James Bay Native Development Corporation

Hydraulic Study

Hydraulic study of the bridge located at the 125th kilometer of route du Nord in the municipality of Eeyou Istchee, James Bay.

Preliminairy Report

Prepared for:
James Bay Native Development Corporation

Prepared by:
Stantec Experts-conseils ltée

Decembre 22nd 2022

O/Réf. : 158100425

Sign-off sheet

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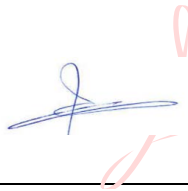

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RECORD OF REVISIONS AND ISSUES		
Revision N°	**Date**	**Description**
A	22 Decembre 2022	Preliminairy report

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1.0 INTRODUCTION

The James Bay Native Development Corporation mandated Stantec Expert-Conseil ltée to produce a hydraulic study of the bridge located at the 125th kilometer of route du Nord in the municipality of Eeyou Istchee, James Bay. The study will establish the requirements for the design of the future bridge if necessary. This investigation will define the flows and water levels for different return periods by modeling with GEOHEC-RAS software. Simulations for actual and future conditions will be carried out.

This report presents the evaluation of the river flow, model inputs and simulation results necessary for the bridge design.

2.0 INFORMATION GATHERING

2.1 PROJECT INPUTS

The data used in this study comes from the following sources:

- IGO2's website IGO2 - Données Québec (gouv.qc.ca)
- MELCC'S website MELCC (gouv.qc.ca)
- Forêt ouverte's website Forêt ouverte (gouv.qc.ca)
- MERN'S website MERN (gouv.qc.ca)
- Stantec's bridge and field survey done on 28th of august 2022. It is presented in appendix 2

2.2 FIELD SURVEY

There was no hydraulic field survey done for this report, consequently the information used comes from structural survey, land survey as well as the satellite pictures of Google earth, Bing maps and *Satellites.pro*. The following conclusions can be made.

The Opawica river, at the crossing of the bridge, is straight. No evidence of beaver dams nor scouring on the banks can be observed. Debris jams was observed during the survey. The banks are composed mainly of dense vegetation and trees further inland.

2.3 WATERSHED

2.3.1 Delimitation and average slope of the watershed

The limits of the watershed upstream of the bridge location, has been determined with ArcGIS software. The watershed of the Opawica River, upstream of the bridge location, covers 9798 km^2. A map of this watershed is at the appendix 1.

IGO2's website supports the hypothesis made for the direction of the flow when delimiting the watershed.

The Watershed have a second outlet as presented at the apprendix 1, approximatively 4.5 Km away from the bridge location.

2.3.2 Watershed surface occupancy

Google Earth Pro's aerial pictures show that the territory is mostly occupied by forest. Paved surfaces are negligeable.

2.4 FLOW ASSESSMENT

The peak flow of Opawica River was first assessed using regional, basin transfer, HP33 and HP40 methods since the area of the watersheds is greater than 25 km².

The peak flows selected for modelling are the average of methods HP40, HP33 and regional. For the transfer method, many acceptable watersheds were founded such as Broadback (hydrometric station 080809) and Turgeon (hydrometric station 080104), however, the results were too variable to detect a significant conclusion. Considering the watershed have two outlets, only a half of watershed's the peak flow was considered.

Table 1 presents the peak flow used for modelling.

A flow increases of 15% was added to consider climate change as recommended by the Ministry of Transportation (MTQ, Tome III, ch. 2, section 2.3.1,2022) for watersheds over 400 km² in zone C – North of Quebec region. These peak flows are summarized in Table 1 and the calculation details are in appendix 3.

Tableau 1 - Peak flows of the Opawica River – Area 9798 km²

RETURN PERIOD (Years)	Calculated PEAK FLOW (m³/s)	PEAK FLOW (Includes 15 % increase - m³/s)	PEAK FLOW Bridge 125 th Km (m³/s)
2	704.9	810.6	405.3
10	965.1	1109.9	555.0
20	1064.4	1224.0	612.0
25	1091.6	1255.4	627.7
50	1182.3	1359.6	679.8
100	1273.3	1464.3	732.2

2.4.1 Floods frequency analysis for Quebec (H.P. 33)

Analysis method H.P. 33 uses the data from 76 hydrometric stations across 12 Quebec regions to determine the daily and instant flow rates of watersheds in these regions.

This method is limited to certain Quebec regions and, for each of them, the area of the watershed has to be inside the recommended limits. In the present case, the studied watershed is in a region covered by the method.

2.4.2 Estimation of daily flow of fall floods from meridional Quebec River method (H.P.40)

H.P. 40 method is another statistical method, similar to H.P. 33 previously described. H.P. 40's method is an analysis carried out from 81 hydrometric stations divided in 6 Quebec regions.

H.P. 40' method considers a more detailed application zone compared to H.P. 33's method since it compares the length of the waterway, the slope of the watershed, the importance of the forest cover, the surface of the lakes and the marsh, the altitude, and annual precipitations in addition to the area of the watersheds used for H.P. 33.

The studied watershed is located in Region 6.

2.4.3 Comparison by watershed transfer

This method statistically analyse the maximal flows registered at a hydrometric station of Quebec gage station network. The data from the gage station are used to determine a recurrence-flow relation.

An inventory of the existing hydrometric stations in the hydrographic region studied was conducted. The stations presenting a natural or lightly influenced flow regime and sufficient hydrometric data were retained. Other parameters were considered, including the topography, the watershed elevation, the precipitation intensity and more, to select the rivers that best match the studied site.

It is important to note the recommended boundaries of this method: a watershed area ration between 0.5 and 2.0. This is respected for all selected stations.

2.4.4 Regional method

The regional method is a statistical method that uses a methematical equation based on the region (the province of Quebec is divided in three (3) regions). The necessary informations to obtain the floods flow are, the watershed area and the region of the watershed.

In the present case, the studied watershed is located in region III. This method comes from ANCTIL, François, Nicolas MARTEL et Van Diem HOANG (1998). « Analyse régionale des crues journalières de la province de Québec », Revue canadienne de génie civil, vol. 25, n° 2, p. 360-369.

3.0 HYDRAULIC ANALYSIS

3.1 DESIGN CRITERIA

According to the MTQ, hydraulic criteria to be consider when modeling a bridge are the clearance of the structure above water surface, the increase of the water level compared to natural flow conditions, flow velocity as well as the flow surface width.

The table 2 presents the requirements related to each criteria as well as their applicability to this specific study.

Conception criteria are based on the 50 year flood.

Tableau 2 - Hydraulic conception criterias of a bridge

Criteria	Requirements	Applicability
CAN/CSA S6-19 (art. 1.9.7.1)	Soffit located at least 300 mm above conception high watermark.	☑
MTQ – Tome III		
Presence of ice jams or debris (Without tide)	Clearance under the bridge: 1 m above expected extreme ice or debris level.	.
Without tide and without jams	Clearance under the bridge: 1 m above conception high watermark (except low traffic road).	.
	Clearance under the bridge: 300 mm above centennial high watermark.	☑
Without tide and without jams (low traffic road)	Clearance under the bridge for a low traffic road: 300 mm above conception high watermark.	.
Tides with ice jams or debris	1 m above expected extreme ice or debris level.	.
Navigable waterway for small embarkations	Soffit located at 1.5 m above high watermark	☑
Road profile elevation	The elevation of the road profile is fixed as anticipating a security margin sufficient above the conception high watermark (E.H.C). The minimal clearance is 1000mm for highways and national roads, and 600mm for other roads.	☑

Free opening (Tome III, Chapter2, page22)	The high watermarks of a return period of 2 years correspond to the yearly water level average.	☑
	The minimal free opening between a bridge abutment has to approach the top width measured at the yearly high watermark.	☑
Fishing and Oceans Canada	Conservation of natural flow conditions by maintaining the physical characteristics of the existing watercourse; the substrat, slope and width.	☑
Maximum flow velocity	It is recommended to limit the increase of the flow speeds compared to natural conditions. The protections usually support velocities inferior to 3,4 m/s for the 100-year flood.	☑

3.2 HYDROLOGY ANALYSE

Neither bathymetry data nor Lidar was available for the bridge 125th km, which make the simulation of the water flow regime not conclusive. River's slope and depth channel information are required to go further on the study.

The figure 1 represent the hydrographic network on the bridge 125th km area consulted from MERN'S website.

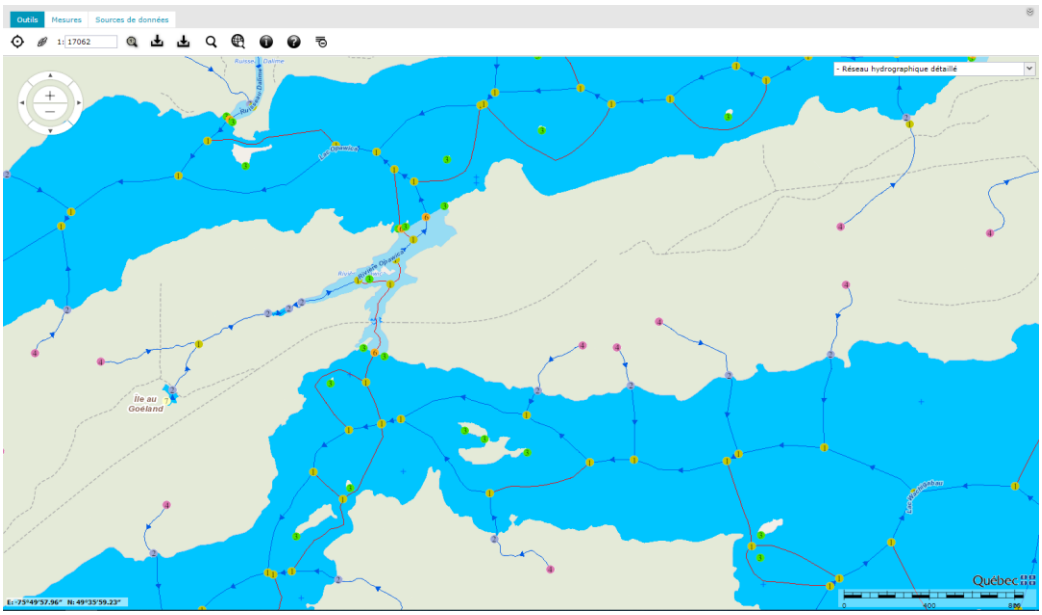

Figure 1 : Hydrographic network on the field study (MERN'S website)

The hydrographic network shows that the Opawica river, at the crossing of the bridge125th km, is an intermittent stream (sixth order) from wachigabau lake. The crossing under the bridge act as a weir, the flow depends more on the water head between to two lakes then the hydrology of the watershed. Which means that the peak flows can not be calculed with the usual methodology.

In this context we were not able to establish the flows under the bridge, a flow measurement survey should be conduct if further hydraulic analysis is considered necessary.

3.3 HYDRAULIC ANALYSE

Without bathymetric survey under the bridge and the particular hydraulic conditions, it was not possible to elaborate hypothesis that would give realistic results. Therefore no hydraulic modelisation was carried out. Only a brief calculation of the hydraulic capacity under the bridge was done. This capacity was estimated à 35 m³/s.

The table 4 present the characterictic of the actuel structure under study.

Tableau 3 - Characteristic of the actual structure

Characteristic	Actual bridge
Type of structure	Reinforced concrete and steel
Bias relative to the stream (degree)	0
Total width of opening (m)	43.5
Height of the structure (m)	1.56
Geodesic elevation of the road (m)	305.50
Geodesic elevation of the soffit upstream (m)	303.13
Geodesic elevation of the soffit downstream (m)	303.03
Apron elevation upstream (m)	305.35
Apron elevation downstream (m)	305.35

4.0 CONCLUSION

The present hydraulic study aims to analyze the impact of the existing bridge at kilometer 125 of *route du nord* crossing *Opawica's river*. Unfortunately, without bathymetric data and particular hydraulic conditions we were not able to establish the flows under the bridge, nor the hydraulic conditions to expect.

To be able to carry out an hydraulic modelisation additional surveys are necessary like flow measurement and complete bathymetry under the bridge.

5.0 BIBLIOGRAPHICAL REFERENCES

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MISTÈRE DES FORÊTS; SERVICE DES INVENTAIRES FORESTIERS. https://mffp.gouv.qc.ca/les-forets/inventaire-ecoforestier/

MISTÈRE DES FORÊTS; SERVICE DES INVENTAIRES FORESTIERS. (2000). Carte de dépôts de surface-Document de travail : Lac des Montagnes Municipalité de la Baie-James, Québec 32O/12. https://diffusion.mffp.gouv.qc.ca/Diffusion/DonneeGratuite/Foret/DONNEES_FOR_ECO_SUD/Depots_surface/32O/

MINISTÈRE DE L'ENVIRONNEMENT ET DE LA LUTTE CONTRE LES CHANGEMENTS CLIMATIQUES. (2020). Débits de crue aux stations hydrométriques du Québec (Débits moyens journaliers). https://www.cehq.gouv.qc.ca/debits-crues/index.htm

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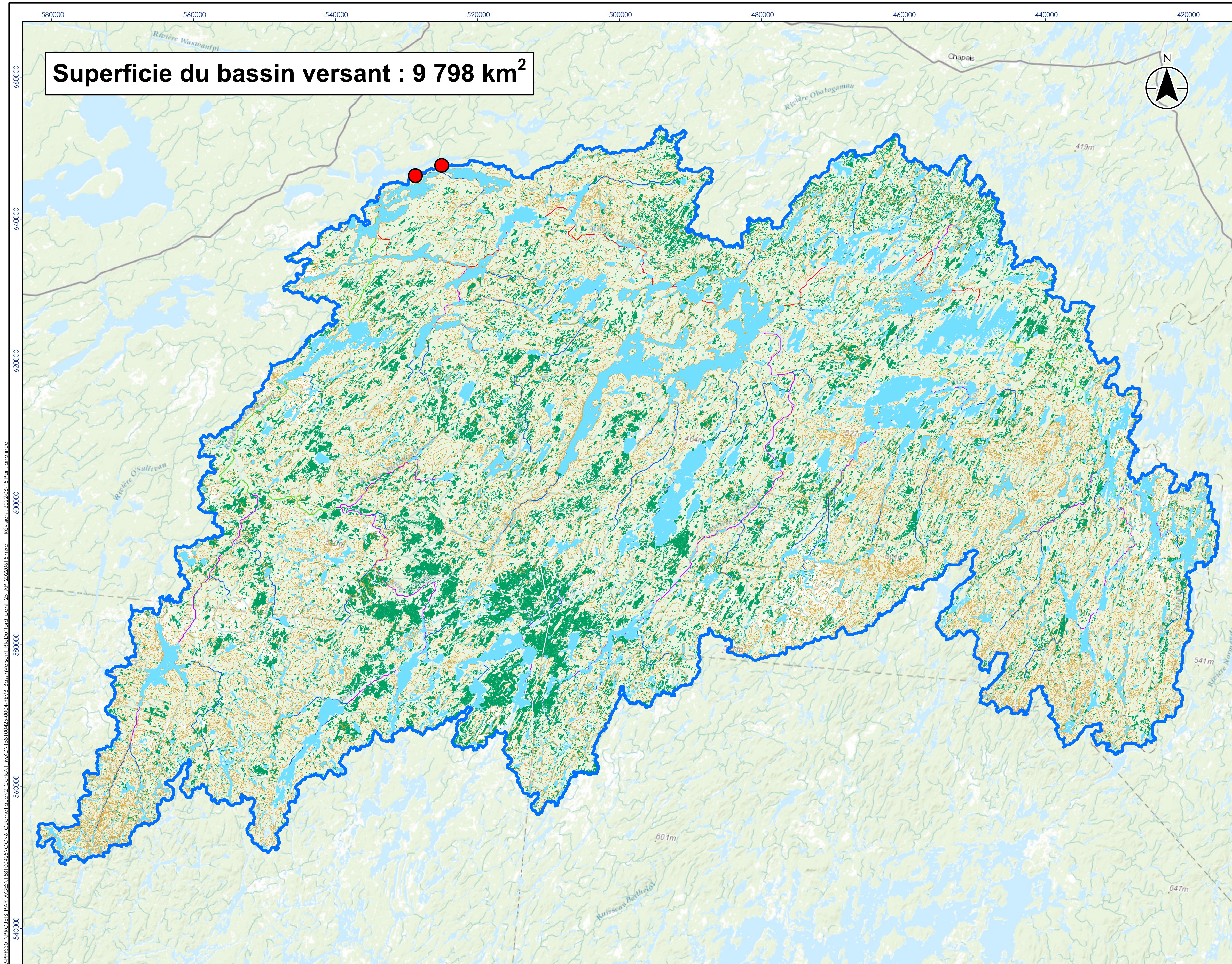
APPENDIX 1

Waster shed boundary



Stantec

- Exutoires du bassin versant
- Route du Nord
- Courbes de niveau (20 m)
- Bassin versant
- Lacs
- Milieux humides

Cours d'eau (Strahler)

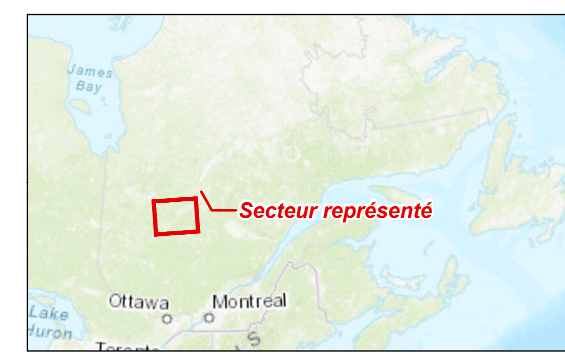
- 5
- 6
- 7
- 8

0 10,000 20,000 mètres

1:550,000
(Au format original 11x17)

Sources

(1) Données d'élévation : MFFP, 2022
(2) Lacs : RNH - Canada, 2020
(3) Bassin versant : Stantec, 2022
(4) Fond de carte : ESRI, 2022
(5) Milieux humides : IEQM, 2021
(6) Système de coordonnées : NAD 1983 Québec Lambert



Localisation du projet
Baie-James, Québec

158100425-0004 REV0
Préparé par A. Prince le 2022-06-15
Vérifié par P. Charette le 2022-06-15

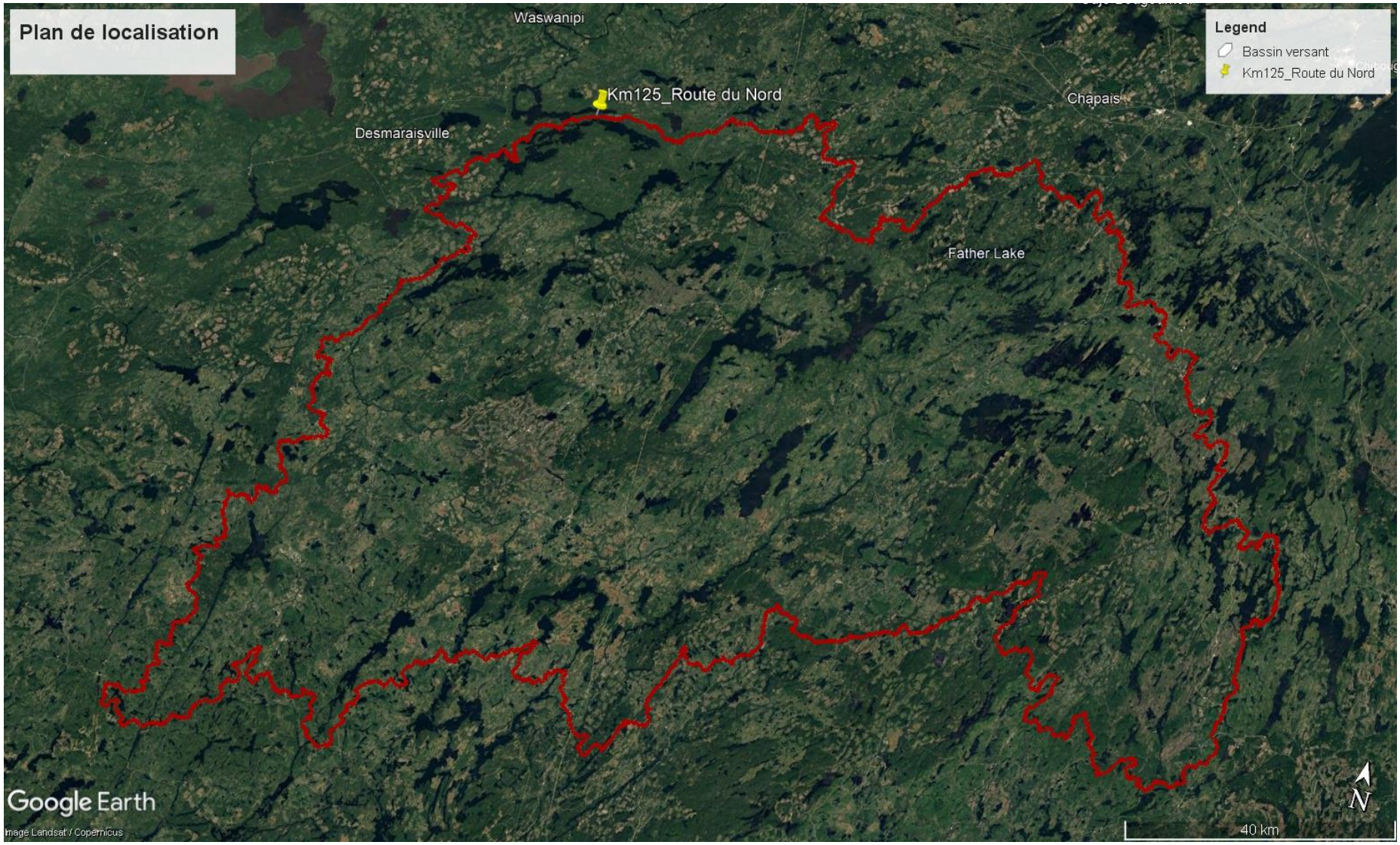
Client/Projet
La Grande Alliance - Feasibility Study
Phase 1

Carte No.
4

CARTE DE TRAVAIL

Titre
Bassin versant - Route du Nord - pont125

CARTE DE TRAVAIL


Plan de localisation
Waswanipi
Km125_Route du Nord
Chapais
Desmaraisville
Father Lake
Legend
Bassin versant
Km125_Route du Nord
Google Earth
Image Landsat / Copernicus
N
40 km

APPENDIX 2

Pictures of the studied site and field survey forms

No.

Date. Page

No. Relevé structure 2022

Date. 2022-08-08 Page

Relevé Rivière Opawica

2022-08-08

Francis Mathon, Arpenteur
Jacinthe Daoust, biologiste
Alexander Christiano, biologiste

GPS R12i, récepteur
GPS R8, base
Station totale 1203+

Température : 15°c

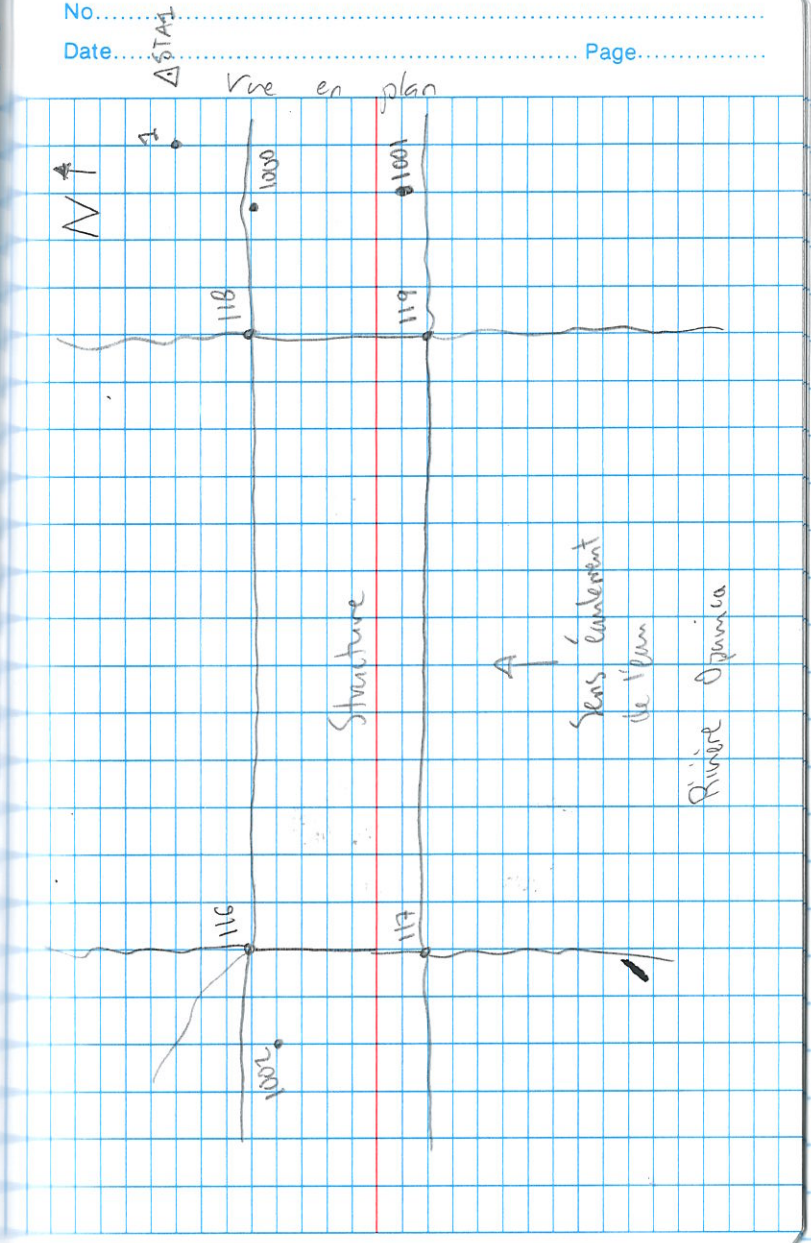
No.....

Date..... Page.....

# point	Commentaires
Transect # 6	Manque TAH et LHE (rive droite)
Transect #11	rive droite, manque TAH, pente très escarpé et présence de roches
Transect #12	inaccessible, roche et pente trop escarpé (rive droite)
Transect #13	TAH inaccessible. (rive droite)
Transect #14	idem (rive droite).
Transect #12	TAB pas de signal, végétation dense.
1	Clou (repère permanent).
1000 à 1002	Clou (repère permanent).
STA1	Base pour GPS
145, 152, 179 et 182	Intersection calée avec pantre.
A	Station datée, utilisé pour 2 points de transects.

No.....

Date..... Page.....



No.....

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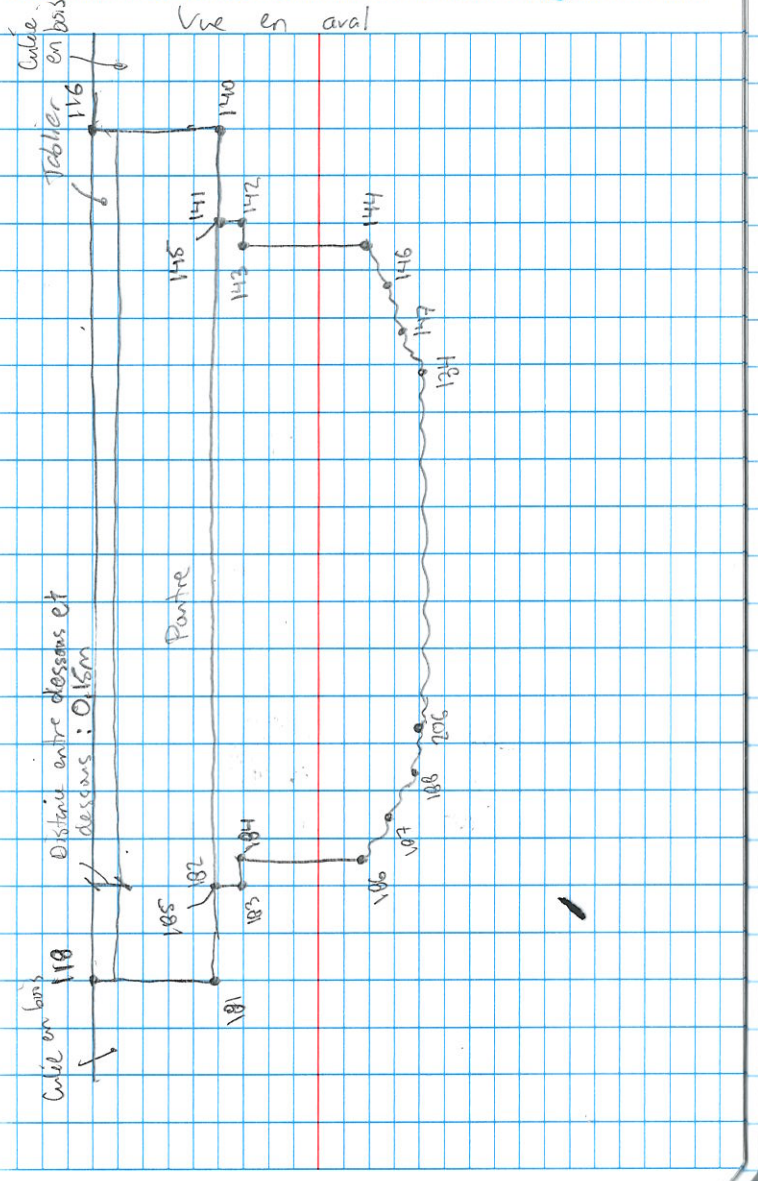

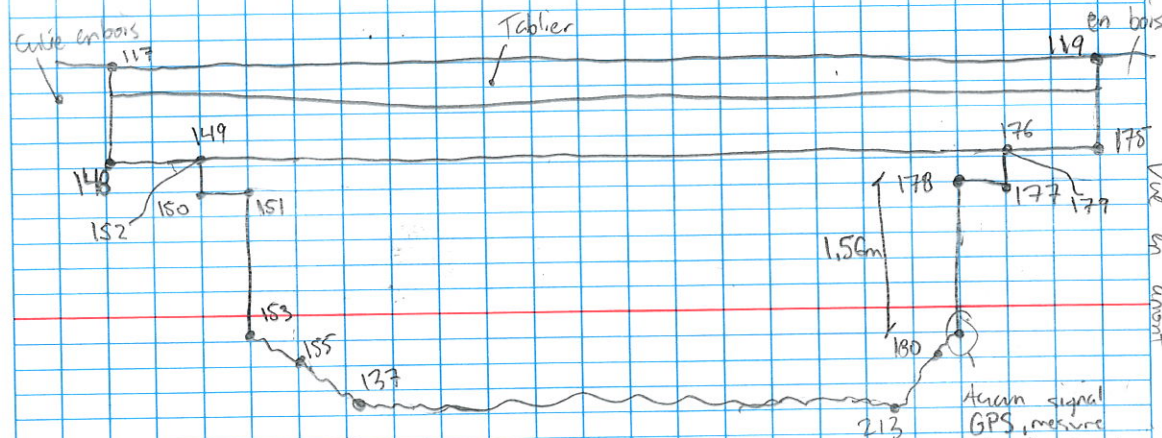
Culée en bois
117
Tablier
Culée en bois
119
149
176
175
148
150
178
177
179
152
151
1,56m
153
180
155
137
213
Accrom signal GPS, mesure ruban à mesurer
Vue en amont

APPENDIX 3

Flow calculation

Dossier : Projet : 158100425
N.Réf. : 158100425

Estimation des débits journaliers de crue printanière des rivières du Québec méridional (H.P.-40)

La méthode de transfert des sonnées est tirée de l'annexe HYD du Guide de préparation des projets routiers du MTQ. L'équation tirée de la section 2.3.2 de la page 1.9 est la suivante :

$$Q_1 = 0{,}3048^3 e^K \left(\frac{A}{2{,}59}\right)^a \qquad \text{(éq. 4b)}$$

où : Q_1 : débit journalier annuel – 1 jour (m³/s)

e : constante népérienne (2,718)

A : superficie du bassin versant (km²)

K, a : constantes régionales données au tableau 3

Tableau 3 – Coefficients et intervalles de récurrence pour la méthode H.P.-40

Région	K	a	Intervalle de récurrence (ans)						
			2,33	5	10	20	25	50	100
I	3,48	0,90	1,07	1,33	1,51	1,68	1,73	1,90	2,06
II	3,18	0,95	1,08	1,33	1,50	1,63	1,68	1,82	1,94
III	3,77	0,76	1,05	1,30	1,49	1,67	1,73	1,90	2,07
IV	3,60	0,92	1,05	1,32	1,54	1,76	1,83	2,05	2,29
V	4,01	0,81	1,05	1,27	1,42	1,57	1,62	1,76	1,91
VI	1,85	0,99	1,03	1,22	1,36	1,50	1,54	1,66	1,80

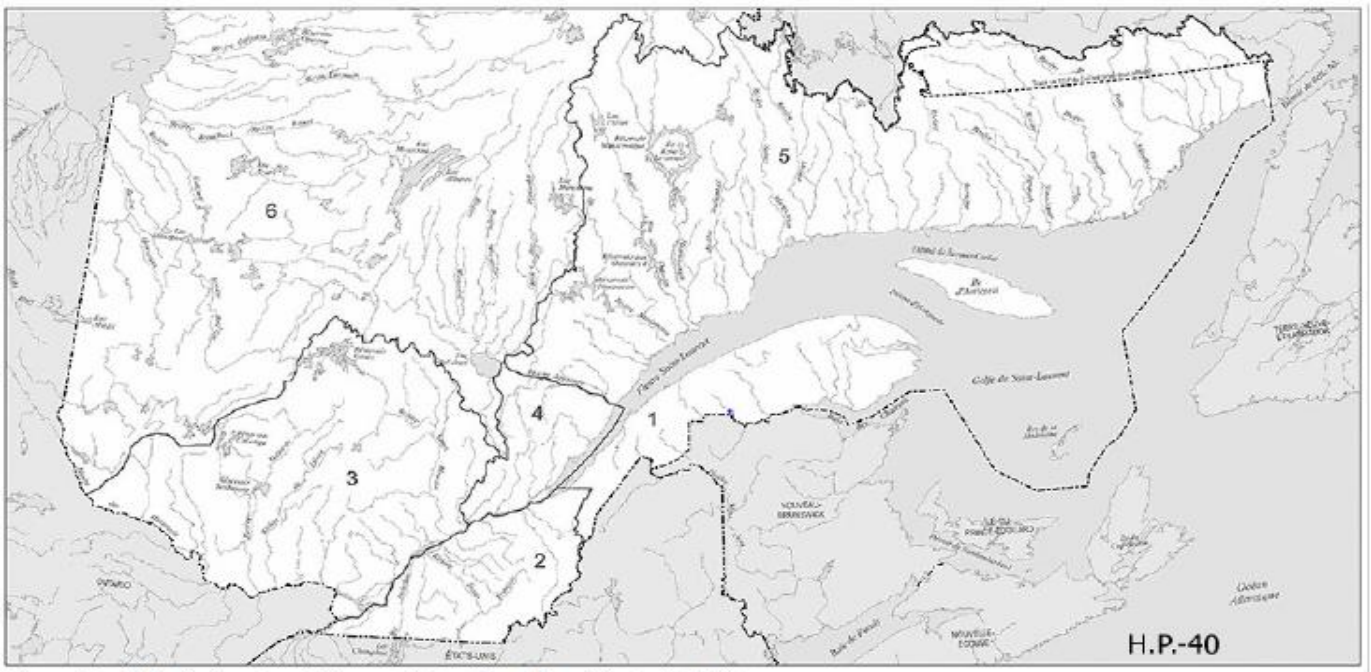

Figure 2 – Délimitation des régions où s'applique la méthode H.P.-40

Basssin versant de la Rivière Opawica

A =	9798	km²	**Q (1 jour) =**	**627,286 m³/s**
K =	1,85			
a =	0,99			

Calcul du débit pour différentes récurrences

Récurrence	Constante	Q journalier	Q instantanné
-	Région 6	m³/s	m³/s
2,33	1,03	646,105	542,454
5	1,22	765,289	642,518
10	1,36	853,109	716,250
20	1,5	940,929	789,981
25	1,54	966,021	811,047
50	1,66	1041,295	874,246
100	1,8	1129,115	947,977

Limites de la méthode HP-40

Tableau 4 – Limites de la méthode H.P.-40

Caractéristique	Limite inférieure	Limite supérieure
Superficie (km²)	150,7	56 980
Pente (%)	0,02	0,95
Longueur (km)	18,5	482,8
Couvert forestier (%)	18	100
Lac et marécage (%)	Trace	36
Élévation (m)	73,2	725,4
Précipitation annuelle (mm)	711,2	1 422,4

Bassin versant à l'étude :

			Conforme
Superficie	km²	9798,00	VRAI
Pente moy.	%		FAUX
Longueur	km		FAUX
Couvert forestier	%		FAUX
Lacs et marécage	%		FAUX
Élévation	m		
Précipitations annuelles	mm		FAUX

Dossier : Projet : 158100425
N.Réf. : 158100425

MÉTHODE DE TRANSFERT DE DONNÉES

La méthode de transfert des sonnées est tirée de l'annexe HYD du Guide de préparation des projets routiers du MTQ. L'équation tirée de la section 2.2.3 de la page 1.5 est la suivante :

$$Q_{Tu} = Q_{Tj}\left(\frac{A_u}{A_j}\right)^n \qquad \text{(éq. 1)}$$

où :
- Q_{Tu} : débit au site non jaugé
- Q_{Tj} : débit au site jaugé
- A_u : superficie du bassin versant au site non jaugé
- A_j : superficie du bassin versant au non jaugé
- n : exposant régional

Selon la section 5.2.6 du document Hydrologie des crues au Canada - Guide de planification et de conception, la valeur de n varie entre 0,6 et 0,9. Il est préférable d'utiliser 0,8 pour des estimations préliminaire. Selon Hoang (1977), il est recommandé d'utiliser 0,9 pour les cours d'eau du Québec.

Cette méthode est valide lorsque le rapport des superficies des bassins versants varie de 0,5 à 2,0.

Au = 9798 km² Bassin rivière Opawica
Région hydrographique : Baies de Hannah et de Rupert
Élévation station météo la plus près :
Limite inférieure: 4899
Limite supérieure: 19596
Données de crues disponible pour différents cours d'eau au Québec sur le site du MDDELCC :
https://www.cehq.gouv.qc.ca/Crue_Etiage-Apps/index.html

Station :	**81002**
St. fédérale	**---**
Nom :	**De Rupert**
Bassin :	40900,0 km²
Q2 :	1326,0 m³/s
Q10 :	1621,0 m³/s
Q20 :	1721,0 m³/s
Q25 :	1751,0 m³/s
Q50 :	1842,0 m³/s
Q100 :	1929,0 m³/s
Période :	1; 1982-2006

Région hydrographique : Baies de Hannah et de Ru
Régime d'écoulement : Naturel
Distance station météo la + près :
Élévation station météo la + près :
Élévation approx. de 81002 :

Exemple :			Récurrence	Débit (m³/s)
T :	25	ans	2	366,5
QTu :	483,9	m³/s	10	448,0
QTj :	1751,0	m³/s	20	475,6
Au :	9798	km²	25	483,9
Aj :	40900,0	km²	50	509,1
n :	0,9		100	533,1
Au/Aj :	0,2396	**NON APPLICABLE !**		

Station :	**81007**
St. fédérale	**---**
Nom :	**De Rupert**
Bassin :	18100,0 km²

Région hydrographique : Baies de Hannah et de Ru
Régime d'écoulement : Naturel
Distance station météo la + près :
Élévation station météo la + près :

Stantec **La Grande Alliance - Pont km125**

Dossier : Projet : 158100425
N.Réf. : 158100425

MÉTHODE DE TRANSFERT DE DONNÉES

Q2 :	660,0 m³/s
Q10 :	815,0 m³/s
Q20 :	865,0 m³/s
Q25 :	880,0 m³/s
Q50 :	925,0 m³/s
Q100 :	968,0 m³/s
Période :	1970-1992

Élévation approx. de 81007 :

Exemple :			Récurrence	Débit (m³/s)
T :	25	ans	2	379,9
QTu :	506,5	m³/s	10	469,1
QTj :	880	m³/s	20	497,9
Au :	9798	km²	25	506,5
Aj :	18100,0	km²	50	532,4
n :	0,9		100	557,2
Au/Aj :	0,5413	**OK**		

Station :	**81006**
St. fédérale	**---**
Nom :	**Témiscamie**
Bassin :	7280,0 km²
Q2 :	660,0 m³/s
Q10 :	815,0 m³/s
Q20 :	865,0 m³/s
Q25 :	880,0 m³/s
Q50 :	925,0 m³/s
Q100 :	968,0 m³/s
Période :	1970-1992

Région hydrographique : Baies de Hannah et de Ru
Régime d'écoulement : Naturel
Élévation approx. de la station :

Exemple :			Récurrence	Débit (m³/s)
T :	25	ans	2	862,3
QTu :	1149,7	m³/s	10	1064,8
QTj :	880	m³/s	20	1130,1
Au :	9798	km²	25	1149,7
Aj :	7280,0	km²	50	1208,5
n :	0,9		100	1264,7
Au/Aj :	1,3459	**OK**		

Station :	**81101**
St. fédérale	**---**
Nom :	**Pontax**
Bassin :	5970,0 km²
Q2 :	594,0 m³/s
Q10 :	911,0 m³/s
Q20 :	1028,0 m³/s
Q25 :	1065,0 m³/s
Q50 :	1178,0 m³/s
Q100 :	1290,0 m³/s
Période :	1976-2018, sans 1997,

Région hydrographique : Baies de Hannah et de Ru
Régime d'écoulement : Naturel
Distance station météo la + près :
Élévation station météo la + près :
Élévation approx. de 081101 :

Exemple :			Récurrence	Débit (m³/s)
T :	25	ans	2	927,8
QTu :	1663,4	m³/s	10	1422,9
QTj :	1065,0	m³/s	20	1605,6
Au :	9798	km²	25	1663,4
Aj :	5970,0	km²	50	1839,9
n :	0,9		100	2014,8
Au/Aj :	1,6412	**OK**		

ANALYSE PAR LA MÉTHODE RÉGIONALE

Tableau des paramètres

Région	epsilon	alpha	kapa
I	0,8397	0,2819	0,0086
II	0,8659	0,2754	0,0993
III	0,891	0,2308	0,1173

Calcul Qmoyen

Superficie	9798	km²
Qmoyen =	1001,43	m³/s

Équation 8.6 $Q = Qr / Qmoyen$

Équation 8.7

Équation 8.8 $Qmoyen = 1{,}61\ A^{0,7}$

RÉCURRENCES	Calcul Q normalisé				Calcul Qr du site				m³/s/km²
	I	II	III		I	II	III		I
2	0,94285733	0,965022941	0,973798592		944,21	966,41	975,19		0,10
5	1,259817607	1,249692423	1,20844185		1261,62	1251,48	1210,17		0,13
10	1,467979345	1,421288056	1,347488069		1470,08	1423,33	1349,42		0,15
20	1,666394679	1,57429655	1,469842192		1668,78	1576,55	1471,95		0,17
25	1,729078487	1,620592048	1,506545305		1731,56	1622,92	1508,70		0,18
50	1,921405782	1,756784105	1,613624547		1924,16	1759,30	1615,94		0,20
100	2,111165831	1,882882392	1,711524787		2114,19	1885,58	1713,98		0,22

Note: La rivière Bleue est située dans la zone I

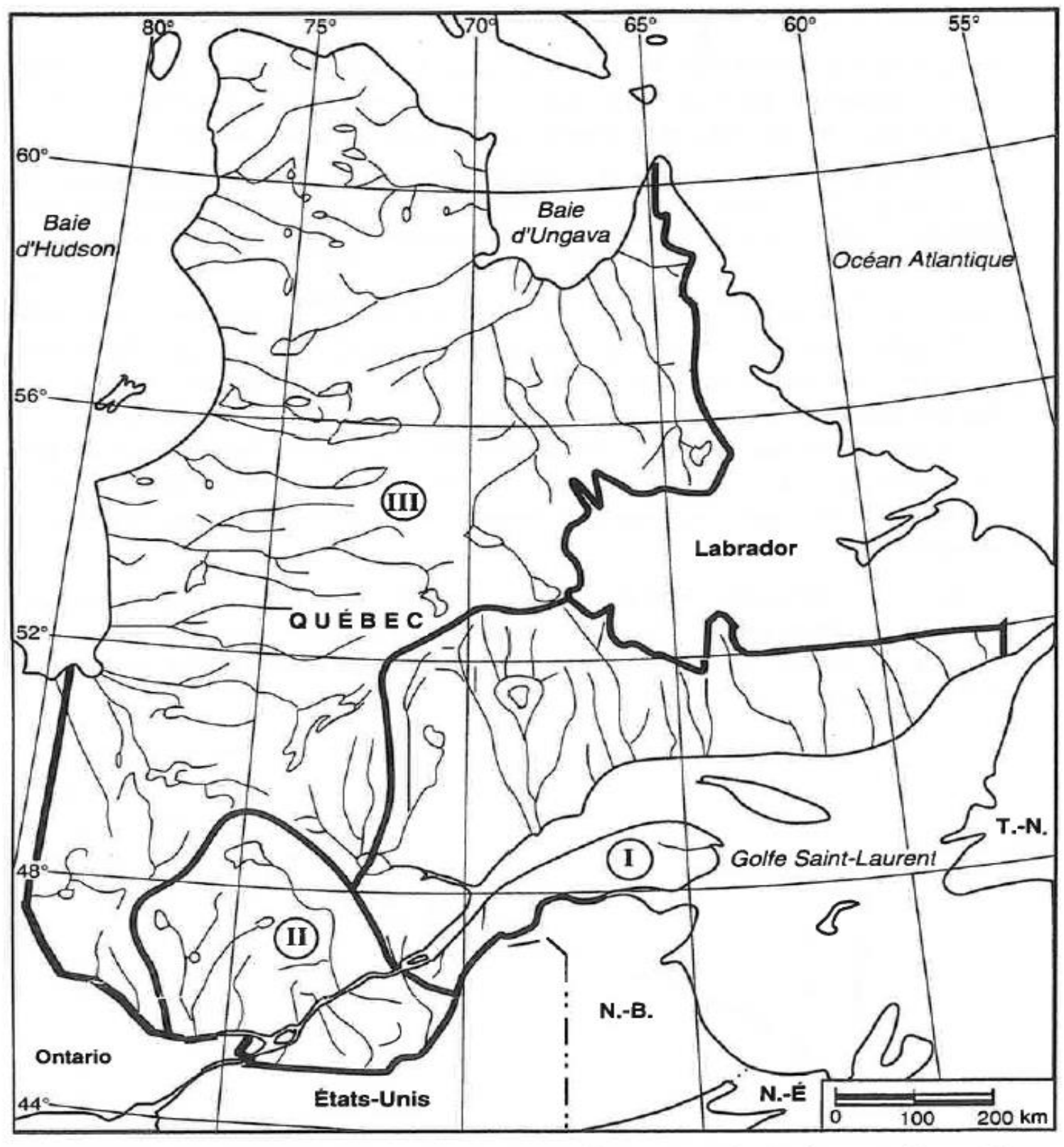

FIGURE 8.3 - Localisation des régions homogènes pour le Québec et des stations de jaugeages retenues et éliminées (Anctil *et al.*, 1998)

Stantec

Identification du projet

Date : 2022-12-21

Client : Société de développement autochtone de la Baie-James (SODAB) — Réf. Client :

Projet : **La Grande Alliance - Feasibility Study Phase 1** — N./Réf.: **158100425**

Route : Route du nord — Chaînage : km125 — Municipalité : Gouvernement régional d'Eeyou Istchee Baie-James

N° bassin versant : 1 — Cours d'eau : **Rivière Opawica** — Analyste : -

$$Q_{2,33} = 0{,}3048^{3} K_2 \left(\frac{A}{2{,}59}\right)^{K_1}$$

1

km125

Hydrologie_ selon la méthode HP33

Carte ou plan de référence : Carte des BV (LiDAR) — Échelle : 1 : 10000 — Méthode de calcul du BV : CDAO

Superficie totale du bassin (A) : **979 800,00** **ha** — Mesurée par : — Catégorie de bassin : **Grand bassin**

Choix de la région

Selon la figure 1 du Guide de préparation des projets routiers (annexe Hydraulique) — Choix de la région : **M**

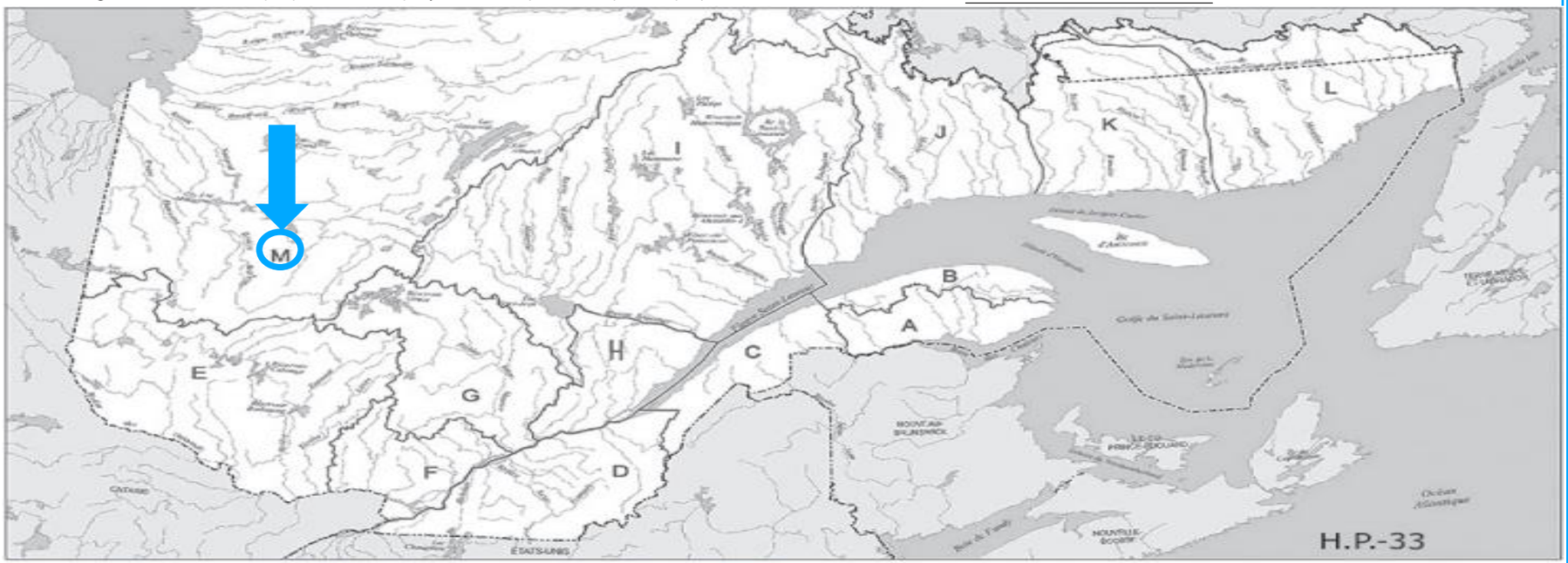

Figure 1 – Délimitation des régions où s'applique la méthode H.P.-33

Coefficient K_2 : **18,1** — Coefficient k_1 : **0,857** — (ha): 99 710 — Limite BV sup.. (A_2) : 5 749 770

(Version 2)

Détermination des débits

Débit moy. annuel ($Q_{2,33}$) : **596,940** **m³/s**

Récurrence (ans)	Débit (m^3/s)
2	596,940
5	722,297
10	829,746
20	931,226
25	955,103
50	1056,583
100	1158,063

Débit de conception

50 ans

1056,583 **m³/s**

Notes