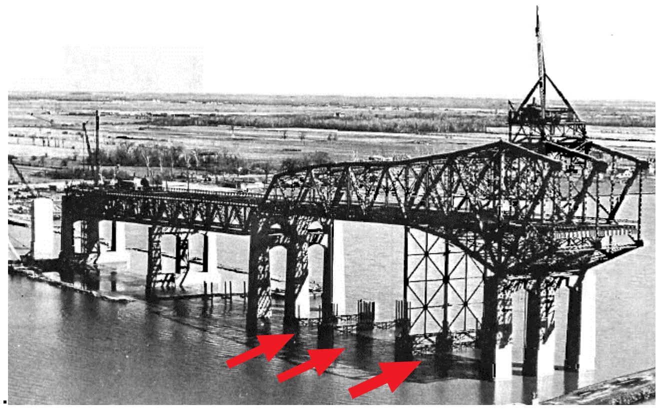


Figure 49 – Erection of Champlain Bridge Mainspan, Three Temporary Support Foundations Visible (source: The Champlain Bridge: A Photographic Story by Hans Van Der Aa)

Table 26 – Advantages/Disadvantages – Reverse erection

ADVANTAGES	DISADVANTAGES
DRaA1 – If anchor span temporary supports and smaller equipment are used, the entire removal operation can be completed from the bridge deck. DRaA2 – The reverse erection method was previously used and offered some combination of economic and schedule value to the original contractor.	DRaD1 – In order to engage the suspended span and allow the span to cantilever to midspan, a moderately complex jacking operation is required. DRaD2 – The construction of multiple bents of temporary supports is required. DRaD3 – Lighter, non-conventional derrick cranes may be required for removal of the suspended span and cantilever portions of the truss. DRaD4 – Complete closure of the Seaway for all key operations or work exclusively during the winter.

4.3.2.3 Balanced Cantilever Dismantling

An alternate to the standard reverse erection method described above is reverse erection method using a balanced cantilever approach. This method is only applicable to the main span portion of the bridge and is particularly advantageous in the event that temporary support towers in the anchor span of the main span structure are undesirable or pose significant challenges. In this method, dismantling is carried out by working from midspan of the suspended span of the main span structure and the end of the anchor span of the main span structure simultaneously. While this method may not completely eliminate the need for temporary vertical support, it is likely that fewer temporary supports with less capacity could be used. Analysis can be conducted to determine a sequence that keeps the structure nearly balanced on the interior piers and requires reduced load capacity from temporary supports.

Figure 50 – Tappan Zee Bridge Construction using Balanced Cantilevers ourtesy of Westchester County Historical Society)

Table 27 – Advantages/Disadvantages – Balanced cantilever dismantling

ADVANTAGES	DISADVANTAGES
DBaA1 – The use of fewer and/or lower capacity temporary supports required.	DBaD1 – The removal sequence is somewhat detailed and may take more time to execute.

4.3.2.4 Span Cable Stays

Another alternate to the standard reverse erection method is reverse erection method using cable stays to support the anchor spans during removal. Cable stays are used to provide an alternative to temporary support towers in the anchor span of the main span structure. This method would require the construction of a temporary tower above the anchor span of the main span structure piers (2W and 2E). The cable stays would be tied to the anchor span of the main span structure and the adjacent 252' steel approach span. This unique load case would require more detailed analysis of the approach span and the anchor span of the main span structure pier.

Figure 51 – Port Mann Bridge Construction (source: courtesy of The Jewish Museum and Archives of BC)

Table 28 – Advantages/Disadvantages – Span cable stays

ADVANTAGES	DISADVANTAGES
DCaA1 – The use of fewer and possibly no temporary supports required.	DCaD1 – The removal sequence is very detailed and will take more time to execute.

4.3.2.5 Strand Jack Lowering

A method to lower portions of the bridge as a single unit with strand jacks located at the corners may be possible for sections of the steel spans. It would be most reasonable to use this method on the approach spans and the suspended span over the Seaway.

For the approach spans, the truss would require retrofits at the ends to allow for lowering between the piers. Retrofit of the piers may also be required depending on the configuration of the lowering components. Strand jacks and lowering frames would be attached to the piers and also to the truss section to be lowered. It may be desirable to remove the deck prior to lowering in order to reduce the weight of the span. The water depth beneath the approach spans would need to be considered to allow barge access or to construct a temporary jetty to support the lowered structures.

Figure 52 – San Francisco Oakland Bay Bridge – 504' Span Dismantling (source: courtesy of Foothills Bridge Co (Photo by Sam Burbank))

For the main span structure, the suspended span is designed to span as an independent unit from the ends of the cantilever structure. It is likely that minimal retrofit will be required to the suspended span in order for it to be lowered. Strand jacks would be attached to the ends of the cantilever spans and the strand jack anchors to the corners of the suspended span truss. The suspended span would be separated from the main structure and lowered to a barge below.

Figure 53 – Lowering of Suspended Span of the Carquinez Bridge
(source: Courtesy of Foothills Bridge Co (Photo by Jakub Mosur))

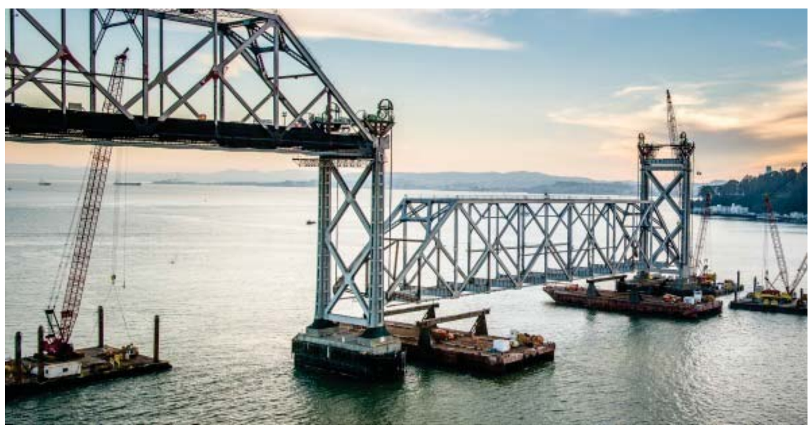


Figure 54 – San Francisco Oakland Bay Bridge – 504' Span Dismantling
(source: Image Courtesy of Foothills Bridge Co (Photo by Sam Burbank))

While less desirable than the approach spans and the suspended span, it may be possible to lower each anchor span in one section. Based on a preliminary structural review of the structure, lowering the anchor span in one section would require removal of the steel orthotropic deck and/or the retrofit of highly stressed bridge members. Similar to the approach trusses, the anchor span would also require retrofits at the ends to allow for lowering between the piers. Lowering of the anchor span would need to be completed after lowering of the suspended span and removal of the cantilever portion of the main span structure. Given that this option eliminates the need for temporary supports, there may be an economic and scheduling benefit.

Table 29 – Advantages/Disadvantages – Strand jack lowering

ADVANTAGES	DISADVANTAGES
DSaA1 – While the preparation for a strand jack lowering operation can be time consuming, the actual lowering operation is relatively fast. DSaA2 – No temporary supports are required in the water. DSaA3 – There may be some advantage in setting up a separate processing area for dismantling large sections of the bridge.	DSaD1 – The truss spans may be too large to be transported far from the bridge site. They may need to be dismantled close by. DSaD2- The suspended span lowering operation will require a complete closure of the Seaway for 24 to 48 hours or work exclusively during winter. DSaD3 – Structural retrofit will likely be required at each lowering location. DSaD4 – The operation requires specialty equipment and expertise in working with specialty equipment.

4.3.2.6 Lifting the Trusses off Bearings

Two methods may be possible for lifting large sections of the approach spans without the use of temporary supports.

4.3.2.6.1 Whole Span

The first method involves lifting full approach spans using modular jacking towers on barges. The jacking towers supported on barges would be positioned under a single approach span truss. The jacking towers would then jack themselves up in modular increments and lift the truss off of its bearings. After lifting the truss clear of its bearings, the barges and truss would be moved away from the piers. The truss would then be lowered to the level of the barges by jacking the modular jacking towers down. The truss could then be further dismantled offsite. In order to reduce weight, the deck could be removed in advance.

Figure 55 – Modular Jack-Up System
(source: Image Courtesy of Burkhalter Rigging)

4.3.2.6.2 Individual or Paired Trusses

The second method of lifting the approach span trusses from their bearings would be to use a barge mounted crane to lift individual trusses (4 total trusses per span). This operation could use a larger single crane that picks up pairs of trusses or a smaller single crane that picks one truss at a time. If pairs of trusses are removed together, the truss should have adequate capacity for this removal method. In order to pick single trusses, a hold crane would be needed to hold the last truss as the second-to-last truss is removed. Additional analysis would be required to determine if the trusses can be removed as single trusses.

Figure 56 – Hood Canal Bridge Removal
(source: Image Courtesy of Foothills Bridge Co)

Table 30 – Advantages/Disadvantages – Lifting

ADVANTAGES	DISADVANTAGES
Whole Span	
DLaA1 – While the preparation for the operation can be time consuming, the actual removal operation is relatively fast. DLaA2 – No temporary supports are required in the water. DLaA3 – There may be some advantage in setting up a separate processing area for dismantling large sections of the bridge.	DLaD1 – The truss spans may be too large to be transported far from the bridge site. They may need to be dismantled close by. DLaD2 – For the use of modular jacking towers on barges, the operation requires specialty equipment and expertise in working with specialty equipment.
Individual or Paired Trusses	
DLaA4 – No temporary supports are required in the water. DLaA5 – Equipment is standard and available to most contractors to rent or own.	DLaD3 – The operation is time consuming and may require the coordination of multiple cranes. Due to the location of the new bridge, access is limited for the positioning of paired cranes. DLaD4 – For the removal of individual and paired trusses, rigging to large sections of truss can be challenging.

4.3.3 CONSTRAINTS SPECIFIC TO THE CHAMPLAIN BRIDGE

The concrete spans are the biggest part of the structure. There are 40 spans between Nuns' Island and the structure over the Seaway, and 10 spans between the Seaway and the City of Brossard. The technique that is used for deconstruction will therefore have to be suited to this considerable repetitiveness in order to minimize delays and the resulting impacts.

The layout of the site is also one of the important aspects to consider. Likewise, the condition of the bridge structure and especially the presence of the various strengthening and repairs are factors that must be carefully reviewed when devising the deconstruction solution.

At this stage of the study, these points will definitely be part of the discussions.

The modular trusses are theoretically the only elements that merit attention. The girders currently just rest on these modular trusses. When the concrete girders are removed, the girders will be lifted, by either crane or launching gantry, and they will no longer be supported by the modular trusses. The modular trusses will be progressively disconnected. The girders will then have to support themselves (i.e., support their own weight). If they cannot, attaching the modular truss and the girder to keep it active postpones the problem to a later stage, particularly in terms of transportation.

4.3.3.1 Complex nature of slab system

The slab system in Section 5 and Section 7 of the Champlain Bridge was the subject of studies during the assessments of the structure's capacity and rehabilitation. In summary, the slabs were cast in place between the upper flanges of the concrete girders and post-tensioning tendons were installed transversally through the slabs and upper flanges over the entire width of the deck to ensure that the components worked together. In the event one of the tendons breaks or is severed, the resistance is still provided, except locally, through the bonding between the tendon and the grout. However, it would not be advisable to count on this bonding to re-anchor the tendons, since it depends on the initial quality of the injection and the ageing.

The behaviour of the slabs in the event of tendon failure or cutting therefore makes the deconstruction of this component of the structure more complex. When designing and selecting deconstruction work methods and sequences, this slab behaviour must be taken into account.

4.3.3.2 Problems associated with existing strengthening

The presence of various strengthening creates considerable constraints. The main constraints are presented in Table 31.

Table 31 – Constraints of existing strengthening

TYPE	COMMENTS
EPT	External prestressing could constitute a risk if, during deconstruction, a tendon were damaged or severed. In all cases, there would be a resulting dissymmetry in prestressing forces on either side of the girder, which would induce a bending moment in the vertical axis. In addition to the directly related loss of resistance, this moment could compromise the girder's resistance. Furthermore, tendon failure constitutes a major risk to the safety of workers in the immediate vicinity. To remedy this risk, one obvious solution is to remove this prestressing before the removal and/or deconstruction operations. Besides the time needed for these operations, this solution is only feasible for girders with sufficient internal residual structural prestressing to guarantee the required capacity of this area of the structure. The prestressing located along the bottom flange is more exposed than the prestressing along the web.
QP1	This type of reinforcement presents disadvantages similar to external prestressing. The problems are further compounded by the space taken up by the system under the girder (about 3 metres), thus significantly increasing the height of the parts to be handled, which could prove prohibitive for certain solutions. This is further exacerbated by the transverse stability components attached to the adjacent girder. Dismantling this type of reinforcement will therefore be critical for girder-by-girder deconstruction.
QP2	This type of reinforcement presents disadvantages similar to external prestressing, as the tendons in this case are not only present along the web, but slightly below the bottom flange. However, this type of reinforcement has fewer disadvantages than the other system (QP1). On one hand, it takes much less space under the girder. On the other hand, it does not involve any components connected to the adjacent girder.
Carbon Fibre Reinforced Polymer (CFRP)	This type of reinforcement, which consists of thin passive components bonded to the structure, should not present any specific problems for the deconstruction work. At the very most, depending on the fragmenting technique that is used, the carbon fibre strips could result in components that are larger or remain attached to one another by the CFRP. In such a case, the carbon fibre strips could be cut.
Strengthening under the span with posts	This type of reinforcement, installed when the deck has a low aboveground height, does not present any particular problems regardless of the deconstruction method being considered. The pillars can either remain in place until the girders are completely deconstructed and then be removed, or be deconstructed at the same time as the deck.
Modular trusses	There are two types of modular trusses: those installed as strengthening for girders without queen posts and those that complete the queen posts. Because of their space requirements under the girder, QP1 posts add a level of complexity due to the overlapping of the two types of strengthening. Furthermore, regardless of the type, these modular trusses play a "simple" support role, as they are connected to the girder by shims. Under these conditions, the strengthening provided by the modular truss will likely be lost in any event at some time or other during deconstruction of the deck. The question of girder resistance without the modular trusses is therefore raised, whether the modular truss is removed prior to the work on the girders or during a second stage, such as after the girders have been hoisted. The bearing system for the modular trusses on the pier caps (see Figure 24) also requires special attention. In fact, these trusses are "suspended" by a linkage system to a metal section involving two bearing points. The corresponding static scheme therefore leads to a lifting reaction on the opposite side of the hanger, a reaction that is applied to the end diaphragm of the adjacent span. The deconstruction of a span will therefore result in the loss of the bearing under the end diaphragm of the truss on the adjacent span. To avoid creating a mechanism and thus maintain the system in balance, measures will need to be taken.

TYPE	COMMENTS
Auxiliary girders	When the clearance under the structure is limited, another type of strengthening girder is used, auxiliary girders. It consists of two steel girders laid out along the edge girders and fastened to the span by prestressing using very large-diameter bars that extend from one edge to the other. Despite a different, more favourable layout, these lateral girders must be removed before any work is done on the span to be deconstructed, which once again brings up the question of girder resistance when no such strengthening is present.
Diaphragms	Diaphragm strengthening combines two techniques: carbon fibre and external prestressing. As was said previously, carbon fibre does not really present a problem for deconstruction. However, contrary to longitudinal prestressing, diaphragm strengthening prestressing must be removed before the deconstruction operations. The only cases where this prestressing can remain in place are: • Removal of the entire span in a single pass • Deconstruction by cutting longitudinal sections while preserving the total width of the structure Given the estimated weight of a full span, the first solution seems problematic. The second solution, although more realistic in terms of weight, requires more cutting work and therefore more time.
Passive slab supports	Passive slab supports, made up of simple metal sections, are not problematic in and of themselves. In the scenario involving longitudinal sawing between the girders, the stability of the slab components becomes an issue once the sections have been removed. Besides the lack of passive reinforcement and the poor condition of the transverse prestressing, the length of the strands remaining after sawing will likely be insufficient to allow re-anchoring by bonding, which naturally assumes an injection of adequate quality.
Active slab supports	This involves transverse prestressing strengthening. Two solutions were used: the first is based on straight tendons, and the second on deflected tendons between certain girders, with the deviators providing a vertical component that reduces the forces in the slab. In both cases, the prestressing is found from one end of the bridge structure to the other. It presents the same problems as diaphragm prestressing. It will therefore have to be slackened before deconstruction.
Pier cap prestressing – sec. 5 & 7	The prestressing in the pier caps does not constitute a problem. At the very most, precautions will have to be taken to protect it from impacts when it is outside the concrete. This protection will only be theoretically justified while the pier supports the deck. Once the deck has been removed, it should be possible to remove the prestressing without impacting the resistance of the pier cap.
Steel lining	If the piers are deconstructed with a rock crusher, or with similar mechanical means, the steel lining will have to be removed. Otherwise, other deconstruction methods will have to be used for the steel-lined portion.

4.3.3.3 Reduced capacity of prestressed concrete girders

The deconstruction sequence of the concrete girders in Sections 5 and 7 will depend on the residual capacity of the girders with and without added strengthening. The condition of the girders, and particularly the edge girders, varies. During the work, an evaluation and a survey of each span (sounding methods) using suitable means will be required shortly before the work, which could result in the use of two separate methods for two adjacent spans. The aim will naturally be to minimize changes in methods in order to ensure speed of execution and limit financial consequences.

4.3.3.4 Prestressing of piers in section 6 (2E & 2W)

Piers 2W and 2E in section 6 include prestressing in the upper and lower arches. These piers provide a transition between the upper deck trusses of the approach spans and the lower deck trusses on the main span. This prestressing will require a few special precautions to be taken to avoid any risks to workers, but it does not constitute a major problem.

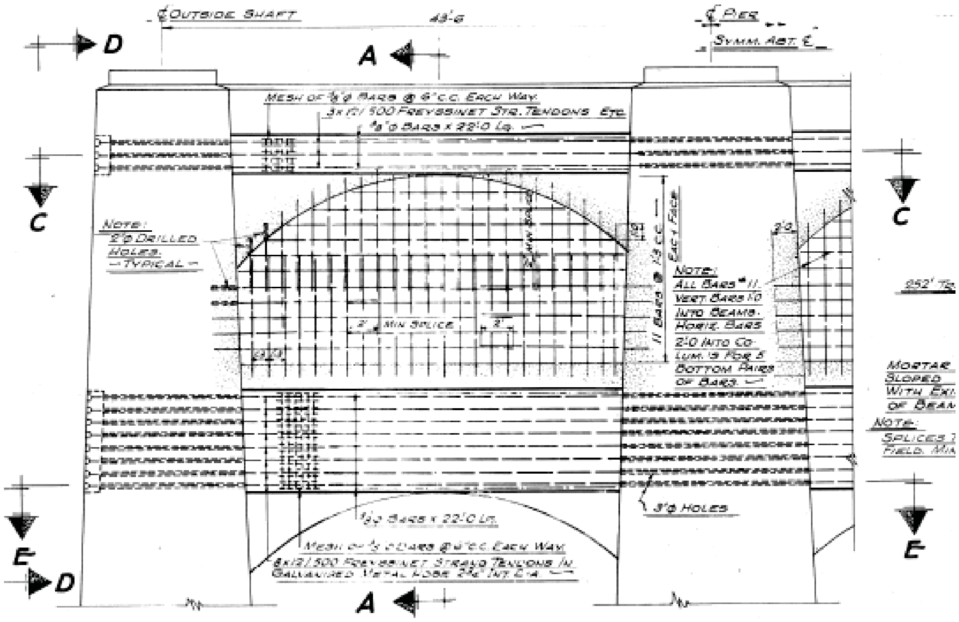


Figure 57 – Piers 2W and 2E – Prestressing

4.3.3.5 Pier caps in sections 5 and 7

The pier caps in Sections 5 and 7A are particular in that they are connected to the pier shafts through two “rails” (Figure 58), with no other rebar connecting them. The pier caps in Section 7B are connected with dowels. The pier caps are fairly heavy, which makes them difficult to handle.

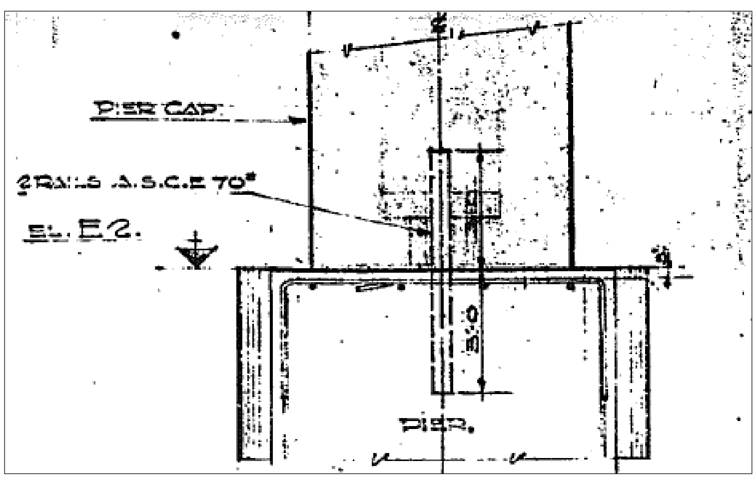


Figure 58 – Detail of pier cap/pier shaft interface

4.3.3.6 Paint – trusses

Although extensive painting work has been done on the Champlain Bridge steel spans over the years, it is virtually impossible that all the lead-based paint has been removed. Since they are assembled members, areas painted or treated in the shop are never accessible during painting work and as a result, lead will always be present. This characteristic will have to be included when preparing the terms of reference for the deconstruction. The samples may not provide an accurate picture of the situation since the nodes must be dismantled to access the areas in question. However, tests will be required for materials recovery.

4.3.3.7 Proximity of the new Champlain Bridge

The proximity of the new Champlain Bridge will add a level of complexity to the work. The bridge structures are relatively close and even share the same areas at the approaches. The interaction between the existing East abutment and the future abutment of the new Champlain Bridge is covered in section 4.3.3.11.1.

This close proximity creates constraints, such as a reduced work space that is more pronounced as you approach the shore. This proximity will require various precautions to be taken, naturally based on the deconstruction method that has been chosen. Photographs of the work (Figure 59) show the proximity of the structures to the approaches.

Figure 59 – Jetties for the new Champlain Bridge (source: www.newchamplain.ca)

As long as the work is being done on the deck of the existing bridge structure, these precautions will not be very extensive, since there will be no particular risk caused by the work. However, precautions will need to be taken to avoid attracting the attention of users on the new structure to the deconstruction works that is under way. In this respect, a solution that is widely used consists of installing screens to hide the work. To be effective, these screens must be high enough to also cover heavy vehicles. The installation of screens of this type on the new Champlain Bridge still has to be reviewed, in particular with respect to wind effects. This evaluation can only be done once the plans for the new bridge structure are available.

For work done from the ground, the risks are also limited. At most, when the structures are very close to each other, there is the risk that machinery could hit a pier. Given the size of the machinery being considered, the consequence of such a relatively small impact should be limited to surface damage.

Work over water will undoubtedly require a more in-depth analysis. In fact, based on the size of the machinery and the operating method, incidents cannot be excluded, such as a break in the mooring lines, rudder failure, engine failure, etc. In such a situation, if any equipment goes adrift, it could collide with one of the piers of the new bridge. This risk is all the greater as the machinery's work area is across from a support of the new structure. The corresponding risks can be fully comprehended by reviewing the installation of the piers of the new structure along with design rules for impact.

Lastly, it is likely that the new bridge will be used to transport materials or supply the deconstruction site. If any restrictions have to be observed, such as during rush hour, it is important to identify them as soon as possible so they can be specified during the consultation. In this regard, an agreement with SSL is recommended.

4.3.3.8 Physical constraints

Given the length of the bridge, it is not surprising that different areas have different constraints. For the purposes of this study, the Champlain Bridge is divided into ten areas:

- Area 5-1 between axes 44W and 41W: concrete girders over land ;
- Area 5-2 between axes 41W and 36W: concrete girders over water – low draught ;
- Area 5-3 between axes 36W and 4W: concrete girders over water – adequate draught ;
- Area 6-1 between axes 4W and 2W: trusses over water – adequate draught ;
- Area 6-2 between axes 2W and 0.5W: cantilever trusses over water – adequate draught ;
- Area 6-3 between axes 0.5W and 0.5E: suspended span over the Seaway ;
- Area 6-4 between axes 0.5E and 2E: cantilever trusses over water – adequate draught, but only at certain times of year since it is linked to the Seaway's operations ;
- Area 6-5 between axes 2E and 4E: trusses over water – adequate draught, but only at certain times of year since it is linked to the Seaway's operations ;
- Area 7-1 between axes 4E and 6E: concrete girders over water – adequate draught, but only at certain times of year since it is linked to the Seaway's operations ;
- Area 7-2 between axes 6E and 14E: concrete girders over land.

Based on the bathymetric data and water levels that were provided, the depth of the river under of the Champlain Bridge varies over the length of the bridge. For this study, 9.6 m is used for the likely minimum water level during the work, which corresponds to the lowest water level in the La Prairie Basin with a rate of exceedance of one hour per year, based on the data in the document "Expertise des niveaux d'eau" prepared by [redacted] dated April 29, 2016. With this likely minimum water level, the possible depths during the work periods range from less than 1 m under spans 41W to 36W to up to about 7 m near pier 27W. In general, depths range from 3 m to 4 m. The water under the spans between axes 1E and 6E is not as deep (around 0.5 m).

The draught between axes 41W and 36W is therefore not sufficient to allow barges to be used. In the past, repair work on these spans had to be done from the deck. Still based on available data, the water level between axes 1E and 6E only appears adequate for the use of barges when the Seaway is open. In fact, as the areas are connected, the water level is dependent on that of the Seaway. JCCBI has a dock on the South Shore that provides access.

4.3.3.9 Roads/waterways crossed

The Champlain Bridge primarily crosses over the St. Lawrence River, as well as over Boulevard René-Lévesque (section 5), the St. Lawrence Seaway (section 6) and Route 132 and its service roads (section 7).

4.3.3.9.1 René-Lévesque Blvd. (Section 5)

René-Lévesque Boulevard is located on Nuns' Island, in the City of Montreal, Borough of Verdun. This road is under the jurisdiction of the City of Montreal. It has two traffic lanes in each direction. Span 42W-43W crosses over this road. The vertical clearance under the span is currently posted at 4.3 m. Clearance signs are installed on Boulevard René-Lévesque on either side of the span to prevent it from being damaged by an impact. Work above this roadway will require agreements with the City of Montreal.

The deconstruction of span 43W-42W will require the complete closure of the road. Work will be done over the weekend to limit the impact on traffic, and will require several weekends. This span was reinforced with a QP2 and auxiliary girders, and to facilitate the work, it is proposed that the single strands be cut with a torch.

The road is under the jurisdiction of the City of Montreal, Borough of Verdun, and requests for traffic disruptions must be submitted well before the work is to be carried out for coordination with other City services and to minimize the negative impact on users.

4.3.3.9.2 St. Lawrence Seaway (Section 6)

The St. Lawrence Seaway, which is managed by the St. Lawrence Seaway Management Corporation (SLSMC), is located between piers 1W and 1E of the Champlain Bridge, more specifically between axes 0.5W and 0.5E. The suspended span of the Champlain Bridge over the Seaway maintains the horizontal and vertical clearances required for navigational purposes. Any work carried out above the Seaway must be the subject of an agreement with the SLSMC.

For a project of this scale, a framework agreement will likely be required. The agreement would cover the general rules, after which each intervention will require specific approval.

4.3.3.9.3 Route 132 (section 7)

Located in the City of Brossard, Route 132 is a major thoroughfare under the jurisdiction of the MTMDET. It consists of three lanes and one service road in each direction. The spans between axes 10E and 11E cross over the highway.

The deconstruction of the spans between axes 9E and 12E over Route 132 and the associated service roads will require the complete closure of the highway. Work will be done over the weekend to limit the impact on traffic. Several weekends will be required to complete the work.

Special care will be given to maintaining the flow of traffic and, when possible, traffic will be detoured to service roads. As Route 132 is under the jurisdiction of the MTMDET, traffic disruption requests must be part of a joint process. Work scheduling must take into account the restrictions involved in maintaining traffic and simultaneous lane closures.

The spans above Route 132 are reinforced with modular trusses and QP2, and this strengthening will partly dictate the deconstruction sequence

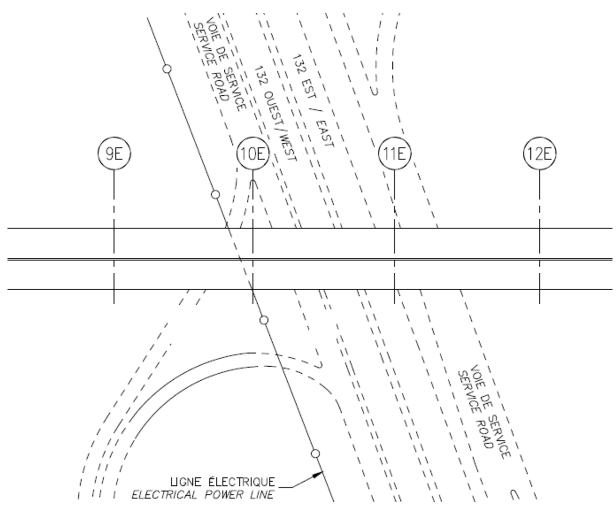


Figure 60 – Route 132

4.3.3.10 Available mobilization areas

The available mobilization areas under JCCBI jurisdiction are:

4.3.3.10.1 Nun's Island

On the Nuns' Island side (north shore), a mobilization area is available along the road leading to the Champlain Bridge Ice Control Structure (Figure 61). However, redevelopment work is planned at the Ice Control Structure approaches, which limits the available area. This area does not provide any direct access to the water, but it is possible to build a jetty between axes 41W and 36W and access it via the Ice Control Structure road.

Based on the available plans[5], it does not appear feasible to set up a mobilization area directly behind the existing abutment (axis 44W), which would present an advantage for the unlaunching method. The space currently occupied by the former Champlain Bridge toll booth also appears to be unavailable.

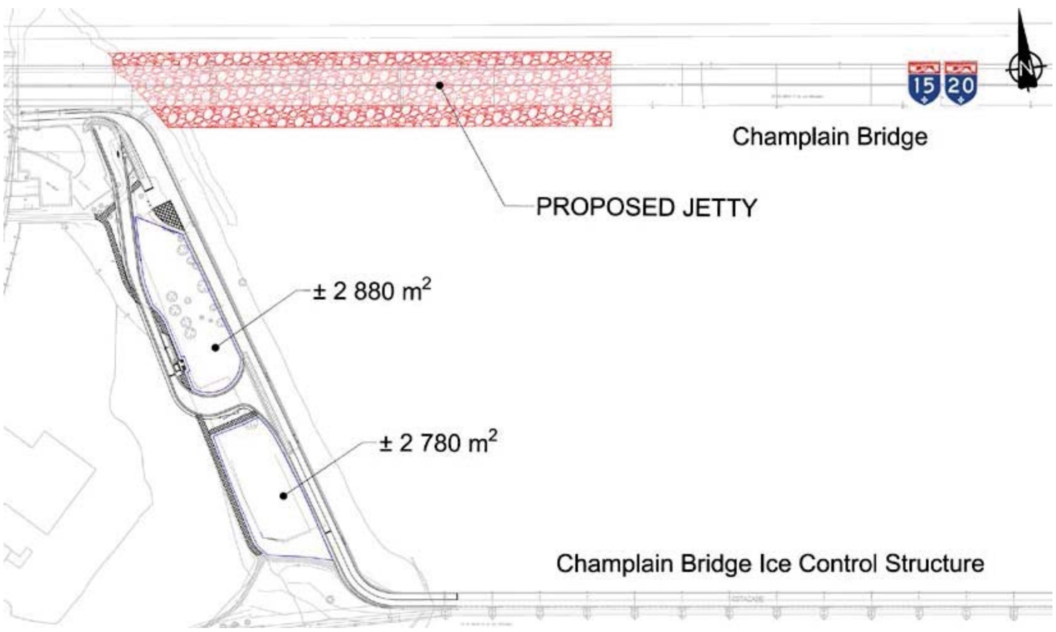


Figure 61 – Mobilization area – Nuns' Island

4.3.3.10.2 St. Lawrence Seaway dike

This area is located at the base of pier 1W on the St. Lawrence Seaway dike (Figure 62). The Ice Control Structure must be used to access the area by road. It is a private road under the jurisdiction of JCCBI. The dike can also be accessed by the river, and various docks have been set up there.

[5] Drawing 7002-ARU-GEN-DR-PR-027103-BI dated 2014-12-05

Figure 62 – Mobilization area – St. Lawrence Seaway dike

4.3.3.10.3 Brossard

Two mobilization areas are available on the South Shore side (Figure 63). The first area is located between axes 6E and 9E. A dock was set up that allows access to the Small La Prairie Basin. The second area is located inside the highway onramps. This is definitely less practical, since it has to be accessed by the highway onramps, which requires additional precautions and, most likely, restricted times for accessing the site (outside of peak hours).

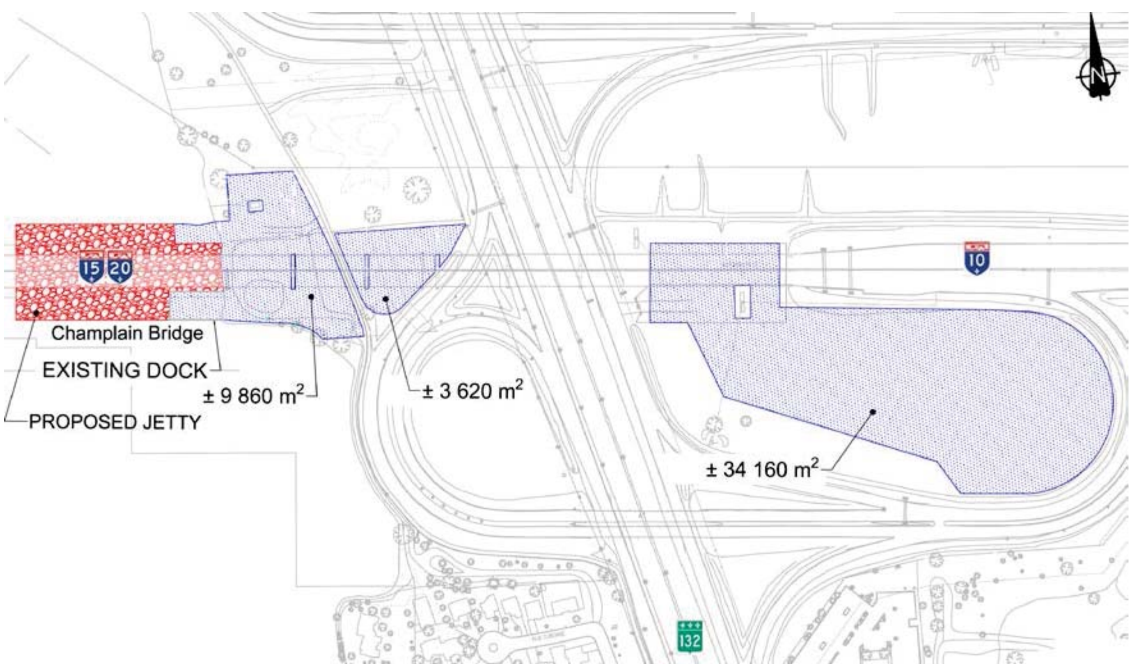


Figure 63 – Mobilization area – City of Brossard

4.3.3.11 Acces to the various areas

This section presents the options for accessing the Champlain Bridge to carry out the deconstruction work. Access will involve a combination of methods, as the complexity of the structure does not allow the use of a single method. The access method is dependent on several variables, including:

- Chosen deconstruction method ;
- Location of the components to be deconstructed ;
- Characteristics of the ground or river in the location of the component to be deconstructed ;
- Height of the component to be deconstructed.

4.3.3.11.1 Access by the deck

Several of the deconstruction methods that have been identified require at least partial access from the bridge deck that will be deconstructed. The deck can only be accessed by land from both ends (abutments 44W and 14E), thus limiting access for equipment and the removal of materials from the site. In this case, the work can be carried out either by accessing the area from one side or by starting from a central point and accessing the area from both ends. The number of access points has a direct impact on the project schedule.

Given the proximity to the new bridge, the 13E-14E span may be demolished in whole or in part in order to complete the abutment work on the new Champlain Bridge. This demolition would significantly reduce access for the deconstruction of the Champlain Bridge. If the demolition work is absolutely required, a temporary ramp that allows access via span 12E-13E could be considered. This requires ensuring there is enough space for the construction of a ramp that is compatible with the machinery that will have to use it.

The major advantage of access by water is the limited footprint of the work in the water. The disadvantages are the slow pace of the work, which must be carried out with no more than two corridors, and the risks associated with the use of a degraded, partially deconstructed structure to support loads.

Special attention is required to ensure work safety, especially when heavy loads or special configurations are needed. Mitigation measures for deck resistance problems are possible, including limiting loads, using methods that are essentially supported by components with greater capacity or that are less deteriorated, such as the piers or internal girders.

4.3.3.11.2 Access by land

Access by land is only feasible for the parts of the bridge that are near the shore or over land. For the Champlain Bridge, the parts that are accessible are between axes 44W and 41W, near axis 1W, and between axes 6E and 14E.

The main advantages are the easy preparation of the site, the possibility of using common equipment, and work methods that are generally more conventional and involve less risk.

4.3.3.11.3 Access by barge

Barges can be used to create a work area on the water. This surface can be used to support and transport work equipment, support and transport materials or components, and receive the pieces that have broken off from the structure.

Modular barges are well-suited to this type of work since they can be connected and set up to form larger surface areas. Depending on the type of barges used and the loads to be supported, barges may be used even at minimum water depths of around one metre.

4.3.3.11.4 Access by temporary jetty

A temporary jetty is an access solution for shallow areas. These jetties are generally made of backfill placed in the waterway and removed once the work has been completed. Access by jetty allows the same work methods to be used as for work over land. A jetty will have environmental and hydraulic impacts on the St. Lawrence River that must be taken into account.

A few sections of the new Champlain Bridge are being built from temporary jetties. Reusing these jetties, by either modifying their configuration or simply reusing the materials, should be considered.

Figure 64 – View of the jetty for the construction of the new Champlain Bridge from the St. Lawrence Seaway dike (photograph taken on June 22, 2016)

Two jetties are being considered, one on the Nuns' Island side, between axes 41 W and 36 W, which corresponds to area 5-2, and another between axes 4E and 6E, which corresponds to area 7-2; this jetty could even be extended to 1E (areas 6-4-partial and 6-5), as is being done for the construction of the new Champlain Bridge (see Figure 66). The first jetty is required since the water depth does not allow the spans to be accessed by water. The second jetty is proposed, since it provides access to the spans at all times rather than for a determined period. In addition, working from a jetty is simpler and more flexible.

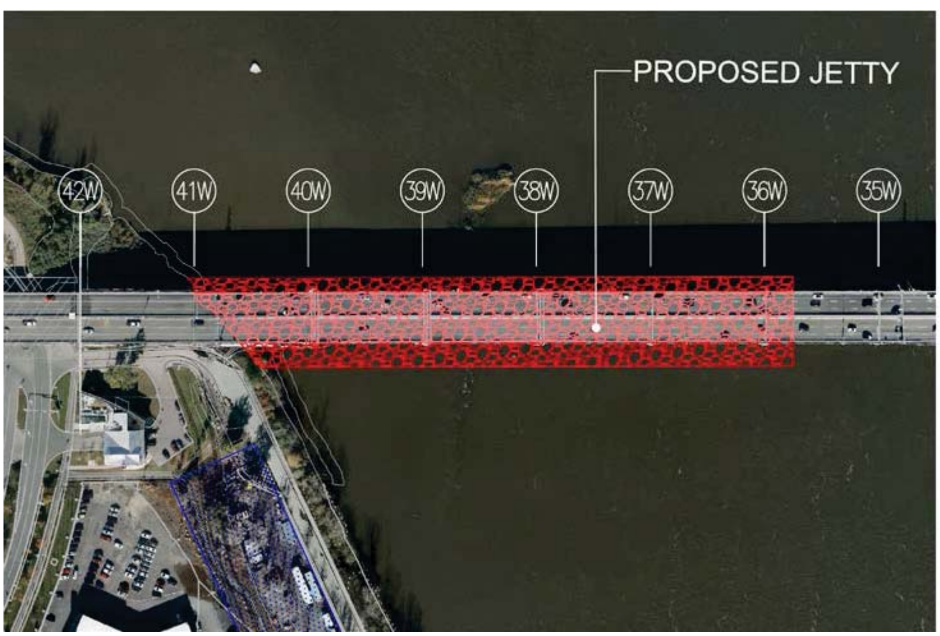


Figure 65 – Sketch – Jetty on Nuns' Island side

Figure 66 – Jetty on Brossard side – New Champlain Bridge (source: newchamplain.ca)

4.3.3.11.5 Access by floating workbridge

In the event that a jetty is not feasible, such as for environmental reasons, a floating workbridge could be considered for accessing low-draught areas.

The floating workbridge is made up of evenly spaced modular pontoons, such as flexifloat pontoons. These pontoons act as a platform for a provisional deck that could be made of simple sections supporting decking. Depending on the load to be supported, a combination of several pontoons is possible to increase their load-bearing capacity. It is even possible to increase the width of the resulting work area in this way.

Naturally, the floating workbridge would have to be kept stable, in particular with respect to the current. Various solutions are possible, such as cables attached to the shore or to moorings on the riverbed.

Figure 67 – Floating workbridge

4.3.3.11.6 Access by ice bridge

Ice bridges provide a way to access parts of the structure to be deconstructed over water. This access method is widely used in the mining and forestry sectors, but could also be considered for bridge deconstruction. An ice bridge provides access similar to a jetty, or can be used to collect debris and prevent it from falling into the river. This method was used to deconstruct the Saskatoon Traffic Bridge in Saskatchewan in the winter of 2016 (Figure 68).

Use of the ice bridge naturally depends on the climatic and hydraulic conditions of the river. The feasibility of this solution has yet to be established. As climatic conditions vary widely from year to year, a non-negligible risk of diverging from the timetable would have to be taken into account.

Figure 68 – Deconstruction of Saskatoon Traffic Bridge using an ice bridge (source: Radio-Canada 2016)

4.3.3.12 Level of deconstruction of footings

The level of deconstruction of the footings must be clearly established. Most of the footings are embedded in the bedrock and completely removing them would require a reworking of the riverbed. For the time being, the level of deconstruction being considered is the riverbed level. This hypothesis is compatible with the requirements stated by Transport Canada at the meeting held on September 30, 2016 (see minutes in Appendix 4):

For navigation, the required levelling height depends on the following cases:

In navigable waters:

- *Piers removed below the water level: a minimum draught of 2.0 m must be ensured at all times (low water levels). This requirement was used for the deconstruction of the Nuns' Island Bridge.*
- *Piers removed above water level: Piers must be removed (or not) high enough so that they are visible even during high waters (no minimum prescribed height). This requirement pertains to navigation only, but other factors may come into play (e.g., hydraulic behaviour, ice movement).*

In non-navigable waters:

- *Beyond approximately pier no. 40, where the draught is too low for navigation, the piers must be removed to the riverbed.*

The possibility of leaving some components in place should also be considered, especially if they may be used for asset development. If any components are left in place, they must be visible for navigation, and at the time of the deconstruction, specific heights will have to be established to prevent them from becoming a hazard so that action is subsequently required to remove them or substantially alter them. A cost analysis is required to estimate the financial consequences of this choice.

4.3.4 ANALYSIS OF METHODS

The standard methods presented in section 4.3.1 were analyzed with the constraints specific to the Champlain Bridge taken into account. Some were completely ruled out, while others were ruled out only for certain areas. A work sequence is presented for the methods that were selected.

4.3.4.1 Preparatory work – All methods

1. Remove lights, road signs, lane traffic lights and any other equipment.
2. Remove asphalt.
3. Remove barriers (it is the contractor's decision whether to remove them as the work progresses or to remove them all at the same time).
4. Remove span expansion joints (it is the contractor's decision whether to remove them as the work progresses or to remove them all and install plates to permit work site vehicles to access the site).
5. Install work site barriers (if needed).
6. Use conventional measures to prevent the fall of debris or materials (protect waterways, crossings, etc.).
7. Set up conventional measures to prevent workers from falling.

Access by the deck (all areas).

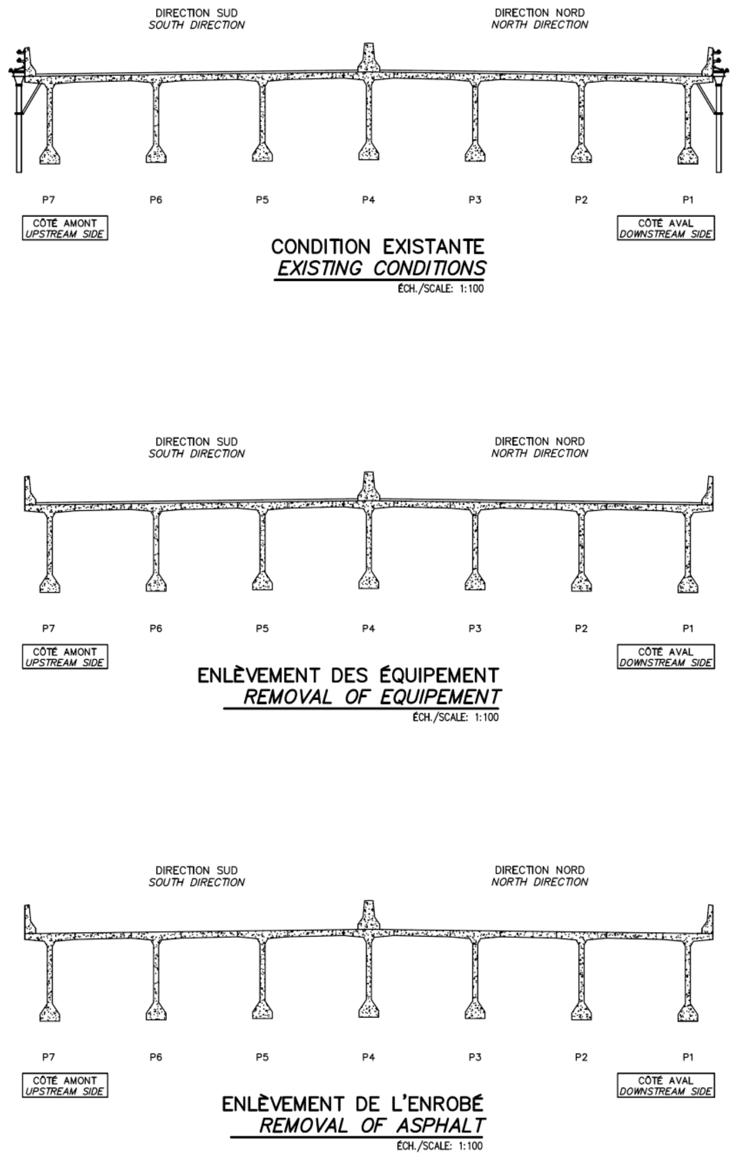


Figure 69 – Preparatory work

4.3.4.2 Standard method

This is the standard method used to deconstruct a structure. It makes use of standard equipment and techniques which contractors are generally very familiar with. As such, they have a definite cost advantage and provide substantial flexibility. These methods are therefore especially suited to areas where deck height, from the ground or barge level, does not exceed about 15 m. Naturally, more specialized equipment can be used for greater heights. The pace of execution and cost of this equipment will have to be assessed versus those of another method. The method can also be used to deconstruct the pier shafts, pier caps and footings outside the water.

Among the sub-technologies mentioned in section 4.3.1.1, some are only optimal for partial deconstruction and cannot be considered effective for full deconstruction, especially given the size of the Champlain Bridge. Hydrodemolition, splitting and thermal cutting and drilling have therefore not been retained for the remainder of this study. Wrecking balls and cranes have also been discarded, as this type of deconstruction provides less control.

4.3.4.2.1 Deconstruction sequence – Concrete deck

1. Remove slab strengthening (passive and active supports and external prestressing of diaphragms). It is expected that the active strengthening can be slackened ; otherwise, the tendons will have to be cut.
2. Girder strengthening:
    a. Modular trusses: remove before the work ; otherwise, they will be damaged by the debris.
    b. EPT: remove before the work if possible ; slacken the tendons or cut with a torch.
    c. QP1: remove before the work ; slacken or cut the bars with a torch.
    d. QP2: remove before the work ; slacken the tendons or cut with a torch.
3. Using equipment on the ground, a jetty or a barge, deconstruct the girders, slabs and diaphragms using jaw crushers, rock crushers, etc. Smaller pieces then fall to the ground, the jetty or the barge. The debris is then transported to nearby available sites (Nuns' Island, South Shore, Seaway dike) or directly hauled away by barge or truck.
4. Pay special attention to the last girder: its stability must be ensured to avoid having it tip over ; a temporary mechanism (local strengthening will likely be sufficient) retaining it to the pier cap is therefore needed.

Access from the ground (areas 5-1 and 7-2), from a jetty (area 5-2) and by barge (areas 5-3 and 7-1).

4.3.4.2.2 Deconstruction sequence – Pier shafts, pier caps and footings – Access from the ground or a jetty

1. Remove the external prestressing of the pier caps.
    a. The external prestressing can be slackened if corresponding measures have been taken, or cut with a torch.
    b. Internal prestressing: it will be handled by the machinery, as it was for the girders.
2. Using equipment on the ground or on a jetty, deconstruct the pier cap, pier shaft and footings in the areas above the ground or above the jetties, using jaw crushers, rock crushers, etc. Smaller pieces will then fall to the ground or the jetty. Excavators will be used to pick up the debris. The debris is then transported to nearby available sites (Nuns' Island, South Shore, St. Lawrence Seaway dike) or directly hauled away by barge or truck.

Access from the ground (areas 5-1 and 7-2) and from a jetty (area 5-2).

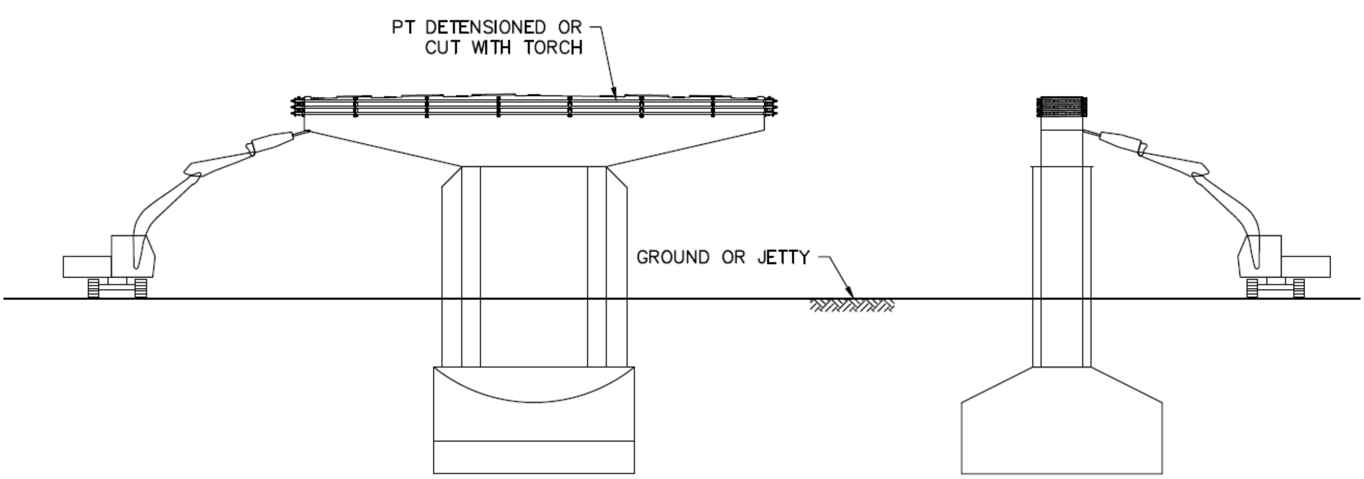


Figure 70 – Standard method – Piers above water – Front and side views

4.3.4.2.3 Required mobilization area and equipment

The currently available mobilization areas are sufficient for this method to be used. The cranes and shovels are of standard size and do not require any particularly large spaces.

4.3.4.2.4 Technical risks

The main risks are:

- Slower pace due to the quantity and high concentration of internal prestressing in the girders.
- Uncontrolled fall of a larger section of girder or pier than anticipated ; personnel safety, as well as risk of damaging or sinking the barges receiving the materials.

4.3.4.2.5 Health and safety

Table 32 presents the main health and safety risks for the methods discussed in this section.

Table 32 – Health and safety – Standard method

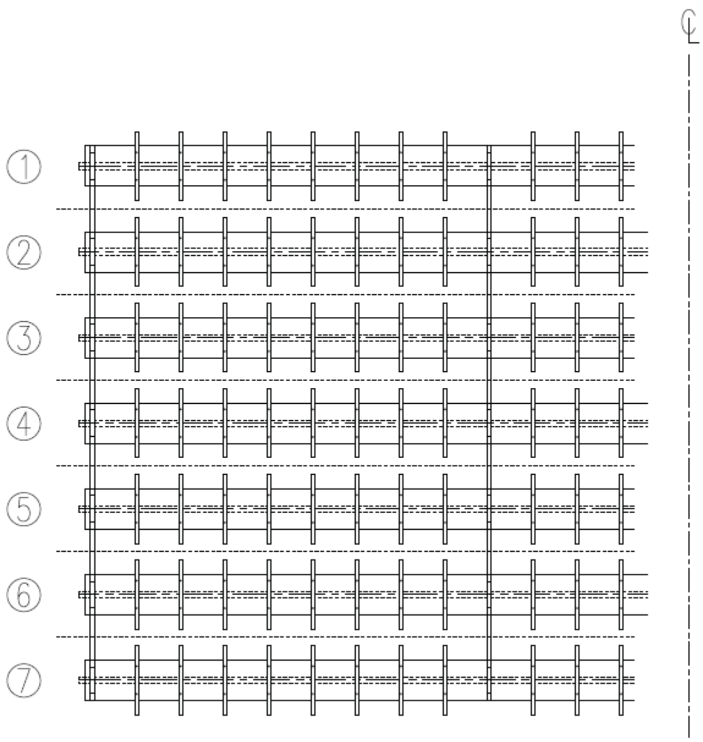
ACTIVITIES	RISKS	EFFECTS
Moving equipment, parts and tools	• Collision • Being hit • Entrapment/Projection/Falling objects • Falling loads	• Abrasions/scrapes/bruises Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death
Work over water	• Person overboard • Collapse	• Hypothermia • Drowning • Crushing • Multiple injuries and death
Signage/traffic management	• Collision • Being hit	• Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing • Multiple injuries, death
Hoisting operations	• Falling objects • Entrapment • Being hit • Projection • Falling loads • Collapse	• Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death
Work at height	• Fall into the water or from a higher level • Falling objects • Fall from a height • Same-level fall	• Sprains/strains/fractures • Contusions/bruises Hypothermia • Drowning • Multiple injuries, death
Work over water	• Person overboard	• Hypothermia • Drowning • Death

4.3.4.3 Unlaunching

This method has been retained for the remainder of the study. This was how the bridge was originally built and the option is still viable today. The lateral launching gantry is used to haul the girders away laterally and transport them either by barge or by self-propelled modular trailer (SPMT).

4.3.4.3.1 Deconstruction sequence – Concrete deck

1. Set up the slab support system: sections or other means (see concept in Figure 71). This support system must be installed from the start over the entire width of the slab. Once the first strips have been installed, the contractor can either install the supports over the entire length of the span, or install them as the sawing progresses, always placing the supports over the entire width of the slab. Otherwise, because of the structural system, the connection between the slab segments and the girder will not be ensured ;



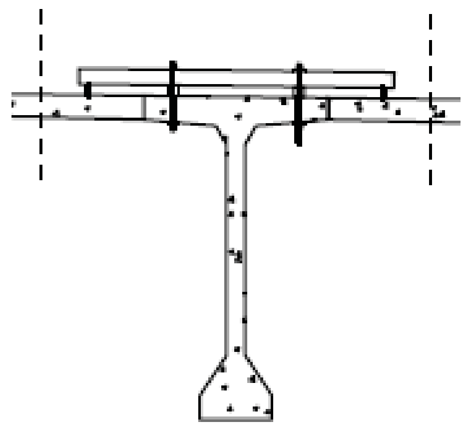


Figure 71 – Concept of slab support system

2. Set up anti-lift mechanisms for the modular truss supports, at the edge of the pier cap opposite to the span being removed (these mechanisms can be reused for all the modular trusses as the work progresses.
3. Remove slab strengthening (passive and active supports) and external prestressing of diaphragms. It is expected that the active strengthening and external prestressing can be slackened ; otherwise, the tendons will have to be cut.
4. Option 1:
    a. Release all the prestressing tendons of the slab between two diaphragms.
    b. Cut the tendons with a torch: the heat will progressively slacken the tendons.
3. Option 2:
    a. Protect the edge of the slab with a metal plate or equivalent system in order to hold the lateral prestressing slab anchors that may be ejected and injure either workers or river users.
4. Saw the slab between the girders, in the middle.

5. Girder strengthening:
    a. Modular trusses: leave the modular trusses in place and remove them immediately after removing the girder, also with the launching gantry.
    b. EPT: leave in place and haul the girder away with the EPT.
    c. QP1: cut the bars with a torch and remove before releasing the girder.
    d. QP2: leave in place and haul the girder away with the QP2.
6. Stabilize the girder that will be removed using a temporary mechanism connecting the diaphragm to the pier cap (this mechanism can be reused for all the girders).
7. Saw the diaphragm, including the internal prestressing cables.
8. Depending on the method:
    a. Conventional launching gantry: the launching gantry places the girder on a self-propelled modular trailer on the deck, on the rear span.
    b. Lateral launching gantry: the launching gantry moves the girder transversely past the edge of the deck and lowers it to a self-propelled modular trailer (SPMT) or barge, depending on the area.

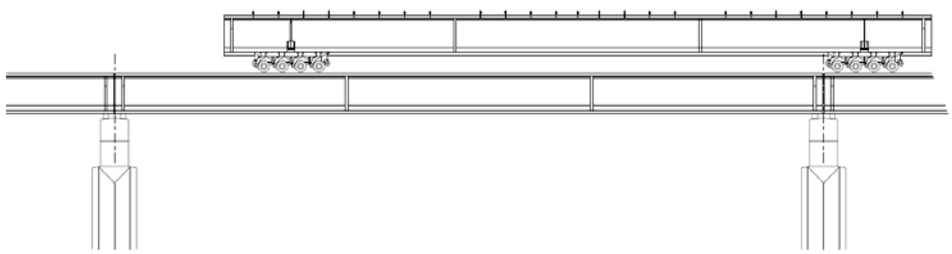


Figure 72 – SPMT – Elevation

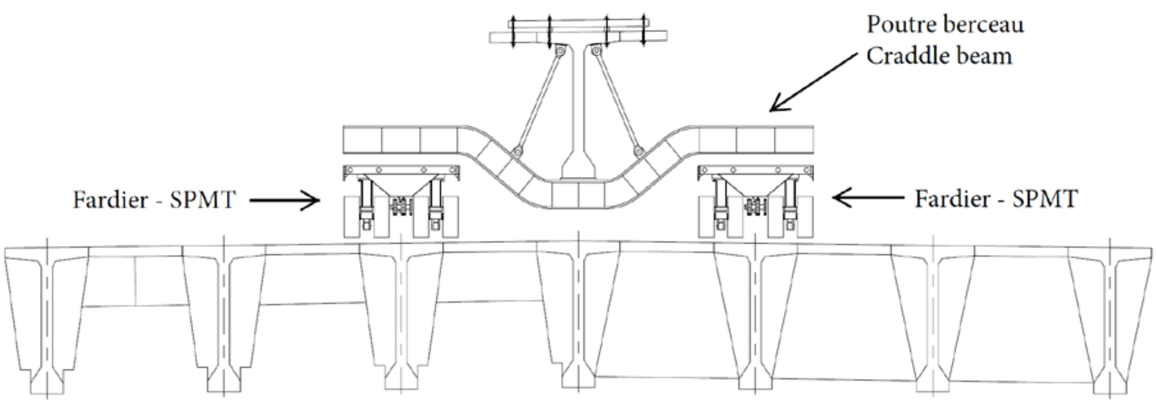


Figure 73 – SPMT – Cross-section at supports and mid-span

9. Pay special attention to the last girder: its stability must be ensured to avoid having it tip over ; the temporary mechanism used for step 6 will likely be adequate.

Conventional launching gantry: Access by the deck (all areas). There are two possible options for hauling the girders away using the SPMT:

a. The SPMT accesses an area outside the deck where the girder is taken for subsequent operations (transport or onsite dismantlement).
b. The SPMT brings the girder to one of the steel spans at the Small La Prairie Basin (span 2E-3E or 3E-4E) where a stationary crane picks it up and places it on a barge to be hauled away, as this section has direct access to the Seaway.

Lateral launching gantry: Access from the ground (areas 5-1 and 7-2), from a jetty (area 5-2) and by barge (areas 5-3 and 7-1). Given the size of the girders, the equipment required for this method is less conventional than for the crane method (see 4.3.4.4) for generally similar results. Therefore, it is proposed that it not be further considered in the remainder of the study.

Launching gantry: access by the deck (all areas).

4.3.4.3.2 Summary evaluation

To ensure the feasibility of unlaunching, some verifications were carried out. These verifications assessed whether:

- The girders can be handled without any major risk of breaking them during the operations. This is also the case for deconstruction using cranes (section 4.3.4.4).
- The girders can be transported using the self-propelled modular trailer on the deck.
- The piers must be capable of withstanding the forces induced by the launching gantry during operation.

At this stage of the study, it is naturally not feasible to verify all possible situations. On the one hand, such a study would require a status report on the condition of the bridge structure just before the work ; this condition will obviously continue to change and there will definitely undergo other repairs or strengthening about which currently little or nothing is known. On the other hand, a detailed study requires good knowledge of the equipment being used – including the geometry and weight of the launching gantry, type of self-propelled modular trailer, etc. – as well as detailed information on the various deconstruction steps.

The verifications that have been done are based on a series of assumptions that are as realistic as possible. The aim is merely to ensure, using simple calculations, that the proposed solution is feasible, perhaps with a few adjustments during the detail studies in future phases.

4.3.4.3.2.1 Isolated concrete girder

For the phase when the girder is to be handled by the launching gantry or cranes, the following assumptions were taken into account in the verifications:

- The girder is in the process of being lifted and is therefore no longer connected to the rest of the span being dismantled. As a result, there is no load effect or transfer to other components.
- EPT1, EPT2 and QP2 prestressing strengthening are in place during the operations.
- The queen-post 1 (QP1), where it exists, has been removed, so its effects are lost.
- Naturally, the modular truss is no longer connected to the girder.

The theoretically most critical girders were identified by examining the information in the Master Data Table dated May 7, 2016. With the various strengthening in play, the most critical girders are not necessarily those that have lost the most tendons, but those for which the loss of tendons associated with the strengthening that were implemented (non-QP1) results in the most critical situation. The criterion used to define this most critical situation was to find the girders where the residual prestressing and the strengthening prestressing resulted in minimal tension.

Girder P7 on span 29W-28W was not considered in the analysis, however. Given its history, this girder must be specifically analyzed.

The analysis consisted of two parts. First, the girders that have lost the most tendons, beginning at nine lost tendons or more. Second, by assessing the residual tension in the remaining tendons using mean values per family and adding the effects of the strengthening found in the Master Data Table. This evaluation allowed the following cases to be retained:

- Girder P7 on span 27W-26W which has lost 10 tendons and which, as soon as its associated queen-post 1 is removed, will have only one EPT1 prestressing strengthening with a tension of 1,695 kN.
- Girder P7 on span 6E-7E, which has lost 9 tendons and which, as soon as its associated queen-post 1 is removed, will have only one EPT1 prestressing strengthening with a tension of 1,252 kN.

The results show that there is very little tension at mid-span – less than 1.5 MPa – before the removal of equipment (and without queen-post 1), and there is no longer any tension once the equipment has been removed.

It can be concluded that it is feasible to use a launching gantry or cranes to handle the girders as long as the non-QP1 strengthening prestressing remains in place.

4.3.4.3.2.2 SPMT movement

It must be ensured that the condition of the structure will allow the girders to be hauled away by machinery travelling on the deck. The corresponding verifications consisted of comparing the stresses created by the SPTM carrying the girder with the traffic loads defined in CAN/CSA-S6.

As previously, the results will naturally depend on the configuration adopted for girder transport: number of trailers used, number of axles, distance between trailers, etc. Reasonable assumptions were once again used.

Given that the central girders – P4 – have lost more tendons than the other internal girders, it seemed preferable to place two self-propelled modular trailers in a transverse direction, as shown in Figure 73. This is also preferable to a single trailer since the load can be distributed transversally. However, this layout has consequences for the design of the launching gantry. It will have to be wider to avoid any conflict between its feet and the movement of the SPMTs.

In terms of load comparison, since the slabs are expected to be cut as the work progresses, there are spans in which the transverse distribution will be reduced to what can be carried by the diaphragms. Given the small number of diaphragms and their relatively wide spacing, it seemed preferable to discount this favourable effect. A longitudinal group of two four-axle SPMTs was therefore used for a single girder without any transfer to the other girders.

With respect to the traffic load, by homogeneity, it was considered that a girder line would use one lane.

Moreover, to reduce the permanent load applied to the structure, it is assumed that the various equipment – e.g. asphalt, barriers – has been removed.

Lastly, for the ultimate limit states, although the standard coefficient of 1.7 was applied for the traffic load, this coefficient was reduced to 1.45 (≈ 0.85 x 1.70 – CAN/CSA-S6 – 3.16), even though a greater reduction is undoubtedly possible.

The results show that:

- At the Serviceability Limit State (SLS), the moment caused by the convoy transporting the girder is about 10% greater than that of the traffic load affected by the coefficient of 0.90, less the moment of the equipment.
- At the Ultimate Limit State (ULS), the situation is reversed, as the moment caused by the convoy transporting the girder is about 10% less than that of the traffic load affected by the coefficient of 1.70, less the moment of the equipment.

It is undoubtedly possible to reduce, or even eliminate, the slight exceedance of the Serviceability Limit State (SLS) by optimizing the characteristics of the SPMT and by choosing less pessimistic lateral distribution assumptions. This should also benefit the Ultimate Limit State (ULS).

It would therefore be reasonable to conclude that a SPMT hauling away a girder can travel over the deck.

4.3.4.3.2.3 Resistance of pier caps

During the removal of the girders, the launching gantry will be supported either directly on the pier cap at the free end of the span being deconstructed or on the deck in the way of a bearing. In all cases, the weight of the launching gantry and the girder being removed will therefore be transferred to the pier caps. It is therefore important to ensure that the pier caps will be able to withstand these conditions, although this was naturally the case when the bridge was being built.

A verification was done in this respect. For this check, the weight of the launching gantry was estimated at 360 t and its length at two spans. During the handling operations, the launching gantry rests on three bearing lines (Figure 74) and is positioned transversely to the vertical of the girder to be removed (Figure 75). Once the girder has been lifted, the launching gantry moves transversely to the deck axis, after which the main trolley move toward the rear span where the girder will be placed on the SPMTs.

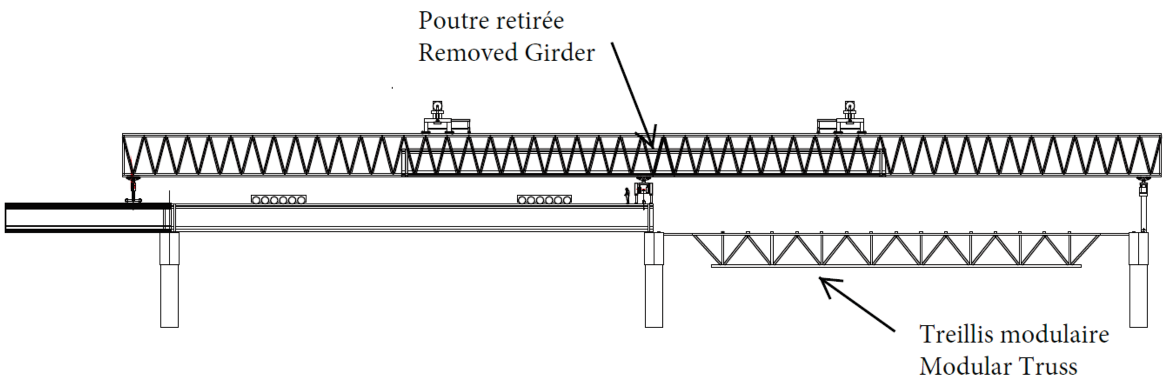


Figure 74 – Launching gantry

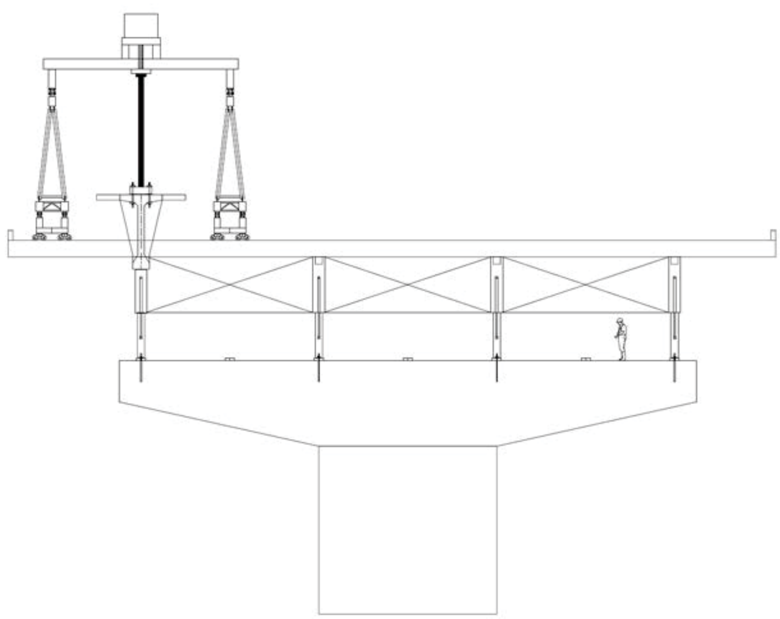


Figure 75 – Launching gantry – Cross section

With these kinematics, the maximum bearing reaction is obtained on the central bearing when the girder is being transferred to the SPMTs. However, this is not the most critical situation for the pier caps, since this reaction applies directly to the vertical of the pier shaft.

The most critical situation for the pier cap is when the launching gantry first lifts an edge girder. In this case, the pier cap must be capable of withstanding the bearing reaction of the launching gantry that is supporting the girder being hoisted and the immediately adjacent girders (P2 or P6) on the two spans under the launching gantry, still on their bearings.

Summary verifications were carried out taking the following into account:

- All the reinforcing bars found at the junction with the pier shaft, i.e., three beds of 12 #18 bars.
- The minimum reinforcement in place going toward the end of the pier cap, i.e., two beds of 12 #18 bars, and one bed of 4 #18 bars.
- The strengthening prestressing, external to the pier cap, made up of 6 bars 36 mm in diameter (this is one of the types of pre-tensioning added to the pier caps ; the other cases will also have to be examined).

Even with the most critical configuration, with the minimum strengthening, the summary calculations show that the pier cap is able to withstand the forces induced by the launching gantry.

Other verifications will naturally be required, particularly when the weight of the launching gantry and its kinematics are more precisely known. It appears, however, that pier cap resistance should not put the feasibility of the unlaunching solution into question.

4.3.4.3.3 Required mobilization area and equipment

Ideally, for an onsite dismantlement, two mobilization areas would be preferable for this method, one at each end of the bridge. As previously explained, it will be difficult to set up on Nuns' Island, so the area on the Brossard side will have to be used. The space in this area allows enough girders to be piled so as to not decrease the optimal pace of the launching gantry, which is one to two girders per day.

When a stationary crane is used, there are no real constraints in the mobilization areas. These areas are limited to the sites where the dismantlement will take place. They may be at the work site, in the dike area or on the South Shore, or far from the site, along the river, as soon as the transport barges are able to access them, with the girders being unloaded by roll-on/roll-off.

A launching gantry equal to about two spans, or about 110 m, is needed. This type of equipment is available from specialized companies, either by customizing an existing launching gantry or by building one that is specially designed for the work site. In the latter case, the investment will be easily amortized given the scope of the deconstruction of the Champlain Bridge.

4.3.4.3.4 Technical risks

The main risks are:

- Self-propelled modular trailers (SPMT) travelling over a damaged deck: the SPMT will travel in the centre, over internal girders P3 and P5, which are in better condition than the edge girders and the central girder.
- Snagging the external girder pretensioning during handling operations: specific procedures must be drawn up and physical mitigation measures included.
- Slower pace and decrease in load capacity when winds exceed about 45 km/h and when temperatures are below -10°C.
- Stopping when winds exceed about 70 km/h, temperatures are below -20°C, and when other unfavourable climatic conditions such as heavy snowfall or storm cells are forecast.
- Stopping work in accordance with the limitations and restrictions of the critical lift plan based on the complexity of the type of lifting involved.

4.3.4.3.5 Health and safety

Table 33 presents the main health and safety risks for the methods discussed in this section.

Table 33 – Health and safety – Unlaunching

ACTIVITIES	RISKS	EFFECTS
Moving equipment, parts and tools	• Collision • Being hit • Entrapment • Projection • Falling objects • Falling loads	• Abrasions/scrapes/bruises Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death
Work over water	• Person overboard • Collapse	• Hypothermia • Drowning • Crushing • Multiple injuries and death
Hoisting operations	• Falling objects • Entrapment • Being hit • Projection • Falling loads • Collapse	• Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death

4.3.4.4 Removal by crane

The use of cranes to remove from one to three girders at a time is a technique suited to the Champlain Bridge. The number of girders that can be simultaneously removed will naturally depend on the capacity of the cranes and their availability. The cranes can be installed on barges, and other barges can go up the river to take the girders to an off-site location or to the available mobilization areas. The deconstruction of the girders at the available mobilization areas should adapt well to the time required for the crane-based dismantling operations, enabling efficient planning. There is no specific requirement to work in a particular sequence. The contractor can make optimal use of its own resources and work on several concrete spans at a time.

4.3.4.4.1 Deconstruction sequence – Deconstruction and removal by crane options – Concrete deck

Note: The sequence that is presented corresponds to the removal of the girders one by one. The principle is the same for the removal of groups of girders.

1. Set up the slab support system: sections or other means (see concept in Figure 71). This support system must be installed from the start over the entire width of the slab. Once the first strips have been installed, the contractor can either install the supports over the entire length of the span, or install them as the sawing progresses, always placing the supports over the entire width of the slab. Otherwise, because of the structural system, the connection between the slab segments and the girder will not be guaranteed.
2. Set up anti-lift mechanisms for the modular truss supports, at the edge of the pier cap opposite to the span being removed (these mechanisms can be reused for all the modular trusses as the work progresses.
3. Remove slab strengthening (passive and active supports) and external prestressing of diaphragms. It is expected that the active strengthening and external prestressing can be slackened ; otherwise, the tendons will have to be cut.
4. Option 1:
    c. Release all the prestressing tendons of the slab between two diaphragms.
    d. Cut the tendons with a torch: the heat will progressively slacken the tendons.
5. Option 2:
    a. Protect the edge of the slab with a metal plate or equivalent system in order to hold the lateral prestressing slab anchors that may be ejected and injure either workers or river users.

6. Saw the slab between the girders, in the middle.
7. Girder strengthening:
    a. Modular trusses: leave the modular trusses in place and remove them immediately after removing the girder with the cranes.
    b. EPT: leave in place and haul the girder away with the EPT.
    c. QP1: cut the bars with a torch and remove before releasing the girder.
    d. QP2: leave in place and haul the girder away with the QP2.
8. Stabilize the girder that will be removed using a temporary mechanism that will connect the diaphragm to the pier cap (this mechanism can be reused for all the girders).
9. Saw the diaphragm, including the internal prestressing tendons.
10. Using cranes on land, a jetty or a barge, lift the girder or group of girders and the associated portion of the slab and place them on a barge or self-propelled modular trailer (on the ground or the jetty).
11. Pay special attention to the last girder: its stability must be ensured to avoid having it tip over ; the temporary mechanism used for step 8 will likely be adequate.
12. Access from the ground (areas 5-1 and 7-2), from a jetty (area 5-2) and by barge (areas 5-3 and 7-1).

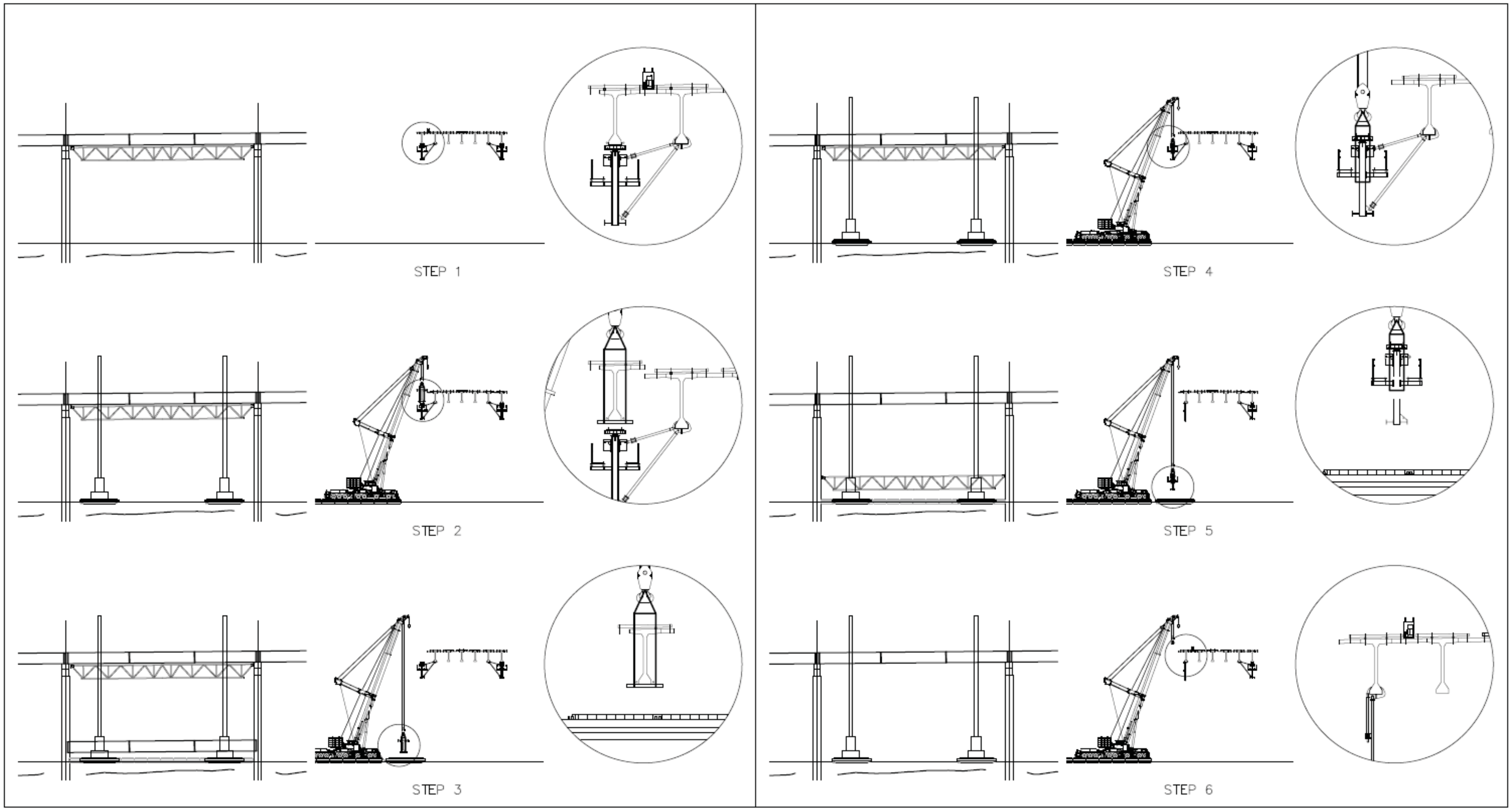


Figure 76 – Removal by crane

4.3.4.4.2 Summary evaluation – Concrete reinforced girder

Same principle as for the launching gantry ; see 4.3.4.3.2.

4.3.4.4.3 Deconstruction sequence – Pier shafts, pier caps and footings – River area and Seaway dike

1. Remove pier cap prestressing.
    a. The external prestressing can be slackened or cut with a torch.
    b. Internal prestressing: it will be sawed, as with the girders (this applies to the piers in sections 5 and 7 as well as section 6: 2W and 2E).
2. Saw the pier cap either at the juncture with the pier shaft or in several pieces (cantilever portion, then at the juncture with the pier shaft, for instance). This option requires temporary supports for the parts of the cantilever pier cap.
3. For the section 6 piers with a steel lining from top to bottom (1W and 1E), the lining will be sawed at the same time as the concrete.
4. Take the pieces and place them on a barge or a transport vehicle using cranes.
5. Saw the non-submerged part of the pier shaft in layers of a weight that is compatible with the capacity of the crane.
6. Take the pieces and place them on a barge or a transport vehicle using cranes.
7. Remove or saw the pier shaft steel lining: if the steel lining is sealed, it must be sawed (section 6, for instance).
8. Saw the pier shafts in layers: the sawing is done by divers protected from the current by deflectors.
9. Haul the pieces away using cranes.
10. Saw the footing in layers down to the riverbed: the sawing is done by divers protected from the current by deflectors.
    a. For the footings under the temporary jetty, either plan from the outset to use cofferdams or another system around the footings to remove them from the jetty or remove the jetty as the footings are deconstructed.
11. Haul away the entire footing above the riverbed using cranes.

Access by barge (areas 5-3 and 7-1).

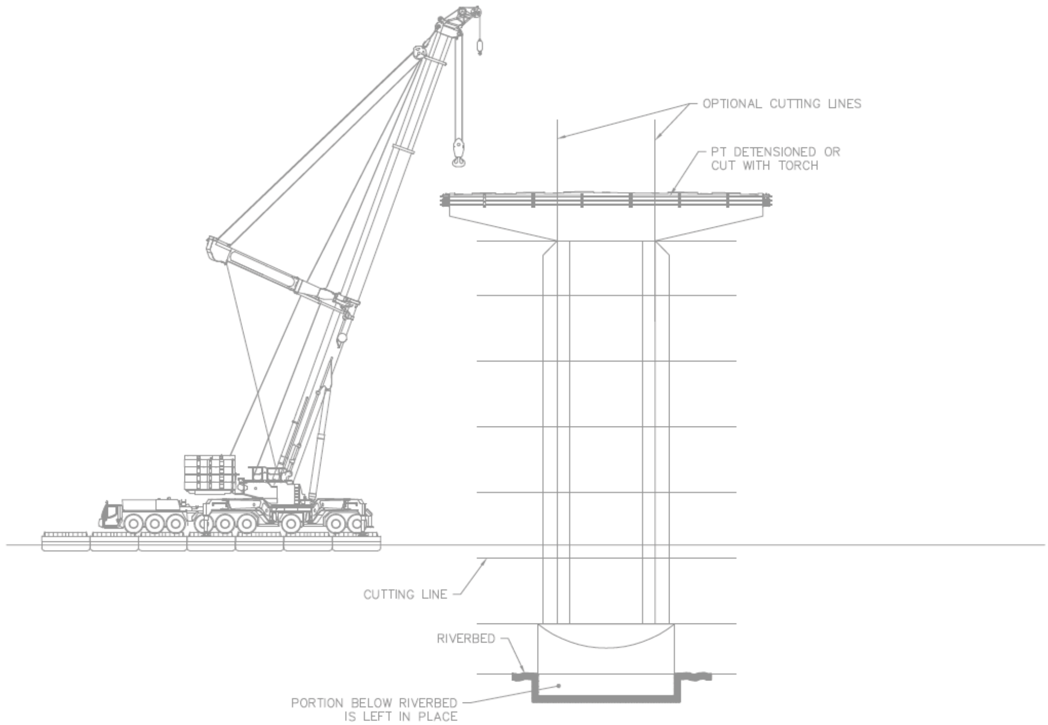


Figure 77 – Piers – Section 5 – Sawing

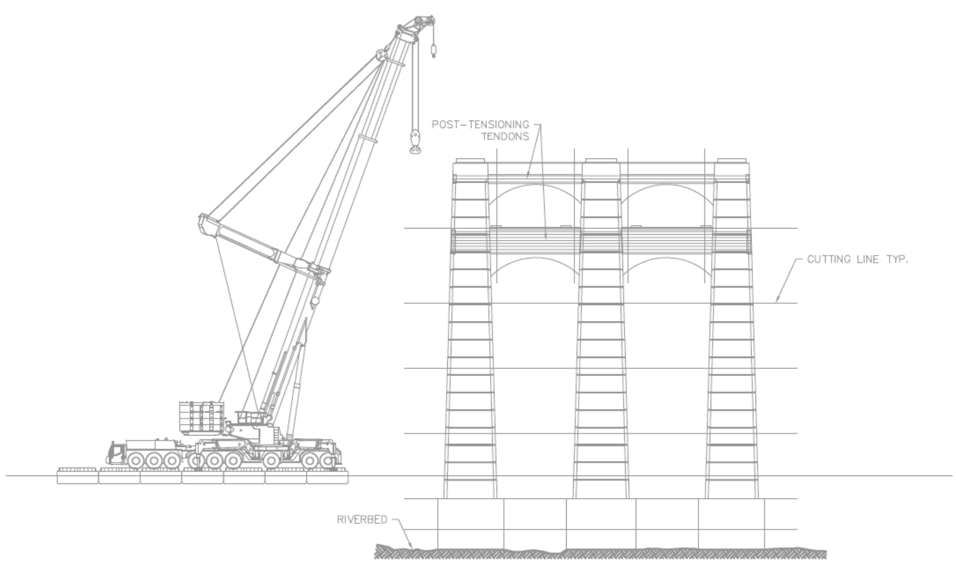


Figure 78 – Piers – Section 6 – Sawing

4.3.4.4.4 Required mobilization area and equipment

The cranes needed to lift the girders and the pier caps are not standard cranes. They must have a capacity of 500 to 1,000 t, depending on the options that are chosen. This equipment is not particularly difficult to obtain, although it does require the use of companies specialized in heavy lifting, such as [redacted]

The available mobilization areas are compatible with this method ; the Seaway dike and the South Shore have enough space to store the pier caps, pier shafts and foundation components. In addition, if parts are hauled away directly by barge to an off-site area, there is even less of a space problem.

4.3.4.4.5 Technical risks

The main risks are:

- Snagging the external girder pretensioning during handling operations: specific procedures must be drawn up and physical mitigation measures included.
- Two-crane lift: more complex operations, greater coordination required.
- Crane use disrupted by climatic conditions, in particular wind and waves. These limitations will be all the more easily attained with high-capacity cranes.
- Slower pace and decrease in load capacity when temperatures are below -5 °C.
- Stopping when winds exceed about 30 km/h, temperatures are below -15 °C, and when other unfavourable climatic conditions such as heavy snowfall or storm cells are forecast.

4.3.4.4.6 Health and safety

Table 34 presents the main health and safety risks for the methods discussed in this section.

Table 34 – Santé et sécurité –Dépose à la grue

ACTIVITIES	RISKS	EFFECTS
Moving equipment, parts and tools	• Collision • Being hit • Entrapment • Projection • Falling objects • Falling loads	• Abrasions/scrapes/bruises Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death
Critical lift plan – two-crane lift (joint activity)	• Collision • Being hit • Falling loads • Collapse	• Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing • Multiple injuries, death
Sawing operation	• Projection • Contact with hazardous objects (e.g., sharp or pointed shapes) • Noise • Silica dust, asbestos dust, etc.	• Abrasions/scrapes/bruises • Contusions • Cuts/lacerations/amputation • Decreased hearing acuity • Loss of balance • Hearing loss
Hoisting operations	• Falling objects • Entrapment • Being hit • Projection • Falling loads • Collapse	• Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death

ACTIVITIES	RISKS	EFFECTS
Work at height	• Fall into the water or from a higher level • Falling objects • Fall from a height • Fall	• Sprains/strains/fractures • Contusions/bruises Hypothermia • Drowning • Multiple injuries, death
Work over water	• Person overboard • Collapse	• Hypothermia • Drowning • Crushing • Multiple injuries and death
Work under water	• Oxygen deficiency • Carried off by current • Entrapment under objects or between obstacles • Sawing under water (see sawing operation above)	• Respiratory problems • Headaches • Hypothermia • Drowning • Multiple injuries, death

4.3.4.5 Explosives

Explosives are suited to the Champlain Bridge, despite the proximity of the new bridge. The deconstruction is highly controlled, and it is possible to deconstruct very close components, as is virtually always the case for explosion demolitions of buildings in urban areas.

For the steel spans, the main inconvenience is the proximity of the Seaway and the need to quickly remove all debris from the Seaway when work is carried out during the navigating season. Work during the winter, when the Seaway is closed, is likely a better option.

Footings can be broken up using explosives, after which excavators can be used to remove the components. This method is feasible for the footings outside of the water as well as footings in the water by placing excavators on the shore, on a temporary jetty or on barges.

This method of bridge footing deconstruction has recently been used for bridges of a similar size as the Champlain Bridge. Explosives were used for seven footings during the deconstruction of the Port Mann Bridge in BC in 2014, and for the deconstruction of the Bay Bridge foundations in San Francisco, California, in 2015. In both cases, the foundations deconstructed with explosives were in water and near a new bridge. After the explosion, the components could be removed with excavators.

Mitigation measures for the protection of fish are required. The identified measures consist of:

- Cofferdams around the footings: by pumping water into the cofferdam, the shockwave from the explosion is no longer directly transmitted to the water around the cofferdam.
- A bubble curtain, used to dampen the shockwave transmitted into the water.
- Use of scare charges to scare off fish in the affected area.

A combination of the last two measures was used for the two examples mentioned here. The bubble curtain method has been successfully used in slow-moving waters, but its use in a strong current has not been verified. For the St. Lawrence River, where currents can reach about 5 knots, the effectiveness of this method will have to be verified. Based on information obtained from people with experience using this method, it should be possible to customize the method for such a current.

The advantage of this deconstruction method is that it minimizes the work time in the water compared with other possible methods.

At the meeting with the Department of Fisheries and Oceans held on September 29, 2016 (see minutes in Appendix 4), the DFO representative expressed reluctance to use this method for the deconstruction of the deck:

Controlled explosion deconstruction

DFO will not authorize the use of this method for the deck. The reason is that there are other deconstruction methods that can be logically considered and that are much less harmful to fish.

For the piers, PTA mentions that this method was used in 2014 for the deconstruction of the former Port Mann Bridge in Vancouver by using small blasts to scare off fish and bubble curtains to dampen shockwaves. According to DFO, at the time of the explosion, a maximum pressure of 100 kPa is authorized. Air is the best interface, which requires the use of cofferdams. The use of explosives may be authorized for the piers, but the request will be carefully reviewed and must be properly substantiated in order to be considered by DFO.

4.3.4.5.1 Deconstruction sequence – Deck, pier shafts, pier caps, footings

1. Strengthening
   a. Modular trusses: remove modular trusses if they are to be recovered.
2. Set up the charges in accordance with a carefully designed blasting plan.
3. Potentially set up containment mechanisms and other means of environmental protection.
4. Proceed to detonate the charges.
5. Collect the debris using excavators.
6. Place debris on barges or trucks.

4.3.4.5.2 Required mobilization area and equipment

The mobilization areas are sufficient ; they will be used to store the excavators and debris. The required equipment will consist of means of access (such as aerial platforms to access the girders from the deck and barges for the piers) and corers to set up the explosives. Excavators will then be needed to pick up the debris.

4.3.4.5.3 Technical risks

The main risk is:

- Proximity to the new Champlain Bridge: periodic closures during blasting work.

4.3.4.5.4 Health and safety

Table 35 presents the main health and safety risks for the methods discussed in this section.

Table 35 – Health and safety –Explosives

ACTIVITIES	RISKS	EFFECTS
Blasting work	• Noise • Projection • Being hit • Dust: dust composition must be known and the presence of any hazardous materials such as asbestos must be confirmed • Fire/explosion • Exposure to hazardous materials	• Discomfort • Headaches • Hearing loss • Abrasions/scrapes/bruises • Crushing/fractures • Multiple injuries, death • Burns • Health damage • Poisoning, irritation • Respiratory problems • Cancer

4.3.4.6 Removal of full span

Removal of a full concrete span requires high-capacity equipment, given the weight involved. Although it is possible to bring in the required equipment, it is proposed that the in-depth study of this technique not be pursued, but that its use not be prohibited if a contractor would like to use it.

The main obstacle in applying the method is the substantial size of the parts being moved. In fact, a complete span is 24.08 m wide and 53.75 m long. The span needs to be either brought close to the bridge (site of Seaway dike, for instance, although the little space available does not appear to be suited to the pace of either removal or deconstruction) or hauled away over the river. The main problem is the crossing of various locks, which are not wide enough to accommodate such large pieces. One solution could be to install the span high enough over the barge to pass through the locks while remaining above their banks.

4.3.4.7 Reverse Erection

The bridge was constructed using temporary supports with lightweight derrick cranes operating along the deck of the partially built structure. The reverse erection method reverses this sequence. Using derrick cranes is less common in bridge construction and dismantling, but is still an option that is sometimes used. Larger equipment will likely be limited for portions of the structure that are not supported by temporary supports (cantilever and suspended spans of the bridge main span). The contractor may choose to retrofit the bridge to allow for larger equipment in the cantilever and suspended spans or choose a different method of removal for this area.

4.3.4.7.1 Approach spans

For the approach spans, reverse erection would substantially consist of:

1. Install temporary supports under the approach span(s). Engage towers to support the span.
2. Retrofit the ends of adjacent spans together by attaching the top and bottom chords at their common pier support resulting in a continuous two span structure.
3. Adjust temporary support load to engage the connection between the adjacent spans.
4. Dismantle the approach span truss and deck utilizing a piece-by-piece sequence moving from one end of the span to the other.

The contractor may choose to locate equipment on the bridge deck or at grade to complete the piece-by-piece removal operation. The size and capacity of temporary supports can be adjusted to accommodate equipment of varying size operating on the bridge deck.

4.3.4.7.2 Main span

For the main span, reverse erection can be done for some or all of this part of the bridge. Including the suspended span in this method adds the complication of engaging the suspended span allowing it to cantilever out to the bridge midspan. If the suspended span is removed using a different method, the removal of the cantilever and anchor spans can still follow the reverse erection method. The reverse erection method for the entire main span is presented here and would substantially consist of:

1. Install temporary supports under the anchor spans. Engage required support towers to support both anchor spans. It is likely that only one temporary support is required for this stage of removal.
2. Remove the steel orthotropic deck along the full length of the structure.
3. Engage the suspended span structure by jacking at the ends of the cantilever portion of the main span. Jacking at the ends of the suspended span relieves the stress in the truss members at midspan.
4. Cut the bridge at midspan to form two independent cantilever structures on the east and west halves of the bridge.
5. Dismantle the truss piece by piece working from midspan back to the anchor span of the main span structure. Temporary supports will likely require adjustment as the bridge is dismantled.

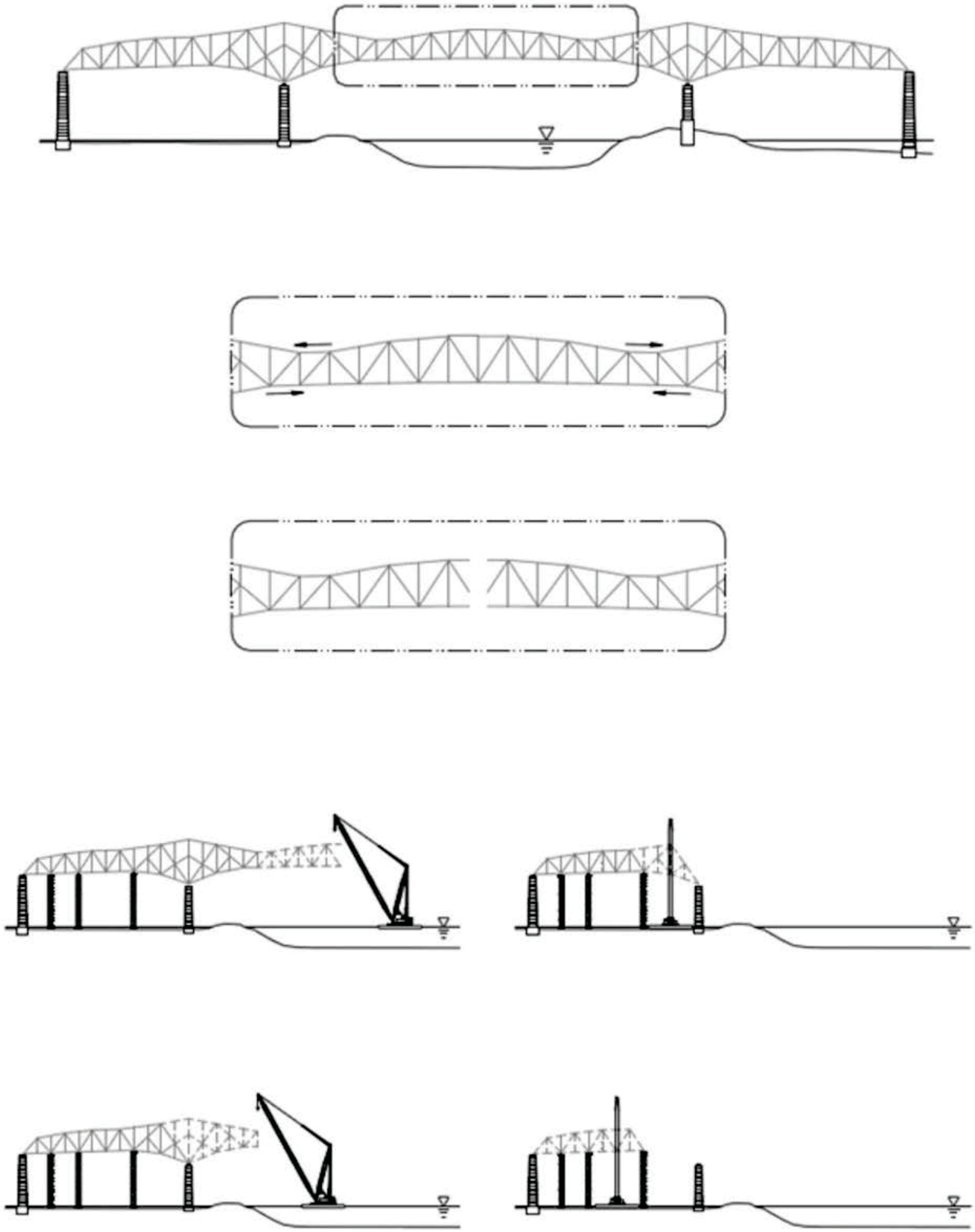


Figure 79 – Section 6 – Reverse Erection – Main Span

4.3.4.7.3 Required mobilization area and equipment

The reverse erection method provides the option of completing the removal operation from the bridge deck or from land/water below. Access below the main span varies and includes shallow water, the active Saint Lawrence Seaway channel, and land-to-water transitions. Thus, if reverse erection is completed from below the structure, the use of a temporary jetty, low draft barges, barge mounted cranes, or other means would be required. Bridge sections can be processed onsite or transported via barge or truck to offsite facilities.

The available mobilization areas are compatible with this method ; like the South Shore, the Seaway dike has enough space to store the metal parts. In addition, if parts are hauled away directly by barge to an off-site area, there is even less of a space problem.

4.3.4.7.4 Technical risks

The main risks are:

- Delays that cause the Seaway to be reopened later than anticipated.
- The unknown impact of operations taking place over the Seaway for extended periods of time.
- The limited capacity of the structure to support adequately sized equipment for dismantling operations.

4.3.4.7.5 Health and safety

Table 36 presents the main health and safety risks for the methods discussed in this section.

Table 36 – Health and safety – Reverse erection

ACTIVITIES	RISKS	EFFECTS
Work at height	• Fall into the water or from a higher level • Falling objects • Fall from a height • Fall	• Sprains/strains/fractures • Contusions/bruises Hypothermia • Drowning • Multiple injuries, death
Work over water	• Person overboard • Collapse	• Hypothermia • Drowning • Crushing • Multiple injuries and death
Work under water	• Oxygen deficiency • Carried off by current • Entrapment under objects or between obstacles	• Respiratory problems • Headaches • Hypothermia • Drowning • Multiple injuries, death
Operation of deconstruction equipment	• Projection • Being hit • Entrapment • Crushing • Falling objects or parts • Dust	• Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death • Health damage • Poisoning, irritation • Respiratory problems • Cancer

4.3.4.8 Balanced Cantilever and Span Cable Stays

Balanced cantilever and the use of span cable stays provide alternatives for the reverse erection method. They both provide options to reduce the number of required temporary supports. While the balanced cantilever option is a reasonable approach, it is unlikely that a cable stay option would be considered unless there are extreme limitations for the installation of temporary supports in the anchor span. All of the equipment, work zone and risks from Section 4.3.4.7 apply to this section.

4.3.4.9 Strand Jack Lowering

Strand jack lowering allows for the removal of large bridge sections. While the preparation for span removal can be quite involved, the actual removal operation can be completed rather quickly. Some locations are more suitable for this type of removal than others.

4.3.4.9.1 Approach Spans

For the approach spans, strand jack lowering can be used for the full span (all four trusses) or for two adjacent trusses. This operation would substantially consist of:

1. Retrofit the ends of the approach spans to allow the span to fit between the existing piers.
2. Install lowering components including stand jacks on the existing piers and retrofit piers if necessary.
3. Attach strand jack anchors to the approach span and engage the strand jacks.
4. Cut the approach span free from its supports and lower to barge or grade below.
5. Transport the span offsite for dismantling or dismantle at grade below.

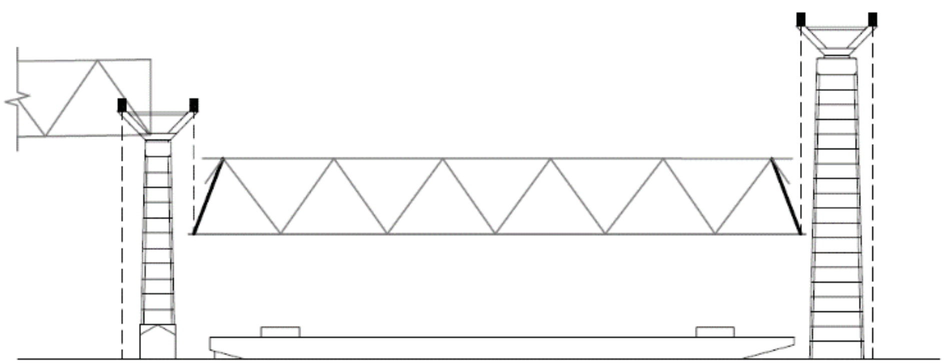


Figure 80 – Section 6 – Strand Jack Lowering – Approach Spans

4.3.4.9.2 Main Span

The sequence for lowering the anchor spans with strand jacks is generally similar to the approach span lowering sequence. The ability of the anchor span to be lowered as a single unit is limited by its structural capacity. As such, using this option will require the removal of the steel orthotropic deck and/or the retrofit of highly stressed bridge members. Sequentially, the prior removal of the suspended span and the cantilever portion of the main span structure will be required.

4.3.4.9.3 Suspended Span

The main span of the bridge was constructed in such a way that lowering the suspended span with strand jacks should be achievable with limited retrofit to the structure. For the suspended span, strand jack lowering would substantially consist of:

1. Remove the steel orthotropic deck in the anchor span or along the full length of the structure.
2. Install temporary supports under the anchor spans.
3. Install lowering components including strand jacks at the ends of the cantilever structure.
4. Attach strand jack anchorages to the suspended span and engage the strand jacks.
5. Cut the suspended span free from the cantilever structure and lower to barge below.
6. Transport span to processing area for dismantling.

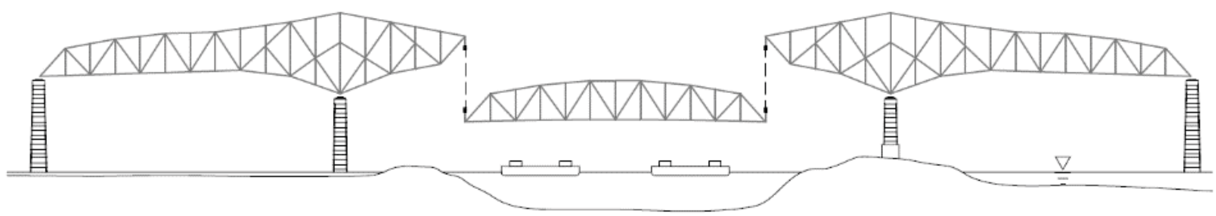


Figure 81 – Section 6 – Strand Jack Lowering – Suspended Span

4.3.4.9.4 Required mobilization area and equipment

As discussed previously, access below the main span varies and includes shallow water, the active Saint Lawrence Seaway channel, and land-to-water transitions. Thus, span lowering using strand jacks will require various work areas. For the approach spans and anchor spans, barges or jetties will likely be used to provide a uniform landing area for each lowered truss. The suspended span will require barges positioned in the Seaway. The size of the suspended span will likely limit the distance it can be transported in the Seaway. Dismantling of the suspended span will likely need to be completed in the basin adjacent to the Seaway or a processing site on land nearby. This will also be the case for the anchor spans and approach spans east of the Seaway if they are removed in full span sections,

The available mobilization areas are compatible with this method ; like the South Shore, the Seaway dike has enough space to store the metal parts. In addition, if parts are hauled away directly by barge to an off-site area, there is even less of a space problem.

4.3.4.9.5 Technical risks

The main risks are:

- Delays that cause the Seaway to be reopened later than anticipated.
- The unknown impact of operations requiring the full closure of the Seaway for short durations.
- The limited size of the Seaway to allow for the transport of the large truss sections and the limited number of nearby locations for dismantling of large truss sections.

4.3.4.9.6 Health and safety

Table 37 presents the main health and safety risks for the methods discussed in this section.

Table 37 – Health and safety – Strand jack lowering

ACTIVITIES	RISKS	EFFECTS
Work at height	• Fall into the water or from a higher level • Falling objects • Fall from a height • Fall	• Sprains/strains/fractures • Contusions/bruises Hypothermia • Drowning • Multiple injuries, death
Work over water	• Person overboard • Collapse	• Hypothermia • Drowning • Crushing • Multiple injuries and death
Hoisting operations (cranes and winches)	• Falling objects • Entrapment • Being hit • Projection • Falling loads • Collapse	• • Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death

4.3.4.10 Lifting the Trusses off Bearings

Similar to using strand jacks to lower spans, the lifting of trusses in complete sections off their bearing also allows for the removal of large bridge sections. While there may be some merit in considering this method for different sections of the main span, it is most likely used for the approach span trusses.

4.3.4.10.1Whole Span

Lifting an entire approach span truss would substantially consist of:

1. Position barge fit with modular jacking towers under approach span.
2. Jack modular jacking towers to engage the approach span.
3. Cut the approach span free at the bearings and lift span.
4. Move span on barge free of the supporting piers.
5. Lower the truss to the level of the barges by jacking the modular jacking towers down.
6. Transport the span offsite for dismantling.

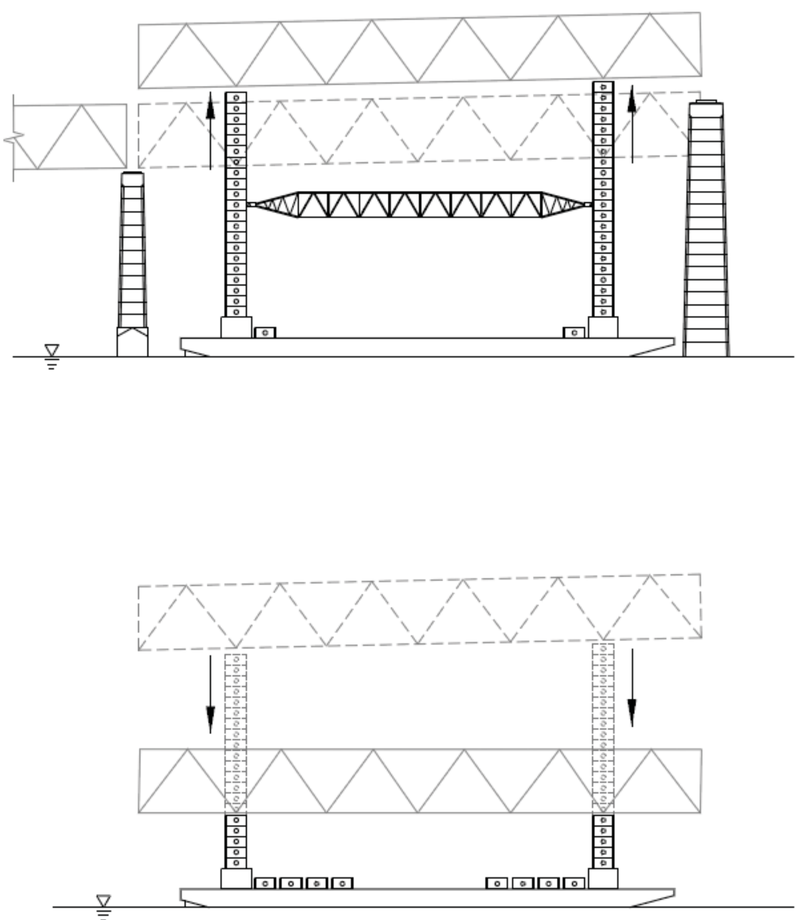


Figure 82 – Section 6 – Lifting the trusses off bearings – Whole span

As it was the case for the concrete spans, this solution is not considered mainly due to handling constraints. The approach spans are longer than the concrete spans, their length is 78 m and 78.5 m.

4.3.4.10.2Trusses

This operation will include the use of a marine crane operating on the water or a land crane operating on a jetty. Depending on the size of crane used, either individual trusses or truss pairs can be lifted at a time. The lifting of truss pairs is generally more structurally stable, but requires a larger crane and more complex rigging. The removal of a full span by lifting individual approach span trusses is presented here and would substantially consist of:

1. Remove the steel orthotropic deck off approach span.
2. Rig to the first truss with the primary crane.
3. Separate the first truss from the adjacent truss and remove the first truss with the primary crane.
4. Repeat steps 2 and 3 for the second truss.
5. Use hold crane or other means to temporarily support the fourth truss.
6. Repeat steps 2 and 3 for the third truss.
7. Rig primary crane to the fourth truss.
8. Release the hold crane and remove the fourth truss with the primary crane.

4.3.4.10.3 Required mobilization area and equipment

The approach spans are located over a shallow water area in the basin and in the Saint Lawrence River. It seems reasonable that a barge supported operation could be used for the proposed full span removal using modular jacking towers. For removal of individual truss spans, there is limited access for the two cranes required to remove the final two individual truss spans. The contractor will need to consider the location of the new bridge relative to the existing bridge for crane placement.

4.3.4.10.4 Technical risks

The main risks are:

- The limited size of the Seaway to allow for the transport of the large truss sections and the limited number of nearby locations for dismantling of large truss sections.
- The location of the new bridge adjacent to the current bridge may make it difficult to position the two cranes required to remove the final two individual truss spans.
- The limited water depth under the east and west approach spans may require some adjustments to the proposed operation.

4.3.4.10.5Health and safety

Table 38 presents the main health and safety risks for the methods discussed in this section.

Table 38 – Health and safety – Lifting the trusses off bearings

ACTIVITIES	RISKS	EFFECTS
Work at height	• Fall into the water or from a higher level • Falling objects • Fall from a height • Fall	• Sprains/strains/fractures • Contusions/bruises Hypothermia • Drowning • Multiple injuries, death
Work over water	• Person overboard • Collapse	• Hypothermia • Drowning • Crushing • Multiple injuries and death
Hoisting operations (cranes and winches)	• Falling objects • Entrapment • Being hit • Projection • Falling loads • Collapse	• Abrasions/scrapes/bruises • Sprains/strains/fractures • Contusions/crushing/amputation • Multiple injuries, death

4.3.4.11 Summary

Table 39 summarizes the methods retained.

Table 39 – Selection of methods

METHOD	RETAINED / NOT RETAINED	CRITERIA FOR USE / REASON FOR EXCLUSION
Standard methods:		
• **Hydraulic hammer**	**Retained for:** • Concrete deck • Pier caps and pier shafts • Footings	Height up to about 15 m to limit dust problems and to use relatively standard equipment
• **Concrete crusher with shear jaws**		Height up to about 15 m to limit dust problems and to use relatively standard equipment
• **Sawing and cutting**		Suited to the piers and the sawing of the slab and diaphragms
• Hydrodemolition	Not retained	Not effective for large volumes ; used mainly for localized deconstructions
• Splitting		Not effective for large surfaces ; only for occasional work
• Demolition wrecking ball and crane		Not efficient for this project due to a lack of accuracy
• Thermal cutting and drilling		Not effective for large surfaces ; only for occasional work
Unlaunching:		
• Standard launching gantry	**Retained for:** • Concrete deck	
• Lateral launching gantry	Not retained	Cumbersome logistics and of little interest compared to removal by crane
Removal by crane	**Retained for:** • Concrete and steel deck • Pier caps and pier shafts • Footings	Retained for the Champlain Bridge only if access by water or jetty is required
Explosives	**Retained for:** • Pier caps and pier shafts • Footings Not retained for: • Concrete deck • Approach spans (4W-2W, 2E-4E) • Anchor spans (2W-0.5W, 0.5E-2E) • Suspended span (0.5W-0.5E)	If there is a reasonable alternative, which is the case here, this method is not acceptable to DFO for components other footings Environmental constraints based on the Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters Risk of temporarily blocking the Seaway for longer than anticipated
Removal of full span	Not retained for the remainder of the study.	High risk for transporting large pieces Width exceeds that of the locks Transportation difficult
Reverse erection	**Retained for:** • Approach spans (4W-2W, 2E-4E) • Anchor spans (2W-0.5W, 0.5E-2E) • Suspended span (0.5W-0.5E)	Temporary bents in the water required for approach spans and anchor spans
Strand Jack Lowering	**Retained for:** • Approach spans (4W-2W, 2E-4E) • Suspended span (0.5W-0.5E)	Strengthening required to make modifications to the structure and allow hoisting Negotiation of closure of Seaway for a short period or work in the winter for the suspended span
Lift trusses off bearings – whole span	Not retained for the remainder of the study.	Problem maintaining the stability of existing parts during the hoisting of the cantilever portion of the anchor spans Uses high-capacity cranes

METHOD	RETAINED / NOT RETAINED	CRITERIA FOR USE / REASON FOR EXCLUSION
Balanced cantilever dismantling	Retained for: • Anchor spans (2W-0.5W, 0.5E-2E)	Technically unsuited for approach spans since they are simple spans
Span cable stays	Not retained for the remainder of the study.	Probably more costly and complex than temporary bents Presents an advantage if there are additional constraints (e.g., environmental, navigation) that limit or prohibit the installation of temporary bents in the water

4.3.5 PROPOSED SCENARIOS

Based on the preceding analyses, the most appropriate methods were retained for each section of the Champlain Bridge. The deconstruction of the deck and foundations for each area is presented in the following paragraphs.

4.3.5.1 Deck– Concrete spans

4.3.5.1.1 Scenario T1

This scenario mainly consists of two methods: standard deconstruction and removal by crane. When all optimal conditions for the standard method are present, then it is used. When conditions are more difficult, removal by crane is used.

Table 40 summarizes the methods retained for each area.

Table 40 – Scenario T1

AREA	DECK METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
5-1	Standard	By land	Truck	Nuns' Island site
5-2	Removal by crane	By jetty/ floating workbridge	Trucks or barges	Jetty
5-3	Removal by crane	By barge	Barges	Seaway dike or offsite (transport directly by barge)
7-1	Removal by crane	By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-2	Standard	By land	Trucks	Brossard site

4.3.5.1.2 Scenario T2

Scenario T2 consists of using a standard launching gantry to remove the concrete girders. This technique can be used for all the concrete girders. However, the first span (44W-43W) on the Nuns' Island side will probably be deconstructed with the standard method simply due to the pillars under the girders. This will probably be easier.

Table 41 – Scenario T2

AREA	DECK METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
5-1	Unlaunching	By the deck	Self-propelled modular trailer (SPMT)	Brossard site or Seaway dike site
5-2				
5-3				
7-1				
7-2				

4.3.5.2 Deck – Steel Spans

4.3.5.2.1 Scenario TA1

This scenario is a combination of several methods. Table 42 summarizes the methods retained for each area.

Table 42 – Scenario TA1

AREA	DECK METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
6-1	Lifting of trusses in pairs	By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-2	Reverse erection with balanced cantilever	Using a temporary support	Barges	Seaway dike or offsite (transport directly by barge)
6-3	Strand jack lowering	By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-4	Reverse erection with balanced cantilever	Using a temporary support	Barges	Brossard site or offsite (transport directly by barge)
6-5	Lifting of trusses in pairs	By barge	Barges	Brossard site or offsite (transport directly by barge)

4.3.5.2.2 Scenario TA2

This scenario consists of deconstructing the bridge using reverse erection. Table 43 summarizes the methods retained for each area.

Table 43 – Scenario TA2

AREA	DECK METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
6-1	Reverse erection	Temporary supports (equipment on structure)	Barges	Seaway dike or offsite (transport directly by barge)
6-2		Temporary supports (equipment on structure)	Barges	Seaway dike or offsite (transport directly by barge)
6-3		Temporary supports (equipment on structure)	Barges	Seaway dike or offsite (transport directly by barge)
6-4		Light equipment on structure	Barges	Brossard site or offsite (transport directly by barge)
6-5		Temporary supports (equipment on structure)	Barges	Brossard site or offsite (transport directly by barge)

4.3.5.3 Pier caps and pier shafts

4.3.5.3.1 Scenario F1

This scenario mainly consists of two methods: standard deconstruction and sawing. When all optimal conditions for the standard method are present, then it is used. When conditions are more difficult, sawing is preferred.

Table 44 summarizes the methods retained for each area.

Table 44 – Scenario F1

AREA	PIER CAP AND PIER SHAFT METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
5-1	Standard	By land	Truck	Nuns' Island site
5-2		By jetty/ floating workbridge	Trucks or barges	Jetty
5-3	Sawing	By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-1/6-2		By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-4/6-5		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-1		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-2	Standard	By land	Trucks	Brossard site

4.3.5.3.2 Scenario F2

Scenario F2 consists of using the standard method to deconstruct the pier caps and pier shafts accessible from land (areas 5-1 and 7-1) and explosives for all the others.

Table 45 summarizes the methods retained for each area.

Table 45 – Scenario F2

AREA	FOOTING METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
5-1	Standard	By land	Truck	Nuns' Island site
5-2		By jetty/ floating workbridge	Trucks or barges	Jetty
5-3	Explosives	By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-1/6-2		By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-4/6-5		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-1		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-2	Standard	By land	Trucks	Brossard site

4.3.5.4 Footings

4.3.5.4.1 Scenario S1

This scenario mainly consists of two methods: standard deconstruction and sawing. When all optimal conditions for the standard method are present, then it is used. When conditions are more difficult, sawing is preferred.

Table 46 summarizes the methods retained for each area.

Table 46 – Scenario S1

AREA	FOOTING METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
5-1	Standard	By land	Truck	Nuns' Island site
5-2		By jetty/ floating workbridge	Trucks or barges	Jetty
5-3	Sawing	By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-1/6-2		By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-4/6-5		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-1		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-2	Standard	By land	Trucks	Brossard site

4.3.5.4.2 Scenario S2

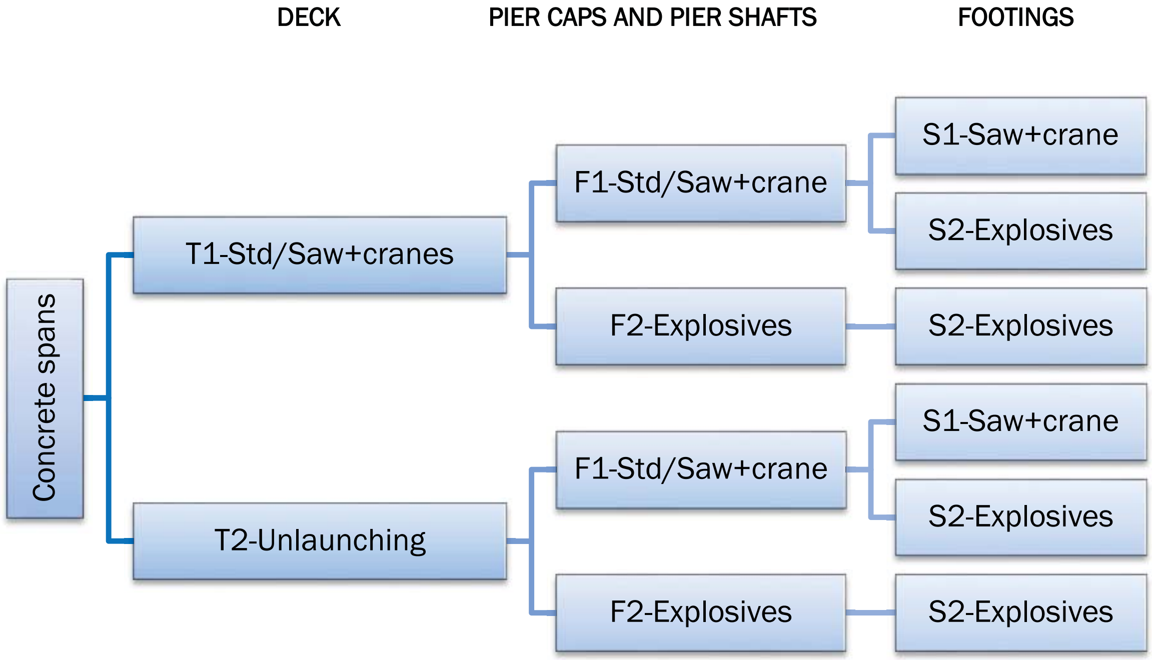
Scenario S2 consists of using the standard method to deconstruct the footings accessible from land (areas 5-1 and 7-1) and explosives for all the others.

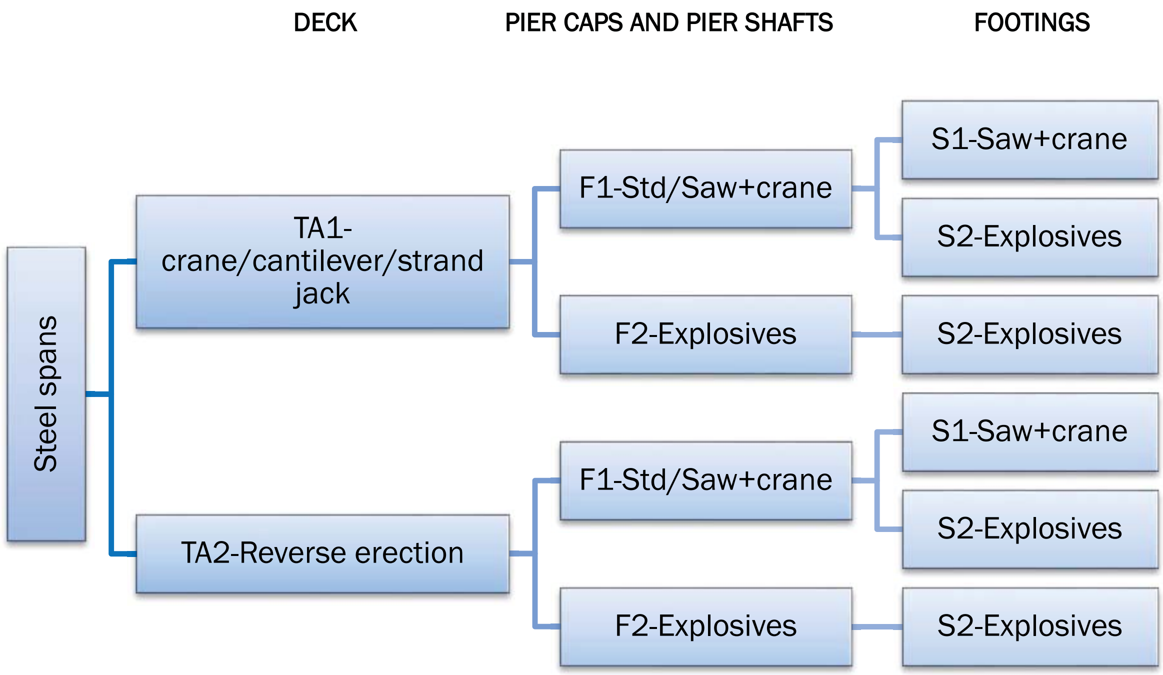
Table 47 summarizes the methods retained for each area.

Table 47 – Scenario S2

AREA	FOOTING METHOD	ACCESS	TYPE OF TRANSPORT	MOBILIZATION AREA
5-1	Standard	By land	Truck	Nuns' Island site
5-2		By jetty/ floating workbridge	Trucks or barges	Jetty
5-3	Explosives	By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-1/6-2		By barge	Barges	Seaway dike or offsite (transport directly by barge)
6-4/6-5		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-1		By barge/jetty/ floating workbridge	Trucks or barges	Brossard site or offsite (transport directly by barge)
7-2	Standard	By land	Trucks	Brossard site

4.3.5.5 Summary of scenarios





4.3.6 POINTS TO CONSIDER

4.3.6.1 Design criteria and engineering

When drawing up terms of reference for the deconstruction of the bridge structure, structural design criteria must be defined to avoid interpretations that significantly diverge from codes and standards. Design codes such as CAN/CSA–S6 basically cover the design of a new structure or the evaluation of an existing structure. With a limited duration of work compared to the lifespan of a new structure (75 years for CAN/CSA-S6), it is reasonable to assume that the weighting factors, as well as the combined actions to be taken into account, are not suited to deconstruction and must therefore be defined in a framework JCCBI considers acceptable.

In the following paragraphs, an initial analysis is proposed for the main actions to be taken. The analysis will naturally have to be refined as the future studies are completed, and will gain in accuracy as the studies get closer to the execution of the work.

The loads resulting from the equipment that is used and the live construction loads will then be known, since by defining its methods, the contractor will have chosen its equipment. The equipment can be grouped into two main categories:

- “Regular” equipment usually present at work sites, such as trucks, small material-handling equipment, etc.
- Equipment that is special, or specific to certain operations, such as high-capacity cranes, a launch beam or SPMT.

Unlike the regular equipment, the characteristics of special equipment will be precisely known in terms of dimension, weight and position. Their use will also be governed by detailed procedures implemented under the supervision of specialized personnel. As a result, there are fewer uncertainties associated with this special equipment, and so their effects are more precisely known.

Because of this, it is suggested that these two categories of equipment be covered separately:

- For regular equipment and, more generally speaking, for everything related to “regular” work, use clause 3.16 in CAN/CSA-S6, namely, clause 3.16.3 on live loads.
- For special equipment, establishing the weighting coefficients to be used based on the type of equipment ; the corresponding values could be determined by reference to similar type loads – known very precisely with respect to size and position, exceptional loads, for instance – by drawing on other codes that cover this type of situation or through a feasibility study.

For the other variable loads such as thermal effects, wind, ice, snow, and earthquakes, it is suggested to keep the usual weightings but to define the return period to be considered. It will then be possible to define the actions that are statistically likely to occur over the return period. This approach can be justified, since deconstruction work occurs within a limited period of time. The variable loads to be retained should also be determined.

Lastly, the state of the structure with no live load at the start of the work must be known to determine whether resistance is ensured under various combined actions. To properly determine this unladen state, the various phasing of work carried out on the structure need to be taken into account as accurately as possible, from construction to the latest strengthening and repairs. Work carried out over the years not only led to the modification of forces in the components worked on, but also to redistributions in the neighbouring components and even in adjacent spans. This phasing induces “locked-in” forces in the structure that need to be considered. The same applies to the forces that will result from the deconstruction phases.

With respect to engineering in general, it is recommended to:

- Require 3D modelling.
- Require minimum qualifications for the contractor’s engineer (e.g., years of experience, deconstruction projects).
- The contractor’s engineer must be present during delicate operations such as the installation of temporary supports, the lifting of parts, etc.
- Consider an independent engineer for the project.

4.3.6.2 Consolidation of available data

Much work has been done to the Champlain Bridge over the years, so there is a substantial quantity of documents (studies, evaluations, drawings, repair estimates, work site follow-ups, monitoring results, etc.) required to understand the work. It is therefore important to set aside enough time to allow tenderers to familiarize themselves with the structure. Another option is to consolidate and summarize all existing documentation prior to the call for tenders, but this would require considerable time and effort.

4.3.6.3 Required permits and associated lead times

The required permits and associated lead times are closely related to the chosen deconstruction methods. These items are covered under “Environmental constraints,” and transportation-related permits are covered in section 5.

Permits and the associated processing times will have an effect on the planning and scheduling not only of the works but also the launching of the call for tenders for the deconstruction contract. For instance, if a jetty is chosen as an access method, the permitting time must be taken into account in the work schedule since the jetty will generally be required at the very start of the deconstruction work. However, this is a marginal cost compared to the total deconstruction costs.

4.3.6.4 Maintenance during deconstruction work

Deconstruction work for a structure of this size will extend over a long period of time compared to what is required for a smaller structure. Therefore, during the work, the parts that have not yet been deconstructed will have to be maintained, and there are associated costs in doing so. Maintenance includes maintaining lighting, monitoring systems, sweeping roadways, snow removal, etc. It will be important to properly define JCCBI criteria and requirements when drawing up the terms of reference for the deconstruction of the structure.

4.3.6.5 St. Lawrence Seaway

The St. Lawrence Seaway plays a key role in the Canadian economy. It is therefore important that the deconstruction methods considered minimize the impacts on the operation of this strategic waterway.

In this regard, the least disadvantageous approach would clearly be to carry out the work while the Seaway is closed, roughly from early January to late February. Although certain deconstruction methods are suitable for this time of year and can even take advantage of the freezing of the Seaway, this is clearly not a favourable time for civil-engineering works.

It will therefore be important to know the restrictions and constraints the work site must abide by for the deconstruction of this part of the bridge structure. These conditions should be quickly discussed with the SLSMC and covered in a memorandum of understanding.

4.3.6.6 Route 132

Route 132 is one of the main thoroughfares in the Montreal area. The work should therefore cause minimal disruptions to users by keeping closures as short as possible. The same applies to the Route 132 service roads.

As previously mentioned, these closures will have to be scheduled over long weekends when there is less traffic. Work phasing should be studied in this respect, especially by taking advantage of the presence of service roads, in connection with the deconstruction method being used. The choice of this method will therefore be influenced by the conditions for maintaining the flow of traffic.

For more detailed preparation of the work related to this part of the works, preparatory work is required with the MTMDET to define the conditions to be met to maintain the flow of traffic.

4.3.6.7 René-Lévesque Boulevard

The deconstruction of the span above René-Lévesque Boulevard requires this road to be closed, like Route 132. A similar approach is therefore feasible, with the City of Montreal as partner in this instance.

4.3.7 TECHNICAL EVALUATION CRITERIA

The technical evaluation criteria are presented in Table 48. Our analysis thus far has allowed us to draw up a list of the following criteria and to retain five (highlighted in the table):

Table 48 – Technical criteria – Deconstruction

	CRITERION	DESCRIPTION	RETAINED	JUSTIFICATION
1	Duration of work	Total duration of deconstruction work – Quantitative / Moderate accuracy	Yes	
2	Risk of additional delays	Vulnerability of option considered with respect to additional delays: frequent interruptions due to climatic conditions, etc. – Qualitative / Moderate accuracy	No	Cost criterion
3	Risks for road and water crossings (Seaway, Route 132, René-Lévesque Blvd.) and neighbouring structures (new bridge)	Risks generated by the option considered: traffic interruptions, damage to neighbouring structures (roads, new bridge) – Qualitative / Moderate accuracy	Yes	
4	Risk of damage to new bridge	Possibility that the method being considered could damage the structure: piers, deck, etc. – Qualitative / Moderate accuracy	No	Included in criterion 3. This risk will be controlled in all the options ; therefore, there is no adequate differentiation among the options
5	Technical difficulty of the method	Inherent level of difficulty of the method – Qualitative / Moderate accuracy	Yes	
6	Difficult access	Option considered makes use of complex access techniques – Qualitative / Moderate accuracy		Included in criterion 5.
7	Problems associated with existing strengthening	Inclusion of the option considered with the existing strengthening and resulting added complexity – Qualitative / Moderate accuracy		Included in criterion 5.
8	Availability of equipment and specialized crews required for the method	Ease of finding the equipment needed for the option being considered (national level) – Qualitative / Moderate accuracy	Yes	
9	Origin of labour	Problem filling the type of jobs needed for the option being considered (local, regional and national levels) – Qualitative / Moderate accuracy	No	Included in criterion 8.
10	Origin of contractors and subcontractors	Problem finding contractors with the required resources at the local, regional and national levels – Qualitative / Moderate accuracy	No	Included in criterion 8.
11	Origin of suppliers	Problem finding suppliers with the required resources at the local, regional and national levels – Qualitative / Moderate accuracy	No	Included in criterion 8.
12	Origin of consultants	Problem finding consultants with the required resources at the local, regional and national levels – Qualitative / High accuracy	No	Included in criterion 8.
13	Required vs. available mobilization areas	Mobilization areas required for the successful implementation of the method being considered – Qualitative / Moderate accuracy	Yes	

4.4 EVALUATION OF OPTIONS

By applying the methodology described in section 3.5, the evaluation of the deconstruction options for the existing Champlain Bridge was completed and is shown in Table 49. The evaluation was primarily carried out by the team in charge of the deconstruction study, assisted by PTA experts for social and environmental issues.

Table 49 – Multicriteria analysis grid for deconstruction options – Concrete deck

ANALYSIS GRID PART 1 : DECONSTRUCTION WORK									
SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS / SCENARIOS - CONCRETE DECK							JUSTIFICATION / COMMENTS
		WEIGHTING	T1: std/cranes			T2: unlaunching			
			Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	
TECHNICAL	Duration of work	1	5	5	51	4	4	56	DCA3; DLA3
	Risks for road and water crossings (Seaway, Route 132, René-Lévesque Blvd.) and neighbouring structures (new bridge)	4	4	16		5	20		T2: no equipment on the ground = minimal risks T1: equipment on the ground = risks slightly higher than T2
	Technical difficulty of the method	3	4	12		4	12		DGA1
	Availability of equipment and specialized crews required for the method	3	4	12		4	12		DCA1; DLD1; DGD2
	Required vs. available mobilization areas	2	3	6		4	8		DLA4
ECONOMIC	Costs	4	4	16	58	5	20	57	see cost estimate - section 10
	Jobs	3	5	15		4	12		see section 3.1- linked to costs
	Origin of labour	4	4	16		3	12		DGA1
	Risk of overstepping project deadline	2	3	6		4	8		DGD1
	Commercial navigation	1	5	5		5	5		neutral
ENVIRONMENTAL	Water quality	3	2	6	23	3	9	39	DLA1
	Greenhouse gas emissions	2	1	2		3	6		DCA2 T1: lots of equipment required (hammers, cranes, barges) T2: les equipment (launching gantry and SPMT) and quicker than T1 = less greenhouse gases
	Biodiversity	3	2	6		3	9		DLA1; DCD2 ;DCD7
	Contaminated soil and sediment	2	3	6		5	10		DLA1
	Consumption of resources/Residual materials	1	3	3		5	5		DCD6
SOCIAL	Recreational navigation	1	3	3	40	4	4	60	DLA1
	Nuisances	4	2	8		3	12		DLA4; DCD2 ; DCD9
	Public support	3	3	9		4	12		DLA6
	Health and safety	4	3	12		4	16		DLA2; DCD3
	Knowledge/Innovation	4	2	8		4	16		DCA1; T1: common methods, very little innovation T2: less common, possibility of developing local expertise
Total points obtained*			T1: std/cranes		172	T2: unlaunching		212	

***see graphical representation of results for visualization by component**

Table 50 – Multicriteria analysis grid for deconstruction options – Steel deck

ANALYSIS GRID PART 1 : DECONSTRUCTION WORK									
SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS / SCENARIOS - STEEL DECK							JUSTIFICATION / COMMENTS
		WEIGHTING	TA1: cranes/cantilever/strand jack			TA2: reversed erection			
			Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	
TECHNICAL	Duration of work	1	5	5	42	4	4	44	.
	Risks for road and water crossings (Seaway, Route 132, René-Lévesque Blvd.) and neighbouring structures (new bridge)	4	4	16		3	12		TA1: 1 single operation above the Seaway, carried out when it is closed = less risks TA2: long duration of work = higher risks
	Technical difficulty of the method	3	2	6		2	6		DRaD1; DSaD4
	Availability of equipment and specialized crews required for the method	3	3	9		4	12		DRaA1; DRaD3; DSaD4
	Required vs. available mobilization areas	2	3	6		5	10		DRaA1; DSaD1
ECONOMIC	Costs	4	5	20	51	3	12	51	see cost estimate - section 10
	Jobs	3	3	9		5	15		see section 3.1- linked to costs
	Origin of labour	4	3	12		4	16		DSaD4
	Risk of overstepping project deadline	2	3	6		3	6		neutral
	Commercial navigation	1	4	4		2	2		DRaD4
ENVIRONMENTAL	Water quality	3	3	9	37	2	6	29	DRaD2 ; DSaA2
	Greenhouse gas emissions	2	2	4		2	4		neutral
	Biodiversity	3	3	9		2	6		DRaD2 ; DSaA2
	Contaminated soil and sediment	2	5	10		4	8		DRaD2
	Consumption of resources/Residual materials	1	5	5		5	5		neutral
SOCIAL	Recreational navigation	1	4	4	56	4	4	52	neutral
	Nuisances	4	3	12		3	12		neutral
	Public support	3	4	12		4	12		neutral
	Health and safety	4	3	12		3	12		neutral
	Knowledge/Innovation	4	4	16		3	12		DSaD4; TA1: contemporary technique and possibility to innovate TA2: common techniques, has been in use for years
Total points obtained*			TA1: cranes/cantilever/strand jack		**186**	TA2: reversed erection		**176**	

***see graphical representation of results for visualization by component**

Table 51 – Multicriteria analysis grid for deconstruction options – Pier shafts and pier caps

ANALYSIS GRID PART 1 : DECONSTRUCTION WORK									
SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS / SCENARIOS - PIER CAPS AND PIER SHAFTS							JUSTIFICATION / COMMENTS
		WEIGHTING	F1: std/cranes			F2: controlled explosion			
			Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	
TECHNICAL	Duration of work	1	2	2	45	5	5	40	DAE1; DCA7
	Risks for road and water crossings (Seaway, Route 132, René-Lévesque Blvd.) and neighbouring structures (new bridge)	4	4	16		3	12		F1: low risk of debris on the roadway F2: slightly higher risks due to blasting
	Technical difficulty of the method	3	4	12		3	9		DCD1; DEA4
	Availability of equipment and specialized crews required for the method	3	3	9		2	6		DED1; DCA1
	Required vs. available mobilization areas	2	3	6		4	8		DEA2
ECONOMIC	Costs	4	3	12	54	5	20	54	DEA1, see cost estimate - section 10
	Jobs	3	5	15		3	9		see section 3.1- linked to costs
	Origin of labour	4	4	16		3	12		DED1
	Risk of overstepping project deadline	2	3	6		4	8		DEA3
	Commercial navigation	1	5	5		5	5		neutral
ENVIRONMENTAL	Water quality	3	2	6	23	1	3	17	DED2; DED3
	Greenhouse gas emissions	2	1	2		2	4		DED2
	Biodiversity	3	2	6		1	3		DED3 ; DCD7
	Contaminated soil and sediment	2	3	6		1	2		DED3
	Consumption of resources/Residual materials	1	3	3		5	5		DCD6
SOCIAL	Recreational navigation	1	3	3	40	2	2	40	DED8
	Nuisances	4	2	8		2	8		DCD9; DED2 ; DEA3
	Public support	3	3	9		2	6		DED4
	Health and safety	4	3	12		2	8		DED7
	Knowledge/Innovation	4	2	8		4	16		DCA1; F1: common methods, very little innovation F2: less common, possibility of developing local expertise
Total points obtained*			F1: std/cranes		162	F2: controlled explosion		151	

***see graphical representation of results for visualization by component**

Table 52 – Multicriteria analysis grid for deconstruction options – Footings

ANALYSIS GRID PART 1 : DECONSTRUCTION WORK									
SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS / SCENARIOS - FOOTINGS							JUSTIFICATION / COMMENTS
		WEIGHTING	S1: std/cranes			S2: controlled explosion			
			Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	
TECHNICAL	Duration of work	**1**	1	1	**38**	5	5	**44**	DEA1; DCA7
	Risks for road and water crossings (Seaway, Route 132, René-Lévesque Blvd.) and neighbouring structures (new bridge)	**4**	4	16		4	16		neutral
	Technical difficulty of the method	**3**	2	6		3	9		DCD1; DEA4
	Availability of equipment and specialized crews required for the method	**3**	3	9		2	6		DED1; DCA1
	Required vs. available mobilization areas	**2**	3	6		4	8		DEA2
ECONOMIC	Costs	**4**	3	12	**54**	5	20	**54**	DEA1 , see cost estimate - section 10
	Jobs	**3**	5	15		3	9		see section 3.1- linked to costs
	Origin of labour	**4**	4	16		3	12		DED1
	Risk of overstepping project deadline	2	3	6		4	8		DEA3
	Commercial navigation	1	5	5		5	5		neutral
ENVIRONMENTAL	Water quality	**3**	3	9	**30**	1	3	**25**	DED2; DED3
	Greenhouse gas emissions	**2**	1	2		2	4		DED2
	Biodiversity	**3**	4	12		4	12		DED3 ; DCD7
	Contaminated soil and sediment	**2**	2	4		1	2		DED3
	Consumption of resources/Residual materials	**1**	3	3		4	4		DCD6
SOCIAL	Recreational navigation	**1**	3	3	**48**	2	2	**48**	DED8
	Nuisances	**4**	3	12		3	12		DCD9; DEA3 ; DEA3
	Public support	**3**	3	9		2	6		DED4
	Health and safety	4	4	16		3	12		DED7
	Knowledge/Innovation	4	2	8		4	16		DCA1 S1: common methods, very little innovation S2: less common, possibility of developing local expertise
Total points obtained*			S1: std/cranes		**170**	S2: controlled explosion		**171**	

***see graphical representation of results for visualization by component**

4.5 ANALYSIS AND CONCLUSION

4.5.1 CONCRETE DECK

The multicriteria evaluation shows that the unlaunching solution (T2) presents a clear advantage. This solution is not only the best one from a technical standpoint, but also from an environmental and social standpoint. With respect to cost, this option is comparable to removal by crane.

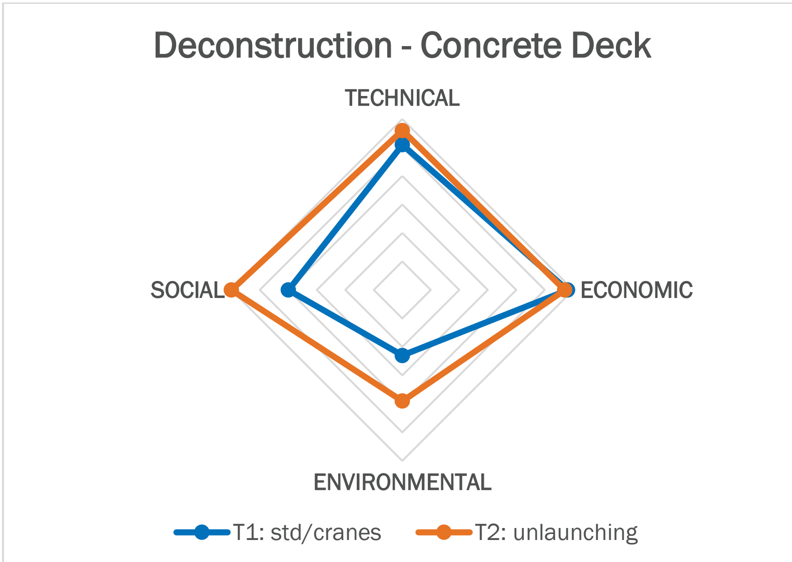


Figure 83 – Comparative analysis – Concrete deck

4.5.2 STEEL DECK

The multicriteria evaluation shows that the crane/cantilever/strand jack solution (TA1) presents a slight advantage. It also presents an advantage from a social standpoint.

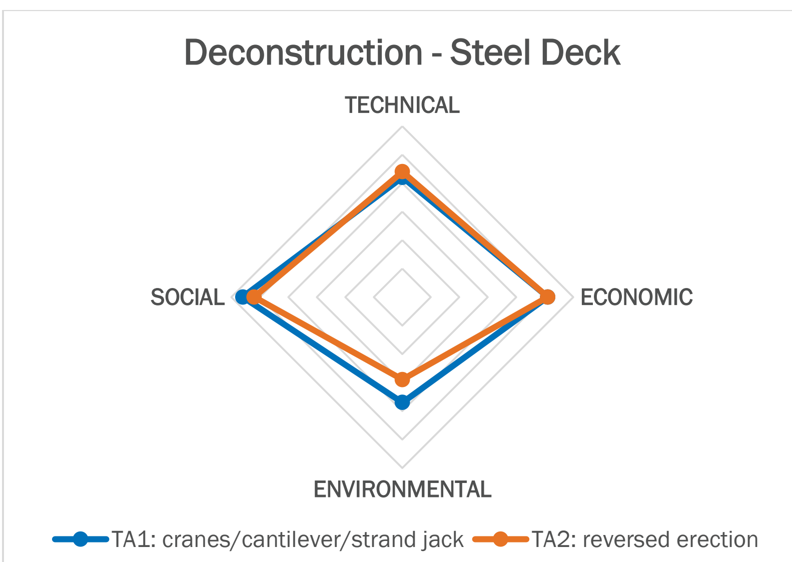


Figure 84 – Comparative analysis – Steel deck

4.5.3 PIER CAPS AND PIER SHAFTS

The multicriteria evaluation shows that the standard method and cranes solution (F1) presents a clear advantage. This solution is better or equivalent for all four criteria (technical, cost, environmental and social).

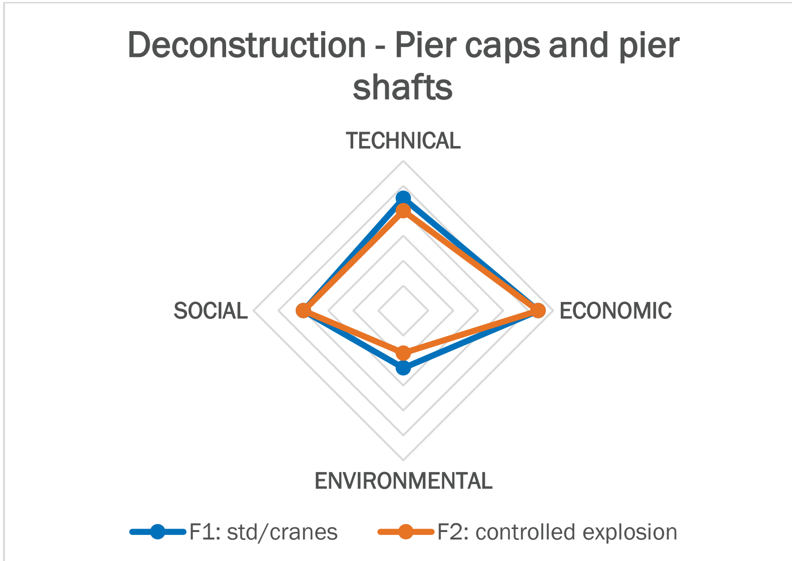


Figure 85 – Comparative analysis – Pier shafts and pier caps

4.5.4 FOOTINGS

The multicriteria evaluation shows that the two solutions are equivalent. They have the almost the same total score. However, the controlled explosion solution (S2) is better from a technical standpoint, and it has a substantially shorter timeframe than the standard method and sawing. In fact, the duration of the work performed with the latter method is especially long (see section 11.2.1), it is estimated at more than three times the duration of the explosion method, which has a considerable impact on the total duration of the work. The reason is that the sawing operations require a lot of time and the number of crews working simultaneously is limited by the availability and cost of the high-capacity cranes required to remove the materials. Therefore, controlled explosion is the preferred solution.

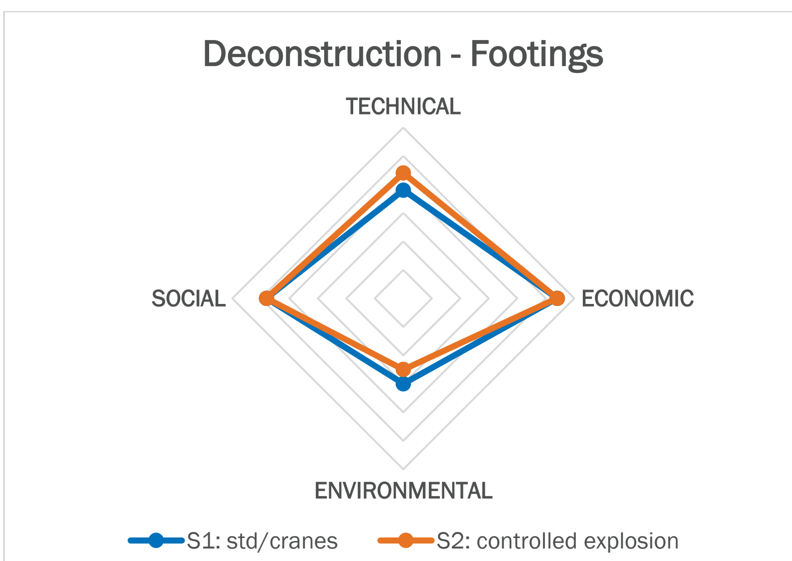


Figure 86 – Comparative analysis – Footings

4.5.5 RECOMMENDED SCENARIO

The following scenario is recommended for deconstruction:

- Unlaunching for the concrete deck (T2) ;
- Cranes/cantilever/strand jacks for the steel deck (TA1) ;
- Standard/sawing for the pier caps and pier shafts (F1) ;
- Controlled explosion for the footings (S2).

5 MATERIALS TRANSPORTATION

5.1 BACKGROUND

Materials transportation is an important aspect of the Champlain Bridge deconstruction project. The transportation method shall be flexible and shall allow the recyclable materials to be transported to their final destinations with minimal disruption to the public.

The means used to transport the materials will depend on the methods and sequences used to dismantle the various sections of the Champlain Bridge, the preferred materials recovery approach, and the selected recycling facilities. The following factors will therefore have a direct impact:

- Project delivery method (traditional, design-build, etc.) ;
- Bridge span dismantling and removal methods ;
- Means used to access and demolish the various sections of the bridge ;
- On-site asset development ;
- Valorization of materials (recovery, recycling).

Transportation will have to take into account the following characteristics in particular:

- Size and weight of the materials to be transported ;
- Sites (work areas) required for materials handling ;
- The Ice Control Structure's structural capacity for the transportation of materials ;
- Load restrictions on the road network, including the new Champlain Bridge, the Ice Control Structure and the bridges in the metropolitan area ;
- Restrictions on the use of the Seaway and the river (marine traffic, congestion, depth, draft, clearance under bridges) ;
- Limitations (size and load) of each mode of transportation ;
- Demand on the road network (congestion) ;
- Timetables to be respected to avoid adverse effects on the public ;
- Permits and authorizations required ;
- Location of intermediate processing sites.

The first part of this section describes the various types of materials to be transported, potential recovery sites, stakeholders, and the technical feasibility of the various modes of transportation.

5.1.1 MATERIALS TO BE TRANSPORTED

During the dismantling of the Champlain Bridge, the materials to be transported will generally fall into one of the following three categories:

1. Steel: steel from full structural sections, dismantled or cut pieces, modular trusses and queen post systems, reinforcing steel from concrete sections, and deck prestressing cables ;
2. Concrete: concrete from girders, concrete covered in CRFP, pieces of concrete and crushed concrete from the slabs and piers ;
3. Other: materials such as light stands, asphalt concrete, electrical housings, the signal system, wiring, the structural monitoring system, etc.

This report focuses mainly on transportation of the first two categories, given their relative importance in terms of quantity. The “Other” materials will have to be removed before dismantling of the structural elements begins, meaning at the bridge decommissioning stage. Such materials can be salvaged by the project owner if their condition allows, or hauled by truck for recycling by the contractor responsible for deconstruction.

The treatment of the external girders and diaphragms having CFRP strips should be verified with recyclers for recovery.

There are also significant materials and pieces from recent bridge maintenance activities, such as queen-post systems and trusses, which need to be taken into account in the transportation scenarios and are included in the “Steel” and “Concrete” quantities.

Some materials could be recovered through re-use or repurposing. Special transportation may be required for large pieces such as full girders.

Section 2.3.5 of this report presents the quantities of materials for each section of the bridge. For study purposes, the total quantity of materials to be transported for the road, marine or rail transport scenarios will be calculated based on a 275,000 t load consisting of 250,000 t of concrete and 25,000 t of steel (metal spans, modular trusses, reinforcing steel).

5.1.2 POTENTIAL MATERIALS PROCESSING AND RECYCLING SITES

The methods and sequence used for the deconstruction of the Champlain Bridge somehow define the need for processing sites before transporting materials to recovery sites or recycling centres.

Analysis of the deconstruction methods that will be recommended and the modes of transportation makes it clear that one or more intermediate sites (between the bridge and the final destination of the materials) will be needed to dismantle the materials into pieces of an appropriate size for each mode of transportation. Among other things, the processing sites will be used to sort the various materials and crush the concrete, and for transportation handling operations.

This section first presents the dismantling and handling sites that might be required depending on the section being deconstructed. It then presents the potential recycling sites and their impact on transportation costs.

Dismantling and Handling Sites

Based on the deconstruction methods identified in the previous section, the following dismantling and handling sites will be required:

A. Nun’s Island site ;
B. Seaway dike site ;
C. Brossard site north of Route 132;
D. Brossard site south of Route 132.

Sites A and C both have a land and a marine portion. The sections of the bridge over land can be accessed from grade, and the zones close to Nun’s Island and the South Shore in Brossard can be accessed from jetties. The two semi-permanent jetties proposed for these zones provide work areas near the bridge for deconstruction, dismantling and materials handling, as well as for shortsea shipping around the bridge.

The deconstruction work zones and dismantling and handling sites can therefore be grouped as follows:

Table 53 – Dismantling and Handling Sites

DECONSTRUCTION ZONE	SPAN (AXES)	MODE OF TRANSPORTATION TO THE HANDLING SITE	DISMANTLING AND HANDLING SITE
5-1	44W to 41W	Land	A
5-2	41W to 36W	Land (Jetty)	A
5-3, 6-1 and 6-2	36W to 0.5W	Marine	B
6-3	0.5W and 0.5E	Seaway	C
6-4, 6-5 and 7-1	0.5E to 4E	Marine	C
7-1	4E to 6E	Marine or land where there is a jetty	C
7-2	6E to 10E	Land	C
7-2	10E to 14E	Land	D

Deconstruction Zones 5-1 and 5-2 –> Dismantling and Handling Site "A"

For the land portion of the Champlain Bridge on Nun's Island between Axes 44W and 41W (Zone 5-1), demolition can take place directly from grade. In this area, the materials from demolition would be dismantled or demolished, bulk crushed, and inventoried for transportation, directly in the work area.

Specific road access will be needed for user traffic during deconstruction of the structure above René-Lévesque Boulevard. The vehicle exit ramp off the Ice Control Structure will have to be adjusted to allow for the site.

For deconstruction of the spans between Axes 41W and 36W (Zone 5-2), a semi-permanent jetty similar to the current one for the new Champlain Bridge will have to be built, as barges cannot access this zone directly due to the shallow water. Like the other zone, the area on the jetty should allow for demolition directly from ground, processing of the materials, and truck loading and haulage.

Conventional demolition of these bridge sections between Axes 44W and 36W is expected to generate an estimated 25,000 t of concrete (10%) and 500 t of steel (3%).

Dismantling site "A", shown in blue in Figure 87, covers an area of approximately 20,000 m². It is expected to provide sufficient space for the work, the equipment operation, and the transport truck traffic.

The materials could also be removed by barge from the semi-permanent jetty. This option is less interesting because it involves more materials handling. If the contractor responsible for deconstruction selects this option, however, the semi-permanent jetty will have to allow for docking of the barges used to transport the materials from demolition to dismantling and handling site "B", or directly to ports such as Montreal, Contrecœur, Trois-Rivières and Valleyfield.

Note that this bridge zone at the edge of Nun's Island is particularly constrained, and the lack of space could be a problem should the contractor choose to use the unlaunching method to remove a significant proportion of the bridge's concrete girders in this area. More detailed analysis will therefore be required at the next engineering stages to confirm the space available in relation to the new bridge, determine the actual surface area of the semi-permanent jetty and lay out traffic lanes for trucks coming off the Ice Control Structure during the work.

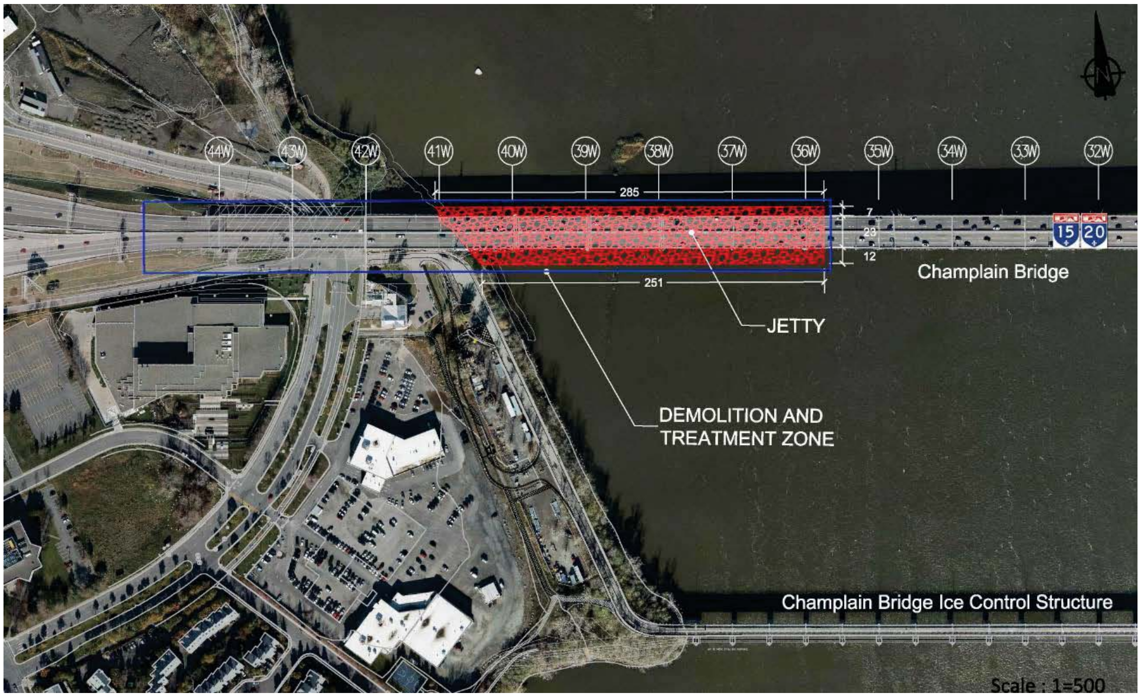


Figure 87 – Dismantling and Handling Site "A" – Nun's Island

<u>Deconstruction Zones 5-3, 6-1 and 6-2 —> Dismantling and Handling Site "B"</u>

These deconstruction zones lie between Axes 36W and 0.5W. They include the concrete section of the bridge over the St. Lawrence River, which represents approximately 65% of the concrete (36W-4W), and part of the metal structure around and above the dike (4W-0.5W). The current plan is to use barges to create a work surface on the water to transport and support the deconstruction equipment (i.e., cranes) and to receive the materials, bridge elements (trusses, girders, etc.) and debris from demolition.

The demolition materials will be transported to the dismantling and handling site "B" on the Seaway dike, illustrated in Figure 88. This is an existing work area with a surface area of approximately 22,000 m². It is currently being used for maintenance work on the Champlain Bridge, with road access via the Champlain Bridge Ice Control Structure. The location of this site is of particular interest because it is relatively far removed from residential areas, and the noise generated by material processing activities would therefore be less audible.

Dismantling site "B" will be used to:

- Dock the barges used for demolition ;
- Serve as a dismantling and handling centre ;
- Receive and load trailers for road transport ;
- Receive and load river barges to transport materials to ports such as Montreal, Contrecœur, Trois-Rivières and Valleyfield.

Assuming that the concrete girders will be deposited by crane, the quantities of materials to be dismantled and treated between Axes 36W and 0.5W represent approximately 160,000 t of concrete and 10,000 t of steel. For the dismantling of the concrete spans, a steady demolition rate of about one span per week represents 2,000 to 2,500 tonnes of concrete per week. In this case, the 22,000 m² of space available on the dike is sufficient for the demolition equipment (shovels, crusher) and for loading onto trucks or barges.

In the case of barge transport, however, handling and transportation of materials from the deconstruction of the bridge's concrete spans could be a problem if the barges cannot move freely on the St. Lawrence River during the winter months.

Dismantling the metal spans could also prove difficult. In the case of steel structures, the mode and pace of deconstruction will have a direct impact on the work areas required. If the metal sections are deconstructed as full spans or trusses, the space available on the dike may be insufficient to process large pieces simultaneously, such as the three 117.5 m trusses located between 2W-1W.

The work space required will therefore have to be assessed in more detail during the next stages of the project, in light of the schedule, the demolition sequence and the transportation mode selected.

Note, however, that if the space on the dike is insufficient, additional barges or floating docks could be used to process the materials or to cut up large steel sections (trusses).

Figure 88 – Dismantling and Handling Site "B" – Seaway Dike

<u>Deconstruction Zones 6-3, 6-4, 6-5, 7-1 and 7-2 —> Dismantling and Handling Site "C"</u>

These deconstruction zones between Axes 0.5W and 10E include the suspended span over the Seaway (0.5W-0.5E), the steel structure of the river segment to the south (0.5E-4E), a concrete section over water (4E-6E) and part of the land section north of Route 132 (6E-10E). Axes 0.5W to 4E would normally be deconstructed using barges. Axes 4E to 6E of the bridge could be dismantled using a semi-permanent jetty similar to the zone on the shore of Nun's Island, and/or barges. The land-based section between Axes 4E and 10E would normally be deconstructed by conventional methods using hydraulic excavators.

Using a semi-permanent jetty to deconstruct Axes 4E to 6E could be an interesting option if the following elements could be combined:

- Conventional deconstruction of the bridge, piers and foundations in this zone ;
- A dismantling and handling site for truck transportation of materials ;
- Docking of barges used to demolish the Seaway and South Sector spans ;
- A dock to receive river barges or "Lakers" for the transportation of recycled materials to ports such as Montreal, Contrecœur and Valleyfield.

The quantities of materials between Axes 0.5W and 10E represent approximately 53,000 t of concrete and 10,000 t of steel. The available surface area is approximately 13,500 m² plus the surface area of the jetty, which is approximately 6,000 m². This entire area would be used to handle the transported materials to be demolished or dismantled, bulk crushed and inventoried for transportation.

As with the section from 36W to 0.5W, the metal spans could prove difficult to dismantle, especially if the 0.5W-0.5E centre section over the Seaway is removed in a single 2,000 t, 117.5-metre long piece. The large 117.5 m trusses of section 1E-2E will also require processing.

All the concrete spans could be dismantled first to optimize the space for dismantling of the steel sections. The work space will have to be studied in more detail in the next stages of the project, based on the schedule, demolition sequence and mode of transportation.

If space is lacking, additional barges or floating docks could also be provided for in this zone to cut large steel segments (trusses).

Figure 89 shows the location of the semi-permanent jetty and the available work area.

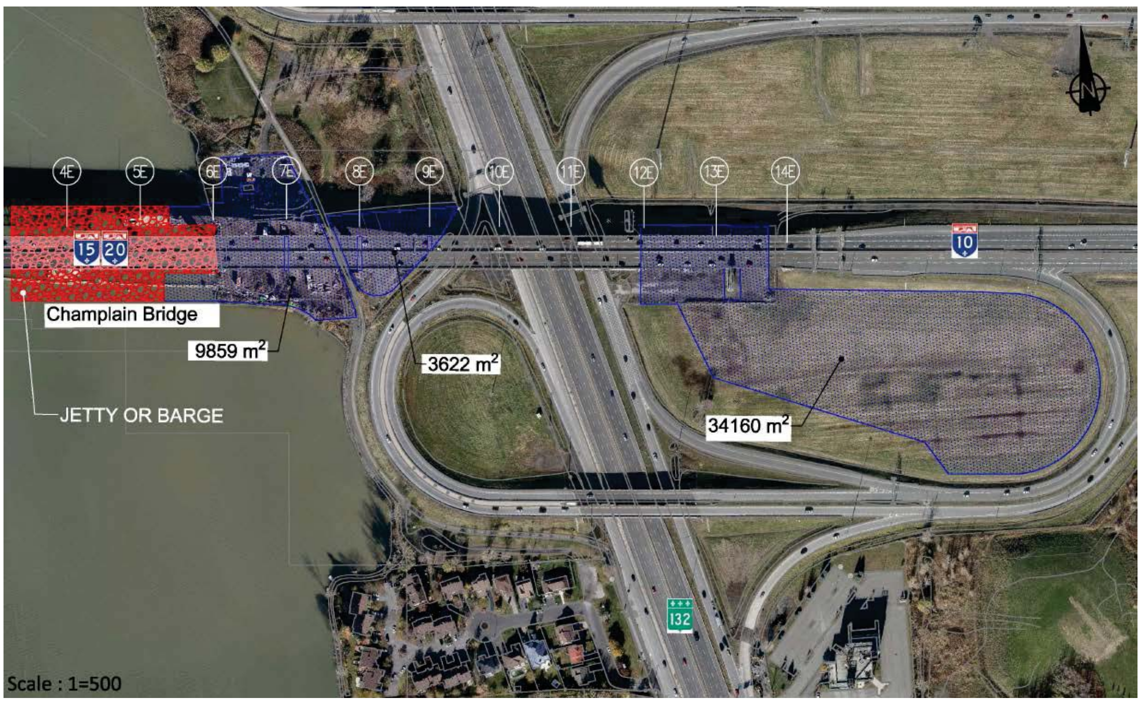


Figure 89 – Dismantling and Handling Site "C" and "D" – Brossard

<u>Deconstruction Zone 7-3 –> Dismantling and Handling Site "D"</u>

The land-based section of the Champlain Bridge in Brossard above and south of Route 132 between spans 10E and 14E allows for conventional demolition directly from grade. The quantities of materials in this section to be dismantled and processed represent approximately 13,000 t of concrete and 100 t of steel.

The surface area available between the access ramps is 34,160 m². An area of approximately 10,000 m² would be required to handle the demolition materials, crush the concrete and organize road transport to recycling facilities and recovery sites. Note, however, that the entire available surface area of the site (34,000 m²) would be occupied by the site facilities and a storage area.

The Route 132 service road would have to be used for access.

Extra work zones

If extra work space is required for the semi-permanent jetties or the Seaway dike site, work areas could be created by using sectional barges in various sizes. For safety, barge stability could be improved with “jack-up” type anchoring piles lowered to bottom of the river bed.

Figure 90 – Sectional Barge

5.1.3 POTENTIAL RECOVERY SITES

The transportation alternatives are directly linked to the location of the recycling facilities and recovery sites. Several demolition contractors have confirmed that all the materials can be recycled in the Montreal area. This would be the most economical approach, because transportation costs are fairly high and have a direct impact on recycling. It is therefore understandable that the need to transport materials over large distances makes it less interesting and profitable for the more remote recyclers and contractors, who would tend to prefer to source locally.

During bridge deconstruction, the contractor may use various recycling sites on Montreal’s North or South Shore or send some of the materials (such as crushed concrete) directly to other construction sites in the metropolitan area.

For the purposes of the study, we have considered various Montreal-area recycling centres, which are shown in Figure 91. Table 54 lists their names and indicates how far they are from the Champlain Bridge. These centres recycle concrete and/or steel.

Our discussions with demolition and recycling companies also led us to understand that concrete is often processed directly on site and steel from demolition is normally cut into pieces that are free from oil or paint residues before being shipped to a steel mill and/or sold at auction. However, the [redacted] has indicated that they could recover the entire steel structure directly if it were delivered to their site.

Going forward, in order to define and optimize the possibility of the materials being recovered by entrepreneurs and potential buyers, it would be wise for JCCBI to hone its knowledge of market demand for materials in light of other major projects underway when deconstruction begins. If necessary, possible contractual clauses for the deconstruction call for tenders should also be reviewed with a view to favouring the preferred alternatives for materials recovery.

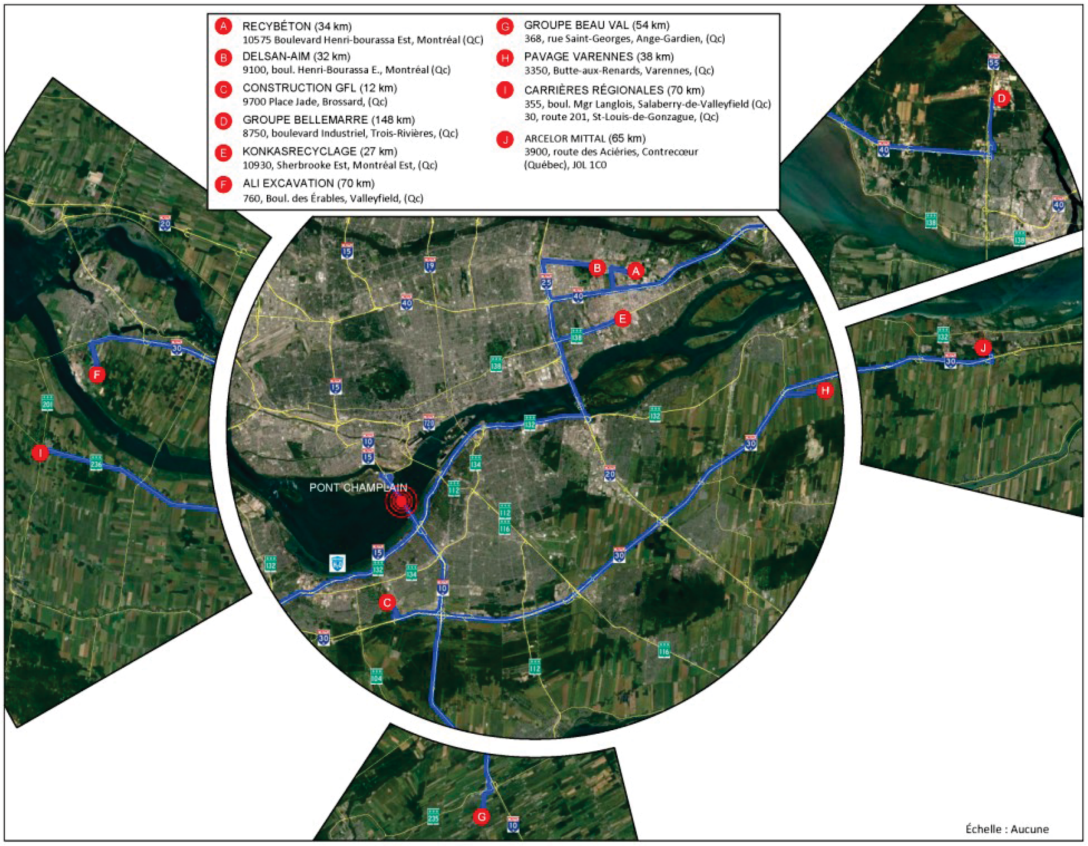


Figure 91 – Recycling Centres

Table 54 – Distance by Road from the Champlain Bridge to the Recycling Centres

	NAME	ADDRESS	DISTANCE
A	Recybéton	10575, boul. Henri-Bourassa E., Montréal	32 km
B	Delsan-AIM	9100, boul. Henri-Bourassa E., Montréal	32 km
C	Construction GFL	9700 Place Jade, Brossard	18 km
D	Groupe Bellemarre	8750, boul. Industriel, Trois-Rivières	150 km
E	Konkas Recyclage	10930, Sherbrooke E. Montréal	36 km
F	Ali Excavation	760, boul. des Érables, Valleyfield	73 km
G	Groupe BauVal	368, rue Saint-Georges, Ange-Gardien	60 km
H	Pavages Varennes	3350, Butte-aux-Renards, Varennes	44 km
I	Carrières Régionales	355, boul. Mgr Langlois, Valleyfield	67 km
J	Arcelor Mittal	3900, rue des aciéries, Contrecœur	65 km

5.2 STAKEHOLDERS

Stakeholders were initially identified on the basis of the documentation made available to the Consortium. JCCBI had also already identified some stakeholders in the request for proposals document. For this field of study, however, the definition of stakeholder was broadened to identify participants who could offer pertinent information or expertise to clarify certain issues or constraints specific to the material transportation.

Stakeholders were grouped into five broad categories: *Governance* (governments, band councils, municipalities, elected officials, etc.), *Community* (local residents, community groups, environmental organizations, etc.), *Users* (car drivers, fishermen, pleasure boaters, etc.), *Economic Partners* (SLSMC, suppliers, subcontractors, workers) and *Experts* (industry associations, research centres, laboratories, etc.). Table 55 below provides an overview of the stakeholders applicable to materials transportation. No stakeholders in the User and Expert resources categories have been identified in this section.

Table 55 – Stakeholders – Materials Transportation

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

Section 8 of this report contains an assessment of stakeholders' influence, along with the outcome of approaches made to the most influential among them.

In addition to approaching influential stakeholders, certain experts were contacted to obtain information relevant to the project. A summary of the discussions was prepared in each case to record the information. The summaries can be found in Appendix 4.

5.3 OPTIONS CONSIDERED

5.3.1 DESCRIPTION OF TRANSPORTATION MODES AND RELATED INFRASTRUCTURE

The terms of reference for the mandate specify that the deconstruction of the Champlain Bridge must be carried out in such a way as to minimize environmental impacts and align with the principles of sustainable development. The method used to transport the materials from demolition should therefore minimize the impact on the environment, local residents and road users. It is important to understand that the Champlain Bridge corridor is heavily used by both vehicular traffic (one of the most heavily used bridges in Canada) and public transport (a major transit corridor).

Maintenance work on the old bridge has also caused many roadblocks and road closures over the years, but this will no longer be the case during the deconstruction work that is the subject of this report.

Traffic may be disrupted by roadwork for the new bridge that is scheduled to be done in 2019 after the bridge opens, as well as drivers' curiosity about the deconstruction work. Finally, adjacent projects must also be taken into consideration, such as the reconfiguration of the Turcot Interchange, the planned widening of Highway 15 within the JCCBI property boundaries, and work on the Bonaventure axis, which may also have an impact on the operation of the Champlain Bridge corridor.

In this regard, this section presents all the transportation alternatives and proposes intermodal scenarios that are of interest from the environmental, efficiency, cost, and other perspectives. Serious consideration should be given to transporting bridge deconstruction materials using modes that do not use the public rights of way.

According to the *Bottin du Transport Maritime Courte Distance*[6] (shortsea shipping directory), the various modes of transportation, namely road, rail and marine, emit different amounts of greenhouse gases (GHG) and consume substantially different amounts of energy per unit of mass transported. The mode that is the most energy-intensive and damaging to the environment is trucking.

Comparisons are presented in Figure 92.[7]

According to the same source, a Laker-type vessel can carry the equivalent of 301 train wagons or 963 trucks. Given that the GHG emitted by the transportation sector accounted for 43% of all GHG emitted in Québec in 2013,[8] it is important to opt for a mode of transportation that will not add to this.

The next sections present the characteristics of the various possible modes of transportation and intermodality scenarios (combined modes of transportation). It should be borne in mind, however, that transportation modes and scenarios are highly dependent on the site to which the materials are being transported.

[6] www.armateurs-du-st-laurent.org
[7] Environmental and Social Impacts of Marine Transport in the Great Lakes-St. Lawrence Seaway Region, Research and Traffic Group (2013)
[8] http://www.mddelcc.gouv.qc.ca/changements/ges/2013/Inventaire1990-2013.pdf

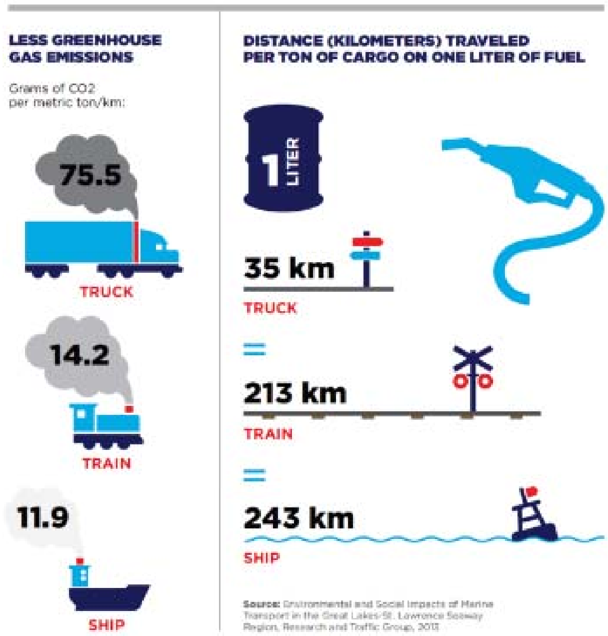


Figure 92 – Mode of Transportation – GHG Comparison

5.3.2 ROAD TRANSPORT

5.3.2.1 Description

Road transport involves the use of various sizes of trailer according to material type and size.

Compared to other transportation methods, road transport makes it possible to remove materials from the demolition zone quickly and continuously, depending, of course, on the transportation infrastructure localized near the site.

Truck transportation offers the advantage of a high degree of flexibility and the ability to service virtually all recycling sites directly. It also allows direct travel from point A to point B, i.e., from the point of origin to the final destination, without changing modes. It can also easily adjust supply (capacity) to demand, which is not necessarily the case for other modes. On the other hand, a significant portion of trucking costs are borne by the public, as trucking uses subsidized public infrastructure at a low cost, unlike other modes of transportation, which generally own their own infrastructure or operate on the basis of a “user-pays” model.

5.3.2.2 Trucking Network

The map below shows the trucking network under MTMDET (*Ministère du Transport, de la Mobilité durable et de l’Électrification des Transports*) jurisdiction. Sections in green are roads with unrestricted access, those in red are roads where trucking is completely or partially banned, and finally those in yellow are restricted roads. It should also be noted that overweight vehicles are not allowed on the current Champlain Bridge since October 11, 2016.

The trucking network can be studied in more detail once the recovery site(s) for the Champlain Bridge demolition have been selected.

At this stage of the study, we can nevertheless conclude that most of the recycling sites identified in Section 5.1.3 are accessible via the trucking network.

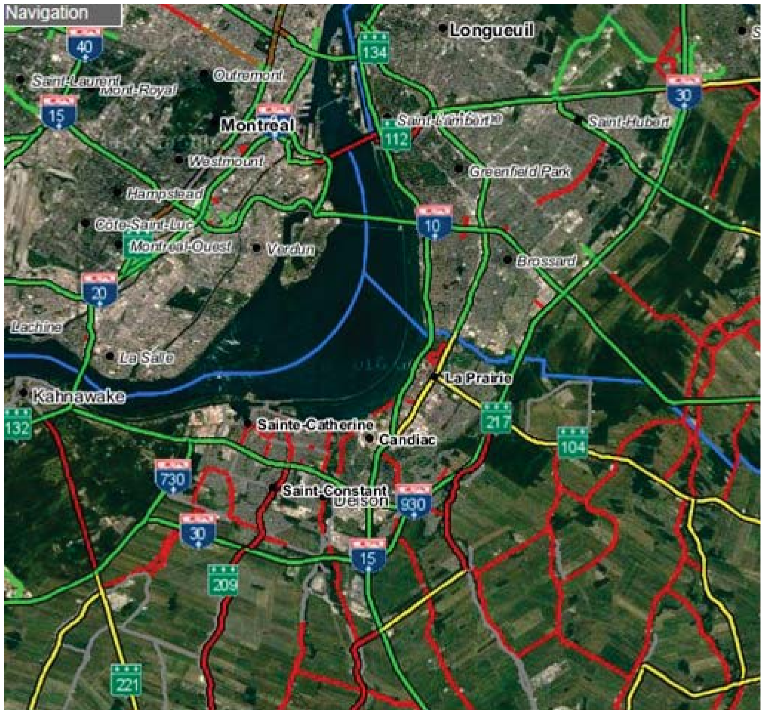


Figure 93 – Trucking Network under MTMDET Jurisdiction (source: Atlas des transports)

5.3.2.3 Capacity of the Road Network in the Metropolitan Area

The Champlain Bridge is located in the heart of the highway network, which sees high traffic volumes. Given recurring congestion, there is no doubt that highways in the metropolitan area are bottlenecks at rush hour. According to a report entitled *Évaluation des coûts de la congestion routière dans la région de Montréal réalisé en 2014 pour des conditions de référence de 2008*,[9] congestion cost $1.85 billion in 2008. We can assume that those costs have risen since.

The new Champlain Bridge will improve the situation for truck transportation, however. The new bridge will make three lanes available per direction at all times on workdays, which is not currently the case. As a result, the recurring afternoon congestion caused by the reserve bus lane from the South Shore towards Montreal should ease, which should improve traffic conditions, subject to actual future demand. According to another report (*Sectorial Report nº 2 – Transportation and Traffic Needs of Pre-feasibility Study Concerning the Replacement of the Existing Champlain Bridge*), peak travel demand will increase. However, this statement does not take into account the *Réseau électrique métropolitain* project announced recently by the *Caisse de dépôt et placement du Québec* (CDPQ).

If trucks transporting demolition materials find themselves in congested traffic, it will inevitably have a substantial impact on transport efficiency, costs and the environment. We must not forget that these are saturated networks and that any addition to them (especially heavy vehicles with low acceleration) will automatically degrade the level of service, increase travel time for all users and extend both the start and end of rush hour. In order for truck transport of the materials to be as efficient as possible, it should take place outside the busiest hours of the day, meaning between 6:00 p.m. and 6:00 a.m.

Figure 94 shows the level of congestion on the highway network around the current Champlain Bridge at the end of the afternoon, in gradations ranging from green to red. The approaches to the old Champlain Bridge can be seen to be congested.

[9] http://www.bv.transports.gouv.qc.ca/mono/1165444.pdf

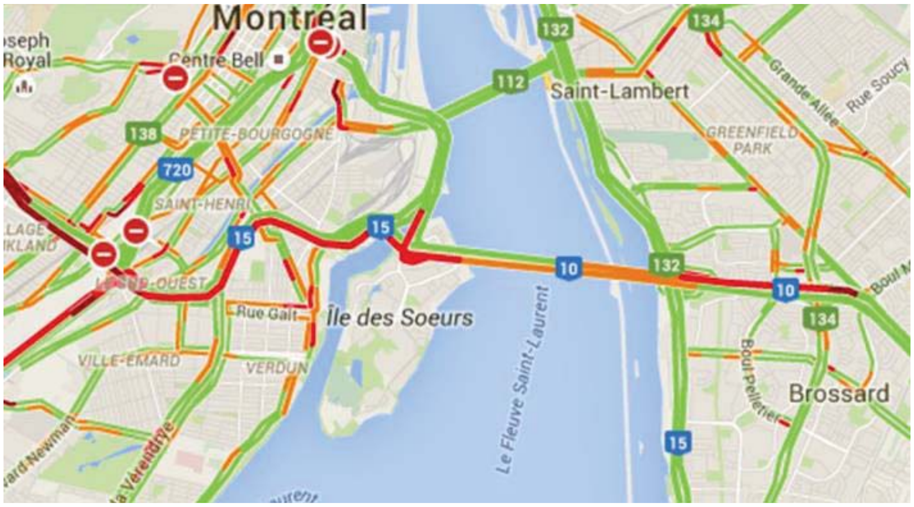


Figure 94 – Degree of Congestion – Highway Network around the Champlain Bridge (source: https://www.toutmontreal.com/avoir/circulation.html)

5.3.2.4 Road Transport Equipment

The type of trailer type that exist can vary greatly depending on the type of material to be transported. Dump trailers such as the one illustrated in the Figure 95 below can be used for bulk materials (broken or crushed concrete). On the other hand, sections dismantled into long or outsized pieces, whether steel or concrete, would require the use of flatbed trailers or trailers of suitable dimensions, like an SPMT (self-propelled modular trailer) or an extendable trailer. The use of this type of trailer requires a road escort and could warrant barriers and/or complete closure of traffic lanes for safety reasons. Moreover, such vehicles cannot travel at any time of day, and it is unlikely that the new bridge could accommodate such loads.

Dump Trailer

Flatbed Trailer

SPMT

Extendable Trailer

Figure 95 – Trailers (source: Manac, Ale, Sarens)

The following types of highway trailers would be needed to transport the materials for the Champlain Bridge demolition project:

- Belt dump trailers;
- Flatbed trailers ;
- Outsized trailers for large pieces.

5.3.2.5 Road Transport Laws and Regulations

Road transport in Québec is subject to various laws and regulations, the main ones being:[10]

- Automobile Insurance Act ;

[10] https://saaq.gouv.qc.ca/en/saaq/documents/laws-and-regulations/

- Highway Safety Code ;
- An Act respecting owners, operators and drivers of heavy vehicles ;
- Transportation Act.

Transportation in Quebec is also affected by the following legislation, albeit to a lesser degree:

- Environmental Quality Act (CQLR, c. Q-2) ;
- Motor Vehicle Transport Act (RSC 1985, c.29, 3rd suppl.).

In addition, truck transport of bulk materials is governed by regulations issued by the *Commission des transports du Québec* (CTQ). The government has passed a legislation stipulating that if a project receives a provincial grant, the project must hire independent truckers who do not have the same size of equipment (less carrying capacity) then the road trailers described above. The federal government can also legislate in some very limited cases.[11] In the case of the Champlain Bridge, which is a federal project, the use of independent truckers is not expected to have a negative impact on the 37-t load capacity set in the road transportation scenario presented at the end of the Transportation of Materials section.

Road Vehicle Load and Size

The Vehicle Load and Size Limits Guide is published by the Quebec's *Ministère des Transports, de la Mobilité durable et de l'Électrification des transports*. The maximum length of a tractor-trailer is 23 m. On average, the trailer alone measures 48 to 53 ft. (14.65 to 16.20 m). Trailer width is 2.6 m, and the height of the vehicle with its load must not exceed 4.15 m. Figure 96 shows the width, length and height of a trailer truck.

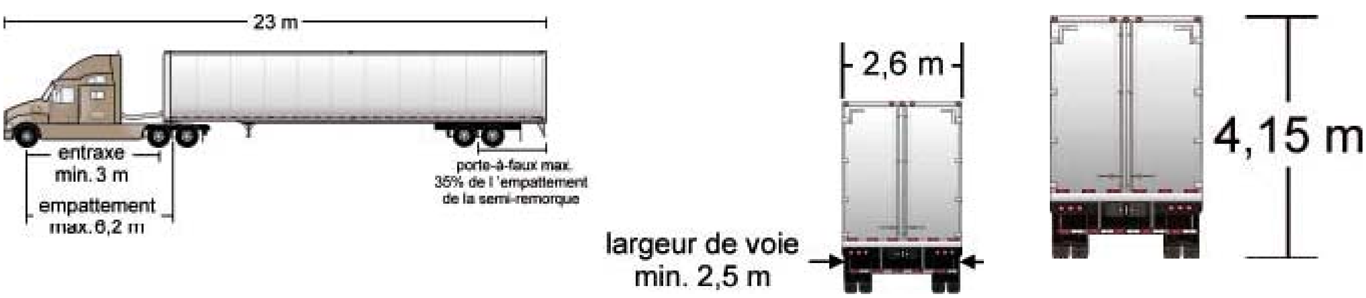


Figure 96 – Road Vehicle Dimensions (source: MTMDET)

Annual Permit for Outsized Loads

Transportation companies in Quebec can obtain an annual permit for exceptional transport. A special travel permit is required if the load of a truck and its trailer is more than 27.5 m long, 4.40 m wide and 4.30 m high.

[11] https://www.tc.gc.ca/eng/acts-regulations/acts-road.htm

Thaw Zones

The Champlain Bridge is located in Thaw Zone 1. Restrictions tend to apply in this zone between mid-March and mid-May each year, and trucks operating during that period will be subject to load restrictions.

Figure 97 – Thaw Zones

Thaw Period Load Restrictions

During thaw periods, the road is 30 to 70% more fragile than usual, which is why load restrictions are imposed on heavy vehicles during such periods. The restrictions are generally 8% to 20%. For payloads and the trailers to be used for demolition, load allowances would be reduced by approximately 12% or 7,500 kg. Load restrictions are shown in the following table and figure:

Table 56 – Thaw Period Load Restrictions

PERIOD	START	END	DUMP TRAILER (TONNES)	FLATBED TRAILER (TONNES)
Normal	Mid-May	Mid-March	37	34
Thaw	Mid-March	Mid-May	30	28

Catégorie de véhicule et d'ensemble de véhicules	Période normal	Période dégel	réduction
	25 250 kg	22 750 kg	10 %
	41 500 kg	36 500 kg	12 %
	49 500 kg	43 000 kg	13 %
	57 500 kg	50 500 kg	12 %
	62 500 kg	57 500 kg	8 %

Figure 98 – Gross Vehicle Weight Limits

GHG Emissions

Road transport of recycled materials provides the greatest flexibility for the dismantling and handling sites to be used for bridge demolition, but is also the most energy-intensive, environmentally costly transportation mode. Table 57 shows greenhouse gas (GHG) emissions for a scenario where the recycled materials would be transported by road. For example, recycling centres in Brossard and Montreal East receiving materials by road would be the environmental option that emits the least GHG emissions compared to the other sites.

Table 57 – GHG Emissions

ACTIVITY	COMPANY	DISTANCE ROUND TRIP	GHG (TONNES)	PROJECT 275,000 T
Recycler	Recybéton (Montréal)	64 km	0.081	22,275
Recycler	Delsan-AIM (Montréal)	64 km	0.081	22,275
Recycler	Consruction GFL (Brossard)	36 km	0.046	12,650
Recycler	Groupe Bellemarre (Trois-Rivières)	300 km	0.380	104,500
Recycler	Konkas Recyclage (Montréal)	72 km	0.091	25,025
Recycler	Ali Excavation (Valleyfield)	146 km	0.185	50,875
Recycler	Groupe BauVal (Ange-Gardien)	120 km	0.152	41,800
Recycler	Pavages Varennes (Varesnnes)	88 km	0.112	30,800
Recycler	Carrières Régionales (Valleyfield)	134 km	0.170	46,750
Recycler	Arcelor Mittal (Contrecœur)	65 km	0.082	22,650

Note that in addition to the above emissions, there may also be emissions from transportation between the recovery site and the final destination, which are impossible to estimate at this time.

<u>Dimensions Required for Truck Manoeuvers</u>

Trucks must be able to perform their turning manoeuvers at the site. Table 58 below shows the turning radius for various types of trucks.

Table 58 – Truck Turning Radii

TYPE	DESCRIPTION	RADIUS (M)
WB-15	Semi-trailer –16.3 m total length	13.7
WB-17	Long semi-trailer – 19.5 m total length	14.6
TST	Maximum length semi-trailer – 20.6 m total length	14.5
A-Train	Maximum length trailer and semi-trailer – 23 m total length	11.5
B-Train	Maximum length trailer and semi-trailer – 25 m total length	12.2

The data in the table show that WB-15 and WB-17 trucks require the most space. In general, 30 to 35 metres of space should be provided to have a safe width to allow a truck to turn around. The dismantling and handling sites must therefore be adapted accordingly.

5.3.2.6 Routes and Technical Constraints

Truck removal of debris and materials from the Champlain Bridge deconstruction will take place at both ends of the bridge, i.e., Nun's Island and Brossard, as well as via the Ice Control Structure from the St. Lawrence Seaway dike.

The possibility of using the Seaway dike as a route to the Victoria Bridge and the Côte Ste-Catherine lock was initially assessed, but the St. Lawrence Seaway Management Corporation rejected these scenarios due to lock bridge constraints, weight restrictions and public safety considerations. Should theses access give a significant advantage to the project, a new validation could be made with the SLSMC based on the chosen method of transport. In this case, risk analysis and modification of the access could be carried out at the JCCBI`s expense to improve capacity and the safety.

Nun's Island

On the Nun's Island side, the new Champlain Bridge to the South Shore and Highway 15 North can be accessed from the western exit of the Ice Control Structure. For the first possibility, trucks must manoeuver around the Champlain Bridge access ramps, or else use René-Lévesque Boulevard and Nun's Island Boulevard, which offer a more standard geometric configuration, as shown in Figure 99.

Figure 99 – Truck Route on Nun's Island

To access Highway 15 North, trucks must take René-Lévesque Boulevard through a roundabout to the north side of Nun's Island, as shown in Figure 100.

Given the work schedule, alignment with the widening works of the Highway 15 corridor toward the Turcot Interchange will have to be verified.

Figure 100 – Nun's Island Routes

The two figures above show the routes for a truck coming off the Ice Control Structure. On their return, the same trucks, now empty, will have to access the Ice Control Structure. Trucks from both the South Shore and the A-15 South will therefore be using the local road network to access the Ice Control Structure.

Finally, it is important to underscore that on Nun's Island, the geometric configuration of some intersections and the location of access ramps may change somewhat with the development of the approaches to the new Champlain Bridge and construction of the *Réseau Électrique Métropolitain* (REM).

<u>Brossard</u>

On the Brossard side, there is already a work area linked to the construction of the new bridge. The main access is sufficiently wide to permit truck entry and exit manoeuvers. It is located on the Route 132 West service road, approximately halfway between an entrance ramp and an exit ramp. There is also a secondary access just at the entrance to the Highway

10 East access ramp. Due to its location, this is likely only used as an entrance, as exiting could be dangerous given the curve of the access ramp.

For the deconstruction of the Champlain Bridge, the work area would need to be somewhat adjusted, as the work space would be have to be located in front of the old bridge. Nevertheless, the current points of access to the area could still be used.

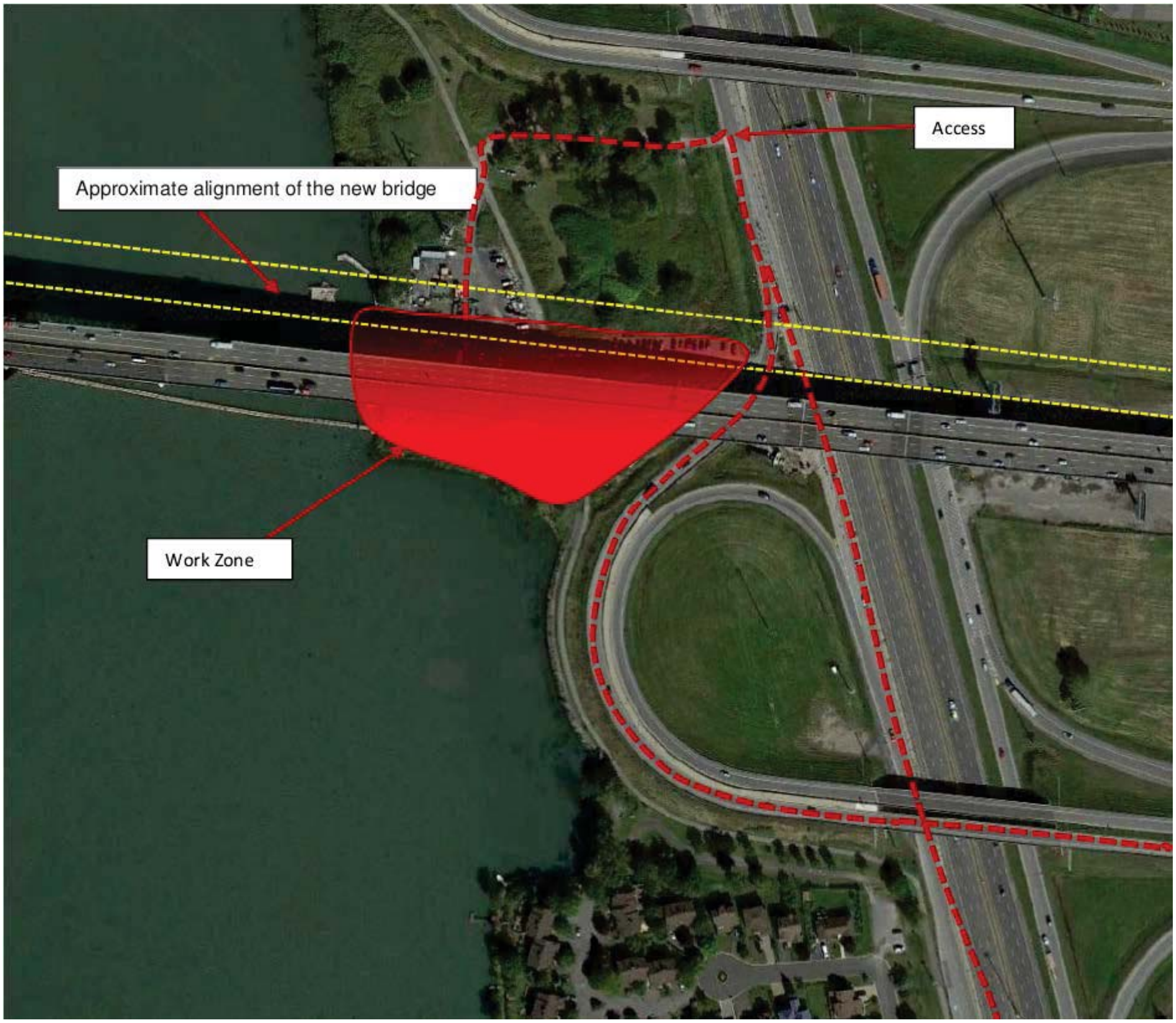


Figure 101 – Truck Routes in Brossard

The work area south of Route 132 would need to be extended for the deconstruction of the Champlain Bridge approach spans to be demolished. However, accessing this land clearly remains a problem, as everything is done via access ramps or the Route 132 service road, which see heavy traffic at rush hour, as well as during the rest of the day. Figure 102 shows the possible points of access to this area.

Figure 102 – Truck Route in Brossard

5.3.2.7 Health and Safety

Table 59 shows the main health and safety risks associated with road transport.

Table 59 – Health and Safety – Road Transport

ELEMENT	RISK	EFFECT
Vehicle operation (road transport)	• Collision • Being hit • Projection • Skid	• Tears/abrasions/bruises sprains/strains/fractures • Contusion/crushing/amputation • Multiple injuries, death

5.3.3 MARINE TRANSPORT

5.3.3.1 Description

As the Champlain Bridge spans the St. Lawrence River and its Seaway, at least part of the materials transportation route will have to be on the water. Several of the deconstruction methods proposed in this study use barges around the deconstruction zones (crane deposition, access to areas near the bridge, transport barges, etc.). The transport barges would allow some pieces of the bridge to be removed and transported to one of the dismantling and handling sites, where the debris could be broken into appropriately-sized pieces for truck and/or marine transport, according to the maximum loads and dimensions allowed by the road and marine networks.

Transportation on the Seaway system is significantly more advantageous than other modes of transportation in terms of energy consumption. The Seaway allows one tonne of cargo to be moved up to 1,100 km using only one gallon (4.54 litres) of fuel, which is much more efficient than other modes of transportation (see Figure 92).

This section describes the marine network around the bridge in order to assess the available marine transport options, depending on the location of the intermediate handling site and the final destination of the materials. Marine transport could be used to move the materials from the bridge to the intermediate handling site or directly from the deconstruction zone to their final destination.

Figure 103 below illustrates Quebec's strategic commercial port system. The available port facilities and potential storage sites for the materials, such as Sainte-Catherine, will be more fully described in subsequent stages.

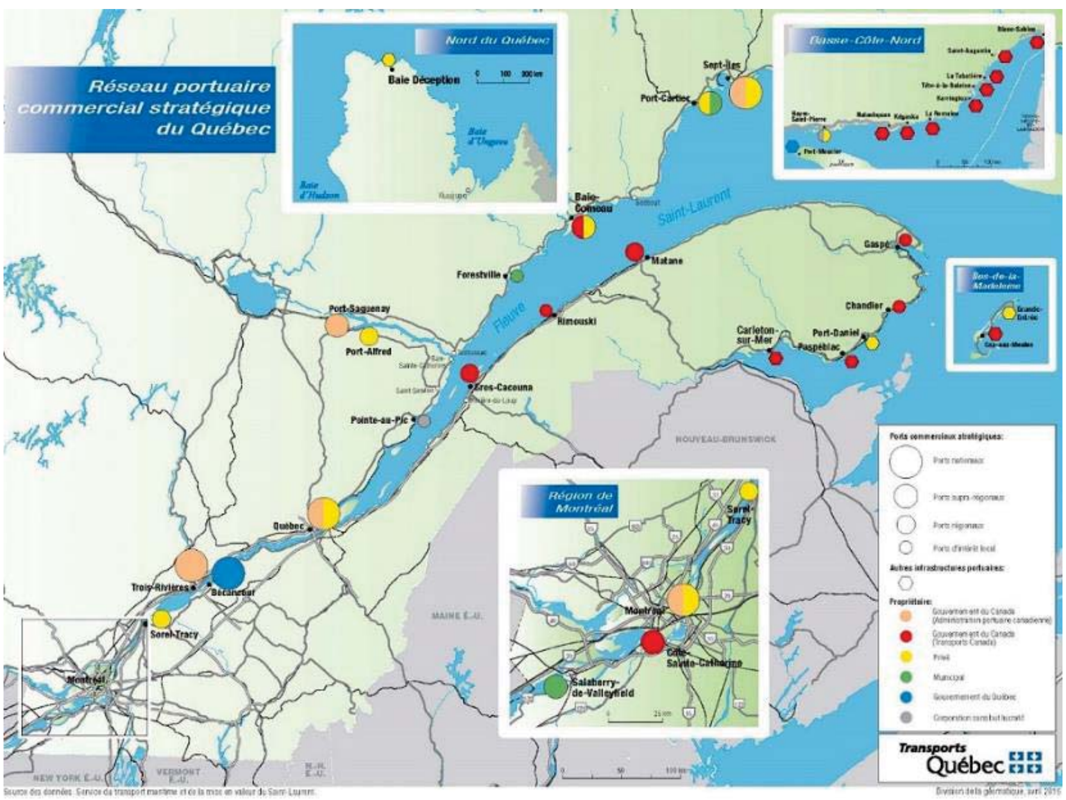


Figure 103 – Quebec's Strategic Commercial Port System

<u>Shortsea Shipping</u>

Shortsea shipping refers to a multi-modal concept involving marine transportation of goods that does not cross oceans, and takes place primarily on the St. Lawrence River and the Great Lakes and along the East Coast of the United States. There is a similar network on the west coast of Canada and the United States. Shortsea shipping is important to Quebec's economy. Approximately 110 million tonnes of goods are transloaded annually in Quebec ports, with domestic traffic accounting for 25% of this volume.

St. Lawrence Seaway

Since 1959, the Great Lakes/St. Lawrence Seaway system has been a vital waterway for the transportation of goods between the North American heartland and international markets. It covers 3,700 km and encompasses the St. Lawrence River and the five Great Lakes. Each navigation season, the locks on the system record the passage of more than 2,000 commercial vessels headed for major US and Canadian ports.

The navigation period for the St. Lawrence Seaway generally extends from mid-March to the end of December. The non-navigation period therefore extends from January 1 to March 10. The section over the Seaway could be demolished when the locks are closed, from January to March each year.

Seaway Locks

The locks near the Champlain Bridge that must be considered during dismantling are mainly those found on the South Shore and Beauharnois canals.

- The South Shore Canal is 14 nautical miles long and has two locks: Saint-Lambert and Côte-Sainte-Catherine.
- The Beauharnois Canal connects Lac Saint-Louis to Lac Saint-François over a distance of 11.3 nautical miles. The Beauharnois Canal also as two locks.

Figure 104 shows the South Shore Canal locks and the Champlain Bridge.

Figure 104 – South Shore Canal

Lock Size and Draft

Each lock is 233.5 m (766 ft) long, 24.4 m (80 ft) wide and 9.1 m (30 ft) deep. A lock fills with about 91 million litres of water in just 7 to 10 minutes.

The Seaway canals can accommodate vessels up to 225.5 m (740 ft) long and 23.8 m (78 ft) wide.

The water level during closing varies from 7.6 m to 9.6 m to facilitate maintenance of the structures. During the navigation period, the managed water level is 11.6 m.

Work Restrictions in the Seaway

If work is to be carried out in the Seaway during the navigation season (mid-March to December), a framework agreement should be negotiated in advance with the SLSMC and a formal risk analysis should be performed. As ship traffic cannot be blocked, it is preferable to work in the locks during the off-season period. Note, however, that while the locks are closed during the off-season period, there is still a slight current to support the operation of the Sainte-Catherine and Saint-Lambert hydroelectric dams.

In general, materials cannot be transported in the Seaway by barge during the off-season period, and the sequence of deconstruction of the Seaway and South Basin spans would therefore have to be planned accordingly.

Marine System around the Champlain Bridge

To assess possible materials removal routes using the marine network, it is important to be familiar with the marine system around the Champlain Bridge, including:

- **Physical constraints** (bridge clearances, Ice Control Structure clearance, locks, promenade, islands, rapids, bathymetry, etc.)
- **Regulatory constraints** (pleasure boating, commercial shipping, safety, etc.)

A good understanding of the marine system around the bridge will also allow the location of the dismantling and handling site to be optimized.

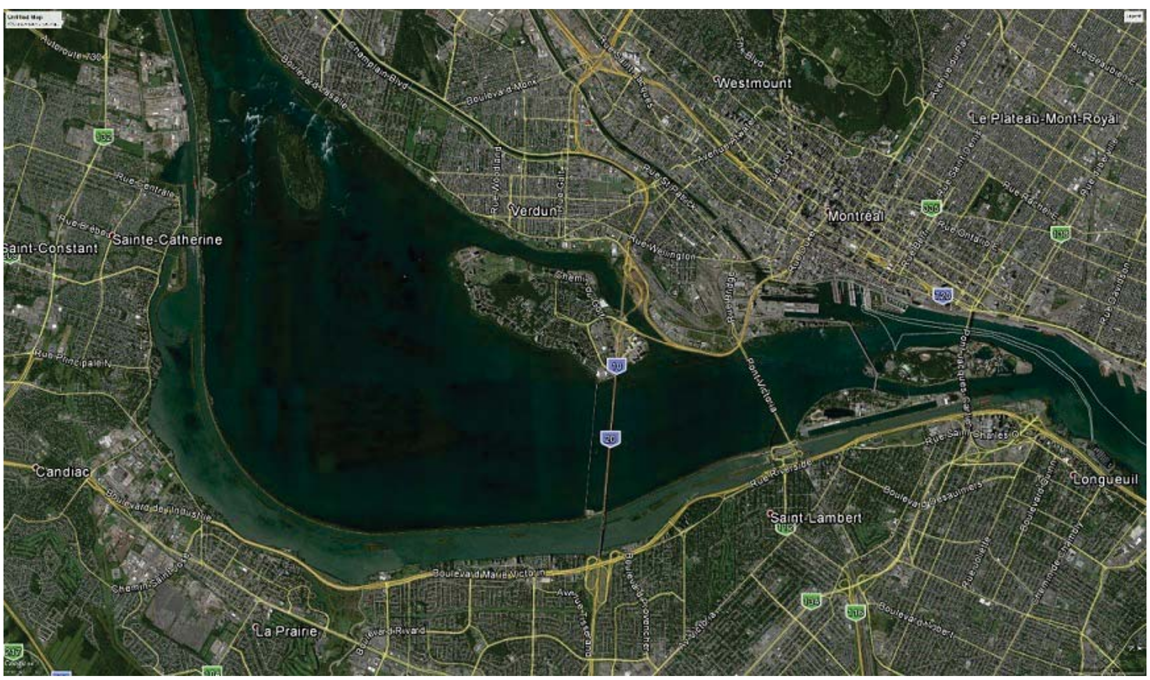


Figure 105 – Marine System

Indeed, maritime constraints such as water depth and marine current allow to consider possible maritime routes of the barges towards the west and east of the Champlain Bridge . These are:

- To the west: The presence of the Lachine Rapids west of the Champlain Bridge prevents the use of the St. Lawrence River. Any westward travel therefore requires the use of the Seaway.
- To the east: Very preliminary analysis of the bathymetry highlights the shallow water to the east on the St. Lawrence River. That being said, a number of physical constraints complicate marine travel to the east (locks, the Victoria

Bridge, the Concorde Bridge, islands, shallows, strong currents, etc.). Here again, the use of the Seaway would facilitate travel.

The marine transportation companies indicated us that it is possible to transport the demolition materials by the St. Lawrence River between the Champlain Bridge site and the Port of Montreal using a special barge equipped with a powerful winch and a tug to steer the barge in the narrow (200 ft - 60.6 m), winding navigable channel that has a low draft (about 7.5 ft (2.27 m) in summer. In addition to the challenge of the channel, the other constraint to consider is the vertical clearance under the Concorde Bridge, which is 38 ft (11.5 m) in spring and 41 ft (12.4 m) in summer. Given that the girders are 3.07 m high and the freeboard of the barges is of the order of 3 m, barges loaded with girders could pass under the Concorde Bridge to travel farther east. The passage of the tug under the bridge could, however, require some manoeuvring of the antennas.

The passage from the St. Lawrence River route to the Seaway is also a major challenge that needs to be analyzed. To this end, the prefeasibility study (Sectorial Report No. 6 – Future of Existing Structure. Consortium BCDE, February 2011; recommended moving the centre span from the Seaway to the La Prairie Basin for dismantling. The feasibility of this option remains to be confirmed, as well as the feasibility of moving the centre span via the Seaway.

An option would be to install a floating dock in the Seaway near the Champlain Bridge. The dock could be used to moor a Great Lakes bulk carrier to load demolition materials or large parts such as the central span. This mode of operation must, however, be analyzed in detail with a risk analysis because the Seaway must be maintained in operation without disrupting navigation. This method may be difficult, as there is less than 150 feet of dredged channel for a 78-foot wide bulk carrier to pass in a curve.

Another option for the dismantling of the central span is to maintain the water level in the La Prairie basin during the winter in order to navigate barges using an air bubble injection system and circulating tugs regularly to prevent ice from forming. It would therefore be theoretically possible to remove the central span of the bridge in winter, while the Seaway is closed to commercial traffic, which considerably reduces the risk of disruption.

It is clear, however, that the centre span cannot pass through the Saint-Lambert locks: the locks are 24.4 m wide and the vessels that navigate the Seaway are 23.7 m wide, while the centre span measures 24.08 m. It must therefore be at least partially dismantled in the Seaway or the La Prairie basin. The water in the La Prairie basin at the level of Champlain Bridge would be about 8 feet (2.4 m) deep, allowing loaded barges to be brought in and dismantling to take place there.

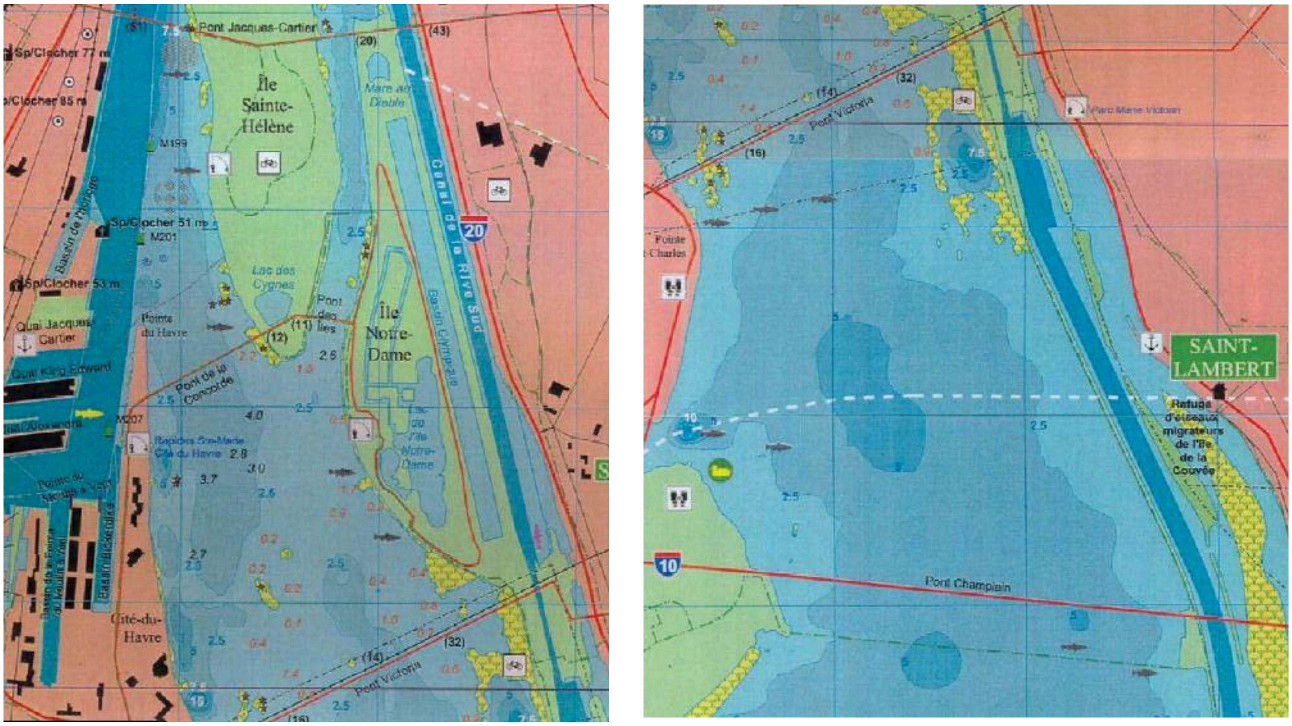


Figure 106 – Marine System around the Champlain Bridge and Montreal

5.3.3.2 Marine Transport Equipment

Barges and floating cranes are the most appropriate equipment for deconstruction operations, and particularly transport operations. The use of such equipment will be assessed in terms of costs, schedule and environmental impact.

<u>Flat-deck Barges</u>

Given that approximately 80% of the Champlain Bridge is above water, there are many potential uses for flat-deck barges. These barges have drafts of 1 to 6 m, and loading capacities ranging from 1,000 to 20,000 t. They can be used to transport full sections or for bridge decommissioning processes. A typical barge is shown in the following figure.

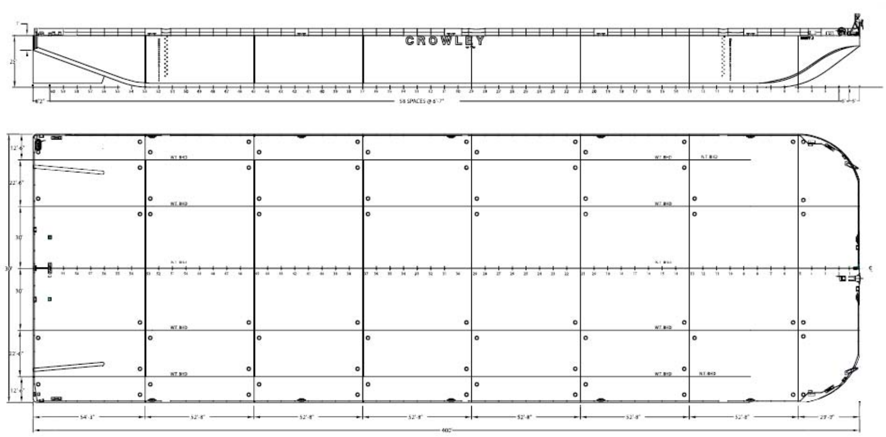


Figure 107 – Barge (source: Crowley)

Due to their capacity and flexibility, barges come in a wide range of sizes and accommodate multiple types of deconstruction materials and equipment. As discussed in Section 4, the deconstruction elements to be transported can range from relatively small pieces of concrete or steel to full girders and stringers or even the deck of an entire span. The handling equipment for such pieces will have to be adjusted accordingly, and will vary from mini loaders and trucks to derrick cranes. The 150 t, 53 m girders could potentially be handled with Mega-Jack hydraulic jacks and unloaded at the dismantling site using a jack & roll system.

The following figure shows a barge being used to transport large parts.

Figure 108 – Barge Transport (source: MARCON, Standard size of flat deck barges)

Barges come in a wide range of sizes, as shown in Table 60.

Table 60 – Barge Size and Capacity

Length	Beam	Depth	Deadweight
100'	30'	8'	360T
120'	40'	8'	600T
180'	50'	10'	1,500T
180'	56'	12'	2,200T
210'	60'	14'	2,800T
230'	60'	14'	3,300T
230'	64'	14'	3,800T
250'	80'	16'	5,500T
270'	70'	16'	5,500T
300'	80'	18'	7,800T
300'	80'	20'	8,200T
300'	90'	18'	8,500T
330'	90'	20'	10,000T
330'	100'	20'	12,000T
365'	92'	23'	12,000T
400'	120'	20'	15,000T

The following figure shows another example of barge transport.

Figure 109 – Barge Transport

Seaway Ships and Barges

The typical ships that use the Seaway are called “Lakers” and operated by [redacted] and [redacted] both based in Montreal. River barges that operate regularly in the Seaway generally belong to [redacted] (Montreal, Hamilton) and [redacted] Quebec). The [redacted] Lakers offer rapid self-unloading solutions ; and their reduced infrastructure and labour requirements make this bulk cargo handling option an effective, competitive solution that helps keep costs down and minimize environmental impact. The [redacted] self-unloaders have a 35,000 t load capacity. These Lakers measure an average of 225 m (740 ft) long by 23.7 m (78 ft) wide, and have an 8 m (26 ft) draft when operating in the Seaway.

In the event that Lakers are used for the dismantling of the Champlain Bridge, a solution would need to be developed, as the jetty and dike east of the 1W pier do not have sufficient support capacity for heavy loads.

Figure 110 – Lakers

River barges like the [redacted] Huron Spirit offer special features for operation in the Great Lakes, Seaway and St. Lawrence River. These barges include a 150-foot self-unloading conveyor boom ideal for efficient discharge of bulk commodities. They have extra deck strength to carry steel and other breakbulk while still maintaining a maximum 18.5 foot draft for shallow port and dock accessibility. These barges average 100 m (328 ft) long by 25 m (82 ft) wide and have a 7 m (23 ft) draft, which is effective for navigating the Seaway. The load capacity for these barges is 10,000 t.

Figure 111 – River Barge

These barges also offer other functionality. They can accommodate high capacity equipment such as 1,200 t cranes and Mega-Jack hydraulic jacks with 500 to 800 t dismantling capacity.

Figure 112 – Mega-Jack

Finally, sectional barges can be assembled to make temporary docks and increase the work area as needed.

Figure 113 – Barge with "Jack-up" Type Anchored Pillar

Figure 114 – Sectional Barges used to Install the trusses of the Champlain Bridge

Figure 115 – Sectional Barges Used to Install the trusses of the Champlain Bridge

5.3.3.3 Marine Transport Laws and Regulations

The main laws and regulations governing marine transport in Canada are:[12]

- Coasting Trade Act (1992, c. 31) ;
- Department of Transport Act ((R.S., 1985, c. T-18) ;
- Canada Shipping Act, 2001 (2001, c. 26) ;
- Canada Marine Act (1998, c. 10) ;
- Canadian Environmental Protection Act, 1999 (SC 1999, c. 33) ;
- Navigation Protection Act (R.S., 1985, c. N-22) ;
- Marine Liability Act (2001, c. 6) ;
- Marine Transportation Security Act (1994, c. 40) ;
- Canada Transportation Act (1996, c. 10).

5.3.3.4 Health and Safety

Table 61 shows the main health and safety risks associated with marine transport.

Table 61 – Health and Safety – Marine Transport

ELEMENT	RISK	EFFECT
Marine operations (ships/boats)	• Man overboard • Collision • Shipwreck	• Hypothermia • Drowning • Multiple injuries • Death

[12] https://www.tc.gc.ca/eng/acts-regulations/acts-marine.htm

5.3.4 RAIL TRANSPORT

5.3.4.1 Description

Québec has an extensive, well-developed rail network. In Canada, 60% of goods are transported by rail.

At the provincial level, two dominant, private Class I rail operators share the freight activity: Canadian National (CN) and Canadian Pacific (CP). Class I railways operate the main networks with the highest revenue/kilometre in the railway industry. CN and CP use shortline railways as partners in local and regional interests. The shortline railways operating near the Champlain Bridge are the Québec-Gatineau (QGRY) and Central Maine & Québec Railway (CMQ).

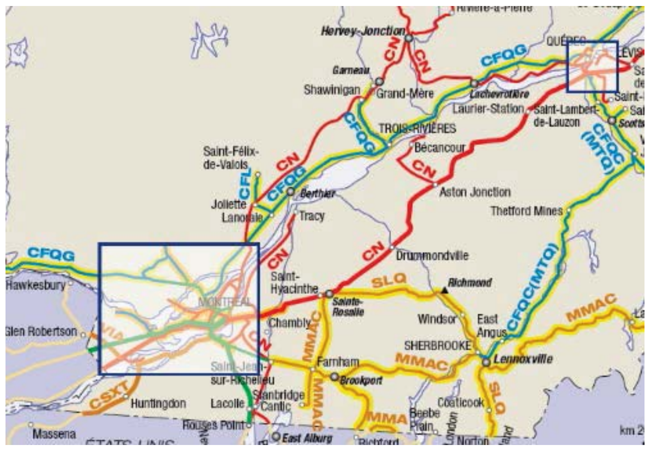


Figure 116 – Québec's Rail Network (source: Atlas des transports, MTMDET)

Figure 117 shows the rail network near the Champlain Bridge. While several sets of tracks can be seen in the area around the Champlain Bridge, their mere presence does not necessarily make them attractive for transporting demolition materials, for the many reasons discussed in the following sections.

Figure 117 – Rail Network near the Champlain Bridge (source: Atlas des transports, MTMDET)

5.3.4.2 Rail Transloading Yard

There are a number of railway tracks near the Champlain Bridge. The CN, CP and Port of Montreal networks all have transloading yards near the Champlain Bridge and offer interesting intermodal options. In the event that some recycled pieces must be transported by rail, CN and CP have a number of transloading facilities on the South Short and on the island of Montreal. CN has three transloading yards on the South Shore and one at their rail yard on the island of Montreal.

- Saint-Lambert: Southwark Marshalling Yard ;
- La Prairie: Track No. K114;
- Port of Valleyfield: Interconnection CN-CP-CSX ;
- Lachine: Lachine Intermodal Yard.

CP has also three transloading centres in the vicinity of the Champlain Bridge, including one on the South Shore and two on the island of Montreal:

- Côte-Sainte-Catherine: Trac-World warehouse ;
- Montréal: Côte-Saint-Luc Marshalling Yard ;
- Port of Montréal.

5.3.4.3 Rail Transportation System

<u>Characteristics</u>

Rail transport is first and foremost mass transport, but it is also repetitive transport, and thus warrants investment in rolling stock, access roads (links with industry, sidings, etc.), and loading/unloading facilities at points of origin and destination. Other characteristics include transport over long distances, loading/unloading constraints and rail car availability. Transport specialists generally recognize that rail can expect to compete with its main competitor, trucking, for transport distances of over 1,000 km, but for smaller distances, trucking is much more appealing. It can also be difficult for a customer who generates a relatively small volume of non-repeat traffic to find a rail car.

<u>Rail Access</u>

The three transloading facilities on the South Shore of Montreal offer the best solution for transportation of materials from the Champlain Bridge demolition. The first, at the Côte Ste-Catherine port, is served by CP. This small port, which specializes in bulk handling (gypsum, fertilizer, etc.), does not seem to have much surplus storage space (unless rented in nearby Kahnawake). This port would be accessible via the Seaway (by barge and tug) or by truck via Route132 132 and the Côte-Sainte-Catherine local road network. The two other transloading centres are the CN facilities in St-Lambert and La Prairie, which do not offer marine transport, only truck and rail.

<u>Loading/Unloading</u>

As we do not yet know what form the recycled concrete will take, we would add a word of caution about loading and, more particularly, unloading options. Full girders or large sections of girder may be relatively easy to load/unload with a crane, but the same cannot be said for granular materials. The mining railways have developed very efficient solutions for unloading ore cars (rotary dumpers, side dump cars, bottom dump cars, etc.), but such specialized equipment is very expensive, requires extensive facilities and is only warranted for major volumes over several years. Smaller volumes could be unloaded with a shovel mounted on a 1.5 m deck, which, while feasible, would not be very efficient. Furthermore, if the loading equipment is stationary (a hopper, for instance), a Trackmobile or a train crew would be required to properly position each car for loading, which adds to the cost.

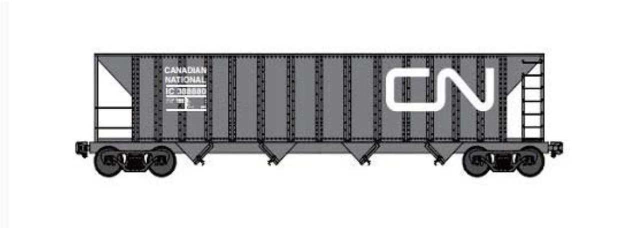
5.3.4.4 Rail Transport Equipment

Flat cars for the transportation of metals and minerals come in different models and lengths. For the transportation of full or sectioned girders and for calculation purposes, the net load that can be carried by a flat car can be estimated at 72 to 113 t, at a width of around 10 feet (3 m) and length of 89 feet (30 m). These cars could therefore carry a half girder (53 m and 166 t divided by two, i.e., 26.5 m and 83 t).

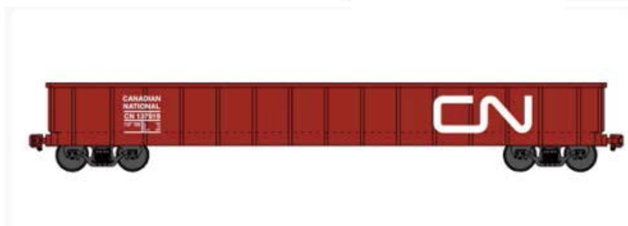
For the transport of crushed concrete and other recycled materials, the gondola car typically offers the following capacities: 116 t (105 t), 2,500 cubic feet (70.8 m³) and 42 feet (12.7 m), which vary depending on the manufacturer.

Crushed concrete can also be transported in open hopper cars. Such cars offer fast, economic loading and unloading of bulk goods, and their large capacity allows for the transport of iron ore and other aggregates. Their load capacity is 91 t. Unloading them, however, requires unloading facilities by the railway track.

FLAT CAR



OPEN HOPPER CAR



GONDOLA CAR

Figure 118 – Rail Transport (source: CN)

<u>Oversized Rail Transport</u>

All railway companies, whether shortline or Class 1, offer the option of carrying oversized and heavy cargo. This service requires the development of a comprehensive logistics assessment method, including an analysis of required clearance based on load height and width. The following table shows the width clearances for goods transported by CN.

Table 62 – Oversized Rail Transport

Categories of Exceptional Transport (dimensional classification)

D - 1	10’ 8”	to	11’ 0”	wide	Regular Train Service
D - 2	11’ 1”	to	11’ 6”	wide	Regular Train Service
D - 3	11’ 7”	to	12’ 0”	wide	Regular Train Service
D - 4	12’ 1”	to	12’ 6”	wide	Dimensional Train Service
D - 5	12’ 7”	to	13’ 0”	wide	Dimensional Train Service
D - 6	13’ 1”	to	13’ 6”	wide	Dimensional Train Service
D - 7	13’ 7”	to	14’ 0”	wide	Special Train
D - 8	14’ 1”	to	14’ 6”	wide	Special Train
D - 9	14’ 7”	wide and over			Special Train

In terms of height, tunnel and bridge clearances will dictate which material can be transported by rail, but vertical clearance tends to be approximately 21 feet (6.4 m). Finally, load capacity is governed by the type of track on which the cars will travel. For instance, Class1 railways such as CN and CP have 286K type tracks, while shortline railways often have a less impressive 263K track capacity. In terms of cargo capacity, a car will carry an average load of 100 t (220,000 pounds) on 286K track and 91 t (200,000 pounds) on 263K track. Payload is thus the combination of track capacity and the maximum load of the car itself.

5.3.4.5 Rail Transport Laws and Regulations

The main laws and regulations governing rail transport in Canada are:[13]

- Department of Transport Act ((R.S., 1985, c. T-18) ;
- Bridges Act* (R.S., 1985, c. B-8) ;
- Canadian Environmental Protection Act, 1999* (SC 1999, c. 33) ;
- Railway Safety Act (1985, c. 32 (4th Supp.)) ;
- Canada Transportation Act (1996, c. 10).

5.3.4.6 Health and Safety

Table 63 shows the main health and safety risks associated with rail transport.

Table 63 – Health and Safety – Rail Transport

ELEMENT	RISK	EFFECT
Rail transport	• Collision • Being hit • Projection • Derailment • Being trapped • Fire/explosion	• Tears/abrasions/bruises sprains/strains/fractures • Contusion/crushing/amputation • Multiple injuries, death

5.3.5 TRANSPORTATION OF MATERIALS SCENARIOS

The scenarios presented in this section are an initial assessment for the project. Note that a marine scenario is one that is characterized by marine transportation of materials over a longer distance than simply to one end of the bridge by barge. Given the presence of the St. Lawrence river, barges will obviously be used for the sections being deconstructed. This section examines the option of transporting them over longer distances.

The main intermodal transportation scenarios are presented in the following sections. To compare the transportation scenarios, the following primary assumptions were made:

- 90% (250,000 t) of the demolished materials will be transported in bulk form, either by road, marine or rail transport ;
- 10% (25,000 t) of the steel materials such as girders, light stands, safety barriers and the like will be transported as separate pieces (breakbulk). Individual pieces of steel, like the bulk products, can also be transported by road, marine or rail ;
- Dismantling operations will take place:
  - 5 days per week ;
  - 180 days per year (9 months).
- It is assumed that deconstruction will not take place during the winter months, except in the case of Section 6;

[13] https://www.tc.gc.ca/eng/acts-regulations/acts-rail.htm

- In order to ease traffic congestion during the day, the hours of operation for road transport will be between 6:00 p.m. and 6:00 a.m., for a total of 10 hours per day, 5 days per week ;
- The final assumption is that transportation of materials for the Champlain Bridge demolition project will be ongoing for three years, or 540 days.

5.3.5.1 Scenario 1 – Road Model

The option of only using road transport for the transportation of recyclable materials offers advantages in terms of logistics but not necessarily in terms of economics. Apart from the primary assumptions listed above, the road model is based on a number of secondary assumptions:

- The model uses a 37-tonne rating for the payload of the dump trailer (with belt), which is the type of trailer that is expected to be used to haul the crushed cement to the recycling centres.

Figure 119 – Dump Trailer

- The model uses a 34-tonne payload rating for road transport using flat-bed trailers. For instance, steel beams, plates, and other steel products will be transported in sections using a flat-bed trailer 14.6 to 16.1 m (48 to 53 ft) long.

Figure 120 – Flat-bed Trailer

Based on the primary assumptions and the assumptions listed above, demolition of the Champlain Bridge will result in approximately fourteen (14) trucks per day between the dismantling sites and the recycling centres.

Table 64 – Number of Trucks per Day

TRAILER TYPE	PAYLOAD (TONNES)	PRODUCT (TONNES)	NUMBER OF LOADS (TOTAL)	PERIOD (DAYS)	NUMBER OF LOADS (PER DAY)
Dump Trailer	37	250,000	6,757	540	13
Flat-bed Trailer	34	25,000	735	540	1

To meet a demand of fourteen (14) loads per day, a fleet of two (2) to five (5) trailers would be required for road transport, depending on the round trip distance between the Champlain Bridge and the selected recycling site. Table 65 shows the number of trailers per day a carrier would need to meet the transportation needs, for each potential site.

Table 65 – Trailers to Support Transportation Flow

ACTIVITY	COMPANY	RETURN TRIP (KM)	TRAVEL SPEED (90 KPH)	TRAVEL TIME (MIN)	LOADING AND UNLOADING (MIN)	TOTAL TRIP TIME (MIN)	OPERATING PERIOD (10 HOURS) (600 MIN)	NUMBER OF TRIPS (#/DAY)	TRAILER FLEET
Recycler	Recybéton (Montréal)	64	90	43	60	103	600	6	3
Recycler	Delsan-AIM (Montréal)	64	90	43	60	103	600	6	3
Recycler	Consruction GFL (Brossard)	36	90	24	60	84	600	8	2
Recycler	Groupe Bellemarre (Trois-Rivières)	300	90	200	60	260	600	3	5
Recycler	Konkas Recyclage (Montréal)	72	90	48	60	108	600	6	3
Recycler	Ali Excavation (Valleyfield)	146	90	97	60	157	600	4	4
Recycler	Groupe BauVal (Ange-Gardien)	120	90	80	60	140	600	5	3
Recycler	Pavages Varennes (Varennes)	88	90	59	60	119	600	6	3
Recycler	Carrières Régionales (Valleyfield)	134	90	89	60	149	600	5	3

Transporting the recycled materials between the dismantling sites and the recycling centres by road offers advantages and disadvantages relative to other modes of transport. The advantages of road transport centre on the flexibility of the operations. Once loaded at the dismantling site, the truck and its trailer travel directly to a recycling facility, where they can be unloaded with ease. Furthermore, having a subcontractor to track makes cost control easier to manage.

On the other hand, road transport is the most energy-intensive of all the transportation modes proposed in this study. Table 66 shows the advantages and disadvantages of road transport.

Table 66 – Advantages/Disadvantages – Road Transport

ADVANTAGES	DISADVANTAGES
Road transport offers the following advantages: TA1 – Logistical flexibility TA2 – Ease of cost control TA3 – Direct transport with no one else involved TA4 – Single loading and unloading operation TA5 – Easy access to transloading sites TA6 – Adaptable to the work sequence and deconstruction method TA7 – Multiple transport companies can participate TA8 – Can be used year-round	Road transport has the following disadvantages: TD1 – CO_2 emissions TD2 – Slight increase in road traffic flows TD3 – Operation between 6:00 p.m. and 6:00 a.m. TD4 – Noise can disturb local residents

5.3.5.2 Scenario 2 – Marine Model

Given that 80% of the surface of the Champlain Bridge is over water, marine transport will have to be used for dismantling operations, but shortsea shipping still needs to be assessed as a means of transporting the materials off site.

First, the use of barges for the Champlain Bridge demolition represents a logistical dismantling cost, not a transportation cost. Regardless of the cost category, however, shipping companies will ask for the following information to allow them to calculate their operating costs:

- What type of equipment is required, e.g., a barge or salvage tug?
- What types, sizes and number of barges are required?
- What type of tug and size of motor (hp) are required?
- How long is the contract?
- What is the draft at the location of the marine operations?

The beams and the other materials will have to be transported by barge to the jetties next to the dismantling sites for the materials to be recycled there. Depending on the size of the beams, the jack & roll system can be used. The advantage of the marine transport mode is the capacity to load and unload pieces that neither road nor rail transport can handle. On the other hand, it is very expensive to rent the equipment and machinery needed to move oversized loads.

Second, marine transport costs will be calculated on the basis of the five primary assumptions listed above, but also the following secondary assumptions:

- For the purposes of the marine transport cost analysis, the point of departure is one of the dismantling and handling sites ;
- Once crushed or cut up at these sites, the materials (concrete and steel) will have to be transloaded onto shortsea shipping barges or ships. This transloading activity could be carried out using a conveyor, a truck with a dump trailer or a shovel/loader. This activity represents the first marine cost ;
- Once the materials have been loaded onto the shortsea shipping barges or ships, the transport units will have to proceed to their port destinations. This activity represents the second marine cost ;
  - Note that the shorter the travel distance, the higher the cost/tonne compared to road transport. In the Montreal area, for instance, truck transport between the Champlain Bridge and the recycling centre would be cheaper. Between the Champlain Bridge and the Gaspé Peninsula, however, the marine mode will have an economic advantage.
- The next step is to moor the shortsea shipping barge or ship at its port of destination and transload its cargo into bulk silos or sheds. This activity, carried out by longshoremen, represents the third marine cost ;
  - Note that in Québec, major ports such as Montréal, Québec and Sept-Îles have higher unloading costs than the municipal port of Valleyfield, the Sainte-Catherine dock or the port of Contrecœur.
- Once transloaded into bulk silos or sheds, the materials will have to be transloaded a second time at the same port into trucks with dump trailers. This activity represents the fourth marine cost ;
- The tractor-trailers then head for the recycling centres. This activity represents the fifth (and last) marine cost.
  - Note that if the recycling centre is located within the port facilities, there would be only three transportation costs.

The recycling centres used in the marine mode must obviously have port access, which is why only the recycling centres located in Montreal, Valleyfield and Trois-Rivières were selected for this mode. GHG emissions are calculated based on a total load capacity of 30,000 t and the distance traveled to haul this load.

The maritime model presented in Table 67 shows an environmental comparison between road transport and shortsea shipping. The emissions below clearly indicate that the marine route between the Champlain Bridge and the Port of Montreal emits the least CO2 during the transportation of recycled materials.

Table 67 – Environmental Comparison – Road Transport and Shortsea Shipping

TRANSPORT MODE	COMPANY	RETURN TRIP DISTANCE (KM)	TOTAL LOAD	TRANSPORT UNIT	RETURN TRIP DISTANCE (KM)	GHG (T)
Trucks	Groupe Bellemare (Trois-Rivières)	300	30,000	811	243 243	309
	Ali Excavation (Valleyfield)	146	30,000	811	118 378	150
	Recybéton (Montréal)	64	30,000	811	51 892	66
Barges	Groupe Bellemare (Trois-Rivières)	300	30,000	3	900	15
	Ali Excavation (Valleyfield)	146	30,000	3	438	7
	Recybéton (Montréal)	64	30,000	3	192	7
Ships	Groupe Bellemare (Trois-Rivières)	300	30,000	1	300	15
	Ali Excavation (Valleyfield)	146	30,000	1	146	7
	Recybéton (Montréal)	64	30,000	1	64	7

The major barge operators ([redacted] recommend roughly the same marine operating model within the limits of the Champlain Bridge and the Concorde Bridge. Basically, they recommend the use of two shallow tugs near the Champlain Bridge, because of the low draft between the Champlain Bridge and the Concorde Bridge. These tugs have capacities of 400 to 1,000 hp. They would operate in the Champlain Bridge area with the barges used for deconstruction activities and with the transport barges over to the Concorde Bridge.

East of the Concorde Bridge, a more powerful tug (1,200 to 1,400 HP) would take over to tug the barges to a transloading port. The proposed model for shortsea shipping uses the following assumptions:

- Approximately 230,000 tonnes (materials from areas B and C) will be transported by barge over short distances.
- One of the operators recommends using a barge type MM 180 barge with a payload (deadweight) capacity of 2,000 tonnes per trip. The barge loading capacity could be lower, however, depending on the work area and water depth.

On the basis of the planned work schedule and the equivalent of 36 months of materials transportation, it can be assumed that one loaded barge per week would head downstream on the St.Lawrence River and return to the Champlain Bridge empty.

Like the road transport mode, the marine mode offers economic and social advantages and disadvantages. Table 68 below shows the strengths and weaknesses of the marine mode.

Table 68 – Advantages/Disadvantages – Marine Mode

ADVANTAGES	DISADVANTAGES
Marine transport offers the following advantages: TA9 – Mode of transportation with the highest load capacity TA10 – Low GHG emissions TA11 – Lowest cost/tonne of all the long-distance transportation modes considered TA12 – Negligible marine congestion TA13 – Helps reduce road congestion and nuisances for local residents	Marine transport has the following disadvantages: TD5 – The highest equipment and machinery rental costs of all modes of transportation considered in this study TD6 – High transloading costs TD7 – Not applicable for conventional demolition from grade TD8 – Less applicable if girders are delaunched toward shore TD9 – Multiples operations, H&S risks for work on water TD10 – Authorization from the Seaway required for travel TD11 – Five cost activities compared to two for road transport TD12 – Less potential for subcontractor participation, market captivity (Ocean, McKeil, Irving) TD13 – Higher cost per tonne for short distances TD14 – The recycling centre must be located within the port facility to minimize costs TD15 – Impossible to remove the materials by barge in winter for the Seaway and Brossard Basin sector (Seaway closed)

5.3.5.3 Scenario 3 – Rail Model

The rail mode offers the option of transporting outsized pieces over a long distance, which trucking cannot offer. The CN, CP and CSX transloading centres on the South Shore and the Island of Montreal listed in Section 5.3.4.2 can therefore be used for any recycled parts that need to be transported by rail.

Rail transport costs will be calculated on the basis of the primary assumptions outlined above, as well as the following secondary assumptions:

- For the purposes of the rail transport cost analysis, the point of departure is one of the dismantling and handling sites ;
- Furthermore, the rail model only considers the transportation of individual pieces (breakbulk) ;
- Once crushed or cut at the dismantling and handling sites, the materials (steel and concrete) must be loaded into trucks with flat-bed trailers. This activity represents the first rail transport cost ;
- Once the materials have been loaded onto the trailers, the trucks must go to one of the CN or CP transloading centres mentioned above. This activity represents the second rail transport cost ;
- Once at a rail transloading centre, the materials are loaded into rail cars by specialized stevedores, which represents the third cost ;
- The loaded car either makes its way to a recycling facility with its own siding (fourth cost) or else ;
- The car travels to another railway transloading facility (fourth cost) to be unloaded on a flat-bed trailer (fifth cost) ;
- Once on a flat-bed, the tractor-trailer hauls the material to a recycling facility, which is the sixth and final activity.

Table 69 below shows the advantages and disadvantages of the rail mode:

Table 69 – Advantages/Disadvantages – Rail Mode

ADVANTAGES	DISADVANTAGES
Rail transport offers similar advantages to marine transport, which are the following: TA14 – A higher load capacity than road transport but lower than marine transport TA15 – Low GHG emissions TA16 – Average cost/tonne for the transportation modes considered in this study TA17 – Helps reduce road congestion TA18 – Best potential for distant markets TA19 – Year-round application	Rail transport has similar disadvantages to marine transport, which are the following: TD16 – Transport of separate pieces (breakbulk) TD17 – High transloading costs TD18 – Multimodal mode TD19 – More complex logistics than the road transport mode due to multiple operations TD20 – Four to six cost activities compared to two for road transport and five for marine transport TD21 – Little potential for subcontractor participation TD22 – Market captivity (CN, CP, CSX) TD23 – Medium contingency cost TD24 – Not applicable for short distances

Materials from bridge deconstruction would be recovered in the metropolitan area. The rail mode is not applicable for short distances as it involves multiple transloading operations between the Champlain Bridge site and the recycler. Consequently, this option was not selected.

5.3.5.4 Scenario 4 – Multimodal Model

There are a number of possible multimodal scenarios that combine road, marine and rail transport. Certain multimodal scenarios should be assessed if potential recovery or recycling sites are at significant distances. For the time being, however, such scenarios have not been selected.

5.4 EVALUATION OF OPTIONS

5.4.1 TECHNICAL EVALUATION CRITERIA

Technical evaluation criteria were identified based on the key factors influencing the mode of transport and the advantages and disadvantages of each of the options being considered. The table below presents the five criteria used to evaluate the options.

Table 70 – Technical Criteria – Transportation of Materials

	CRITERIA	DESCRIPTION	SELECTED	RATIONALE
1	Flexibility / adaptability	Flexibility and adaptability of the transport mode to the various demolition scenarios and to getting to the recovery/recycling sites (Qualitative / Medium accuracy)	Yes	The transport mode must not hamper deconstruction work or materials recovery
2	Availability of required mobilization areas	Mobilization areas needed for the mode being considered to operate smoothly (Quantitative / Medium accuracy)	Yes	
3	Number of handling operations required	Number of handling operations required between the departure point at the Champlain Bridge and the final recovery/recycling site (Quantitative / Medium accuracy)	Yes	Has an impact on time and cost and increases risk
4	Route disruption	Disruption of transport routes between the Champlain Bridge and the final recovery/recycling site (Qualitative / Medium accuracy)	Yes	Disturbs users
5	Required permits / authorizations	Permits and authorizations required to move material from the demolition site to the final site (Quantitative / Low accuracy)	Yes	Difficulty obtaining permits or authorizations could affect the choice of scenario

5.4.2 POINTS TO CONSIDER

The following points should be taken into consideration in the selection of transport mode.

Deconstruction and Materials Removal Methods (technical criteria 1 and 2)
The deconstruction method will have a direct impact on the mode of transport. Some of the deconstruction work will take place from grade (spans 44W to 41W and 6E to 14E) or from a working jetty near the riverbank (spans 41W to 36W and 4E to 6E). Demolition work in these areas will be carried out using conventional methods. It is therefore likely that materials from these areas will be transported by truck.

Delaunching is the most advantageous deconstruction method for the concrete deck. In the same way as for the spans over the ground, if the beams are delaunched toward the ends of the bridge from grade, truck transport can be expected to be preferable to barge transport. Adequate work space must, however, be available.

For the deconstruction of sections of the bridge over water that require the use of marine equipment, road transport is possible, but marine transport of materials would be a more logical choice if the equipment (barges and tugs) can be used for both deconstruction and transportation activities.

Location of the Recovery Sites
The location of the recovery sites will also affect the selection of transport method. Unless specific guidelines are included in the tender documents, contractors will promote recycling of demolition materials in the Greater Montréal area. The demolition and recycling companies have in fact indicated that they can take all the materials. The cost of transporting the materials is a significant factor. It is therefore understandable that a more remote recycler or user (in Quebec City, for instance) would not be particularly interested in demolition materials from the Champlain Bridge, as the transportation costs would cut into their profits ; they would tend to prefer local materials, which would be cheaper.

A demolition and recycling company in the metropolitan area can thus be expected to choose to transport the materials by truck. There is no advantage in using barge transport, which is more suitable for longer distances, but more restrictive and expensive for local transport.

Number of processing and handling operations (transloading)
Another important factor influencing the choice of mode of transport is the number of processing and handling operations (transloading activities) between the site and the final recovery site. This has a direct impact on costs and consequently on the interest of the prospective buyer.

Discussions with a number of firms quickly revealed that it is not realistic to transport the raw demolition materials (without any on-site processing). Large pieces such as 53-metre concrete girders or structural steel sections cannot be transported by truck. There would therefore be a problem with the sections of the bridge over land or at the riverbank (above the jetties). Barge transport of these large parts (concrete girders) might be an option, but additional handling activities at the port of destination (handling by longshoremen) are costly and make this alternative less interesting unless the demolition and recycling company has its own port facilities. The transport of large steel sections, such as the 2,000-tonne centre span, also presents a problem in terms of weight and size in relation to port capacity. Transporting a load to the port of Contrecœur for recycling at the Arcelor Mittal steel mill, for instance, would require dismantling large pieces on barges docked at the port before unloading. This option is less practical and more costly. It is more realistic to reduce the size of the concrete or steel to transportable dimensions at the site prior to transport. With this in mind, we have assumed that the materials will be cut on site before being transported to a recycling facility or construction site.

The demolition contractors and recyclers may want to limit the number of handling operations. It would be efficient, for instance, to break up the 0-700 mm heavy gauge concrete at the site and then transport it to a crushing site. However, this approach involves a two materials handling operations: one to break up the concrete into transportable sizes at the site and another to crush it at the recycling site. Depending on market demand at the time of the project, a contractor may wish to completely transform the materials and send them to various sites on the North Shore, in Montreal, or on the South Shore, or even to different construction sites.

Sections 5.3.5.1 and 5.3.5.2 cover transloading activities as they relate to the transportation of materials. Road transport requires two transloading operations as the material goes directly from the deconstruction site to the recycling site, while marine transport entails five.

Limitations of the Transport Routes Used (Road or Marine)

The limitations of the transport routes can have a direct impact on the mode of transportation. Trucking can take place year-round but is subject to load limits, road configurations and noise issues. Marine transport, on the other hand, is difficult in winter on the St. Lawrence River (clearance under the Concorde Bridge) and would not work in the Seaway. In general, working with barges entails higher safety and project risks due to more complex working conditions and the current.

5.4.3 EVALUATION OF OPTIONS

The various options for the transportation of materials were evaluated using the approach described in Section 3.5, as shown in Table 71. The evaluation was primarily carried out by the transportation of materials team, supported by PTA social and environmental specialists.

Table 71 – Multi-Criteria Evaluation of Options for the Transportation of Materials

ANALYSIS GRID PART 2 : TRANSPORTATION OF MATERIALS

SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS							JUSTIFICATION / COMMENTS
		WEIGHTING	Road transport			Marine transport			
			Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	
TECHNICAL	Flexibility / Adaptability	**3**	4	12	**43**	3	9	**34**	TA1, TA5, TA6, TA8, TD7, TD8, TD9, TD15
	Availability of required mobilization areas	**2**	3	6		3	6		TA5, TA9, TD7, TD8
	Number of handling operations required	**3**	5	15		3	9		TA3, TA4, TD11
	Route disruption	**2**	3	6		4	8		TA12, TA13, TD2
	Required permits / authorizations	**1**	4	4		2	2		TD10
ECONOMIC	Costs	**4**	5	20	**67**	3	12	**50**	TA2, TA11, TD4, TD5, TD6, TD13, TD14
	Jobs	**3**	4	12		3	9		Montreal area
	Origin of labour	**4**	5	20		5	20		Province of Québec, TA7, TD12
	Risk of overstepping project deadline	2	5	10		3	6		TA3, TA6, TA8, TD9, TD15
	Commercial navigation	1	5	5		3	3		TA12
ENVIRONMENTAL	Water quality	**3**	3	9	**31**	3	9	**35**	No significative impact
	Greenhouse gas emissions	**2**	1	2		3	6		TA10, TD1
	Biodiversity	**3**	3	9		3	9		Neutral
	Contaminated soil and sediment	**2**	5	10		5	10		No manipulation of soil
	Consumption of resources/Residual materials	**1**	1	1		1	1		Neutral
SOCIAL	Recreational navigation	**1**	5	5	**35**	4	4	**48**	TA12
	Nuisances	**4**	2	8		3	12		TA13, TD2, TD3, TD9
	Social adhesion	**3**	2	6		4	12		TD2
	Health and Safety	4	3	12		3	12		TD9
	Knowledge / Innovation	4	1	4		2	8		Known methods
Total points obtained *			Road transport		**176**	Marine transport		**167**	

*** see graphical representation of results for visualization by component**

5.5 ANALYSIS AND CONCLUSION

Multi-criteria evaluation shows that truck transport is the best option from the technical and economic standpoint. Both truck and marine transport score the same from an environmental perspective, but marine transport scores higher for the social criterion.

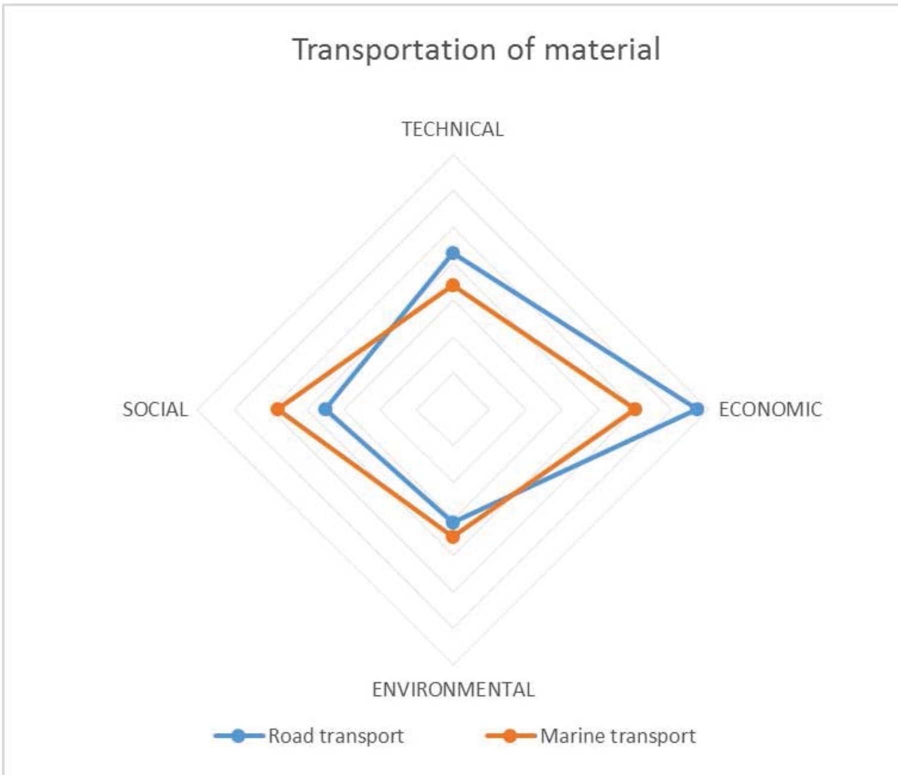


Figure 121 – Comparative Analysis – Transportation of Materials

The above indicates that there is no real alternative to truck transport. This mode is simpler, more flexible and much less expensive, especially for demolition and recycling companies in the Montreal area. It allows for the transportation of all the deconstruction materials.

Marine transport should also be expected to play a role in the dismantling process. Marine transport equipment (barges and tugs) is often “leased” on a monthly basis for the duration of the project. Since the equipment will already be on site for the demolition of certain sections, such as the piers, transportation activities should be combined to take full advantage of the lease.

In the next project stages, it will therefore be important to take a closer look at the deconstruction operations that call for the use of barges and tugs, to see which work scenarios minimize costs by using the same equipment for deconstruction and transportation activities.

As indicated in the text, and barring exceptional circumstances, we do not foresee the use of rail transport for this project.

Finally, we believe that after having set the project conditions and constraints, JCCBI should allow competitive forces in the transportation market so as to obtain the best conditions for project execution.

6 MATERIALS RECOVERY

6.1 BACKGROUND

Standard practice for the recovery of deconstruction materials from public infrastructure in Quebec is greatly influenced by the *Québec Residual Materials Management Policy 2011-2015*, which sets a recycling or recovery target of 80% for waste concrete, brick and asphalt. Another influential guidelines for the management of concrete, brick and asphalt from construction and demolition work (*Lignes directrices relatives à la gestion du béton, de brique et d'asphalte issus de travaux de construction et de demolition*), was published in 2009 by the MDDELCC.

To a lesser extent, the *Federal Sustainable Development Strategy for Canada 2013-2016* identifies targets and implementation strategies that could have an impact on the recovery of deconstruction materials from federal projects:

- 7.1.1.5. Manage construction, renovation and demolition waste in Crown-owned buildings in an environmentally responsible manner ;
- 7.3.1.8. Minimize all non-hazardous solid waste generated and leverage service offerings to maximize the diversion of waste.

The *Federal Sustainable Development Strategy (FSDS) 2016-2019* is presently at the public consultation stage, but does not include any additional measures for the recycling of materials from demolition.

Thus, for a bridge structure, standard practice involves removing the secondary elements (light stands, safety barriers, signage), scarifying the asphalt, crushing the concrete components on site to extract the reinforcing steel, and cutting the major steel elements into easily transportable sections. The steel components are then shipped to foundries for recycling, and the concrete and asphalt are recycled in accordance with the above-mentioned guidelines. While in the past structural elements could be left in place when they did not conflict with the new structures (see Figure 122), current practice tends to remove such structures if they cannot be incorporated into a specific development project.

Figure 122 – Abandoned Structural Elements in Trois-Rivières (source: Google Earth 2016)

In the context of the current mandate, JCCBI has clearly expressed its desire to explore more ambitious recovery options. Other possible uses of full elements of the existing Champlain Bridge (beams, piers, modular trusses, sections of the steel structure, etc.) should therefore be considered, along with other ways of repurposing the materials than the standard approach recommended in the MDDELCC guidelines.

6.1.1 MATERIALS

Section 2.3.5.3 provides a thorough description of the types of materials for which recovery options should be explored. In decreasing order of volume, these materials are:

1. Concrete (girders, deck, piers, pier caps, footings...) ;
2. Steel (Section 6 of the bridge, reinforcing steel, cables, stiffeners, orthotropic deck, etc.) ;
3. Asphalt ;
4. Aluminium (light stands, oversized signs, etc.) ;
5. Carbon fibre ;
6. Miscellaneous components (neoprene bearings, street lights, rubber cable sheaths, PVC drain, etc.).

Given that the first three materials likely represent over 80% of the volume to be recovered, the options explored will mainly focus on them.

6.1.2 QUANTITIES

The technical feasibility of some of the options explored will be closely linked to the ability of certain stakeholders and industrial sectors to recover the volumes of materials generated by the deconstruction of the existing Champlain Bridge. For the purposes of this mandate, the quantities considered are as follows:

1. Concrete: 253,031 t
2. Steel: 17,567 t
3. Asphalt: 11,764 t

In addition to the tonnage of material, the following data should also be borne in mind:

- Section 5:
  - 40 spans of 7 concrete girders = 280 girders some 53 m long by 3 m high ;
  - 24 cables per span = 960 prestressed cables.
- Section 7:
  - 10 spans of 7 concrete girders = 70 girders some 53 m long by 3 m high ;
  - 210 prestressed cables.
- Section 6:
  - 9 spans for a total of 31 steel girders ;
  - Girders ranging from 49 m to 117 m long ;
  - Girder ranging from 9 m to 32 m high.
- 90 recently installed modular trusses and 4 auxiliary girders.
- Many dozens of light stands.

6.1.3 POTENTIALS CONSTRAINTS

Aside from the constraints of the natural and human environments presented at the beginning of the report, the main general constraints to be considered in identifying materials recovery options are as follows:

- Contamination of the materials (e.g., de-icing salt in concrete, lead paint on steel, etc.) ;
- State of certain components (girders, piers, etc.) ;
- Capacity to transport major pieces off site for re-use ;
- Capacity of the demolition materials recycling industry.

As the work progresses, certain constraints may prove decisive, and may determine the feasibility of some options.

Finally, the reader should be aware that some of the options identified could be beyond JCCBI's control depending on the choice of execution method. For example, supplying materials for artworks or full components for other building projects largely depends on the market at the time that the work is taking place, and may not occur.

6.1.4 INDUSTRIES OF POTENTIAL INTEREST

The materials of the existing Champlain Bridge are of interest to various industries in the Montréal region. In fact, given the current high level of construction activity in the city, there are good opportunities for materials recovery, and partnerships should be developed to maximize them. While not exhaustive, the following is a list of the types of projects that, due to their location and timeframe, constitute opportunities for JCCBI:

- The *Réseau Électrique Métropolitain* (light rail) ;
- Road infrastructure reconstruction ;
- Large residential development projects.

Such projects can represent recovery opportunities both in terms of the materials they require and the space they liberate.

6.1.5 OBJECTIVES

The objective of this area of study is to perform a generic analysis of the advantages and disadvantages of the options considered, up to the last link within JCCBI's control. While many possible end uses for the materials and elements of the existing Champlain Bridge will be discussed, there can be no assurance that the market will have the necessary desire or capacity in relation to those end uses when deconstruction actually takes place. However, recommendations can be formulated based on successful experiences of a similar nature to inform JCCBI's consideration of this aspect during future stages of the existing Champlain Bridge deconstruction project.

6.2 STAKEHOLDERS AND PARTNERS

Stakeholders were initially identified on the basis of the documentation made available to the Consortium. JCCBI had also already identified some stakeholders in the request for proposals document. For this field of study, however, the definition of stakeholder was broadened to identify participants who could offer pertinent information or expertise to clarify certain issues or constraints specific to materials recovery.

Stakeholders were grouped into five broad categories: *Governance* (governments, band councils, municipalities, elected officials, etc.), *Community* (local residents, community groups, environmental organizations, etc.), *Users* (car drivers, fishermen, pleasure boaters, etc.), *Economic Partners* (SLSMC, suppliers, subcontractors, workers) and *Experts* (industry associations, research centres, laboratories, etc.). Table 72 below provides an overview of the stakeholders applicable to materials recovery.

Table 72 – Stakeholders – Materials Recovery

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

Section 8 of this report contains an assessment of stakeholders' influence, along with the outcome of approaches made to the most influential among them.

In addition to approaching influential stakeholders, certain experts were contacted to obtain information relevant to the project. A summary of the discussions was prepared in each case to record the information. The summaries can be found in Appendix 4.

6.3 RECOVERY OPTIONS

6.3.1 RETAIN AND TRANSFORM PARTS OF THE EXISTING STRUCTURE

This set of options relates to retaining elements of the existing Champlain Bridge, either in their current state or repaired, and conserving or transforming them for tourist, ecological, cultural or even economic ends. Some possible options are listed below, and are more fully described, with images, in Appendix 5-5.

Table 73 – Options – Retain and Transform Parts of the Existing Structure

DESCRIPTION OF THE OPTION	GOAL	EXAMPLE/PRECEDENT
Retain piers (e.g., 1W) to provide nesting sites (swallows, falcons)	Ecological	
Retain piers (e.g., 1W and 6E) to turn them into observation points	Tourism	Cumberland Park, Nashville
Retain piers (e.g., 1W and 6E) to turn them into climbing walls	Recreational	Landschaftspark, Duisburg
Transform the piers along the banks of the river to install platforms for river access/observation	Tourism/Recreational	River Pedestrian Bridge, Providence
Transform the piers along the banks of the river to support a real estate development project	Economic	Kraanspoor, Amsterdam

This approach reduces the volumes of materials to be handled and thus clearly generates a gain. Furthermore, incorporating retained elements into asset development is likely to generate a high level of social acceptance. However, retention is highly dependent on the condition of structural parts concerned, and may well require manoeuvers that could affect the project schedule. Retaining the structures would also entail operating or maintenance costs. From an environmental perspective, development based on retained elements can be either positive (new natural environments) or negative (intrusive development).

Under Option 6 in Section 7, which maximizes asset development, approximately 15% of the concrete materials and 17% of the steel materials of the existing Champlain Bridge could be recovered using this approach. Based on the market prices for the materials on October 20, 2016, recovery of the remaining materials by off-site recycling would cost approximately [redacted] [redacted] less than the cost of recycling all the materials.

Table 74 – Advantages / Disadvantages – Retain and Transform Parts of the Old Structure

ADVANTAGES	DISADVANTAGES
VA1 – Lower volume of materials to recover and transport ; VA2 – Lower materials recovery cost ; VA3 – Multiple opportunities for new uses (e.g., ecological, tourism, recreational, economic) ; VA4 – Historical and cultural reference (social acceptance) ; VA5 – Local job creation for adaptation work and operation.	VD1 – Dependent on the condition of the structures ; VD2 – Imposes the need for additional investment for the new use ; VD3 – Retaining elements may require the use of methods that affect the project schedule ; VD4 – Imposes operating or maintenance costs ; VD5 – Fewer recycling jobs ; VD6 – May require third party involvement.

6.3.2 IN SITU REUSE OF ELEMENTS OF THE EXISTING STRUCTURE

This set of options involves dismantling elements of the existing structure to use them on site for another purpose. This approach entails a potential gain by limiting the volumes of materials to be transported off site, which is also an advantage for social acceptance of the project. However, it is highly dependent on the condition of the materials, their size and weight. It is also limited by the need for such elements on the immediate work site or on sites managed by JCCBI.

Table 75 shows ways in which bridge structural elements can be reused in urban infrastructure, public art and architectural projects.

Table 75 – Options – In Situ Reuse of Elements of the Existing Structure

DESCRIPTION OF THE OPTION	GOAL	EXAMPLE/PRECEDENT
Reuse parts of the metal structure in building structures (e.g., visitor centre for public areas)	Economic	Big Dig House, Lexington
Reuse lighting equipment	Economic	Turcot Project
Reuse safety barriers	Economic	Turcot Project
Reuse signaling equipment	Economic	Turcot Project
Use elements to erect artworks in public areas	Cultural	City Museum, St-Louis

More specifically, Section 7.3 presents JCCBI asset development projects, some of which propose the re-use of structural elements of the existing Champlain Bridge. Note that one temporary in situ reuse could be strength testing of the various reinforcing elements during deconstruction of the existing Champlain Bridge, which is currently being developed by JCCBI through its Centre for Infrastructure Innovation (CII) and various research centres.

Information available to date indicates that a very small volume of the materials in the existing Champlain Bridge could be recovered in this way. Almost all of the remaining materials would therefore be recovered by off-site recycling, at an estimated cost of $[redacted], based on the market prices of materials on October 20, 2016.

Table 76 – Advantages / Disadvantages – In Situ Reuse of Elements of the Existing Structure

ADVANTAGES	DISADVANTAGES
VA6 – Smaller volume of materials to be transported off site (nuisance effect, GHG) ; VA7 – Fewer handling operations ; VA8 – Less raw material consumption ; VA9 – Generation of new knowledge (strength tests).	VD7 – Dependent on the condition of the elements ; VD8 – Difficulty in transporting large elements (MTMDET restrictions) ; VD9 – Few in-situ users (low potential volume).

6.3.3 OFF SITE REUSE OF ELEMENTS OF THE EXISTING STRUCTURE

This set of options involves dismantling finite components and elements of the existing structure in order to sell them to stakeholders to be used elsewhere than on the work site or sites managed by JCCBI. Descriptions of off-site reuse are presented below.

Table 77 – Options – Off Site Reuse of Elements of the Existing Structure

DESCRIPTION OF THE OPTION	GOAL	EXAMPLE/PRECEDENT
Reuse parts of the metal structure in building structures	Economic	Bay Bridge, San Francisco
Reuse lighting equipment	Economic	Turcot Project
Reuse safety barriers	Economic	Turcot Project
Reuse signaling equipment	Economic	Turcot Project
Use elements to erect artworks in public areas	Cultural	*Huru* by Mark di Suervo, San Francisco
Donate girders and other elements to research centres	Education	
Donation of modular trusses to other partners (MTMDET, municipalities, …)	Economic and cultural	

This approach involves a potential gain by reducing the volume of materials destined for disposal. There is therefore an element of social acceptance, albeit tempered by the need to transport materials off site (nuisances). However, this option is also highly dependent on the condition of the materials and elements involved. It is also very limited for large components given the many existing restrictions placed on their transportation. In addition, there is considerable uncertainty regarding interest for such elements at the local and regional level. It should be noted, however, that at the meeting held on

August 17, 2016, the *Ministère du Transport, de la Mobilité durable et de l'Électrification des transports* (MTMDET) showed some interest in reusing some of the road equipment (light stands, safety barriers, etc.).

According to the information available to date, between 1% and 5% of the materials of the existing Champlain Bridge could be recovered in this way. Based on the market prices for the materials on October 20, 2016, recovering the remaining materials through off-site recycling would cost approximately $[redacted] $ [redacted] less than if all the materials were to be recycled.

To increase the portion of elements reused off site, JCCBI could consider issuing a call for expressions of interest for the elements and materials of the existing Champlain Bridge. This call for interest should be made rapidly in the future stages, as some proposals could have an impact on the planning and execution of deconstruction work. Finally, use of an intermediate site could be considered to store the elements prior to delivery to their site of final re-use, to increase the chances of finding a buyer.

Table 78 – Advantages / Disadvantages – Off Site Reuse of Elements of the Existing Structure

ADVANTAGES	DISADVANTAGES
VA10 – Smaller number of materials handling operations ; VA11 – Lower raw materials consumption ; VA12 – Potential re-use of the road equipment (light stands, signage, safety barriers) ; VA13 – New knowledge (donations to research centres).	VD10 – Dependent on the condition of the elements ; VD11 – Difficulty in transporting large elements (MTMDET restrictions) ; VD12 – High level of uncertainty regarding off-site users (low potential volume) ; VD13 – Potential disturbance from transportation to the final site.

6.3.4 IN SITU RECYCLING OF MATERIALS

This set of options relates to the use of transformed materials from the deconstruction of the existing Champlain Bridge at the work site or at sites managed by JCCBI.

Table 79 – Options – In Situ Recycling of Materials

DESCRIPTION OF THE OPTION	GOAL	EXAMPLE/PRECEDENT
Recycle crushed concrete as fill material or surfacing for service roads	Economic	Turcot Project
Recycle concrete and steel elements for bank stabilization purposes	Ecological	Living Breakwaters, New York
Recycle crushed paving for walking path or bike path	Ecological	Landfill Garden, Providence
Use materials to erect artworks in public areas	Cultural	*ArcelorMittal Orbit*, London

This approach involves handling and sometimes separating the recyclable elements. It has the advantage of reducing the volumes of materials to be transported off site, but is limited by the need for such materials on the immediate work site or at sites managed by JCCBI. Note that the St. Lawrence Seaway Management Corporation (SLSMC), which shares the immediate vicinity with JCCBI, has shown no interest in recycling such materials at its properties.

According to the information available to date, a very small volume of the materials from the existing Champlain Bridge could be recovered in this way. Recovering almost all of the remaining materials by off-site recycling would cost approximately $[redacted] based on the market prices for the materials on October 20, 2016.

Table 80 – Advantages / Disadvantages – In Situ Recycling of Materials

ADVANTAGES	DISADVANTAGES
VA14 – Smaller volume of material to be transported off site (nuisances) ; VA15 – Less raw materials consumption ; VA16 – Greater flexibility in transportation.	VD14 – Few in-situ users (low potential volume) ; VD15 – Requires materials handling/preparation.

6.3.5 OFF SITE RECYCLING OF MATERIALS

This set of options relates to the provision of transformed materials from the deconstruction of the existing Champlain Bridge to third parties for reuse elsewhere than at the work site or sites managed by JCCBI.

Table 81 – Options – Off Site Recycling of Materials

DESCRIPTION OF THE OPTION	GOAL	EXAMPLE/PRECEDENT
Recycle crushed concrete as fill material or surfacing for service roads	Economic	Turcot Project
Recycle concrete and steel elements for bank stabilization purposes	Ecological	Living Breakwaters, New York
Incorporate asphalt and concrete into new pavement (MR)	Economic	
Recycle steel in foundries	Economic	
Use materials to erect artworks in public areas	Cultural	*ArcelorMittal Orbit*, London

This approach requires handling and sometimes separating recyclable elements on or off site. Storing the elements at an interim site before delivery to their place of final reuse could also be considered to increase the chances of finding a buyer.

Multiple discussions with experts in August 2016 suggested that there would be no capacity constraints on the part of the recycling industry to absorb the volumes of concrete, steel and asphalt that will be generated by the deconstruction of the existing Champlain Bridge.

For steel, members of the Canadian Steel Producers' Association, which include a steel mill near Montreal, integrate approximately 7 million tonnes of scrap metal into their production annually. They usually source from scrap metal brokers, some of whom are also found in the Montreal area. Note that some preparation may be required (e.g., cutting to a specific length) depending on the final recycling facility, but in all cases it will be necessary to ensure that the metal pieces are free of lead paint. A detailed study in this regard will be required during a subsequent phase of the project to optimize the recycling process for the steel elements.

For concrete, several experts and recyclers contacted directly said they could absorb up to 100,000 tonnes of concrete annually, mainly on the south shore of Montreal.

According to information available to date, approximately 100% of the materials in the existing Champlain Bridge could be recovered in this way. Based on the market prices for the materials on October 20, 2016, this would cost approximately $[redacted] This estimate is based on expected revenue from the sale of Grade 2 steel (oversized pieces) and the cost of handling the concrete and asphalt with a view to crushing and reuse. Transportation costs are not included as they are considered in the Transportation of Materials field of study. As most steel recyclers require some sort of preparation, including the removal of lead paint, a detailed investigation of the presence of lead on the steel structure of the existing Champlain Bridge is recommended at a later stage to refine this estimate.

Table 82 – Advantages / Disadvantages – Off Site Recycling of Materials

ADVANTAGES	DISADVANTAGES
VA17 – Many local buyers (potentially high volume) ; VA18 – Less raw materials consumption ; VA19 – Greater flexibility in transportation.	VD16 – Large volume of materials to be transported off site (nuisances) ; VD17 – Requires materials handling/preparation.

6.3.6 IMMERSION AND BURIAL

Major structures have been immersed in the past to create underwater habitats (vehicles, ships, concrete beams). This practice is almost exclusively used in marine environments, where the immersion of major structures does not conflict with navigation and water flow. Regardless, this approach has much in common with the off-site re-use considered in Section 6.3.3.

Some of the materials may ultimately need to be buried (rubber, mixed scrap). It should be understood that by “burial”, we are not referring to the use of material for daily cover in landfill sites ; the burial in question involves the total loss of the value of the material.

Strictly speaking, this option does not constitute recovery of the deconstruction materials from the existing Champlain Bridge, and it was therefore not assessed.

6.3.7 REUSE OF SSL FACILITIES AND SPACES

When their condition permits, SSL’s facilities, equipment and workspaces could be reused. This approach could help limit certain mobilization and demobilization activities, thus reducing the associated nuisances (e.g., dikes, handling areas). Extending the use of equipment already put in place by SSL would also have the advantage of extending its depreciation period (e.g., air monitoring stations, barges, cranes, temporary power supply).

At the end of the existing Champlain Bridge deconstruction project, these facilities, equipment and spaces will also have to be recovered on the basis of the options discussed above.

6.4 TECHNICAL EVALUATION CRITERIA

The technical advantages and disadvantages of the options considered are an important means of identifying the technical evaluation criteria. The table below lists the technical criteria considered and those used to evaluate the options.

Table 83 – Evaluation Criteria

	CRITERIA	DESCRIPTION	SELECTED	RATIONALE
1	Volume	Volume of the various materials that can be recovered with this option – Quantitative / Medium accuracy	Yes	
2	Control over the option	JCCBI control over the option – Qualitative / High accuracy	Yes	
3	Timeline	Compatibility of the implementation timeline for the option with the overall project schedule – Qualitative / Medium accuracy	Yes	
4	Transportation	Whether or not the option is limited by transportation constraints – Quantitative / High accuracy	Yes	
5	Market availability	Buyers’ capacity to manage the volumes of the various materials – Quantitative / Medium accuracy	Yes	
6	Value / Revenue	Revenue that could be derived from the recovery option – Quantitative / Low accuracy	No	Difficult to quantify given the uncertainty of volumes to be used by certain options
7	Travel distance	Location of the main buyers for the materials – Quantitative / Medium accuracy	No	Incorporated into criterion 4.
8	Handling operations required	Preparation, transfer and other handling operations required – Quantitative / High accuracy	No	Can be considered part of the Transportation aspect.

6.5 EVALUATION OF OPTIONS

The various options for materials recovery were evaluated using the approach described in Section 3.5, as shown in Table 84. The evaluation was carried out jointly by the materials recovery and asset enhancement teams, supported by PTA social and environmental specialists. A number of assessment workshops were held between August 23 and October 20, 2016.

Table 84 – Multi-Criteria Evaluation of Materials Recovery Options

ANALYSIS GRID PART 3: MATERIALS RECOVERY																	
SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS															JUSTIFICATION / COMMENTS
		WEIGHTING	Retain structures			In situ reuse			Off site reuse			In situ recycling			Off site recycling		
			Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	Score 1 to 5	Weighted score	Result	
TECHNICAL	Volume	3	3	9	41	1	3	28	2	6	21	1	3	31	5	15	46	VA1; VD9; VD12; VD14; VA17
	Control over the option	2	4	8		5	10		2	4		5	10		3	6		VD6; VD9; VD12; VD14; VA17
	Timeline	1	3	3		4	4		3	3		4	4		5	5		VD3; VD12; VA17
	Transportation	3	5	15		3	9		2	6		4	12		4	12		VA1; VD8; VD11; VA19
	Market availability	2	3	6		1	2		1	2		1	2		4	8		VA3; VD9; VD12; VD14; VA17
ECONOMIC	Costs	4	5	20	65	4	16	61	4	16	61	4	16	63	4	16	66	VA2; VD9; VD12; VD14; VD16; VD17
	Jobs	3	4	12		4	12		4	12		4	12		5	15		VA5; VD9; VD12; VD14; VA17
	Origin of labour	4	5	20		5	20		5	20		5	20		5	20		VA5; VA17
	Risk of overstepping project deadline	2	4	8		4	8		4	8		5	10		5	10		VD3; VD7; VD10
	Commercial navigation	1	5	5		5	5		5	5		5	5		5	5		Neutral
ENVIRONMENTAL	Water quality	3	3	9	41	3	9	41	3	9	39	3	9	39	3	9	37	Neutral
	Greehouse gas emissions	2	4	8		4	8		3	6		3	6		2	4		VA1; VA6; VD13; VA14; VD16
	Biodiversity	3	3	9		3	9		3	9		3	9		3	9		Neutral
	Contaminated soil and sediment	2	5	10		5	10		5	10		5	10		5	10		Neutral
	Consumption of resources/Residual materials	1	5	5		5	5		5	5		5	5		5	5		Neutral
SOCIAL	Recreational navigation	1	5	5	65	5	5	57	5	5	57	5	5	49	5	5	45	Neutral
	Nuisances	4	3	12		3	12		3	12		2	8		2	8		VA1; VA6; VD13; VA14; VD16
	Public support	3	4	12		4	12		4	12		4	12		4	12		VA3; VA4; VA6; VA12; VA14
	Health and safety	4	5	20		3	12		3	12		4	16		3	12		VA1; VA6; VD6; VD11; VA14; VD16; VD17
	Knowledge/Innovation	4	4	16		4	16		4	16		2	8		2	8		VA3; VA9; VA13
Total points obtained *			Retain structures		212	In situ reuse		187	Off site reuse		178	In situ recycling		182	Off site recycling		194	

*** see graphical representation of results for visualization by component**

6.6 ANALYSIS AND CONCLUSION

Multi-criteria evaluation for this component of the study yielded the following scores for the five materials recovery options:

1. Retain and transform the structures: 212 points
2. Recycle the materials off site: 194 points
3. Reuse structural elements in situ: 187 points
4. Recycle the materials in situ: 182 points
5. Reuse structural elements off site: 178 points

Before concluding that the best alternative is to retain and transform the structures, it is worth reviewing the highlights of the results, which are described below.

6.6.1 RETAIN AND TRANSFORM PARTS OF THE EXISTING STRUCTURE

The strong result for this option is largely due to its high score for the social evaluation criterion (65) compared to the other options (45 to 57 points). The new uses have a significant social acceptance aspect and are an excellent opportunity to acquire new knowledge. The absence of deconstruction and materials transportation activities also reduces the health risks to workers and road users.

This option also has the best environmental score (41) because it has a favourable carbon footprint compared to the other options.

For the economic criteria, this option ranks second, mainly due to the potential impact on the project timeline. Leaving structures in place, especially metallic structures, may require a more restrictive approach to deconstruction.

Finally, this option also ranks second for the technical criteria, mainly due to the relatively small volume of materials that can be recovered and the extension of the project timeline that may be required to carry out the related development.

6.6.2 OFF SITE RECYCLING OF MATERIALS

This option rates second highest because it has the best score for the technical criteria (46, compared to 21 to 41 points for the other options). The main technical advantages are the potential to recover the vast majority of the materials, compatibility with the project schedule and the market's capacity to absorb the materials.

This option also has the best score (66) for the economic criteria, but by a small margin (scores ranged from 61 to 66). In fact, this is the option that would generate the most jobs.

Similarly, off site recycling of materials yields the worst score (37) for the environmental criteria but again, by a small margin (scores ranged from 37 to 41). The main disadvantage is the on-site preparation of materials for transportation resulting in high greenhouse gas (GHG) emissions.

Finally, this option rates poorly from a social perspective, gaining the worst score (45, compared to 49 to 65 for the other options). It generates little new knowledge, and the preparation of materials for transportation is expected to cause multiple nuisances.

6.6.3 IN SITU REUSE OF ELEMENTS OF THE EXISTING STRUCTURE

This option is in a tie with the "retain and transform the structures" option for best environmental score (41) due to its favourable carbon footprint.

It ranks second for the social criteria (57), in particular because it offers potential for new knowledge and limits nuisances by keeping materials on site.

The option is penalized, however, by the low potential volume of reused materials, and thus rates poorly for the technical (4th) and economic (5th) criteria. It also scores poorly for the technical criteria due to the difficulties anticipated with the transportation of large parts on the site itself.

6.6.4 IN SITU RECYCLING OF MATERIALS

This option ranks relatively well for the technical (3rd), economic (3rd) and environmental (2nd) criteria, but is heavily penalized for the social criteria (4th). Like the off-site recycling option, this approach generates little new knowledge, and preparation and transportation of the materials is expected to cause considerable a number of nuisances. Moreover, like the option of in situ reuse of structural elements, this option is penalized on the technical and economic levels due to the low potential volume of in situ recycling of materials.

6.6.5 OFF SITE REUSE OF ELEMENTS OF THE EXISTING STRUCTURE

This option ranks lowest, particularly for the technical (5th) and economic (5th) criteria. Its main weaknesses are the low potential volume of material reuse, the difficulties anticipated for the transportation of large pieces, and the uncertainty regarding potential interest in reusing the structural elements.

Nevertheless, the potential volume of off-site reuse of elements of the existing structure could increase if other partners (MTMDET, municipalities, etc.) show interest ; therefore its technical score would be valued.

This option does, however, have a relatively favourable social and environmental assessment (2nd), mainly due to fewer nuisances.

6.6.6 COMPARATIVE ANALYSIS AND CONCLUSION

When placed on the four-axis graph in Figure 123, the quantitative results discussed above indicate that retaining and transforming existing structures provides the best balance of the technical, economic, environmental and social evaluation criteria, followed by off-site recycling, in situ reuse, in situ recycling, and off-site reuse. Thus, comparative analysis does not change the order of preference of the options.

Table 85 – Comparative Analysis – Materials Recovery

OPTION	QUANTITATIVE EVALUATION RANKING	COMPARATIVE ANALYSIS RANKING
Retain and transform the structures	1	1
Recycle the materials off site	2	2
Reuse structural elements in situ	3	3
Recycle the materials in situ	4	4
Reuse structural elements off site	5	5

Accordingly, PTA is of the opinion that, insofar as possible, the retention of existing structures should be a key consideration in JCCBI's asset development efforts. Only a limited amount of the materials (about 15%) can be recovered using this approach, however, and off site recycling should be prioritized for the remainder of the materials, with mitigation measures developed in collaboration with the affected stakeholders improve social acceptance.

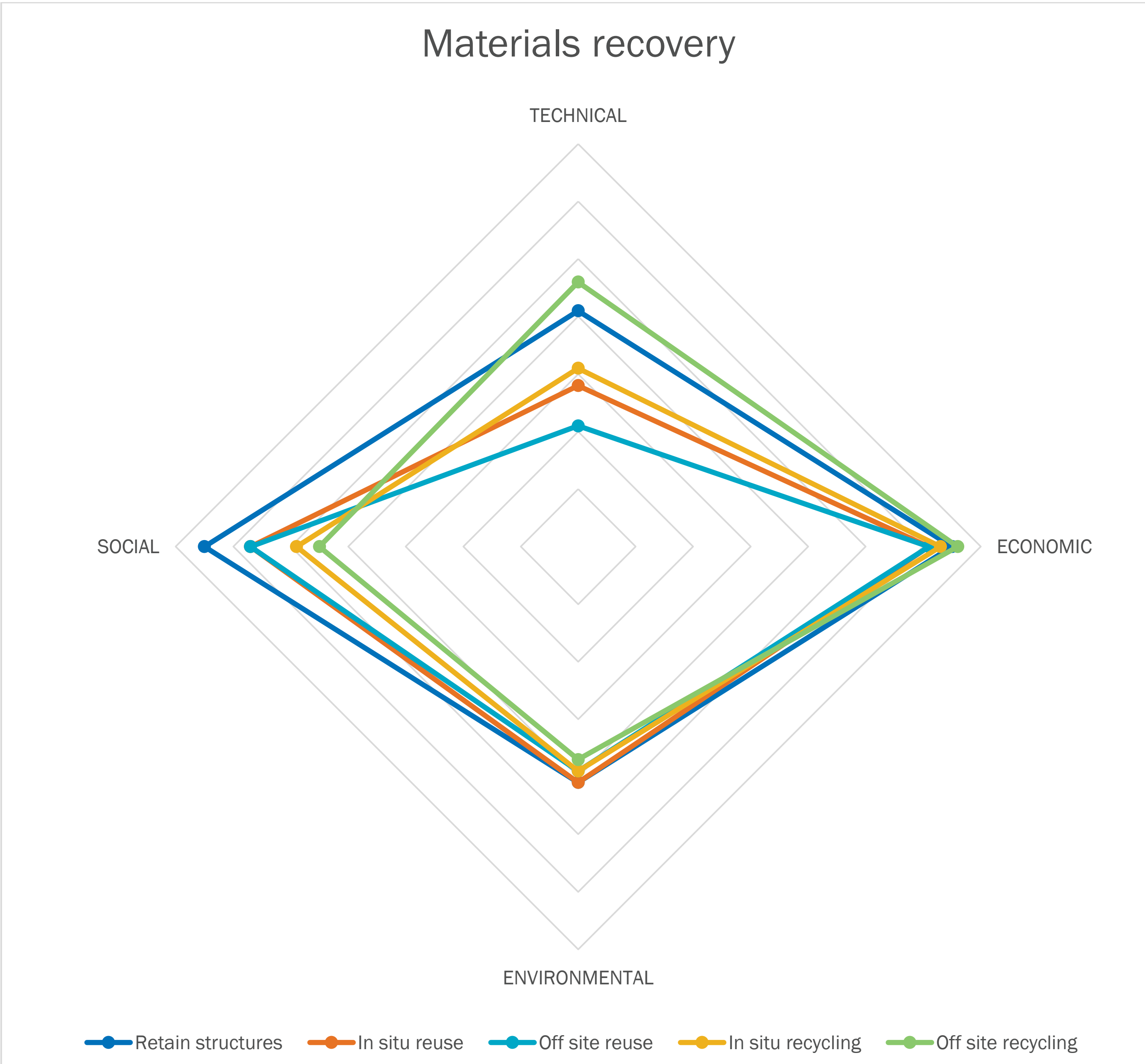


Figure 123 – Comparative Analysis – Materials Recovery

7 ASSET ENHANCEMENT

7.1 BACKGROUND

The Champlain Bridge has been an economic link between the island of Montreal and its surrounding areas ever since it was first built. The commissioning of the new bridge in 2018 will mark the end of useful life of the old bridge as transportation infrastructure. Other cities in the world have faced similar challenges, and have taken bold steps to repurpose obsolete infrastructure rather than destroy it. Given the attributes of the Champlain Bridge, there is no doubt that Montreal could be among the leaders in this area, setting an example for others to follow.

The enhancement process allows the existing infrastructure and associated JCCBI property to be used by acknowledging its value and identifying a second vocation. This approach has a number of potential advantages, including: significant savings due to only partial demolition, a reduction in the amount of waste generated, minimization of work-associated nuisances, development of cutting-edge know-how, and creation of wildlife habitats, not to mention the transformation of the old Champlain Bridge site into a cultural beacon.

This section covers the following aspects: the bridge's setting, which is presented to highlight the strengths and weaknesses of the area and clarify the existing dynamics ; the client's property, which is analyzed in detail to provide a better understanding of the site's specific challenges and opportunities ; various development options, which are presented and assessed using multi-criteria evaluation ; and finally, recommendations.

This section is limited to the JCCBI property, i.e., the bridge and adjoining lands ; opportunities for off-site recovery of the materials are presented in Section 6.

The JCCBI property associated with the Champlain Bridge includes parts of the City of Brossard, the Seaway dike, the St. Lawrence River and Nuns' Island (Borough of Verdun, City of Montreal), as shown in yellow in the figure below.

The JCCBI property associated with the Champlain Bridge includes parts of the City of Brossard, the Seaway dike, the St. Lawrence River and Nuns' Island (Borough of Verdun, City of Montreal), as shown in yellow in the figure below.

Figure 124 – JCCBI Property and its Setting (source: JCCBI)

7.1.1 PROJECT SETTING

7.1.1.1 Metropolitan Setting

The Champlain Bridge is an integral part of the *Communauté métropolitaine de Montréal* (CMM), an entity that coordinates the development of the 82 municipalities in the Montreal region through the implementation of the Metropolitan Land Use and Development Plan (PMAD). The goal of PMAD is to ensure the competitiveness and attractiveness of the Greater Montréal area from a sustainable-development viewpoint, by defining policy directions, objectives and criteria[14]. To support this goal, PMAD defines three challenges on which to focus development: land use, transportation and environment (see Table 86).

Table 86 – Land Use and Development Challenges (source: CMM, 2012)

	CHALLENGE	DESCRIPTION
1	Land Use	Greater Montreal must determine the preferred type of urbanization to accommodate the projected growth of some 530,000 people (or 320,000 new households) by 2031, as well as the 150,000 jobs that will be created, keeping in mind that the space and financial resources available are limited.
2	Transportation	Greater Montreal must optimize and develop existing and planned land-transportation networks in order to promote urban consolidation and sustain the growing mobility of goods and people.
3	Environment	Greater Montreal must protect and enhance its natural and built assets (waterways, landscapes, woodland areas and heritage complexes) to foster the area's attractiveness.

The third challenge is of particular relevance to the JCCBI property because it encourages the development of natural areas through measures to protect riverbanks, shorelines, wetlands and landscapes, among other things[15]. Given that JCCBI's property includes portions of riverbank, overlooks the river and crosses sensitive habitats, it might be wise to align JCCBI's work on enhancing the area's appeal with the CMM's objectives (Table 87). Moreover, the PMAD suggests "establishing a metropolitan recreational and tourism network that would be structured around a green and blue belt, thereby allowing residents and visitors to benefit fully from these leisure, cultural and recreational areas".[16]

Table 87 – Policy Direction 3: A Greater Montreal with a Protected, Enhanced Environment (source: CMM, 2012)

OBJECTIVE	CRITERIA
3.1 Protect 17% of the Greater Montreal area	3.1.1 Identification of protected areas, metropolitan woodland areas and forest corridors
	3.1.2 Wetland identification and characterization
	3.1.3 Protection of metropolitan woodland areas and forest corridors
	3.1.4 Adoption of a wetland conservation plan
3.2 Protect riverbanks, lakeshores and floodplains	3.2.1 Floodplain identification
	3.2.2 Protection riverbanks, lakeshores and floodplains
3.3 Protect landscapes of metropolitan importance	3.3.1 Identification of landscapes of metropolitan importance
	3.3.2 Protection of landscapes of metropolitan importance
3.4 Protect built heritage of metropolitan importance	3.4.1 Identification of built heritage of metropolitan importance
	3.4.2 Protection of built heritage of metropolitan importance
3.5 Enhance landscapes and the natural and built environments in a comprehensive, integrated manner, for recreational and tourism purposes	3.5.1 Development of elements of the Green and Blue Belt

[14] http://cmm.qc.ca/fileadmin/user_upload/pmad2012/documentation/20120530_PMAD.pdfMetropolitan Land Use and Development Plan: An Attractive, Competitive and Sustainable Greater Montreal, Communauté métropolitaine de Montréal. CMM, April 2012
[15] Ibid.
[16] Ibid.

Recreation and Tourism

The recreation and tourism development concept presented by the CMM in the PMAD (Figure 125), places the Champlain Bridge outside the main recreation and tourism area. Furthermore, no tourism development nodes/clusters are expected to be consolidated or developed in the vicinity of the infrastructure. The same applies for the proposed recreation and tourism complexes associated with waterbodies and waterfront spaces ; these are far from the bridge, in Boucherville, Lachine and Saint-Anne-de-Bellevue. Nevertheless, the waterfronts of Montreal's South Shore, Nuns' Island and the Island of Montréal are identified as waterbodies and waterfront spaces to be preserved and developed as heritage resources. As JCCBI property includes part of the waterfronts of the St. Lawrence River, this enhancement of the banks should be consider to align with the CMM's intentions.

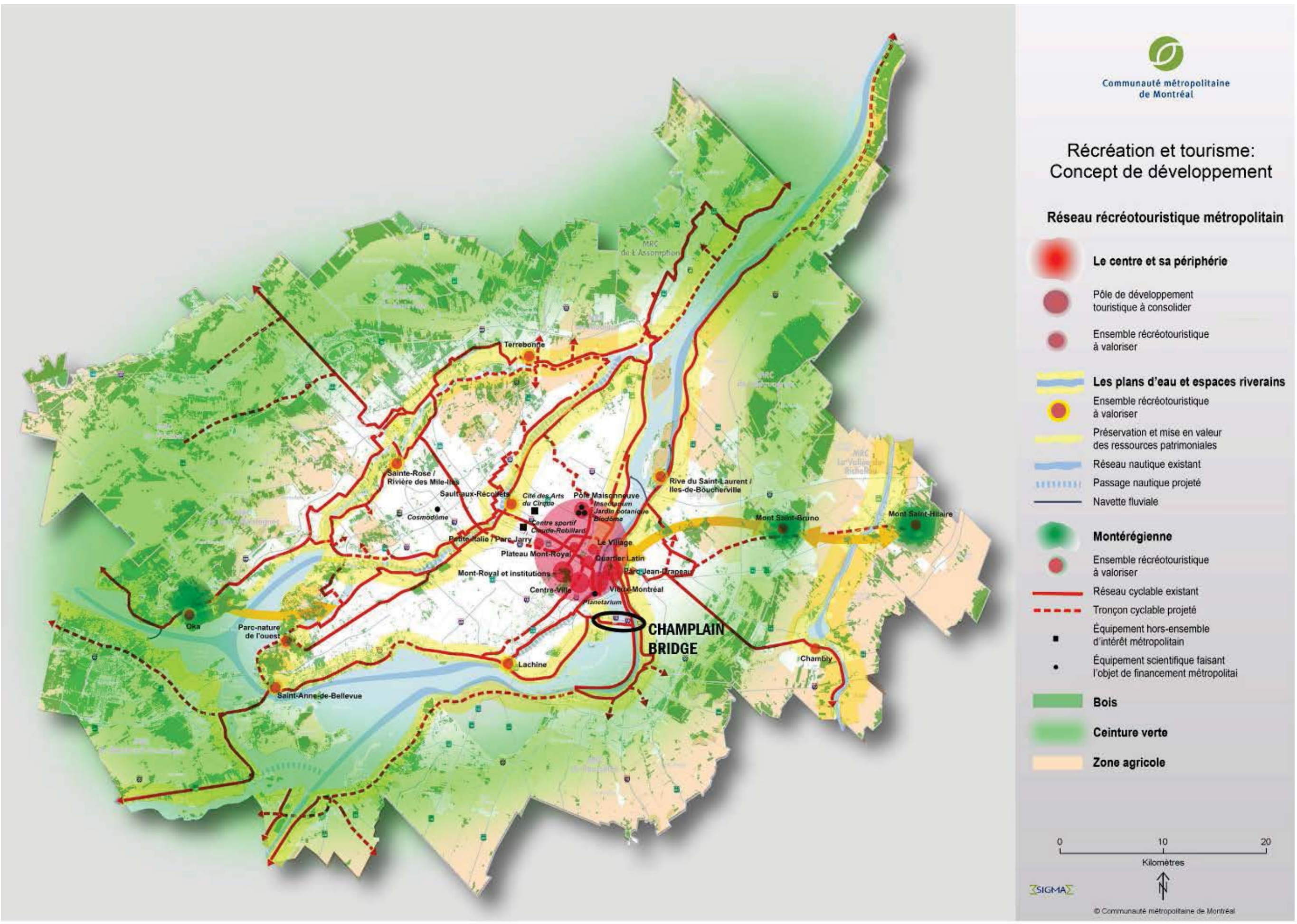


Figure 125 – Metropolitan Recreational and Tourism Network (source: CMM, 2012)

Mobility and Access

Transportation is one of the challenges defined in the PMAD, for drivers, transit users, cyclists and pedestrians alike. As Montreal is an island, the quality and the type of link between the two banks of the river are critical to Greater Montreal's connectivity. The figure bellow shows the components of the metropolitan road network, including multiple links between the South Shore and the City of Montréal: the Lafontaine Tunnel (Highway 20/25), the Jacques Cartier Bridge (Route 134), the Champlain Bridge (Highway 10) and the Mercier Bridge (Route 138) ; the Jacques Cartier Bridge and the new Champlain Bridge are the only two that offer an active mobility link.

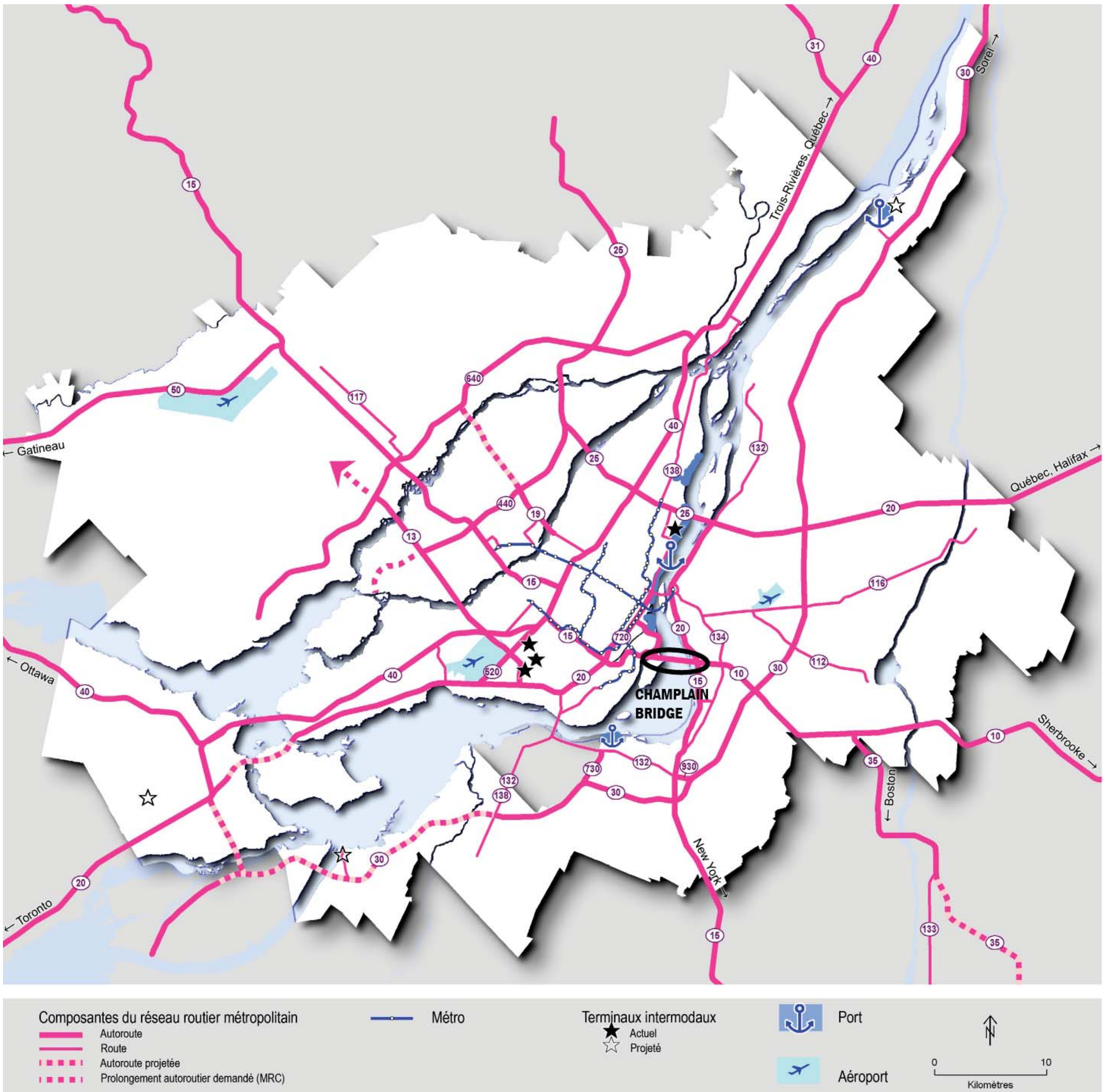


Figure 126 – Map of the Metropolitan Road Network (source: CMM, 2012)

The current transit system does not allow for easy access to the bridge. Neither Nuns' Island nor Brossard has a metro station. This is likely to change with the construction of the light rail transit (LRT) line being promoted by the *Caisse de depot et placement du Québec*. Figure 127 indicates that the North Shore, Laval, Montreal West, downtown Montreal, Nuns' Island and Brossard will all be served by the new transit system. In fact, there will be an LRT lane on the new Champlain Bridge and a new station on Nun's Island, a welcome addition in terms of asset enhancement, providing new ways of accessing the area around the JCCBI site.

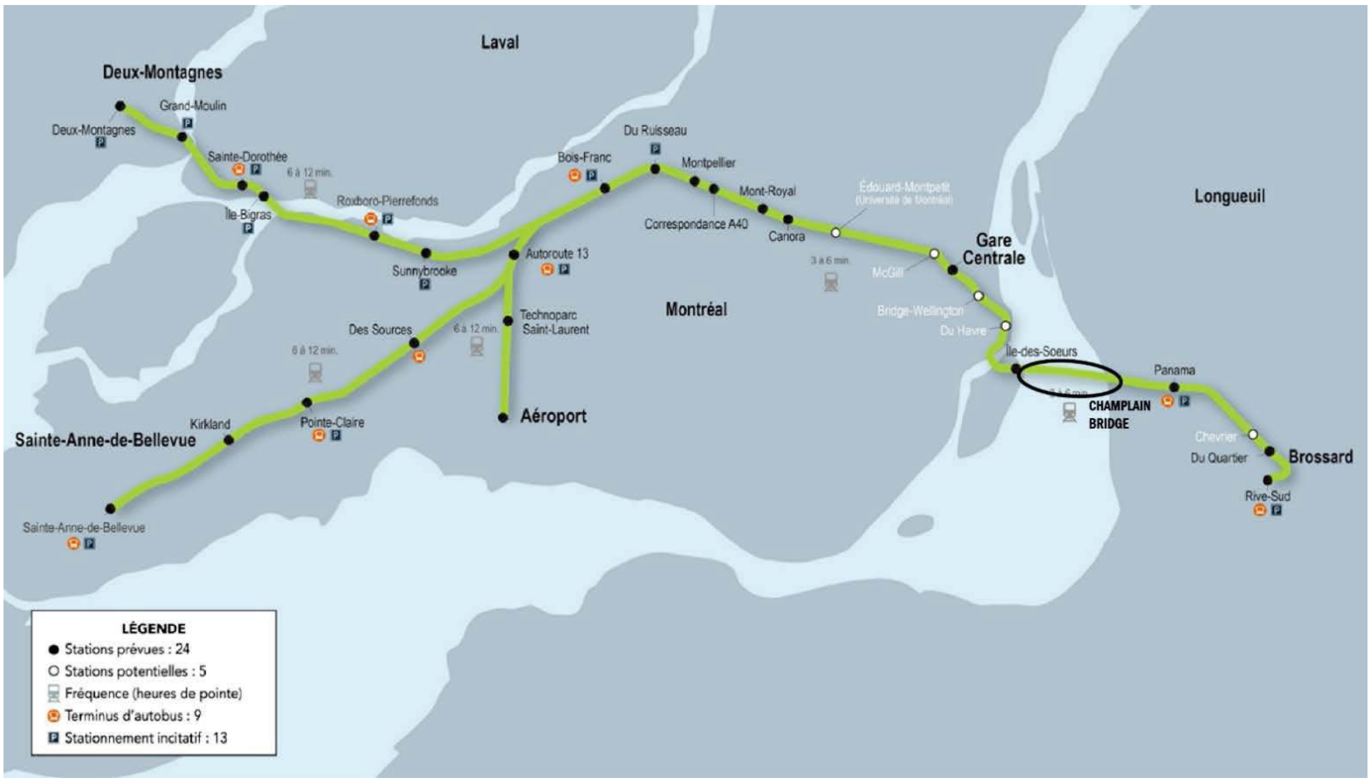


Figure 127 – Réseau électrique métropolitain (REM) (source: CDPQ Infra, 2016)

In terms of active mobility, there is an extensive bike network on the CMM's territory. Called the *Route Verte*, it is an important tourist asset, linking many regions of Québec and often associated with specific services for cyclists. None of the cyclist rest areas or services are in the vicinity of the Champlain Bridge, however. As Figure 128 shows, the network runs along the southern part of the St. Lawrence River and leads into Montreal, crossing either the Jacques Cartier Bridge, the Seaway via the Saint-Lambert locks and then the Concord Bridge, or the Champlain Bridge Ice Control Structure via the Seaway dyke. These routes then provide access to both to the Old Port and the waterfront heading out to the West Island.

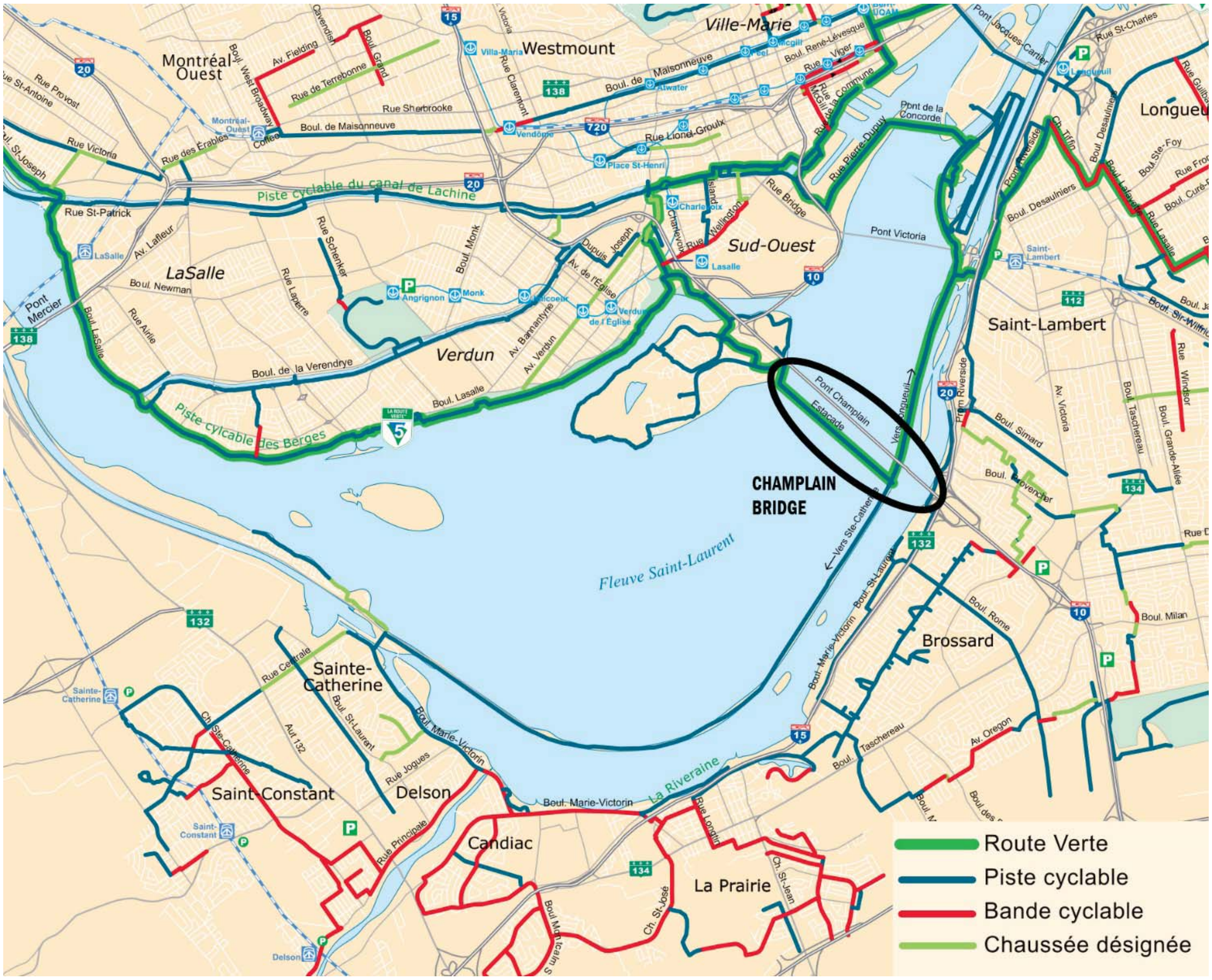


Figure 128 – Extract of the Greater Montreal Bikeway Map (source: Vélo Québec.ca, 2010)

Access to the Champlain Bridge Ice Control Structure (estacade) to cross the river from the South Shore is complicated. Users can either take the *Route Verte*, which means passing through the Saint-Lambert locks, or use the Sainte-Catherine locks. In both cases, this involves travelling a long distance to access the Ice Control Structure, rendering a portion of the JCCBI property difficult to access for many potential users. As indicated in blue on the map, bike paths along the waterfront in Brossard and Nuns' Island provide access to both to the river and the surrounding areas.

Note that there are river shuttles between the South Shore and the City of Montreal that provide access to points of interest, as shown in Figure 125 but they are far from the JCCBI asset.

Green and Blue Belt

The elements of recreation and tourism interest presented above are defined by various environmental and wildlife concerns in the St. Lawrence River corridor, as shown on the map of the Green and Blue Belt (Figure 129). A series of protected areas can be seen along the St. Lawrence River, such as the Bouchard, Sainte-Thérèse and Grosbois islands. For the most part, these areas extend into the area south of the St. Lawrence River. There are also protected areas in parts of the Nuns' Island waterfront, as well as on a section of the river west of the bridge. The PMAD identifies many areas of regional interest, but the Champlain Bridge is a special case, because it is the only place with areas of interest on opposite banks of the river, facing each other.

This figure also shows the *Grand Bleu*, a circuit for pleasure boating and enhancement of the St. Lawrence River in the CMM. The *Grand Bleu* is an extensive network that includes the JCCBI property.

Overall, the PMAD reveals the many interests associated with developing this asset, for the quality of its existing landscapes and the recreation and tourism network of which it is part, as well as for the important role it plays in the environment.

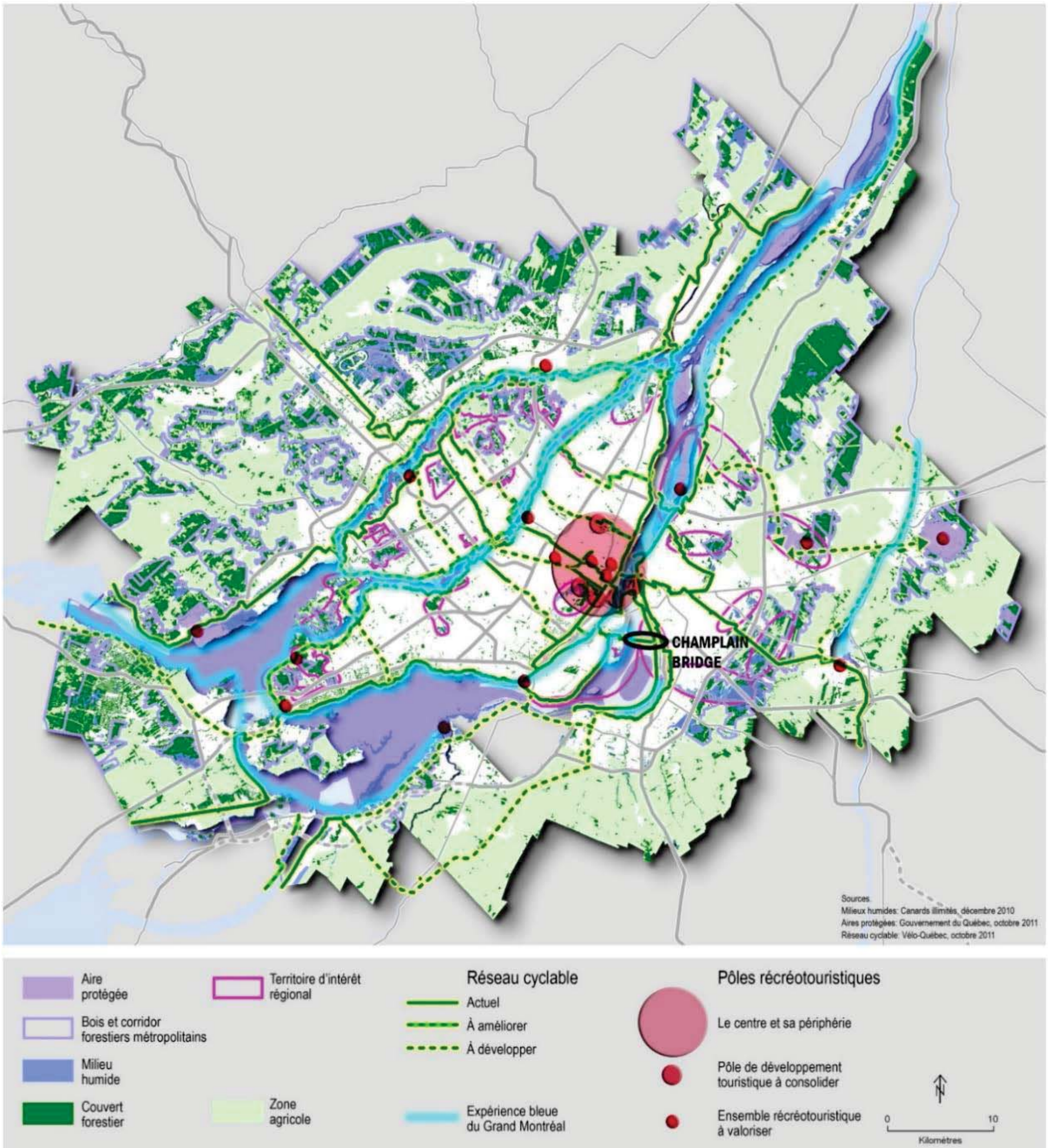


Figure 129 – Green and Blue Belt (source: CMM, 2012)

To tackle the various challenges, the CMM proposed to create the Green and Blue Belt, which combines elements of landscape, natural and heritage interest. Five metropolitan projects were proposed for the development of the belt, including one that directly targets the eastern portion of the JCCBI property, namely:

- Creation of a linear park and beaches on the Seaway dike.

The Greater Montreal Green and Blue Belt plan proposes to turn the entire Seaway dike from Saint-Lambert to Sainte-Catherine into the “Parc-plage du Grand Montréal” (see Figure 131).

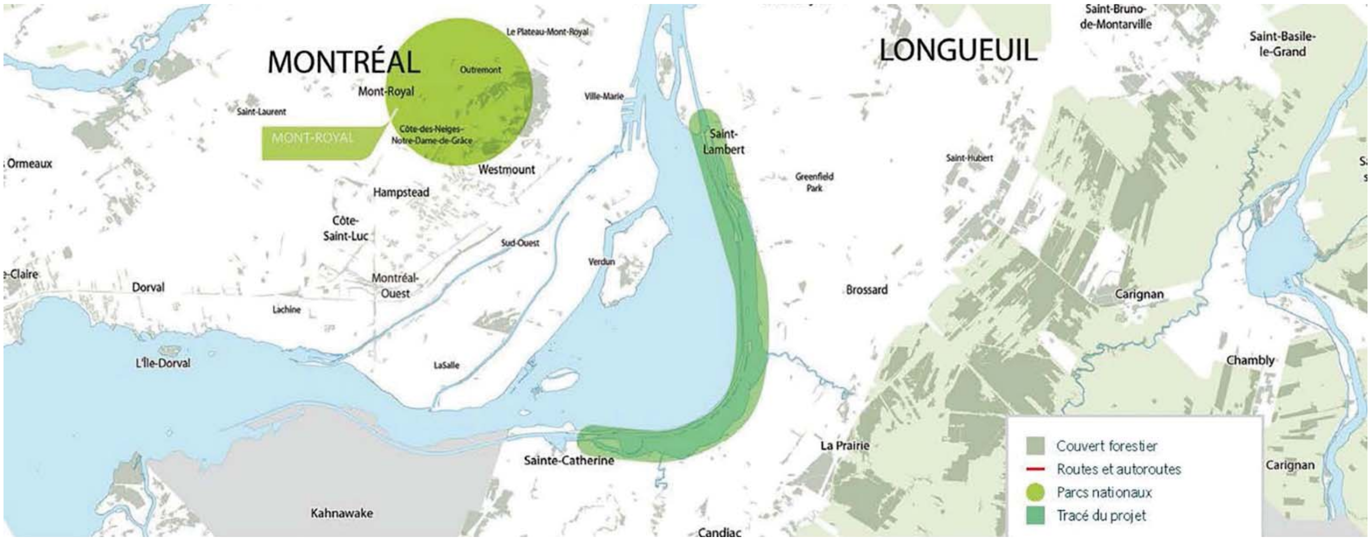


Figure 131 – Creation of a Linear Park on the Seaway Dike (source: CMM, 2013)

In connection with this, the CMM has set up a financial assistance program to support site development and encourage the protection and enhancement of natural environments. A series of investments has already been made under the program, including the development of a beach on the western portion (Récré-O-Parc), at Saint-Catherine.

In 2016, the CMM set out the details of its vision for the area in a master plan for the development of the Seaway dike Appendix 5-1). In the plan, the CMM identifies three activity nodes and four characteristics specific to the segments between the nodes (Figure 130). The portion of the dike from the Champlain Bridge to the Victoria Bridge is slated as an “urban” sector, with multiple activities linked by trails and a shuttle service. The CMM is also proposing a beach south of the Ice Control Structure and an agora under the new Champlain Bridge. This proposed development does not extend to the JCCBI property associated with the old Champlain Bridge, which is simply labelled as the “New Champlain Bridge Work Area”.

This is an opportunity for JCCBI to take the lead and propose new elements that would complement the CMM’s proposal.

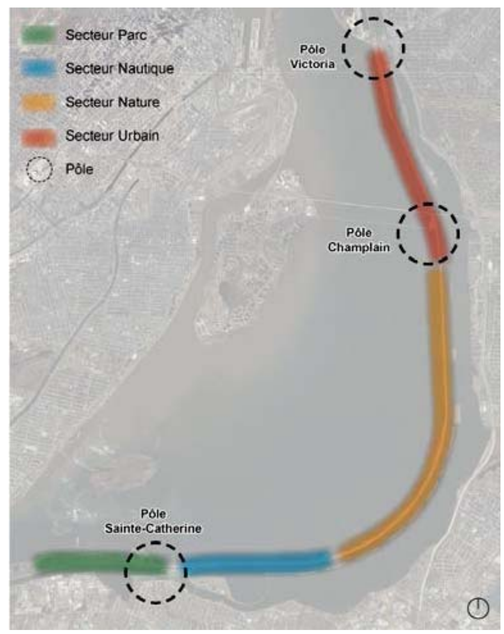


Figure 130 – Dike Enhancement Concept (source: CMM, 2016)

7.1.1.2 Local Setting

The map below shows the JCCBI property relative to the local municipal boundaries. As it shows, part of the old Champlain Bridge is located within the territory of the City of Brossard (Longueuil), including part of the waterfront on the city side and part of the Seaway dyke, and the other part is on the shores of Nuns' Island (Borough of Verdun, City of Montréal).

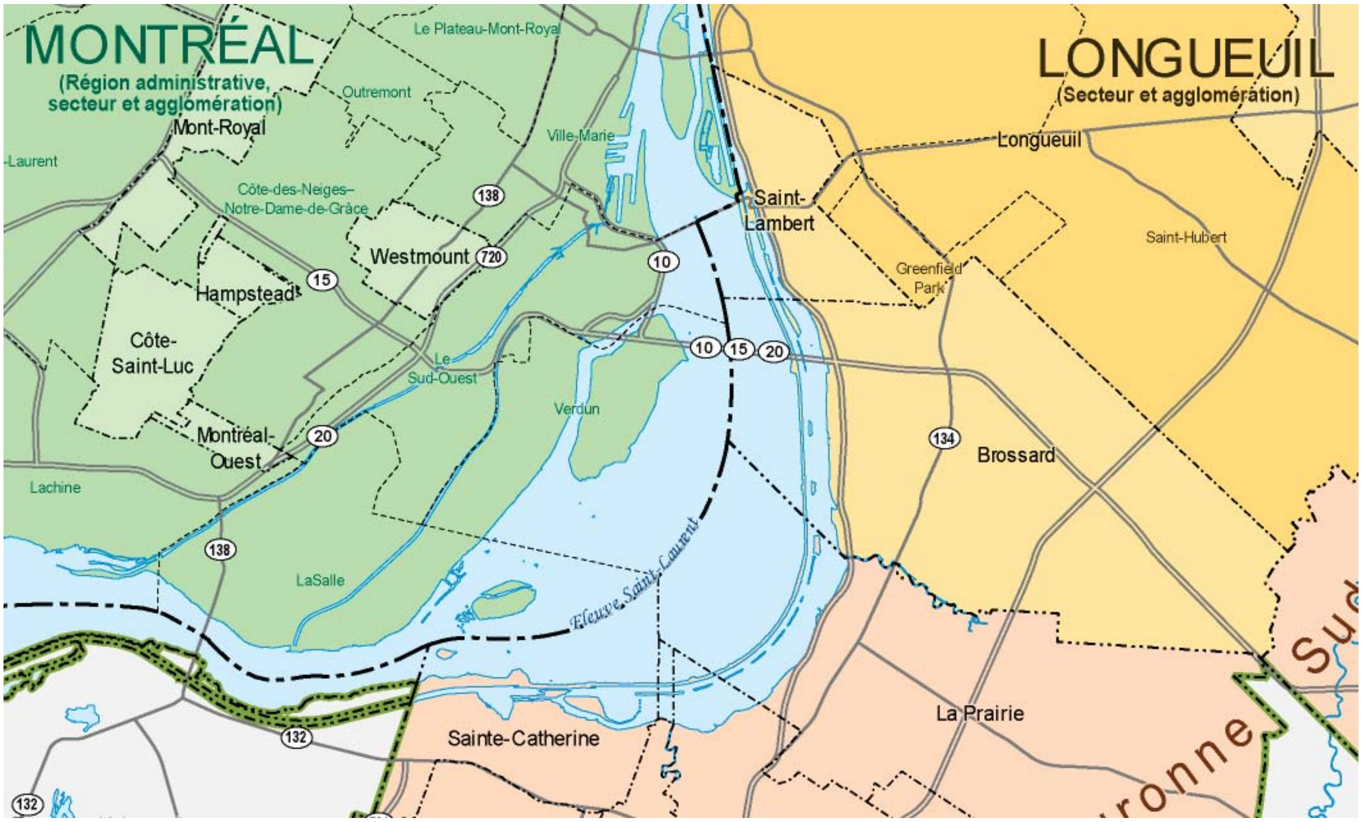


Figure 132 – CMM Municipal Boundaries (source: CMM, 2015)

Brossard is in the peculiar situation of having its riverfront cut off from the rest of the city by Route 132 (Figure 132). This road runs along the St. Lawrence River from Longueuil to Candiac, limiting access to the JCCBI site from Brossard. The site is in fact very difficult for all users to access ; while the Longueuil transportation network (RTL) has bus stops nearby, there is no formal way to access the bridge. The only defined option for getting to Brossard's waterfront is the bike path. As for the Seawall dike, there is simply no direct way to access it from the town of Brossard.

The City of Longueuil's vision for local development is presented in its land use plan (Appendix 5-2; extract in Figure 133, below).

Figure 133 – Extract from the Map of Main Land Uses (source: City of Longueuil, 2016)

This plan presents the surroundings of the Champlain Bridge, and clearly illustrates that the main use is residential. Multifunctional areas, meaning those with various types of activities, mainly stores, offices and community services, are located at the intersection of Highway 10 and Highway 30 and at Boulevard Taschereau. The Brossard waterfront associated with the JCCBI assets is assigned for recreational purposes, thus allowing heavy recreational use and community facilities. The dike is zoned for protection and recreational purposes, indicating that the importance of this ecosystem is recognized but that intensive recreational use and community facilities are nevertheless permitted.

Between these two banks, a number of islands can be seen along the Seaway. These are assigned a conservation function, meaning that they are part of fragile natural environments that require protection.

Overall, it can be seen that the JCCBI asset has little interaction with the City of Brossard. Development of the property for recreational purposes is in line with the city's vision, but particular attention will have to be paid to ensuring the sustainability of existing natural areas.

The situation on the Nuns' Island side (Borough of Verdun) is different, as the JCCBI property is not isolated from the commercial and residential communities by a highway. Boulevard René Lévesque, a local street, borders the site and hosts several elements, such as the Ice Control Structure access road and the *Route Verte*. The area around the Champlain Bridge is accessible to various users, including drivers, cyclists and public transit users. Moreover, as mentioned in the previous section, the establishment of a nearby LRT station will improve general access to the area for people from the CMM. Nevertheless, because it is an island, Nuns' Island has little connection to the neighbouring Montreal boroughs.

In terms of the organization of the Nun's Island area, the land use plan shows a very different dynamic from that of Brossard (see Figure 134 or Appendix 5-2).

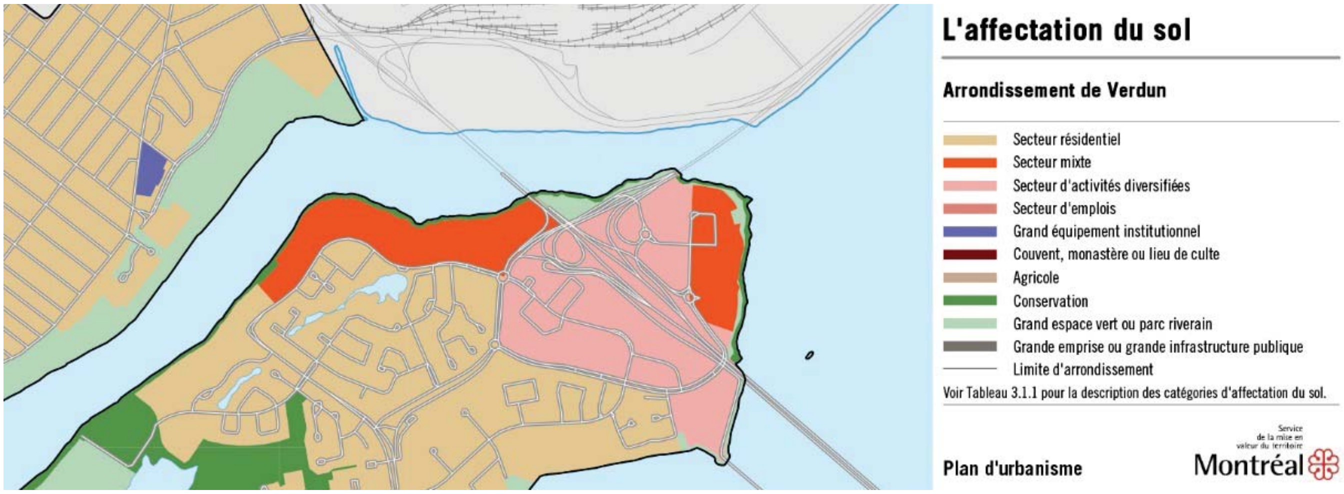


Figure 134 – Nun's Island Land Use Map (source: City of Montréal, 2012)

The southern portion of this area is zoned for residential and conservation uses, while the northern fringe is assigned a mixed use. A mixed area is defined as an area with multiple activities, including shops, offices, light industry, community or institutional facilities and housing (if compatible). However, there is a narrow strip between the Ice Control Structure and the Champlain Bridge that is designated as a large green space or waterfront park, thus allowing for Montreal-scale green and natural spaces. To the north of this band, an area has been designated for conservation, thus supporting biodiversity-enhancing activities. This designation along the Nun's Island waterfront echoes what is found on the Brossard side.

In general, the JCCBI asset is accessible to various users based on different constraints, but must be developed in a way that respects and protects the existing ecosystems.

7.1.1.3 New Champlain Bridge

The federal government awarded the design, construction, financing, operation, maintenance and rehabilitation of the new Champlain Bridge corridor project to the Signature on the Saint Lawrence Group (SSL). Although located near its predecessor, this new bridge will be very different from the current Champlain Bridge, in both appearance and use.

The shape and geometry of the bridge (designed by ARUP, Dissing+Weitling and Provencher_Roy) feature an emblematic design that differs from the architecture of the old Champlain Bridge. With its 170-m high main pylon connected to the deck by a system of stay cables and its series of characteristic pillars, the new bridge will definitely be a feature of Montreal's landscape. No longer reserved for the exclusive use of motorists, the bridge will allow shared use, with a light rail system (LRT) in the central corridor and a separate bike path with a pedestrian strip running alongside. This bike/pedestrian link, shown in Figure 135, will include rest stops with lookouts.

The information provided by JCCBI and SSL does not provide a detailed picture of the planned waterfront facilities at the foot of the infrastructure in Brossard, on the Seaway dike or on Nun's Island. Nevertheless, Figure 136 shows that an observation area will be built on the Seaway dyke, facing Montreal. In order to offer a cohesive, dynamic development, it would be important to link the old bridge development project with the intentions of the new bridge, to ensure a good fit.

Figure 135 – View of the Multi-use Path (source: New Champlain Bridge, 2016)

Figure 136 – View from the Seaway Dike Looking toward the City of Montreal (source: New Champlain Bridge, 2016)

7.1.2 PROJECT SITE

7.1.2.1 Site description

The site is described in terms of its different dimensions to highlight its characteristic features and asset enhancement potential. Information presented in this section is mainly derived from two preliminary studies on the new Champlain Bridge: the *Pre-feasibility Study Concerning the Replacement of the Existing Champlain Bridge* - Sectorial Report No. 7 - Environmental Aspects. Consortium BCDE, February 2011; and A *New Bridge for the St. Lawrence - Environmental Assessment* - Part 1, Sections 1 to 4 - Project and Environmental Description - Final Version. Dessau, Cima+, March 2013.

Land use

JCCBI lands all consist in large part of mobilization areas owned and operated by the corporation, with the remainder consisting of natural settings along river banks. Mobilization areas cover roughly 33 400 m^2, or about 50% of the land area of the site (see orange areas in the figure below). Given the prime location of the site along the river and close to urban areas and the fact that it is connected to a well-established bike path network, it is useful to reexamine the type of land use with a view toward asset enhancement. This will be addressed in Section 7.3.

The urban land use map for the City of Longueuil presented earlier shows a recreational potential for the land in Brossard on either side of the approach to the bridge. Prior to the start of construction of the new bridge, these lands were partly occupied by the Parc du Pont Champlain, a small recreation park along the river. While this park had to be dismantled to enlarge the JCCBI mobilization area, it seems important to restore the recreational use of this land once construction work is completed.

Figure 137 – Map of JCCBI mobilization areas within the study site's limit

Mobility and access

Bike paths are the main way to access and move through the site, although motor vehicles can access the Nun's Island and Seaway dike portions of the site through the access road reserved for service vehicles that use the Ice Control Structure (estacade). Once on the dike, service vehicles can use the multi-use path.

The bike paths that run through the site are part of the Routes vertes #1 and #3, as well as the City of Montreal and South Shore bike path networks (see map below). These bike paths are generally open from April 15 to October 31, from 6:00 a.m. to 11:00 p.m., so that access to the site using active transportation is restricted to these dates and hours. In addition, the bicycle link between the Seaway dike and Brossard currently involves a roughly 7.2 km detour through the Saint-

Lambert locks, which seriously restricts connectivity for cyclists. Improving this link would enhance the existing bike path network.

The new Champlain Bridge will make it possible to diversify bike links in the area. A dedicated bike path is planned as part of the future bridge route, which will provide a direct link between the South Shore and Nun's Island. No link with the Seaway is planned however.

Pedestrian access is possible from Nun's Island, the Seaway dike and the Route verte #3 in Brossard. However, given the significant distances involved, very few pedestrians use the dike or Route verte #3 to access the site. Public transit access is very limited, the closest stops to the site being along René Lévesque Boulevard on Nun's Island (bus lines 12, 21, 168). The light rail station planned along the highway will provide new ways to access the site.

Figure 138 – Map of road, bicycle and public transit network associated with the site

Concerning the Ice Control Structure, re-enforcement work on the deck and construction of a new dedicated bike path were completed in the summer of 2015. The new dedicated bike path is located on the south side of the structure and a dedicated ramp links it to the dike Figure 139).

Figure 139 – Dedicated bike path on the Ice Control Structure ([redacted]

Biophysical environment

This section provides an overview of the biophysical components of the site, with a focus on the fauna and flora, hydrology, and environmental contamination. It should be mentioned that the various surveys and studies carried out as part of the new Champlain Bridge project and which are used as reference herein do not cover all of the site for which asset enhancement is considered ; data are missing, for instance, on the land and aquatic parts of the site located between the

Champlain Bridge and the Ice Control Structure. Additional surveys and studies will be necessary to complete the biophysical description of the site.

Fauna and flora

Due to its close integration within the St. Lawrence River ecosystem, the site includes and evolves around sensitive natural settings that must be considered when selecting asset enhancement options. Below is a list of sensitive settings and special status species identified as part of the environmental impact assessment for the new bridge over the St. Lawrence River and which will need special attention (see Figure 140 and Appendix 5-4 for a complete description)[17]:

- A protected waterfowl concentration area (Quebec) offshore of Nun's Island to the south of the Champlain Bridge ;
- Several sensitive areas for fish habitat along the shores of the Lesser and Greater La Prairie Basins ;
- Wetlands along the St. Lawrence River banks ;
- A protected migratory bird sanctuary (federal) to the north of Pier 1E of the Champlain Bridge (Île de la Couvée Sanctuary) ;
- The presence of species requiring special attention[18]:
    - Peregrine falcon anatum – vulnerable species: nesting site on the Champlain Bridge ;
    - River redhorse– vulnerable species: found in the river near Nun's Island during migration ;
    - Brown snake – species likely to be designated threatened or vulnerable ; presence noted on the Seaway dike and north of the western Champlain Bridge abutment on Nun's Island ;
    - Rough Bugleweed and American Bugleweed – herbaceous species likely to be designated threatened or vulnerable ; occurrence observed to the east of Nun's Island, on the dike, and along the banks on the Brossard side.

[17] Pre-feasibility Study Concerning the Replacement of the Existing Champlain Bridge - Sectorial Report no 7- Environmental Aspects. Consortium BCDE, February 2011.
[18] Pre-feasibility Study Concerning the Replacement of the Existing Champlain Bridge - Sectorial Report no 7- Environmental Aspects. Consortium BCDE, February 2011.

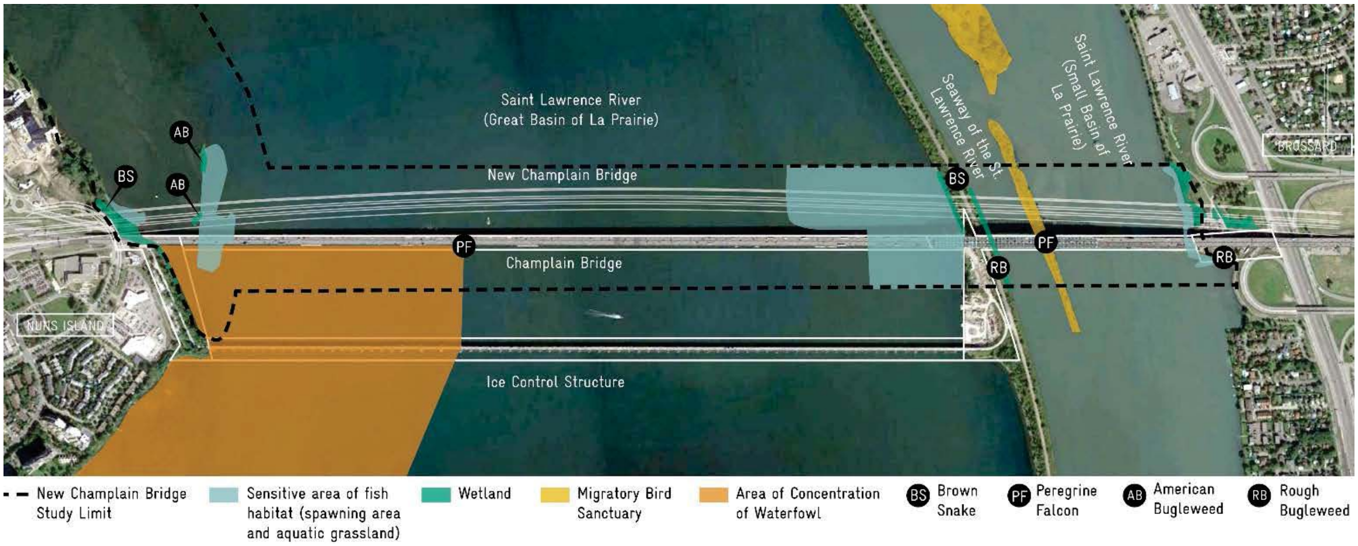


Figure 140 – Map of biophysical settings (source: Dessau-Cima+, 2013)

Aside from these special status species, the site is host to a wide diversity of animals and plants typical of an archipelago setting, as this type of setting provides a wide variety of habitats that lend themselves to high biodiversity, including wetlands, riparian strips, fast- and slow-moving water of variable depth, a variety of substrates, etc.

Hydrology

The portion of the St. Lawrence River located under the bridge, which is the property of the Province of Quebec, is characterized by a range of depths and current velocities (see Appendix 5-4B and Appendix 5-4C). In the Greater La Prairie Basin, water depths range from 3 to 6 m on average between the middle of the St. Lawrence River and the Nun's Island shore, with a main channel characterized by depths ranging from 7 to 9 m and a shallow near-shore area with depths ranging from 0 to 2 m. A few riffles or rocky islets make for tricky navigation on that side of the river. On the dike side, depths range from 1 to 3 m. Current velocity in the Greater La Prairie Basin can by quite high locally, ranging from 1.2 to 1.35 m/s in the channel and around 0.9-1.05 m/s along the shores on the Nun's Island and Seaway dike sides of the river[19].

On the Lesser La Prairie Basin side, the Seaway navigation channel is roughly 9.1 m wide and 8.23 m deep on average, and it is separated from the rest of the basin by islets made of fill excavated during digging of the channel. The average depth of the basin is approximately 2.5 m and ranges from 1 to 3 m (see Appendix 5-4B). As it is physically separated from the river current by locks, the Lesser La Prairie Basin is a flatwater area with nearly no current. The shores of the Lesser La Prairie Basin are 85% manmade and are therefore continually degraded as a result of water level management as part of Seaway facilities maintenance after the end of the navigation season.

It is important to consider the foregoing data on St. Lawrence River hydrology when planning future activities at the site that have a bearing on aquatic settings, and they should serve as guidance in the choice of future actions.

Contamination

Soil analyses indicate moderate sediment contamination in the entire Lesser La Prairie Basin with higher localized point sources. This contamination includes heavy metals, PCBs, and PAHs[20]. Moreover, given the current use of JCCBI mobilization areas, it is highly likely that they contain non-negligible contamination due to the presence of machinery and

[19] id.
[20] id.

the storage of various materials. It will be important to analyze contaminant concentrations for a better characterization of these lands prior to their potential enhancement for purposes described in more detail in Section 7.3.

Landscape characteristics

For a more useful description of landscape characteristics, the site was divided into three areas, namely the Nun's Island, Seaway, and Brossard areas. This allows for a more detailed analysis of ambient conditions and landscape components.

Nun's Island area

Anchored on the western abutment of the existing Champlain Bridge on Nun's Island, this area extends out to the Ice Control Structure further south and comprises the shoreline area between these two structures (see Figure 141). It contains an important active transportation network comprising a bike path section that connects the Nun's Island network with the Ice Control Structure bike path.

Figure 141 – 3D map of the Nun's Island area (source: Google maps)

This waterfront area is mainly characterized by dense and diverse vegetation that contrasts with the surrounding urban setting, and by its elevated position relative to the River, there being a 5 m elevation difference accommodated by a talus with a 30% slope that makes up the interface between this portion of the site and the river. The land adjacent to the bike path has sparser free-growing vegetation, with a mixture of herbaceous, shrubby, and treed strata (see Figure 142). Because of this vegetation, the JCCBI mobilization area is not visible from the bike path, and river views are for the main part obstructed. The view opens up however when approaching the Ice Control Structure, which provides views over the river and its rocky banks (see Figure 143 to Figure 145). The dismantling of the existing Champlain Bridge provides an opportunity to reconnect natural settings along the shoreline and thus strengthen landscape identity on this part of Nun's Island

Figure 142 – Vegetation along the bike path near the Ice Control Structure (source: [redacted])

Figure 143 – Ramp onto the Ice Control Structure bike path (source: [redacted] (picture taken before revegetation)

Figure 144 – Rocky shoreline on the north side of the Ice Control Structure (source: [redacted]

Figure 145 – View of the shoreline on the south side of the Ice Control Structure (source: [redacted])

Seaway area

Stretching from the Seaway dike western shore to the Brossard western shore, this area includes the emblematic steel structure of the Champlain Bridge (section 6 of the bridge) as well as the portion of the Seaway dike located between the Champlain Bridge and the Ice Control Structure (see Figure 146). Linking the Ice Control Structure and the Seaway bike paths (see Figure 147), this area acts as a structuring element for the active transportation network by connecting Nun's Island, the South Shore, Île-Notre-Dame, and Île-Sainte-Hélène.

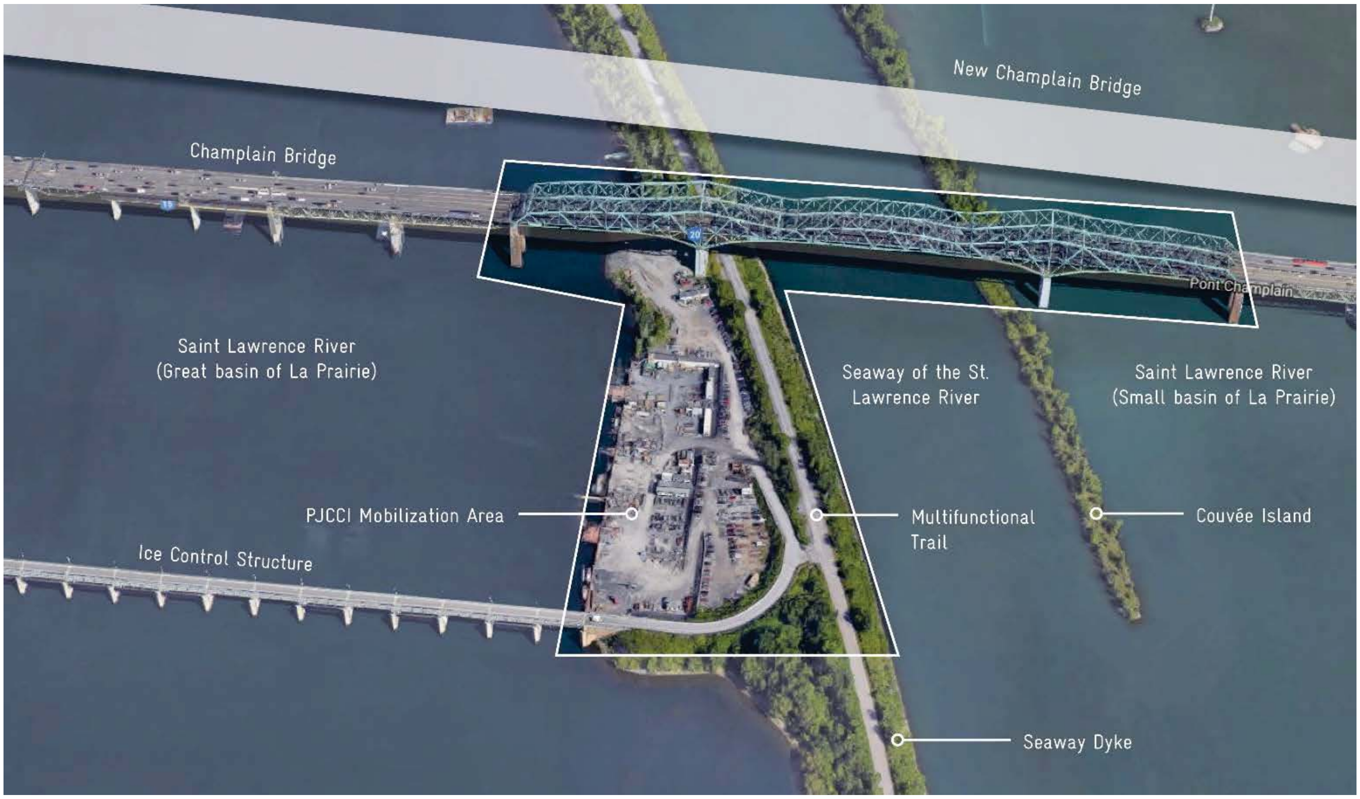


Figure 146 – 3D map of the Seaway dike area (source: Google maps)

The Seaway dike, which is entirely manmade, offers a unique natural setting characterized by a free-growing shrub and poplar-rich tree assemblage along a thin raised strip of land (~50 m wide) with a multifunctional path in its center and vegetated slopes on either side (see Figure 151). Because of this abundant and dense vegetation, the nearby river is visible only in a few places. A few openings are found along the path that provide views of river landscapes, including the Île de la Couvée located immediately to the east (see Figure 149). This vegetation screen has the distinct advantage of concealing most of the JCCBI mobilization area. The interface between this mobilization area and the river consists in part in a retaining wall that rises 1-3 m above water level. An informal trail north of the Ice Control Structure bike path abutment leads to the edge of the river below, where a striking natural pebble beach is located (see Figure 148 and Figure 152) that provides an open view of the river and Nun's Island and direct contact with the water in a very quiet setting. This is one of the rare locations along the dike where there is access to the shoreline.

The portion of the Seaway area located under the bridge structure provides an open area of great interest showcasing the architecture of the bridge and its relationship to the river (see Figure 150). The presence of this structure creates a strong visual reference point along the dike and adds a spectacular dimension to the path due to its imposing scale. The significant contribution of this structure to the landscape of the dike will be emphasized as part of the asset enhancement strategy described later in this report.

Figure 147 – Junction of the Ice Control Structure and Seaway dike bike paths (source: [redacted]

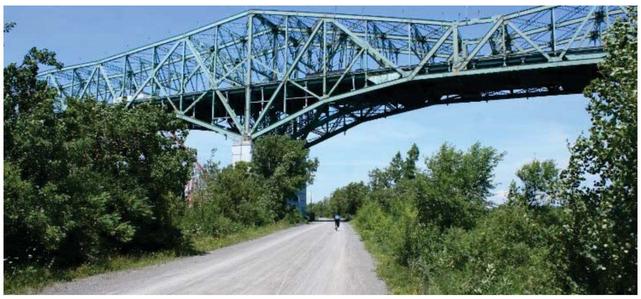


Figure 149 – Open view to Île de la Couvée and the bridge structure further to the East (source: [redacted]

Figure 151 – Vegetation along the Seaway dike multifunctional path (source: [redacted])

Figure 152 – Informal path leading from the Seaway bike path to the edge of the river (source: [redacted]

Figure 148 – Pebble beach on the south side of the Ice Control Structure (source: [redacted]

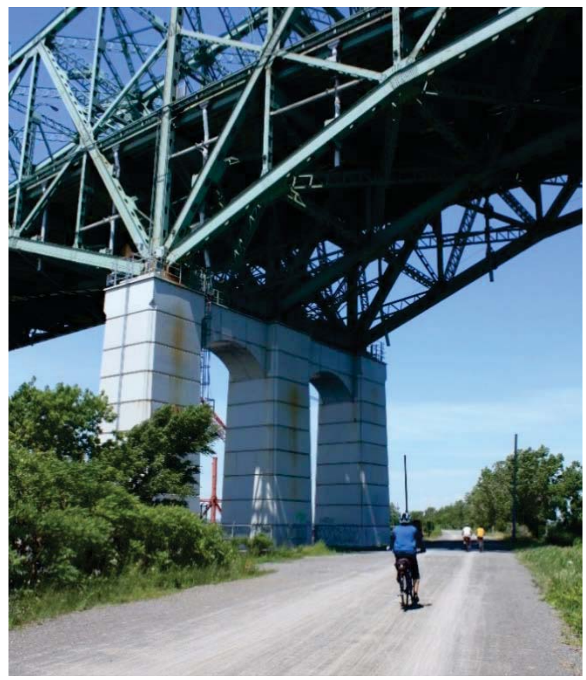


Figure 150 – Multifunctional path near the steel structure of the bridge (source: [redacted]

Brossard area

At the time of writing, this area was for the main part used for construction of the new Champlain Bridge, which restricted visual inspection of the area during the site visit. It was possible to have a look at the adjacent physical setting along the banks because of the access provided by the La Riveraine bike path (Route verte #3) along which it is usually possible to cross under the Champlain Bridge structure along the shore of the Lesser La Prairie Basin.

Figure 153 – 3D map of the Brossard area (source: Google Maps)

Landscapes in this area are mainly characterized by vegetation consisting of a mix of herbaceous species, grasses and shrubs, the composition and configuration of which locally provide ample views onto the river (see Figure 154 and Figure 156). The relationship to the river is easier to perceive in this area because of the smaller elevation difference and the gentler slopes between the water body and the terrestrial environment. Vegetation along the bicycle path is somewhat maintained and controlled to create open areas for cyclists to rest. Plant inventories contained in the Dessau and Cima+[21] report indicate that prior to construction in this area, the shoreline section hosted a marshy area dominated by common reed, an invasive exotic species, which extended toward Route 132 on the North side of the bridge, and a strip dominated by free-growing grasses between this marsh and Route 132 (see Figure 155). The bridge approach on the Brossard side provides ample vertical clearance, which confers a feeling of lightness to the bridge structure.

[21] Environmental Assessment – Part I, Sections 1 to 4 – Project and Environmental Description – Final Version. Dessau, Cima+, March 2013.

Figure 154 – Vegetation along the Brossard bike path North of the Champlain Bridge (source: [redacted])

Figure 155 – Common reed marsh along the Brossard bike path (source: [redacted])

Figure 156 – Opening onto the river in Brossard, North of the Champlain Bridge (source: [redacted])

Figure 157 – Elevated bridge approach on the Brossard side of the bridge (source: [redacted])

Activities

The activity that is most widely practiced on the site is without a doubt biking, due to the presence of an extensive and functional bike path network in a unique natural setting. Other activities are more marginal due to a lack of adequate infrastructure and access to the site.

Nautical activities such as kayaking and canoeing have been noted in both the Greater and Lesser La Prairie Basins. There are two itineraries on the Greater Basin side: a Route Bleue itinerary, called the Tour de l'Île-des-Sœurs, and an itinerary associated with the Point de mire youth center in Verdun. The Tour de l'Île-des-Sœurs goes around Nun's Island in a clockwise direction, starting and ending at the Verdun Marina. On the Lesser La Prairie Basin side, there is only one itinerary: the Route Bleue called Petit Bassin de La Prairie, which links Brossard to Saint-Lambert (see Appendix 5-4D to see these different itineraries). These itineraries all hug the shoreline. Paddling season runs from early May to mid-October.[22]

Given the shallowness of the water and strong currents at the level of the Greater La Prairie Basin, this portion of the river has no marked channel for pleasure and recreational crafts (commercial navigation is strictly limited to the Seaway). Most

[22] Environmental Assessment – Part I, Sections 1 to 4 – Project and Environmental Descriptin – Final Version. Dessau, Cima+, March 2013.

crafts use the Seaway to cross under bridge structures. However, Canadian Coast Guard hovercrafts, the Saute-Moutons Company jet boats and a few dozens of motorized and non-motorized crafts use this part of the river from April to October.[23]

The St. Lawrence Seaway comes under the Navigable Waters Protection Act and, as a result, vessels going through it must comply with certain requirements. Each year, the section of the Seaway located between Montréal and Lake Ontario averages 2,271 motorized pleasure craft passages. Recreational activities such as swimming, waterskiing, fishing, and diving are strictly prohibited in all Seaway canals, as well as its channels, and from its pleasure-boating wharves, locks and their approaches. Sailing is also prohibited.[24]

Angling and fly-fishing are carried out on the site or nearby. In general, anglers access the river near the Nun's Island banks in small motor launches. This activity seems to be quite restricted, with fewer than a dozen fishing boats per day observed during the summer season. Fishing from shore is also done on the Brossard side just north of the Champlain Bridge. In winter, ice fishing is possible near the former Parc du Pont-Champlain in Brossard.[25]

Other activities include windsurfing, rabascaw and water skiing, all done in the Lesser La Prairie Basin. A well-known windsurfing site is located just North of the Champlain Bridge and will be disrupted by construction work on the new bridge. Bird watching is another identified activity, with Nun's Island being known as an important migratory stop for birds, which makes it a favorite spot for professional and amateur bird watchers alike.

Champlain Bridge structure

In order to enhance Champlain Bridge-related assets, it is important to characterize and study its various components and to identify elements of interest for preservation and possible re-use for other purposes. Possible enhancement options for these components are presented in Section 7.3

The most interesting structures for preservation and enhancement are without a doubt those that re associated with section 6 of the bridge, which crosses over the Seaway (see Figure 158). The triangulated steel beam structure is the most symbolic and emblematic element of the bridge thanks to its unique architecture (cantilevered main span) and strong visual presence in the Greater Montreal landscape. Because of the modular nature of this structure, its various steel components can be reclaimed individually for functional and esthetic purposes. The distinctive shape of the concrete piers that support this section of the bridge also makes them interesting. Because of their height and more detailed architecture, they are of interest for in situ preservation and re-use in asset enhancement. The pier that rests on the Seaway dike is in a particularly strategic location with respect to the existing recreational network and warrants special attention. The shaft of this pier, like that of the next pier to the east, is covered in a white steel protective lining.

Sections 5 and 7 of the bridge, which correspond respectively to the western and eastern portions of the Champlain Bridge, are of lesser architectural value (see Figure 159). The series of concrete piers supporting these sections form a repetitive string of massive and unremarkable concrete elements, the shape of which is typical for this type of structure. Some of these piers, however, do have a functional potential, especially those located closer to shore, which can potentially serve as support structures for new facilities or buildings.

[23] Environmental Assessment – Part I, Sections 1 to 4 – Project and Environmental Descriptin – Final Version. Dessau, Cima+, March 2013.
[24] Ibid.
[25] Ibid.

Figure 158 – Section 6 of the Champlain Bridge with its trusses (source: TC Media)

Figure 159 – Western portion of the Champlain Bridge near Nun's Island (section 5) (source: Denis Carl, 2005)

7.2 STAKEHOLDERS

Stakeholders were initially identified on the basis of the documentation made available to the Consortium. JCCBI had also already identified some stakeholders in the request for proposals document. For this field of study, however, the definition of stakeholder was broadened to identify participants who could offer pertinent information or expertise to clarify certain issues or constraints specific to asset enhancement.

Stakeholders were grouped into five broad categories: *Governance* (governments, band councils, municipalities, elected officials, etc.), *Community* (local residents, community groups, environmental organizations, etc.), *Users* (car drivers, fishermen, pleasure boaters, etc.), *Economic Partners* (SLSMC, suppliers, subcontractors, workers) and *Experts* (industry associations, research centres, laboratories, etc.). Table 88 below provides an overview of the stakeholders applicable to asset enhancement.

Table 88 – Stakeholders – Asset enhancement

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

STAKEHOLDER	CATEGORY	DESCRIPTION / RATIONALE
[redacted]		

Section 8 of this report contains an assessment of stakeholders' influence, along with the outcome of approaches made to the most influential among them.

In addition to approaching influential stakeholders, certain experts were contacted to obtain information relevant to the project. A summary of the discussions was prepared in each case to record the information. The summaries can be found in Appendix 4.

7.3 PROPOSED OPTIONS

This section outlines asset enhancement strategies proposed for the dismantling of the existing Champlain Bridge with a view to enhancing land and infrastructure in the JCCBI property. These proposals are based on background information presented in Section 7.1 of this report and on urban infrastructure regeneration projects completed worldwide in which the intrinsic qualities of the site and existing infrastructure components are integrated into new facilities.

Asset enhancement approach

Supported by guidance provided by JCCBI's mission and vision centered on sustainable development as a vector of social and urban improvement, asset enhancement is based on five basic principles that guide and structure the enhancement projects presented in the following section, namely:

1- **To commemorate** the existing Champlain Bridge in order to highlight its symbolic value and etch its history in the collective memory ;
2- **To cast** the strategy within the Communauté métropolitaine de Montréal (CMM)'s vision by highlighting the St. Lawrence River and allowing residents to make theirs its waters and shores ;
3- **To consolidate** and diversify the range of activities and attractions provided along the St. Lawrence River to complement existing opportunities ;
4- **To protect** and develop natural environments, be they aquatic or terrestrial, and raise public awareness about the importance of these environments in an urban setting ;
5- **To strengthen** the existing active transportation system to promote active mobility by implementing actions that enhance what is currently available.

These principles, combined with the identification of site-specific opportunities and constraints (Section 7.1.2), will provide orientations to guide the development of measures to implement on JCCBI property. To ensure consistency, these orientations are subdivided in categories arising from the site analysis, namely land use, mobility and access, the biophysical environment, landscape characteristics, activities, and the Champlain Bridge structure (see Figure 160).

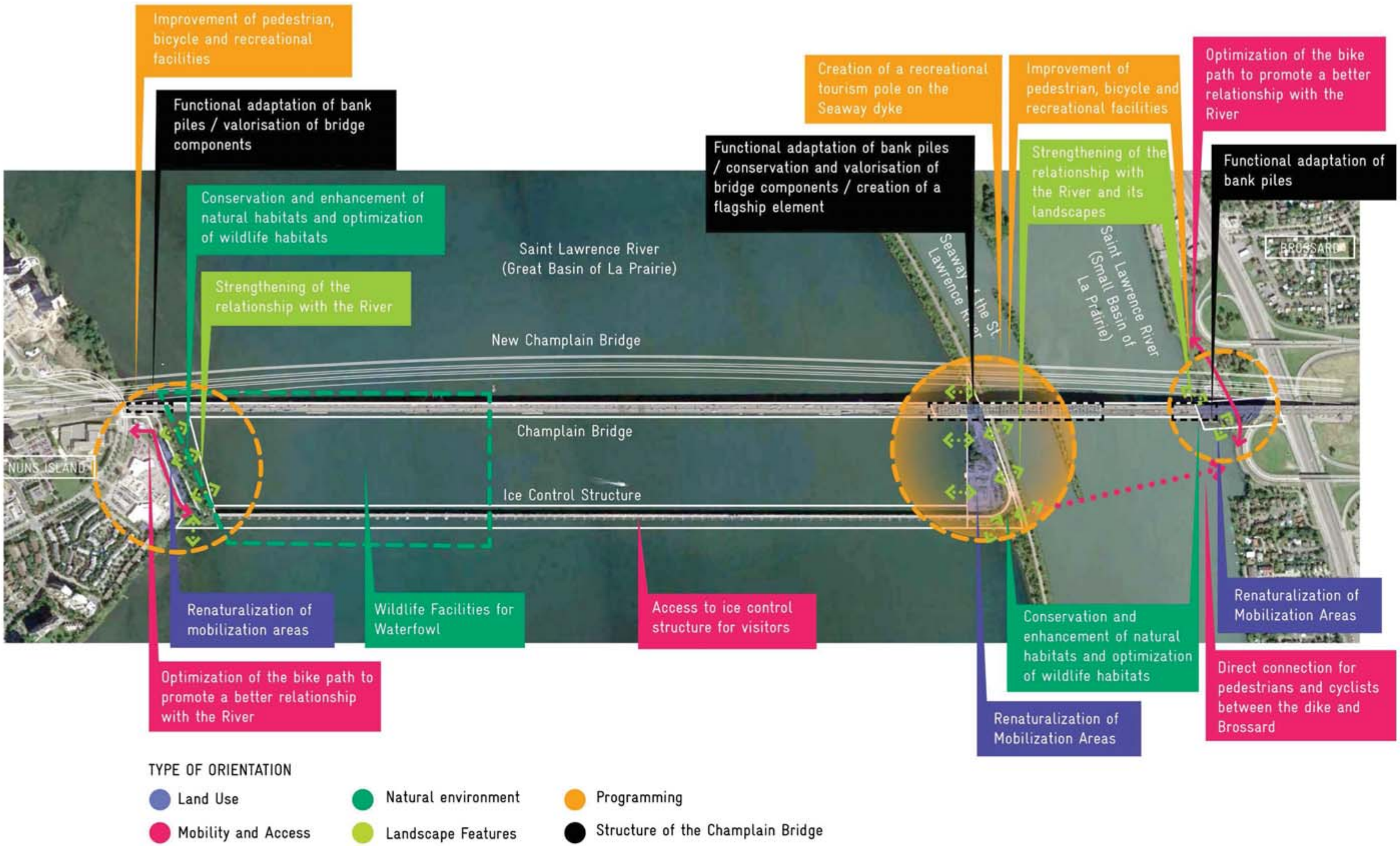


Figure 160 – Spatial representation of opportunities related to the basic principles of asset enhancement

7.3.1 PRE-DECONSTRUCTION OPPORTUNITIES

Many opportunities are available prior to demolition of the Champlain Bridge, including deconstruction-related research opportunities that could be explored with JCCBI's Centre for Infrastructure Innovation (section 8.1.3), and site regeneration-related research opportunities with various development, environment, and engineering research chairs. The enhancement options set forth in Section 7.3.2 would lead to the development of state-of-the-art techniques and methods that will contribute to the development of international and national expertise.

Opportunities exist for commemorating the importance of the bridge prior to its deconstruction in the form of various temporary events. Only motorists have used the Champlain Bridge, and it would therefore be interesting to open it up to other users, as depicted Figure 161 and Figure 162. These alternative uses would provide unprecedented views toward Brossard, Montreal, the St. Lawrence River, and even the new Champlain Bridge. Moreover, such events require relatively small investments and help showcase the project as a whole.

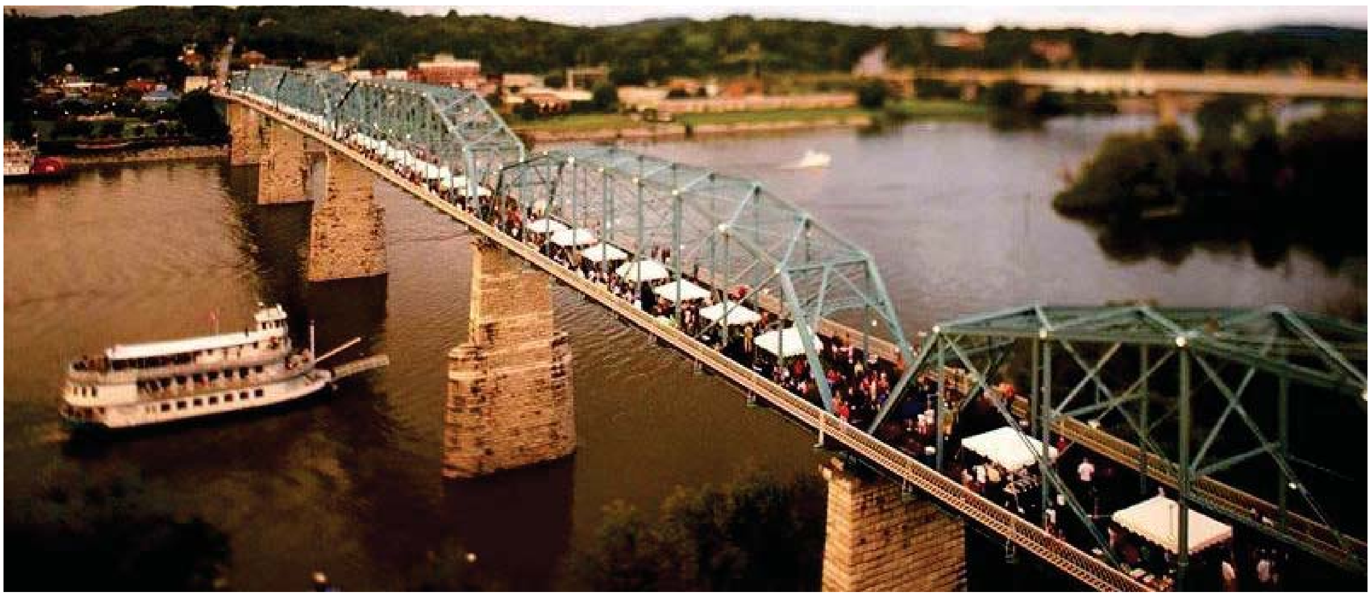


Figure 161 – Walnut Street Bridge during an event (source: tnvacation, N.D.)

Figure 162 – Pedestrian et cyclists – Walkway Over the Hudson State Historic Park (source: Country wisdom News, N.)

7.3.2 DEMOLITION-RELATED ASSET ENHANCEMENT OPTIONS

The process used to define asset enhancement options began with a search of inspiring actions and projects around the world, some of which are presented in Appendix 5-5. After establishing an understanding of the background (section 7.1.) and setting general guiding principles, various possible actions were identified for the three main areas of the JCCBI property (Nun’s Island, Seaway and Brossard). To one degree or another, these actions fall within the tourism and recreation, environmental, commemorative, architectural, or arts fields. Although each of these actions adds value to the site, the success of any given enhancement option depends not only on the set of actions it comprises, but also on its successful integration into its setting.

Proposed actions were therefore grouped into six consistent and logical asset enhancement options. These options are cumulative, making it possible to introduce the simplest to the most complex action and thus show how, by maximizing investments, it is possible to create activity clusters with increasing public resonance.

To facilitate their understanding, management, and coordination, these different proposals are introduced according to their primary intent, after which related actions and expected benefits are described. For the sake of clarity, their implementation, cost and related technical issues are described, as well as the required actions that will need to be developed to make their implementation possible. These costs do not include saving associated with a partial deconstruction as there is still an important number of unknowns at this time of the analysis. Finally, to facilitate understanding, examples/cross-sections/axonometrics presented for each option.

With these elements in mind, it will be possible to pull out the strengths and weaknesses of the different options that will be reflected in the evaluation of options presented in Section 7.5.

It is important to note that this is not a definitive list of solutions, but rather an overview intended to highlight the breadth and wealth of opportunities that the site offers. Should JCCBI put together another set of enhancement actions, Appendix 5-6 may be used to understand the costs related to each individual action.

7.3.2.1 Option 1: Network of cyclist rest areas and windows on the St. Lawrence linked with a network of enhanced natural environments

Primary intent	To improve the bike path network, and strengthen and enhance natural environments to support plant and animal species in the area while providing visitors with the opportunity to connect with these environments
Proposed actions	• Restoration, conservation and enhancement of existing natural environments ; • Renaturalization and reshaping of mobilization areas ; • Existing and restored wildlife habitat enhancement and conservation plan ; • Construction of natural environment interpretive trails ; • Construction of lookout points/windows on the St. Lawrence River ; • Construction of waterfowl staging areas on preserved and modified piers on the IDS side of the bridge ; • Construction of boat ramps on the IDS and Brossard sides of the bridge ; • Relocation of parts of the bike path (IDS and Brossard) to improve its relationship to the River ; • Construction of cyclist rest areas ; • Integration of signature furniture to the various facilities ; • Implementation of a bike and pedestrian river shuttle service between the Seaway dike and Brossard.
Benefits	This option improves existing networks (green spaces, Route Bleue, bike path network) without interfering with current activities along the banks of the St. Lawrence River. It fits in with the St. Lawrence River archipelago recreation and tourism axis, which includes Île Sainte-Hélène and Île Notre-Dame, as well as the Récré-O-Parc in Sainte-Catherine. The combined implementation of various actions will result in local enhancement of the St. Lawrence ecosystem, for instance by improving habitat quality for species using its perimeter. Given that several vulnerable species have been inventoried near the existing bridge, these actions will help maintain and even increase existing populations. Efforts to develop these areas align with the goal to bring the general public closer to the river. The construction of interpretive trails, cyclist rest areas and lookout points will highlight the quality of these areas and serve to raise public awareness about environmental conservation issues. Easier access to the JCCBI property will bring in more users, which is essential to support the proposed programming. Although no direct revenue source is associated with the project, its environmental and social benefits must be taken into account.

OPTION 1

NETWORK OF CYCLE STOPS AND WINDOWS ON THE RIVER IN RELATION TO A DEVELOPMENT NETWORK OF NATURAL AREAS

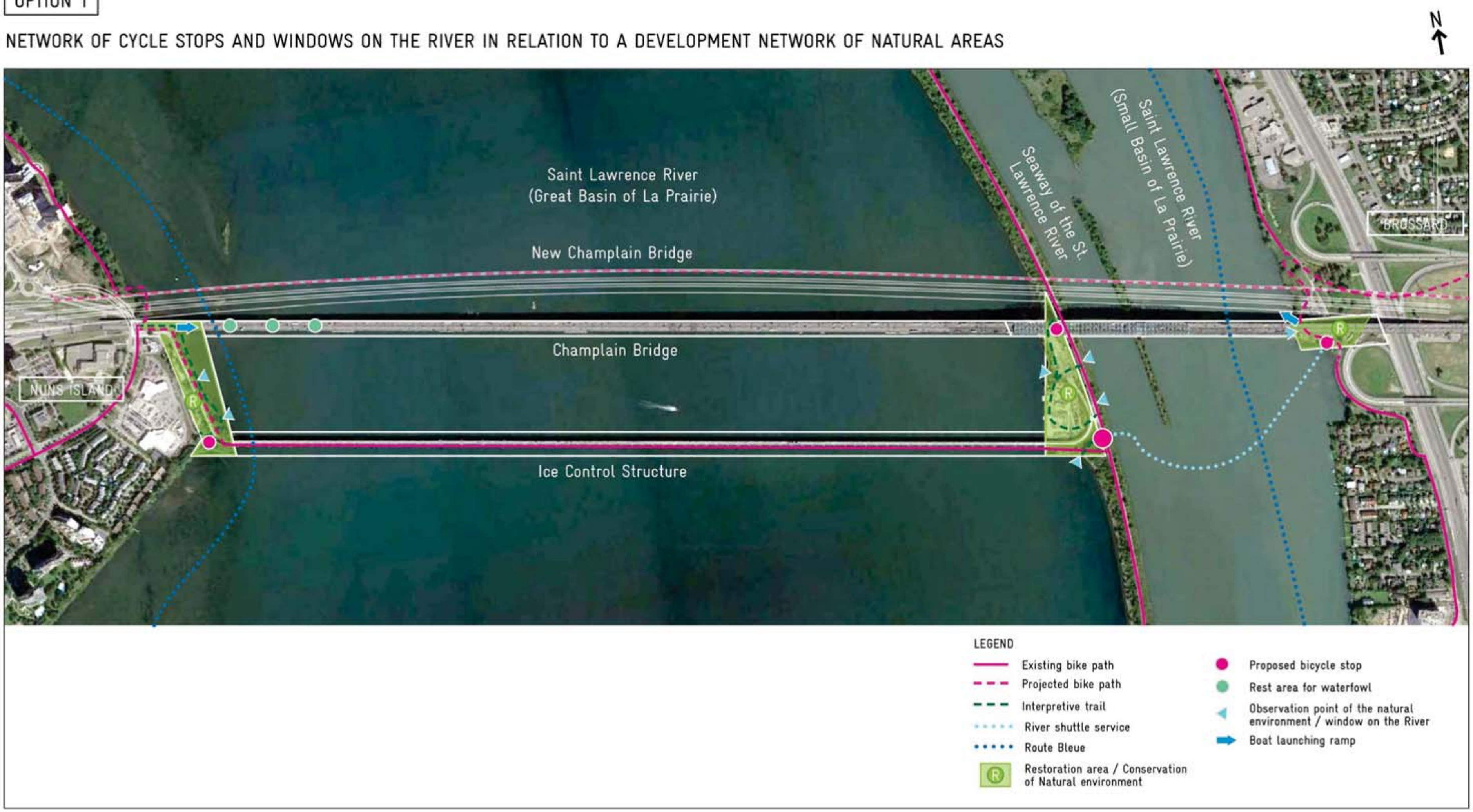


Figure 163 – Master plan for Option 1 (source: NIPPAYSAGE)

Direct cost of option	[redacted] tax excluded (see details in Appendix 5-6)
Structural components preserved	Possibility of reusing materials from the steel structure of the existing bridge as new structural components, or as supports for interpretation panels and wildlife management items (e.g. nesting boxes).
Assessment of structural capacity	The complexity and end uses of components differ according to the proposed asset enhancement option. Should a component be used or changed, such use or change should be verified. How this is verified depends on the end use of the component and its current state. The end use will determine which loads are included in this analysis. In certain cases, this analysis will identify required reinforcements or modifications. Actions presented for Option 1 identify waterfowl staging areas, potentially on preserved bridge piers or parts of piers. Given the small loads associated with this type of use, the required reinforcements or changes identified in this analysis will likely be minor.
Implementation actions	Preliminary phase: • Habitat, and animal and plant species inventories ; • Preparation of a natural environment enhancement and conservation plan ; • Bank stability and biological integrity analyses ; • Analysis of existing soils (composition, contamination, etc.) ; • Agreement with the St. Lawrence Seaway Management Corporation on the routing of the river shuttle ; • Design contest for signature furniture or for the site as a whole ; • Partnership with an environmental organization or company for the provision of educational and animation programming related to the interpretive trail system. During the project: • Environmental protection actions and development of a specific schedule for inventoried species ; • Soil decontamination (mainly in the JCCBI mobilization areas) ; • Reshaping of the JCCBI mobilization area on the Seaway dike. Post-project: • Studies and monitoring of natural environments related to the natural environment enhancement and conservation plan ; • Facilities maintenance (bike path, cyclist rest areas, windows on the St. Lawrence River).

ADVANTAGES		DISADVANTAGES	
MA1	Limited investment required ;	MD1	Does not preserve Champlain Bridge structure in place ;
MA2	Minimal maintenance cost ;	MD2	Actions have limited symbolic value ;
MA3	Long project lifetime ;	MD3	Few material recovery opportunities ;
MA4	Relatively simple and quick implementation ;	MD4	Limited contribution to the development of unique expertise ;
MA5	Does not cause deconstruction delays ;	MD5	Not a tourism asset likely to significantly increase the number of users ;
MA6	Improves water quality in the River ;	MD6	Does not provide significant historical references ;
MA7	Improves biodiversity ;	MD7	Low job creation potential ;
MA8	Does not interfere with recreational or commercial boating ;	MD8	No revenue generation.
MA9	Reduces atmospheric pollution ;		

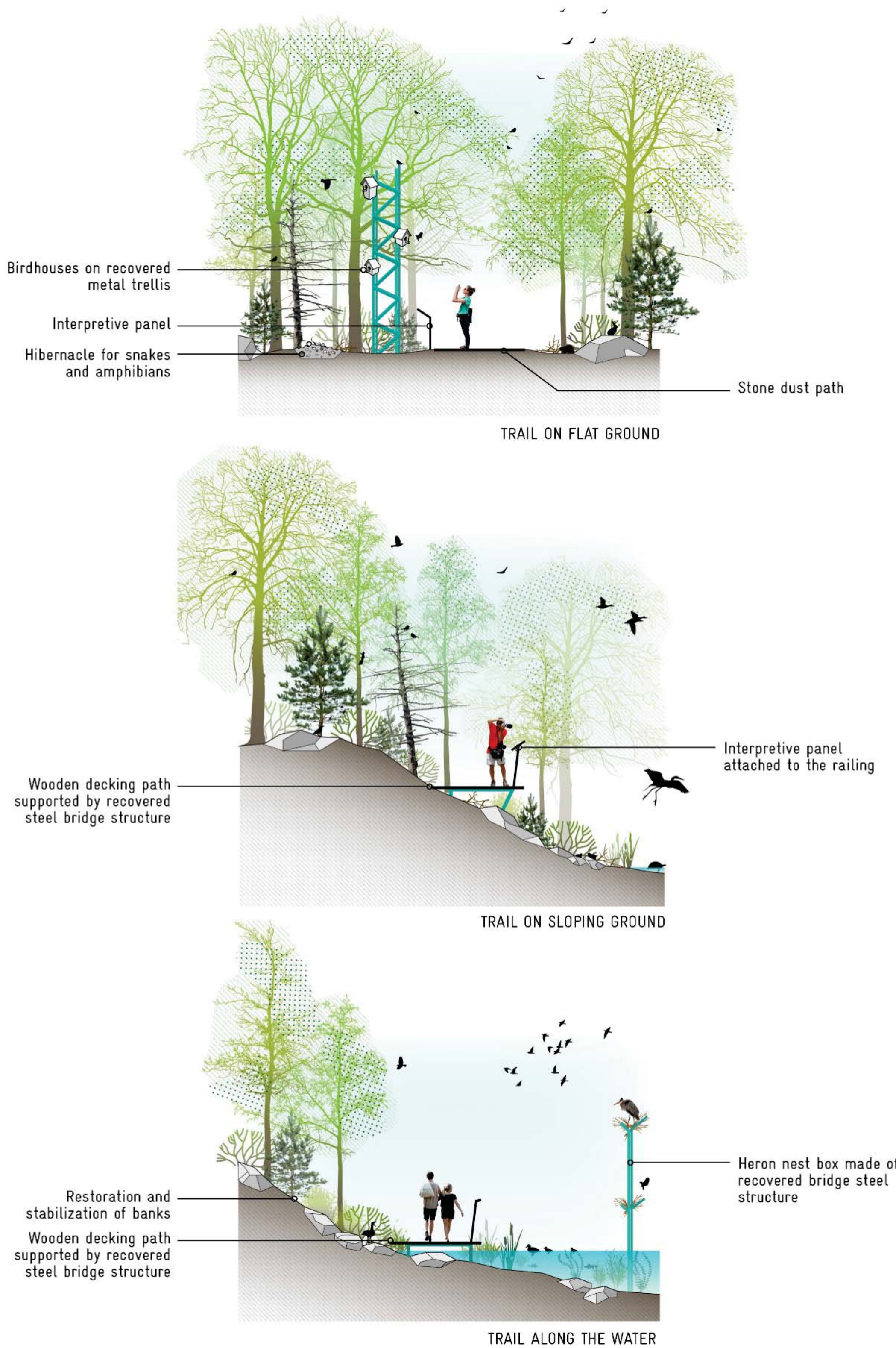


Figure 164 – Types of interpretive trails (source: NIPPAYSAGE)

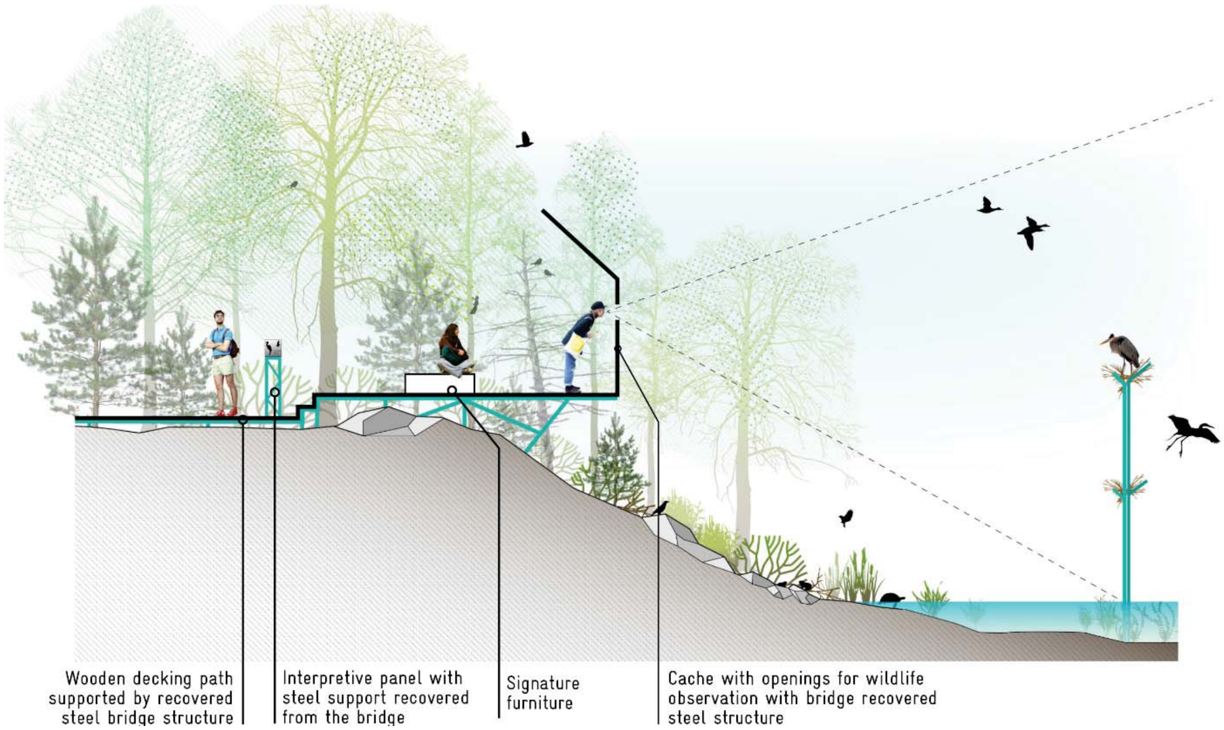


Figure 165 – Window on the St. Lawrence River (source: NIPPAYSAGE)

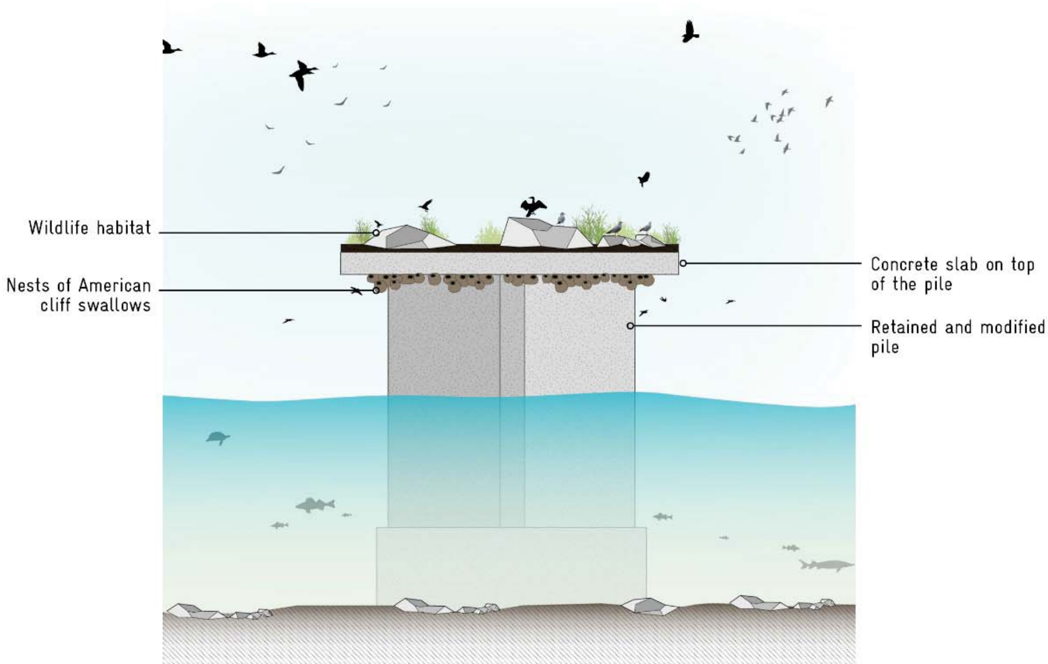
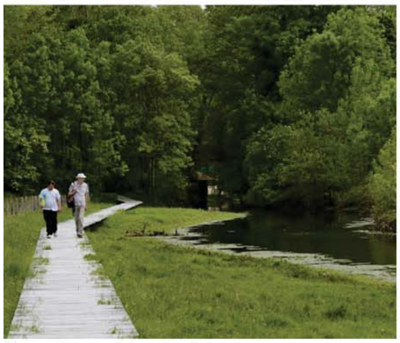


Figure 166 – Aquatic bird staging area on a modified existing pier (source: NIPPAYSAGE)


Multi-units nest box


Tortoise Observation Cache, Cap Saint-Jacques, NIPPAYSAGE

Interpretive panel, Botanical Garden of Mtl, Vlan paysages


Shoreline wodden deck trail


Window on a landscape

Small interpretive panel


Bicycle stop with shelter and signage


Metal shelter and rest area


Rest area with signature furniture

Figure 167 – Rest area – Examples of precedents for Option 1

7.3.2.2 Option 2: Historical and arts itinerary (+ option 1)

Primary intent

To commemorate the history of the site through the creation of historical and arts itineraries related with the bike path and foot trail network.

Proposed actions

- Incorporation of artwork made from materials reclaimed from the bridge ;
- Integration of periodically updated interpretation panels on the history of the bridge and the Seaway.

Additional benefits

This option highlights the engineering of the old bridge infrastructure through incorporation of artwork made from components recovered from the bridge, as well as interpretation panels describing the history of the site. The development of this itinerary on both banks of the St. Lawrence River and the Seaway dike brings together the various parts of the site and adds a historical and cultural component to the project. This addition will make the site more attractive by increasing the number of possible activities it offers.

This option reflects a will to protect the land located along the St. Lawrence River and make it more attractive to visitors without requiring intensive use of that land.

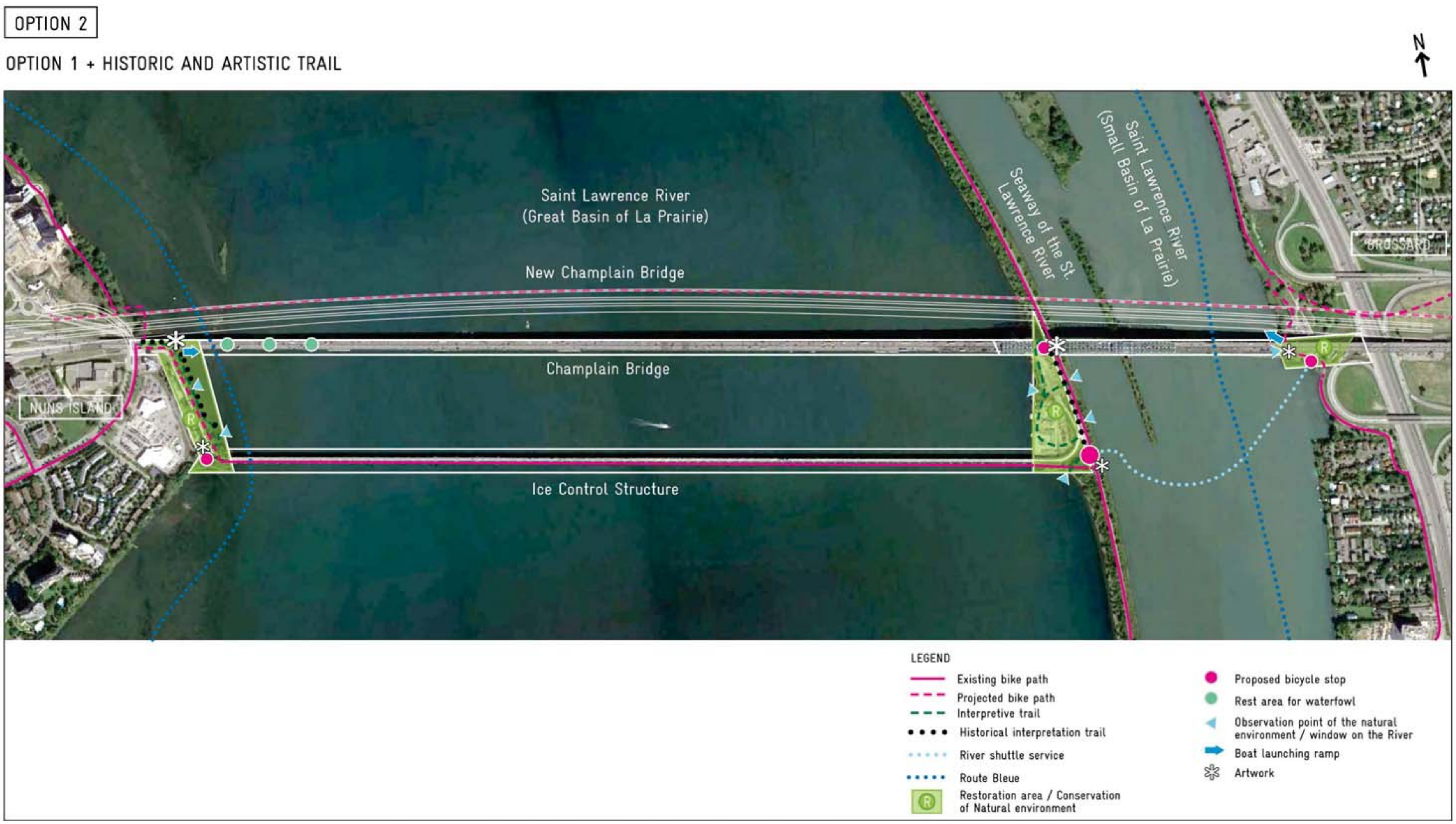


Figure 168 – Master plan for Option 2 (source: NIPPAYSAGE)

Direct cost of option [redacted] tax excluded (see details in Appendix 5-6)

Structural components preserved

- Reuse of materials from the steel structure for artwork.

Assessment of structural capacity

The complexity and end uses of components differ according to the proposed asset enhancement option. Should a component be used or changed, such use or change should be verified.

How this is verified depends on the end use of the component and its current state. The end use will determine which loads are included in this analysis. The design of the proposed historical and arts itineraries must comply with current standards and not pose a risk for the general public.

Implementation actions

*See previous option for additional implementation items.

Preliminary phase:

- Development of historical exhibit themes by a partner with expertise on the history of transportation infrastructure in the Montreal area ;
- National or international art contest focusing on the incorporation of materials reclaimed from the bridge. Prior determination by a multidisciplinary team of components of the bridge that can be used in the creation of artwork ;
- Partnership with an organization or company in the field of the arts and culture for the provision of educational and animation programming related to the arts and historical itineraries.

During the project: N/A

Post-project:

- Oversight of partners.

ADVANTAGES		DISADVANTAGES	
MA10	Limited investment required ;	MD9	Does not preserve Champlain Bridge structure in place ;
MA11	Minimal maintenance cost ;	MD10	Actions have limited symbolic value ;
MA12	Provides a historical reference to the presence of the bridge ;	MD11	Limited contribution to the development of unique expertise ;
MA13	Provides opportunities for creative recovery of bridge materials ;	MD12	Not a tourism asset likely to significantly increase the number of users ;
MA14	Long project lifetime ;	MD13	Low job creation potential ;
MA15	Relatively simple and quick implementation ;	MD14	No revenue generation ;
MA16	Does not cause deconstruction delays ;	MD15	Potentially complex implementation of the arts component.
MA17	Improves water quality in the River ;		
MA18	Improves biodiversity ;		
MA19	Option likely to gain social approval ;		
MA20	Does not interfere with recreational or commercial boating ;		
MA21	Reduces atmospheric pollution.		

Figure 169 – Conceptual cross-section of historical itinerary with interpretive panels (source: NIPPAYSAGE)

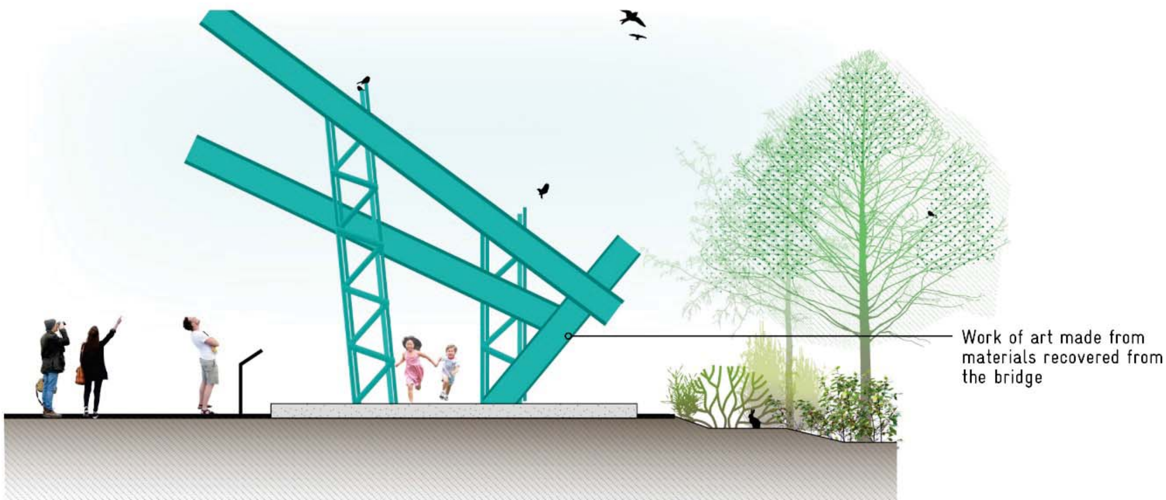


Figure 170 – Conceptual cross-section of artwork (source: NIPPAYSAGE)


Mark Di Suvero Artwork


Otis Griffith Artwor


Antony Gormley Artwork

Double-sided display panel. Atwater Market, Montreal


Exhibition panel with delicate light metal support

Triple sided display panel

Figure 171 – Examples of precedents for Option 2

7.3.2.3 Option 3: Multi-use wharves and infrastructure for aquatic activities (+ options 1 and 2)

Primary intent

To provide residents new access to the St. Lawrence River through the creation of points of interest along its banks, including wharves and surfing waves.

Proposed actions

- Construction of multi-use wharves with boat ramp supported in part on converted existing bridge piers ;
- Construction of manmade surfing waves in the Greater La Praire Basin for surfers and whitewater kayakers.

Additional benefits

New points of interest and activities along the River will attract visitors and encourage them to make the space theirs. Reuse of parts of the old bridge, as well as development of JCCBI assets will convey a desire to optimize past investments and recall the presence of the former structure.

Construction of new wharves will establish the more formal presence of current activities in the area, such as fishing, and promote others, such as recreational boating. In some places, there will be historical and artistic itineraries, which will create multi-use public spaces. The redevelopment will also make it possible to develop new aquatic activities, such as surfing and whitewater kayaking. Although these sports are increasingly popular, there are few places in Montreal where they can be done. Construction of a landing pier will provide access to the Seaway dike to all users.

By integrating actions on the Nun’s Island, Seaway dike and Brossard banks, this option showcases the existence of a network and reflects a desire to increase the attractiveness of the site by making it more versatile.

Figure 172 – Master plan for Option 3 (source: NIPPAYSAGE)

Direct cost of option	[redacted] tax excluded (see details in Appendix 5-6)
Structural components preserved	• Preservation in place of modified piers as structural components of the new wharves ; • Use of reclaimed concrete blocks from the old bridge for constructing manmade waves.
Assessment of structural capacity	The complexity and end uses of components differ according to the proposed asset enhancement option. Should a component be used or changed, such use or change should be verified. How this is verified depends on the end use of the transformed component and its current state. In certain cases, required reinforcements or modifications will be identified once this analysis is completed. An assessment of the use of the proposed multi-use wharves must be carried out. Analyses will have to comply with applicable current standards. Live loads, whether for pedestrians or vehicles, must be defined for these components, and the analysis must be done accordingly. The risk for the general public is greater and required analyses will be more stringent. Existing Champlain Bridge footings can likely be converted into footings for multi-use wharves. Their usability will need to be confirmed and any required modification or reinforcement must be identified and designed through a structural analysis once the design criteria have been set.
Implementation actions	* See previous options for additional implementation items. Preliminary phase: • Assessment of the structural capacity of modified piers for potential use in wharf construction ; • Assessment of the steel components of the bridge that may be used as structural components of wharves and manmade waves ; • Assessment of environmental impacts related to wharf and surfing wave construction as well as possible mitigation/compensation measures ; • Hydraulic studies and modelling to support the design of manmade waves ; • Partnership with a (non-motorized) recreational boating organization or company for the management of water activities (equipment rental, lessons, expeditions, etc.) ; • Optional: National or international design contest for the wharves or the site as a whole. During the project : • Implementation of protection, mitigation and/or compensation measures for aquatic wildlife. Post-project • Monitoring and adjustments to manmade waves by a team comprising hydraulic engineers ; • Study of the impacts of manmade waves and human activities on the aquatic environment and implementation of any required mitigation measure ; • Oversight of partners in charge of facilities operation ; • Routine maintenance of preserved bridge structures.

ADVANTAGES	DISADVANTAGES
MA22 Relatively limited investment required ; MA23 Long project lifetime ; MA24 Provides a historical reference to the presence of the bridge MA25 Relatively simple implementation ; MA26 Causes minimal deconstruction delays ; MA27 Provides opportunities for recovery of bridge materials ; MA28 Preserves parts of the existing Champlain Bridge structure ; MA29 Improves biodiversity ; MA30 Option likely to gain social approval ; MA31 Promotes and supports recreational boating ; MA32 Does not interfere with recreational or commercial boating ; MA33 Reduces atmospheric pollution.	MD16 Actions have limited symbolic value ; MD17 Tourism asset likely to increase the number of users slightly ; MD18 Limited contribution to the development of unique expertise ; MD19 Low job creation potential ; MD20 Some impacts on aquatic environments ; MD21 Limited revenue generation. MD22 Some actions required to ensure the site is safe.

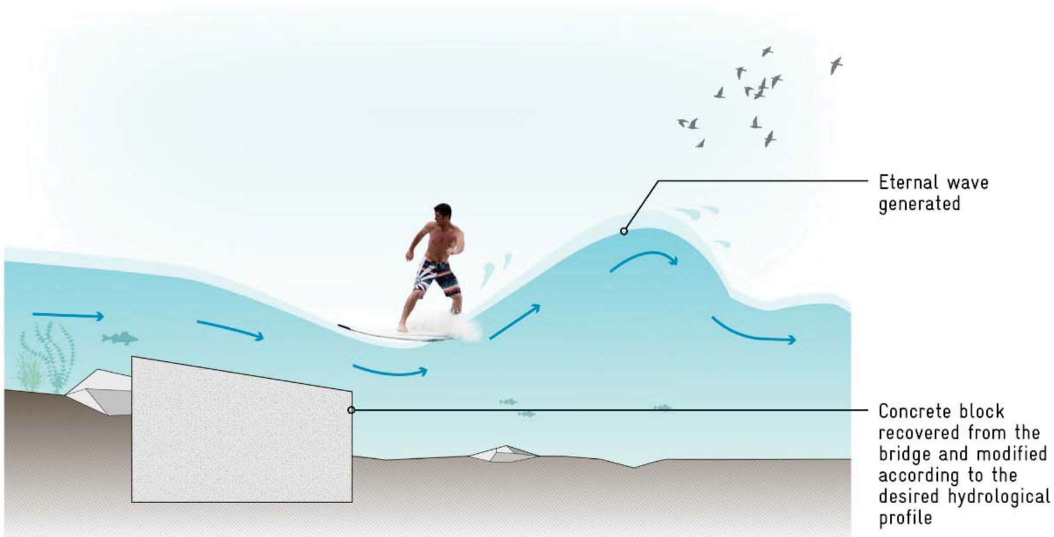


Figure 173 – Conceptual cross-section of a standing wave produced by the addition of an underwater concrete block (source: NIPPAYSAGE)

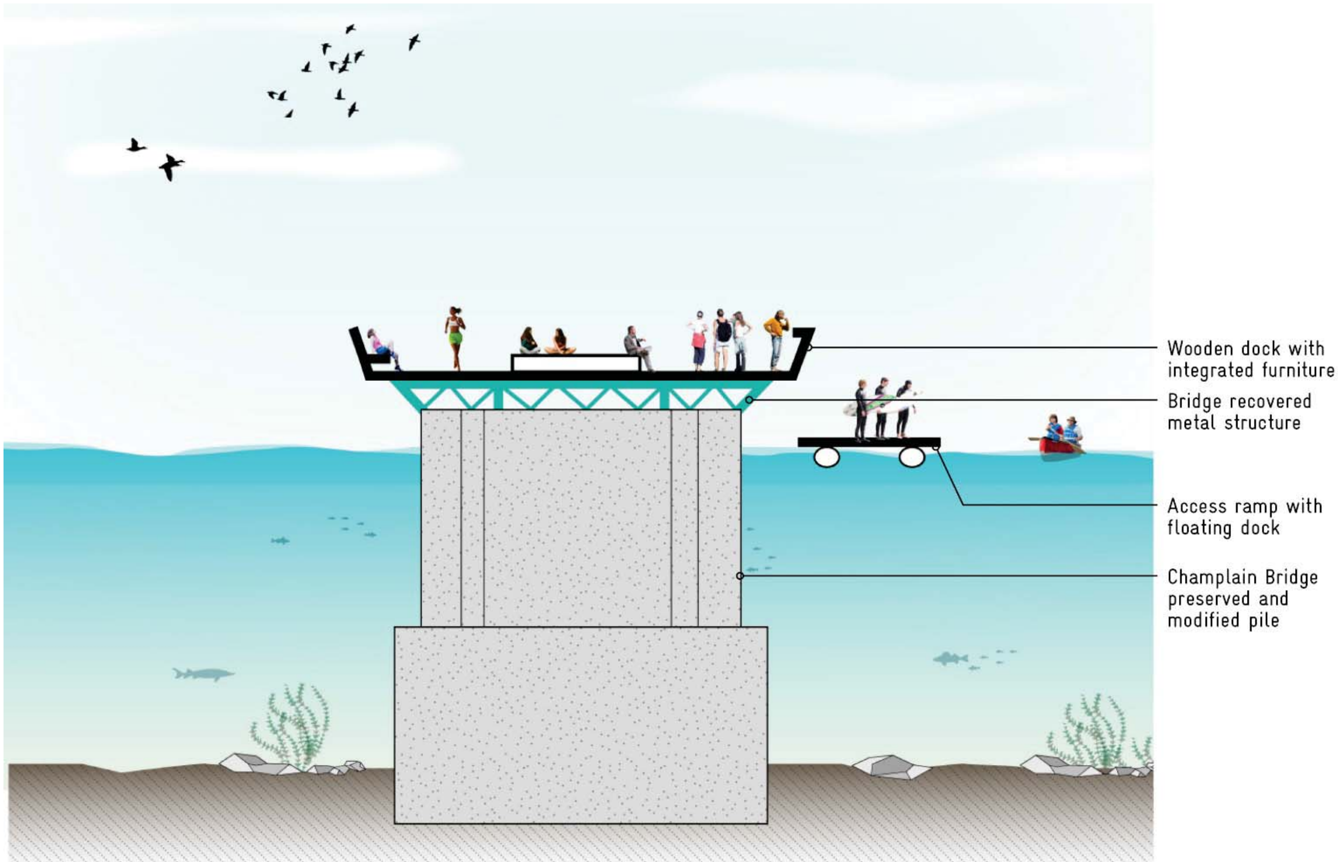


Figure 174 – Conceptual cross-section of wharf supported by bridge pier (source: NIPPAYSAGE)

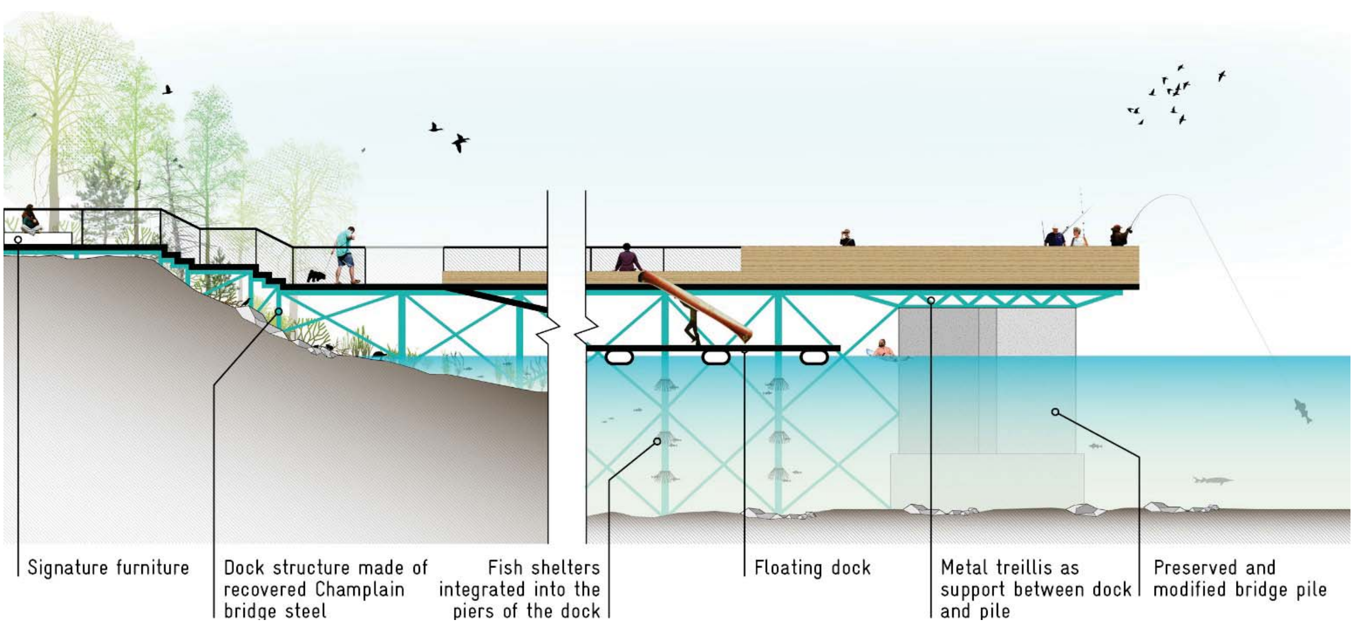
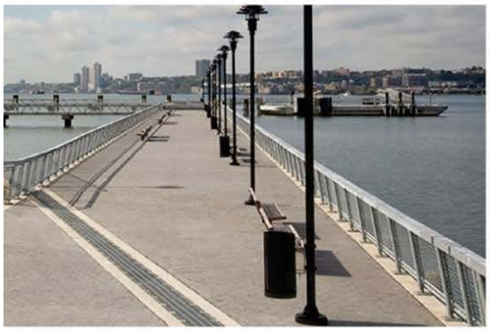


Figure 175 – Longitudinal conceptual cross-section of a multi-use wharf (source: NIPPAYSAGE)


Dock with mixed wood-metal guardrail


Undulating decking and signature furniture


Alignment of lampposts on mineral dock


Signature furniture on mineral dock


Quai des Cageux - Promenade Samuel de Champlain


Surfing on the eternal wave near Habitat 67, Montreal


Surfing on an river artificial wave, Boise River Park, USA

Figure 176 – Example of precedents for wharves and surfing waves

7.3.2.4 Option 4: Construction of a nature beach (+ options 1 to 3)

Primary intent	To increase the attraction potential of the Seaway dike and strengthen the relationship with the St. Lawrence River by providing a natural-type beach along the banks of the Greater La Prairie Basin.
Proposed actions	• Construction of a pebble beach with a service building along the Seaway dike.
Additional benefits	The addition of a nature beach on the Seaway dike will provide a unique attraction along the St. Lawrence River that reaffirms the recreation and tourism character of the site. This project is consistent with the desire of the Communauté métropolitaine de Montréal to leverage the Seaway dike and its attributes as a unique recreation and tourism component. It also addresses the wish of Greater Montreal residents to connect directly with the St. Lawrence River through a range of activities. The design of this beach will have to be sensitive to the existing natural environment in order to minimize habitat disturbance. By ensuring its construction aligns with the reshaping and renaturalization of the JCCBI mobilization area, it will be possible to restore a more natural relief and thus create habitat opportunities for local wildlife and plant species. This beach provides opportunities for financial benefits through the rental of the site to a specialized operator.

Figure 177 – Master plan for Option 4 (source: NIPPAYSAGE)

Direct cost of option	[redacted] tax excluded (see details in Appendix 5-6)
Structural components preserved	• N/A (no additional structural element is required for this option)
Assessment of structural capacity	N/A
Implementation actions	* See previous options for additional implementation items. Preliminary phase: • Hydrologic studies to define optimal parameters for construction of the beach along the dike ; • Assessment of environmental impacts related to construction of the beach as well as possible mitigation/compensation measures ; • Partnership with a tourism organization or company or a government agency for the management and operation of the beach site (including the service building) ; • Optional: National or international design contest for the nature beach site or the site as a whole. During the project : • Implementation of protection, mitigation and/or compensation measures for aquatic wildlife. Post-project • Study of the impacts of the beach and related human activities on the aquatic environment and implementation of any required mitigation measures ; • Oversight of partners in charge of facilities operation.

ADVANTAGES	DISADVANTAGES
MA34 Creation of a recreation and tourism pole of interest ; MA35 Long project lifetime ; MA36 Significant increase in number of visitors ; MA37 Potential financial benefits from operation of the site ; MA38 Causes minimal deconstruction delays ; MA39 Preserves parts of the existing Champlain Bridge structure ; MA40 Improves biodiversity ; MA41 Promotes and supports recreational boating ; MA42 Does not interfere with commercial boating ; MA43 Reduces atmospheric pollution. MA44 Creation of several jobs.	MD23 Moderate investment required ; MD24 Actions have limited symbolic value ; MD25 Requires collaboration pre- and post-construction ; MD26 Some technical and environmental challenges ; MD27 Operating costs difficult to estimate ; MD28 Need for a study of impacts on biodiversity ; MD29 Need for mitigation and compensation measures ; MD30 Some impacts on animals and plants ; MD31 Some actions required to ensure the site is safe.

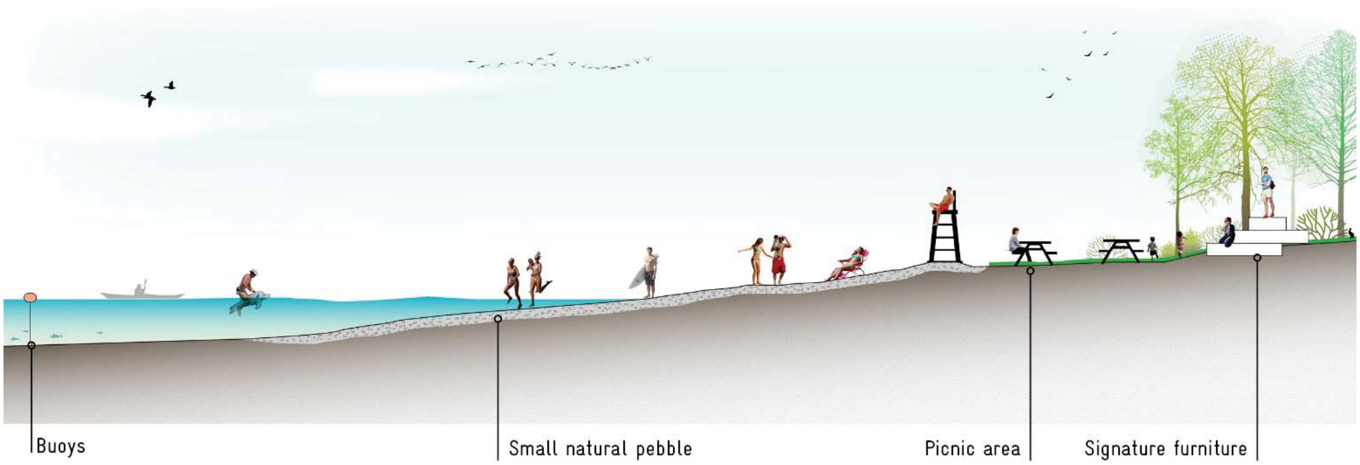


Figure 178 – Conceptual cross-section of nature beach (source: NIPPAYSAGE)

Natural beach found south of the boom along the Saint-Lawrence river seaway dyke

Natural beach in pebble

Vegetation by the beach

Beach inserted in a small bay

Small service building

Figure 179 – Examples of nature beach precedents

7.3.2.5 Option 5: Construction of an aerial extreme sports facility (+ options 1 to 4)

Primary intent	To leverage existing large vertical elements along the Seaway dike to include aerial extreme sports activities.
Proposed actions	• Development of climbing routes on the preserved Seaway dike pier combined with a climbing block ; • Construction of a series of extreme sports decks (bungee, zip line, aerial courses) on the preserved Seaway dike pier, along the Ice Control Structure, and in the renaturalized portion of the dike.
Additional benefits	The conversion of an old Champlain bridge pier to develop an extreme sports facility will add unique value to the infrastructure in addition to preserving an element of architectural and heritage value. This will result in lower deconstruction costs through levering of specific structural features of the infrastructure, namely its height and massive nature, to turn it into a high-profile recreation and tourism facility. The preserved pier will also serve as a strong visual landmark along the Seaway, visible from the South Shore and Nun’s Island. The facility will attract a large number of visitors looking for thrills and novelty, who will see it as a unique destination in the Greater Montreal area. Sports competitions could also be held at the site, and special measures can be included to ensure the safety of the site. The large number of visitors will make the site profitable, so that it can support other program components, thus ensuring that the project is sustainable.

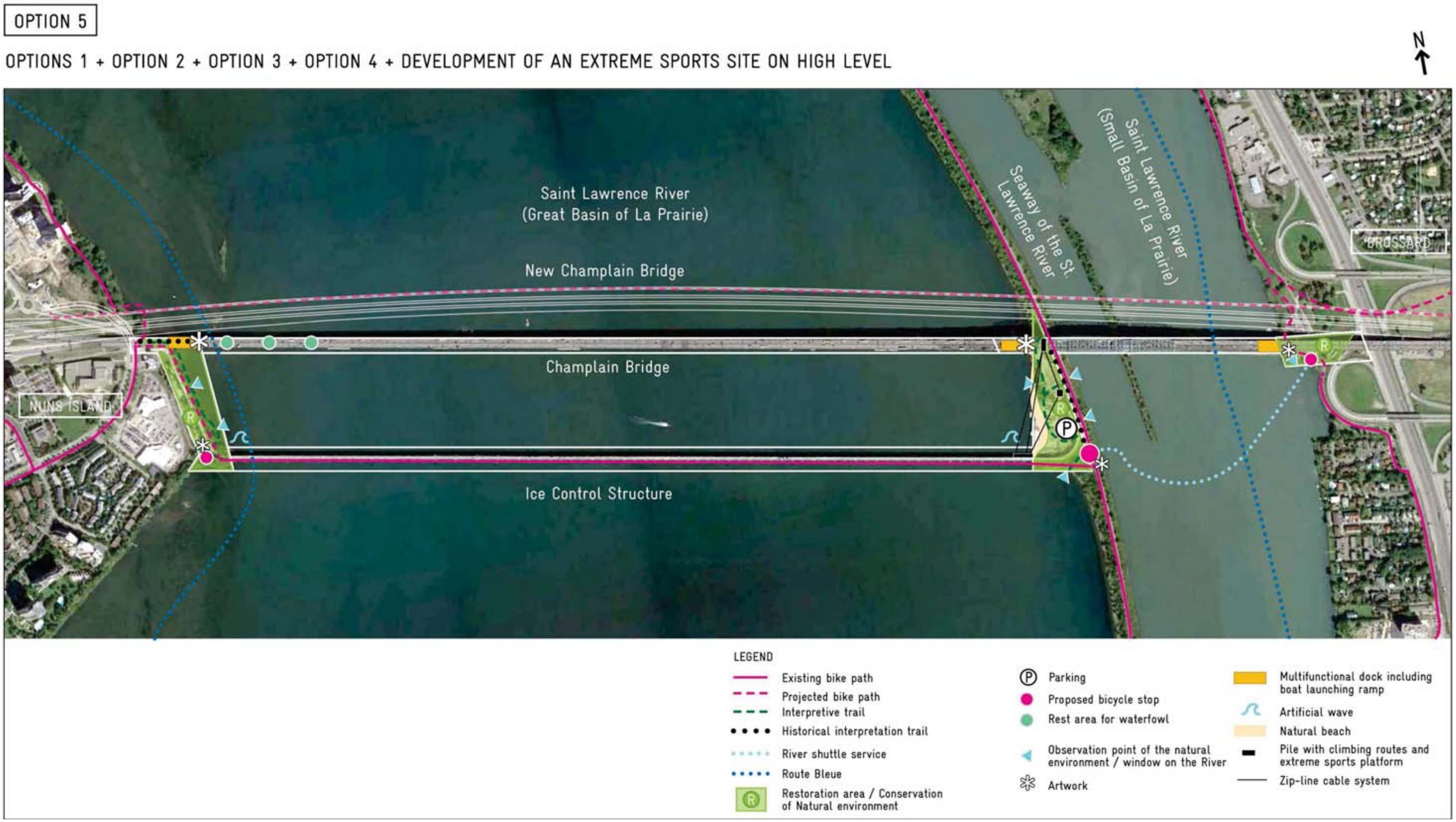


Figure 180 – Master plan for Option 5 (source: NIPPAYSAGE)

Direct cost of option	[redacted] tax excluded (see details in Appendix 5-6)
Structural components preserved	• Preservation of a lined pier on the Seaway dike.
Assessment of structural capacity	The complexity and end uses of components differ according to the proposed asset enhancement option. Should a component be used or changed, such use or change should be verified. How this is verified depends on the end use of the transformed component and its current state. In certain cases, required reinforcements or modifications will be identified once this analysis is completed. It is likely that the Ice Control Structure or existing piers will be able to support the proposed extreme sports decks, depending on several variables, including their size and the planned live loads. Each of the proposed action will require changes to structural components to make them suitable for the proposed use. The complexity of these changes will vary from one component to the next and depend on the specified loads and the current state of the components, as determined through an analysis.
Implementation actions	* See previous options for additional implementation items. Preliminary phase: • Assessment of the structural integrity and capacity of the preserved Seaway dike pier before construction of decks and development of a plan to prepare to pier for the proposed activities ; • Partnership with climbing or aerial extreme sports organizations or companies for the design, management, and operation of the facilities ; • Study of the visual impacts of the facilities on the landscape. During the project: N/A Post-project: • Study of the impacts of human activities on the aquatic and terrestrial environment and implementation of any required mitigation measures ; • Oversight of partners in charge of facilities operation.

ADVANTAGES		DISADVANTAGES	
MA45	Creation of a recreation and tourism pole of interest ;	MD32	Moderate investment required ;
MA46	Intermediate project lifetime ;	MD33	Requires moderate collaboration pre- and post-construction ;
MA47	Significant increase in number of visitors ;	MD34	May delay bridge deconstruction ;
MA48	Potential financial benefits from operation of the site ;	MD35	Complex implementation ;
MA49	Recovery and preservation of several bridge components ;	MD36	Operating costs difficult to estimate ;
MA50	Numerous material recovery opportunities ;	MD37	Need for a study of impacts on biodiversity ;
MA51	Creation of several jobs ;	MD38	Need for mitigation and compensation measures ;
MA52	Opportunity to develop expertise in infrastructure requalification and conversion ;	MD39	Some nuisances for animals and plants ;
MA53	Promotes and supports recreational boating ;	MD40	Several actions required to ensure the site is safe.
MA54	Does not interfere with commercial boating ;		
MA55	Reduces atmospheric pollution.		
MA56	Several new activities created.		

Figure 181 – Various examples of aerial extreme sports

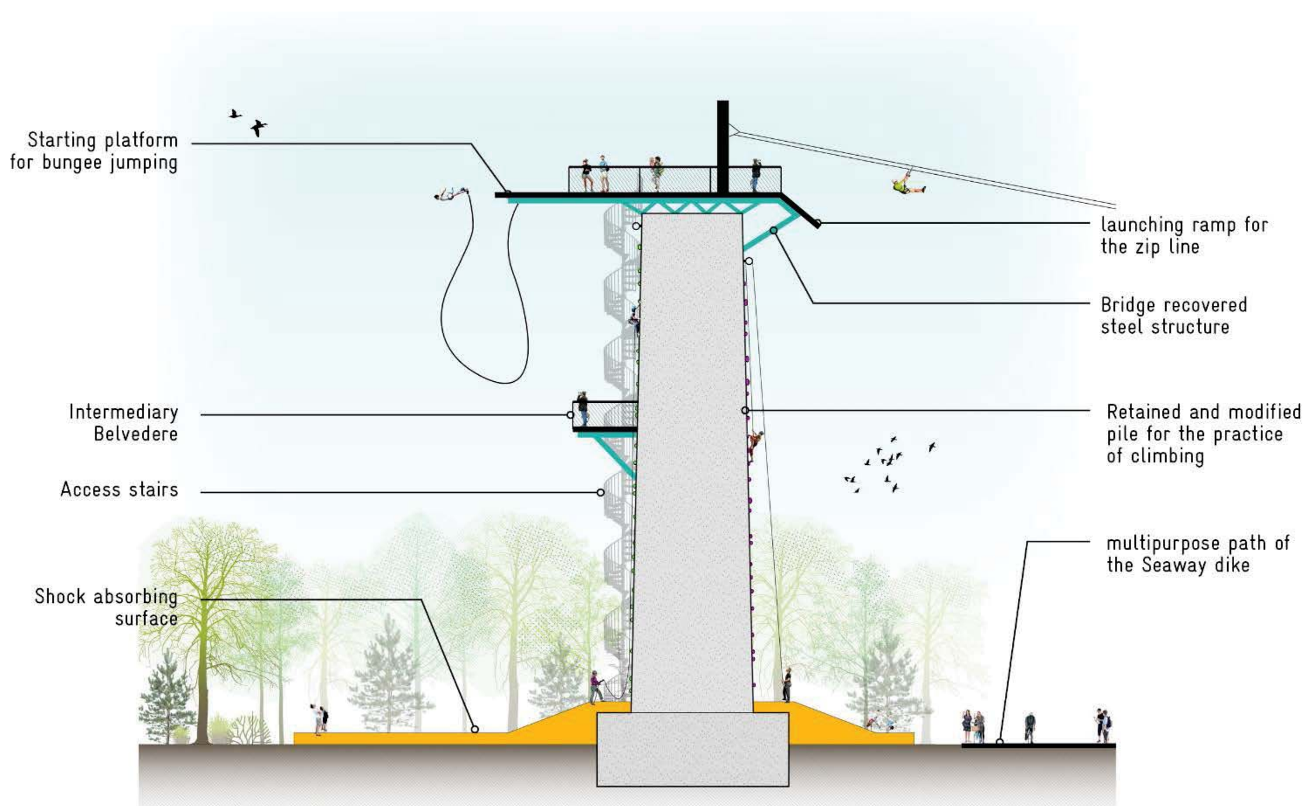


Figure 182 – Conceptual cross-section of the Seaway dike pier modified to serve as an aerial extreme sports facility (source: NIPPAYSAGE)

7.3.2.6 Option 6: Construction of a multi-use belvedere (+ options 1 to 5)

Primary intent	To maximize the preservation and enhancement of existing Champlain Bridge infrastructure by building a one-of-a-kind belvedere.
Proposed actions	• Construction of a multi-use belvedere on top of the preserved Seaway dike pier while reusing part of the steel structure of the bridge.
Additional benefits	Preservation of a pier and a significant portion of the overlying steel structure will be a bold engineering initiative likely to place Montreal among leading cities in terms of infrastructure re-use. This project aims to reclaim part of Montreal's heritage by and for Montrealers. The multi-use belvedere on top of the Seaway dike pier will be a significant asset allowing a large number of people to enjoy unique views of the surrounding area and the new bridge. It will also perpetuate the emblematic nature of the existing Champlain Bridge while providing Greater Montreal residents with a unique public space. At once park and public space, the site will include a service building that can house a café, museum or restaurant and provide recreational areas, densely vegetated grounds and large spaces for hosting events. The site will act as a catalyst for the JCCBI property as a whole by increasing the number of visitors, its visibility and potential revenues.

Figure 183 – Master plan for Option 6 (source: NIPPAYSAGE)

Direct cost of option	[redacted] tax excluded (see details in Appendix 5-6)
Structural components preserved	• Preservation of the western span of Section 6 of the existing bridge, including the steel structure over the Seaway dike.
Assessment of structural capacity	The complexity and end uses of components differ according to the proposed asset enhancement option. Should a component be used or changed, such use or change should be verified. How this is verified depends on the end use of the transformed component and its current state. In certain cases, required reinforcements or modifications will be identified once this analysis is completed. Conversion of part of Section 6 of the existing Champlain Bridge to a belvedere is more complex and will likely require additional reinforcements and changes to existing components.
Implementation actions	* See previous options for additional implementation items. Preliminary phase: • Assessment of the structural capacity of the preserved Seaway dike pier before construction of the vegetated belvedere ; • Assessment of the structural integrity and lead content of the preserved steel structure of the bridge and development of a restoration plan ; • Partnership with a government agency for the management and operation of the facilities (including the service building and elevator) ; • Study of the visual impacts of the belvedere on the landscape ; • Optional: National or international design contest for the belvedere or the site as a whole ; • Development of a concept for lighting the preserved steel structure of the bridge. During the project: N/A Post-project • Study of the impacts of human activities on the aquatic and terrestrial environment and implementation of any required mitigation measures ; • Oversight of partners in charge of facilities operation ; • Implementation of a belvedere-specific maintenance program.

ADVANTAGES	DISADVANTAGES
MA57 Creation of a regional recreation and tourism pole of interest ; MA58 Significant development of JCCBI assets ; MA59 Intermediate project lifetime ; MA60 Major preservation of components of symbolic and historical value ; MA61 Numerous material recovery opportunities ; MA62 Development of a unique viewpoint over surrounding areas; MA63 Potential financial benefits from operation of the site ; MA64 Very significant increase in the number of visitors ; MA65 Significant opportunity to develop expertise in infrastructure requalification and conversion ; MA66 Promotes and supports recreational boating ; MA67 Does not interfere with commercial boating ; MA68 Reduces atmospheric pollution ; MA69 Creation of several jobs.	MD41 Significant investment required ; MD42 Requires close collaboration pre- and post-construction ; MD43 May delay bridge deconstruction ; MD44 Very complex implementation ; MD45 Operating costs difficult to estimate ; MD46 Environmental impact studies required ; MD47 Some nuisances for animals that must be compensated ; MD48 Need for mitigation and compensation measures ; MD49 Several actions required to ensure the site is safe.

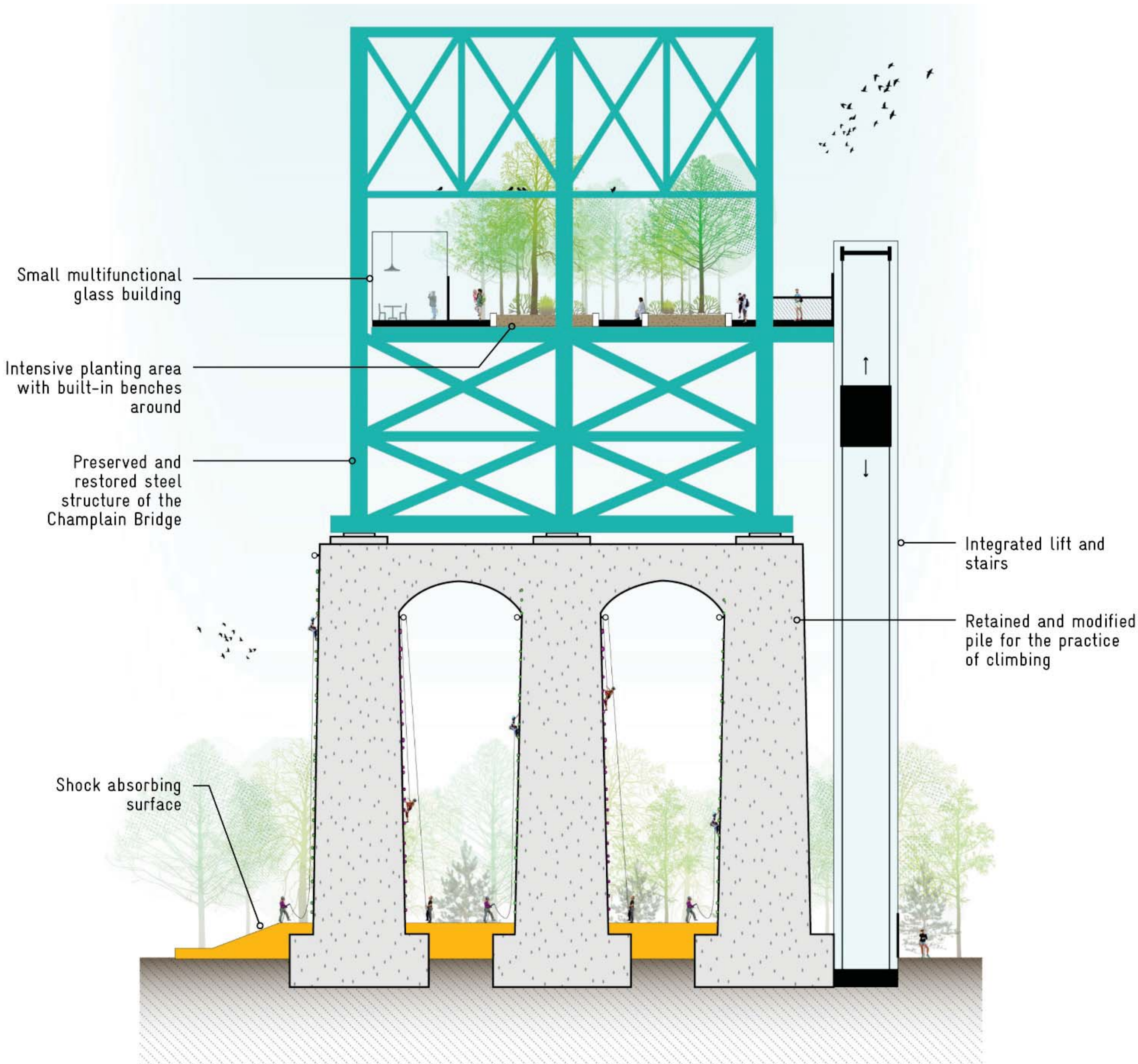


Figure 184 – Cross-section of the belvedere and its supporting pier (source: NIPPAYSAGE)

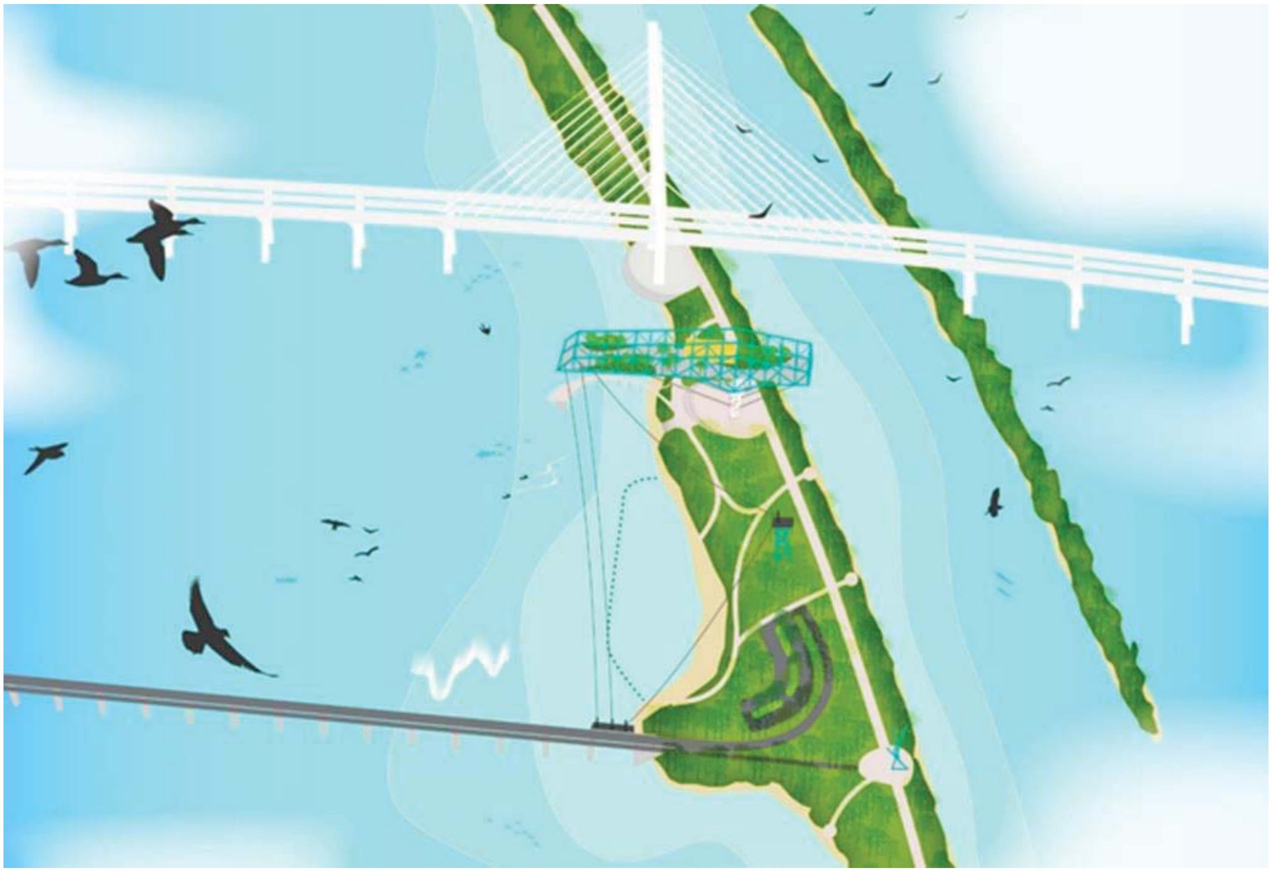


Figure 185 – Conceptual representation of Option 6, Seaway dike area (source: NIPPAYSAGE)

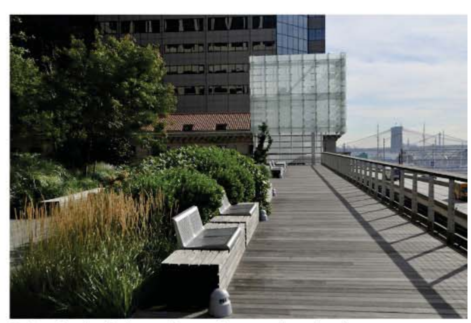
Wooden Amphitheater on the Highline, New York

Mineral and vegetable plaza near watercourse

Glass building on a building

Planted Bridge concept

Belvedere on the Highline, New York



Raised planted walkway in wooden deck

Figure 186 – Examples of belvedere construction precedents

7.4 TECHNICAL EVALUATION CRITERIA

Technical evaluation criteria are presented in Table 89. Analyses to date have produced a list of the following criteria, of which five are selected as follows:

Table 89 – Evaluation criteria

	CRITERIA	DESCRIPTION	SELECTED	RATIONALE
1	Financial benefits	Annual operating revenue minus annual costs of maintaining/operating the structures	Yes	
2	Lifetime	Lifetime of the project (based on structural components and before any necessary major renovation)	Yes	
3	Tourism and recreation	Assessment of the increase in attraction potential of the area based on the number of visitors, in other words, the relative increase in people using the site	Yes	
4	Implementation complexity	Assessment of the feasibility and difficulty to achieve the project	Yes	
5	Historical/cultural reminder	Does the option act as a historical or cultural reminder?	Yes	
6	Vulnerability to climate change	Are structures and facilities arising from the project vulnerable to an increase in water levels or extreme climate events?	No	Difficult to evaluate given the uncertainty related to climate change and proposed projects

7.5 EVALUATION OF OPTIONS

An evaluation of asset enhancement options was completed using the approach described in Section 3.5, and results are presented in Table 90. This evaluation was primarily performed by the asset enhancement team with the help of PTA experts on economic, environmental, and social issues.

Table 90 – Multi-criteria evaluation of asset enhancement options

EVALUATION OF COMPONENT 4: ASSET ENHANCEMENT																					
SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	EVALUATION OF OPTIONS/ASSET ENHANCEMENT SCENARIOS																			RATIONALE / COMMENTS
		REL. WEIGHT	OPTION 1: Cyclist rest areas and natural environments			OPTION 2: Historical and arts itinerary			OPTION 3: Multi-use wharves			OPTION 4: Nature beach			OPTION 5: Extreme sports facility			OPTION 6: Multi-use belvedere			
			Score (1 to 5)	Weighted score	Result	Score (1 to 5)	Weighted score	Result	Score (1 to 5)	Weighted score	Result	Score (1 to 5)	Weighted score	Result	Score (1 to 5)	Weighted score	Result	Score (1 to 5)	Weighted score	Result	
TECHNICAL	Financial benefits	4	1	4	36	1	4	40	2	8	41	3	12	48	4	16	54	5	20	60	MA2, MA11, MA48, MA62, MD8, MD14, MD21, MD27, MD32, MD36, MD41, MD45
	Lifetime	3	5	15		5	15		4	12		4	12		3	9		3	9		MA3, MA14, MA23, MA24, MA35, MA46, MA59
	Tourism and recreation	3	1	3		1	3		2	6		3	9		4	12		5	15		MA34, MA36, MA45, MA47, MA56, MA61, MA63, MD5, MD12, MD17,
	Implementation complexity	3	4	12		4	12		3	9		3	9		3	9		2	6		MA4, MA25, MD15, MD26, MD35, MD44
	Historical/cultural reminder	2	1	2		3	6		3	6		3	6		4	8		5	10		MA12, MA27, MA28, MA39, MA57, MA60, MD1, MD2, MD6, MD9, MD10, MD16, MD24
ECONOMIC	Costs	4	5	20	56	5	20	56	5	16	56	5	12	57	5	8	59	1	4	48	MA1, MA10, MA22, MD23
	Job creation	3	1	3		1	3		1	3		2	6		4	12		5	15		MA44, MA51, MA64, MD7, MD13, MD19
	Labour source	4	5	20		5	20		5	20		5	20		5	20		5	20		Neutral
	Delay to project schedule	2	4	8		4	8		4	8		3	6		3	6		2	4		MA5, MA15, MA16, MA26, MA38, MD25, MD33, MD34, MD42, MD43
	Commercial shipping	1	5	5		5	5		5	5		5	5		5	5		5	5		MA8, MA20, MA32, MA42, MA54, MA67
ENVIRONMENTAL	Water quality	3	4	12	50	4	12	50	3	9	38	3	9	38	3	9	35	3	9	32	MA6, MA17,
	Greenhouse gases	2	5	10		5	10		4	8		4	8		4	8		3	3		MA4, MD44
	Biodiversity	3	5	15		5	15		3	9		3	9		2	6		2	6		MA7, MA18, MA29, MA40, MD20, MD28, MD29, 30, MD37, MD38, MD39, MD46, MD47, MD48
	Contaminated soil and sediment	2	4	8		4	8		4	8		4	8		4	8		4	8		Neutral
	Resource consumption/residual materials	1	5	5		5	5		4	4		4	4		4	4		3	3		MA4
SOCIAL	Impacts	4	5	20	65	5	20	65	4	16	61	4	16	61	4	16	64	4	16	62	MA9, MA21, MA33, MA43, MA55, MA68
	Pleasure boating	1	5	5		5	5		5	5		5	5		5	5		5	5		MA31, MA41, MA53, MA66
	Social acceptance	3	4	12		4	12		4	12		4	12		5	15		3	9		MA18, MA30
	Health and safety	4	5	20		5	20		4	16		4	16		3	12		3	12		MD22, MD31, MD40, MD49
	Knowledge/Innovation	4	2	8		2	8		3	12		3	12		4	16		5	20		MA13, MA50, MA52, MA60, MA65, MD3, MD4, MD11, MD18
		Result	OPTION 1		207	OPTION 2		211	OPTION 3		196	OPTION 4		204	OPTION 5		212	OPTION 6		202	

*See graphic representation of results for visualization

7.6 ANALYSIS AND CONCLUSION

The different options were evaluated and compared using a multi-criteria evaluation grid. It is important to recall that the options are cumulative and arranged from the simplest (network of cyclist rest areas and enhancement of natural environments) to the most complex (recreation and tourism facilities with belvedere). Thus, in the grid above, increasing scores for a given criterion indicate increasing benefits and decreasing scores indicate increasing negative impacts or uncertainty.

Given that the difference between the option with the highest score and that with the lowest score is only 15 points, it is not possible, using the grid, to identify options that do not align with JCCBI's will or that are best aligned with its vision. It is therefore necessary to assess the different options based on the spread of scores for the different themes, namely social, economic, environmental and technical, as shown in Figure 187.

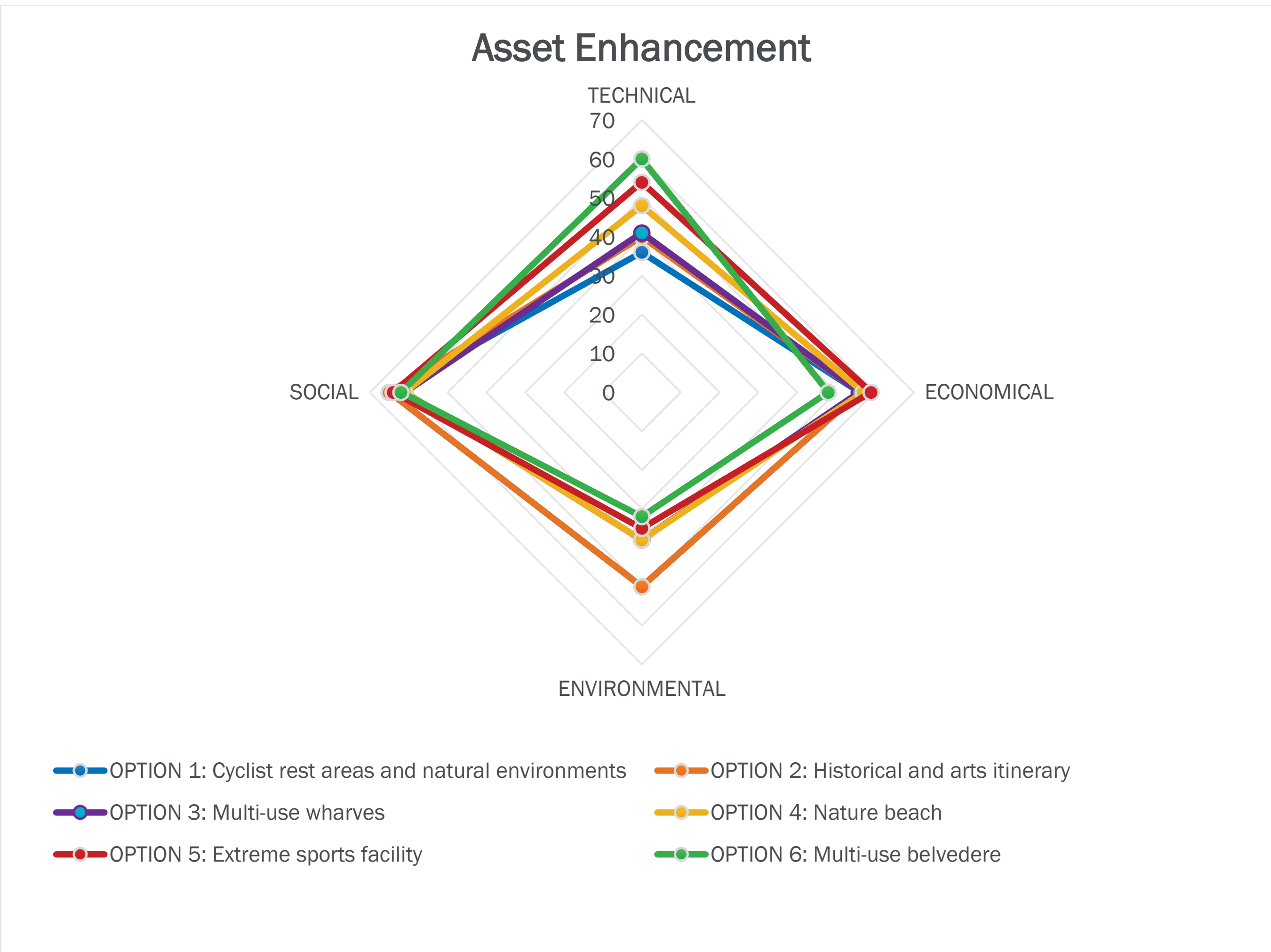


Figure 187 – Distribution of asset enhancement options

The above figure shows similar scores for the economic and social components, whereas technical and environmental scores vary greatly between options. In general, options that yield the highest technical scores yield the lowest environmental scores.

As far as the social axis is concerned, the different options give very similar scores. The effects on pleasure boating are nil in all cases and nuisances are minor compared to the current situation in the vicinity of the existing Champlain Bridge. Social acceptance and innovation are the criteria for which scores show the greatest variations. The option with the most complex implementation – building a belvedere – will require a very significant investment, and that may not be well-received by the general population although it would lead to the development of new knowledge and unique expertise in Canada. The converse relationship is true for Option 1, in which construction cyclist rest areas and enhancement of natural environments are unlikely to stir protest, but do not necessarily generate novel practices.

As far as the economic component is concerned, similar conclusions may be drawn. Proposed options do not affect commercial shipping during project implementation and the skills and capacities necessary to carry out the various options are available within the Canadian workforce. More complex actions, such as those included in Option 6, require significant investments as well as prior coordination ahead of deconstruction work. However, these major works will create many jobs, several of which will be long-term.

For the environmental component, results for the various asset enhancement options vary according to asset use intensity. Thus, there is greater uncertainty associated with actions such as construction of a beach or a belvedere ; in other words, there are more related unknowns. The preservation of structural components of the bridge would reduce greenhouse gas emissions during deconstruction, but the fact that their transformation produces greenhouse gases makes for lower scores. For biodiversity, the current state of knowledge would suggest that less intense options are better, although the evaluation did not factor in the potential use of novel mitigation measures in the case of more complex projects, which could affect scores. Finally, all proposed options have similar impacts on water quality, soil and sediment and on consumption of non-renewable resources.

As far as technical components are concerned, or asset enhancement-specific criteria, results are very polarized and tend to favor more complex projects. Although the implementation of such projects is trickier, the development of a major recreation and tourism cluster with a strong symbolic and historical character would lead to an increase in the number of users, which would generate significant financial benefits. The lifetime criterion is not a discriminating factor in this case because all options have similar lifetimes.

In conclusion, the option that yields the highest score is Option 5, the extreme sports facility. However, its score is not sufficiently different from scores for the other options to make it stand out clearly. It is important to keep in mind that benefits arising from more complex options are associated with uncertain elements, whereas simpler options produce fewer benefits. It is therefore recommended that all asset enhancement options be retained in order to examine their relationship with the various aspects of the existing Champlain Bridge deconstruction, but also that all stakeholders be consulted to obtain a better understanding of their interests for the various projects and to lift uncertainties arising from some of the proposed actions.

8 ASSESSMENT OF STAKEHOLDER INFLUENCE

To show that the identification of the optimal scenario reflects, to the extent possible, the needs, constraints, and concerns of the context in which it will be set, a broad consultation of stakeholders must be conducted as part of this mandate. Given the large number of stakeholders and partners identified in each field of study, it is impractical to consult them all. An in-depth examination is therefore required to assess how these entities view the project (favorably or unfavorably) and their potential influence on its smooth implementation. Figure 188 shows a stakeholder classification scheme proposed by JCCBI.

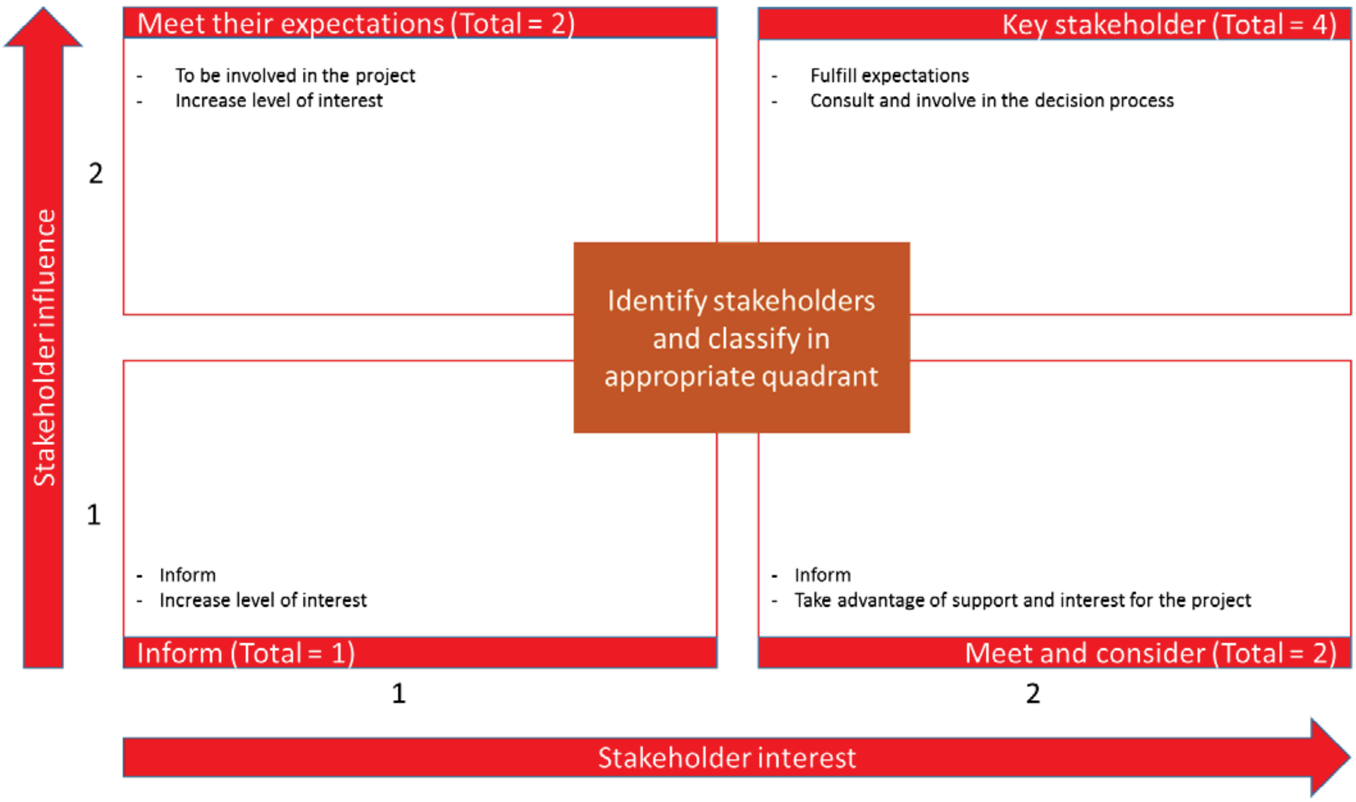


Figure 188 – Proposed stakeholder classification scheme

A quantitative indicator of a stakeholder's influence is the fact that this stakeholder is known have an influence on all fields of study. Shared land with a stakeholder or the immediate proximity of a stakeholder with the planned deconstruction site are qualitative indicators of the influence of this stakeholder. The classification grid was completed during a joint JCCBI/PTA Consortium work meeting (see details in Appendix 4). The following table only shows stakeholders deemed of higher priority.

Table 91 – Priority stakeholders

	STAKEHOLDERS	DESCRIPTION OF INTERACTION
[redacted]		

Since August 2016, meetings were held with some of these stakeholders (shaded boxes in Table 91). JCCBI plans meetings with government authorities and are held with the support of the PTA Consortium, whereas discussions with other stakeholders are held directly by PTA Consortium representatives. In both cases, a meeting agenda is prepared and minutes of the discussions are kept and submitted to the relevant stakeholders for approval. Minutes prepared by the PTA Consortium are included in Appendix 4.

Meetings with some of the priority stakeholders have not yet taken place (e.g. Environment and Climate change Canada, Groupe SSL, Infrastructure Canada).

8.1.1 TRANSPORT CANADA

During the meeting with Transport Canada held on September 30, 2016, discussion took place about the height at which footings should be dismantled (see minutes in Appendix 4). Transport Canada's requirements are as follows:

For navigation, the required heights for dismantling of footings depend on general use as follows:

Within navigable areas:

- *Piers cut below water level: a minimum clearance of 2.0 m must be provided at all time (low water). This requirement was applied for the Nun's Island Bridge demolition ;*
- *Piers cut above water level: Piers must be cut, as required, at a height that makes them clearly visible even during times of high water (no minimum height set). Although this requirement is only for boating, other factors might need to be considered (hydraulic behavior, ice movements, etc.).*

In non-navigable areas:

- *Beyond Pier #40 or thereabout, where clearance is insufficient for navigation, piers must be cut down flush with the river bed.*

8.1.2 DEPARTMENT OF FISHERIES AND OCEANS

A meeting with a Fisheries and Oceans Canada representative was held on September 29, 2016 (see minutes in Appendix 4).

For pier and footing deconstruction, the DFO sets no removal targets for environmental compensation. However, if footings must be left in place, the DFO would like the maximum height after removal to be 45 cm above the river bed to ensure conservation of existing habitat. Where complete removal is required, the DFO suggests removal down to at least 45 cm below the level of the river bed to allow the restoration of suitable fish habitat.

During the meeting, this representative expressed reservations about the use of the following method for deconstructing the bridge deck:

<u>Demolition using controlled explosion</u>

In the case of the bridge deck, the DFO will reject this method, because other logistically feasible demolition methods are much less harmful to fish.

For piers, PTA mentioned that this method was used for the demolition of the old Port Mann Bridge in Vancouver in 2014 using preliminary detonations to scatter fish away and air curtains to dampen the shock wave. The DFO mentioned that a maximum pressure of 100 kPa is allowed during blasting. The best interface remains air, which requires construction of cofferdams. The use of explosives may be allowed for the piers, but the request will be reviewed carefully and a compelling case will have to be made to the DFO.

8.1.3 JCCBI'S CENTRE FOR INFRASTRUCTURE INNOVATION

During its lifetime, the existing Champlain Bridge has been the focus of numerous studies and analyses that have led to various reinforcements and repairs. The demolition of the bridge provides an opportunity for JCCBI to conduct destructive or non-destructive investigations and tests on structural elements, either on site or in the laboratory. This is a unique opportunity for acquiring new data and knowledge that JCCBI can use to manage its current assets and strengthen its position as an expert work provider.

Through its Centre for Infrastructure Innovation, JCCBI, in collaboration with various research institutes and specialized companies, will be able to develop an investigation program that meets its needs and aligns with its orientations. As these investigations will have an impact on the demolition contract, the program will have to be defined early enough to be included in tender documents for the demolition. To date, JCCBI has not provided any information on this and scenarios for the different fields of study have not been affected by any research program.

8.1.4 THE ST. LAWRENCE SEAWAY MANAGEMENT CORPORATION (SLSMC)

Meetings with the St. Lawrence Seaway Management Corporation (SLSMC) were held on August 15 and November 4, 2016 (see minutes in Appendix 4). At the request of JCCBI, the SLSMC outlined the steps required of SSL Group to provide certain facilities and carry out some work on SLSMC property for the construction of the new Champlain Bridge. Similar steps will be required of JCCBI as part of its own work, including signing a framework agreement and negotiating specific agreements based in part on a risk analysis for each action on SLSMC property involved in the deconstruction of the existing Champlain Bridge.

Finally, SLSMC insists on a project schedule that will ensure that most of the work done directly above the navigation channel will take place during the winter closure period, from late December to mid-March.

9 PROJECT DELIVERY METHODS

An assessment of the various project delivery methods considered for the work associated with the deconstruction of the existing Champlain Bridge is presented in this section.

9.1 DEFINITIONS

Project delivery methods fall into four main groups, of which the first three are very common in the industry whereas the last one is a relatively recent method that is emerging in the United States and Canada:

- Traditional ;
- Design-Build ;
- Public Private Partnership (PPP) ;
- Construction Management (Construction Manager/General Contractor (CM/GC)).

9.1.1 TRADITIONAL

In a traditional delivery project, the client manages the overall project delivery. He contracts out the work to different entities and then coordinates their work, as well as the various parts of the project. Once the needs analysis has been completed, the client acts as project designer, defining the design and the technical specifications. These tasks are generally contracted out to specialized consulting firms, who carry them out in whole or in part. The traditional delivery method typically involves producing all detailed contract drawings and specifications and then sending out a call for tenders for the construction of the entirety of the project by a general contractor. The client takes on the majority of the risks and must budget for contingencies.

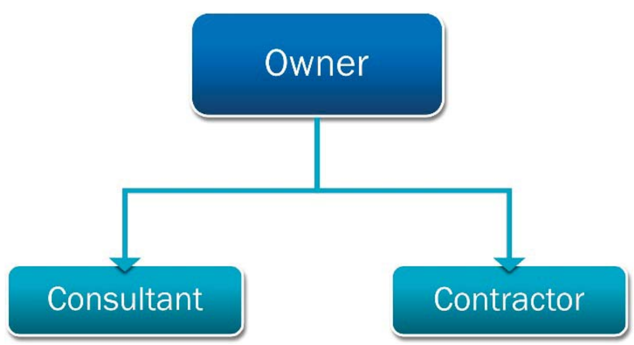


Figure 189 – Traditional delivery method

It is also relevant to consider a variation on the traditional deliver method, called the hybrid traditional method, for this project. This method involves preparing drawings and specifications with a lower level of detail than for the standard traditional method. The tender documents specify all the necessary details to fully layout the work required but allow the contractor sufficient freedom to develop the most efficient methods to carry out the required work.

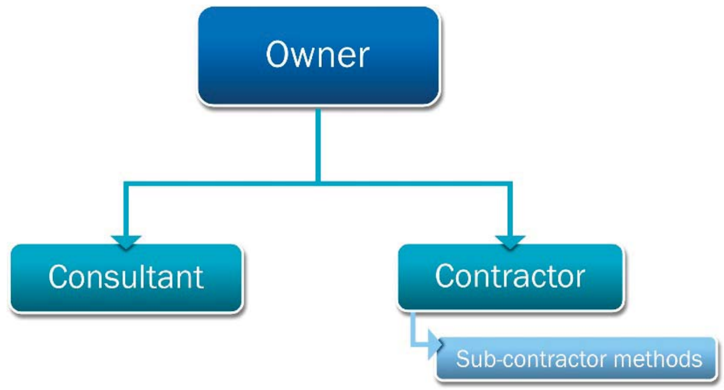


Figure 190 – Hybrid traditional project delivery method

9.1.2 DESIGN-BUILD

The design-build project delivery method can take different forms, one of the most common being turnkey construction. This type of contract allows the client to interact with a single entity, who is responsible for both the design and construction of the project. This entity prepares all drawings and specifications for all fields of activities (civil and structural engineering, architecture, electrical, etc.) and is in charge of construction.

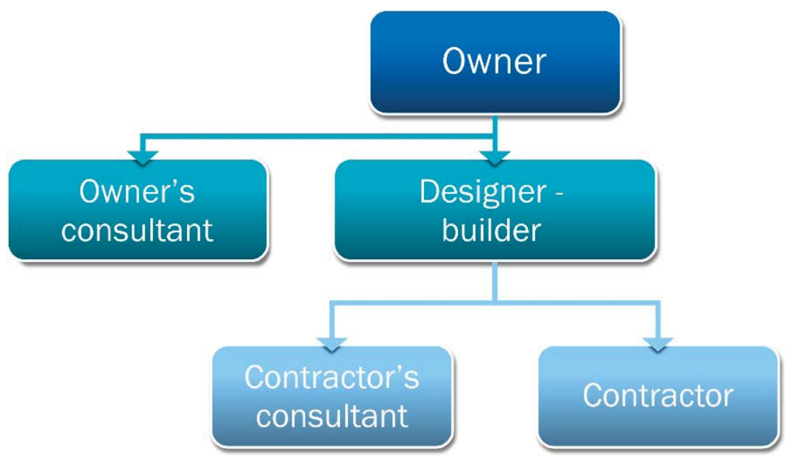


Figure 191 – Design-build project delivery method

In this delivery method, the client must first define broad requirements. Performance specifications are prepared for the project, which might include a base design concept. It is essential that these specifications reflect the client's expectations because the bid price and responsibilities of the selected bidder will be limited to what is set out in these specifications. Considerable efforts must therefore go into writing the performance specifications and base design concept, which should clearly define all expectations regarding the desired outcomes of the project design and construction.

This delivery method allows the client to transfer some of the risks to the design-build entity, particularly those risks related to project costs and construction schedule.

9.1.3 PUBLIC-PRIVATE PARTNERSHIP (P3)

There are several variations on the public-private partnership (P3) delivery method that exist. In general, it is defined as a private company mandated by a public client for the design, construction, financing, operation, maintenance, and rehabilitation of public facilities in return for financial compensation for a set period of time (longer than 25 years in general). Tolls, for instance, are a common source of income for this type of contract, although they are not an essential part of P3 delivered projects.

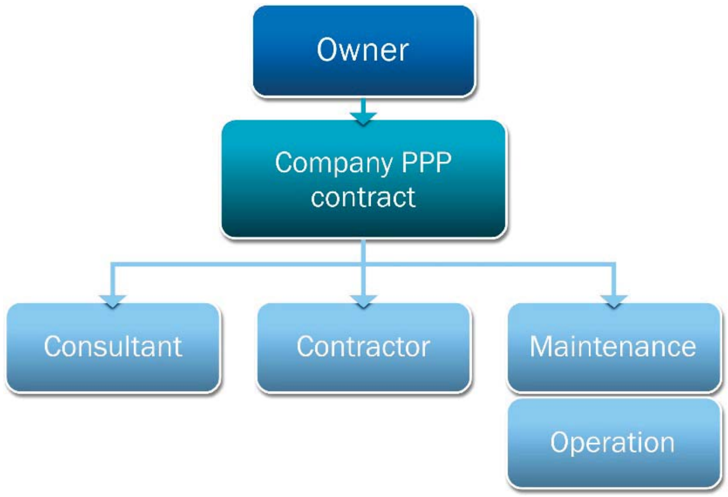


Figure 192 – Public-private partnership delivery method

A definition of a public-private partnership set forth by Infrastructure Québec is as follows: "A public-private partnership is a long-term contractual agreement between public and private partners that sets out expected outcomes to improve the delivery of public services. This agreement establishes a sharing of responsibilities, investments, risks, and benefits in such a way as to provide mutual benefits in the attainment of the desired outcomes."

9.1.4 CONSTRUCTION MANAGEMENT

In the construction management delivery method, a contractor is part of the team in charge of preparing tender documents, along with the owner and a design consultant. This delivery method calls upon the expertise of a specialty contractor to enhance the constructability of the work to be performed.

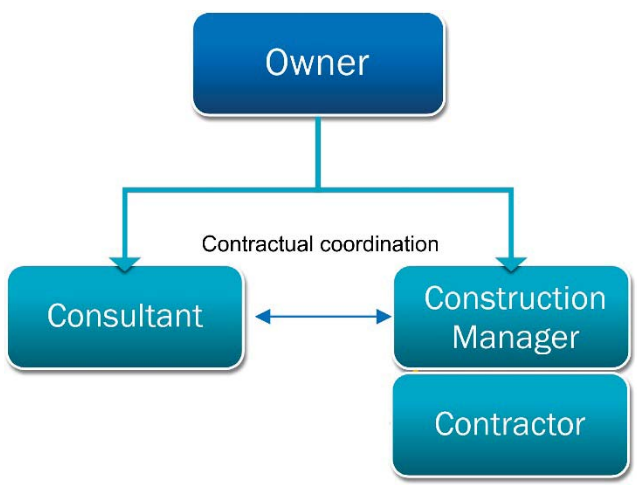


Figure 193 – Construction management delivery method

While there are several types of construction management contracts, two are recognized in Public Works and Governmental Services Canada’s (PWGSC) Procurement Management Manual, and are used by agencies in Canada, namely:

- Construction Manager in an Advisory capacity, and
- Construction Manager Semi–at-Risk.

The construction management in an advisory capacity method is similar to the traditional method, except that a contractor is added within the design consultant’s team. In the construction management semi-at-risk method, this contractor is also the general contractor for the construction phase of the project. The contractor is selected based on expertise and, when the design is nearly completed, a price for the work is negotiated. If this negotiation is successful, the contractor carries on as general contractor. If not, there is a call for tenders and the rest of the work is done following an approach similar to the traditional delivery method.

In this project delivery method, risk management is shared between the client, the specialty contractor, and the designer.

9.2 METHODS CONSIDERED

The “traditional” and “hybrid traditional”, “design-build”, and “construction management” project delivery methods will be considered. The public-private partnership method is not optimal for deconstruction work because there is no operation phase and, at this stage of the project, there is no significant source of income for the contractor. The PPP approach could be considered if, for instance, surplus land could be included for development or if an income-generating tourist attraction was planned, in which case the generated income could offset some of the deconstruction costs for the developer.

The well-known traditional project delivery method, which is commonly used by JCCBI, is not analyzed any further. The other three remaining methods are analyzed in the following sections.

9.3 ANALYSIS

9.3.1 METHODS CONSIDERED

The choice of a project delivery method has considerable implications on how the project will be carried out. To analyze and assess the different delivery methods, the following elements must be considered:

- Risk transfert ;
- Schedule for completion of the work ;
- Cost.

Table 92 summarizes the main advantages and disadvantages of each method considered.

Table 92 – Advantages and disadvantages of project delivery methods considered

PROJECT DELIVERY METHOD	ADVANTAGES	DISADVANTAGES
Hybrid traditional	• Standard and well-established contract documents • Changes are easy to make and have more limited financial consequences if made during the design phase • Flexibility to include likely input from various stakeholders • Costs set when contract is signed with contractor • Methods optimization by contractor	• Costs subject to market constraints • Owner is responsible for cost overruns • Limited interaction between designers and contractors • Project subject to annual budget constraints (may affect project duration and, hence, costs) • Client takes on most of the risk
Design-build	• Shortest project schedule • Streamlined work (concurrent design and construction) • Significant interactions between designer and contractor to optimize concepts • Project costs set at contract signing • Cost- and schedule-related risks are passed on to the design-builders	• Much less flexibility if changes are needed • Complex contract documents: significant efforts required to precisely define the project in order to minimize extras • Three short-listed design-builders must be paid a stipend for the preparation of tenders • Requests by other stakeholders are difficult to include once the design-build agreement is signed • Costs reflect the fact that the contractor takes on the risks
Construction management	• Average costs lower than traditional method • Faster schedule than traditional method • Fewer extras compared to other methods, because contractor manages risks with the client during the design phase • Owner is part of the team that prepares the concept and maintains more control than in the design-build approach • Easier for owner to communicate knowledge about the structure • Owner manages innovations to meet his specific needs	• No standard contract documents or process in place • Owner must mobilize more resources • Risk of delayed schedule if price negotiations are unsuccessful • Choice of a specialty contractor is based on technical criteria, not on the lowest bid, which is unusual for the industry and JCCBI

The following points, which may differ among delivery methods, must be considered in the analysis because they will affect the overall contract strategy:

- Contractor preselection (financial, economic, technical, and professional capacity): considering the scale of the work, a preselection appears warranted and would allow JCCBI to check that contractors have the necessary technical and financial capacity to fulfill contract requirements ;
- Contract-awarding approach: evaluation of tenders (technical and financial aspects) or lowest compliant bid.

The processes for each of the three delivery methods are presented chronologically in the following figure to show their relationship with the planned work schedule. These schedules do not include potential public consultation should the federal Environment Minister designate the deconstruction of the existing Champlain Bridge project a physical activity under Section 14 of the Canadian Environmental Assessment Act (CEAA).

Hybrid traditional

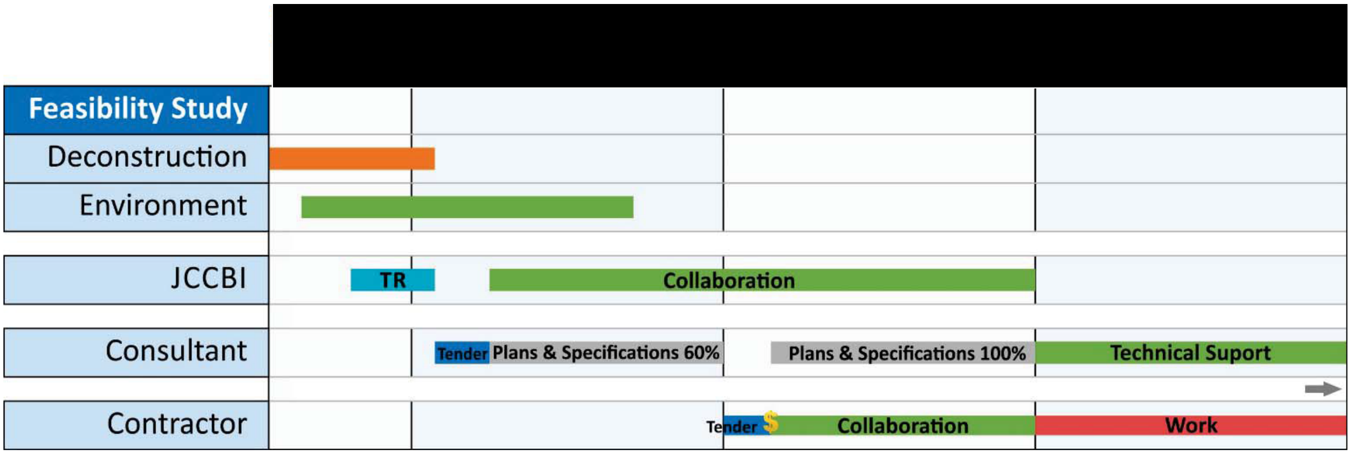


Figure 194 – General schedule – Hybrid traditional delivery method

After preselection of three qualified contractors based on a technical assessment, the hybrid traditional mode involves the selection of the lowest compliant bid. Qualified contractors prepare their tenders based on drawings and specifications that are only about 60% advanced, thus providing the selected contraction sufficient leeway to develop methods that will allow him to carry out the work as efficiently as possible. This requires a longer tender preparation period for qualified contractors than the pure traditional approach.

Design-build

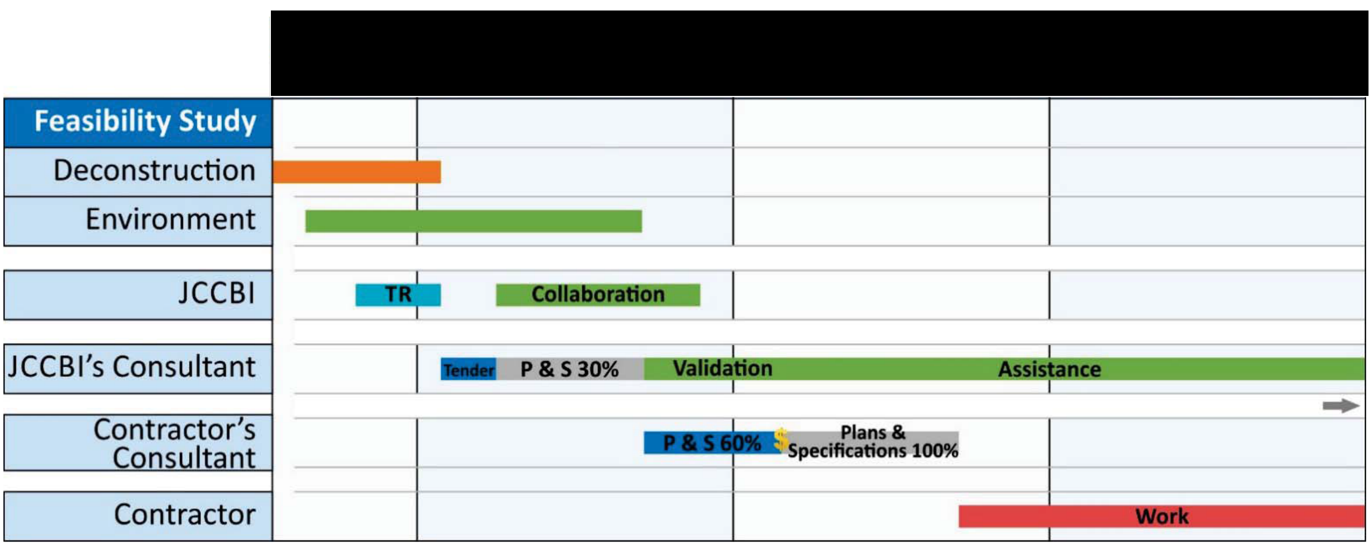


Figure 195 – General schedule – Design-build delivery method

After preselection of three qualified design-builders based on a technical assessment, the design-build approach involves the selection of the lowest compliant bid. Qualified design-builders prepare their tenders based on drawings and specifications that are only about 30% advanced. The selected design-builders is responsible for all of the detailed engineering, procurement and construction. In this approach, the design-builders guarantees the performance of the work and this responsibility ends after commissioning of the project.

The main hurdle to a pure design-build delivery is the large number of items that must be defined. The drawings and specifications required to meet all JCCBI's technical, environmental, economic, and social requirements would be too detailed to be considered as a design-build approach, since they would essentially include the same level of detail as in a hybrid traditional approach.

Construction management

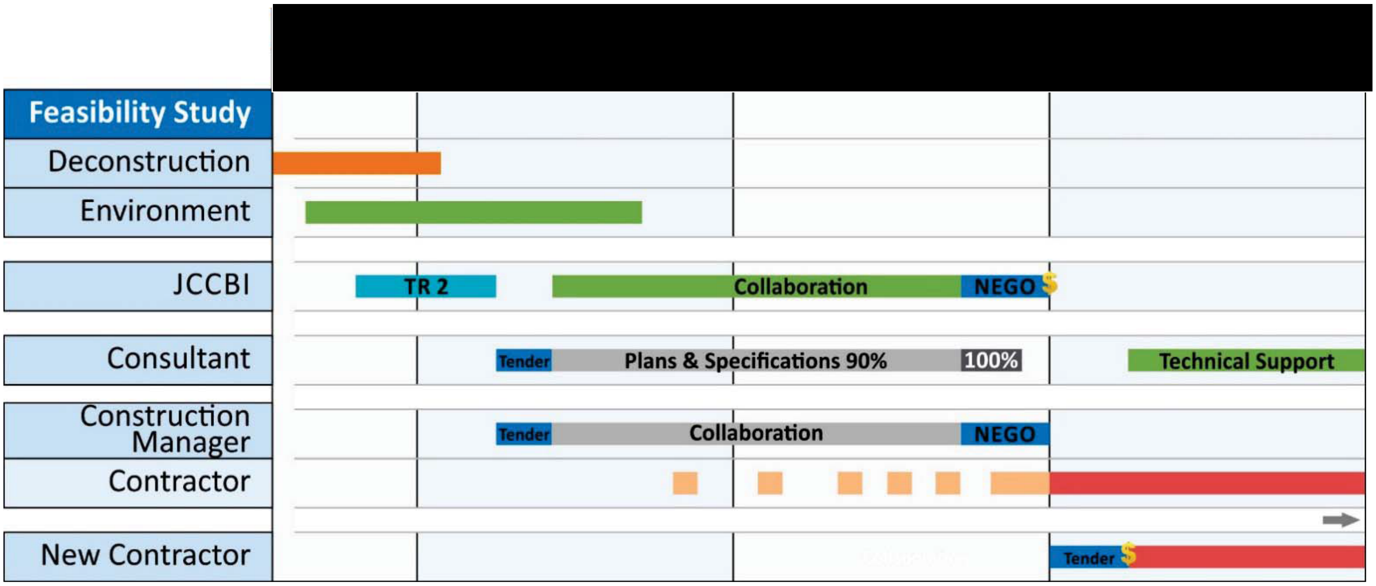


Figure 196 – General schedule – Construction management delivery method

Compared to the hybrid traditional delivery method, the construction management approach requires that a contractor be selected earlier in the process, as soon as the preparation of drawings and specifications begins. The contractor is also selected based on a technical assessment of the tenders, not on the lowest compliant bid. The selected contractor will set an asking price at the end of the design process, which will be negotiated with JCCBI. If it is not possible to come to an agreement with the contractor, JCCBI must then turn to other contractors for a new tender prior to awarding the contract.

9.3.2 MODIFIED PROGRESSIVE DESIGN-BUILD

Selecting contractors based on criteria other than price could make it difficult to comply with JCCBI procurement rules. Except for design-build projects, contractors are normally selected based on the bid price for the work defined in 100% advanced tender documents (traditional delivery method), which would not be the case for the hybrid traditional and construction management methods. To get around this hurdle, JCCBI developed a variation on the hybrid traditional method in which preparation of drawings and specifications is advanced to 30%, 60% or 80% levels, and is done concurrently with three design-builders. At the end of the design process, each of them submits a bid price, the contract being awarded to one of the three based on the usual JCCBI lowest compliant bid rules or a variation on these rules which includes an assessment quality and price against pre-established sustainable development criteria.

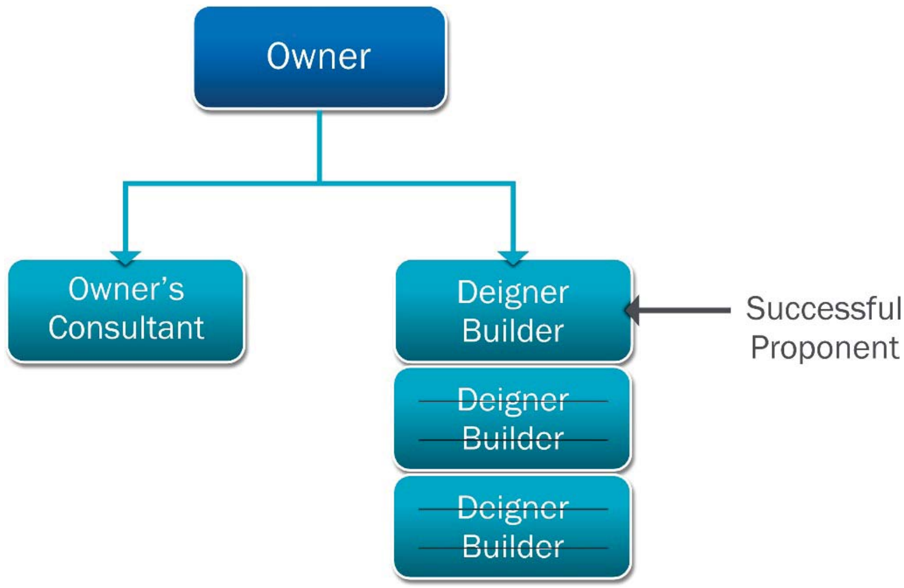


Figure 197 – Progressive design-Build project delivery method

This procurement approach is similar to the so-called progressive design-build method, which is a design-build approach involving multiple contractors. The advantage of this approach is that it is consistent with the JCCBI procurement process while allowing limited risk sharing.

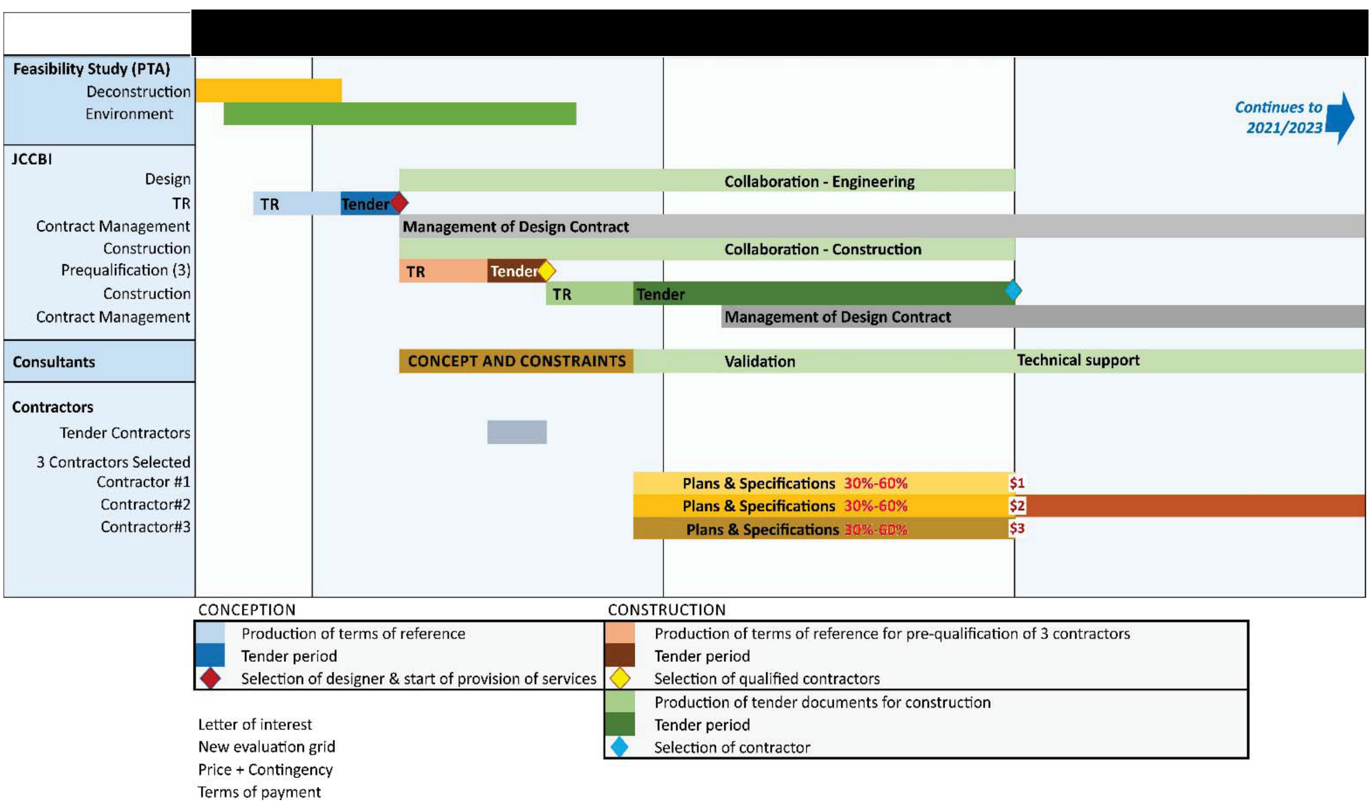


Figure 198 – General schedule – Progressive design-build delivery method

However, this process has the following drawbacks:

- It requires very close interfacing with the three contractors to ensure sound and productive collaboration, while treating all three equitably ;
- Must fund the preparation of three distinct packages of drawings and specifications, which will be advanced from 30% to 60% or 80%, meaning funding the preparation of three nearly complete distinct projects. For a project of this size, this represents a considerable effort from both a resource mobilization and financial standpoint ;
- Contractors may show limited interest in this type of process because they have to take on the advanced development of the project (more advanced than in a design-build approach) with no certainty that they will be awarded the deconstruction contract. They must mobilize key personnel on a single project for a longer period than in a purely design-build approach.

9.4 REFERENCE PROJECTS

9.4.1 MAJOR PROJECTS

A number of major projects are presented in Table 93 as references for different types of delivery methods discussed. The table is provided for information purposes only, without any indication on the success of the approach or whether problems were encountered, because it is very difficult to obtain clear and reliable information of this type, particularly for P3 projects.

Table 93 – Examples of projects completed with different delivery methods

PROJECT	DELIVERY METHOD
Demolition of the Waldo Hancock Bridge, Maine	Traditional: complete deconstruction approach developed by consultant
Replacement of the Carquinez Bridge, New York	Hybrid traditional, with considerable leeway given to the contractor about the choice of methods (demolition included in the scope of work for the new bridge construction)
Demolition of the Oakland Bay Bridge, San Francisco	Hybrid traditional, with considerable leeway given to the contractor about the choice of methods
Replacement of the Turcot iInterchange, Montreal	Design-build (demolition included in the scope of work for the new interchange construction)
Demolition of the old Port Mann Bridge, Vancouver	Design-build (demolition included in the scope of work for the new bridge construction)
Replacement of the Tappan Zee Bridge, New York	Design-build (demolition included in the scope of work for the new bridge construction)
Replacement of the Christopher S. Bond Paseo Bridge, Kansas City	Design-build (demolition included in the scope of work for the new bridge construction)
Extension of the A-25 Autoroute, including several bridges with one over Rivière-des-Prairies, Montreal	P3
Construction of the new Champlain Bridge, Montreal	P3
Replacement of the Goethals Bridge, New York	P3 (demolition included in the scope of work for the new bridge construction)
Replacement of the Grand River Bridge (West CMGC 3), Cayuga, Ontario (MTO)	Construction management
Improvement of the West CMGC 40/401 Hwy 401/Hwy 40 interchange, including replacement of 3 bridges, Chatham, Ontario (MTO)	Construction management
Replacement of the Grand River Bridge (West CMGC Former Hwy 6 Argyle St.), Caledonia, Ontario (MTO)	Construction management
Replacement of the historical 6th Street Bridge, Los Angeles	Construction management (demolition included in the scope of work for the new bridge construction)

There are few deconstruction only projects, which do not include construction of a new bridge. The table shows that the traditional delivery approach has not been used in any recent deconstruction projects. Based on our consortium's experience on a few deconstruction projects, it is clear that involvement of the contractor from design to deconstruction is essential, which is something that a pure traditional delivery approach does not allow.

9.4.2 JCCBI PROJECTS

JCCBI has launched many calls for tenders for large projects in the past. Table 94 provides a summary of delivery methods used for these projects.

Table 94 – Examples of JCCBI projects

PROJECTS	DELIVERY METHODS
Champlain Bridge: repairs	Traditional
Bypass bridge	Traditional
Champlain Bridge: replacement of Section 6 deck	Traditional
Jacques-Cartier Bridge: deck replacement	Design-build
Mercier Bridge: deck replacement	Design-build

9.5 RECOMMENDATIONS

9.5.1 PROJECT DELIVERY METHOD

The recommended delivery method is construction-management. Collaboration with the designer and the contractor from the onset will make it possible to identify the best methods, which will result in a shorter delivery schedule and lower costs. In the case of the Champlain Bridge, an assessment of span capacity, particularly for concrete spans, will require considerable efforts. Considering all available methods and equipment will be very difficult. In a construction management approach, the designer and the contractor will be able to benefit from JCCBI's expertise acquired over the years. A thorough knowledge of the bridge and its history of repairs will no doubt be an asset for method development. An integrated team will make knowledge transfer more effective, and risk sharing will result in lower costs, as well as the sharing of benefits from innovations introduced during the project. In addition, JCCBI will have more flexibility to include research and innovation projects that best meet its needs (pre-stress testing, CFRP aging, new concrete testing methods, loading tests, etc.) and the specific needs of its infrastructure, which includes other prestress girder bridges and long span steel bridges.

If the planned JCCBI project schedule does not allow the implementation of a new procurement system or if procurement rules preclude such an approach, two other methods may be recommended:

The hybrid traditional delivery method, which is essentially a traditional approach with sufficient flexibility to allow the contractor to determine the best possible deconstruction methods and adapt the transportation as needed. In this way, the main advantages of a design-build approach are maintained while allowing JCCBI to retain sufficient control over the project. The drawings and specifications used in the call for tenders will define project limits, environmental restrictions, applicable codes and standards, mobilization areas, transportation restrictions, desired material re-use, site enhancement, and other criteria, without imposing specific methods, thus transferring those responsibilities onto the contractor while giving him the flexibility to decide which methods are optimal given his equipment as well as the availability and expertise of his staff. In addition, the time required to prepare tender documents is less than for a traditional approach since the level of detail is not as great.

The progressive design-build delivery method is similar to the hybrid traditional method. However, because three contractors (design-builders) are involved in the preparation of drawings and specifications instead of just one, the procurement process is clearly compliant with effective CCBI rules. However, this approach does require significant human and financial resources during the design phase.

9.5.2 OTHER RECOMMENDATIONS

Contract splitting

The deconstruction study has shown that the work can be subdivided in three independent parts, namely deconstruction of the deck, piers and footings. As a result, the deconstruction contract could be subdivided into three distinct contracts. However, this is not recommended, the main reasons being the required contractor supervision and the added complexity arising from managing the various entities involved. Subdividing the work into distinct contracts requires the following:

- Providing sufficient workspaces for all contractors: if large parts such as prestress girders must be moved, this can be complicated ;
- Coordinating access and egress at both ends of the bridge, which will be in one of the contractors' space ;
- Ensuring significant coordination.

With the following consequences:

- A transfer of risk to JCCBI because, ultimately, JCCBI will manage much of the work ;
- Seriously compromised deconstruction scenarios such as the use of a launching gantry, which is much less interesting for fewer spans ;
- Lower potential for economies of scale
- The need to go through method and procedure approvals with each contractor ;
- Significant effort required to ensure that the various contractor schedules are compatible ; one contractor may remove an access or part of the bridge which another contractor might need for his work (e.g. if concrete girders are removed along the deck and on only one side of the bridge, the steel spans must be removed last) ;
- Likely longer completion schedule to accommodate the constraints of all parties involved.

Timely delivery

To ensure timely delivery of the project, as a whole or in phases, incentive disincentive clauses can be added to the contract imposing fines on the contractors in case of delays and bonuses if work is completed ahead of schedule.

However, extreme care must be given to the writing of these clauses so that assessments of work completion may not be easily challenged and bonuses not be given when results do not meet expectations.

10 COST ESTIMATE OF THE WORK

10.1 DECONSTRUCTION

10.1.1 GENERAL CONSIDERATIONS

Deconstruction costs were estimated based on previous deconstruction work carried out in North America. The cost of deconstruction work includes the following:

- Estimates in [redacted] Canadian dollars, given a [redacted] annual inflation rate ;
- Accuracy: Class C estimate [redacted] ;
- Site organization: [redacted] of cost of work ;
- Contingencies: [redacted] of cost of work ;
  - [redacted] to account for the level of detail of available documents (feasibility study instead of drawings and specifications) ;
  - [redacted] to account for environmental, traffic, and other constraints that will be defined over time ;
  - [redacted] to account for variations in quantities.
- Professional services: [redacted] of cost of work ;
  - Drawings and specifications: [redacted]
  - Site supervision and laboratory work [redacted]
  - Technical Office support: [redacted]

10.1.2 EXCLUSIONS

The following items are not included in the costs:

- Right of way ;
- Land acquisitions ;
- Deconstruction of span 13E-14E ;
- Construction of access to pier 13E ;
- Any deconstruction work beyond abutment 44W and pier 13E ;
- Traffic control outside of the work site ; traffic control is included for work above René-Lévesque Boulevard and Route 132, but any other traffic control activities are not included in the costs ;
- Costs incurred by the Owner (insurance, project staff, etc.).

10.1.3 COST ESTIMATE FOR THE WORK

Table 95 shows costs by construction method and Table 96 provides a summary of costs for the various scenarios proposed. Estimated deconstruction costs range from [redacted]

The cost of the recommended scenario, T2-TA1-F1-S2, is estimated a [redacted] (highlighted in blue in Table 96). The most expensive scenario is T1-TA2-F1-S1, with an estimated cost of [redacted] (highlighted in red in Table 96), and the least expensive is T2-TA1-F2-S2 at [redacted] (highlighted in green in Table 96).

Table 95 – Cost estimate – Deconstruction methods

	COST OF DECONSTRUCTION WORK	PROFESSIONAL SERVICES
T1 – Crane Removal	[redacted]	
T2 – Unlaunching		
TA1 – Cranes/Reverse Erection/Strand Jack		
TA2 – Reverse Erection		
F1 – Standard/Sawing		
F2 – Explosives		
S1 – Standard/Sawing		
S2 - Explosives		

Table 96 – Cost estimate – Deconstruction scenarios

	COST OF DECONSTRUCTION WORK	PROFESSIONAL SERVICES
T1-TA1-F1-S1	[redacted]	
T1-TA1-F1-S2		
T1-TA1-F2-S2		
T1-TA2-F1-S1		
T1-TA2-F1-S2		
T1-TA2-F2-S2		
T2-TA1-F1-S1		
T2-TA1-F1-S2		
T2-TA1-F2-S2		
T2-TA2-F1-S1		
T2-TA2-F1-S2		
T2-TA2-F2-S2		

10.2 MATERIAL TRANSPORTATION

Table 97 shows costs for materials transportation. At this stage of the project and for costing purposes, transportation by water assumes that materials will be transported to the Port of Contrecœur.

Table 97 – Cost estimate – Materials transportation

TRANSPORTATION METHOD	COST
Transportation by road (Montreal area)	[redacted]
Transportation by road (Contrecœur area)	
Transportation by water (Contrecœur area)	

10.3 MATERIAL RECOVERY

Table 98 shows the costs of the various materials recovery options, which range from [redacted] It is important to note that revenues are expected from the sale of steel, whereas recycling of concrete will represent an expense. Cost estimates provided below were derived based on the market prices of materials as of October 20, 2016.

Table 98 – Cost estimate – Materials recovery

	COST
Preservation and transformation of structures	[redacted]
Off-site recycling of materials	
In situ re-use of materials	
In situ recycling of materials	
In situ re-use of structural elements	

10.4 ASSET ENHANCEMENT

Table 99 shows total costs for the various JCCBI asset enhancement options. These costs vary greatly between options, ranging from [redacted] A detailed description of the costs of the various actions included in the six options is presented in Appendix 5-6.

Table 99 – Cost estimate – Asset enhancement

	COST
Option 1 - Network of cyclist rest areas and windows on the St. Lawrence linked with a network of improved natural environments	[redacted]
Option 2 - Historical and arts itinerary (+ option 1)	
Option 3 - Multi-use wharves and infrastructure for aquatic activities (+ Options 1 and 2)	
Option 4 - Construction of a nature beach (+ Options 1 to 3)	
Option 5 - Construction of an aerial extreme sports facility (+ Options 1 to 4)	
Option 6 - Construction of a multi-use belvedere (+ Options 1 to 5)	

11 WORK SCHEDULE

11.1 GENERAL ASSUMPTIONS

The duration of work is estimated for each superstructure and foundations demolition method. Estimates are based on logical scheduling of the work and realistic work output estimates. At this stage of the studies, the work schedule is not optimized.

The work schedule is based on the following main assumptions

Work season and duration

- From mid-December to mid-March: work on site is at a complete stop except on the suspended span above the Seaway ;
- Work week: 5 days ;
- Normal and realistic pace of work.

Deck – concrete spans

- Launching gantry assembly: 2 months ;
- Launching gantry output: 5 days per span ;
- Concrete sawing.

Deck– steel spans

- Suspended span: work allowed only from mid-January to mid-March.

Foundation – Pier caps and shafts

- Concrete sawing: 1.0 m^2/hr ;
- 2 work crews.

Foundation - Footings

- Concrete sawing: 1.0 m^2/hr ;
- Debris recovery: 5 days per span ;
- 2 work crews

11.2 WORK DURATION

11.2.1 WORK DURATION OF THE DIFFERENT METHODS

The duration of work for the various bridge components and methods is shown in Figure 199, which clearly shows that the foundation deconstruction method selected will have a significant impact on the total duration of the work.

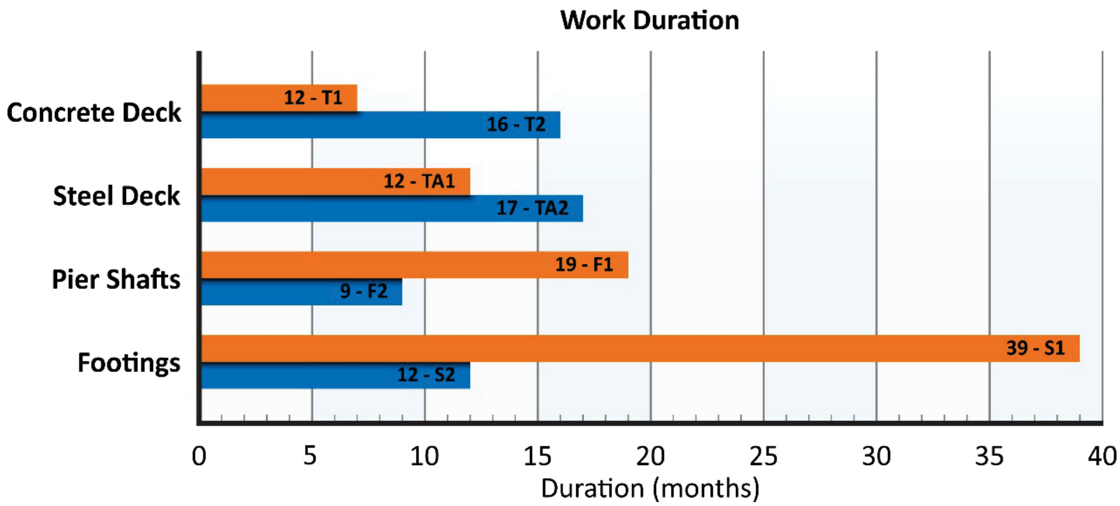


Figure 199 – Comparison of work duration

The scenario selected based on the assessment is as follows:

- Deconstruction of the concrete deck using the unlaunching method (T2) ;
- Deconstruction of the steel deck using the cranes/reverse erection/strand jacks method (suspended span in winter) (TA1) ;
- Deconstruction of pier caps and shafts using the standard/sawing method (F1) ;
- Deconstruction of footings using either the standard/sawing (S1) or controlled explosion (S2) method. Since both solutions give similar scores, they are both shown below.

11.2.2 DURATION OF SCENARIOS

11.2.2.1 General scheduling

Given the various constraints, with the main one being a single mobilization area for the unlaunching method (T2), deconstruction of Section 6 may only be carried out after deconstruction of the Section 5 deck. The general scheduling is as follows:

1. Deconstruction of the Section 5 deck ;
2. Launching gantry moved to Section 7;
3. Possibility for concurrently carrying out:
   - o Deconstruction of the Section 7 deck ;
   - o Deconstruction of the Section 6 deck.

11.2.2.2 Scenario T2-TA1-F1-S1

The preliminary work schedule for the T2-TA1-F1-S1 scenario is presented in Figure 200. The total duration of work is estimated at 50 months spread over 5 years (no work during the winter, except as noted - see 11.1).

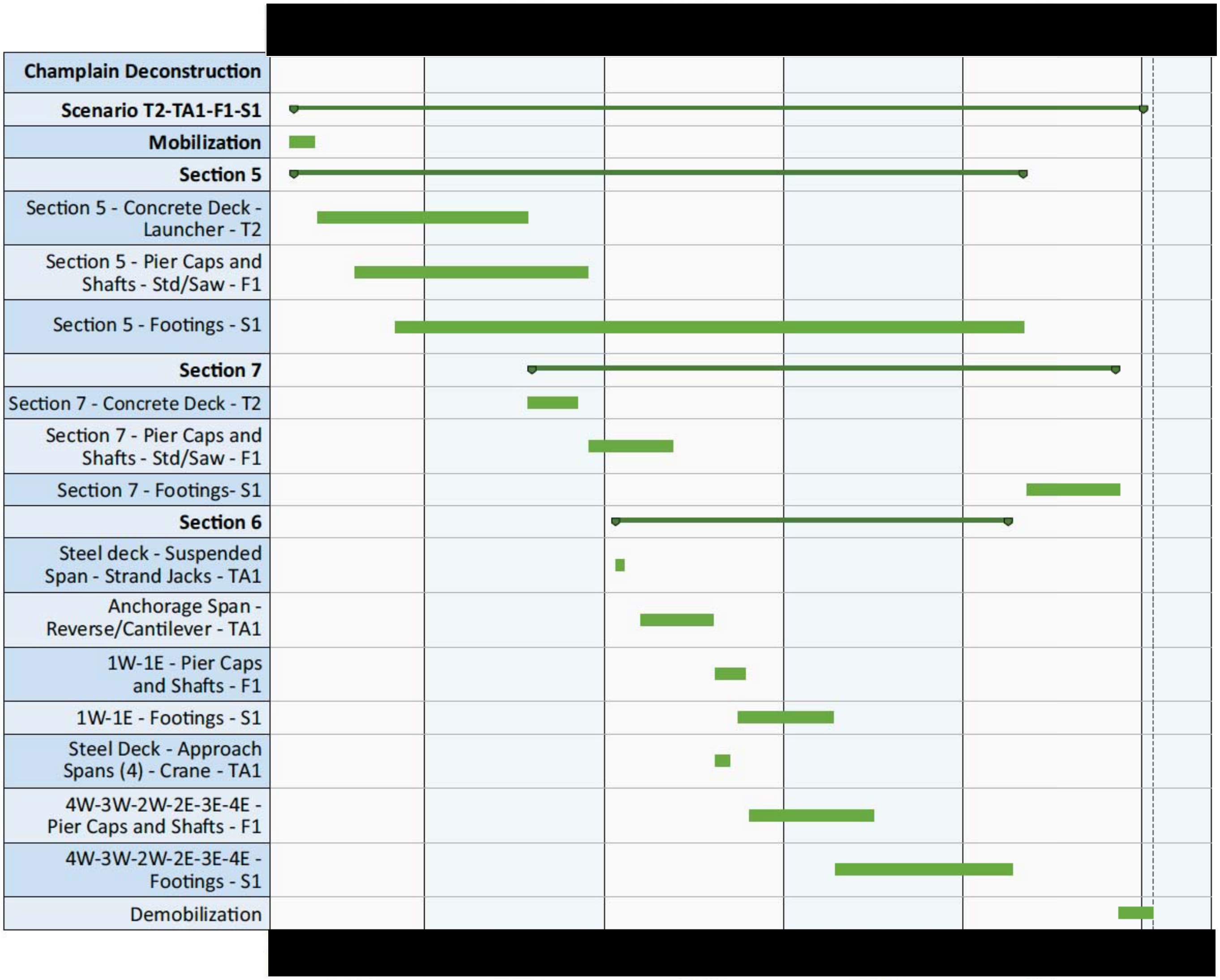


Figure 200 – Duration of work – T2-TA1-F1-S1 scenario

11.2.2.3 Scenario T2-TA1-F1-S2

The preliminary work schedule for the T2-TA1-F1-S2 scenario is presented in Figure 201. The total duration of work is estimated at 36 months spread over 4 years (no work during the winter, except as noted - see 11.1).

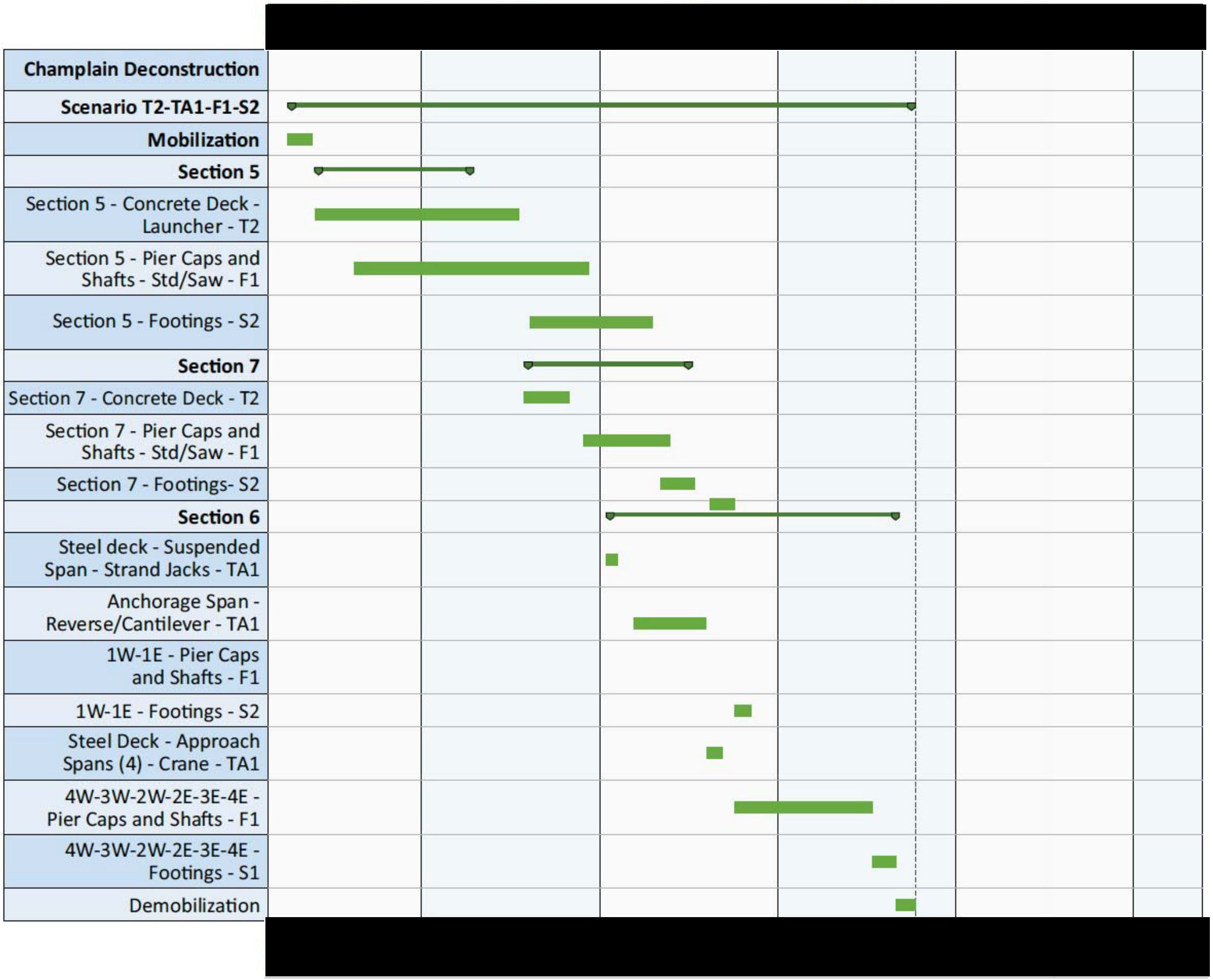


Figure 201 – Duration of work – T2-TA1-F1-S2 scenario

12 CONCLUSION

12.1 REVIEW OF THE MANDATE

The mandate of the feasibility study to be carried out by the PTA Consortium is to make a recommendation to JCCBI regarding a deconstruction approach for the existing Champlain Bridge that complies with sustainable development principles and takes into account the stated needs of the most influential stakeholders. The analysis was subdivided into four distinct fields of study representing the four main components of the project: deconstruction work, materials transportation, materials recovery, and asset enhancement.

Teams working on each of the fields of study identified and described options for their respective fields, as well as the advantages and disadvantages of these options, and classified them based on technical, economic, environmental, and social evaluation criteria, aiming to find the kind of balance set forth in sustainable development principles. For each field of study, the following best options were identified:

- Deconstruction work – concrete deck: unlaunching option ;
- Deconstruction work – steel deck: removal of whole elements option ;
- Deconstruction work – shafts and pier caps: standard deconstruction option ;
- Deconstruction work – footings: controlled explosion option ;
- Materials transportation: overland transportation option ;
- Materials recovery: preservation of existing structures option ;
- Asset enhancement: construction of extreme sports facility option (including Options 1-4).

12.2 CROSS ANALYSIS OF OPTIONS FOR EACH FIELD OF STUDY

The set of options for the four fields of study should intuitively represent the best option to recommend to JCCBI. To ensure that this is the case, the compatibility of the materials transportation, materials recovery, and asset enhancement options with the various deconstruction options is assessed through a cross analysis. This analysis is based on deconstruction options because technical and financial issues play a dominant role in this field of study.

This analysis consists in a table showing the relationship between deconstruction options for various elements of the existing Champlain Bridge (concrete deck, steel deck, shafts, footings) and options for the other fields of study. In each case, options are arranged according to their assessed scores in Sections 4, 5, 6, and 7. Thus, for each deconstruction option, an assessment is made of whether it is compatible (C) or not (X) with each of the options for the other fields of study.

The set of options selected for deconstruction of each existing Champlain Bridge element will be the set that is most compatible with the best options for the other fields of study.

The cross analysis table is shown on the next page and may be read as follows:

- Horizontal axis: deconstruction options for the various elements of the bridge (concrete deck, steel deck, shafts, footings) – presented in order of preference for each element ;
- Vertical axis: options for the other fields of study (transportation, recovery, enhancement) – presented in order of preference for each field of study ;
- Green box = best combination of deconstruction options and other fields of study options.

Table 100 – Cross-analysis of options for the various fields of study

			Transportation		Materials recovery					Asset enhancement						
Options			Overland	Water	Preservation of structures	Off site recycling	In situ recycling	In situ reuse	Off-site reuse	Extreme sports facility	Historical and arts itinerary	Cycle paths and natural environments	Nature beach	Multi-use belvedere	Multi-use wharves	Selected sets of options
		Rank	1	2	1	2	3	4	5	1	2	3	4	5	6	
Concrete deck deconstruction	Unlaunching	1	C	C	C	C	C	C	C	C	C	C	C	C	C	Deconstruction by unlaunching, overland transportation, preservation of structures, extreme sports facility
	Standard	2	C	X	C	C	C	X	X	C*	C*	C	C*	C*	C*	
Steel deck deconstruction	Whole elements	1	C	X	C	C	C	C	C	C	C	C	C	C	C	Deconstruction of whole elements, overland transportation, preservation of structures, extreme sports facility
	Reverse erection	2	C	C	C	C	C	C	C	C	C	C	C	C	C	
Shafts deconstruction	Standard	1	C	X	C	C	C	X	X	C*	C*	C	C*	C*	C*	Standard deconstruction, overland transportation, preservation of structures, extreme sports facility
	Controlled explosion	2	C	X	C	C	C	X	X	C*	C*	C	C*	C*	C*	
Footings deconstruction	Controlled explosion	1	C	X	C	C	C	X	X	C*	C*	C	C*	C*	C*	Controlled explosion, overland transportation, preservation of structures, extreme sports facility
	Standard	1	C	X	C	C	C	X	X	C*	C*	C	C*	C*	C*	

* The historical and arts itinerary option is included in the extreme sports, nature beach, belvedere and wharves options. Scheduling of standard demolition and controlled explosion could be planned to allow the preservation in place of structures slated for asset enhancement.

For all elements involved in the deconstruction of the existing Champlain Bridge, the preferred option in Section 4 of this report is also the option that is most compatible with options for the other fields of study.

For deconstruction of the concrete deck, the two options are compatible with the best option for each of the other fields of study. The unlaunching option is therefore selected on its own merit (best environmental and social scores) over the standard deconstruction option. In addition, the unlaunching approach is compatible with all options for the other fields of study, making it very flexible. In this respect, the standard deconstruction option is less interesting because most of the concrete deck is located above the St. Lawrence River, where water transportation is very limited.

For deconstruction of the steel deck, the two options are similarly compatible with the best option for each of the other fields of study. Deconstruction by removal of whole elements is therefore selected on its own merit (best environmental and social scores) over the reverse erection option. However, the fact that part of the steel deck is not above the seaway may make water transportation of these elements more difficult.

For deconstruction of shafts and pier caps, the two options are similarly compatible with the best option for each of the other fields of study. The standard deconstruction option is therefore selected on its own merit (best technical and environmental scores) over the controlled explosion option.

The case of the two options for deconstruction of the footings is identical to the two options for deconstruction of the shafts and pier caps. Because the two options have the same relationship with options for the other fields of study, the controlled explosion option is selected on its own merit (shorter-term technical benefit) over the standard deconstruction.

12.3 CONCLUSION

Results of this analysis are consistent with a preponderance of preferred deconstruction options described in Section 4 of this report.

These options are compatible with the three best materials recovery options, which will provide JCCBI significant flexibility. Such flexibility is necessary because only about 15% of materials can be recovered through preservation of structures in place, and the use of other recovery approaches, including off site recycling, will be required for the remainder of the materials.

These options are also compatible with the preferred transportation mode (overland). Thus, because navigation on the St. Lawrence River is limited, this mode of transportation is less interesting for deconstruction of the shafts, pier caps and footings, which are mainly located in the river, as well as for standard deconstruction of the concrete deck.

For asset enhancement, the best deconstruction options are those for which most asset enhancement options are possible, thus giving JCCBI greater flexibility. It is worth recalling that the historical and arts itinerary option is included in the extreme sports, nature beach, multi-use belvedere and multi-use wharves options, and any deconstruction option that involves transformation of existing Champlain Bridge elements (controlled explosion, standard deconstruction) imperils the historical and arts itinerary option and, hence, the full implementation of associated options. However, standard deconstruction and controlled explosion may be planned in such a way as to preserve in place structures included in asset enhancement options, thus giving JCCBI greater flexibility. Standard deconstruction work can also be planned to include the removal of specific elements of the existing Champlain Bridge for use as historical and cultural reminders. This would require additional planning of the work, but would provide JCCBI with an even greater range of asset enhancement options.

13 RECOMMENDATIONS

13.1 DECONSTRUCTION WORK

For future studies, the following deconstruction scenario is recommended:

- Deconstruction of the concrete deck using the unlaunching method (T2) ;
- Deconstruction of the steel deck using the cranes/reverse erection/strand jacks method (suspended span in winter) (TA1) ;
- Deconstruction of pier caps and shafts using the standard/sawing method (F1) ;
- Deconstruction of footings using the controlled explosion method (S2).

The cost of this scenario is estimated at [redacted] and completion of the work will take approximately four years.

However, at this stage of the project, it would make sense not to limit the range of options to a single scenario. For future studies and for the environmental impact assessment, it is recommended that the following variations also be considered, since the environmental impact assessment must look at a range of solutions that include the many possible scenarios arising from different combinations of the proposed approaches.

- Deconstruction of the concrete deck using the crane removal method (T1) ;
- Deconstruction of the steel deck using the reverse erection method (TA2) ;
- Deconstruction of pier caps and shafts using the controlled explosion method (F1) ;
- Deconstruction of footings using the standard/sawing method (S1).

13.2 MATERIALS TRANSPORTATION

The mode of transportation is directly related to deconstruction (methods, scheduling, duration of work, etc.) and the location of recovery sites. Road transportation is more flexible and less expensive, especially if materials recovery is in the Montreal metropolitan area. However, water transportation should not be discarded because it minimizes nuisances for local residents and is interesting if materials recovery is done outside of the Montreal area.

Here are some recommended future steps:

- Confirm the location of the Nun's Island and Brossard dismantling areas ;
- Preferentially condition materials on site ;
- Preferentially transport materials by truck for all sections of the bridge deconstructed using the standard method ;
- Review transportation modes and costs after more details are known about the deconstruction steps, particularly for water transportation ;
- Endeavour to limit the number of handlings.

13.3 MATERIALS RECOVERY

The PTA Consortium believes that, as part of its asset enhancement efforts, JCCBI should try, to the extent possible, to preserve existing structures in place. However, because only a limited amount of materials (~15%) can be recovered in this way, off-site recycling for the remainder of materials should be the preferred approach, with mitigation measures developed in collaboration with affected stakeholders to ensure greater social acceptance.

Another avenue that should be explored going forward to increase the off-site re-use of components and materials is to launch a call for interest for existing Champlain Bridge components and materials. This call for interest should take place early in the next steps of the project because some proposals could affect the progress and planning of deconstruction work. Finally, using an intermediate storage area prior to hauling components to their final re-use site may also increase the likelihood of finding an outlet for these materials.

13.4 ASSET ENHANCEMENT

The option that produces the highest score is Option 5, Extreme sports facility. This option also includes enhancement of natural environments, construction of cyclist rest areas, historical and arts itineraries, construction of multi-use wharves and construction of a beach. However, the scores for other options are not sufficiently different from that for Option 5 to warrant rejecting the other options. It is important to keep in mind that benefits arising from more complex options are associated with many uncertain elements, whereas the most well-defined options produce the fewest benefits. To ensure that the enhancement process is successful, it is recommended that the selection of an asset enhancement option take place before the start of the bridge deconstruction process. To facilitate the decision-making process, it is suggested that:

- The environmental analysis be completed to provide a better understanding of constraints associated with the JCCBI property ;
- The various stakeholders be consulted to get a better understanding of their interests for the proposed options and to remove any uncertainty.

13.5 PROJECT DELIVERY METHOD

The recommended delivery method is construction-management. Although it is relatively recent, this method is recognized in Public Works and Governmental Services Canada's (PWGSC) Procurement Management Manual and used by agencies in Canada. The project delivery method does require some adjustments to the JCCBI procurement process, and should it turn out that such adjustments cannot be made in the time available, two other delivery methods may be considered: the hybrid traditional method and the progressive design-build method.

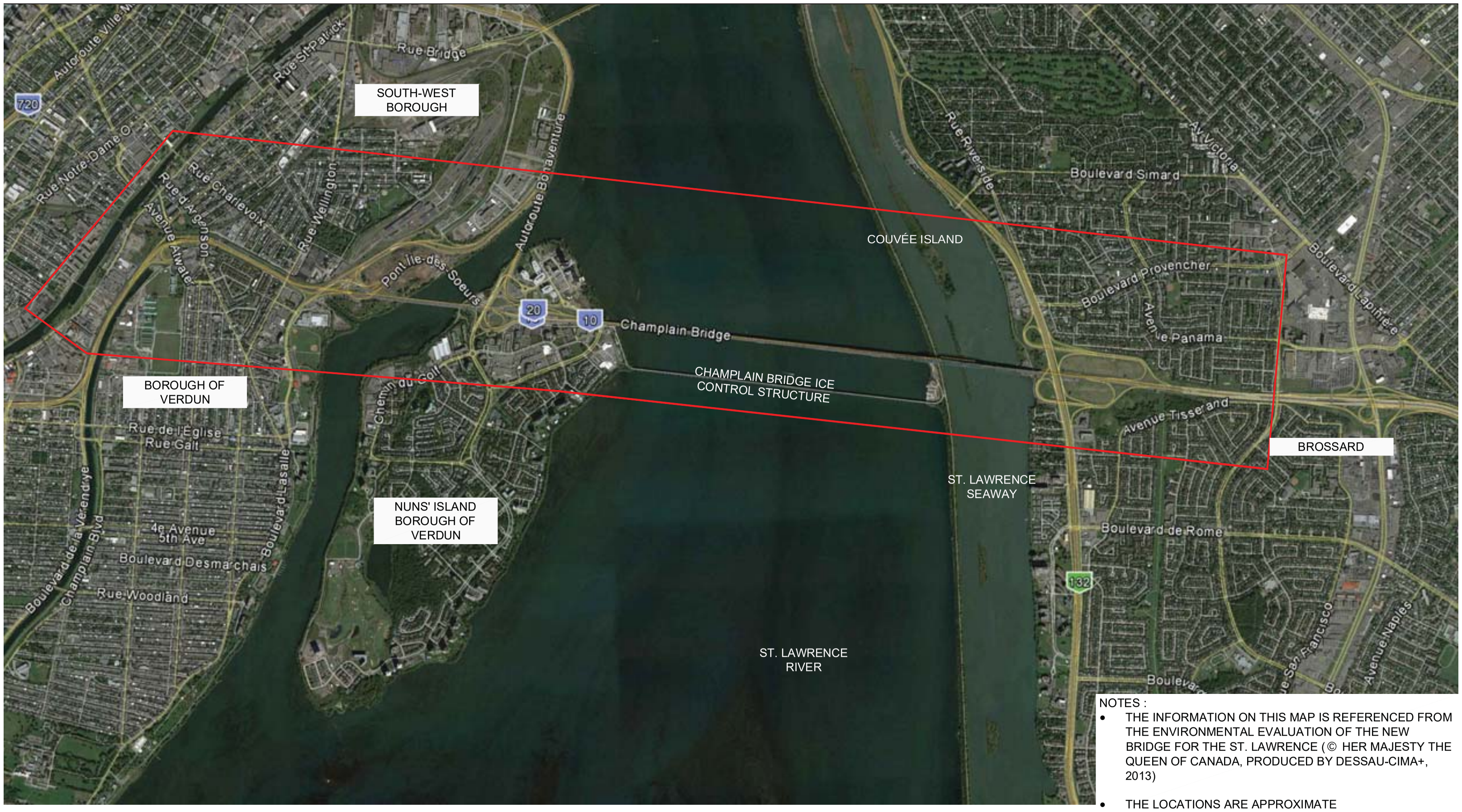
13.6 FUTURE STEPS

The following next steps are recommended:

- Identification of the asset enhancement option which JCCBI prefers prior to deconstruction work to ensure proper coordination of the work.
- Meetings and discussions with the following stakeholders:
  - Infrastructure Canada: examine the possibility of recovering new Champlain Bridge facilities already in place ;
  - MTMDET: coordinate transportation and traffic control, particularly for Route 132;
  - SLMSC: launch process to implement a framework agreement for the work ;
  - JCCBI's Centre for Infrastructure Innovation: identify JCCBI desired orientations to include them in tender documents prior to bridge deconstruction work ;
  - Cities of Montreal (Verdun Borough) and Brossard: coordinate traffic control, nuisance reduction (noise, dust, permitting), and asset enhancement ;
  - Environment Canada and Canadian Environmental Assessment Agency: determine which environmental assessment regime is applicable to the project (Section 67 of the CEAA or designated project).
- Implement the stakeholder consultation process developed by JCCBI for the project ;
- Begin studies on materials:
  - Identification of contaminants on materials: discussions with expert resources have highlighted the importance of having access to comprehensive information on the state of materials slated for re-use or recycling. The presence of contaminants such as lead paint or asbestos can decrease the recovery potential of some materials ;
- Soil and sediment characterization: the way excavated materials are managed hinges heavily on the presence or absence of contaminants in soil and sediments in areas where the work will be performed. A detailed characterization in these work areas will reduce associated risks (costs, delays) ;
- Acquire additional work areas (Nun's Island, Brossard, etc.) or negotiate agreements (lease, easements, etc.) for the use of such areas.

Appendix 1

Study Zone – Environmental constraints



NOTES :

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- THE LOCATIONS ARE APPROXIMATE

SCALE: 1:30 000

0 500 1 000 1 500 2 000m

STUDY AREA

SOURCE :
GOOGLE EARTH, 2016
(SATELLITE IMAGE : 2013)

REFERENCE DRAWINGS:
068-P-0000810-110-GO-D-0044-00

Sceau / Seal:

Préparé par:
Prepared by:

Parsons
Tetra Tech
Amec Foster Wheeler

Ponts JACQUES CARTIER + CHAMPLAIN Bridges
Canada

FEASIBILITY STUDY
DECONSTRUCTION OF THE
CHAMPLAIN BRIDGE

LOCATION OF THE STUDY AREA

Échelle / Scale	1:30 000	Date	2017-01-06
Dessiné / Drawn	[redacted]	Vérifié / C	[redacted]
Conçu / Design		Approuvé	
No Contrat / Contract No.	62453		
No Dessin / Drawing No.	125859-0101	Rév. / Rev.	3

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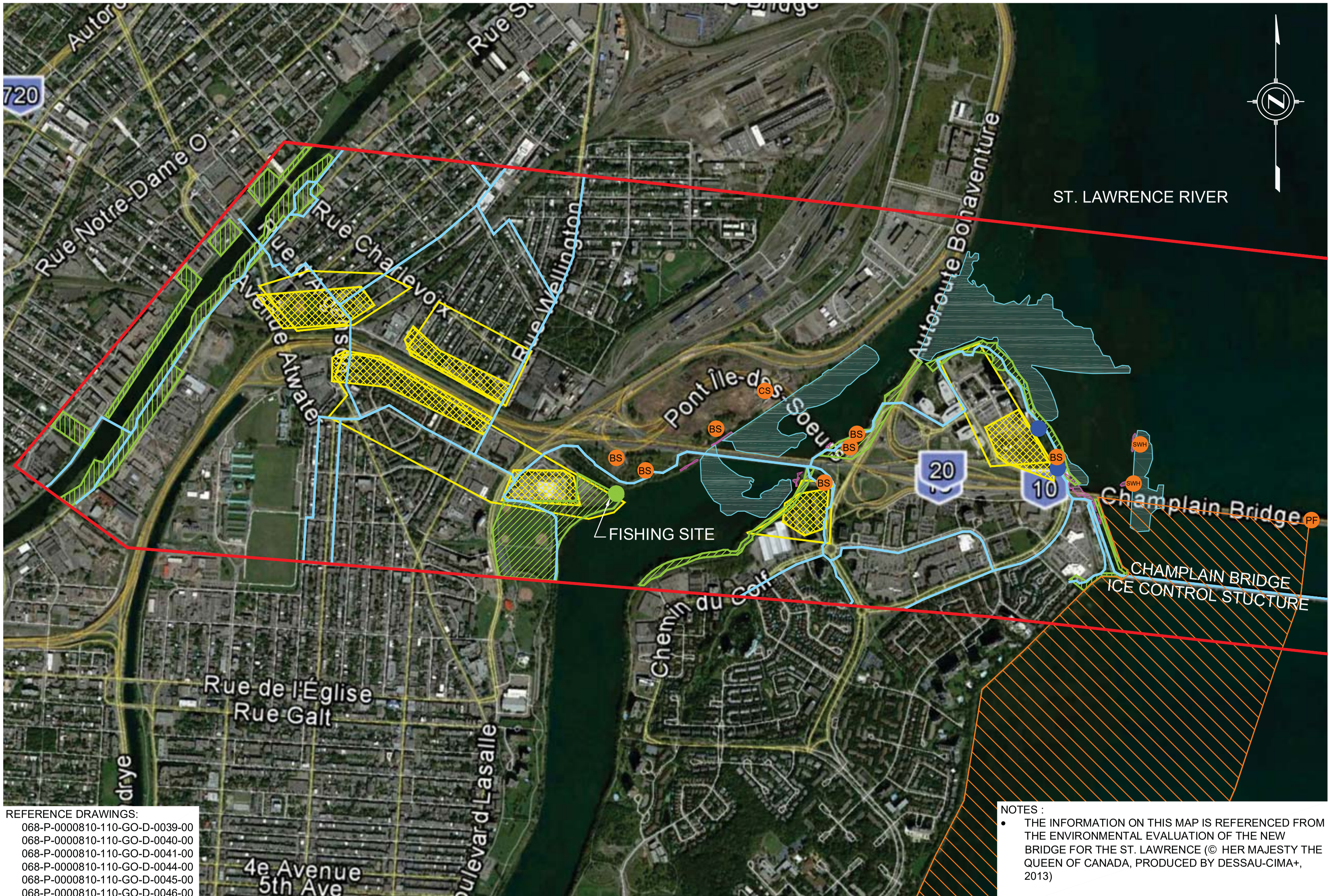
2016-11-01



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SOURCE :
GOOGLE EARTH, 2016
(SATELLITE IMAGE : 2013)

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- THE LOCATIONS ARE APPROXIMATE

SCALE: 1:15 000
0 250 500 750 1 000m

Prepared par / Prepared by: Parsons, Tetra Tech, Amec Foster Wheeler

Ponts Jacques Cartier + Champlain Bridges Canada

FEASIBILITY STUDY
DECONSTRUCTION OF THE CHAMPLAIN BRIDGE

IDENTIFICATION OF THE ENVIRONMENTAL CONSTRAINTS WESTERN PORTION OF THE STUDY AREA

Échelle / Scale	1:15 000	Date	2017-01-12
Dessiné / Drawn	[redacted]	Vérifié / Checked	[redacted]
Conçu / Design	[redacted]	Approuvé / Approved	[redacted]
No Contrat / Contract No.	62453		
No Dessin / Drawing No.	125859-0102	Rév. / Rev.	2

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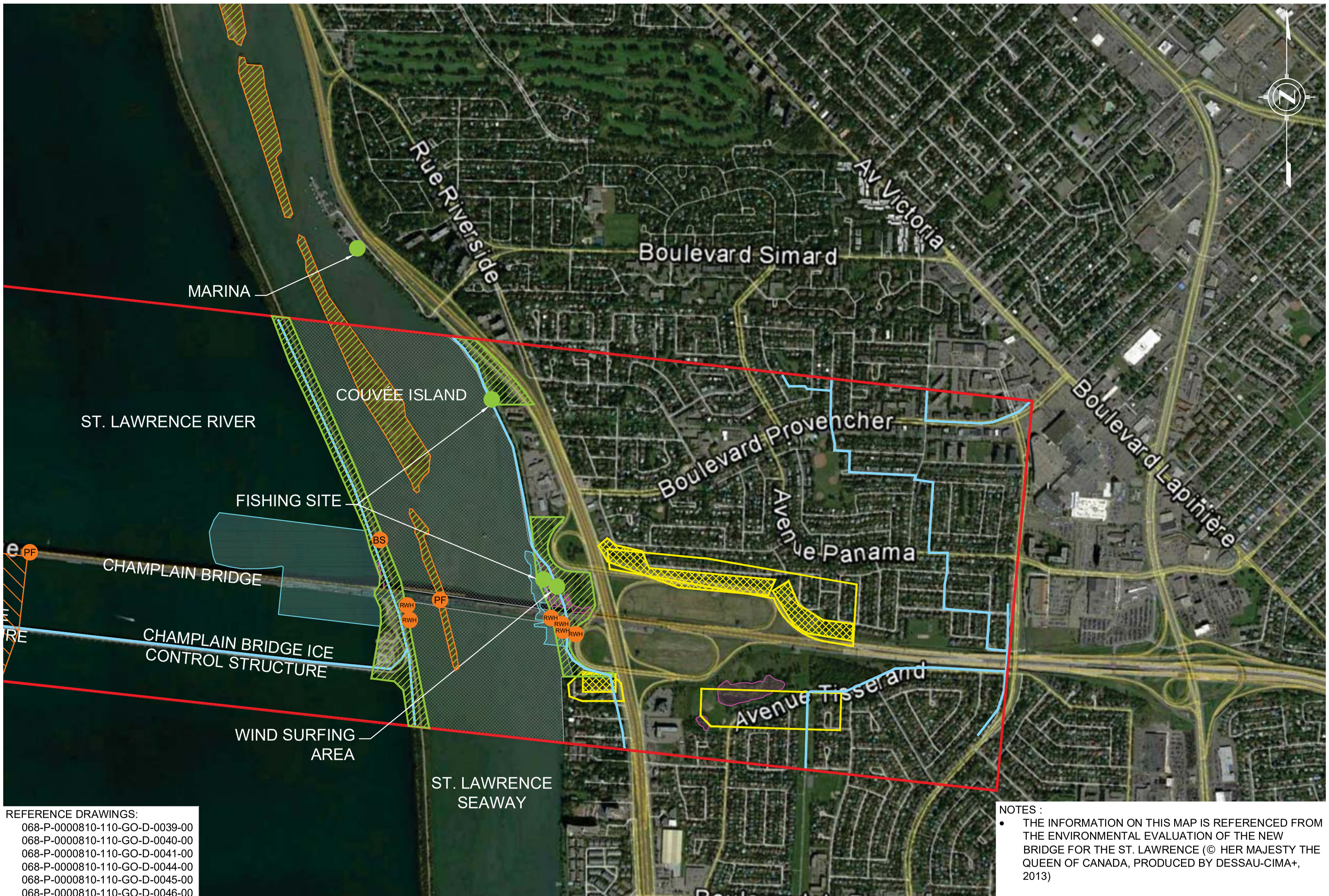
2016-11-01



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SOURCE :
GOOGLE EARTH, 2016
(SATELLITE IMAGE : 2013)

NOTES :
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- THE LOCATIONS ARE APPROXIMATE

SCALE: 1:15 000
0 250 500 750 1 000m

STUDY AREA

PHYSICAL ENVIRONMENT
CONTAMINATED SEDIMENT (APPROXIMATE AREA)
AIR QUALITY SENSITIVE AREA

BIOLOGICAL ENVIRONMENT
WETLAND
SENSITIVE FISH HABITAT (SPAWNING AND AQUATIC GRASS AREAS)
MIGRATORY BIRD SANCTUARY
RWH ROUGH WATER-HOREHOUND
BS BROWN SNAKE
PF PEREGRINE FALCON

HUMAN ENVIRONMENT
NOISE SENSITIVE AREA
SOUND IMPACT AREA (POTENTIALLY NEGATIVE)
GREEN SPACE OR RIVERFRONT PARC, CONSERVATION ZONE
RECREATIONAL/TOURISTIC ACTIVITIES
BICYCLE PATH

Sceaux / Seals

Préparé par / Prepared by:
Parsons
Tetra Tech
Amec Foster Wheeler

Ponts Jacques Cartier + Champlain Bridges Canada

FEASIBILITY STUDY
DECONSTRUCTION OF THE CHAMPLAIN BRIDGE

IDENTIFICATION OF THE ENVIRONMENTAL CONSTRAINTS
EASTERN PORTION OF THE STUDY AREA

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Conçu / Design: [redacted]	Approuvé / Approved: [redacted]
No Contrat / Contract No: 62453	
No Dessin / Drawing No: 125859-0103	Rév. / Rev.: 2

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2016-11-01

Appendix 3

Option's evaluation guideline for economic, environmental and social criteria

SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	WEIGHTING	Definition	Evaluation guidelines
ECONOMIC	Costs	4	**Cost of work including materials disposal** Quantitative / Moderate precision	Rate construction costs (including materials disposal) in following increasing order: 1. From 100th to 81th percentile 2. From 80th to 61th percentile 3. From 60th to 41th percentile 4. From 40th to 21th percentile 5. From 20th to 1st percentile
	Jobs	3	**Number of jobs directly linked to the project (client, consultants, contractors, subcontractors, providers, etc.)** Quantitative / Moderate precision	Rate approximate job number linked to the project in following increasing order: 1. From 0 to 20th percentile 2. From 21th to 40th percentile 3. From 41th to 60th percentile 4. From 61th to 80th percentile 5. From 81th to 100th percentile
	Origin of labour	4	**Origin of labour directly linked to the project (consultants, contractors, subcontractors, providers, etc.)** Qualitative / Moderate precision	1. No labour from national origin 2. Low qualified labour from national and international origin, and qualified labour from international origin 3. Low qualified labour mainly from national origin, and qualified labour from international origin 4. Low qualified labour mainly from national origin, and qualified labour from national and international origin 5. All labour from national origin
	Risk of overstepping project deadline	2	**Vulnerability to complications generating delays** Qualitative / Moderate precision	1. High vulnerability, complication cannot be controlled, limited mitigation measures. 2. High vulnerability, complication difficult to control, mitigation measures possible. 3. Moderate vulnerability, complication can be controlled, mitigation measures possible. 4. Low vulnerability, complication can be controlled, mitigation measures possible. 5. No vulnerability, complication can be totally controlled, mitigation measures possible.
	Commercial navigation	1	**Required negotiation with St-Lawrence Seaway to work on or above the navigation channel, and cost/delay associated** Qualitative / High precision	1. Commercial navigation impossible for duration of construction work 2. Commercial navigation impossible for extended period during construction work 3. Commercial navigation impossible for short periods during construction work 4. No interruption but risks of delays/impact (MOU required) 5. No interruption and no risks of delays/impact (no MOU required)

SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	WEIGHTING	Definition	Evaluation guidelines
ENVIRONMENTAL	Water quality	3	**Impact on river water quality during and after work (sedimentation, spills…)** Qualitative / High precision	1. Impacts exceed regulatory thresholds during and after construction work. No possible mitigation measure. 2. Impacts exceed regulatory thresholds during construction work. Possible mitigation measures. 3. Limited or no impact on river water quality. 4. Option allows marginal increase of river water quality. 5. Option allows long term increase of river water quality.
	Greenhouse gas emission	1	**Carbon footprint of various options** Qualitative / Moderate precision	1. Strong carbon footprint 2. Moderate carbon footprint 3. Limited carbon footprint 4. Neutral carbon footprint 5. Negative carbon footprint
	Biodiversity	3	**Local/regional reduction of biodiversity by loss of habitat (fish habitat - spawning areas, wetlands, shade areas, carbon sequestration, bird nesting sites, waterfoul concentration areas, herptofauna habitat, endangered flora species, loos of biomass…)** Quantitative / Moderate precision	1. Major negative impact on biodiversity. Large habitat losses. Survival of endangered species compromised. Repercussion at regional level. 2. Moderate negative impact on biodiversity. Small habitat losses. Survival of endangered species not compromised. Limited repercussion at local and regional levels. 3. No impact on biodiversity. No loss of habitat. 4. Moderate improvement of biodiversity. Limited habitat gain. 5. Major improvement of biodiversity. Strong gain of habitat, particularly for endangered species.
	Contaminated soil and sediments	2	**Handling of contaminated soil or sediments** Qualitative / Moderate precision	1. Unavoidable handling of contaminated soil or sediments increasing area of contamination. 2. Unavoidable handling of contaminated soil or sediments limiting contamination within work site. 3. Possible handling of contaminated soil or sediments limiting contamination within work site. 4. Possible handling of contaminated soil or sediments allowing limited rehabilitation of sector. 5. No handling needed of contaminated soil or sediments.
	Consumption of resources/Residual materials	1	**Consumption of raw materials (rock, fuel, water…) for temporary use** Quantitative / Moderate precision	1. Major consumption of non recyclable raw materials 2. Major consumption of recyclable raw materials 3. Moderate consumption of non recyclable raw materials 4. Moderate consumption of recyclable raw materials 5. Limited or no consumption of raw materials

SUSTAINABLE DEVELOPMENT COMPONENT	CRITERIA	WEIGHTING	Definition	Evaluation guidelines
SOCIAL	Recreational navigation	1	**Negative impact on recreational navigation** Qualitative / High precision	1. Recreational navigation impossible. 2. Recreational navigation greatly reduced. 3. Recreational navigation possible with limitations (weight, dimension). 4. Recreational navigation slowed for limited periods. 5. No impact on recreational navigation.
	Nuisances	4	**Impact during and after construction work on ambient air quality, noise, odours, vibrations, cleanliness of public road, road traffic** Qualitative / High precision	1. Major nuisances during and after construction work. No possible mitigation measure during construction. 2. Moderate nuisances during construction and possible mitigation measures. 3. Low or no impact. 4. Option allows marginal improvement. 5. Option allows significant long term improvement.
	Public support	3	**Public support for the project by stakeholders** Qualitative / Low precision	1. Option susceptible to be strongly contested by citizens and experts. 2. Option susceptible to be contested by some citizens and experts. 3. Option susceptible to be supported by some citizens and experts. 4. Option susceptible to be strongly supported by citizens and experts. 5. Option supported by large consensus of citizens and experts.
	Health and safety	4	**Health and safety of labour and users during and after construction work** Qualitative / Moderate precision	1. Option cannot allow compliance with Health & Safety governmental regulations during and after construction work. Danger elements cannot be controlled. 2. Option represents major danger during and after construction work. Dangers cannot all be controlled. 3. Option represents major danger during and after construction work. Dangers can be controlled. 4. Option represents minor danger during and after construction work. Dangers can be controlled. 5. Option represents little or no danger.
	Knowledge/Innovation	4	**Use of new technology and development of new knowledge** Qualitative / Moderate precision	1. Option allows no development of new knowledge or technology. 2. Option allows limited development of new knowledge and technology. 3. Option allows development of new site specific knowledge and technology. 4. Option allows development of exportable new knowledge and technology. 5. Option allows development of exportable new knowledge and technology with commercial added value.

Appendix 4

Stakeholders

Ponts JACQUES CARTIER + CHAMPLAIN Bridges Canada	**COMPTE RENDU** 2016-08-18	
Date de la réunion : Lundi le 15 aout 2016 – 10h30 à 12h15	**CT 62453**	Page 1 de 4

Description du projet :	**Réunion N° : 1**	**Lieu :**
Pont Champlain, services de consultants, étude d'avant-projet portant sur la déconstruction de l'actuel pont Champlain (2016-2017)		**Salle Jacques-Cartier** PJCCI 1225, rue St-Charles O, 5e étage Longueuil (Québec) J4K 0B9

RÉUNION DE COORDINATION

But de la réunion :

Coordination avec la Corporation de Gestion de la Voie Maritime du Saint-Laurent (CGVMSL):

Personnes présentes :

- Catalin Petcu	Chargé de projet	PJCCI
- Pascal Lévis	Directeur des projets, Champlain	PJCCI
- Sylvain Montminy	Chargé de projet	PTA
- [redacted]	Volet Déconstruction	PTA
- Alain Robitaille	Volet Transport matériaux	PTA
- [redacted]	Volet Valorisation matériaux	PTA
-	Volet Valorisation matériaux	PTA
-	Spécialiste environnement	PTA
-	Spécialiste environnement	PTA
- Jack Meloche		CGVMSL
- Marie Gaudreault	Gestionnaire, Gestion de l'infrastructure	CGVMSL
- Michel Thibault		CGVMSL
- Karine Mageren		CGVMSL
- Jean Aubry-Morin	Vice-président, relations externe	CGVMSL

Copies conformes :

Aux personnes convoquées et

[redacted]

Bertrand Voutaz

ACTION PAR :

1. Présentation de l'ordre du jour

2. Introduction des participants et de leurs rôles

3. Présentation du mandat

PTA présente les grandes lignes du présent mandat qui lui est confié par PJCCI, à savoir l'étude d'avant-projet de la démolition du pont Champlain.

La CGVMSL demande quel mode d’approvisionnement sera utilisé.

PTA mentionne que le mode d’approvisionnement n’est pas encore connu, mais des recommandations à ce sujet font partie du présent mandat.

4. Méthodes de déconstruction envisagées

4.1 Béton

4.2 Acier

5. Contraintes et opportunités de CGVMSL

5.1 PTA ouvre la discussion sur les possibles contraintes émanant des opérations et installations de la CGVMSL (ex. : gabarits à respecter, périodes de travaux possibles, etc.).

5.2 La CGVMSL mentionne que dans la plupart des gros projets similaires à celui de la déconstruction du pont Champlain, elle procède à la négociation d’une entente cadre en début du projet et qu’ensuite chaque activité est autorisée individuellement, souvent avec l’appui d’une analyse de risques.

5.3 La CGVMSL donne l’exemple des travaux du NPSL et du groupe SSL. L’entente dans leur cas exige que les travaux dans la voie maritime soient faits hors de la période de navigation. Si des travaux doivent s’y faire pendant la période de navigation, une analyse de risques formelle est requise. Une telle entente sera aussi requise pour les travaux de déconstruction du pont Champlain. La CGVMSL mentionne que les ententes sont faites au cas par cas.

5.4 La CGVMSL mentionne que tout le monde a le droit d’utiliser la voie maritime et qu’il y a un manuel de lignes directrices qui définit les limites et règles applicables. Ce manuel est disponible gratuitement sur le site web de la CGVMSL.

5.5 La CGVMSL mentionne que la période de non-navigation s’étend généralement du 1er janvier au 10 mars. La CGVMSL mentionne aussi que l’écluse de St-Lambert est fermée pendant cette période alors il n’y a pas d’accès par la voie maritime.

5.6 La CGVMSL mentionne aussi que pendant cette période de non-navigation, un certain courant est requis pour les centrales hydroélectriques trouvées en amont et en aval. Ceci pourra constituer une contrainte pour créer un pont de glace dans la voie maritime.

5.7 La CGVMSL mentionne que le niveau d'eau pendant la période de non-navigation est entre 9,6 m à 7,6 m pour faciliter l'entretien de leurs structures. Pendant la période de navigation, le niveau de l'eau normal en service est de 11,6 m.

5.8 La CGVMSL mentionne que dans le cas de la jetée temporaire construite dans le bassin de Brossard par SSL, la CGVMSL a exigé de laisser un libre passage des bateaux de plaisance dans le bassin pour ne pas les forcer à passer par la voie maritime.

5.9 PTA demande si un maintien de piles dans le bassin de Brossard nécessitera une coordination et implication de la CGVMSL. La CGVMSL le confirme et mentionne l'exemple du déplacement du pylône électrique fait récemment par le MTQ. La CGVMSL a exigé que les fondations soient démolies jusqu'à 1 m au-dessus du fond marin. La CGVMSL mentionne qu'une évaluation de risques est requise pour chaque cas.

5.10 PTA considère la possibilité d'utiliser des infrastructures de la CGVMSL pour le trafic routier à camion pour le transport de déconstruction. La CGVMSL mentionne qu'une analyse de risques est requise pour faire l'évaluation de cette option. La CGVMSL mentionne toutefois que des contraintes majeures pour l'utilisation des ponts des écluses existent pour les écluses de St-Catherine et de St-Lambert. Des exemples de contraintes données : limites de poids, protection du public et des touristes.

5.11 La CGVMSL mentionne qu'aucun quai d'embarquement pour des bateaux n'existe à l'intérieur de la voie maritime.

5.12 PTA demande des informations à propos des opérations de SSL où des matériaux granulaires ont été apportés par bateau et transportés par convoyeur de l'autre côté de la digue de la voie maritime. La CGVMSL mentionne que cette opération a été faite environ 8 fois avec une durée de 12 à 13 heures chaque fois. L'autorisation a été donnée suite à une analyse de risques.

5.13 PTA explique qu'il y a un intérêt dans le projet de déconstruction du pont Champlain à réutiliser les matériaux et que des applications de réutilisation locales sont particulièrement intéressantes. PTA demande si la CGVMSL à un intérêt à l'utilisation de matériaux récupérés dans la déconstruction du pont Champlain. La CGVMSL répond qu'elle ne prévoit pas une application possible dans leurs activités pour ces matériaux.

5.14 La CGVMSL demande si l'échéancier du projet de déconstruction du pont Champlain est connu. PJCCI répond que l'échéancier n'est pas encore défini.

5.15 PJCCI demande si la CGVMSL peut donner une estimation du temps requis pour la négociation des ententes. La CGVMSL répond en donnant l'exemple de l'entente pour le projet de l'A30 qui a été négociée en 2.5 années, que d'autres projets ont été négociés en moins de temps.

5.16 PJCCI demande si la CGVMSL à des critères d'analyse de risques déjà établis. CGVMSL donne l'exemple du NPSL où une matrice a été fournie à Infrastructure Canada, et que cette matrice a été incluse dans l'appel de propositions. La CGVMSL précise qu'une entente est requise pour fournir de l'information et que les analyses de risques sont faites au cas par cas et que les conclusions sont faites dans un contexte particulier, et qu'ils ne sont pas nécessairement transférables à un autre cas.

6. Levée de réunion

La réunion se conclue à 12h15.

Préparé par : [redacted]	**Accepté par :** [redacted]
Date : 18 aout 2016	Date : 2016-08-22

Si ce compte rendu n'est pas conforme aux discussions tenues lors de cette réunion, veuillez nous en avertir dans les sept jours. À moins d'un avis contraire, le contenu de ce compte rendu sera considéré comme exact.

JH

Ponts JACQUES CARTIER + CHAMPLAIN Bridges Canada	**COMPTE RENDU** 2016-08-29

Date de la réunion : Mercredi le 17 août 2016 – 09h45 à 11h00	**CT 62453**	Page 1 de 4

Description du projet : <u>Pont Champlain, services de consultants, étude d'avant-projet portant sur la déconstruction de l'actuel pont Champlain (2016-2017)</u>	**Réunion N° : 1**	**Lieu :** Salle SSQ Honoré-Mercier PJCCI 1225, rue St-Charles O, 5e étage Longueuil (Québec) J4K 0B9

RÉUNION DE COORDINATION

But de la réunion : Coordination avec la Ministère des Transports, de la Mobilité durable et de l'Électrification des transports (MTMDET): **Personnes présentes :** - Catalin Petcu — Chargé de projet — PJCCI - Sylvain Montminy — Chargé de projet — PTA - [redacted] — Volet Déconstruction — PTA - Alain Robitaille — Volet Transport matériaux — PTA - [redacted] — Volet Déconstruction — PTA - [redacted] — MTMDET	**Copies conformes :** Aux personnes convoquées et [redacted] Bertrand Voutaz **ACTION PAR :**
1. Présentation de l'ordre du jour	
2. Introduction des participants et de leurs rôles	
3. Présentation du mandat PTA présente les grandes lignes du présent mandat qui lui a été confié par PJCCI, soit l'étude d'avant-projet de la démolition du pont Champlain.	
4. Méthodes de déconstruction envisagées 4.1 Béton PJCCI mentionne que dans les documents traitant de la construction du pont Champlain, il est noté que le lanceur n'a pas été transporté sur les travées en acier. Ce n'était pas permis par le concepteur de ces travées, Dominion Bridge. 4.2 Acier	

5. Contraintes et opportunités de MTMDET 5.1 : PTA ouvre la discussion sur les contraintes possibles : Les contraintes majeures identifiées par PTA sont : Contraintes pour le Rte 132 • Travées 9E à12E • Fermetures possibles • Coordination pour le maintien de la circulation • Protocoles Exigences pour le transport hors normes • Permis – est-ce qu'il y a une procédure particulière pour un nombre élevé de camions hors normes ? • Exigences particulières • Horaires	
6. Discussion de contraintes 6.1 : MTMDET mentionne qu'ils vont prendre connaissances des questions de PTA et de PJCCI posées lors de cette réunion et faire une recherche à l'interne du MTMDET pour contacter les personnes appropriées et trouver les bonnes informations. 6.2 : MTMDET mentionne que l'accès au chantier sur la rive Sud peut avoir des contraintes à cause du volume de trafic durant la journée et les restrictions sur le bruit pendant la nuit. 6.3 : MTMDET mentionne qu'une fermeture de fin de semaine de la Route 132 est probablement une option pour les travaux de déconstruction des travées par-dessus de la Route 132. Une autre option possible est une fermeture de 22h00 à 5h00, mais cette option limite la fenêtre de travail de façon importante. Une fermeture de la Route 132 doit être communiquée en avance, mais la décision finale de la date exacte sera faite à court terme. 6.4 : MTMDET mentionne que, pour les camions hors norme définis par le poids et les dimensions, des permis sont à demander. Il y a du personnel chez le MTMDET qui traite les permis hors normes. PTA demande si des trajets préférés sont déjà prédéfinis? MTMDET mentionne que des cartes avec des trajets définis ne sont probablement pas disponibles, mais il va s'informer auprès du personnel qui traite les permis hors normes. 6.5 : PTA mentionne que certaines options de déconstruction qui sont considérées dans l'étude prévoient de 30 à 40 camions chargés par jour qui doivent circuler.	MTMDET MTMDET

Est-ce que ceci présente des contraintes particulières par rapport au MTMDET? MTMDET mentionne que si les camions sont à l'intérieur des normes, ils sont permis, mais s'ils sont hors normes, des permis sont requis. En générale, MTMDET préfère que les autres moyens de transport soient privilégiés, par exemple le ferroviaire ou par bateau. 6.6 : PTA demande si MTMDET à des terrains proches du site du pont Champlain qui pourraient servir pour les travaux de déconstruction. MTMDET mentionne que l'espace du MTMDET à cet endroit est restreint et que les terrains appartiennent à plusieurs parties, comme la ville de Brossard et PJCCI. 6.7 : PTA demande si le MTMDET à des cartes d'arpentage de ces terrains qui pourraient être partagées? MTMDET va investiguer si ces cartes peuvent être partagées. 6.8 : PTA demande si le MTMDET sera intéressé à utiliser des poutres ou portions de structures pour des essais? PTA demande si MTMDET sera intéressé à réutiliser des renforcements (comme les treillis modulaires) ou des capteurs récupérés du pont Champlain? MTMDET mentionne qu'il y a peut-être un intérêt et le personnel approprié sera contacté pour investiguer.	MTMDET MTMDET
7. Levée de réunion La réunion se conclut à 11h00.	
Un résumé des points pour discussion future est : Les contraintes majeures identifiées par PTA sont : <u>Contraintes pour le Rte 132</u> • Travées 9E à12E • Fermetures possibles • Coordination pour le maintien de la circulation • Protocoles à suivre pour fermetures et maintiens de circulation <u>Exigences pour le transport hors normes</u> • Permis – quelles sont les démarches requises pour obtenir un permis pour le transport hors norme ? • Exigences particulières : est-ce qu'il y a une procédure particulière pour un nombre élevé de camions hors normes ? • Restriction d'horaires de transport hors normes ? <u>Autres</u> Intérêt de MTMDET de réutilisation d'éléments selon point 6.8 de ce CR?	

Préparé par : [redacted]	**Accepté par :** [redacted]
Date : 29 août 2016	Date : 2016-08-31

Si ce compte rendu n'est pas conforme aux discussions tenues lors de cette réunion, veuillez nous en avertir dans les sept jours. À moins d'un avis contraire, le contenu de ce compte rendu sera considéré comme exact.

JH

Ponts Jacques Cartier + Champlain Bridges Canada	**COMPTE RENDU** 2016-10-07

Date de la réunion : Jeudi 29 septembre 2016 – 13h30 à 15h30	**CT 62453**	

Description du projet : <u>Pont Champlain, services de consultants, étude d'avant-projet portant sur la déconstruction de l'actuel pont Champlain (2016-2017)</u>	**Réunion N° : 10**	**Lieu :** Salle SSQ Honoré-Mercier PJCCI 1225, rue St-Charles O, 5e étage Longueuil (Québec) J4K 0B9

RÉUNION DE COORDINATION

But de la réunion :

Coordination avec le Ministère Pêches et Océans Canada (MPO)

Copies conformes :

Aux personnes convoquées

Personnes présentes :

- Catalin Petcu	Chargé de projet	PJCCI
- Elizabeth Boivin	Ingénieure, Environnement	PJCCI
- Pascal Levis	Directeur des projets, Champlain	PJCCI
- Martin Chiasson	Directeur Environnement	PJCCI
- Bertrand Voutaz	Adjoint au chargé de projet	PTA
[redacted]	Spécialiste en développement durable	PTA
	responsable de l'équipe d'ÉEE	PTA
- [redacted]	Biologiste	PTA
- [redacted]	Biologiste	PTA
- Serge-Éric Picard	Pêches et Océans Canada	MPO

ACTION PAR :

1. Introduction des participants et de leurs rôles

2. Position de PJCCI sur la LCEE

PJCCI signale qu'à ce jour, leur compréhension des exigences de la LCEE les amènent à faire réaliser une évaluation des effets environnementaux (ÉEE) pour répondre à l'article 67 de la LCEE. Une rencontre aura lieu d'ici peu avec Environnement et Changement climatique Canada à cet égard.

3. Présentation du mandat

PTA présente les grandes lignes du présent mandat qui lui a été confié par PJCCI, soit l'étude d'avant-projet de la démolition du pont Champlain, qui comprend l'ÉEE.

4. Méthodes de déconstruction envisagées

Les diverses méthodes de déconstruction retenues à ce jour (avancement 60%) sont présentées. Les méthodes sont spécifiques à différentes parties de l'ouvrage :

- Tablier en béton / tablier en acier
- Chevêtres et fûts des piles
- Semelles de fondation

5. Discussion des méthodes de déconstruction avec le MPO

L'étude d'impact réalisée pour la construction du NPSL comprenait une partie consacrée à la démolition du pont existant. Cependant, cette section est très succincte et ne peut être considérée comme suffisante. L'autorisation délivrée par MPO dans le cadre du projet du NPSL n'inclut donc pas la déconstruction du pont existant. Toutefois, il est à noter que le lieu est déjà complètement caractérisé. En amont, la zone considérée s'arrête cependant à mi-distance entre le pont Champlain et l'estacade. Il serait judicieux de compléter la caractérisation un peu plus en amont, soit jusqu'à l'estacade. Les éléments suivants doivent être caractérisés dans cette zone : vitesse d'écoulement, bathymétrie, substrat, végétation aquatique.

Projet désigné

Selon le MPO aussi, le projet ne devrait pas être désigné. Il n'est pas sur la liste des projets désignés, et ne sera pas ajouté. Toutefois, PJCCI reste prudent car le Ministre de l'Environnement peut le désigner de façon discrétionnaire selon l'intérêt du public.

Démolition à l'explosif contrôlé

Dans le cas du tablier, cette méthode sera refusée par le MPO. La raison est qu'il existe d'autres méthodes de démolition qui peuvent logiquement être envisagées, et qui sont beaucoup moins dommageables pour le poisson.

Dans le cas des piles, PTA mentionne que cette méthode a été utilisée pour la démolition de l'ancien pont Port Mann à Vancouver en 2014, en utilisant des détonations préliminaires pour éloigner le poisson et des rideaux de bulles pour amortir l'onde de choc. Le MPO mentionne que lors de l'explosion, une pression maximale de 100 kPa est autorisée. La meilleure interface reste l'air, ce qui implique la construction de batardeaux. Il est possible que l'utilisation d'explosif soit autorisée pour les piles, mais la demande sera étudiée attentivement et elle devra être solidement étayée pour pouvoir être considérée par le MPO.

Niveau de démolition des semelles

Le niveau de démolition importe peu pour le MPO, tous les niveaux sont possibles mais la meilleure option demeure celle qui n'implique pas de travaux dans ou près du lit du fleuve. Trois cas de figures se présentent :

1. La semelle est démolie jusqu'à une hauteur d'au moins 18 pouces au-dessus du lit : pas de changement au niveau de l'habitat du poisson.

2. La semelle est arasée au niveau du lit de la rivière : On obtient un gain de surface du fait que la semelle disparaît, mais aucun crédit environnemental ne serait accordé.

3. La semelle est démolie jusqu'à une profondeur d'au moins 18 pouces sous le niveau du lit : gain en terme d'habitat du poisson et obtention d'un crédit environnemental car le lit se reconstitue.

Le MPO mentionne que du matériel granulaire fin se trouve localement dans le fleuve, approximativement entre la digue de la voie maritime et la pile no 11.

<u>Utilisation des barges</u>

Les expériences faites avec des barges dans la zone du pont Champlain montrent qu'il ne faut pas être trop optimiste quant aux accès avec celles-ci. La bathymétrie doit être soigneusement étudiée. Une combinaison de barges / jetées / pontons est une bonne approche. Du côté de l'île des Sœurs, une jetée est préférable à un ponton du fait du faible tirant d'eau.

Les jetées construites par SSL doivent être démantelées au plus tard le 31 décembre 2018. Il serait envisageable de les transférer à PJCCI, du moins le matériel qui pourrait être déplacé.

Le tirant d'eau est faible entre les axes W1 et W6.

Le lien entre le chantier et le port de Montréal doit se faire par la voie maritime, le chemin direct en passant sous le pont de la Concorde n'est pas envisageable, le tirant d'eau ne le permet pas et il ne sera pas possible d'obtenir des autorisations pour faire du dragage à cet endroit.

<u>Projets de mise en valeur des actifs</u>

Plusieurs idées de mise en valeur touchent le fleuve (vague de surf). Pour le MPO, cela constitue un autre projet, indépendant du projet de déconstruction du pont. Cela fera l'objet d'une procédure séparée.

<u>Mesures de compensation</u>

Du fait des autres projets réalisés ou en cours de réalisation, les possibilités sont maintenant limitées dans la région, il faudra donc considérer des compensations dans des secteurs plus éloignés.

<u>Voie Maritime</u>

Il est possible de faire des bulles dans la Voie Maritime pour éviter la formation de glace en période hivernale, car des habitats de faible valeur sont présents dans ce secteur.

6. Recommandations du MPO

<u>Présentation générale de l'étude environnementale</u>

Le MPO propose de suivre le modèle de l'étude préparée dans le cadre du NPSL.

<u>Jetée</u> Lors de la conception d'une jetée, veiller à prévoir des passes à poisson au-travers de la jetée. Pour la jetée de 500m de SSL, 3 passes sont intégrées. Différentes configurations sont possibles, comme par exemple un ponceau à déversoir. Si une jetée est prévue dans le petit bassin de La Prairie, les passes doivent permettre le passage de l'eau dans les deux sens, puisque le sens du courant peut varier dans cette zone. Des sédiments contaminés se trouvent dans cette zone. Le pourcentage de restriction n'est pas applicable dans ce secteur. Un phasage des travaux de la jetée doit être présenté : il faut démontrer qu'on travaille de façon à minimiser les impacts. <u>Plan de gestion de l'eau</u> Prévoir un plan de gestion de l'eau dans le cas de batardeau, en fonction du débit de pompage prévu : petit, moyen, élevé. Les expériences actuelles de SSL montrent que des débits élevés peuvent être rencontrés. Dans l'ÉEE, il faudra mentionner qu'un plan de gestion de l'eau sera élaboré et décrire sommairement son contenu. <u>Remise en état des lieux (piles, jetées)</u> La remise en état doit être présentée en fonction de la carte environnementale de départ, soit celle qui est présentée dans l'évaluation environnementale du nouveau pont pour le St-Laurent. À noter que le crédit est plus important lorsque le projet permet la remise en état d'habitats de valeurs. <u>Présentation du projet aux autochtones</u> La présentation sera dirigée par PJCCI, qui est l'initiateur du projet, avec le support du MPO. Il est important de présenter suffisamment d'information, mais pas un projet abouti puisqu'il sera sujet à des modifications. <u>Station hydrométrique de Lasalle</u> Le MPO mentionne la présence de la station hydrométrique de Lasalle, en amont du pont, qui fournit des mesures journalières ainsi qu'un historique des mesures, qui est représentatif pour les conditions dans la zone du pont. <u>Plans B pour les méthodes</u> Il est judicieux de prévoir un plan B pour les méthodes : si la méthode privilégiée ne fonctionne pas, la deuxième sera déjà évaluée du point de vue environnemental. <u>Périodes de restriction</u> Les périodes de restriction définies dans le cadre de l'évaluation environnementale portant sur la construction du nouveau pont s'appliqueront pour le projet de déconstruction du pont Champlain. <u>Mesures d'atténuation</u> Le MPO fera parvenir la liste des mesures d'atténuation standardisées.	 MPO

7. Suite de l'étude Le MPO propose que le rapport lui soit remis par étape, afin qu'il puisse faire ses commentaires avant l'émission du rapport final (par exemple : description du projet et du milieu; évaluation des impacts et mesures de mitigation).	
8. Levée de réunion La réunion se conclut à 15h30.	

Préparé par : Bertrand Voutaz, PTA Date : 7 octobre 2016	**Accepté par :** [redacted] Date : 2016-10-07

Si ce compte rendu n'est pas conforme aux discussions tenues lors de cette réunion, veuillez nous en avertir dans les sept jours. À moins d'un avis contraire, le contenu de ce compte rendu sera considéré comme exact.

BV

COMPTE RENDU

2016-10-14

Date de la réunion : Jeudi 30 septembre 2016 – 09h30 à 12h00	CT 62453	

Description du projet :	Réunion Nº : 11	Lieu :
Pont Champlain, services de consultants, étude d'avant-projet portant sur la déconstruction de l'actuel pont Champlain (2016-2017)		Salle SSQ Honoré-Mercier PJCCI 1225, rue St-Charles O, 5e étage Longueuil (Québec) J4K 0B9

RÉUNION DE COORDINATION

But de la réunion :

Coordination avec Transports Canada (TC)

Copies conformes :

Aux personnes convoquées

Personnes présentes :

- Catalin Petcu	Chargé de projet	PJCCI
- Elizabeth Boivin	Ingénieure, Environnement	PJCCI
- Pascal Levis	Directeur des projets, Champlain	PJCCI
- Lidia Capece	Resp. des évaluations environnementales	TC
- Vicki Da Silva Casimiro	Agente, Consultations autochtones	TC
- Pascale Couroux-Smith	Resp. des évaluations environnementales	TC
- Robert Giroux (par vidéoconférence)	Protection de la navigation	TC
- Bertrand Voutaz	Adjoint au chargé de projet	PTA
- [redacted]	Spécialiste en développement durable	PTA
- [redacted]	Biologiste	PTA

ACTION PAR :

1. **Introduction des participants et de leurs rôles**

2. **Position de PJCCI sur la LCEE**

   PJCCI signale qu'à ce jour, leur compréhension des exigences de la LCEE les amènent à faire réaliser une évaluation des effets environnementaux (ÉEE) pour répondre à l'article 67 de la LCEE. Le projet n'est pas sur la liste des projets désignés, toutefois, PJCCI reste prudent car le Ministre de l'Environnement peut le désigner de façon discrétionnaire selon l'intérêt du public.

3. **Présentation du mandat**

   PTA présente les grandes lignes du présent mandat qui lui a été confié par PJCCI, soit l'étude d'avant-projet de la démolition du pont Champlain, qui comprend l'ÉEE.

4. Méthodes de déconstruction envisagées

Les diverses méthodes de déconstruction retenues à ce jour (avancement 60%) sont présentées. Les méthodes sont spécifiques à différentes parties de l'ouvrage :

- Tablier en béton / tablier en acier
- Chevêtres et fûts des piles
- Semelles de fondation

5. Discussion de l'interaction des travaux avec la navigation

<u>Méthodes de déconstruction</u>
Quelle que soit la méthode utilisée, une sécurisation des lieux est nécessaire. TC n'a pas d'objection particulière en ce qui concerne la méthode par explosion contrôlée.

<u>Niveau d'arasement des piles</u>
TC va demander qu'un relevé bathymétrique soit effectué dans la zone concernée.

Pour la navigation, le niveau d'arasement requis dépend des cas de figure suivants :

Dans les zones navigables :

- Piles arasées sous le niveau de l'eau : un tirant d'eau minimal de 2,0 m doit être garanti en tout temps (basses eaux). Cette exigence a été appliquée pour la démolition du pont de l'Île-des-Sœurs.

- Piles arasées au-dessus du niveau de l'eau : Les piles doivent être arasées (on non) suffisamment haut pour qu'elles soient bien visibles même lors des hautes eaux (aucune hauteur minimale prescrite). Cette exigence concerne la navigation uniquement, mais d'autres facteurs peuvent entrer en ligne de compte (comportement hydraulique, mouvement des glaces, etc.)

Dans les zones non navigables :

- Au-delà de la pile no 40 environ, où le tirant d'eau est trop faible pour la navigation, les piles doivent être arasées au niveau du lit du fleuve.

<u>Chenal de navigation</u>
Il n'existe pas de carte de navigation officielle dans ce secteur. TC peut accepter une certaine interférence à la navigation (par exemple en laissant des piles en place dans le cas de projets de mise en valeur), cependant cela doit faire l'objet d'une approbation de sa part. Le chenal doit rester évident, simple, ne contraignant pas les bateaux à faire un « slalom » entre les piles et autres obstacles, en tenant compte du NPSL.

Le chenal de navigation peut être modifié durant les travaux, comme actuellement pour la construction du NPSL.

<u>Gabarit de navigation durant les travaux</u>
Il n'y a pas de largeur navigable minimale imposée, le fleuve est suffisamment large pour qu'il y ait toujours suffisamment d'espace de navigation.

Le tirant d'air doit être suffisant pour la navigation de plaisance et la garde côtière. Le tirant d'air de l'estacade peut être pris comme référence. <u>Quai d'accostage ou jetée temporaire</u> Un quai d'accostage ou une jetée temporaire durant les travaux doivent être approuvés par TC. <u>Barges et quais flottants</u> L'utilisation de barges et de quais flottants, même s'ils sont ancrés à des piles, doit faire l'objet d'une approbation par TC. <u>Autorisations de TC</u> Les approbations et autorisations doivent être demandées à TC pour : • Les situations temporaires de chantier, en fonction de la méthodologie privilégiée par l'entrepreneur (jetées, quais, barges, ...); • La situation finale, à la fin des travaux. Une fois que la demande d'approbation est soumise à TC, 30 jours sont nécessaires pour la consultation des parties prenantes, si requis. Il faut éventuellement prévoir des consultations publiques et la consultation des autochtones.	
6. Suite de l'étude PJCCI propose que le rapport d'ÉEE soit remis à TC par étape, afin que TC puisse faire ses commentaires avant l'émission du rapport final.	
7. Communications Les communications avec TC passeront par Mme Lidia Capece.	Tous
8. Levée de réunion La réunion se conclut à 12h00.	

Préparé par :	Accepté par : [redacted]
Bertrand Voutaz, PTA	
Date : 14 octobre 2016	Date : 2016-10-18

Si ce compte rendu n'est pas conforme aux discussions tenues lors de cette réunion, veuillez nous en avertir dans les sept jours. À moins d'un avis contraire, le contenu de ce compte rendu sera considéré comme exact.

BV

Description du projet :

Pont Champlain, services de consultants, étude d'avant-projet portant sur la déconstruction de l'actuel pont Champlain (2016-2017)

Réunion Nº : 12

Lieu :
Salle SSQ Honoré-Mercier
PJCCI
1225, rue St-Charles O,
5e étage
Longueuil (Québec)
J4K 0B9

RÉUNION DE COORDINATION

But de la réunion :

Coordination avec l'arrondissement de Verdun

Copies conformes :

Aux personnes convoquées

Personnes présentes :

- Catalin Petcu	Chargé de projet	PJCCI
- Vincetn Guimont-Hébert	Ingénieur, Environnement et DD	PJCCI
- Pascal Levis	Directeur des projets, Champlain	PJCCI
- [redacted]	Ingénieure, grands projets	Ville de Mtl
-	Chargé de projet, Direction des infra.	Ville de Mtl
-	Chef de division, urbanisme	Arr. Verdun
-	Directeur des travaux publics	Arr. Verdun
- Bertrand Voutaz	Adjoint au chargé de projet	PTA
- Alain Robitaille	Ingénieur Transport	PTA
- [redacted]	Ingénieur Transport	PTA
- Sylvain Gariépy	Urbaniste principal	PTA

ACTION PAR :

1. **Introduction des participants et de leurs rôles**

2. **Présentation du mandat**

PTA présente les grandes lignes du présent mandat qui lui a été confié par PJCCI, soit l'étude d'avant-projet de la démolition du pont Champlain, qui comprend l'évaluation des effets environnementaux. La présentation est jointe en annexe au présent compte rendu.

L'étude d'avant-projet s'articule autour de 4 champs d'étude, soit :

- Les travaux de déconstruction
- Le transport des matériaux
- La valorisation des matériaux
- La mise en valeur des actifs

PJCCI a souhaité accorder une attention particulière au développement durable. Ainsi, les différentes solutions développées dans le cadre de ce projet sont évaluées non seulement sur des critères techniques et économiques, mais aussi sur des critères environnementaux et sociaux.

L'étude d'avant-projet de la démolition doit être terminée à la fin de l'année, alors que l'évaluation des effets environnementaux débute actuellement et doit être compléter à l'automne 2017.

3. Méthodes de déconstruction

Les diverses méthodes de déconstruction retenues à ce jour (avancement environ 80%) sont présentées. Les méthodes sont spécifiques à différentes parties de l'ouvrage :

- Tablier en béton / tablier en acier
- Chevêtres et fûts des piles
- Semelles de fondation

L'échéancier des travaux est encore en cours d'analyse, mais la durée totale des travaux de déconstruction peut être estimée à 2,5 à 3 ans.

4. Transport des matériaux

Le transport des matériaux est prévu selon deux modes :

- Transport routier
- Transport maritime

Le transport routier est prévu essentiellement de nuit. Pour le béton, qui représente la plus grande partie des matériaux de démolition, la quantité transportée est évaluée à 1500 to à 2000 to par semaine.

L'estacade permet le passage de camion, la capacité portante du tablier répond aux exigences du code canadien sur les ponts routiers.

5. Valorisation des matériaux

La partie valorisation n'est pas présentée car peu pertinente dans le cadre de cette rencontre.

6. Mise en valeur des actifs

Sylvain Gariépy présente les réflexions menées pour la mise en valeur des actifs. Quatre principaux secteurs sont identifiés dans le corridor du pont Champlain pour différentes interventions : la rive de l'Ile-des-Sœurs, le fleuve, la voie maritime et la rive de Brossard.

Les référents retenus à ce jour sont les suivants : un belvédère, un mur d'escalade, une place publique, un quai, un monument et la mise en valeur environnementale et faunique à petite échelle.

Suite à l'évaluation des options (à venir), une à deux solutions seront poursuivies et seront prises en considération dans l'étude environnementale qui débute.

[redacted] mentionne que l'arrondissement de Verdun est sur le point d'engager une firme pour développer des concepts d'aménagement dans la zone du nouveau pont sur le Saint-Laurent. Dans ce contexte, il souhaite donc qu'une autre rencontre ait lieu avec PJCCI.

Verdun a un intérêt certain pour les aménagements visant à s'approprier les berges, pour permettre aux citoyens de se rapprocher de l'eau. Pour exemple, un site de pratique du kayak, avec possibilité de location, existe depuis quelques années à la Point Nord de l'Ile-des-Sœurs.

Verdun prévoit des consultations publiques pour les nouveaux aménagements. Il existe déjà des comités de citoyens prêts à s'impliquer dans de tels projets, ceux-ci seront donc consultés.

Verdun exprime finalement son intérêt pour les concepts de mise en valeurs du projet, et souhaite poursuivre le dialogue avec PJCCI.

6. Principe de développement durable

En conclusion, Vincent Guimont-Hébert présente brièvement les principes de développement durable mis en œuvre dans le cadre de ce projet. Une évaluation multi-critères est effectuée pour les options envisagées dans chacun des champs d'étude, menant à une représentation graphique des résultats. PJCCI souhaite que les critères de développement durable soient pris en compte tout au long du projet.

7. Levée de réunion

La réunion se conclut à 12h00.

ANNEXE : Présentation du projet

Préparé par :	Accepté par : [redacted]
Bertrand Voutaz, PTA	
Date : 24 octobre 2016	Date : 2016-10-28

Si ce compte rendu n'est pas conforme aux discussions tenues lors de cette réunion, veuillez nous en avertir dans les sept jours.
À moins d'un avis contraire, le contenu de ce compte rendu sera considéré comme exact.

BV

Ponts Jacques Cartier + Champlain Bridges Canada	**COMPTE RENDU** 2016-11-23	
Date de la réunion : Vendredi 4 novembre 2016 – 13h30 à 15h00	**CT 62453**	

Description du projet :	**Réunion N° : 1**	**Lieu :**
Pont Champlain, services de consultants, étude d'avant-projet portant sur la déconstruction de l'actuel pont Champlain (2016-2017)		**Salle Jacques-Cartier** PJCCI 1225, rue St-Charles O, 5e étage Longueuil (Québec) J4K 0B9

RÉUNION DE COORDINATION

But de la réunion :

2e coordination avec la Corporation de Gestion de la Voie Maritime du Saint-Laurent (CGVMSL)

Copies conformes :

Aux personnes convoquées et

[redacted] PTA
Alain Robitaille, PTA
[redacted] PTA
Sylvain Gariépy, PTA

Personnes présentes :

- Catalin Petcu	Chargé de projet	PJCCI
- Pascal Lévis	Directeur des projets, Champlain	PJCCI
- Andy Woo	Directeur Planification	PJCCI
- Marie Gaudreault	Gestionnaire, Gestion de l'infrastructure	CGVMSL
- Jean Aubry-Morin	Vice-président, relations externes	CGVMSL
- Martin Vallée	Superviseur entretien – canal Beauharnois	CGVMSL
- Richard G. Côté	Capitaine au long cours	CGVMSL
- Michel Thibault	Ingénieur civil - Inspections	CGVMSL
- Sylvain Montminy	Chargé de projet	PTA
- Bertrand Voutaz	Adjoint au chargé de projet	PTA

ACTION PAR :

1. **Introduction des participants et de leurs rôles**

2. **Présentation du mandat**

Cette deuxième rencontre fait suite à la première rencontre qui a eu lieu le 15 août 2016. PTA présente l'avancement du projet à 90%, en particulier les solutions retenues pour la déconstruction du pont dans son ensemble. Le franchissement de la voie maritime est toutefois le centre d'intérêt de la rencontre.

Une présentation PowerPoint survolant l'ensemble du projet est présentée en réunion, une copie de celle-ci est jointe au présent compte-rendu.

Les commentaires et points particuliers pertinents discutés en réunion sont consignés ci-dessous.

3. Méthodes de déconstruction pour la superstructure en acier

Pour la superstructure en acier, les méthodes de déconstruction privilégiées sont :

- Le dé-hissage (strand jacking) de la travée centrale suspendue;
- La construction inversée pour les parties restantes en porte-à-faux et les travées d'ancrages;
- Le dé-hissage des travées d'approche par groupe de deux poutres en treillis.

Lors du dé-hissage, la travée centrale suspendue sera déposée sur une barge et évacuée à proximité pour être démantelée. Il est envisagé de procéder à cette opération juste après la fermeture de la voie maritime ou juste avant sa réouverture. La CGVMSL préconise de procéder juste après la fermeture, pour éviter les problèmes de glace.

La CGVMSL mentionne que la période de fermeture s'étend généralement de fin décembre / début janvier jusqu'à mi-mars. La date de fermeture de la voie maritime est déterminée par la CGVMSL chaque année aux alentours de début novembre.

Pour les opérations de construction inversée, il est difficilement envisageable d'utiliser une grande grue sur barge durant l'hiver :

- En période hivernale, le tirant d'eau dans la voie maritime est abaissé de 2 à 4 mètres, ce qui est très limitatif.

- Il est pratiquement impossible d'éliminer la glace présente: un brise-glace est inefficace sur un plan d'eau aussi confiné. Un aéroglisseur serait plus efficace, mais pratiquement impossible à obtenir (celui de la garde-côtière n'est pas disponible). Un système à bulles d'air a un effet de courte durée seulement, avant que la glace ne se forme. Un tel système peut aussi être très coûteux.

PTA mentionne les opérations de SSL où des matériaux granulaires ont été apportés par bateau et transportés par convoyeur de l'autre côté de la digue de la voie maritime. La CGVMSL mentionne que cette opération permettait de décharger 900 tonnes de matériaux à l'heure. En considérant la quantité de béton des piles du pont Champlain, une opération inverse à celle de SSL nécessiterait environ 10 à 12 transbordements successifs sur des vraquiers. Une telle autorisation peut être octroyée suite à une analyse de risques.

4. Analyse de risque

La CGVMSL mentionne que dans la plupart des gros projets similaires à celui de la déconstruction du pont Champlain, elle procède à la négociation d'une entente cadre en début du projet et qu'ensuite chaque activité est autorisée individuellement, généralement avec l'appui d'une analyse de risques. La CGVMSL mentionne que les ententes sont conclues au cas par cas. Une telle entente sera donc requise pour les travaux de déconstruction du pont Champlain.

Si des travaux doivent être effectués pendant la période de navigation, une analyse de risques formelle est requise. Chaque méthode de travail nécessite la mise sur pied d'une analyse de risque. Le processus d'analyse de risque doit être piloté par PJCCI, avec la participation de la CGVMSL. Une fois le processus lancé, des rencontres et autres ateliers ont lieu régulièrement, tout au long des travaux.	
5. Échéancier La CGVMSL demande si l'échéancier du projet de déconstruction du pont Champlain est connu. PJCCI répond que les travaux devraient commencer au début de 2019, peu après la mise en service du NPSL, et s'échelonneront sur une période de 3 ans à 5 ans. En vue de la préparation de l'entente cadre, PJCCI devra faire parvenir un document d'intention à la CGVMSL, qui pourra ainsi planifier les ressources nécessaires. La CGVMSL mentionne que son année fiscale débute le 1er avril.	
6. Varia Une copie du rapport final sera transmise à la CGVMSL par PJCCI.	PJCCI
7. Levée de réunion La réunion se conclue à 15h00.	
Préparé par : Bertrand Voutaz, PTA Date : 23 novembre 2016	

Si ce compte rendu n'est pas conforme aux discussions tenues lors de cette réunion, veuillez nous en avertir dans les sept jours.
À moins d'un avis contraire, le contenu de ce compte rendu sera considéré comme exact.

BV

Appendix 5

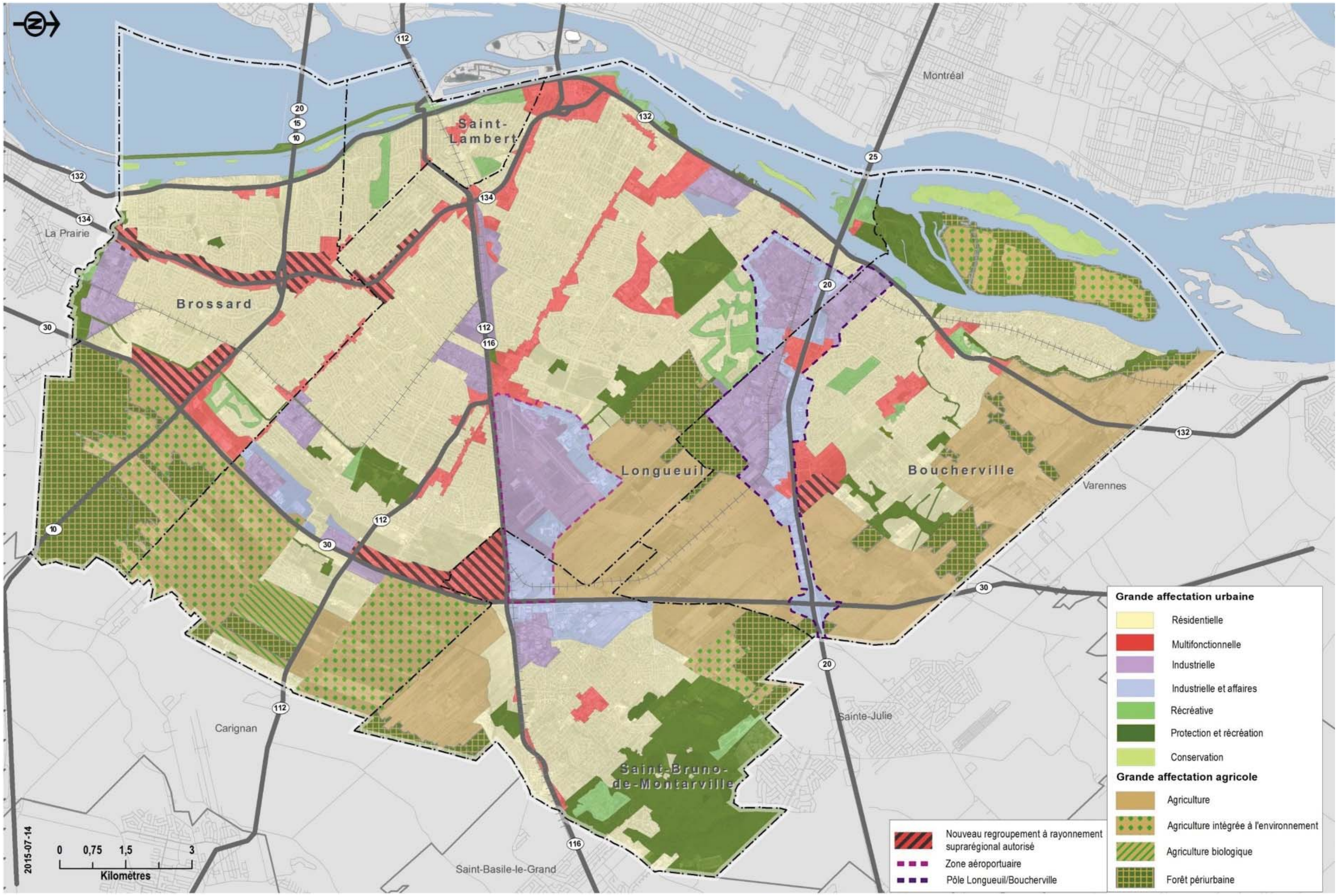
Asset Enhancement

Appendix 5-1: Plan directeur du Parc-plage du Grand Montréal (Master Plan for the Greater Montreal Beach Park)

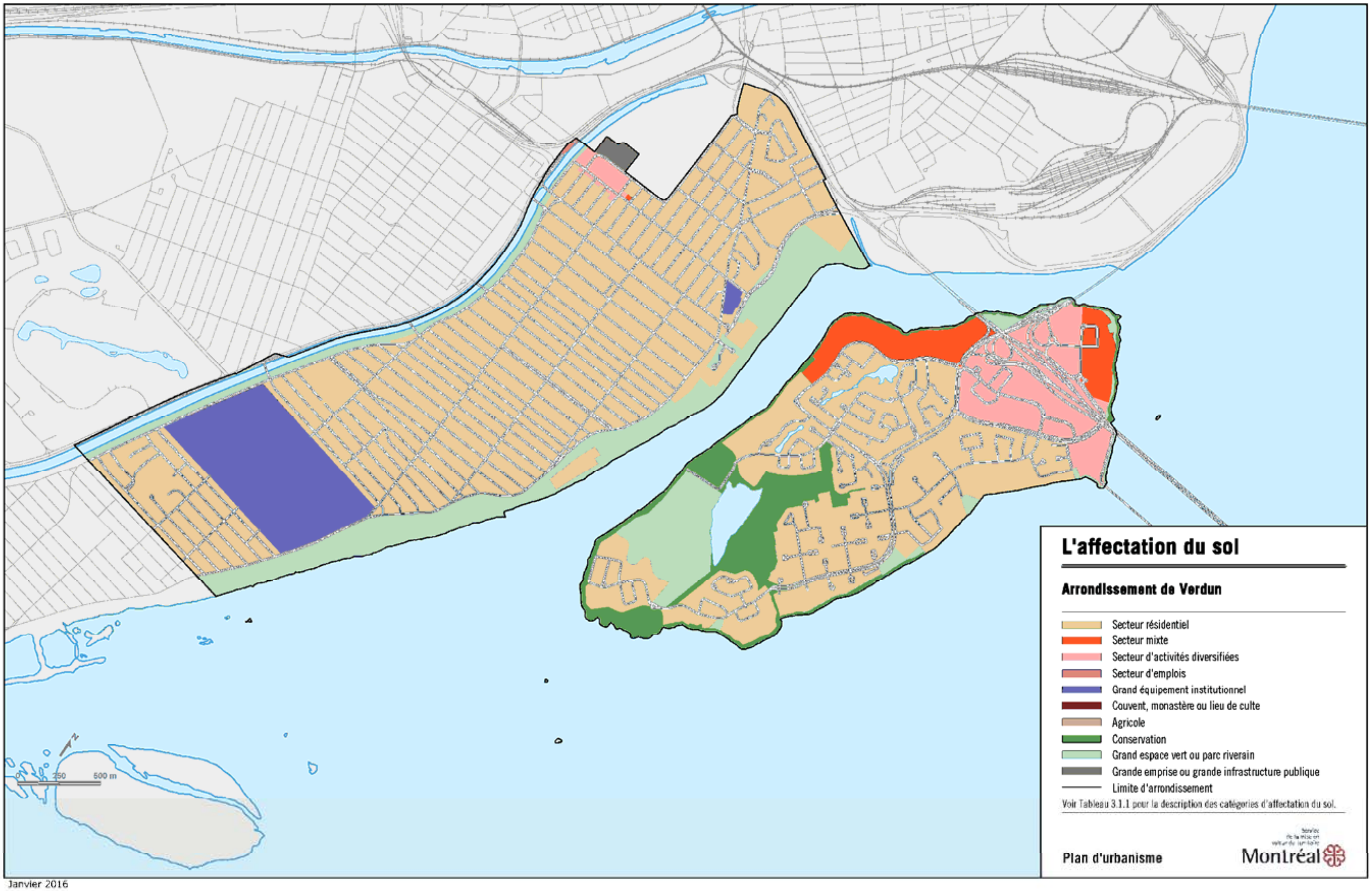
Master Plan for the Greater Montreal Beach Park: General layout. Source: CMM, 2016

Appendix 5-2: Land use in Brossard and Nun's Island

Map of main land uses. Source: City of Longueuil, 2015



Borough of Verdun: Land use. Source: City of Montreal, 2016



Appendix 5-3: Bike path network in and around Montreal

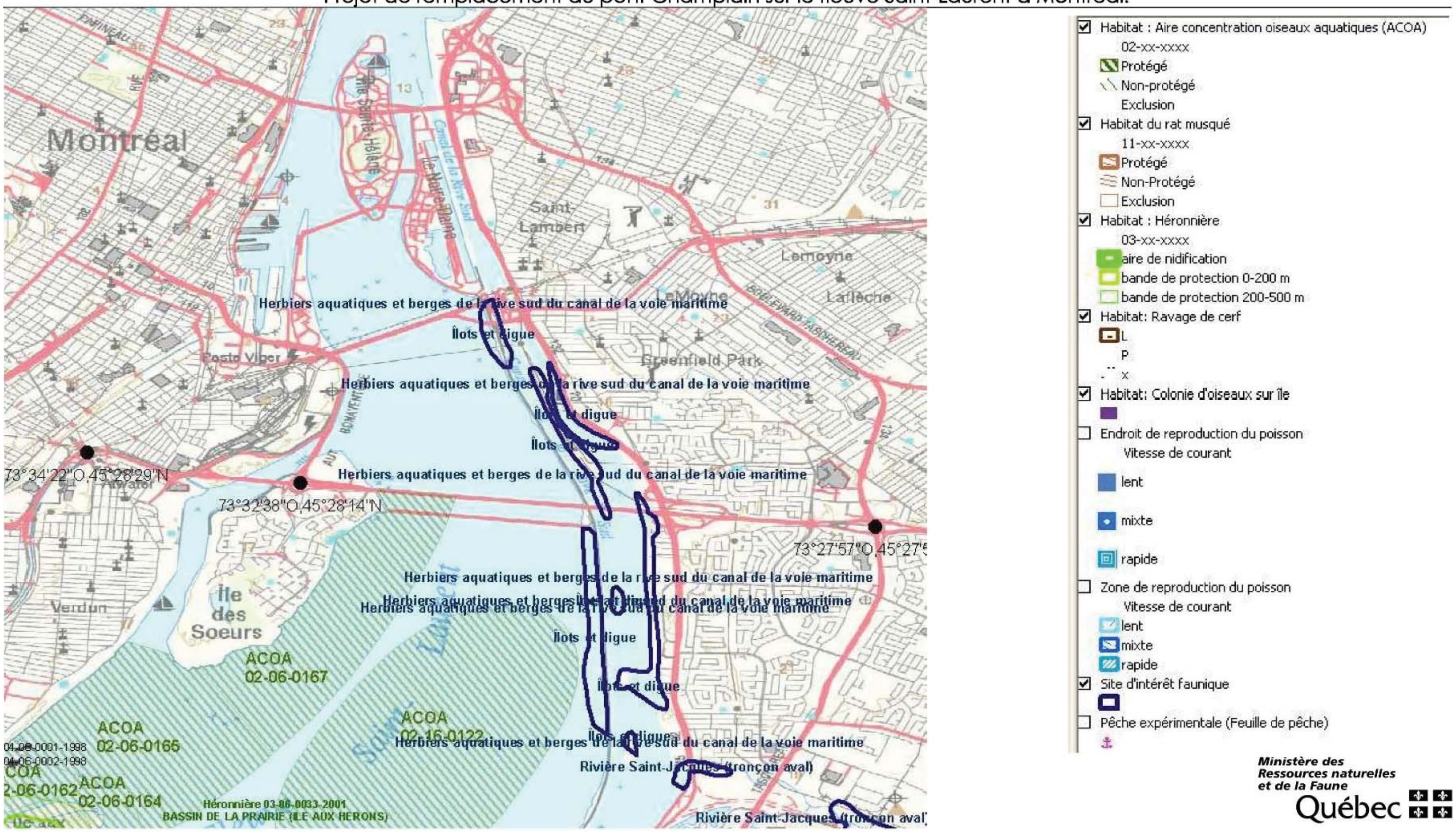
Bike path network in and around Montreal. Source: Piste cyclable 2016

Appendix 5-4: Environmental studies

APPENDIX 5-4A – MAP SHOWING WATERFOWL CONCENTRATION AREAS AND SITES OF INTEREST FOR WILDLIFE

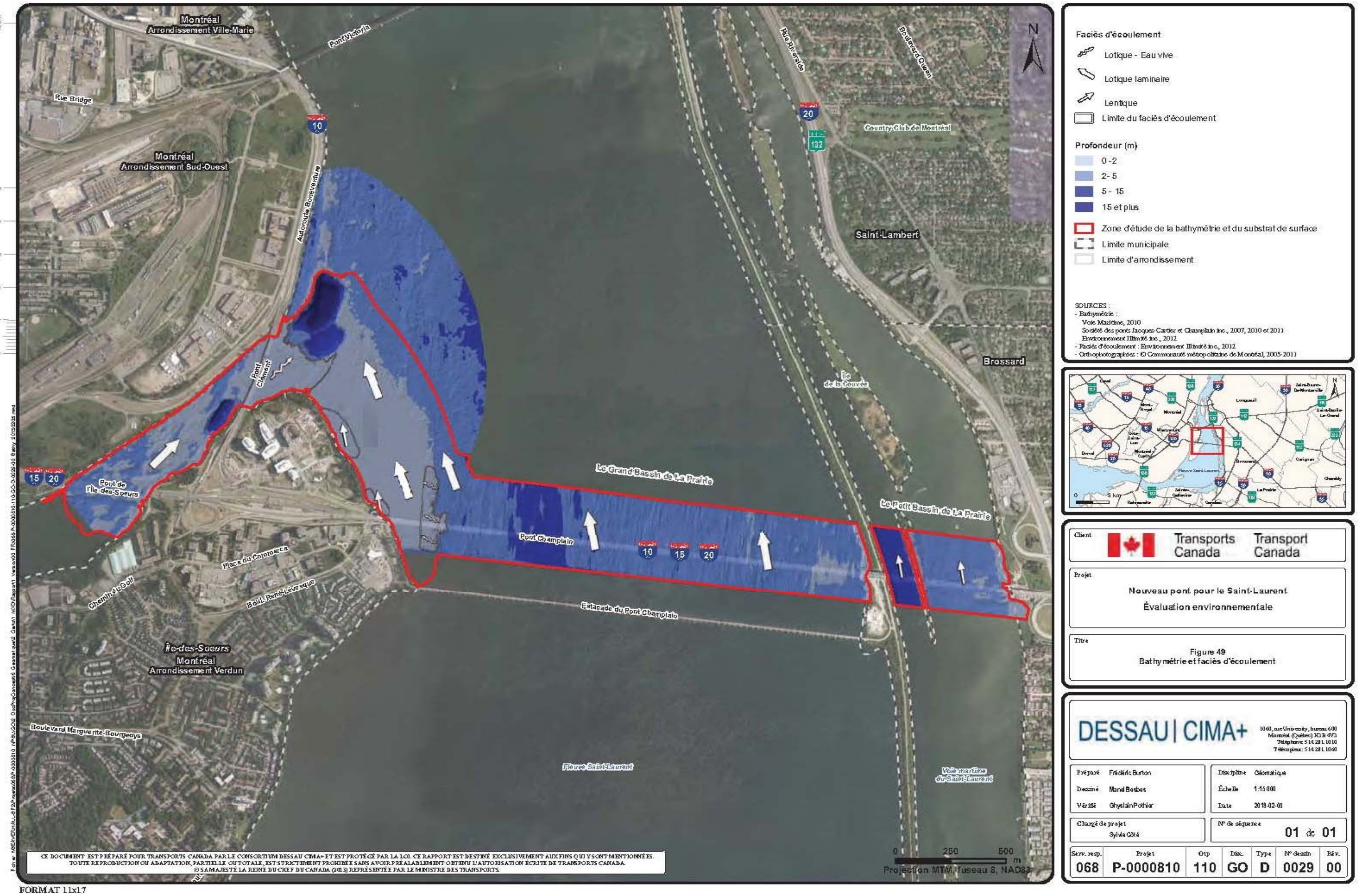
DOSSIER 4293

Projet de remplacement du pont Champlain sur le fleuve Saint-Laurent à Montréal.



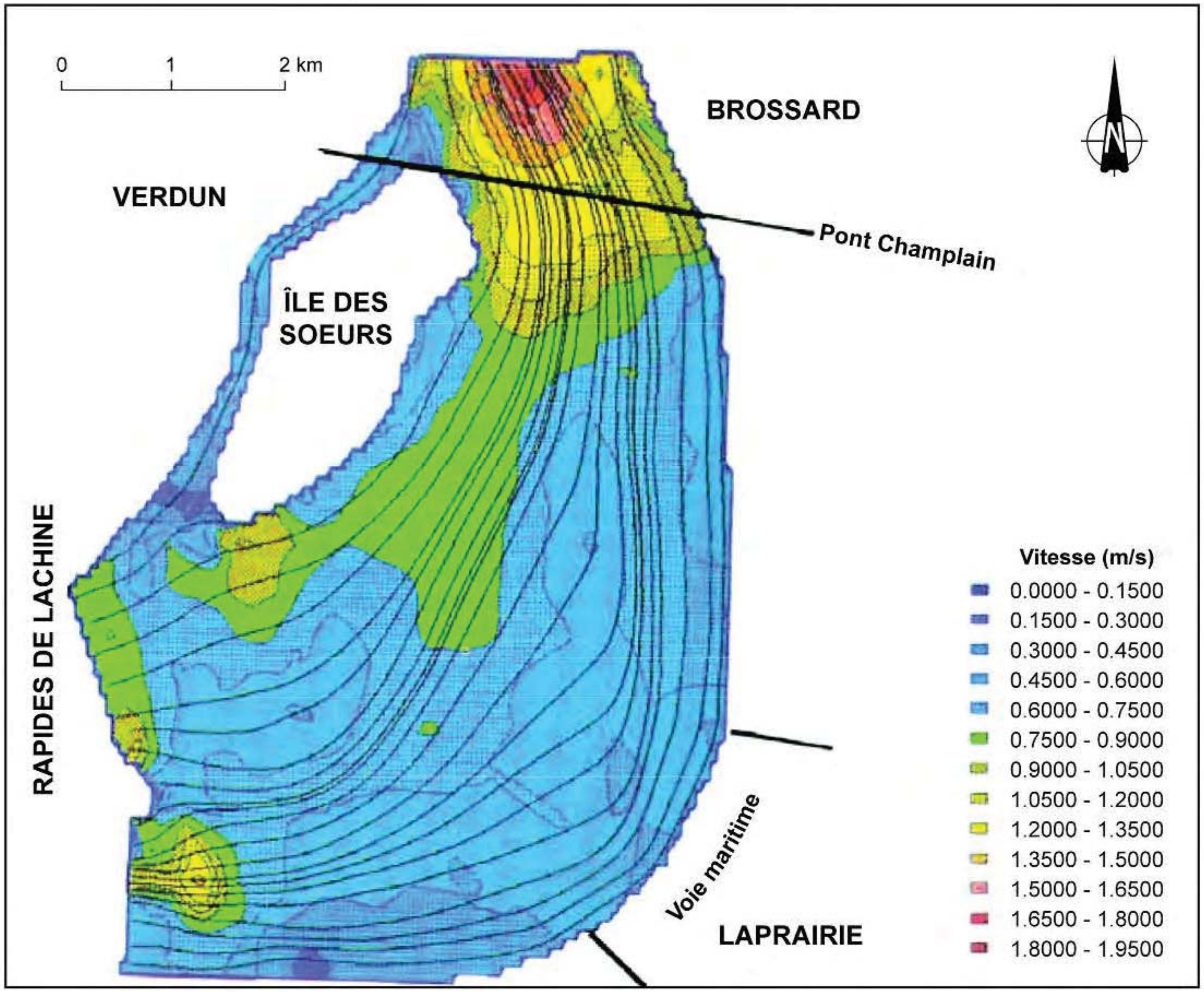
Carte produite par Virginie Boivin le 2010/03/01. Données du Ministère des Ressources Naturelles et de la Faune du Québec.

APPENDIX 5-4B – MAP SHOWING WATER DEPTH IN THE ST. LAWRENCE RIVER IN THE VICINITY OF THE CHAMPLAIN BRIDGE

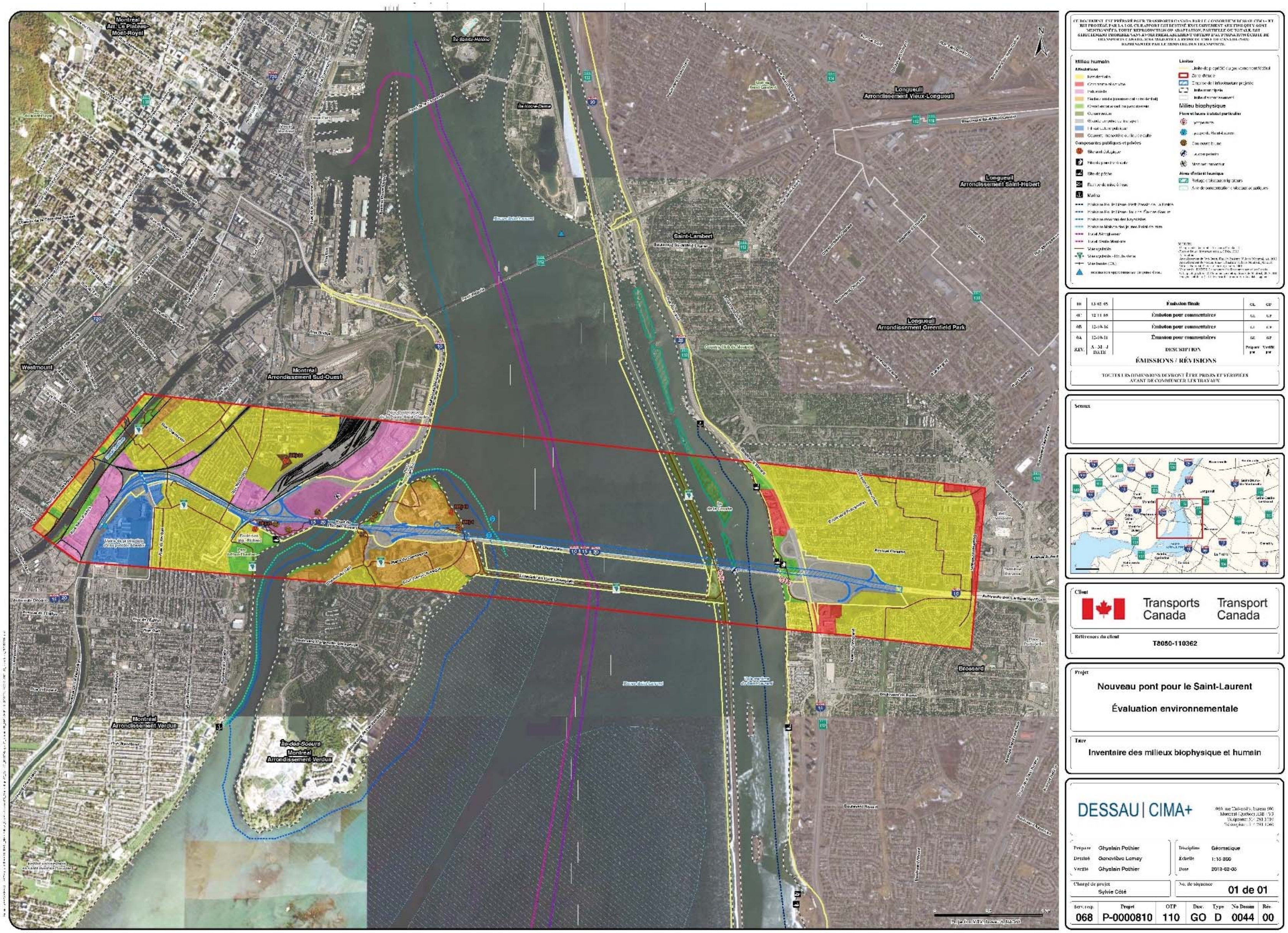


APPENDIX 5-4C – MAP SHOWING WATER CURRENTS IN THE GREATER LA PRAIRIE BASIN NEAR THE CHAMPLAIN BRIDGE

Figure 63 Champs de vitesse et trajectoire d'écoulement (Leclerc *et al.* 1987)



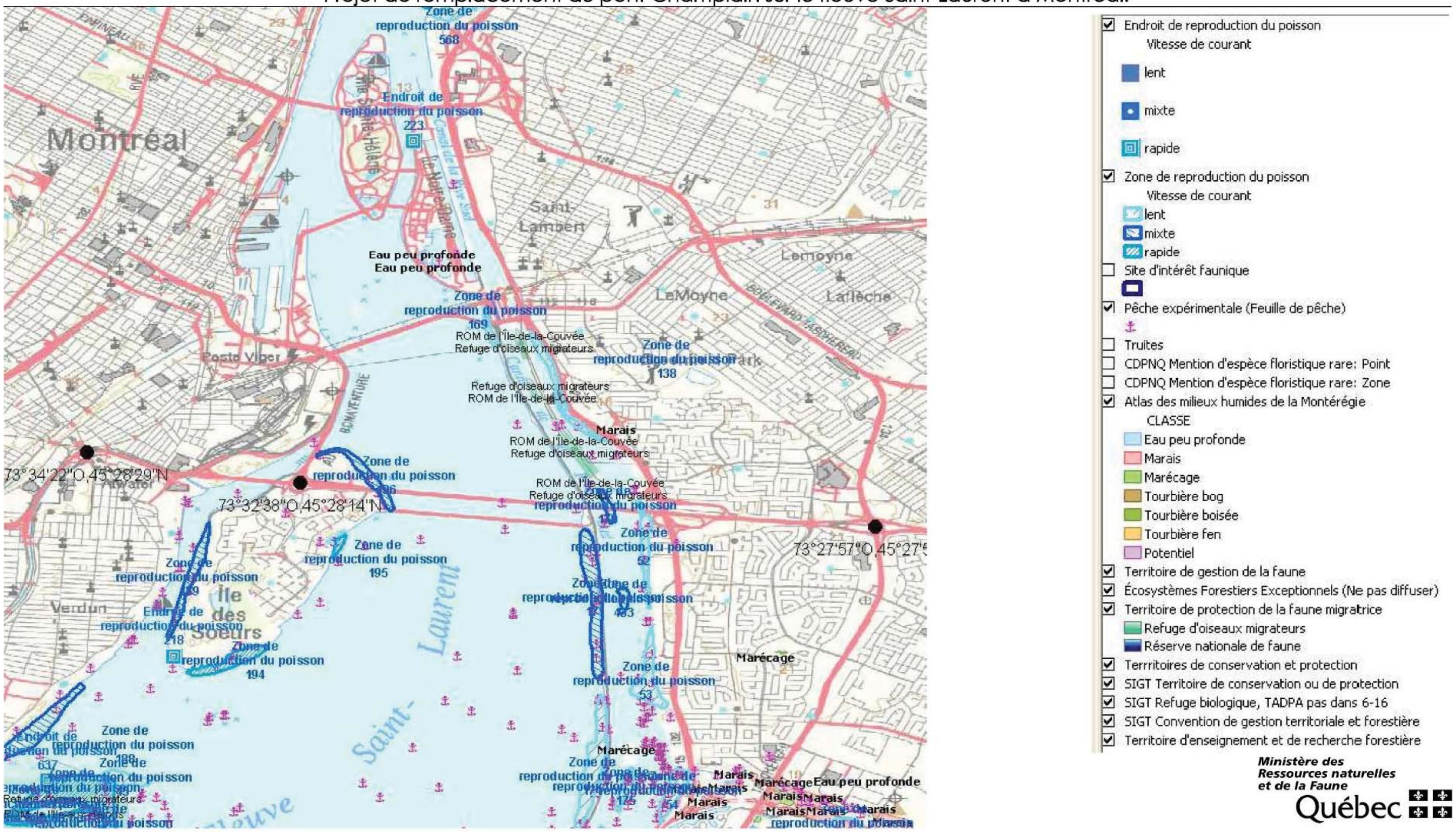
APPENDIX 5-4D– MAP OF BIOPHYSICAL AND HUMAN SETTINGS IN THE VICINITY OF THE CHAMPLAIN BRIDGE



APPENDIX 5-4E– MAP OF FISH SPAWNING GROUNDS AND ASSOCIATED CURRENT VELOCITIES IN THE VICINITY OF THE CHAMPLAIN BRIDGE

DOSSIER 4293

Projet de remplacement du pont Champlain sur le fleuve Saint-Laurent à Montréal.

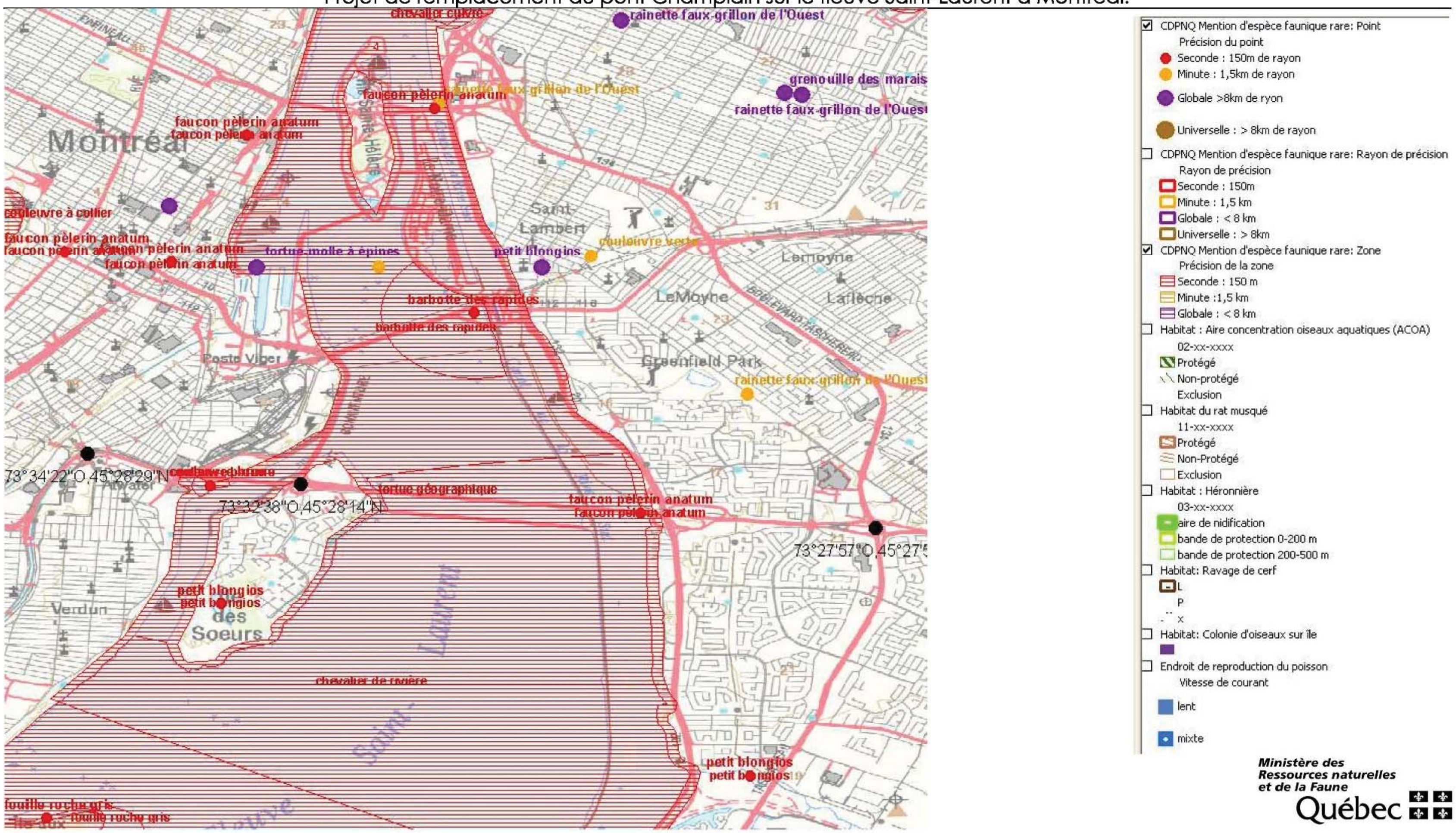


Carte produite par Virginie Boivin le 2010/03/01. Données du Ministère des Ressources Naturelles et de la Faune du Québec.

APPENDIX 5-4F– LOCATION OF WILDLIFE SPECIES IN THE VICINITY OF THE CHAMPLAIN BRIDGE

DOSSIER 4293

Projet de remplacement du pont Champlain sur le fleuve Saint-Laurent à Montréal.



Carte produite par Virginie Boivin le 2010/03/01. Données du Ministère des Ressources Naturelles et de la Faune du Québec.

Appendix 5-5: Examples of asset management projects

TOURISM AND RECREATION

Figure 1 – General view of the project. Source: Landezine, 2013

Name: Cumberland Park

Use: Urban park
Type: Landscaping/conservation/riparian zone restoration/brownfield rehabilitation
Designer: Hargreaves Associates
Client: Metropolitan Development and Housing Agency
Years: 2006-2015
Cost: 9.5 M$
Location: Nashville, Tennessee, USA
Area: 6.5 acres

HIGHLIGHTS

This public park project is located in an old brownfield area along the Cumberland River in Nashville and is part of the City's New Riverfront Revitalization Plan. It was designed to highlight the unique cultural and historical features of the site in order to provide a family-oriented recreational and leisure area. To make the site suitable for use as a park, contaminated soils were encapsulated under relief elements of the park. Several above ground industrial structures were preserved and restored as interpretative elements. Some of these structures are accessible to visitors, such as the old bridge overlooking the river which includes an elevated footbridge. One of the concerns of the designers was to preserve the floodplain function of the banks. The original riparian strip was therefore restored and runoff water is managed in an ecological way. Finally, riprap material used in the park is locally derived.

Figure 2 – Footbridge under the old retractable bridge. Source: Landezine, 2013

Figure 3 – General layout. Source: Landezine, 2013

Figure 4 – Relief element under which contaminate soil is encapsulated. Source: Landezine, 2013

TOURISM AND RECREATION

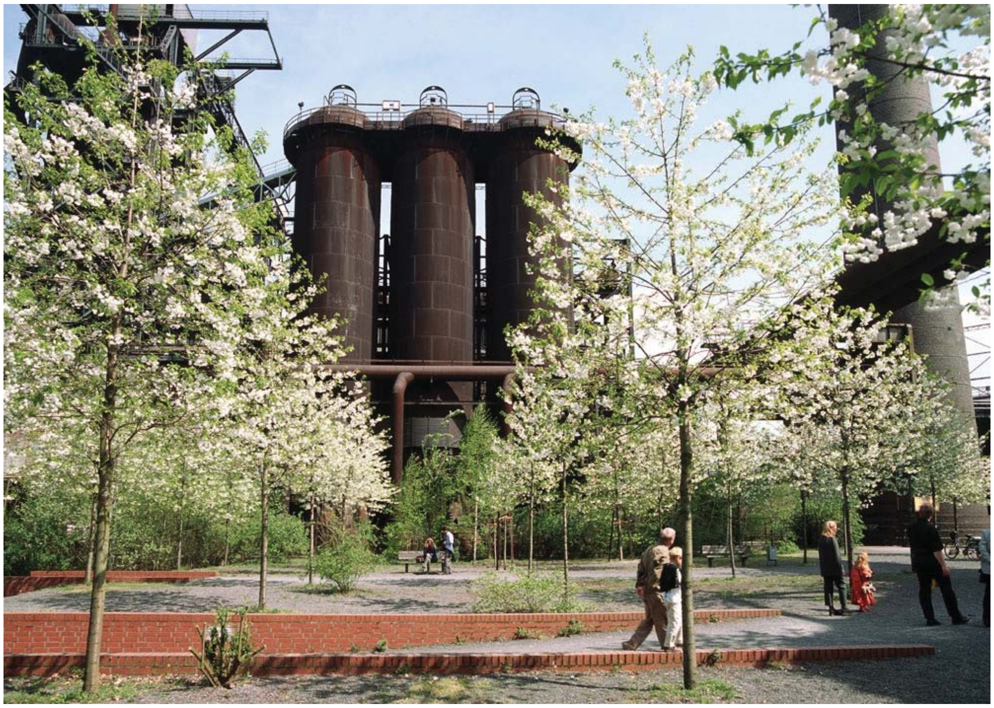


Figure 5 – Blast Furnace Park. Source: Landezine, 2011

Name: Landschaftspark Duisburg North

Use: Multifunctional park
Type: Landscaping/conservation/commemoration/contaminated soil reclamation
Designer: Latz + Partner
Client: Agora, société de développement
Years: 1992-2002
Cost: 15.500.000 EUR
Location: Duisburg, Germany
Surface area: 230 hectares

HIGHLIGHTS

This imposing multifunctional park is a pioneering post-industrial site enhancement project. Located on the site of a former blast furnace and its processing and handling facilities, the park comprises several old industrial facilities rehabilitated to serve various functions or simply act as historical relics. For instance, one of these industrial structures houses an art gallery. Some industrial components had to be dismantled and some of the materials were recovered and incorporated into the new facilities, such as iron plates formerly used to cover the casting molds that are now used as ground cover in the central area. The project also boasts an exemplary approach to ecological management of contaminated soils and runoff.

Figure 6 – Skate park built under existing facilities. Source: Landezine, 2011

Figure 7 – Old sewer canal converted into a clean water canal. Source: Landezine, 2011

Figure 8 – Climbing facility built on old concrete structures. Source: Landezine, 2011

TOURISM AND RECREATION

Name: Providence River Pedestrian Bridge

Use: Pedestrian bridge and urban park
Type: Landscaping /conservation /
Designer: In-Form Studio
Client: City of Providence
Year: Under construction
Cost: $13.2 M (estimated)
Location: Providence, Rhode Island, USA
Surface area: N/A

Figure 9 – Architectural rendering. Source: Providence Journal, 2015

HIGHLIGHTS

This pedestrian bridge project, which is under construction, is the result of a design competition launched by the City of Providence in 2010 to convert a motor vehicle bridge into an active transportation bridge. One of the competition requirements was the integration of the five existing concrete pillars of the former Route I-195 bridge. The multifunctional nature of the bridge (water games for children, commercial kiosk, sculpture, fishing, terrace, café) and its seamless integration into the city's active transportation network are what sets the winning team's proposal apart. The proposal also includes the creation of two new waterfront parks near the pedestrian bridge and the construction of an environmental interpretation center along the river's edge.

Figure 10 – General layout showing the five concrete pillars from the old bridge. Source: City of Providence, 2014

Figure 11 – General layout showing the two planned waterfront parks. Source: City of Providence, 2014

Figure 12 – Detailed view of existing pillars that will be used as foundation for the new pedestrian bridge. Source: City of Providence, 2014

ECOLOGICAL

Name: Living breakwaters

Use: Riparian protection strip

Type: Landscaping/recovery

Designer: SCAPE/Landscape architecture

Client: N/A, competition

Year: Not yet completed, 2016

Cost: $60M

Location: Banks along the South shore of Staten Island, NY, USA

Surface area: N/A

Figure 13 – Rendering of Staten Island shoreline. Source: Rebuild by Design, 2016

HIGHLIGHTS

The "Living breakwaters" project is one of the winners of the 2015 Rebuild by design competition which highlights projects focused on development that is sustainable and resilient to climate change.

The project involves the installation of wave-breaking reefs to prevent bank erosion, enhance biodiversity, and create a strong link between the local population and the shoreline.

This project is located on the shores of Staten Island, near New York Bight. The area was hit by Hurricane Sandy in 2012 and is likely to be affected by other major climate events in the future. Although the project as proposed extends over a large area, the Tottenville beach site is the only one considered at the moment.

The creation of reefs using different types of concretes and rocks of varying dimensions will prevent bank erosion and dampen waves. By providing shelter and food, the reefs will be a boost to the local fauna and flora.

The project will enhance the waterfront area by creating different poles of interest for recreation, conservation, and research. These elements will be linked with local schools to raise residents' awareness about site enhancement and the importance of ecology.

Figure 14 – Map detail showing Staten Island's South shore. Source: Rebuild by Design, 2016

Figure 15 – Cross-section of manmade reefs. Source: Rebuild by Design, 2016

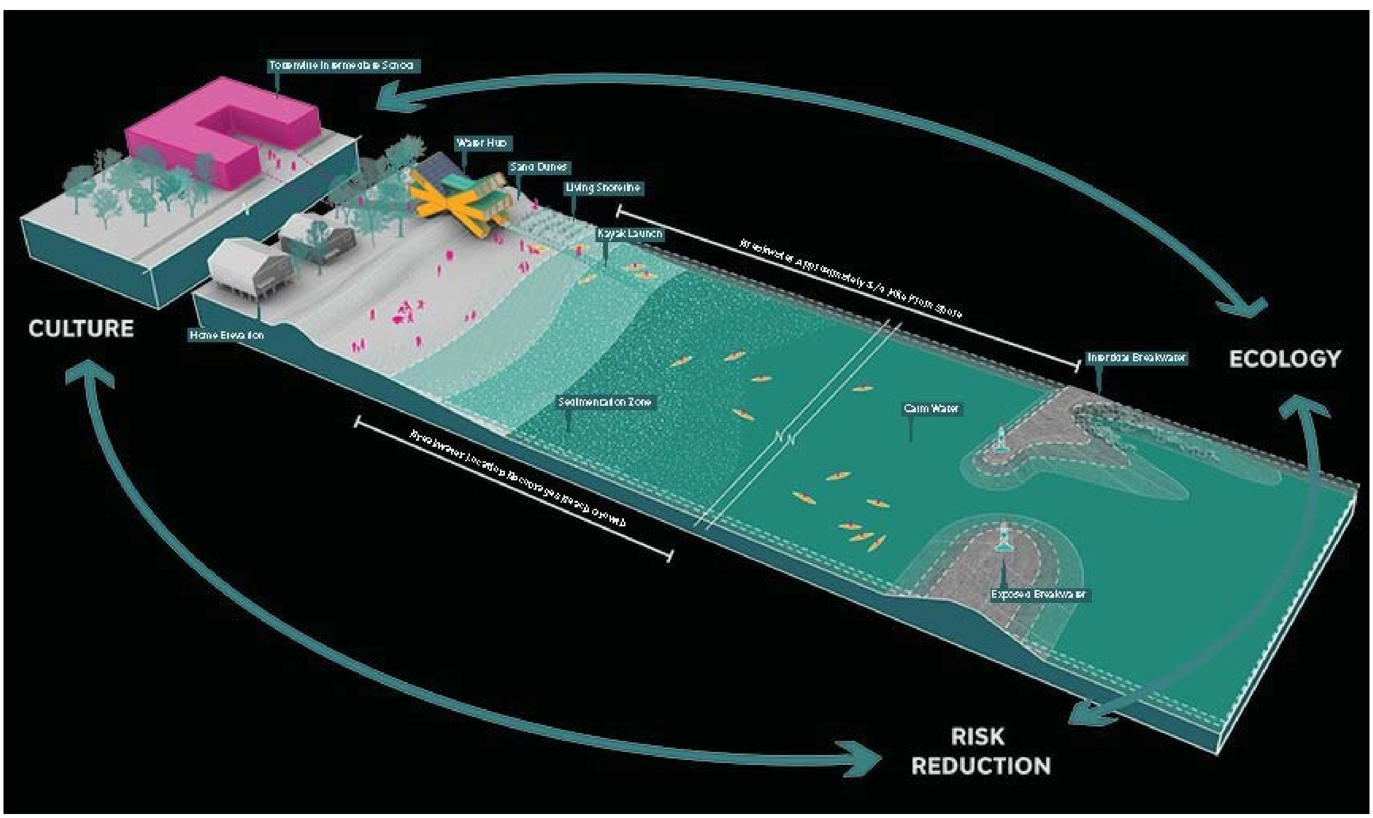


Figure 16 – Schematic view of the relationship between environmental risks, ecology, and culture. Source: Rebuild by Design, 2016

ECOLOGICAL

Name: Alumnae Valley

Use: Site rehabilitation
Type: Landscaping/habitat restoration/phytoremediation / water management /contaminated soil management/academic
Designer: Michael Van Valkenburgh Associates, Inc.
Client: Wellesley College
Years: 2001-2005
Cost: N/A
Location: Wellesley College, Massachusetts, USA
Surface area: 13.5 acres

Figure 17 – General layout. Source: MVVA Inc., N/A

HIGHLIGHTS

Located on the Wellesley College campus in Massachusetts, this project involves the rehabilitation of highly contaminated land formerly occupied by an industrial dump site, then by a parking lot. The concept restores the natural glacial topography of the site, the grassland typical of this valley, and native plant communities. Contaminated soils are managed through a complex system of plant processing units integrated into the landscape concept. The project also includes the restoration of wetlands and wildlife habitats. Experimental monitoring of the effectiveness of decontamination by plants is carried out by a team of scientists.

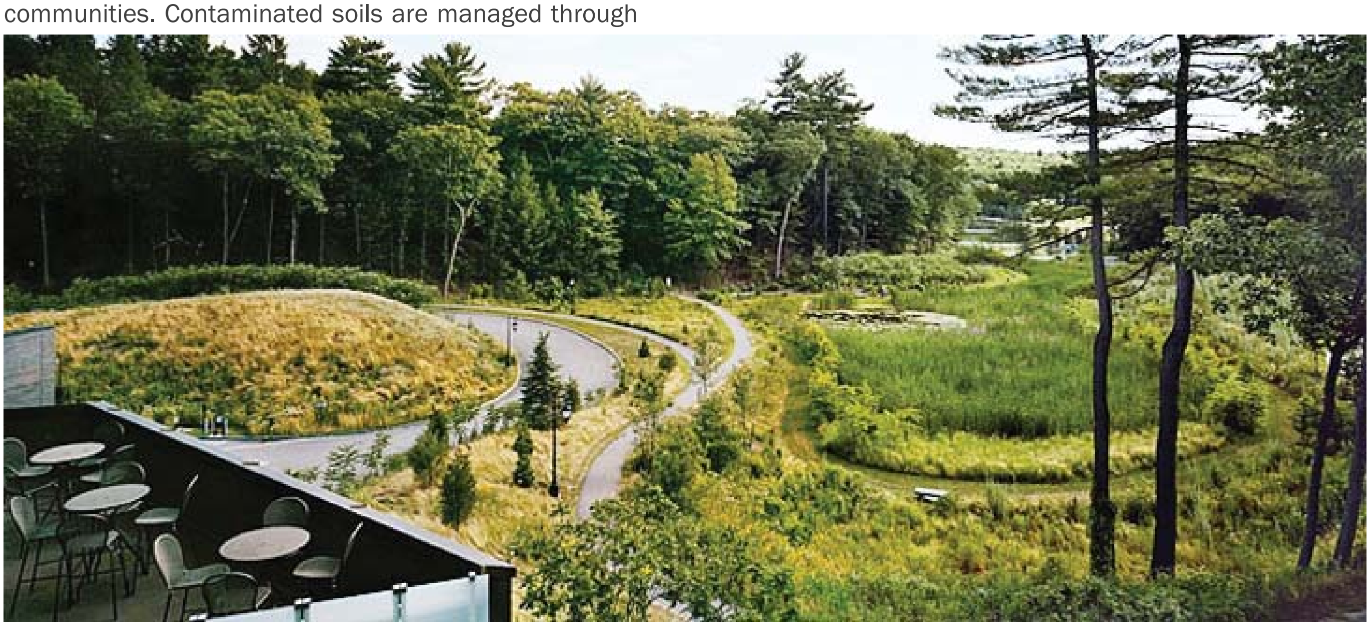


Figure 18 – View of the site from Alumnae Hall. Source: MVVA Inc., N/A

Figure 19 – Aerial view. Source: MVVA Inc., N/A

Figure 21 – Vegetable atmosphere. Source: MVVA Inc., N/A

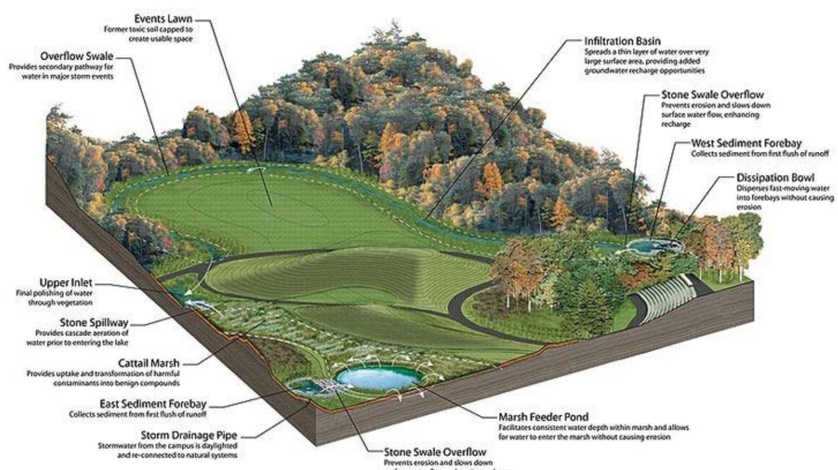


Figure 20 – Block diagram of the project. Source: MVVA Inc., N/A

ECOLOGICAL

Name: St-Patrick's Island

Use: Nature park
Type: Landscaping / habitat restoration and creation
Designer: Balmori associates, NIPPAYSAGE
Client: Calgary Municipal Land Corporation
Year: 2011 (competition)
Cost: $10M (estimated)
Location: St-Patrick's Island, Calgary, Canada
Surface area: 31 acres

Figure 22 – Conceptual rendering – nesting boxes. Source: Balmori associates, 2011

HIGHLIGHTS

Finalist proposal for the St-Patrick's Island redefinition design competition in Calgary. The concept primarily aims to attract and support wildlife on the island. To do so, the project includes a habitat assemblage comprising an ecological mosaic that allows local animals and plants to thrive. The proposal includes a diverse plant cover, improved topography, integrated aquatic ecosystems, and the incorporation of various types of features specifically designed to support a variety of species. Visitors are brought into contact with these ecosystem features via a network of interpretative itineraries through the various wildlife habitats on the island.

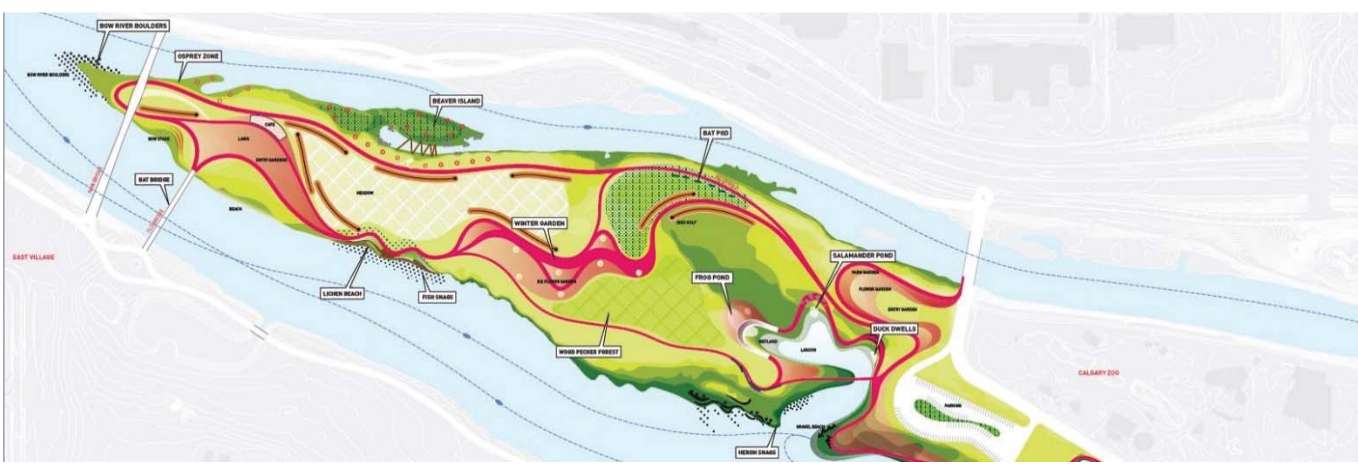


Figure 23 – General layout of the different wildlife habitats. Source: Balmori associates, 2011

Figure 24 – Conceptual rendering – falcon nesting platforms. Source: Balmori associates, 2011

Figure 25 – Types of relationships between trails and the environment. Source: Balmori associates, 2011

COMMEMORATIVE

Name: The Floating Memorial

Use: Commemoration
Type: Installation work
Designer: Soo Bum You and Bongjai Shin
Client: N/A
Year: 2012 (competition)
Cost: N/A
Location: Seattle, Washington, USA
Length: 2.3 km

Figure 26 – Competition plate. Source: Archdaily, 2012

HIGHLIGHTS

This project is one of the proposals developed as part of the ideas contest for the transformation of the former Highway 520 bridge into Seattle. This installation work is intended to celebrate the original pontoon-supported floating bridge. Its sculptural and moving design transforms this historical relic into a commemorative element that could leave a lasting imprint in collective memory. Its positioning parallel to the new bridge enhances its visibility and historical symbolism. From a functional standpoint, the installation serves as a breakwater structure to reduce wave intensity. The pontoon sections are anchored to the water bottom by cables.

ARTWORK

Figure 27 – Huru sculpture by artist Mark di Suvero. Source: The Bubbly Bay, N/A

Figure 28 – AcelorMittal Orbit by artist Anish Kappor. Source: Fubiz, 2015

Description of images:

93- Huru _ Mark di Suvero, 2013 / San Francisco, California, USA. Sculpture made of recovered steel I beams.

94- ArcelorMittal Orbit _ Anish Kapoor and Cecil Balmond, 2012 / Queen Elizabeth Olympic Park, London, Great Britain
115-m monumental lookout sculpture made of 60% recycled steel recovered from washers and used cars. Includes a long spiral slide.

95- Irene Hixon Whitney Bridge _ Siah Armajani, 1988 / Minneapolis Sculpture Garden, Minnesota, USA.
Bridge sculpture built over six traffic lanes allowing pedestrians to cross from one side to the other. Made of steel, wood, paint, and brass.

Figure 29 – Irene Hixon Whitney Bridge by artist Siah Armajani. Source: Raintaxi, N/A

Name: Bay Bridge old eastern span

Use: Artwork
Type: Management
Designer: N/A
Client: N/A
Year: Not implemented
Cost: N/A
Location: San Francisco, California, USA
Surface area: N/A

Figure 30 – Suggestion of materials re-use. Source: Baybridge house, 2016

HIGHLIGHTS

The Bay Bridge old eastern span deconstruction project in San Francisco focuses on the recovery of bridge materials.

The Bay Bridge Steel Program focuses on the re-use of infrastructure materials by incorporating them into public art projects. Only a small part of the steel from the bridge, 600 tons of steel, out of a total of 58,000, is made available to the artists, who must send an application to the Oakland Museum of California and submit their proposal to the management committee for evaluation.

Submitted projects have to meet the following criteria:

- Located within the State of California;
- Highlight the eastern span, the qualities or the history of the bridge in a creative way
- Use recovered steel elements;
- Demonstrate the feasibility of the project at multiple levels.

Because the dismantling of the bridge is currently under way, as is the tendering process, the success of this initiative is not known.

Figure 31 – View of the new and old bridges. Source: Forbes, 201

Appendix 5-6:
Cost estimates – Asset enhancement

CHAMPLAIN BRIDGE DEMOLITION

DEVELOPMENT OF ASSETS

November 30th 2016

Indicative Cost Estimate - SUMMARY

	OPTION 1 Network of cycle stops and windows on the river in relation to a development network of natural areas	OPTION 2 Historic and artistic trail (+option 1)	OPTION 3 Multifunctional docks and supports for aquatic activities (+options 1-2)	OPTION 4 Natural beach development (+ options 1-3)	OPTION 5 Development of an extreme sports site on high level (+options 1-4)	OPTION 6 Development of a multifunctional lookout (+option 1-5)
Protection measures and mobilization	[redacted]					
Mobilization, site organization and surveying, protection of the environment and the riparian environment						
Renaturalization of natural environments						
Dismantling of PJCCI mobilization areas equipments and retaining wall, management of contaminated soils, supply of topsoil and planting.						
Conservation and enhancement of existing natural environments						
Inventory and characterization of natural environments, protection plan for the conservation and development of natural environments, wildlife habitat, consolidation of banks						
Natural environment interpretation trail						
Trails in stone dust and wood decking, stairs, furniture, signage and interpretive signs, supports for nesting boxes						
Boat launching ramp for small non-motorized boats						
Access ramp in gravel or wood with a floating dock attached to the main dock						
Bike path (relocated)						
Asphalt coating, foundation, drainage, marking and lampposts						
Windows on the River (70 m² in each)						
Wooden visitors' caches, signature furniture, interpretation panels, stone dust access path, renaturalization of the surroundings, observation telescope						
Bike stops						
Stone dusting and / or prefabricated concrete pavers, signature furniture, signs, covered shelter, water supply						
Historical interpretive pannel						
Historical interpretation panels with support and anchoring on concrete base						
Artwork						
Works of art made from materials recovered from the bridge (1% of the total asset development budget)						
Visitors parking						
Asphalt coating with concrete curbs, lampposts powered by solar panels, automated payment system terminal, automated barrier, optimised stormwater management, naturalization of surroundings						
Artificial waves						
Modeling by hydraulic engineer, installation of concrete blocks recovered from the bridge on the River bed, development of a trail and a dock for access to the banks						
Multifunctional dock						
Modification of existing stack as main support, wood or concrete decking, additional structure and supports, under-docking riprap, lampposts, integrated furniture, railing						
Nature beach (seaway sector pnly)						
Remodeling of the ground to create a small bay protected from the current, natural pebble coating, signature furniture, service building						
Extreme sports site on high level (seaway sector only)						
Climbing: Climbing paths on the sides of the pile and an independent climbing block, high absorbency rubber coating at the base of the pile and the block Zip-line bungee and aerial courses development of a series of raised platforms, one of which is on the conserved pile, a zip-line system and aerial courses linking the platforms, a free fall system Service Building						
Multifunctional belvedere (seaway sector only)						
Maintenance, adaptation and reinforcement of the preserved span and pile of the dyke, additional supports, decontamination and repainting of the metalic structure, power supply and lighting fixtures, elevator and small reception building, emergency staircase, drinking water supply syster sanitary and storm drainage, mineral surface, intensive planting areas, service building (gallery, coffee, ect.), signature furniture, railing						
Total of Nuns' Island Area						
Total of Seaway dyke area						
Total of Brossard area						
Sub-total						
Design contingencies [redacted]						
TOTAL						

This estimate is for illustrative purposes only, the estimated costs represent an order of magnitude considering that several bidders will participate
It is based on functional requirements of the known use at the time of estimation, as well as available data on historical costs incurred for similar work.
No engineering calculations were made for this estimate.
The following costs are not included: engineering costs, professional fees, financing, construction contingencies.
Expected margin of [redacted]
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