


# Toxic Contamination in Sediments

## Lake Saint-François: A Century-Old Story

Photo: Isabelle Saulnier, St. Lawrence Centre

*Taking a sediment core*

### Background

The majority of organic (polychlorinated biphenyls, insecticides, herbicides, polycyclic aromatic hydrocarbons, etc.) and inorganic (mercury, lead, cadmium, etc.) contaminants have the capacity to move with the mineral particles and organic matter suspended in water. Under certain hydrodynamic conditions, suspended solids settle along the bottom of watercourses or lakes to form sediment. The accumulation of these particles in successive layers constitutes a veritable historical record of the natural and anthropogenic events occurring in a drainage basin.

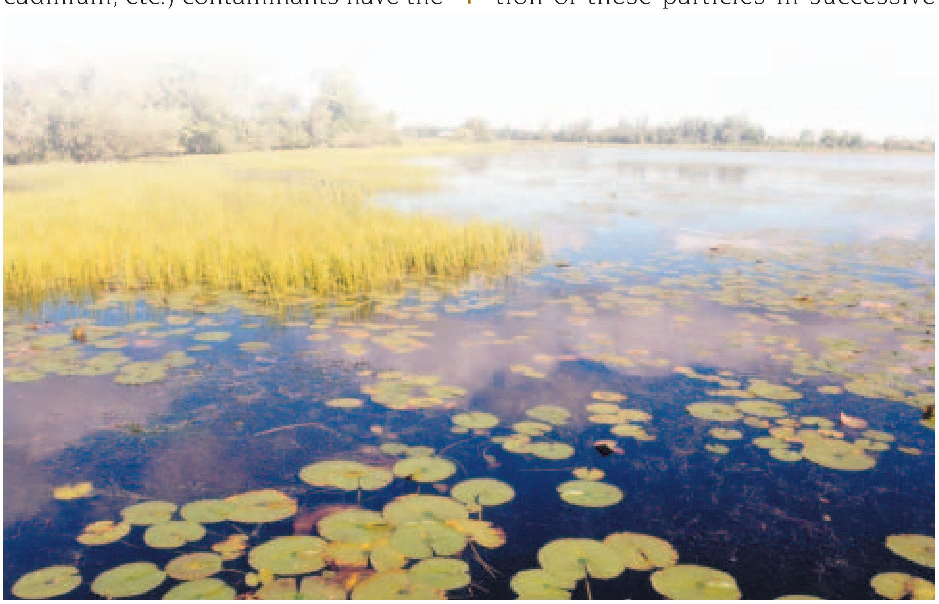

Photo: Martin Jean, St. Lawrence Centre

*Low marshes in Lake Saint-François*

Lake environments support a huge variety of organisms that get their food energy from the organic matter disseminated in sediments. It is therefore essential that we are able to understand and assess their degree of contamination.

The sediments in Lake Saint-François have been recognized as sinks for high concentrations of mercury (Hg) and polychlorinated biphenyls (PCBs) for decades. Most of these substances can be traced back to the industrialization of the Cornwall–Massena area during

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the 20th century. Today, these contaminants remain a threat to the health of benthic organisms, a critical link in the aquatic food chain.

While Lake Saint-François may not be representative of the entire St. Lawrence River system — most particularly because its water level is controlled by dams located both upstream and downstream — the geochemical characterization of lake sediments nonetheless allows us to determine its present state of contamination by industrial-source toxic substances, evaluate the success of the remediation measures undertaken over the last few years, and measure the impacts of certain infrastructures on this lake environment.

## Overview of the Situation

Lake Saint-François, first riverine lake of the St. Lawrence downstream of the Great Lakes, has become a gateway for international maritime commerce (Figure 1). A bastion of petrochemical plants and textile mills, the towns of Cornwall, Ontario, and Massena, New York, experienced major industrial growth, beginning at the turn of the 20th century, with the construction of hydro-electric dams and development of the St. Lawrence Seaway. There have been considerable impacts on the aquatic environment, however, due to the discharge of massive quantities of toxic substances into the lake.

The first traces of inorganic contaminants, including mercury, in the sediments appeared after the First World War (Figure 2). Around 1940, sediment quality had deteriorated to the point that contamination levels exceeded the present quality assessment criteria.

**Figure 1.** **Location map of Lake Saint-François**

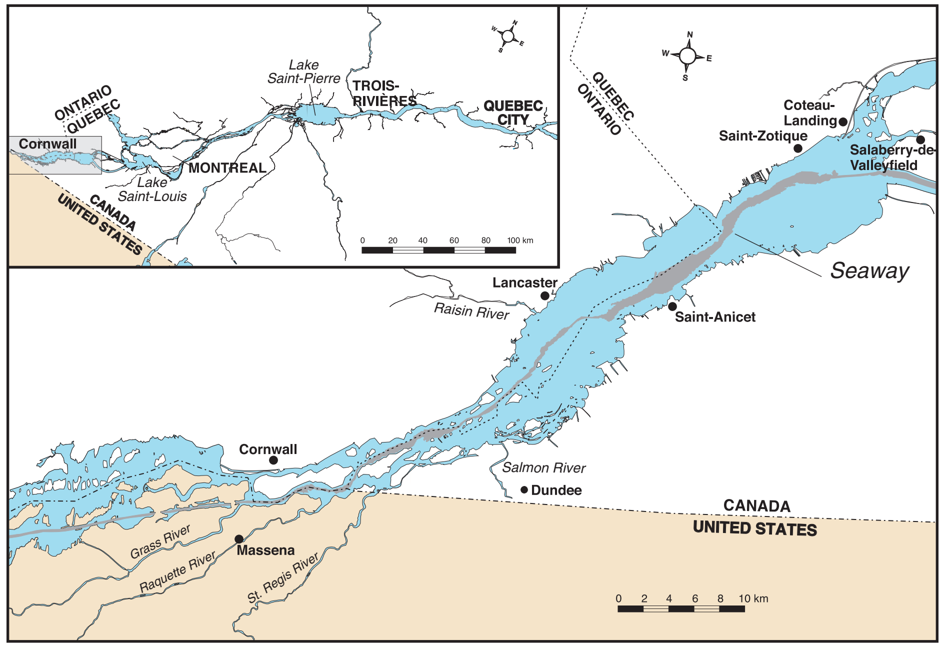



**Figure 2.** **Distribution of mercury (Hg) concentrations and polychlorinated biphenyls (PCBs) deposited in the sediment layers in Lake Saint-François over time**

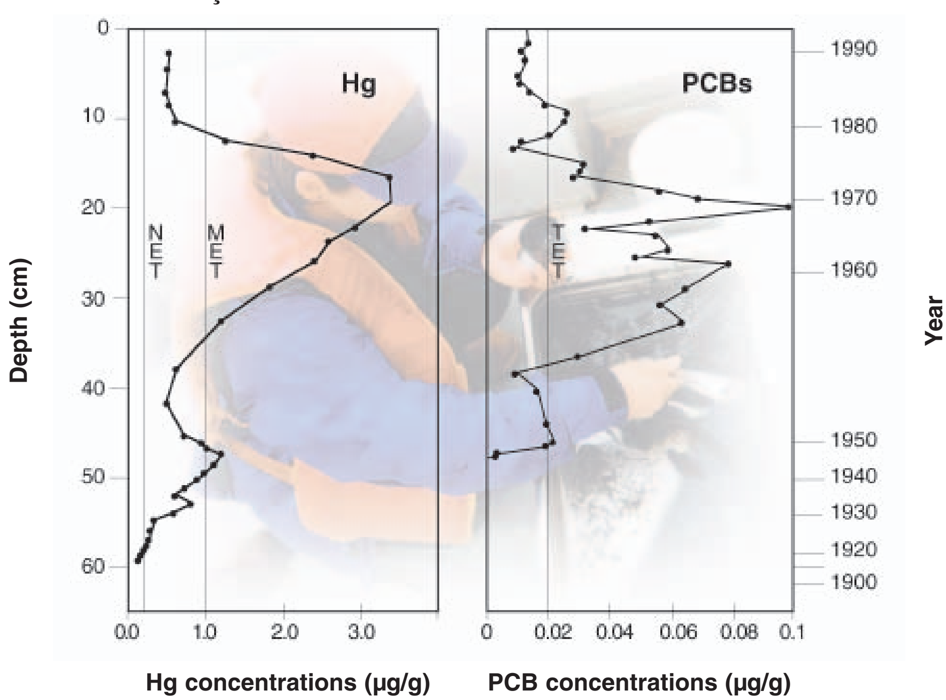
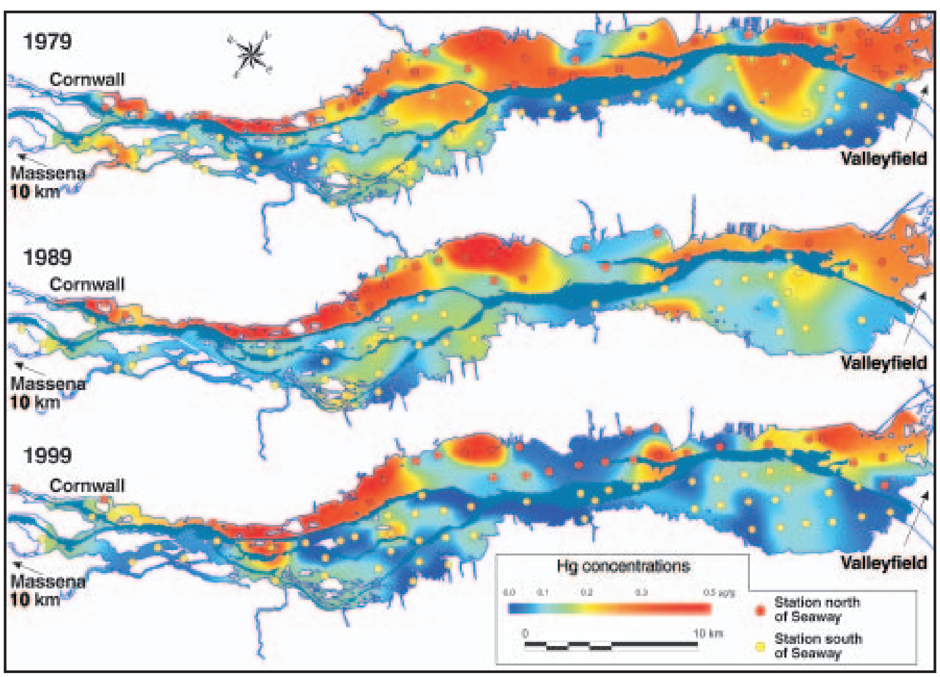


Photo: Serge Lepage, St. Lawrence Centre

*Sampling sediments with a Shipek grab*

**Figure 3. Spatial distribution of mercury (Hg) in sediments in Lake Saint-François between 1979 and 1999**




By contrast, concentrations of inorganic contaminants fell by about half between 1940 and 1955, the result of inputs of clean particles from the eroding banks and islands upstream, carried in by higher water levels.

Following this period of dilution, concentrations of metals (copper, zinc and lead), metalloids, (mercury) and organic compounds (PCBs and other substances) climbed anew, reaching values similar to or higher than 1940 levels and surpassing the toxic effect threshold (TET) for aquatic life. A number of mitigation and remediation measures were subsequently put into place to reduce the discharge of contaminants to Lake Saint-François.

Consequently, concentrations of mercury and PCBs have declined considerably since the 1970s. Today, levels are similar to those recorded in the 1950s. Although mercury has not yet reached preindustrial levels and PCBs remain in the environment, substantial progress has been made in reducing the concentrations of these contaminants, and thus lessening the health risks to benthic organisms.

The sediments in areas north of the Seaway were heavily contaminated with mercury, a particularly toxic substance, and one of the inorganic elements that originate primarily from the wastewaters of petrochemical plants and textile mills in Cornwall (Figure 3). Today, mercury concentrations in sediments represent no more than about 50% of the concentrations measured in the late 1970s; the average of 0.23 µg/g is close to the minimal effect threshold (MET). The highest concentrations below the TET are found in the upstream section of the lake, between Cornwall and the mouth of the Raisin River.

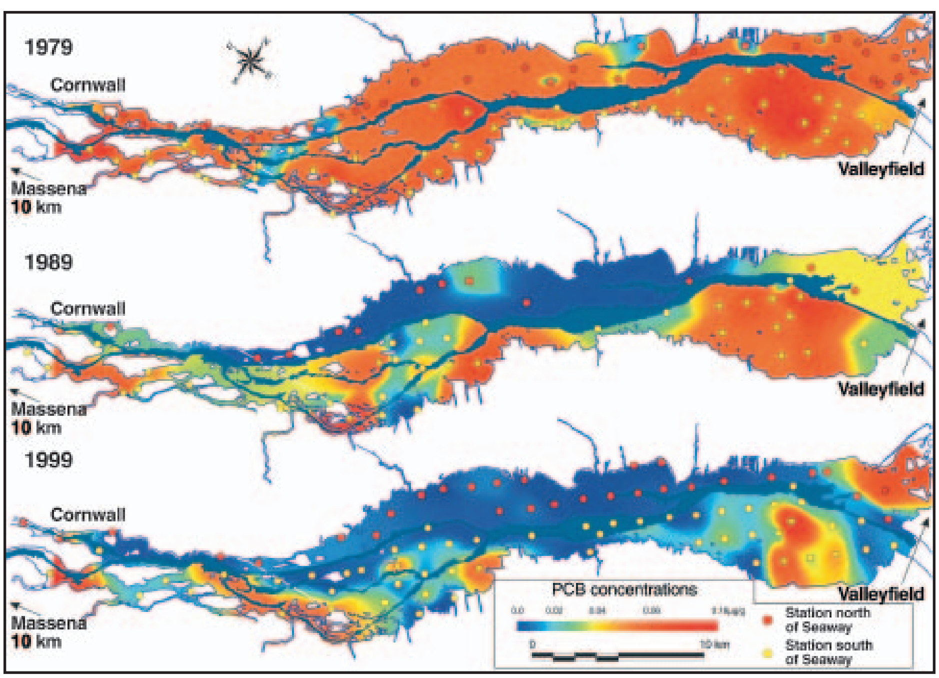
Carcinogenic polychlorinated biphenyls (PCBs), designated as priority substances by Environment Canada, have their roots in the industrial effluents of Massena's aluminum smelters and automobile manufacturing plants, which have contaminated all the sediments in the southern portions of the lake (Figure 4). In 1979, almost all the sampling stations on the lake recorded levels exceeding the MET, whereas geochemical analyses performed in 1999 showed that concentrations of PCBs had fallen by close to 95% in the 20 years since. This decline is linked to the ban on the use of PCBs outside of closed-circuit systems, the introduction of environmental regulations, a few plant shutdowns, and the inflow of cleaner material to the sedimentary basin. Though still being compared against quality criteria established for commercial products containing PCBs, the present average concentration of 0.028 µg/g in sediments in the southern part of the lake is close to the no effect threshold (NET). Only a few areas upstream of the lake continue to present levels exceeding this threshold.

Although the geochemical results obtained for PCBs and mercury are still sketchy, we can consider that the quality of surficial sediments has improved tremendously in 20 years. We should remember, however, that this thin layer of cleaner sediment covers a substantial amount of contaminated sediment that could be resuspended by violent weather events or human activities such as dredging, ship wake waves or the construction of riparian infrastructures.

Photo: Serge Lepage, St. Lawrence Centre

*The Potamos-1*

**Figure 4. Spatial distribution of polychlorinated biphenyls (PCBs) in sediments in Lake Saint-François between 1979 and 1999**




## Outlook

Sediment quality is monitored in both the deep layer, considered as a sink for toxic substances, and at the surface, to characterize annual inputs of particles. By monitoring target areas like Lake Saint-François, we can produce an up-to-date snapshot of the situation of contaminants in the aquatic environment and determine the main anthropogenic events that might affect the habitat of many benthic organisms.

Up to now, Lake Saint-François has served as the foundation for the development of a sediment monitoring program for the entire St. Lawrence River. In the coming years, the scientific data already collected on other sections of the river

(Lake Saint-Louis, Lake Saint-Pierre and the river corridor) will be collated and interpreted from this same perspective. This interpretation, enhanced over time as new information on sediments becomes available, will strengthen our understanding of the sedimentary processes in the St. Lawrence River, provide an overview of its geochemical state, and identify the short- and long-term trends in chemical substances.

Photo: Martin Jean, St. Lawrence Centre

Photo: Serge Lepage, St. Lawrence Centre

## KEY VARIABLES

### Criteria and Contamination Thresholds

Two types of tools are used to monitor sediment quality: interim criteria, designed especially for St. Lawrence sediments, and the threshold of significant contamination (TSC).

The interim quality criteria define three levels of contamination: 1) the no effect threshold (NET), which corresponds to an average preindustrial level (in the case of metals) or defines the concentration below which no effect is detected in organisms (in the case of organic compounds); 2) the minimal effect threshold (MET), at which organisms most sensitive to toxic substances are affected; and 3) the toxic effect threshold (TET), above which 90% of organisms are affected by a given contaminant.

As for the threshold of significant contamination or TSC, it applies only to metals and is defined by an anthropogenic enrichment factor (AEF). This factor is the rate by which a contaminant exceeds its preindustrial concentration, to which is applied a factor of 2.5 to account for natural variations. When the preindustrial level is not known, the AEF can be calculated with the help of the TSC. We estimate that levels of contamination above the TSC can not be the result of variations in sediment texture or geology alone, but that a relatively substantial anthropogenic input is the cause.

Photo: Martin Jean, St. Lawrence Centre

## To Know More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## State of the St. Lawrence Monitoring Program

Four government partners — Environment Canada, the ministère de l'Environnement du Québec, the Société de la faune et des parcs du Québec, and Fisheries and Oceans Canada — are pooling their expertise and efforts to provide Canadians with information on the state of the St. Lawrence and long-term trends affecting it. To this end, environmental indicators have been developed on the basis of data collected as part of each organization's ongoing environmental monitoring activities. These activities cover the main components of the environment, namely water (quality and quantity), sediments, biological resources (species diversity and condition), uses and, eventually, shorelines.

For additional copies or the complete collection of fact sheets, contact the St. Lawrence Vision 2000 Coordination Office:

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The fact sheets and additional information about the program are also available on the Web site: **www.slv2000.qc.ca** .


Published by Authority of the Minister of the Environment



Published by Authority of the Ministre d'État aux Affaires municipales et à la Métropole, à l'Environnement et à l'Eau du Québec



Catalogue No. En4-17/2002E
ISBN 0-662-33252-0
Envirodoq: ENV/2002/0345A
Legal deposit – National Library of Canada, 2002
Aussi disponible en français sous le titre : *La contamination des sédiments par les toxiques – Le lac Saint-François : une histoire centenaire*

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