Environmental flow determination in southern Quebec (Canada): actual and future hydrologic and climatic context

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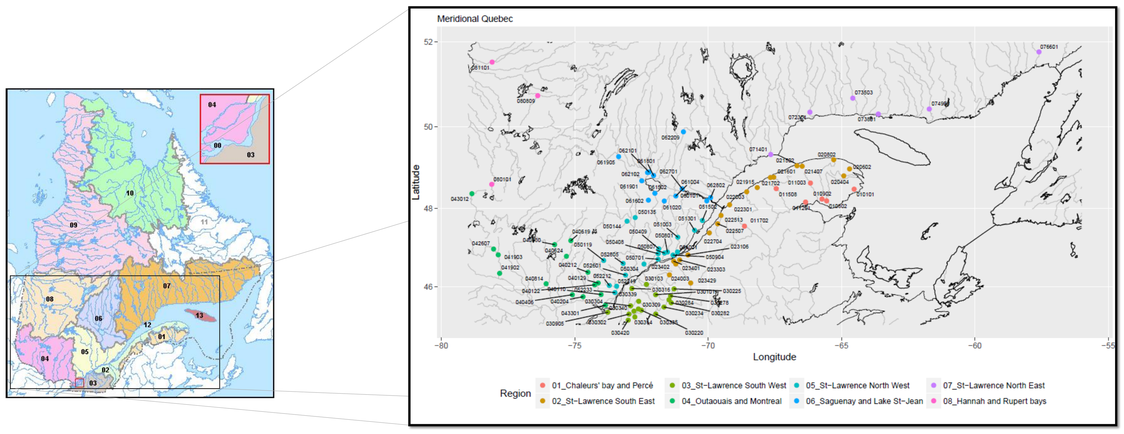
Abstract
Faced with increasing demands for surface water and groundwater withdrawals, the Quebec Ministry of Sustainable Development and the Fight against Climate Change (MDDELCC) is questioning its policy which is currently advocating the use of 7Q2, as the environmental flow (e-flow) of 7 consecutive days and an occurrence of 2 years, in the rivers. Indeed, the use of 7Q2 and its impact is not documented and some members of the scientific community suspect that it does not ensure the protection of lotic ecosystems. Studies and reviews of methods for assessing environmental low flows in Canada have been completed but validation studies are scarce.
Therefore, the MDDELCC commissioned the INRS to evaluate the relevance of the 7Q2 indicator, define and test the most appropriate method for assessing environmental flows in southern Quebec.

LEGISLATIVE CONTEXT

- Great Lakes St. Lawrence River Basin Sustainable Water Resources Agreement (2005) : the Quebec government has to ensure the protection of water resources (*art.31.76 of LQE, MDDELCC*):
  - *Sustainable, equitable and efficient management;*
  - *Precautionary principle;*
  - *Take into account the effects of climate change*.
- « Guide de conception des installations de production d'eau potable » (Vol.1, MDDELCC, 2015)*:*
  - *During periods of low water, we must consider the low flow over seven consecutive days with a period of recurrence of two years (7Q2).*
- Act respecting the conservation and development of wildlife (2015, Ministry of Forests, Wildlife and Parks (MFFP):
  - Use of the « *ecological flowrate* » : *minimum flow necessary to maintain fish habitats; quantity and acceptable quality of habitats and free movement of fish*;
  - Use of a *standard limiting withdrawals for mining, gas and oil exploration activities and brine and underground reservoir explorations in fish habitat to a maximum of 15% of stream flow during periods of low flow*.

HYDROLOGICAL CONTEXT

There are 8 hydrographic regions in the Southern Quebec, from 01 to 08 (Fig.1):



Source : Centre d'expertise hydrique du Québec

Figure 1: Hydrometric stations retained for the e-flow assessment in southern Quebec

In total, the MDDELCC has a data base (historical and actual) of 749 geo-referenced hydrometrics stations, both flow (519) and water level (230) measurements. River flows are natural or can have different influences (computed daily or monthly) due to the hydraulic structures upstream, hydroelectric dam, water retention…, and water withdrawal for agriculture, municipalities and industries.

For this study, a selection was made to have the largest possible number of hydrometric stations (flow measurements) with the longest period of recording data. Missing data were accepted at the rate of 10% per year and 5% for the entire record period of each hydrometric station. In total, 100 stations were retained for 12 concomitant years of recording.

METHODOLOGY

Hydrological metrics and indices

A review of hydrological metrics and indices is the first step to assess environmental flows in Southern Quebec.
The aim is to compare the different metrics (tables and graphs) and indices (multivariate analysis) at different spatio-temporal scales in the hydrographic regions. The list is based on studies establishing the most relevant indices for eastern Canada (Linnan Saari et al., 2013, Daigle et al., 2011, Caissie et al., 2007, 2014). Fig.2 presents the different characteristics that are studied.

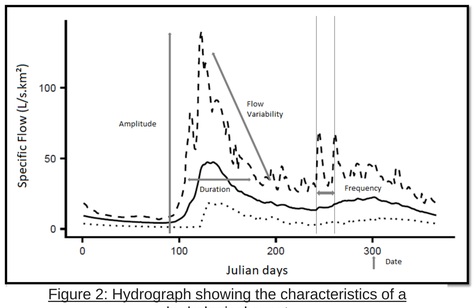


Figure 2: Hydrograph showing the characteristics of a hydrological event

To compare between regions, after having verified the basic assumptions of independence of the minimum values of moving average for 7 and 30 consecutive days, environmental flows were computed for an occurrence of 2, 10 and 5 year (7Q2, 7Q10 and 30Q5).

Methods for different time scales and sizes scales using in North America will also be compared:
- Percentage of Mean Annual Flow (Tennant, 1976)
- Sustainable Boundary and Presumptive Standard Approaches (Richter 2010, Richter and al., 2011)
- Range of Variability Approach (Richter and al., 1997, Richter and al., 1998)
- Q50 of the lowest flow month (Caissie and al., 2014)

METHODOLOGY

Hydraulic parameters

Links between low flows and the hydraulic data base of the MDDELCC (using HEC-RAS) will be made. Moreover, some gauging stations will be surveyed this summer on well known and well studied rivers by scientists, the MDDELCC and the MFFP to have more data for our future hydrological model on e-flows.

Expert solicitation

It will be interesting to hold a meeting with ecological experts to discuss the real efficiency of the e-flow methods that will be proposed to the MDDELCC to maintain a good environmental state in southern Quebec's rivers.

Climate change, water temperature and adequacy of the 2Q7

Then, climate change scenarios used to produce the hydro-climatic Atlas of Southern Quebec (MDDELCC, 2018) will allow the calculation of hydrological indices for these future hydrological scenarios (using HYDROTEL). Finally, a study of the link between water temperature and flow will be made and a conclusion will be given on the relevance of the use of the standard 7Q2.

FIRST RESULTS

Metrics: differences and similarities

Figures 3, 4 and 5 present first metrics calculations. In Fig.3, it seems that Q95 and 7Q2 are giving the same order of e-flows for the hydrometric stations in southern Quebec. Using Q95 could be a good alternative to 7Q2, to avoid biaises associated with the use of a statistical distribution for 7Q2.

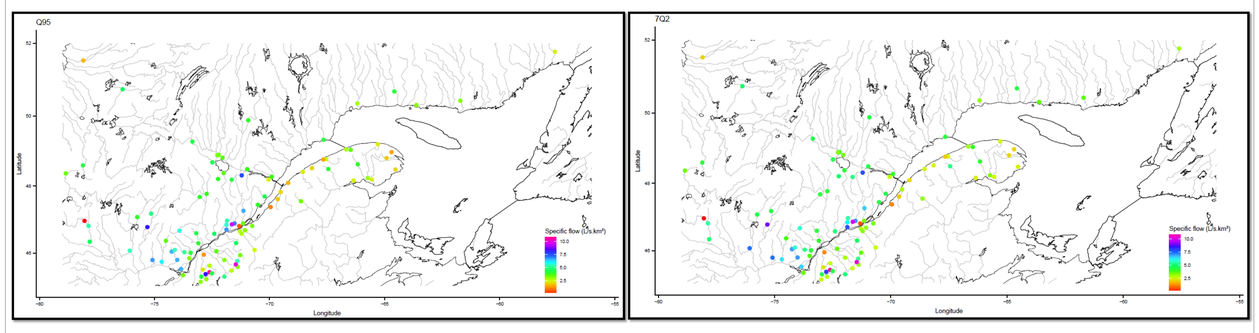


Figure 3: Specific flow of hydrometric stations for different metrics : Q95 and 7Q2

Figure 4 shows differences between metrics and the mean annual flow and Figure 5 shows differences with the size of watershed, for the year, the summer and the winter in Region 01. This comparison of different metrics allows to classify, order the metrics and identify the most restrictive ones.

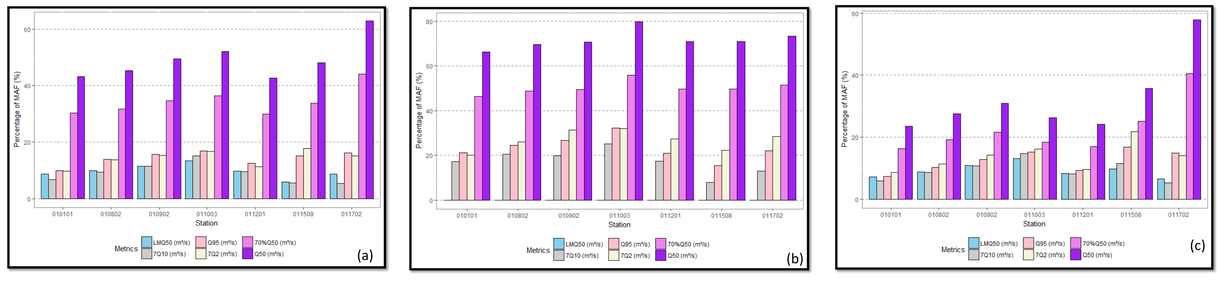


Figure 4: Metrics and percentages of MAF (a) Annual (b) Summer (c) Winter for the Region 01

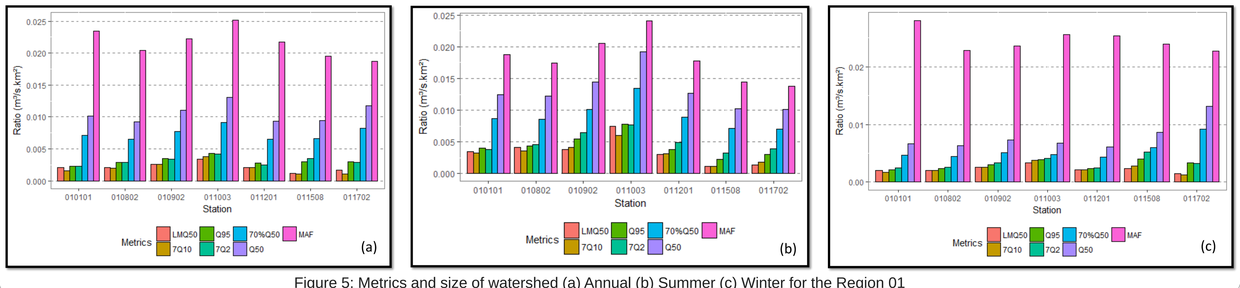


Figure 5: Metrics and size of watershed (a) Annual (b) Summer (c) Winter for the Region 01

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