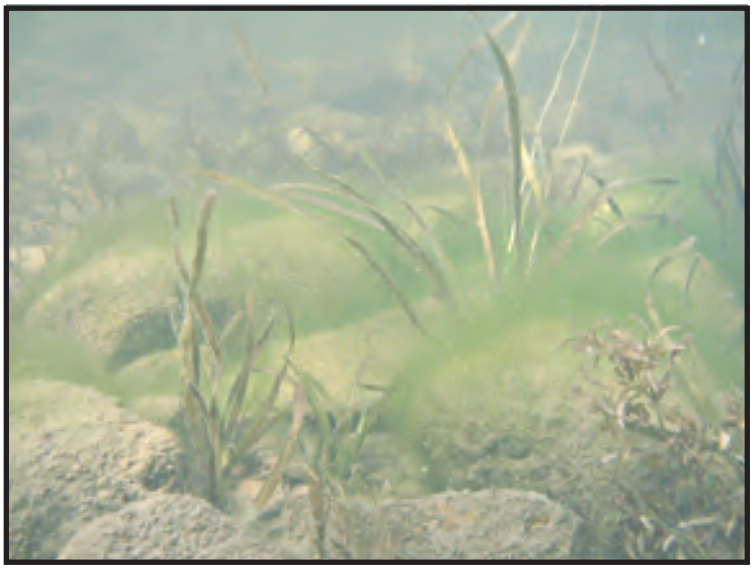
OPÉRATION SANTÉ DU LAC MEMPHRÉMAGOG
(PHASE 1)



SUMMARY OF THE REPPORT
APRIL 2005

Opération Santé du Lac
(phase 1)

Summary of the Final Report

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Summary

Well known for its seductive countryside, for its rich aquatic fauna as well as for the many uses and activities it offers, Lake Memphremagog is without a doubt a body of water of prime importance in the Eastern Townships. Its preservation therefore has ecological, economical and social stakes. However, various types of pollution of human origin compromise the health and durability of this lake. Shoreline and watershed **erosion** as well as the various forms of nutritive elements (ex. phosphorus and nitrogen) brought about by human activity rank among its many sources of degradation. Indeed, certain shoreline, municipal, urban, agricultural and forestry activities alter the aquatic components of Lake Memphremagog as well as those of its tributaries while they create a premature ageing process of this body of water (called **eutrophation**).

In order to assess the state of health of the Québec part of Lake Memphremagog, MCI (Memphremagog Conservation Inc.), in collaboration with RAPPEL (Regroupement d'associations pour la protection de l'environnement des lacs et des cours d'eau de l'Estrie et du Haut bassin de la Saint-François), undertook during the Summer of 2004 – as the first phase of Operation Healthy Lake - the study of two important symptoms of erosion and eutrophation of the shoreline, namely **siltation** and **invasion by aquatic plants**. To do so, a team composed of a biologist and of students in applied ecology covered the whole of the littoral on the Québec side of the lake and did an inventory (shallow zone) at three different water depths (1, 2 and 3 meters). The percentage of coverage occupied by aquatic plants, the three dominant plant species as well as the type of dominant substrate were assessed and siltation accumulation measurements were taken at each of the three depths on portions each measuring 100 meters' long and two meters' wide. In total, over 3, 000 portions such as these were taken into inventory and geo-referenced. These were then grouped into sixteen areas in order to facilitate their analysis and interpretation. Finally, in order to improve this study, data relative to the **degree of shoreline artificiality** and **algae presence** at the bottom of the lake were collected. In addition, results obtained were completed by a synthesis of the literature concerning the tests of the **quality of the deep waters of the Lake and of its tributaries** performed respectively by the Environment Ministry (MENV) and the Memphremagog MRC during these last few years.

Results from Operation Healthy Lake indicate that the Québec shoreline of Lake Memphremagog manifests, in certain areas, siltation symptoms and a proliferation of aquatic plants that are signs of premature ageing. Thus, the northern part of the lake, also known as the "head of the lake", (Magog Bay, Southière-sur-le-lac, and the Three Sisters) constitutes areas that show the most severe signs of degradation. On the other hand, the healthiest parts - or the least disturbed (central area of the lake around Owl's Head) - are starting to show signs of degradation as well. For example, deposits of organic matter can be observed on the rocks near the shoreline (a symptom of ongoing siltation).

Globally, rocks and rock formations cover half of Lake Memphremagog's shoreline, but mud constitutes the dominant substrate over 29% of the studied bottom. Also, 8% of the analyzed shoreline is covered by more than a meter of unconsolidated sediments. This important accumulation of fine sediments in these parts indicates an increased erosion of the shoreline and soils of the watershed which bring into the lake big quantities of soil particles due to land run-offs, ditches and tributaries of the lake. Moreover, the accumulation of mud at the bottom disrupts the fauna there, notably by plugging up (siltation) the spawning grounds which in turn asphyxiates the eggs of many species of fish such as trout, yellow pike, pike and bass.

Moreover, the total coverage of aquatic plants on the whole of the Québec side of the littoral ranges from 25 to 50% of the surface. More precisely, close to one-quarter (24%) of the studied portions are characterized by a total coverage superior to 50% of the surface and 14% of the portions show a total coverage of over 75%. These strong densities reveal the presence of run-offs that feed nutritive elements, such as phosphorus, into the lake which in turn feeds aquatic flora in excess. Lake Memphremagog is also comprised of a great variety of habitats and a great diversity of species of aquatic plants. Indeed, during the on-sight phase of Operation Healthy Lake, over thirty different species of plants were taken into inventory. Among these, tape grass (*Vallisneria americana*), eurasian water milfoil (*Myriophillum spicatum*), and the slender water nymph (*Najas flexilis*) are, respectively, the three most dominant species in Lake Memphremagog. However, eurasian water milfoil, an introduced species, is known to be invasive in natural habitats (Environment Canada 2004), since it has the potential to reproduce quickly and to form dense grass patches which can take over indigenous species. Furthermore, this species occupies more than a quarter (28%) of the area studied, a fact which could eventually become problematic.

On the other hand, Lake Memphremagog still benefits from many areas kept in an almost pristine state. We estimate that one-third (34%) of the shoreline is kept in an almost natural state. However, a quarter of the shoreline (24%) is considered almost completely or totally artificialized (clear-cutting of the original vegetation, building of human structures). This artificial shoreline, contrary to a natural one, contributes in bringing sediments and nutrients as well as increasing water temperature in shallow waters, which in turn is detrimental to the health of the lake.

According to the MENV, Lake Memphremagog's deep waters are considered globally mesotrophic, typical of lakes characterized by waters enriched with organic matter and phosphorus as well as by a lack of oxygen in their deeper parts. These findings indicate that the lake is undergoing rapid eutrophation, since a lake of this age and with such depth should theoretically be composed of water far less abundant in phosphorus and organic matter (Simoneau, 2004). Furthermore, according to the MRC's results, certain tributaries carry phosphorus, suspended matter and fecal coliforms into the lake, which are all harmful to the lake's good health. Oliver, Bunker, Gale, McCutcheon, Fitch and Castle Brook as well as Cherry River have become, over the years, the most problematic of the lake's tributaries (MRC Documents).

Finally, it appears that the main areas to be prioritized are Fitch Bay and its tributary brooks (Bunker, Gale, and McCutcheon), the Southière-sur-le-lac area, Castle Brook, the whole of the Magog Bay area as well as Oliver Brook. While enacting a plan of action, energy should be focused on these priority zones. However, the importance of acting in a preventive manner so as to preserve zones which are still healthy or less damaged should also be kept in mind. After all, the lesser the degradation is, the easier it is to put a stop to it and restore the milieu.

In conclusion, Lake Memphremagog is submitted to human pressures which exceed its capacities for absorption, making it age prematurely. With this in mind, it is important to act quickly to limit its imminent degradation and stop the loss of ecological and human activities which inevitably follow. Shoreline erosion control, a careful watch over the tributaries' run-offs and a reduction of nutrients carried into the lake are now a must. In order to achieve this, all the local players must act as one. Indeed, shoreline residents, local administrators (MRC and municipal), farmers, forestry workers and business people can put together concrete initiatives to limit their own negative impact on the lake and its tributaries. Particular attention must be paid to the preservation and restoration of the shoreline, the management of used waters and ditches, as well as the fertilization of surrounding lands. Depending on what measures will be taken, one can hope that the lake's degradation will be slowed down and that, in the long run, its health will improve.

Key words: Lake Memphremagog, shoreline state, eutrophation, siltation, macrophyte-caused siltation

Chapter 4 : State of the Lake's Health

This chapter addresses the global state of health of Lake Memphremagog as well as that of each determined area. This chapter is in fact a summary of chapters 6, 7, 8 & 9 which, for their part, explain in detail each of the parameters' analysis. In order to better understand the present chapter or to obtain more details, please see the following chapters.

First off, you will find, in this chapter, a synthesis of the diverse parameters used to assess Lake Memphremagog's state of health. These include the shoreline state of artificiality (artificially planned bank), the state of the littoral (the degree of siltation and invasion by aquatic plants), and the quality of the water (deep waters and tributaries). You will notice the use of "traffic lights" to illustrate the interpretation of the results. These colors should be read as follows:

- Green light: the state does not seem to be problematic (keep a watchful eye)
- Yellow light: the state is preoccupying (be on alert and act in order to curb the problem)
- Red light: the state is problematic (prioritize in the plan of action to correct the situation)

The lights were attributed in response to the most problematic situation arising within a parameter. For example, if the analysis in a tributary shows that the water quality is good one year and bad the next, the interpretation light will be red (meaning a bad quality). Table 1 shows the various classes of parameter interpretations. You will note that qualitative information also appear (types of sediments, invasive species, presence of algae on the substrate).

Table 1: Classes of different results for the analysis of a body of water's state of health

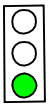
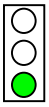
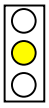
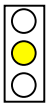
Parameters			
Degree of artificiality	Natural or Low artificiality (0-25 % artificial)	Moderately artificial (50 % artificial)	Highly artificial (75-100 % artificial)
Thickness sediments	0-5 cm or 5-10 cm	10-50 cm	50 cm +
Total coverage provided by aquatic plants	0-10 % 10-25 %	25-50 %	50 % +
Water quality	oligotrophic	mesotrophic	eutrophic
Water quality of tributary (SM / P / FC)	good	doubtful	bad

SM: Concentration of suspended matter P: Concentration of phosphorus FC: Fecal coliforms

Afterwards, a list of priority sectors and problematic areas was established. These hot spots indicate where the energy should be focalized in a plan of action. In fact, these designate areas where human pressures are strong and where restoration should be done without delay in order to reduce the serious degradation as well as the loss of ecological and human uses which ensue. In the long run, if serious rehabilitation measures are introduced, one can foresee that the ecological and recreational potential for these zones could potentially be recovered. However, acting in a preventive way and taking measures to reduce the degradation of areas which are still healthy remains of prime importance. Even more so since the less severe the degradation is, the more it is possible to put an end to it and indeed, even reverse it.

Finally, you will find an overview of the main causes, either environmental or human, which are potentially at play behind the siltation and spreading of aquatic plants. Moreover, comments concerning the state of health of Lake Memphremagog made by shoreline residents whom we met during the operation are available in the annex entitled *Shoreline Residents' Perception*.

4.1.1 Synthesis of the State of Health

	Parameters	Assessment	
STATE OF THE SHORLINE	Degree of artificiality	Low artificiality	
STATE OF LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 5-10 cm	
	Type of substrate	Mainly rocks and mud	
	Total coverage by aquatic plants (median)	1 m zone : 10-25 % 2 m zone : 10-25 % 3 m zone : 25-50 %	
	Invasive species	Eurasian water milfoil is the 2nd most abundant	
	Presence of algae on the substrate	Moderate presence of diatoms algae Moderate presence of green algae	
WATER QUALITY	Waters offshore	Mesotrophic	

4.1.2 Priority Sectors

- Fitch Bay (North East)
- Fitch Bay (Long Bay)
- Southière-sur-le-lac
- Magog Bay
- Three Sisters

Please refer to figure 1 to better visualize the localization of priority areas.

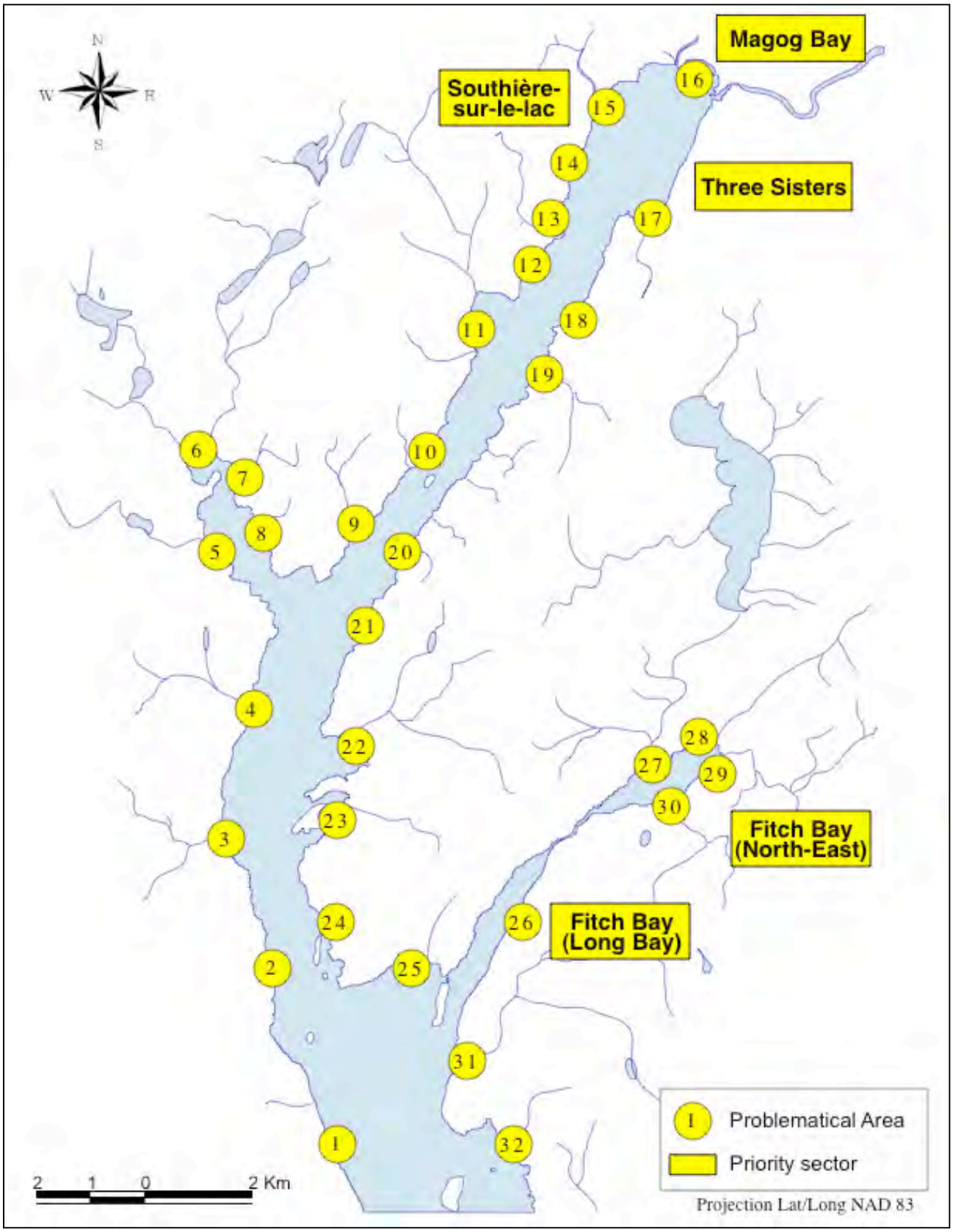
4.1.3 Problematic Areas

Table 2 shows problematic areas identified through the results of Operation Healthy Lake. These areas are numbered clock-wise (starting at the South Western end of the lake) and not according to an order of priority. We invite you to refer to figure 1 to better visualize the localization of problematic areas. It should be reminded that these areas should be at the forefront of any plan of action which aims at reducing the sources of degradation on Lake Memphremagog. However, it is also important to act in a preventive manner to avoid the degradation of still healthy or relatively untouched areas.

Table 2: Priority Areas According to Operation Healthy Lake

Number	Area	Sector
1	Portion near the border (around the brooks)	Leadville
2	Bay located to the West of Skinner Island	Leadville
3	Vale Perkins wharf and Vale brook	Vale Perkins
4	Around the boat ramp and Château Brook	Vale Perkins
5	Glen Brook and the surrounding marinas	Sargent's Bay
6	North of Green Bay (Powell and West Brook)	Sargent's Bay
7	Scott Brook	Sargent's Bay
8	1105 Brook	Sargent's Bay
9	Abbey's Bay (brooks)	Bryant's Landing
10	Bryant's Landing wharf and Patterson Brook	Bryant's Landing
11	Channel Bay (McIntosh Brook and unnamed brook)	Cummins & Channel bays
12	Bay located between Channel and Cummins	Cummins & Channel bays
13	Cummins Bay (unnamed brooks)	Cummins & Channel bays
14	Unnamed brook located to the South of Southière	Southière-sur-le-lac
15	Castle Brook and Southière area	Southière-sur-le-lac
16	Magog Bay in general and Cherry River	Magog Bay
17	Bay located to the East of Lafrenaye Point (unnamed brook)	Three Sisters
18	Anse Bay	Eastern part
19	Oliver Brook	Eastern part
20	1103 Brook	Georgeville
21	Georgeville wharf (Tuck Bay)	Georgeville
22	McPherson Bay (Taylor Brook and unnamed brook)	Quinn & McPherson bays
23	Quinn Bay (Boyton Brook and unnamed brook)	Quinn & McPherson bays
24	Area to the North of Long Island (brooks)	Molson Landing
25	Lime Kiln Bay (brooks)	Magoon Point
26	Eastern side of the South part of Fitch Bay	Fitch Bay (Long Bay)
27	Fitch Brook	Fitch Bay (North East)
28	Bunker Brook	Fitch Bay (North East)
29	Gale Brook	Fitch Bay (North East)
30	McCutcheon Brook	Fitch Bay (North East)
31	Harvey Bay	Cedarville
32	Cedarville Bays & Reid Bay	Cedarville

Figure 1 : Priority Sectors and Problematic Areas According to Operation Healthy Lake



4.1.4 Impacts of Eutrophation on the Lake's Ecology

- **Degradation of potential spawning grounds**
  The accumulation of fine sediments clogs (destroys) reproduction sites for a great many species of fish (trout, bass, yellow pike, pike). Fish will avoid laying eggs in such areas.

- **Egg mortality of many intolerant fish species**
  The accumulation of fine sediments on the eggs hinders the natural flow of water around them, which in turn inhibits gas and metabolic residues exchanges between the eggs and the environment and eventually leads to their intoxication and subsequent death. For instance, a one-millimeter deposit of sediments over bass eggs is enough to kill them.

- **Modification to the diversity of species**
  Physicochemical changes (a rise in water temperature, a drop in the dissolved oxygen concentration) engendered by premature ageing harm the quality of the habitats of intolerant species (trout, bass, yellow pike…). These populations decline as a result and are progressively replaced by species better adapted to eutrophation (catfish, yellow perch, common sunfish…)

4.1.5 Impacts of Eutrophation on Humans

Parallel to these serious ecological consequences, the deterioration of an aquatic environment can limit human activity, notably those activities which are related to recreation and tourism. Tolerance levels to eutrophation symptoms vary from one individual to the next. However, in general, really dense water plant communities as well as a thick layer of mud remain undesirable for many activities. For example, a significant amount of mud on the littoral can be disagreeable when going for a swim. Also, water plant invasion can make some nautical activities more difficult. We must also remember that premature ageing also impacts the survival and reproduction of many species of fish, which has a negative impact on fishing. Furthermore, our water supply potential is directly linked to the state of health of the body of water. Nonetheless, despite the many uses expected of it, a lake is before anything else an aquatic ecosystem which we must protect.

4.1.6 Environmental Characteristics

- Due to its slow slope and the natural flow of water, the "head of the lake" (Magog Bay, Southière-sur-le-lac, Three Sisters) appears among the areas most naturally vulnerable to siltation and the growth of aquatic plants.

- Due to its slow slope and the tranquility of its waters (narrows), Fitch Bay (North Eastern part) appears among the areas most naturally vulnerable to siltation and the growth of aquatic plants.

4.1.7 Anthropogenic Causes (of Human Origin)

- **Artificial planning of the lake's shoreline and of its tributaries**
  The cutting of vegetation along the shoreline as well as the installation of artificial structures (breaker walls, ripraps…) prevent the retaining of sediments and nutritive elements on the shore and contribute to the rise in temperature in shallow waters.

- **Use of pesticides and chemical fertilizers near the lake and its tributaries**
  These products contaminate water and enrich it with nutritive elements.

- **Municipal throwbacks, used water treatment plant overflows and urban run-offs**
  These inputs bring in important amounts of suspended matter, nutrients and organic matter.

- **Badly maintained road and forestry ditches**
  Ditches where vegetation has been completely removed deteriorate the quality of the water that circulates in them before reaching these bodies of water (these contaminated waters asphyxiate the bodies of water since they contain less oxygen, are warmer and are carrying soil particles as well as nutrients).

- **High residential density in certain areas of the lake**
  Human activities can produce more input (sediments and nutrients) as a result of certain practices (poorly maintained septic installations, use of fertilizers and pesticides).

- **Certain leisure activities**
  Some nautical activities bring various pollution agents into the water (hydrocarbons, nutrients) and add to shoreline erosion.

- **Some activities linked to tourism in the watershed area**
  Some golf courses, ski stations, marinas and camping grounds can bring considerable quantities of sediments and nutrients to the lake.

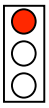
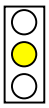
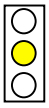
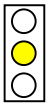
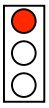
- **Some agricultural practices in the watershed area**
  Spreading liquid and solid manure or chemical fertilizers for agricultural use near a body of water as well as various cultural practices which make the ground bare for long periods of time are a source of sediments and nutrients.

- **Some forestry practices in the watershed area**
  Abusive clear cutting of forests, as well as certain types of passages and crossings in tributaries, brings sediments and/or nutrients into the lake.

- **Some construction activities**
  Construction practices which leave a bare ground accentuate erosion.

- **Some industrial activities**
  Many companies, extraction or landfill sites are susceptible to important discharges of polluting agents.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Highly artificial shoreline	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 5-10 cm 3 m zone : 10-50 cm	
	Type of sediments	Mainly sand and mud	
	Total coverage by aquatic plants (median)	1 m zone : 25-50 % 2 m zone : 25-50 % 3 m zone : 25-50 %	
	Invasive species	Eurasian water milfoil is the second most abundant species	
	Presence of algae on the substrate	Absence of diatoms algae Moderate presence of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of Cherry River	SM: good quality P: quality ranges from good to bad FC: quality ranges from good to bad	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Area

- Magog Bay in general and Cherry River

Environmental characteristics

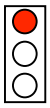
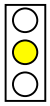
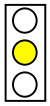
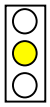
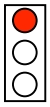
- The natural flow contributes to the carrying of SM coming in from areas located to the South.
- The slow slope facilitates siltation and the settlement of aquatic plants.
- The undertow and strong exposure to waves favor the migration of SM towards the 2-3 meter depth zones.

Anthropogenic causes (of human origin)

- The highly artificialized shoreline in this area does not prevent sediments or nutrients from entering the lake and contributes to the temperature increase in shallow waters. 78% of these shores are considered highly or totally artificialized.
- Magog Bay possesses the lake's highest residential density which can generate further inputs (sediments and nutritive elements).
- Agricultural, forestry, urban and leisure activities in the watershed of this area are potential sources of sediments and nutrients.
- Road ditches favor the run-off of soil particles towards the lake.
- The upper part of Cherry River is potentially subject to erosion and fertilization. Fortunately, the Cherry River marsh is capable of absorbing a great many sediments and nutrients coming from upriver.

In conclusion, the Magog Bay area is a sector which manifests the most symptoms of "premature ageing", therefore of degradation. Its state of health appears to us as worrying. This area should be prioritized in a plan of action which aims at reducing the number of degradation sources for Lake Memphremagog. Action in this area should mainly consist in restoring the shoreline in Magog Bay as well as reducing the input in sediments and nutrients (see chapter 10). Special attention should be given to road ditches and municipal run-offs since they seem to bring into the lake vast quantities of input. Furthermore, we also recommend that a plan of action be devised for the sources of degradation located upstream of Cherry River.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Highly artificial shoreline	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 5-10 cm 3 m zone : 10-50 cm	
	Type of sediments	Mainly sand and mud	
	Total coverage by aquatic plants (median)	1 m zone : 25-50 % 2 m zone : 25-50 % 3 m zone : 50-75 %	
	Invasive species	Eurasian water milfoil is the most abundant species	
	Presence of algae on the substrate	Low presence of diatoms algae Moderate presence of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of Castle Brook	SM: good quality P: good quality FC: quality ranges from doubtful to bad	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- The mouth of Castle Brook and the Southière area
- The mouth of the brook (unnamed) located at the South of Southière-sur-le-lac sector

Note on Figure 2 the brown cloud caused by fine particles coming in through Castle Brook and the highly artificialized shoreline of Southière-sur-le-lac.

Figure 2: Amounts of sediments coming from upstream erosion in Castle Brook and from the artificialized area of Southière-sur-le-lac

Environmental characteristics

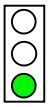
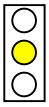
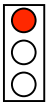
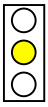
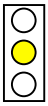
- The natural flow contributes to the carrying of SM coming in from areas located to the South.
- Currents carry SM towards the North and the Castle Brook mouth.
- The slow slope facilitates siltation and the settlement of aquatic plants.
- The undertow and strong exposure to waves favor the migration of SM towards the 2-3 meter depth zones.

Anthropogenic causes (of human origin)

- The highly artificialized shoreline in this area does not prevent sediments or nutrients from entering the lake and contributes to the temperature increase in shallow waters. 68% of these shores are considered highly or totally artificialized.
- Southière-sur-le-lac possesses a high residential density which can generate further inputs (sediments and nutritive elements).
- Agricultural, forestry, urban and leisure activities in the watershed of this area are potential sources of sediments and nutrients.
- Road ditches favor the run-off of soil particles towards the lake.
- The upper part of Castle Brook is potentially subject to erosion and fertilization. Even if, at the time the water sampling was performed (2003 and 2004), the suspended matter and phosphorus concentrations the mouth of this tributary were not considered problematic, the abundance of fine sediments and aquatic plants accumulated in this area indicate otherwise. It is possible that, in time of heavy rains, this brook carries important quantities of sediments and nutrients. Also, during these two years, the waters at the sampling station located further upstream proved to be rich in SM (Curry, 2003 and Curry, 2004).

The Southière-sur-le-lac area is one of the sectors which manifest the most symptoms of "premature ageing", and its state of health appears as worrying. This is why we recommend that this area be prioritized in a plan of action which aims at reducing the number of degradation sources affecting Lake Memphremagog. Action in this area should mainly consist in restoring the Southière-sur-le-lac shoreline as well as reducing the input of sediments and nutrients (see chapter 10). To this effect, special attention should be paid to road ditches and to the upper part of Castle Brook.

State of Health Summary

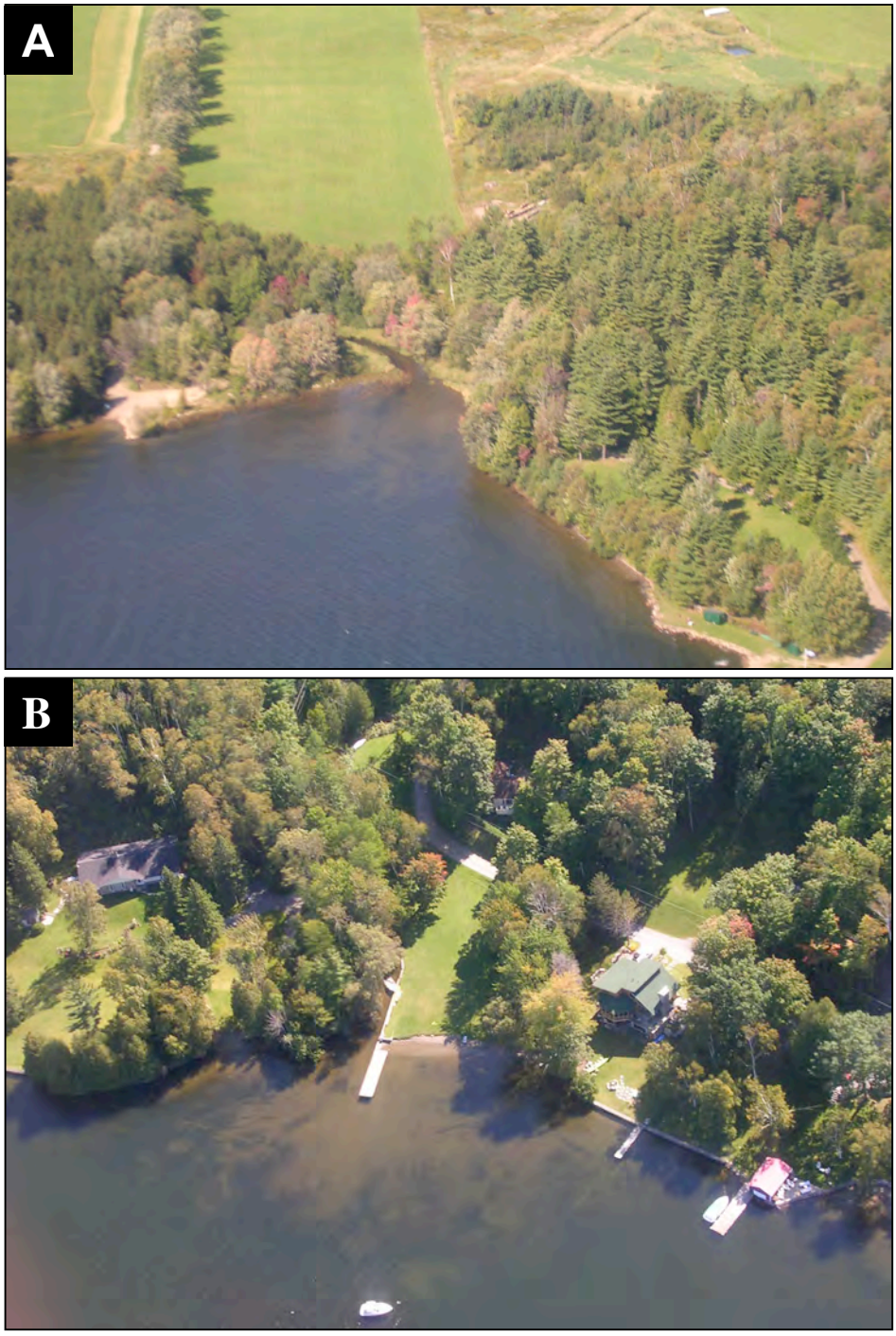
	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 10-50 cm	
	Type of sediments	Mainly sand and rocks	
	Total coverage by aquatic plants (median)	1 m zone : 10-25 % 2 m zone : 10-25 % 3 m zone : 50-75 %	
	Invasive species	Eurasian water milfoil and broad-leaved pondweed are moderately abundant species	
	Presence of algae on the substrate	Low presence of diatoms algae Moderate presence of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of McInthosh (Benoit) Brook	SM: good quality P: quality ranges from good to doubtful FC: quality ranges from good to doubtful	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- Channel Bay (1094 Brook and Benoît Brook – also called McIntosh)
- Cummins Bay (brook)
- The bay located between these two bays.

Figure 3: Inputs of sediments coming from upstream erosion in McIntosh Brook and from the brook in Cummins Bay.



Environmental characteristics

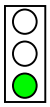
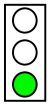
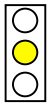
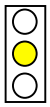
- The slow slope facilitates siltation and the settlement of aquatic plants.
- Areas to the South West of these two bays are more susceptible to siltation and the growth of aquatic plants since they are sheltered from wind and waves.
- The natural flow contributes to the carrying of SM coming in from areas located to the South.

Anthropogenic causes (of human origin)

- Some artificially planned shoreline in this area does not prevent sediments or nutrients from entering the lake and contributes to the temperature increase in shallow waters. 19% of these shores are considered highly or totally artificialized.
- Residential density reaches higher levels *vis-à-vis* the zones where sediments and nutritive elements are most abundant.
- Agricultural, forestry, urban and leisure activities in the watershed of this area are potential sources of sediments and nutrients.
- Road ditches favor the run-off of soil particles towards the lake.
- Benoît (McIntosh) Brook, 1094 Brook and Cummins Bay are suffering from potentially high erosion and fertilization since a delta of sedimentation and dense water plant communities is formed at their mouth.

In conclusion, the area of Channel and Cummins bays manifests symptoms of "premature ageing", therefore of degradation, mainly at the three meter mark (density of the water plant community, abundance of algae and sub aquatic deltas). In order to slow down this process, the main actions in this area should consist in restoring the shoreline as well as reducing the input of sediments and nutrients (see chapter 10). Ditches and the three brooks should also receive special attention. It is also important to us to characterize the waters of 1094 Brook as well as those of the brook which flows into Cummins Bay.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Moderately artificial	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 0-5 cm	
	Type of sediments	Mainly rocks and mud	
	Total coverage by aquatic plants (median)	1 m zone : 0-10 % 2 m zone : 10-25 % 3 m zone : 25-50 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	High level of diatoms algae Low level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- The surroundings of Bryant's Landing's wharf (mouth of Patterson Brook)
- Abbey's bay (mouth of the brooks)

Environmental characteristics

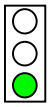
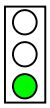
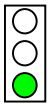
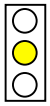
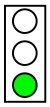
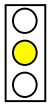
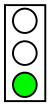
- The natural flow of water contributes to the migration of SM towards the North.
- The moderate to abrupt slope limits siltation and the settlement of aquatic plants.

Anthropogenic causes (of human origin)

- **The few artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 21% of these shores are considered highly or totally artificialized.
- **The public wharf** modifies the natural flow of water which makes the site prone to siltation and aquatic plant growth.
- **Agricultural, forestry, urban and leisure activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Road ditches** favor the run-off of soil particles towards the lake.
- The **upstream parts of Patterson Brook and the Abbey's Brook** are subject to potential erosion and fertilization.

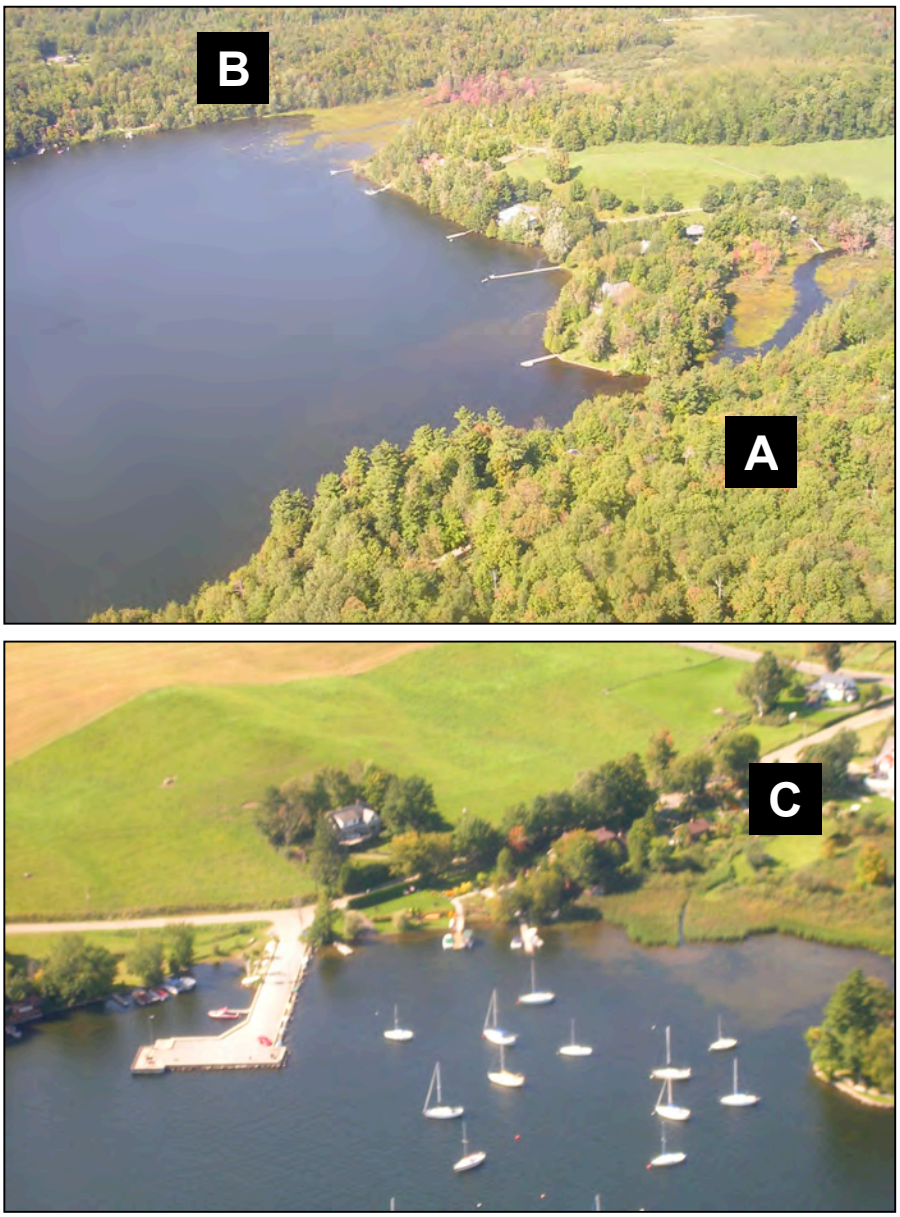
Bryant's Landing seems to be an area where siltation is less problematic on the littoral, even if it seems to show signs of siltation in certain areas. However, the aquatic plant invasion seems more preoccupying, especially at the 3 meter mark, despite environmental factors which should hinder the settlement and progression of aquatic plants. Moreover, the high levels of diatoms algae indicate that the waters are rich in nutrients. In order to prevent "premature ageing" in this area and in areas located North of it, it is important to set actions in motion, by restoring the shoreline and reducing the input of sediments and nutrients (see chapter 10). To this end, road ditches, Patterson Brook and the Abbey's brook as well as the wharf area should receive close attention. It would also be quite useful if the waters which transit through these two tributaries were characterized.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 0-5 cm	
	Type of sediments	Mainly rocks and mud	
	Total coverage by aquatic plants (median)	1 m zone : 0-10 % 2 m zone : 10-25 % 3 m zone : 10-25 %	
	Invasive species	Eurasian water milfoil is the most abundant species	
	Presence of algae on the substrate	Low presence of diatoms algae Moderate presence of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of Powell Brook	P: good quality FC: good quality	
	Waters of West Brook	SM: good quality P: good quality FC: quality ranges from good to doubtful	
	Waters of Glen Brook	SM: good quality P: good quality FC: good quality	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Figure 4: Abundance of sediments and aquatic plants at the mouth of Powell Brook (A), West Brook (B), and a ditch near the Knowlton Landing wharf (C)



Problematic Areas

- North part of Green Bay (surroundings of Powell and West brooks)
- Glen Brook and the surrounding marinas
- 105 Brook
- Scott Brook

Environmental characteristics

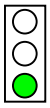
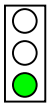
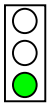
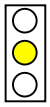
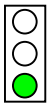
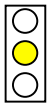
- The natural flow of water and slow slope contribute to making Green Bay and other bays located South-West of this area more prone to siltation and settlement of aquatic plants.
- The undertow and waves favor the migration of SM towards zones at least 3 meters deep.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, and urban activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Leisure activities and the high population density** in the summer (in Sargent's and Green Bay as well as around the wharf and marinas) contribute to the input in nutrients.
- **The upstream part of Powell, West, Glen, Scot and 1105 Brook** is potentially subject to erosion and fertilization. Indeed, even if at the time we visited these areas, the SM and phosphorus concentrations were low, the abundance of fine sediments and aquatic plants show the likelihood of substantial inputs. Thus, it is possible that in times of heavy rains (for example, during the heavy downfalls of spring), these brooks carry substantial amounts of sediments and nutrients which accumulate at their mouth.
- **Residential density**, a potential source of inputs (sediments and nutrients), reaches higher levels near the zones where siltation and water plant invasion are most abundant.
- **Road ditches** favor the run-off of SM and nutrients towards the lake.
- **Some heavily artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 8 % of these shores are considered highly or totally artificialized.

In short, Sargent's Bay area is on the whole in rather good health but shows signs of "premature ageing", therefore of degradation, in certain areas. On the other hand, the settlements of Eurasian water milfoil in this area happen to be dense and well spread in this area. As a matter of fact, this species could eventually invade the whole of the littoral in such a way that it would be problematic. In order to prevent the spread of the Eurasian water milfoil and to prevent the eutrophation of Sargent's Bay, it is important to set actions in motion, such as restoring the shoreline as well as reducing the input of sediments and nutrients (see chapter 10). Furthermore, road ditches, as well as Powell, West, Glen, 1105 and Scott Brook should also receive special attention since they contribute in a major way to inputs of sediments and nutrients. It would also be useful if the waters of these tributaries were characterized.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 0-5 cm	
	Type of sediments	Mainly rocks and mud	
	Total coverage by aquatic plants (median)	1 m zone : 0-10 % 2 m zone : 0-10 % 3 m zone : 0-10 %	
	Invasive species	Eurasian water milfoil is the second most abundant species in the area	
	Presence of algae on the substrate	High level of diatoms algae Moderate level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of Château Brook	SM: good quality P: good quality FC: good quality	
	Waters of Vale Brook	SM: quality ranges from good to doubtful P: quality ranges from good to doubtful FC: doubtful quality	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- Surroundings of the Vale Perkins' wharf and Vale Brook
- Surroundings of Château Brook and the landing ramp

Figure 5 : Sediment inputs coming from erosion upstream of Château Brook

Environmental characteristics

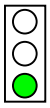
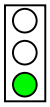
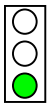
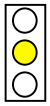
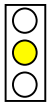
- Aquatic currents help the migration of SM from this area towards the deep zones or towards the northern end of the lake.
- The abrupt slope (rocky façade) makes this area less favorable to the settlement of aquatic plants.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, urban and recreational activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Road ditches** favor the run-off of SM and nutrients towards the lake.
- **Château Brook and Vale Brook** are likely to suffer from potential erosion and fertilization. Indeed, even if the water at the mouth of these brooks showed low levels of SM and phosphorus when our team visited the area, the abundance of fine sediments and aquatic plants at their mouth show considerable inputs. Thus, it is possible that in times of heavy rains (for example, during the heavy downfalls of spring), these brooks carry substantial amounts of sediments and nutrients which accumulate at their mouth.
- **Some artificially planned banks** in this area do not retain sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 5 % of these shores are considered highly or totally artificialized.
- **The public wharf** modifies the natural flow of water which makes the site prone to siltation and aquatic plant growth.

Vale Perkins shows as one of the least damaged areas since, in general, it shows few symptoms of "premature ageing". Also, the environmental conditions in place do not favor siltation or the multiplying of aquatic plants. However, the abundance of aquatic plants and siltation in certain spots reveal ongoing deterioration. Furthermore, the abundance of diatoms algae and green algae indicate that the water is rich in nutrients. In order to limit this ageing and to preserve the quality of water in this sector, it would be proper to set in motion certain initiatives aimed at reducing the input in nutrients and sediments (see chapter 10). Also, special attention should be devoted to the ditches, the shoreline, Château and Vale Brook, as well as the boat launching ramp and the public wharf.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone: 0-5 cm 2 m zone: 5-10 cm 3 m zone: 5-10 cm	
	Type of sediments	Mainly rocks and sands	
	Total coverage by aquatic plants (median)	1 m zone: 0-10 % 2 m zone: 10-25 % 3 m zone: 10-25 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	High level of diatoms algae Moderate level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of Bear Brook	SM: quality ranges from good to doubtful P: good quality FC: good quality	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- The portion near the boarder (surroundings of Bear Brook)
- The bay located to the West of Skinner Island

Figure 6 : Abundance of sediments on the Leadville area littoral (near Round Island)

Environmental characteristics

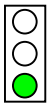
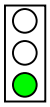
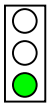
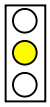
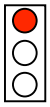
- The natural flow of water contributes to the input of SM and nutrients coming in from the United States.
- Zones suffering most from eutrophation symptoms (that is, the southern portion of this area) correspond to the zones most vulnerable to sedimentation and the growth of aquatic plants due to the littoral's soft slope.
- Undertow and waves favor the migration of SM towards the zones at least 2 to 3 meters deep.

Anthropogenic causes (of human origin)

- **Water flowing in from the United States** is rich in phosphorus. The MENV station located in the United States "varies from others inasmuch as its phosphorus readings are always higher than 10 μg/l and its waters are the least transparent in the group" (Simonneau, 2004)
- **Agricultural, forestry, urban and leisure activities** in the watershed of this area are potential sources of sediments and nutrients.
- **The few artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 6 % of these shores are considered highly or totally artificialized.
- **Road ditches** favor the run-off of soil particles towards the lake.
- The **upstream portions of Bear Brook and other brooks** are subject to potential erosion and fertilization. Indeed, even if the water at the mouth of Bear Brook showed low levels of SM and phosphorus when our team visited the area, the abundance of fine sediments and aquatic plants at its mouth shows potential inputs. Thus, it is possible that in times of heavy rains (for example, during the heavy downfalls of spring), these brooks carry substantial amounts of sediments and nutrients which accumulate at their mouth.

In conclusion, Leadville is an area that indicates few symptoms of "premature ageing", therefore of degradation. However, the formation of an organic layer on the rocks, the presence of diatoms algae and green algae, as well as the abundance of aquatic plants in certain areas all indicate that the sector is currently deteriorating. As a preventive recourse, we call upon you to instigate different actions aimed at reducing the input in nutrients and sediments (see chapter 10). In particular, the ditches and brooks in this area should receive special attention. It would also be pertinent to characterize the quality of water in these brooks.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 0-5 cm	
	Type of sediments	Mainly rocks and gravel	
	Total coverage by aquatic plants (median)	1 m zone : 0-10 % 2 m zone : 10-25 % 3 m zone : 10-25 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	Low level of diatoms algae Moderate level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of Tompkin Brook	SM: good quality P: quality ranges from good to bad FC: good quality	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- The surroundings of Cedarville Bays and Reid Bay
- Harvey Bay

Environmental characteristics

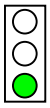
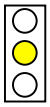
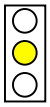
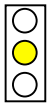
- The natural water currents contribute to the input of SM and nutrients entering with the waters flowing from the United States.
- The bays and the portion located to the East of Whetstone Island which are most vulnerable from an environmental standpoint (soft slope and stillness of water) show more symptoms of "premature ageing".
- Zones suffering most from eutrophation symptoms (that is, the southern portion of this area) correspond to the zones most vulnerable to sedimentation and the growth of aquatic plants due to the littoral's soft slope.
- Undertow and waves around Bullis Point favor the migration of SM towards the deep zones.
- The Tompkin Brook marsh catches a large portion of the sediments and nutrients coming from upstream.

Anthropogenic causes (of human origin)

- **Waters flowing in from the United States** are rich in phosphorus. The MENV station located in the United States "varies from others inasmuch as its phosphorus readings are always higher than 10 μg/l and its waters are the least transparent in the group" (Simonneau, 2004)
- **Agricultural, forestry, urban and leisure activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Some artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 16% of these shores are considered highly or totally artificialized.
- **Residential density is at its highest** near the areas most invaded by sediments and aquatic plants.
- **Road ditches** favor the run-off of SM and nutrients towards the lake.
- The upstream parts of Tompkin Brook and other brooks located in Cedarville Bay are potential subjects to erosion and fertilization.

In conclusion, sedimentation and the presence of aquatic plants do not seem to be problematic in most of the Cedarville area. However, we notice signs of siltation (presence of an organic layer on the rocks) as well as abundant green algae in many parts of this sector. Also, important aquatic plant settlements, localized in the most vulnerable parts of the area, indicate substantial inputs in SM and nutrients. Furthermore, some invasive species of aquatic plants could eventually become problematic if measures to reduce fertilization are not implemented. Various concrete actions can be taken to curb the inputs in nutrients and sediments in view of safekeeping the area's state of health and reducing such inputs (see chapter 10). Also, special attention should be devoted to the shoreline, the ditches and the various tributaries. Finally, we recommend that the brooks in Cedarville Bay be characterized.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 10-50 cm 3 m zone : 10-50 cm	
	Type of sediments	Mainly mud and rocks	
	Total coverage by aquatic plants (median)	1 m zone : 25-50 % 2 m zone : 25-50 % 3 m zone : 25-50 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	Low level of diatoms algae Low level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	

Problematic Area

- Eastern side of the area

Environmental characteristics

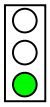
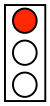
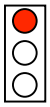
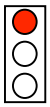
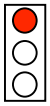
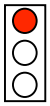
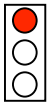
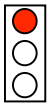
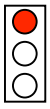
- Currents contribute to the input of SM and nutrients coming in from the North-West part of Fitch Bay.
- The narrowing of Fitch Bay (The Channel) constitutes an area naturally more propitious to siltation and aquatic plant growth.
- The relatively soft slope and the stillness of water allow for the deposit of suspended matter in the water and a more abundant settlement of aquatic plants.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, urban and leisure activities** in the watershed of this area are potential sources of sediments and nutrients.
- **The few artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 7% of these shores are considered highly or totally artificialized.
- **Residential density is highest** on the shore on the eastern side and in the North-West portion of the area and can thus bring in a lot of input (sediments and nutrients).
- **Badly maintained road ditches** favor SM run-offs into the lake.

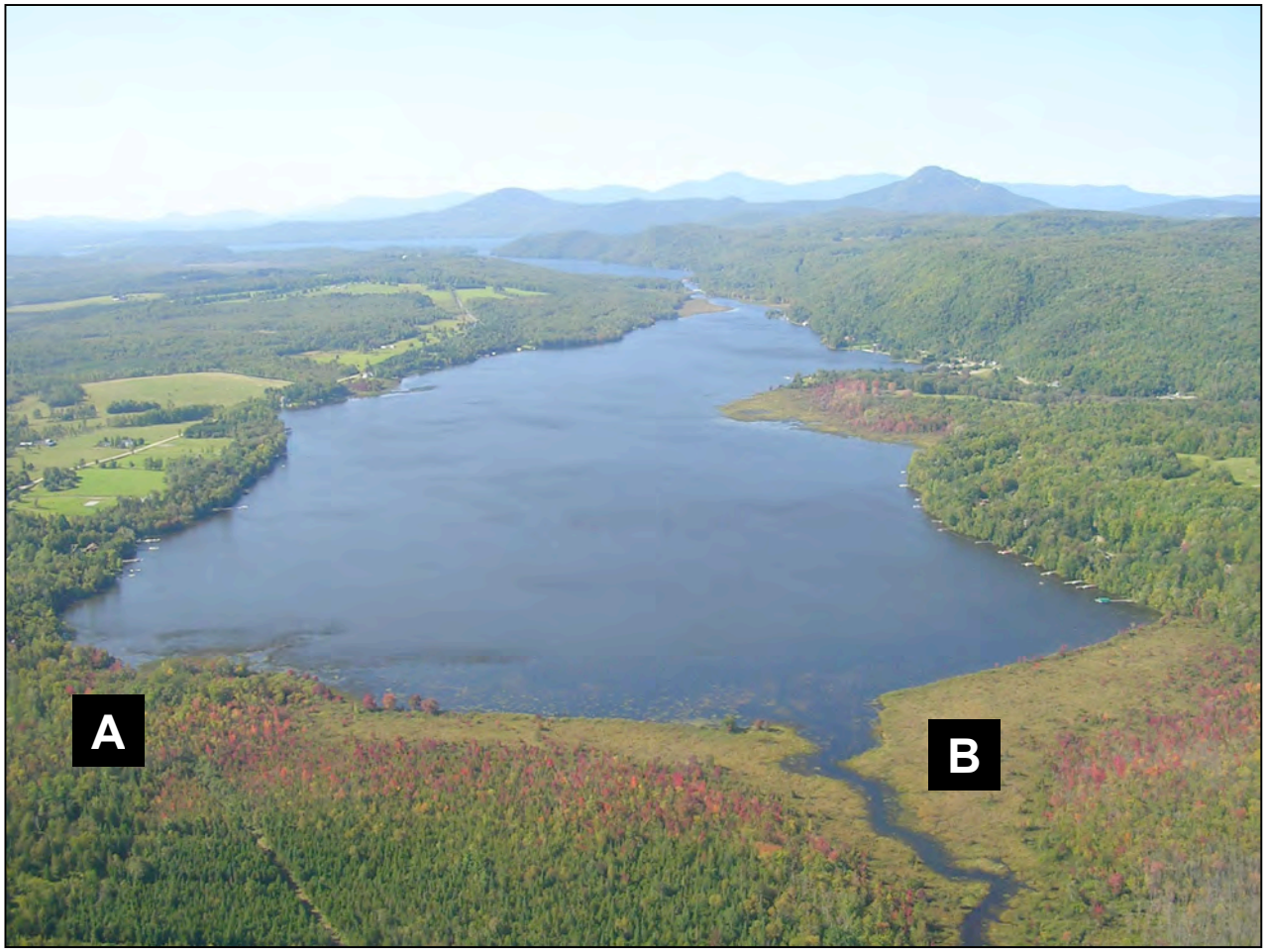
In conclusion, the Fitch Bay (Long Bay) area seems to be one of the areas indicating most symptoms of "premature ageing", and therefore, degradation. According to some comments made to us, this ageing has been perceivable for many years, but is now stabilized (see Annex, *Shoreline Residents' Perception*). The state of health of this sector (density of plants, siltation, presence of algae, water quality) is worrying and therefore will have to be addressed as a priority in the future plan of action aimed at reducing the sources of degradation of Lake Memphremagog. Reducing the input in nutrients and sediments is the key to success (see chapter 10). Special attention should be devoted to the shoreline, the North-East part of Fitch Bay as well as the ditches.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 10-50 cm 2 m zone : 10-50 cm 3 m zone : 50-100 cm	
	Type of sediments	Mainly mud and rocks	
	Total coverage by aquatic plants (median)	1 m zone : 75-100 % 2 m zone : 25-50 % 3 m zone : 0-10 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	Low presence of diatoms algae Moderate presence of green algae	
WATER QUALITY	Waters offshore	Eutrophic	
	Waters of McCutcheonBrook	SM: quality ranges from good to bad P: quality ranges from good to bad FC: quality ranges from good to bad	
	Waters of Gale Brook	SM: quality ranges from good to doubtful P: quality ranges from doubtful to bad FC: quality ranges from good to doubtful	
	Waters of Bunker Brook	SM: quality ranges from good to bad P: quality ranges from doubtful to bad FC: quality ranges from good to doubtful	
	Waters of Fitch Brook	SM: good quality P: quality ranges from good to bad FC: quality ranges from good to bad	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Figure 7 : Abundance of sediments and aquatic plants at the mouth of Gale Brook (A) and Bunker (B)



Problematic Areas

- Bunker Brook
- Gale Brook
- McCutcheon Brook
- Fitch Brook

Environmental characteristics

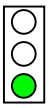
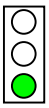
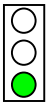
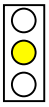
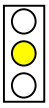
- The stillness of the water and soft slope contribute to making Green Bay favor siltation and the settlement of aquatic plants over the entire area.

Anthropogenic causes (of human origin)

- **The upstream part of Bunker, Gale, McCutcheon, and Fitch Brook** is potentially subject to erosion and fertilization, as indicated by the results gathered by the MRC.
- **Agricultural, forestry, urban and leisure activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Some heavily artificially planned banks** in this area do not retain sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 23% of these shores are considered highly or totally artificialized.
- **Road ditches** favor the run-off of soil particles into the lake.

In conclusion, the Fitch Bay area (North East) is the sector that shows the most severe symptoms of "premature ageing", as attested by the sedimentation, the invasion by aquatic plants, the proliferation of green algae and the poor quality of its waters. This sector will have to be addressed as a priority in the future plan of action aimed at reducing the sources of degradation of Lake Memphremagog. The main actions to be taken should include a reduction in the inputs of nutrients and sediments which travel through the ditches and Bunker, Gale, McCutcheon and Fitch Brook, as well as the restoration of the artificially planned shoreline (see chapter 10).

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Natural shoreline	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 0-5 cm	
	Type of sediments	Mainly rocks and gravel	
	Total coverage by aquatic plants (median)	1 m zone : 0-10 % 2 m zone : 0-10 % 3 m zone : 0-10 %	
	Invasive species	Eurasian water milfoil and broad-leaved pondweed are present but not abundant	
	Presence of algae on the substrate	Low level of diatoms algae Low level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic	
	Waters of Lime Kiln Brook	SM: quality ranges from good to doubtful P: good quality FC: doubtful quality	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Area

- Lime Kiln Bay area (Lime Kiln Brook and a unnamed brook)

Environmental characteristics

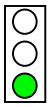
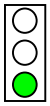
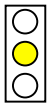
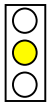
- Currents contribute to the input of suspended matter flowing in from adjacent sectors.
- Undertow and waves favor the migration of SM towards the deep zones and limit the growth of aquatic plants.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, and urban activities** in the watershed of this area are potential sources of sediments and nutrients.
- **The essentially natural shoreline** in this area prevents sediments or nutrients from entering the lake and contributes to the cool temperature in shallow waters. 78% of these shores are considered natural.
- **Road ditches** favor SM run-offs into the lake.
- **The upstream part of Lime Kiln Brook and that of other brooks in this area** are potential subjects to erosion and fertilization. Even if the water at the mouth of Lime Kiln Brook showed low levels of SM and phosphorus when our team visited the area, the abundance of fine sediments and aquatic plants at its mouth indicate probable inputs. Thus, it is possible that in times of heavy rains (for example, during the heavy downfalls of spring), these brooks carry substantial amounts of sediments and nutrients which accumulate at their mouth. The presence of fecal coliforms in this tributary indicates a pollution of fecal origin combined with nutrient pollution.

The Magoon Point area shows very few symptoms of "premature ageing", and therefore, of degradation. The natural aspect of the shoreline combined with environmental characteristics which make it less favorable to sedimentation and water plant growth help maintain this part of the lake in good health. However, restoration of the few spots where the banks have been artificially planned remains to be done. Control of potential nutrient and sediment inputs constitute another strategy to adopt in order to preserve the state of health of this sector and prevent any eventual deterioration (see chapter 10).

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 5-10 cm	
	Type of sediments	Mainly rocks and mud	
	Total coverage by aquatic plants (median)	1 m zone : 25-50 % 2 m zone : 25-50 % 3 m zone : 25-50 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	Low level of diatoms algae Low level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic	

Problematic Area

- The area north of Long Island (around the brooks)

Environmental characteristics

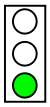
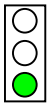
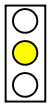
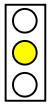
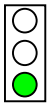
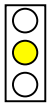
- Currents contribute to the input of suspended matter coming in from the adjacent sectors.
- The stillness of waters and the soft slope near Long Island make this zone more vulnerable to siltation and the settlement of water plants in comparison to the rest of the area.
- Undertow and waves favor the migration of SM towards zones at least 3 meters deep.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, urban and leisure activities** in the watershed of this area are potential sources of sediments and nutrients.
- **The few heavily artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters (6% of these shores are considered highly or totally artificialized).
- **Road ditches** favor the run-off of soil particles into the lake.
- **The upstream part of the brooks** is potentially subject to erosion and fertilization.

In conclusion, the Molson Landing sector is an area where sedimentation is not problematic on the littoral; however, the 3 meter zone shows invasive aquatic plant settlements which could become a nuisance if preventive measures are not taken (see chapter 10). Moreover, in order to prevent "premature ageing", special attention should be devoted to the shoreline, the ditches and the upstream part of brooks which feed this area.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone: 0-5 cm 2 m zone: 0-5 cm 3 m zone: 5-10 cm	
	Type of sediments	Mainly rocks and gravel	
	Total coverage by aquatic plants (median)	1 m zone : 10-15 % 2 m zone : 25-50 % 3 m zone : 25-50 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	Low level of diatoms algae Moderate level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic	
	Waters of Boyton Brook	SM: good quality P: good quality FC: good quality	
	Waters of Taylor Brook	SM: good quality P: good quality FC: quality ranges from good to doubtful	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- The end of MacPherson Bay (Taylor Brook and unnamed brook)
- The end of Quinn Bay (Boyton Brook and unnamed brook)

Figure 8 : Inputs of sediments resulting from erosion upstream of Taylor Brook

Environmental characteristics

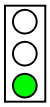
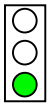
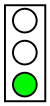
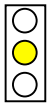
- Water currents contribute to the input of suspended matter coming in from adjacent sectors.
- The soft angle of the slope and the stillness of the waters in the end part of each bay favor siltation and settlement of aquatic plants.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, and urban activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Some heavily artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 18% of these shores are considered highly or totally artificialized.
- **Residential density**, which can create more sources of inputs (sediments and nutrients), reaches higher levels near the zones where siltation and water plant invasion are most abundant.
- **Road ditches** favor the run-off of SM and nutrients towards the lake.
- **The upstream portions of Taylor, and Belmere Brook** are potentially subject to erosion and fertilization. Indeed, even if at the time when we visited these areas, the SM and phosphorus concentrations were low, the abundance of fine sediments and aquatic plants at their respective mouth show probable substantial inputs. Thus, it is possible that in times of heavy rains (for example, during the heavy downfalls of spring), these brooks carry substantial amounts of sediments and nutrients which accumulate at their mouth. The presence of fecal coliforms in the water of Taylor Brook indicates pollution of fecal origin.

The area of Quinn and MacPherson Bay appears to be a sector where sedimentation is having little effect on the littoral; however, the 3 meter zone shows signs of siltation in many spots. For its part, the water plant invasion seems more preoccupying. Besides, aquatic plant species which are considered invasive could become more problematic if effective measures aimed at reducing nutrient and sediment inputs are not taken (see chapter 10). Furthermore, in order to prevent this area's "premature ageing", special attention should be paid to shorelines, ditches as well as to Taylor and Belmere Brook.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Low level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 0-5 cm	
	Type of sediments	Mainly rocks and gravel	
	Total coverage by aquatic plants (median)	1 m zone : 0-10 % 2 m zone : 0-10 % 3 m zone : 10-25 %	
	Invasive species	Eurasian water milfoil is the dominant species in the area	
	Presence of algae on the substrate	Moderate level of diatoms algae High level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic	

Problematic Areas

- Georgeville wharf (Tuck Bay)
- 1103 Brook

Environmental characteristics

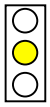
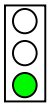
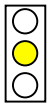
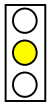
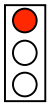
- The undertow and strong exposure to waves favor the migration of suspended matter towards the deeper zones.
- The abrupt slope makes this area less favorable to the settlement of aquatic plants.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, and urban activities** in the watershed of this area are potential sources of sediments and nutrients.
- **The few artificially planned banks** in this area do not prevent sediments or nutrients from entering the lake and contribute to the temperature increase in shallow waters. 2% of these banks are considered totally artificialized and 53% are mildly or moderately artificialized.
- **Residential density** is highest in this area near the zones where water plant invasion is ongoing.
- **Road ditches** favor the run-off of soil particles into the lake.
- **The upstream part of 1103 Brook** is potentially subject to erosion and fertilization.

The Georgeville area shows only a few signs of "premature ageing", therefore of degradation. However, the abundance of green algae reveals localized sources of pollution by nutrients. Furthermore, the Eurasian water milfoil is plentiful in diverse areas and could become problematic if measures are not taken to curb the input in fertilizers. The main steps to be taken consist in maintaining the natural shoreline, restoring the few artificially planned banks as well as reducing erosion and various types of fertilizer inputs (refer to chapter 10). Special attention should be given to Tuck Bay (Georgeville wharf), ditches, as well as 1103 Brook. It is recommended that the water quality of this tributary be analyzed.

State of Health Summary

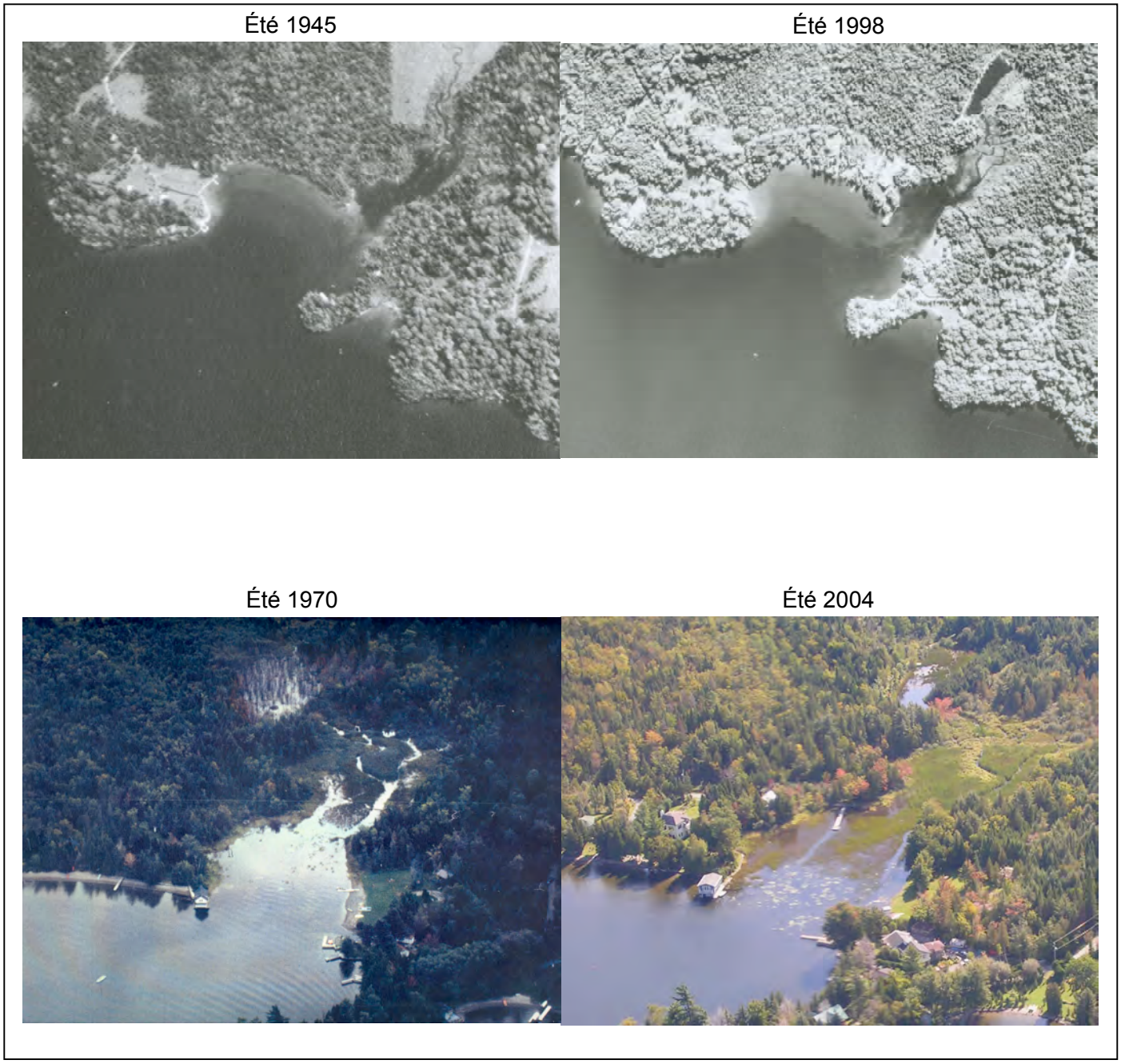
	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Moderate level of artificiality	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 0-5 cm 3 m zone : 0-5 cm	
	Type of sediments	Mainly rocks and mud	
	Total coverage by aquatic plants (median)	1 m zone : 10-25 % 2 m zone : 25-50 % 3 m zone : 25-50 %	
	Invasive species	The three invasive species are moderately abundant	
	Presence of algae on the substrate	High presence of diatoms algae Moderate presence of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	
	Waters of Oliver Brook	SM: bad quality P: quality ranges from doubtful to bad FC: quality ranges from doubtful to bad	

SM: Concentration of suspended matter **P:** Concentration of phosphorus **FC:** Fecal coliforms

Problematic Areas

- Oliver Brook (especially at the water quality level)
- Cove Bay

Figure 9 : Evolution of Oliver Bay's siltation



Environmental characteristics

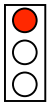
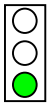
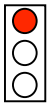
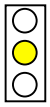
- The bays are more vulnerable to siltation and the settlement of aquatic plants considering their slow slope and the stillness of their waters.
- The undertow and strong exposure to waves favor the migration of suspended matter towards the deeper zones.

Anthropogenic causes (of human origin)

- **Agricultural, forestry, and urban activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Certain heavily artificialized banks** in this area do not retain sediments or nutrients and contribute to the temperature increase in shallow waters.
- 36% of these banks are considered heavily or totally artificialized.
- **Road ditches** favor the run-off of soil particles into the lake.
- **The upstream portions of other brooks in this area (1099 & 1097)** are potentially subject to erosion and fertilization.

In conclusion, the Eastern Part area is a sector where sedimentation is less problematic on the littoral, but where siltation is currently at play in many spots (organic layer on the rocks). The settlement by water plants seems equally preoccupying. In addition, aquatic plant species which are considered invasive could become more problematic if effective measures aimed at reducing nutrients and sediments inputs are not taken (refer to chapter 10). The main recourses include, among others, restoring the artificially planned shoreline as well as a reducing erosion and various types of abusive fertilization. Marinas, ditches as well as Oliver Brook should receive special care. Furthermore, it seems important that the quality of water in the area's other brooks be characterized in order to better identify the causes for the degradation of the bottom part of all these little bays which are more vulnerable to premature ageing.

State of Health Summary

	Parameters	Assessment	
STATE OF THE SHORELINE	Degree of artificiality	Highly artificialized shoreline	
STATE OF THE LITTORAL	Thickness of sediments (median)	1 m zone : 0-5 cm 2 m zone : 5-10 cm 3 m zone : 5-10 cm	
	Type of sediments	Mainly rocks and mud	
	Total coverage by aquatic plants (median)	1 m zone : 25-50 % 2 m zone : 25-50 % 3 m zone : 50-75 %	
	Invasive species	The three species considered invasive are not problematic	
	Presence of algae on the substrate	Moderate level of diatoms algae Moderate level of green algae	
WATER QUALITY	Waters offshore	Mesotrophic (early stage)	

Problematic Area

- The bay to the East of Lafrenaye Point (mouth of the brook)

Environmental characteristics

- Aquatic currents contribute to the input of suspended matter coming in from the adjacent sectors.
- The stillness of waters and the soft slope in the bay East of Lafrenaye Point make this zone more vulnerable to siltation and the settlement of water plants.
- Undertow and waves favor the migration of SM towards zones at least 3 meters deep.

Anthropogenic causes (of human origin)

- **Heavily artificialized banks** in this area do not retain sediments or nutrients and contribute to the temperature increase in shallow waters. 65% of these banks are considered heavily or totally artificialized.
- **Residential density** is highest in this area near the zones where water plant invasion is ongoing.
- **Agricultural, forestry, and urban activities** in the watershed of this area are potential sources of sediments and nutrients.
- **Road ditches** favor the run-off of soil particles into the lake.
- **The upstream part of the brook East of Lafrenaye Point** is potentially subject to erosion and fertilization.

In conclusion, the Three Sisters area is a sector where sedimentation is less problematic on the littoral, but where siltation is currently at play in many spots (organic layer on the rocks), especially at the 3 meter mark. Environmental characteristics of the area facilitate the migration of SM towards the deeper zones. However, the invasion by water plants seems preoccupying since the settlements' density is indicating eutrophic areas. Moreover, the presence of green and diatoms algae reveal that the water is rich in nutrients. In order to limit the abnormal growth of plants, effective measures aimed at reducing nutrient and sediments input have to be taken (refer to chapter 10). Special care should be given to the restoration of the artificially planned shoreline as well as to the reduction of erosion and fertilization near the lake. It is also recommended that the quality of the water transiting through the tributary located in the bay East of Lafrenaye Point be characterized.

Chapter 10 : Solution proposals

Activities held within the shoreline environment play a significant role in Lake Memphremagog's state of health. Daily events taking place in the watershed area can equally pollute the lake and its tributaries. Thus, all the concerned parties in the area, mainly MCI, regional decision makers (municipalities, MRC, government), shoreline residents and other citizens, as well as the farming, forestry and business communities have a responsibility towards the safekeeping of the lake and its tributaries. All of these key players can - and must – make concrete gestures to limit the sources of degradation and help preserve this irreplaceable resource for future generations. In this chapter, we describe the main solution proposals to the aforementioned parties. But firstly, it is important to remember that any precise and effective intervention must respect two important basic principles:

1- **Reducing the input in sediments by better controlling soil erosion.**
(Control of ground stability and reduction in the removal of vegetation)

2- **Reducing the input in nutrients such as phosphorus and nitrogen.**

10.1 MCI

Memphremagog Conservation Inc. (MCI) is a representative of Lake Memphremagog's shoreline population – including that of Vermont – and has been involved for over 35 years in the protection of the quality of the lake. Here are a few suggestions to help it further its cause:

Involve the territory's administrators in the creation of a management committee for Lake Memphremagog and to participate in various consultation meetings
While collaborating with the various government officials involved, a committee must be formed to act as a political authority and management body for the whole of Lake Memphremagog and its tributaries. Within this committee, territorial administrators would call upon other concerned parties in the area as well as citizens to draw up and implement a global plan of action aimed at protecting the lake (please refer to the section about management). Overlap with other existing commissions (Urban Planning Commission, MRC Environment Committee, Québec/Vermont Commission) should be avoided.

Support the administrators (municipalities, MRC, government) in the protection of the shoreline and in the control of soil erosion and nutrient inputs
Mangers involved should be encouraged to use concrete means to reduce the sediment and nutrient inputs into the lake (i.e. Inferior Third method for ditch maintenance, anti-erosion structures for steep slopes, prohibition of pesticides, herbicides and chemical fertilizers for aesthetic use near a body of water). Problematic cases should be reported to the authorities in order for corrective measures to be taken.

Support the administrators in getting Vermont more involved in the analyses of the lake's state of health
Vermont should be supported and encouraged to set up a study of the littoral, the tributaries and the environment as a whole on the American side of the lake. The Québec/Vermont Commission could be useful to this end.

Organize, in collaboration with the territory's administrators, a widespread information and awareness campaign about ecological lawn caretaking
Using flyers, conferences and on-site workshops, this action would help educate the public about the negative impact of using pesticides and chemical fertilizers as well as provide alternative methods for the care of lawns and flower beds, especially on the shoreline.

Participate, along with the territory's administrators, in a study of the lake's watershed
This would help identify the specific causes for the degradation of the lake's tributaries

Support the administrators in pursuing and completing the study of the lake and its tributaries' state of health
Until now, excellent work has been accomplished by MCI, the MRC, RAPPEL and the MENV as well as by other organizations in studying and monitoring the water quality of Lake Memphremagog and of its tributaries. However, it is important to pursue data gathering by increasing both the frequency of sampling and the number of tributaries studied in order to obtain a more precise appraisal of the situation. Markers should also be used to better assess and monitor the effect of measures taken to remedy the situation.

Organize a shoreline restoration campaign
The importance of vegetation along the shoreline (3 strata) should be advertised as the last line of protection for the lake during on-site workshops destined to educate shoreline residents. These workshops should include explanations and concrete demonstrations on how to restore the banks. Energy should be focused on the "Head of the Lake" (North of the lake) and the Fitch Bay area.

Name and support an "Environmental Protector" for each "zone" of the lake
This person would receive information and redirect it towards the proper authorities. This measure would ensure the close monitoring of any action taken and guarantee that shoreline residents are well informed.

Municipalities and the MRC play a key role in protecting Lake Memphremagog. Indeed, they are essential in the education of citizens with respect to the safekeeping of the environment, in the promotion of this will, in the supervision of the territory's urban planning as well as in the creation and application of legislation. In keeping with these various roles, we propose the following solutions, to be prioritized according to need.

Education

Raising awareness remains an excellent means of ensuring the lake's good health. Some people mistreat the environment with a behavior that has a negative impact on the aquatic ecosystem simply because they don't know that their actions indeed cause harm. It is therefore recommended that users of the lake be sensitized to the reasons and means to better preserve the natural shoreline and to restore the zones which are currently degraded.

Provide information kits to new residents on good and bad practices in a shoreline environment and on the rules and regulation protecting the aquatic ecosystems
In order to prevent further prejudice to aquatic ecosystems, it is important to raise the awareness of new residents on the shoreline about rules and regulations, the negative impact of certain shoreline uses and about concrete ways to better preserve their lake.

Inform and heighten the awareness of the various involved parties (shoreline residents, foresters, agricultural workers) on the importance of protecting the lake's shoreline and its tributaries
To this day, the shoreline is a biological, economical and legal entity which is both poorly known and respected by involved parties in the area.

Launch, in collaboration with MCI, a vast information and awareness campaign on ecological lawn caretaking
This campaign would use flyers, conferences and on-site workshops to spread information about the negative impact of pesticide and chemical fertilizers on the environment. Ecological alternatives could be proposed for lawn and flower bed caretaking in a shoreline environment.

Inform and heighten the awareness of shoreline residents about the lake and its tributaries' state of health, its evolution and sources of degradation
In order to mobilize the population, citizens must be made aware of the lake's state of health and of the consequences of the present situation on the ecosystem, on consuming, swimming, fishing and on the area's economy.

Organize information sessions with professionals (e.g. ministerial experts and concerned groups) about the lake's state of health and the sources of its degradation
This should help make shoreline residents better users of the territory and better protectors of the environment.

The management of ditches is a key factor which falls directly under the administrators' supervision. Indeed, about 50% of the waters which feed into the lake transit through ditches before reaching it (RAPPEL). These poorly maintained ditches (where vegetation has been completely removed) are easily subject to erosion and help deteriorate the quality of the water that circulates through them. Less oxygenated, warmer and charged with suspended matter and various polluting agents, this water asphyxiates bodies of water. In order to ensure better care of ditches:

Systematically apply the Inferior Third method while cleaning ditches
This economical and ecological technique allows on one hand better filtration of SM, cooler temperatures and more oxygen in the water, which in turn reduces the amount of siltation in bodies of water. On the other and, it also allows a cut-back of 20% in cleaning and maintenance costs spent on ditches by reducing the frequency of maintenance visits and the amount of clearing (MTQ, 1998).

To find out more: *Le fossé écologique… et économique* (RAPPEL, 1999)
Fiche de promotion environnementale FPE-01 de Transports Québec (MTQ, 2000)

Install anti-erosion structures (verges or sills) in road ditches where the incline is steeper than 7 degrees
This measure prevents water which circulates in the ditches from becoming erosive by slowing down the speed of the flow.

To find out more: *Guide de lutte à l'érosion des sols mis à nu* (RAPPEL, 2003)

The management of municipal polluting effluents is another important task under the territorial administrators' supervision. To better manage effluents:

Respect the capacity of water-treatment plants
The capacity of treatment plants must allow for adequate treatment of all the water used for residences and industries to which these plants are connected in order to prevent overflowing. This could limit the proliferation of aquatic plants as well as that of pathogen microorganisms which alter the health of the water and water network.

Avoid the backwash of overflows
These can be eliminated if combined domestic and rain water networks are isolated from one another and by creating retention traps in determined areas.

Store de-icing salts and snow removal deposits on impermeable ground
It is also important to ensure that snow removal deposits be placed at a good distance from any body of water and to catch the sedimentation they contain before it has a chance of seeping back into the water network. These removal sites should be managed according to safety guidelines.

Choose de-icing salts which are less toxic to the environment

Protecting Lake Memphremagog's watershed involves many levels of government. Consultation is essential, so that everyone can play their part and people can get involved. Here are some proposals :

Involve the population and citizen groups further in protecting the environment
Citizens and citizen watch-groups are excellent wardens of the lake's state of health. As such, they must be "equipped" and granted power and responsibilities (for example, the education of newcomers in the area about rules and regulations in place on the lake's shoreline); this strategy has proven itself to be quite efficient.

Simplify procedures for lodging complaints about environmental abuse
Citizens are the territorial administrators' eyes on the ground. It is therefore essential to manage efficiently - as well as follow up on - all of their complaints.

Harmonize the legal framework by promulgating and ensuring the coherence of all municipal by-laws within the Memphremagog MRC's urban development plan
This measure should facilitate the management of protective regulations while augmenting their effectiveness.

Further involve Vermont State in analyzing the lake's state of health
Vermont must be called upon to lead a study of the littoral on the American side of Lake Memphremagog, as well as its tributaries and watershed.

Conduct further studies on the lake and its tributaries
Acquiring data regarding the lake, its tributaries and their sources of degradation is the best way to draw a precise picture of the lake's present state of health. Markers should be used to better monitor the situation and evaluate the impact of decisions taken. Results should be made public on a wide scale.

Draw a precise portrait of the uses made of the territory comprising the lake and its watershed
To this end, a management committee (having political power) would be put in charge of protecting the lake while involving concerned municipalities (Québec & Vermont) and citizens in the area. This committee's task would be to devise a plan of action as well as a list of strategies to be put into use in the near and distant future by order of priority (according to the severity of the negative impact sustained, the ease of implementation, the availability of concerned parties and the money at hand); it should also set a precise timetable, and afterwards act upon these measures! The implementation of a concrete plan of action is necessary to ensure the quality of lakes (Goupil, 2002).

Organize meetings to address better ways of protecting the environment
Representatives of involved parties (local administrators, concerned professional groups, ministerial experts in the area, MCI, RAPPEL, etc.) need a forum where dialogue can take place.

Regulation

The existing legislation aims at ensuring a global protection of the water; however, several shortcomings exist. In addition to passing by-laws which comply with the MRC Urban Development Plan, municipalities can also pass supplementary protective measures to respond to a particular situation or to address some of these shortcomings (Goupil, 2002). Here are some proposals:

Protect bodies of water as well as vulnerable, fragile or sensitive locations
Certain remarkable wooded areas, spawning grounds, wetlands and shoreline must be better protected so that their durability and ecological role is guaranteed. Before subdividing a lot or emitting a building permit, the presence of any body of water or wetland should be taken into consideration so as to ensure their protection.

Verify that the bodies of water appearing on the MRC Urban Development Plan are listed exhaustively and complete the list if necessary
All of the identified bodies of water on the place names register established at a 1/20 000 scale in 1978 appear on the MRC plan and are protected. However, many streams with either permanent or intermittent flow as well as certain wetland areas important to the lake are likely not to be listed on the map. To include these bodies of water in that list is the first step in protecting them. Moreover, it is recommended that a single definition for "streams" be adopted (government, MRC, municipalities) in order to avoid confusion as much as possible.

Regulate the use of pesticides for aesthetic purposes on residential lawns, more especially in the wooded areas within a 300 meter band around the lake
Considering the undeniable negative impact these pesticides have on aquatic ecosystems, many municipalities in Québec, including some located around Lake Memphremagog, have adopted such regulation. Furthermore, as is the case for public and parapublic lawns since 2003, it will be forbidden to use certain pesticides (the most harmful ones) on private lawns as of April 2006 (MENV- Québec).

Adopt a by-law controlling sediments on construction sites
In the space of only one year, 10 to 100 tons of soil can be removed from construction sites or wherever the ground is laid bare. However, there are numerous techniques which could be used to curb down this excessive erosion (please refer to section 10.5).

To find out more: *Guide de lutte à l'érosion sur les sites de construction ou de sols mis à nu* (RAPPEL, 2003)
Règlement-type municipal pour le contrôle de l'érosion (RAPPEL, 2002)

Lower to 2 ha the dimension of wetlands to be protected and include these on the list stated by the MRC Urban Development Plan
According to the *Law on Fauna Habitats* (LFH), all wetlands of 5 ha or more are *de facto* protected. However, considering how rare and ecologically important they are, wetlands of smaller dimension should also be protected. To this end, Article 22 of the *Law on the Quality of the Environment* (LQE) can protect any wetland when interventions or construction is planned.

Controlling

In many cases, the current legislation should be sufficient to ensure the lake's protection but it is not always respected. For example, despite clear bylaws about respecting the natural state of vegetation within a certain distance from the shoreline, we must admit that these regulations are often disregarded. Better control to ensure respect of the environment is a must.

Verify that the regulation about respecting the lake's shoreline and its tributaries is enforced
Considering the many roles it plays, the portion of the shoreline within the first 10 or 15 meters from the water (according to the slope) around lakes and streams must be respected. It is highly recommended that municipal inspectors be properly trained and supported in enforcing these bylaws.

To find out more: *Guide des bonnes pratiques pour la protection des rives, du littoral et des plaines inondables* (Goupil, 2002)

Make sure septic installations on isolated properties are complying with the law
The characterization of the use and state of septic installations (septic tanks and drainfields) as well as an appraisal of their functionality constitute an excellent way to prevent polluting runoffs. Municipalities have the obligation to ensure the conformity of these installations on their territory.

To find out more: *Règlement sur l'évacuation des eaux usées des résidences isolées*

Make sure septic installations are emptied when needed
In order to do so, municipalities can create a register which evaluates the need for sewage removal and in which companies performing the removal must put a copy of the receipt for the removal.

Ensure that business owners respect the environmental protection laws and bylaws
Construction company operators, industries, landfills, golf courses, marinas, camping grounds and all other businesses must comply with MENV and municipal regulations.

Implement a restoration plan for landfills which are no longer operational
These sites can become important sources of sediments and pollutants.

Make sure that lots sold have sufficient space
In order to allow for at least 50% of natural forest cover, lots sold must be at least 3716 m^2 (40, 000 square feet) so as to fit within the framework of lakeside wooded property provided by the *Law on Urban planning and territorial management in Québec* (Bill 125).

People who decide to settle on the shoreline of a lake usually do so in order to find a quality of environment that enables them to engage in activities such as swimming or fishing. However, for that quality to endure, shoreline residents who live on the Memphremagog or one of its tributaries must be particularly mindful of the impact that these activities can have. Shoreline residents can avoid deteriorating the ecosystem any further and even help in the long run to improve the lake's state of health by safekeeping the natural characteristics along the shoreline, by making sure their septic system is complying with the law and, on the whole, being more respectful of the lake.

Natural Characteristics of the Lake

A lake that keeps its natural characteristics is a lake that remains beautiful and a source of attraction for the public. However, many banks on the Memphremagog, just like many other lakes in the area (RAPPEL, 2000 & 2004) are undergoing worrying changes in their natural characteristics. It is undeniable that the artificial planning of the shoreline has a negative impact on the aquatic ecosystem: soil erosion and run-offs, undue increases in water temperatures, siltation of the bottom, water plant proliferation and premature ageing. Moreover, artificially planned banks have less value on the real estate market compared to natural ones (Dubé, 1998). Here are a few suggestions that would allow for the preservation of the banks' natural character that is so indispensable to the lake's preservation, its ecology, biology and its economic worth.

To find out more: *Stratégies de l'environnement des lacs* (McNeil, 2004)
Guide des bonnes pratiques pour la protection des rives, du littoral et des plaines inondables (Goupil, 2002)
Guide de renaturalisation des rives (RAPPEL, 2001)

Respect the shoreline integrity

The vegetation strip surrounding a lake or a waterway is vital to aquatic ecosystems since it keeps erosion in check, filters nutrients, cools off the water, and provides a habitat to fauna. This strip must be at least 10 to 15 meters wide (according to the steepness of the slope) starting from the highest water mark on the shoreline (Goupil, 2002). The shoreline strip is usually composed of three natural vegetation stratums (herbaceous plants, shrubs, and trees). When damaged, the shoreline must be restored by letting the grass grow (and letting nature do its own work) or by planting various indigenous species.

When the shoreline needs to be stabilized, it is important to do so using the most natural way possible

A steep lot, strongly eroded, or where the shoreline is highly exposed to waves can necessitate supplementary stabilization work. When such is the case, it is preferable to prioritize whichever technique that will facilitate the settlement of vegetation in order to reestablish the banks' natural character (Goupil, 2004). Different structures of vegetal engineering (fascines, brushwood fenders, branch mats) can thus be used to this end.

Revegetate artificially planned banks
Covering the walls, low walls and gabions (in wood, concrete, or rocks) with plants and shrubs helps to curb down excessive increases in water temperature caused by these structures; it also helps to further stabilize the shoreline and offers a more natural transition between land and water environments, not to mention the economic factors stated previously.

Integrate lawns to nature and ensure natural vegetal coverage on at least 60% of lakeshore properties
An integrated lawn – with a minimal area behind the natural strip – provides a pleasant area for sunbathing and has a lesser negative impact on the lake than typical urban lawns. In order to ensure minimal human impact, it is important to maintain natural cover on at least 50% of a property's total area when the said property is inferior in size to 3716 m^2. When the property's total area is superior to that number, then at least 60% of it should be maintained in a natural state. It is also recommended to favor the lawn's biodiversity by using a mix of grass and clover.

Create a "green window" to give access to the lake
When the slope is inferior to 30%, create a 5-meter wide path that runs at a 60 degree angle parallel to the shoreline. When the slope is upwards of 30%, it is preferable to use stairways instead, while preserving the shrub and grass stratums (Goupil, 2002). This "green window" provides access to the lake without compromising the integrity of the shoreline strip and without creating erosion.

Adequately build and renovate wharves, launching ramps and boathouses
In order to guarantee the free flow of water, the protection of spawning grounds and to avoid sedimentation beds as well as aquatic plant proliferation, it is compulsory to build structures on piles. Moreover, it is preferable to build and renovate with inert materials and untreated wood (tamarack & cedar), aluminum or plastic.

To find out more: *Guide des bonnes pratiques pour la protection des rives, du littoral et des plaines inondables* (Goupil, 2002)
ABC des quais (Burns, 2002)

Never cog or dredge the littoral; never build directly on the lakebed
Current laws must be respected in order to protect spawning grounds located in these areas and to prevent the destruction of the aquatic ecosystem.

Caretaking of lawns and flowerbeds
Caretaking of lawns and flowerbeds is one of the biggest sources of degradation affecting bodies of water (RAPPEL, 2000). Indeed, a lawn cannot prevent erosion, nor can it act as a filter for nutrients or prevent water form becoming warmer. Furthermore, a great amount of fertilizers and pesticides used on a lawn seep into the surrounding bodies of water. The negative impact these have on local fauna (fish and batrachians) is undeniable. However, it is possible to maintain a healthy and splendid lawn without adding to the lake's degradation. In order to do so, please refer to the following titles:

To find out more: *Pelouses et couvre-sols* (Smeesters, 2002)
Trousse d'action de la Coalition pour une alternative aux pesticides (CAP, 2004)

Abolish the use of chemical fertilizers within a 300 meter strip around the lake
Spreading fertilizers and chemical minerals - quickly released and easily carried off by rain (wash-off) should be abolished within a 300 meter strip around the lake in order to avoid abnormal aquatic plant proliferation.

Limit the use of organic fertilizers as much as possible
Regular inspection on the ground as part of an integrated plan of action would allow for the early identification of harmful agents at play. If all preventive methods fail and the use of pesticides becomes warranted, then only the products with the least impact on human health and the environment should be used. As of April 2006, it will be forbidden to use the most harmful types of pesticides on private property – as is the case with public and parapublic lawns since 2003.

Private septic installations and used water treatment

For many years, water pollution caused by private septic installations was a serious problem in Québec. Thanks to a change in mentality and in practices, it is no longer the case today, since all used waters must be treated through the means of septic installations in accordance with the *Bylaw on the evacuation and treatment of used waters of isolated properties*. However, it is important to remain watchful and to pay attention to certain aspects:

To find out more: *L'installation septique traditionnelle* (Le Sauteur, 2004)
Règlement sur l'évacuation et le traitement des eaux usées des résidences isolées

Ensure the load capacity and usability of the septic tank, inspect its level on a regular basis and have it emptied when necessary
These measures allow the septic installation system to work at its best, while avoiding costs linked to a blocked system and preventing run-offs which contaminating bodies of water.

Do not clog the septic tank with matter that cannot decompose
In order to prevent clogging up the septic tank, non-biodegradable waste should not be discarded into it (cigarette butts, sanitary napkins, hair…).

Protect and avoid overloading the septic installation
Rain run-offs should never be channeled towards the septic installation. Cars and trucks should avoid circulating above the leaching field and grass should be grown above it. Cleaning products containing phosphates and other pollutants should also be avoided

To show both public-spiritedness towards other users of the lake and respect for the environment pays off. Here are some behaviors which should be adopted:

Drive in a safe and responsible manner, especially close to the shore
The idea is to circulate on the lake, particularly near the shore, in order to avoid creating big waves which erode the banks. To do so, speed limits proposed in MCI's Code of Ethics and in Fisheries and Oceans Canada's *Boating Restriction Regulations* should be respected.

To find out more: *MCI's Code of Ethics* (2004)
Boucher Report (Boucher, 1999)
Nautical Safety Guide (FOC, 2003)

Avoid using vessels which are susceptible of being invasive and harmful to the lake
Certain types of small vessels (cigarette boats and personal watercrafts) create more damage to the lake than others; this should be taken into account when buying or renting such vessels.

To find out more: *MCI's Code of Ethics* (2004)

Avoid feeding ducks and other migrating birds
Feeding such birds attract them to the lake in greater numbers and for longer periods of time than usual. Bird droppings help reduce the water's quality by bringing phosphorus and fecal coliforms into it.

To find out more: Contact MCI, RAPPEL or other environmental groups

To act as a protector of the environment on the ground
It is the shoreline residents' responsibility to help support territorial administrators by denouncing acts which harm the environment as well as practices deemed abusive. Moreover, other shoreline residents must be made aware of good uses and practices and be kept up to date about the activities of groups dedicated to the lake's protection

To find out more: Contact your local municipal environment inspector
Contact MCI, RAPPEL or other environmental groups

Large-area pollution caused by farming has become a major problem everywhere in Québec (BAPE, 2000), and the Memphremagog watershed is no exception. In 1993, the Québec/Vermont Commission stated that large-area pollution constitutes the main source of phosphorus inputs into the watershed of the lake (QVC, 1993). Due to Québec's climactic conditions, all areas where natural cover has been removed are subject to soil erosion. Studies reveal that one (1) acre of farmland in a slow slope left without vegetal protection can mean run-offs into the watershed of up to seven (7) tons per annum (ODNR, 1996). This excessive erosion – in addition to causing stream siltation – constitutes an economical problem for any enterprise's productivity. Protecting the environment may seem like spending important amounts in the short term, but in the long run, the economical benefits vastly outweigh the invested sums. Furthermore, MAPAQ offers financial help to farmers and agricultural workers who want to reduce the amount of pollution they put out through an assistance program called *Prime Vert*. Here are some concrete suggestions to reduce agricultural pollution.

Shoreline Strip

Many studies (Doucet, 1998) have demonstrated that granting cattle free access to streams contributes to the degradation of the banks on the lake's tributaries; it also plays a big role in the sedimentation process at the bottom of the lake and contaminates the water by spreading pathogenic microorganisms. On the other hand, preventing animal access to streams ensures the cattle's better health which translates into a productivity increase for the business.

- **Respect the integrity of a 5 meter strip on the banks of all streams, including man-made ditches and all other catch drains.**
- **Pull the cattle out of the streams and remove it from the banks by setting up a controlled drinking station, by fencing in the strip on the banks, and by building ford crossings.**

To find out more: *Aménagement des sites d'abreuvement contrôlé pour le bétail au pâturage* (Laroche, 2002)

Cultivation Practices

When fertilizers are not absorbed by cultivated plants, they are carried off by water and cause excessive aquatic plant growth. This happens particularly when excessive spreading occurs near a stream or when it is performed during a dormancy period, or when the ground is not permeable (either frozen or covered with snow). Moreover, agricultural soil drainage can cause important losses of arable soil as well as create important inputs in the water network (80% of sediments entering waterways come from cultivated fields – BAPE, 2000). Finally, ground laid bare, such as ploughing tilling soil, is particularly sensitive to erosion.

Furthermore, water seeping in from storage, breeding or milk production facilities are laden with phosphorus, SM, bacteria and other pollutants; they can thus contaminate surface as well as underground water. In Québec, during the last 20 years, the retention of these waters has been compulsory and has allowed for a considerable reduction in this type of limited pollution. However, this change in practice (solid waste *vs* liquid waste) means background ambient pollution problems. In order to reduce the negative impacts on the environment, we propose the following measures:

- **Create a fertilization agricultural/environmental plan (FAEP), taking into consideration the plants' real needs as well as the ground's capacity for support; optimal quantities in fertilizers should be accounted for in order to use only the necessary amount.**

- **Favor solid manure management as opposed to liquid manure**
  Phosphorus contained in solid manure is more concentrated and is better distributed to plants, as opposed to liquid manure or black liquid.

- **Spread agricultural fertilizers far from streams, lakes, ditches and wetlands**
  For example, in Europe, a 30 meter strip must be respected around lakes.

- **Spread exclusively when plants are capable of absorbing fertilizers**
  It is better to use this practice when plants are not in their dormancy stage or when the ground is not frozen and covered with snow.

- **Dig wide and shallow drain ditches; make sure they have grass coverage at the bottom, ensure their maintenance using the Inferior Third method; have the water settle in a filtration marsh before conveying it in a natural stream.**
  Plough the ground following the natural contour lines and make sure that the ground remains without natural cover for as little time as possible (ex. autumnal sowing, vegetal residue deposits).

- **Favor minimal ploughing and perennial cultures**
  Confine animal manure, dairy waters and water seeping from waterways in an impermeable storage infrastructure.

To find out more: *Lisier ou fumier* (Desautels et Gravel, 2003)
Règlement sur les exploitations agricoles
Consulter un conseiller agricole (MAPAQ)

Certain forestry activities diminish the quality of the ground, lead to erosion and make the soil more sensitive to the impact of rain drops, which in turn has negative repercussions on the surrounding aquatic ecosystems. However, it is easy to conciliate forest management and water quality. Indeed, there are techniques and methods which allow foresters to limit their input in sediments and nutrients.

Harvesting practices

In order to avoid wash-off and soil compaction and in order to upkeep and maintain a healthy ground, the following actions can be most useful:

- **Avoid cutting in slopes of 30% or more.**
- **Practice thinning exclusively, precommercial thinning, sanitation cutting and salvage felling while maintaining forest cover on at least 50% of the territory.**
  Respect minimal increments within the 20 meter strip from the shoreline (a maximum of 30% on stems and without the use of heavy machinery)
- **Depending on the location, work exclusively on frozen ground, using light machinery only.**
- **Favor lighter machinery**
- **Level the ruts**

To find out more: *Guide des pratiques forestières sur terrain privé* (Memphremagog MRC, 2004)
Guide d'achat de l'équipement sylvicole au Québec (ACFE, 2004)

Cutting sites

The proximity between a cutting site and a surface water network is an important factor determining the impact of tree cutting. Maintaining a protective strip around the cutting sites allows for a significant reduction in the severity of the impact. Appropriate measures include:

- **Respect a 20 meter protection strip around streams (RNI).**
- **Be particularly prudent within the 300 meter strip of wooded areas around lakes.**
- **Do not practice cutting in protected areas such as wetlands, fauna habitats as well as in zones which are designated as natural sites.**

To find out more: *Politique de protection des rives du littoral et des plaines inondables* (c.Q-2, r.17.2)
Urban Development Plan (Memphremagog MRC)

Forestry Road Networks

To avoid bridge or pipe culvert obstruction, inundations, landslides, productive surface loss or rut formation (a series of phenomena linked to erosion in forestry ditch and road networks), the following measures are indicated:

- **Ditch water should be diverted at least 20 meters away before reaching a stream.**
- **Build stable forestry roads, while helping their restoration by sowing grass and installing anti-erosion mechanisms (microsills and berms) when the slope exceeds 7°.**
- **Allow drainage and seepage water to settle by diverting run-offs towards vegetation zones.**
- **Build crossings and pipe culverts to cross streams.**

To find out more: *Le fosse écologique… et économique* (RAPPEL, 1999)
Urban Development Plan (Memphremagog MRC)

Construction sites

A construction site that is laid bare can produce from 10 to 100 tons of soil erosion in a year, a number which is 10 times greater than the level of farmland erosion, 200 times superior to that of grazing land, and 2, 000 times larger than a forest's normal erosion rate (ODNR, 1996 and Goldman & al., 1986 in GDTQ, 1993). This input in soil particles entering the water network can be avoided by using the following basic principles:

- Prevent water from becoming erosive
- Avoid cutting vegetation as much as possible – a 3 to 5 meter strip around any construction is sufficient.
- Protect dirt mounds with tarps.
- Provide coverage on grounds laid bare by using covering brushwood, a vegetal carpet or peat.
- Catch and divert water using obstacles (retention berms or microsills).
- Catch sediments in sedimentation tanks or through the use of barriers made of straw bundles or erosion control fabrics.

To find out more: *Maudits sediments!* (RAPPEL, 2001)
Guide de la lutte à l'érosion sur les sites de construction ou de sol mis à nu (RAPPEL, 2003)

Golf Courses

Large quantities of fertilizers and pesticides used on golf courses end up upstream of waterways which feed directly into Lake Memphremagog, therefore affecting the state of the water (Doucet, 1998). The use of these poisons increases health hazards in humans as well. Here are a few suggestions to reduce the negative impact of these practices:

Implement a plan to reduce pesticide use

- Calculate the optimal quantity of pesticides and fertilizers needed and avoid further use.
- When all other means have been exhausted, favor the product that is least harmful and least persistent.
- Warn concerned people when such products are used (responsibility and public health).

Make sure that the residues do not come into contact with streams

- A 20 meter strip along lakes and streams and a 10 meter strip around drainage systems, intermittent brooks and wetlands should always be respected.
- Drain water should be washed by letting it rest in a settling tank, a retention trap or a treatment system using aquatic warblers or cattails.

Aim for an environmental certification

To find out more: *Cooperative Sanctuary* (Audubon Society Program)

Even today, many of these businesses produce vast quantities of important pollutants which seep into nature, despite strict regulations. Industries such as agri-food businesses and fish farming are releasing toxic waste and other harmful organic substances. Without efficient means to control these outputs, landfills are capable of emissions which can be extremely dangerous for the lake. Marinas are places where excessive water plant growth occurs, often because boat owners sometimes discharge their onboard used water tank. Also, ski station slopes often suffer from massive erosion when the ground thaws in the spring or when new slopes are cleared. In 1993, MLCP stated on this subject that "the link between the slope-clearing which occurred on Mount Giroux and the sedimentation of the lower part and mouth of Castle Brook is undeniable" (QDTQ/V, 1993). Camping grounds are also likely to be sources of vast quantities of phosphorus and sediments if used water treatment is inadequate. In order to reduce these impacts we suggest the following:

Reduce sediment, nutrient and toxic substance inputs

- Respect an effective shoreline strip.
- Respect the MENV norms.
- Provide proper installations to retain used waters.
- Make sure used waters are treated adequately.
- Prevent gasoline spills in marinas.
- Implement an effective restoration plan (extraction sites).
- Respect the *Regulations on quarries and sandpits* (extraction sites).
- Demand effective means to better control erosion when work is performed that leaves the ground bare.

To find out more: *Guide de lutte à l'érosion sur les sites de construction ou de sol mis à nu* (RAPPEL, 2003)