



Characterization of the riparian strip of Lac Notre-Dame and delineation of Eurasian watermilfoil beds

Report submitted to the
Municipality of La Pêche

By

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Reference to cite: ABV des 7 (2014). *Caractérisation de la bande riveraine du lac Notre-Dame et délimitation des herbiers de myriophylle à épi*. Report presented to the municipality of La Pêche, Gatineau, 77 pages.



CONTENTS

Agence de bassin versant des 7 was commissioned in June 2014 by the municipality of La Pêche to characterize the riparian strip of Lac Notre-Dame, assess the physico-chemical quality of the water as well as delineate the lake's Eurasian watermilfoil beds. This information was used to draw up a portrait of the current situation with a view to slowing the eutrophication of the lake and combating its invasion by Eurasian water milfoil.

The protocol of the Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) (now MDDELCC) and the Conseil régional de l'environnement des Laurentides (CRE Laurentides) (2007) was used to characterize the riparian zone. In terms of water quality assessment, the ABV des 7 collected and analyzed total phosphorus and *Escherichia coli* (*E. coli*) data provided by the Association des lacs Notre- Dame et Usher (2005 to 2011 and 2013) as well as by the municipality (2008 to 2013). ABV des 7 also collected and analyzed data on dissolved oxygen concentration and saturation, pH, depth and conductivity of the water acquired during field visits on July 17, 2014. ABV des 7 subsequently identified and mapped Eurasian watermilfoil beds on September 3, 2014.

The Lac Notre-Dame riparian buffer zone comprises 42 homogeneous zones in which only three land-use categories were identified: natural (46.9%), inhabited or frequented (51.4%) and infrastructure (1.7%). In terms of development types, 82% of the riparian buffer is composed of natural vegetation, 9.4% of ornamental vegetation and 8.6% of inert materials. According to management classes based on the percentage of natural vegetation, of the riparian buffer is made up of plant species (trees, shrubs, herbaceous plants), which cover 80-100% of the surface area of the areas studied. Only 8.1% of the riparian strip is disturbed: bare soil and erosion sites account for 2.5% of the shoreline, and low walls and embankments cover 5.6% of the lakefront.

Overall, the riparian strip of Lac Notre-Dame is sparsely disturbed and largely vegetated.

In addition, water quality data show that Lac Notre-Dame is showing signs of eutrophication: its condition now tends more towards mesotrophy than oligotrophy. *E. coli* (between 2 and 10 CFU/100 ml) and total phosphorus (0.015 mg/L) data collected in 2013, as well as water transparency (4 to 5 m) and dissolved oxygen (saturation < 54%) obtained in 2014, support this trend.

Characterization of Eurasian watermilfoil beds in Lac Notre-Dame revealed that this invasive exotic plant now occupies more than a quarter (26.6%) of the lake's total surface area. Over 70% of the beds are dense monospecific milfoil beds, and over 20% of the mixed beds are sparse. This suggests that the seagrass beds are becoming dense and monospecific over the years, as it successfully pushes out native plants.

In light of this information, ABV des 7 recommends : 1) to apply the shoreline protection regulations in force on the territory; 2) to revegetate degraded sections of the shoreline; 3) to control the proliferation of Eurasian water milfoil in problem areas; 4) continue lake water quality analysis and 5) detailed monitoring septic tank conditions; and 6) educate residents about good water protection practices, such as the use of phosphate-free cleaning products and the recovery of ashes from outdoor fireplaces.



ACKNOWLEDGEMENTS

We would like to thank all the members of the Association des lacs Notre-Dame et Usher for their invaluable collaboration throughout this project and the writing of this report. Special thanks also go to Danielle Doré-Levesque and Jacqueline Lambert-Madore, accompanied us and lent us their boats to take measurements on the lake and characterize the riparian buffer strips.

Finally, we would like to thank Philippe Vlasiu and Marcel Marchildon of the municipality of La Pêche for their knowledge of the area and their time spent providing us with information relevant to this study.



TABLE OF CONTENTS

WORK TEAM.....	i
CONTENTS	ii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS.....	v
LIST OF FIGURES	viii
LIST OF TABLES.....	x
LIST OF ACRONYMS, SYMBOLS AND ABBREVIATIONS	xi
1 INTRODUCTION	1
1.1 Setting the scene.....	1
1.1.1 Eutrophication	1
1.1.2 Eurasian watermilfoil	2
1.2 Mandate	2
2 METHODOLOGY	3
2.1 Riparian buffer characterization	3
2.2 Water quality monitoring.....	5
2.2.1 Data provided by the Association des lacs Notre-Dame et Usher and the Municipality of La Pêche	5
2.2.2 Dissolved oxygen and other physico-chemical parameters	7
2.3 The beaver	9
2.3.1 Beaver characteristics	9
2.3.2 Home preferences	10
2.3.3 Beaver activity	10

2.3.4 Power supply	11
2.3.5 Reproduction.....	11
2.4 Delimitation of Eurasian watermilfoil beds	11
2.3.1 Characteristics of Eurasian watermilfoil	11
2.3.2 Mapping Eurasian watermilfoil beds	13
3 RESULTS AND ANALYSIS	15
3.1 Description of Lac Notre-Dame and its watershed	15
3.1.1 Location and hydrography.....	15
3.1.2 Portrait and history of Lac Notre-Dame	17
3.1.3 Land use	18
3.1.4 Road network	20
3.2 Riparian buffer characterization.....	20
3.2.1 Land use categories	20
3.2.2 Types layout.....	22
3.2.3 Design classes	24
3.2.4 Shoreline degradation	25
3.2.5 Shoreline degradation classes by percentage of disturbed shoreline	26
3.2.6 Information summary.....	28
3.3 Beaver issues	29
3.3.1 The beaver population	29
3.3.2 Consequences	30
3.3.3 Conclusion	31
3.4 Eurasian watermilfoil problems	32
3.4.1 Overview of the situation at Lac Notre-Dame	32
3.4.2 Possible control methods.....	35
3.4.3 Actions carried out by local residents	40

3.4.4 Conclusion	42
3.5 Water quality results and analysis	42
3.5.1 Faecal coliforms (<i>E. coli</i>)	42
3.5.2 Total phosphorus	43
3.5.3 Joint analysis of changes in fecal coliform and concentrationtotal phosphorus 45	
3.5.4 Water transparency	49
3.5.5 Dissolved oxygen and temperature	49
3.5.6 Conductivity and pH	51
4 Summary of information and recommendations	54
4.1 Potential phosphorus inputs	54
4.2 Recommendations	54
5 CONCLUSION	57
REFERENCES	58
APPENDIX A	60
APPENDIX B	71
APPENDIX C	73

LIST OF FIGURES

Figure 1: Illustration of the eutrophication process in lakes.....	1
Figure 2: Illustration of the riparian buffer zone	3
Figure 3 . Examples of riparian zone land use categories	4
Figure 4 . Lake Notre-Dame and Usher Association water sampling stations.....	6
Figure 5 . Municipality of La Pêche water withdrawal stations.....	7
Figure 6: Illustration of thermal stratification in summer	8
Figure 7 . Multi-parameter probe type YSI 600QS.....	8
Figure 8: Photo of beaver	9
Figure 9: Diagram of beaver constructions: the lodge with underwater entrance (center) and the dam (right) to keep the water level high.	11
Figure 10. Photos of roots formed by the plant for asexual reproduction by cuttings.....	13
Figure 11. Photo of aqua-scope II	14
Figure 12. Location map of the Lac Notre-Dame watershed	16
Figure 13. Relative importance of different types of land use in watershedthe Lac Notre-Dame	19
Figure 14. Land use map of Lac Notre-Dame watershed	19
Figure 15. Examples of the three categories of riparian zone land use at Lac Notre-Dame....	21
Figure 16. Relative importance of land use categories in the Lac riparian zoneNotre-Dame .	21
Figure 17. Location of homogeneous land-use zones at Lac Notre-Dame by category	22
Figure 18. Examples of the three types of riparian buffer development and degradation shoreline present at Lac Notre-Dame	23
Figure 19: Relative importance of types shoreline development and shoreline degradation at Lac Notre-Dame.....	24
Figure 20. Location of Lac Notre-Dame riparian buffer sections according their natural vegetation management class.....	25
Figure 21. Location of Lac Notre-Dame riparian buffer sections according to their shoreline degradation class	27

Figure 22: Importance of types of development and degradation of the riparian buffer zone according to land-use categories at Lac Notre-Dame.....	29
Figure 23. Presence of a beaver lodge in a marshy bay on Lac Notre-Dame	30
Figure 24. Location of Eurasian watermilfoil beds on Lac Notre-Dame in 2004	32
Figure 25. Location of mixed and monospecific Eurasian watermilfoil beds.....	33
Figure 26. Location of dense and sparse Eurasian watermilfoil beds	34
Figure 27. Awareness and instruction signs for boat washing	36
Figure 28. Underwater photo of burlap with native plants	39
Figure 29. Changes in <i>E. coli</i> concentration (CFU/100 ml) in Lac Notre-Dame from 2005 to 2011	43
Figure 30. Diagram of trophic level ranking of lakes according to total phosphorus concentration	44
Figure 31. Trends in total phosphorus concentration (mg/l) in Lac Notre-Dame from 2005 to 2011.....	44
Figure 32. Total phosphorus concentration trends (mg/l) for stations sampling 1, 2 and 3 at Lac Notre-Dame from 2005 to 2011.	46
Figure 33. <i>E. coli</i> concentration trends (CFU/100ml) for stations sampling 1, 2 and 3 at Lac Notre-Dame from 2005 to 2011.....	46
Figure 34. Changes in total phosphorus concentration in Lac Notre-Dame from 2008 to 2013	48
Figure 35. Changes in <i>E. coli</i> concentration in Lac Notre-Dame from 2008 to 2013.....	48
Figure 36. Changes in temperature and dissolved oxygen saturation as a function of depth at Lac Notre-Dame.....	50
Figure 37. Changes in temperature and dissolved oxygen concentration as a function of depth at Lac Notre-Dame.....	50
Figure 38. Changes in conductivity as a function of depth at Lac Notre-Dame	52
Figure 39. Changes in conductivity as a function of depth at Lac Notre-Dame	53

LIST OF TABLES

Table 1. List of main benefits attributed to riparian buffer strips	4
Table 2. Categories land use and types development and degradation shoreline related to the riparian buffer inventory	5
Table 3. Main characteristics of Lac Notre-Dame	15
Table 4. Land use categories in the Lac Notre-Dame watershed	18
Table 5. Percentages of riparian zone management classes for Lac Notre- Dame	24
Table 6. Percentage of shoreline degradation according to the three categories of use land present at Lac Notre-Dame	26
Table 7. Percentage of riparian strip according to disturbance classes shoreline	27
Table 8. Importance of riparian buffer development and degradation by land use category at Lac Notre-Dame	28
Table 9: Natural impacts of beavers	31
Table 10. Classification, area and percent cover of beds Eurasian watermilfoil at Lac Notre-Dame in September 2014	35
Table 11. Classification of water quality for recreational use	43
Table 12. Trophic level classes of lakes with corresponding values water transparency	49
Table 13. Comparison of oxygen concentration and saturation values obtained at Lac Notre-Dame with theoretical values provided by MDDELCC for the survival of aquatic organisms ..	51
Table 14. Sources of phosphorus in the Lac Notre-Dame watershed	54
Table 15. Recommendations for maintaining and protecting water quality in Lac Notre- Dame	55

LIST OF ACRONYMS, SYMBOLS AND ABBREVIATIONS

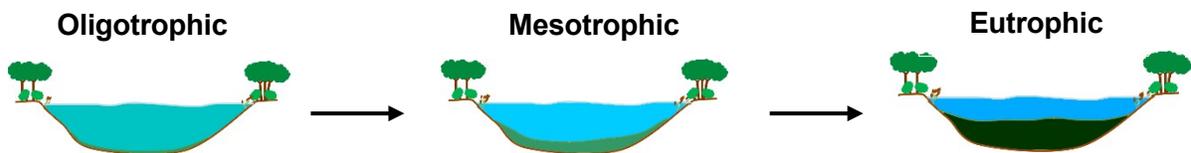
ABV des 7	Agence de bassin versant des 7
BV	Catchment area
CRE Laurentides	Conseil régional de l'environnement des Laurentides
<i>E. coli</i>	<i>Escherichia coli</i>
ha	Hectares
km	Kilometer
L	Liter
LQE	Environmental Quality Act
m	Meter
MDDEP	Ministry of Sustainable Development, Environment and Parks
MDDELCC	Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (Ministry of Sustainable Development, Environment and the Fight against Climate Change)
mg	Milligram
ml	Milliliter
RCM	Regional County Municipality
UFC	Colony-forming unit
µg	Microgram

1 INTRODUCTION

1.1 Setting the scene

1.1.1 Eutrophication

Lac Notre-Dame is located on the territory of the municipality of La Pêche in the MRC des Collines-de-l'Outaouais, Outaouais. It is an oligotrophic lake, meaning it is low in nutrients (e.g., phosphorus and nitrogen) (MDDELCC, 2014a). A lake with such a trophic level is generally characterized by clear, well-oxygenated waters, few aquatic plants, a bottom composed of rocks, gravels and sands, and a good diversity of animal species (RAPPEL, 2012). It is important to preserve this condition from the process of lake eutrophication, in other words, from aging (Figure 1).



Source: ABV des 7

Figure 1: Illustration of the eutrophication process in lakes

Eutrophication is characterized by an increase in the biological production of the lake, i.e., a significant rise in the growth rate of algae and aquatic plants. This increased production modifies the lake's characteristics, resulting in a greater accumulation of sediment and organic matter, a reduction in dissolved oxygen and a successive replacement of organisms by species best adapted to the new environmental conditions (MDDELCC, 2014a).

The aging process of lakes can take place very slowly, on the scale of a geological period, in a natural context, i.e., without human intervention. It can, however, be accelerated by disturbances due to human activities, including agricultural, forestry and industrial activities as well as urbanization and vacationing, which can increase nutrient and sediment (soil particles) inputs to the lake (RAPPEL, 2012).

1.1.2 Eurasian watermilfoil

In Lac Notre-Dame, an invasive exotic plant is becoming increasingly abundant. Eurasian watermilfoil (*Myriophyllum spicatum*) has managed to introduce itself many lakes in North America. It is often found in areas 0.5 to 10 m deep, but generally settles in at depths of between 0.5 and 3.5 m, where it branches abundantly and forms thick mats of plants. Native to Europe, Asia and North Africa, the plant is thought to have been introduced to North America in the 1940s and is now found in many Canadian provinces, including Quebec, Ontario and British Columbia (ABV des 7, 2014).

Eurasian watermilfoil stands can cause a reduction in lake biodiversity, as well as profound changes in water physico-chemical parameters (e.g. temperature, acidity, dissolved oxygen concentration, etc.). They can disrupt recreational tourism activities by becoming entangled in boat motors and limiting or even preventing the use of water bodies for swimming (ABV des 7, 2014).

1.2 Mandate

Agence de bassin versant des 7 (ABV des 7) was commissioned in June 2014 by the municipality of La Pêche to characterize the riparian strip of Lac Notre-Dame, assess the physico-chemical quality of the water as well as delineate the lake's Eurasian watermilfoil beds. This information will be used to draw up a portrait of the current situation with a view to preventing eutrophication of the lake and combating the invasion of the lake by Eurasian water milfoil.

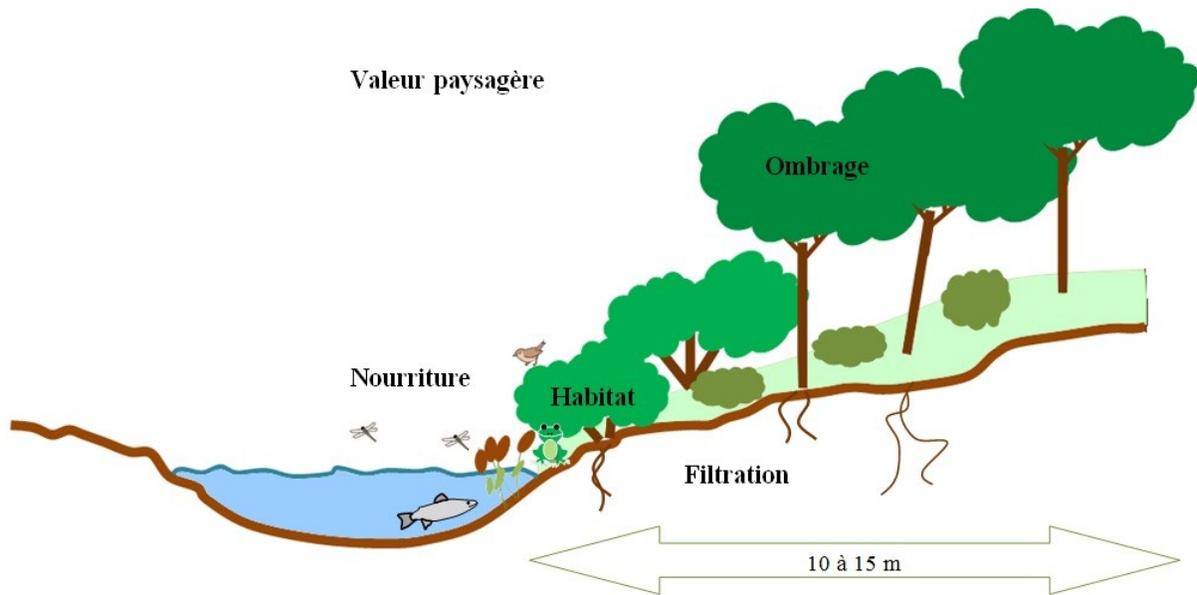
The next section of the report describes the methodology used in this study. The results and analysis are then provided in section 3, on the basis of which recommendations are finally presented in the next section of the document.

2 METHODOLOGY

A specific method was applied to characterize the riparian strip, assess water quality, note the presence of beaver and delimit Eurasian watermilfoil beds.

2.1 Riparian buffer characterization

A riparian buffer zone is the 10-15 m wide strip of land bordering the lake (Figure 2).



Source: ABV des 7

Figure 2: Illustration of the riparian buffer strip

A riparian buffer zone provides numerous environmental, social and economic benefits (Table 1).

Table 1. List of main benefits attributed to riparian buffer strips

<p>Economic</p>	<ul style="list-style-type: none"> • Avoidance of costs associated with work required in the event of erosion, pollution, flooding and drought caused by poor riparian buffer management (e.g. excessive wood cutting, bare soil, etc.); • Maintain or increase local economic spinoffs from the agricultural and recreational tourism industries, as well as real estate values around the lake.
<p>Social</p>	<ul style="list-style-type: none"> • Maintain or : <ul style="list-style-type: none"> - development of recreational and tourism activities; - increase in landscape quality; - increase in the overall quality a living environment.
<p>Ecological</p>	<ul style="list-style-type: none"> • Maintaining biodiversity (from the variety of living environments and the protection of habitats); • Bank stabilization (reduced erosion); • Limits water heating; • Regulation of the hydrological cycle; • Filtration of pollutants.

Characterizing a riparian zone involves : 1) describing and locating land use and development types around the lake and; 2) estimating their significance for lake as a whole. The method selected to meet these objectives is described in the protocol of the Ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) (currently MDDELCC) and the Conseil régional de l'environnement des Laurentides (CRE Laurentides) (2007).

In short, the aim is to identify and characterize segments of the riparian strip, known as homogeneous zones, in which land use and denaturalization characteristics are constant or similar (Figure 3 and Table 2).

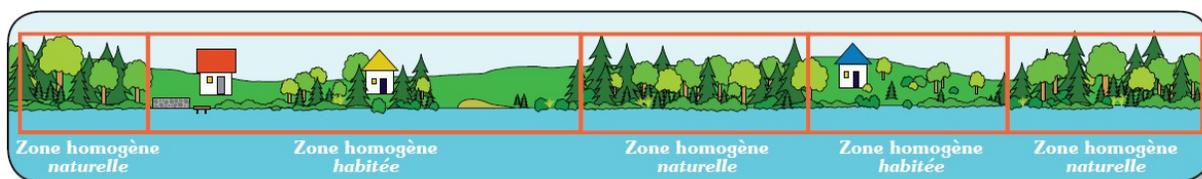


Figure 3: Examples riparian zone land use categories

Source: Taken from MDDEP and CRE Laurentides, 2007.

Table 2. Categories land use and types shoreline development and degradation related to the riparian buffer inventory

Caractéristiques des zones homogènes - groupe 1		Caractéristiques des zones homogènes - groupe 2	
Catégories d'utilisation du sol dans les premiers 15 mètres	Description	Types d'aménagement de la bande riveraine et de dégradation du rivage	Description
Entièrement naturelle	La bande riveraine est entièrement naturelle, sans perturbation humaine*. La végétation peut être composée d'arbres, d'arbustes ou de plantes. Les caps de roches sont inclus dans cette catégorie.	Végétation naturelle	Une partie de la zone est en végétation naturelle. La végétation peut être composée d'arbres, d'arbustes ou de plantes.
Agriculture	La bande riveraine est utilisée pour l'agriculture : culture, fourrage et pâturage.	Végétation ornementale, cultures, coupes forestières	Une partie de la zone est en végétation ornementale (gazon, arbres, arbustes et plantes entretenues) ou utilisée pour l'agriculture ou pour des coupes commerciales d'arbres.
Foresterie	Une coupe forestière a été effectuée dans la bande riveraine au cours des dernières années.	Matériaux inertes	Une partie de la zone est recouverte de matériaux inertes (bâtiments, asphalte, béton, gravier, sable).
Infrastructure	Une infrastructure est présente dans la bande riveraine (route, chemin forestier, barrage, chemin de fer).	Sol dénudé et foyer d'érosion	Le rivage (interface de l'eau et de la terre) présente des sols dénudés et des foyers d'érosion reliés aux activités humaines.
Zone habitée ou fréquentée	Des habitations et des bâtiments (chalets, maisons, commerces et autres bâtiments) ou des terrains privés ou publics utilisés à des fins de villégiature (accès au lac, campings, plages et parcs publics) sont présents dans la bande riveraine.	Murets et remblais	Des remblais et des murets de soutènement sont présents le long du rivage (interface de l'eau et de la terre).

* Certains exemples de cas particuliers sont présentés dans le document de soutien de ce protocole.

Source: Taken from MDDEP and CRE Laurentides, 2007.

2.2 Water quality monitoring

2.2.1 Data provided by the Association des lacs Notre-Dame et Usher and the Municipality of La Pêche

The Association des lacs Notre-Dame et Usher has been taking water samples from Lac Notre-Dame since 2005. The parameters studied are total phosphorus and *Escherichia coli* (*E. coli*). Figure 4 shows the Association's water sampling stations.

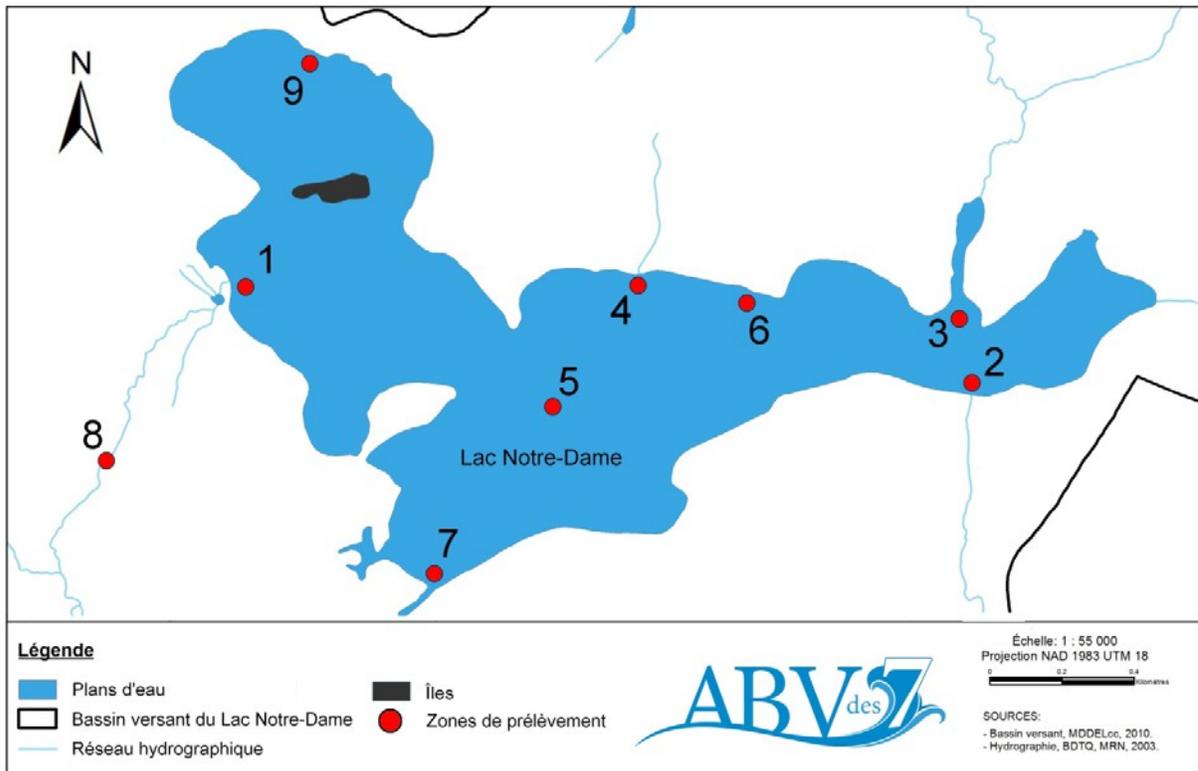


Figure 4: Lake Notre-Dame and Usher Association water sampling stations

ABV des 7 collated and processed data from the municipality of La Pêche and the Notre-Dame and Usher lakes association using Microsoft Excel® software. The analysis revealed trends in these parameters from 2005 to 2011. In addition, the municipality of La Pêche provided data for these same parameters for the period 2008 to 2013. It should be noted that the sampling stations differ from those of the Association (Figure 5).

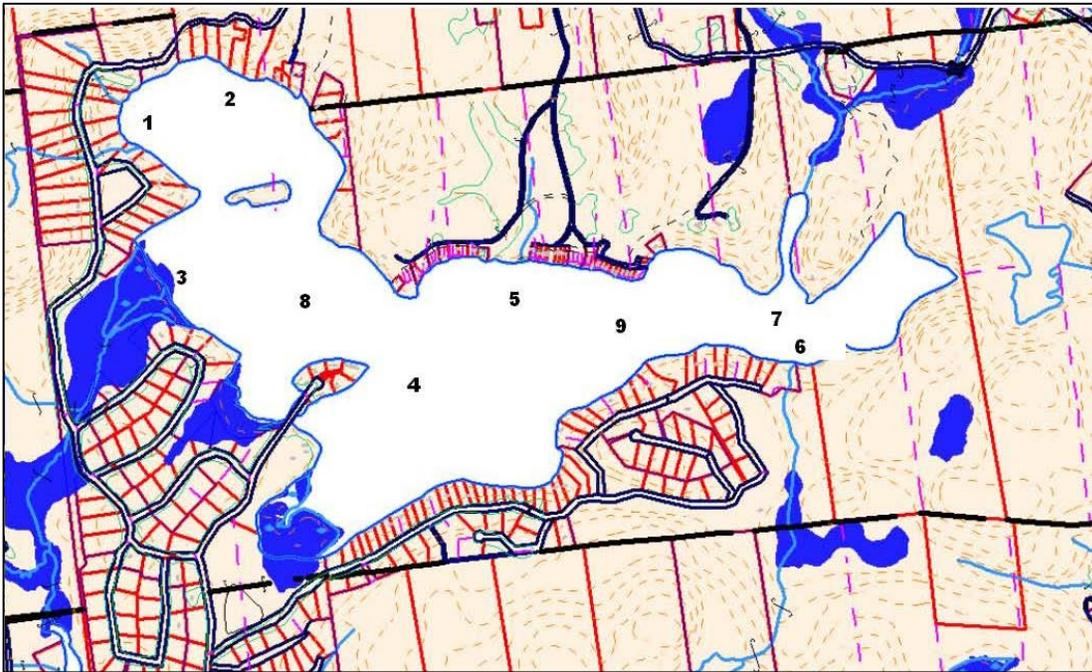


Figure 5. Municipality of La Pêche water withdrawal

2.2.2 Dissolved oxygen and other physico-chemical parameters

In addition to the data collected by the municipality of La Pêche, ABV des 7 has acquired data on the concentration of dissolved oxygen in lake water, an indicator of a lake's metabolism (MDDELCC, 2014a). Dissolved oxygen in the water is consumed during the degradation of dead organic matter. The richer a lake is in organic matter, the more dissolved oxygen is consumed. In the upper layers of the water column, where light penetrates, the oxygen consumed during the degradation of organic matter and the respiration of organisms is renewed through photosynthesis. In the lower layers of the water column, on the other hand, no light penetrates. As a result, there are no longer any organisms capable of photosynthesizing and renewing the oxygen consumed. During periods of thermal stratification, when there is no mixing with the upper layers, dissolved oxygen levels in the lower layers fall. The bottom layer of the lake, known as the hypolimnion, is then at a temperature of around 4°C. At this temperature, water density is at its highest. The upper layer of the water column, known as the epilimnion, has a higher temperature and therefore a lower density. Because of their different densities, the two layers can no longer mix under the effect of the wind (Figure 6).

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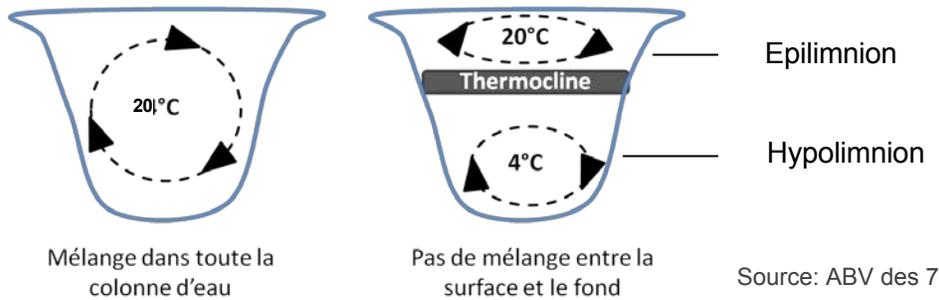


Figure 6: Illustration of thermal stratification during the summer period

ABV des 7 collected data, on dissolved oxygen concentration in Lac Notre- Dame, on July 17, 2014, using a YSI brand multi-parameter probe, model 600QS at the pit located near the island (figure 7). Parameters were first measured at the surface, then the probe was lowered at depths of less than a meter, to the lake bottom. Data taken at the bottom of the lake in the first sediments were removed from the analysis to ensure unbiased interpretation.



Source : www.ysi.com

Figure 7. Multi-parameter probe type YSI 600QS

At the same time, data on water temperature, pH, depth, saturation and conductivity were also collected from the multi-parameter probe. These data were collated and analyzed as part of the lake's water quality monitoring program.

2.3 The beaver

2.3.1 Beaver characteristics

The beaver (*Castor canadensis*) is the largest rodent in North America (figure 8). An adult beaver weighs from 16 to 32 kg, and can measure up to 1.3 m including its 30 cm tail. Beavers can live up to 12 years. The beaver moves slowly on land, but is very fast and skilful in water. The beaver's most remarkable feature is its flat, scaly tail, which can be used for support when felling a tree, as a rudder when moving through water, as a fat reserve in winter, or as an alarm mechanism to warn fellow beavers of imminent danger. The beaver's eyes have a nictitating eyelid to protect them underwater. Its nostrils and ears are adapted for underwater travel, closing automatically when it dives. These adaptations, combined with an equally remarkable respiratory capacity, enable the beaver to remain underwater for more than fifteen minutes. The beaver has two pairs of curved incisors developed for peeling bark and wood. The incisors are long, sharp and strong, growing steadily hardened by a layer of dark orange enamel on the outside. So, as the animal rubs its upper incisors against its lower ones, the outer tip of the teeth retains the sharpness of a chisel. Equipped with such teeth, the beaver is capable of felling very large trees.



Figure 8: Photo of beaver
Source: <http://infographie.univ-lyon2.fr/>

2.3.2 Home preferences

Although most often found in wooded areas, beavers also live in wetland habitats bordering watercourses. The main factor determining a stream's potential for beavers is the slope of the land. Streams with a steep gradient, i.e. greater than 6%, are in practice avoided by beavers, whereas around 80% of colonies settle along streams with a gradient of less than . Topography is therefore an important factor in colony establishment.

2.3.3 Beaver activity

From April to the beginning of May, the ice melts on the water bodies, ushering in a new season of beaver activity. Adults and young beavers, born the previous year, are busy repairing breaches in the dam following the spring flood. Every day, the beaver alternates between periods of activity and rest. They are most active from dusk to dawn; in the middle of the day, they are usually in their lodges, summer and winter alike. The beaver's life depends on felling trees for food and shelter. The beaver is an outstanding builder; what it builds depends on where it lives. The best-known structure, the dam, is only made by beavers who need to enlarge the underwater habitat to which they will have access during the winter. Beavers can also build lodges and channels. The dam usually creates a pond deep enough to prevent the water from freezing, enabling the beaver to store food for the winter and have year-round access to its underwater lodge, safe from predators (figure 9).



Figure 9: Diagram of beaver constructions: the lodge with underwater entrance (center) and the dam (right) to keep the water level high.

2.3.4 Power supply

The beaver feeds mainly on tree wood and plant roots and stems. Its favorite trees are aspen, poplar, willow and birch. The beaver's diet shifts from woody plants in winter to herbaceous plants in spring, as new shoots appear. In summer, the beaver feeds on grasses, herbs, woody plant leaves, fruit and aquatic plants.

2.3.5 Reproduction

Mating takes place in January and February. Shortly before the birth of the young, the female drives the male out of the lodge they've built, and he temporarily moves to an old lodge or burrow on the riverbank. Beavers have only one litter (three or four young) a year, in May or June, and the young are born after a gestation period of 100 days. They measure around 12.5 cm and weigh around 450 grams. From birth, the young have good fur and teeth, can see, walk and swim, but usually don't leave the hut for at least a month.

2.4 Delimitation of Eurasian watermilfoil beds

2.3.1 Characteristics of Eurasian watermilfoil

Eurasian water milfoil (*Myriophyllum spicatum*) is a perennial aquatic plant that lives submerged at depths of between 0.5 and 10 m (especially between 0.5 and 3.5 m). The plant takes root

at the bottom and grows towards the surface, where it branches and forms a carpet. Native to Europe, Asia and North Africa, it is thought to have been introduced to North America in the 1940s. Present in over 40 Canadian regions, this species is considered highly invasive.

Like all invasive species, Eurasian water milfoil has the ability to adapt to almost any type of habitat. It is therefore more competitive than other plant species, growing en masse and gradually eliminating them. The introduction of Eurasian watermilfoil into lakes therefore leads to major environmental disturbances and a significant reduction in biodiversity. Dense weed beds prevent native plant species from growing and aquatic fauna from inhabiting the area. Milfoil can even establish itself in spawning grounds, leading to their destruction. At night, plants breathe and consume oxygen, so high plant density leads to high oxygen consumption, resulting in anoxic conditions (i.e. lack of oxygen in the water) in deep lakes.

Eurasian watermilfoil reproduces in two ways, either sexually by seed or asexually by cuttings. It reproduces mainly the second way. Thus, fragmentation of its stems is the major cause of its colonization. Waterfowl, human activities such as fishing, aquaristics, water sports, horticulture, navigation and boat transport from one lake to another are the main vectors of dissemination.

A particularity of this species is that it produces roots on its offshoots in the aerial part of the plant, which then detach naturally. These rooted cuttings then move with the current and quickly establish themselves in the soil, creating a new herbarium or reinforcing the original one. Figure 10 illustrates this phenomenon with photos.



Source: ABV des 7

Figure 10. Photos of roots formed by the plant for asexual reproduction by cuttings

This phenomenon can be observed at the same time as the spikes on mature plants that have reached the water surface. So, it's not until August or September, depending on the year, that Eurasian watermilfoil plants appear to reproduce sexually with the seeds from the spikes, or asexually through natural fragmentation.

2.3.2 Mapping Eurasian watermilfoil beds

Eurasian watermilfoil beds are delimited using a Garmin GPSmap 62 geolocation device.

The beds are then mapped using ArcGIS version 10.2 software. It is important to map the beds as accurately as possible in order to know the distribution of Eurasian water milfoil in a lake. With detailed, accurate mapping, it's easier to find appropriate solutions for each situation.

Several methods can be used to carry out such mapping. Firstly, Eurasian watermilfoil beds should be identified at the end of the summer season, when the plants have reached their maximum growth. Once the plants are on the lake, they can be delineated using GPS and an Aqua-Scope II for underwater viewing (figure 11).



Source: ABV des 7

Figure 11. Photo of aqua-scope II

It's possible that the seagrass beds are larger than can be illustrated on a map, since visibility is influenced by the weather (cloudy, sunny or windy) during the field trip and transparency of the water. For more accurate mapping, it is advisable to use a probe that detects the presence of plants at depth and in all climatic conditions.



3 RESULTS AND ANALYSIS

3.1 Description of Lac Notre-Dame and its watershed

3.1.1 Location and hydrography

Located 50 km north of the City of Gatineau, Lac Notre-Dame has geographic coordinates of latitude 45° 43' 54" North and longitude 76° 01' 2" East. It is located in the Gatineau River watershed (Figure 12).

With a surface area of 146.46 ha, Lac Notre-Dame has an elongated shape running east-west, with the first half to the east, and an elongated shape running north-south, with the second half to the west. An island with a perimeter of 515 m is present on the lake. The lake's watershed covers an area of 1,900 ha, and includes Usher Lake with a surface area of 17.3 ha. The outlet of Lac Notre-Dame lies to the northeast of the watershed, where its waters feed Lac Bernard.

The main morphological characteristics of Lac Notre-Dame are presented in Table 3 below.

Table 3. Main characteristics of Lac Notre-Dame

Lake area (ha)	146,46
Lake perimeter (km)	10,451
Island perimeter (km)	0,515
Total lake perimeter (km)	10,966
BV area (ha)	1 900

Characterization of the riparian strip of Lac Notre-Dame and delineation of Eurasian watermilfoil beds

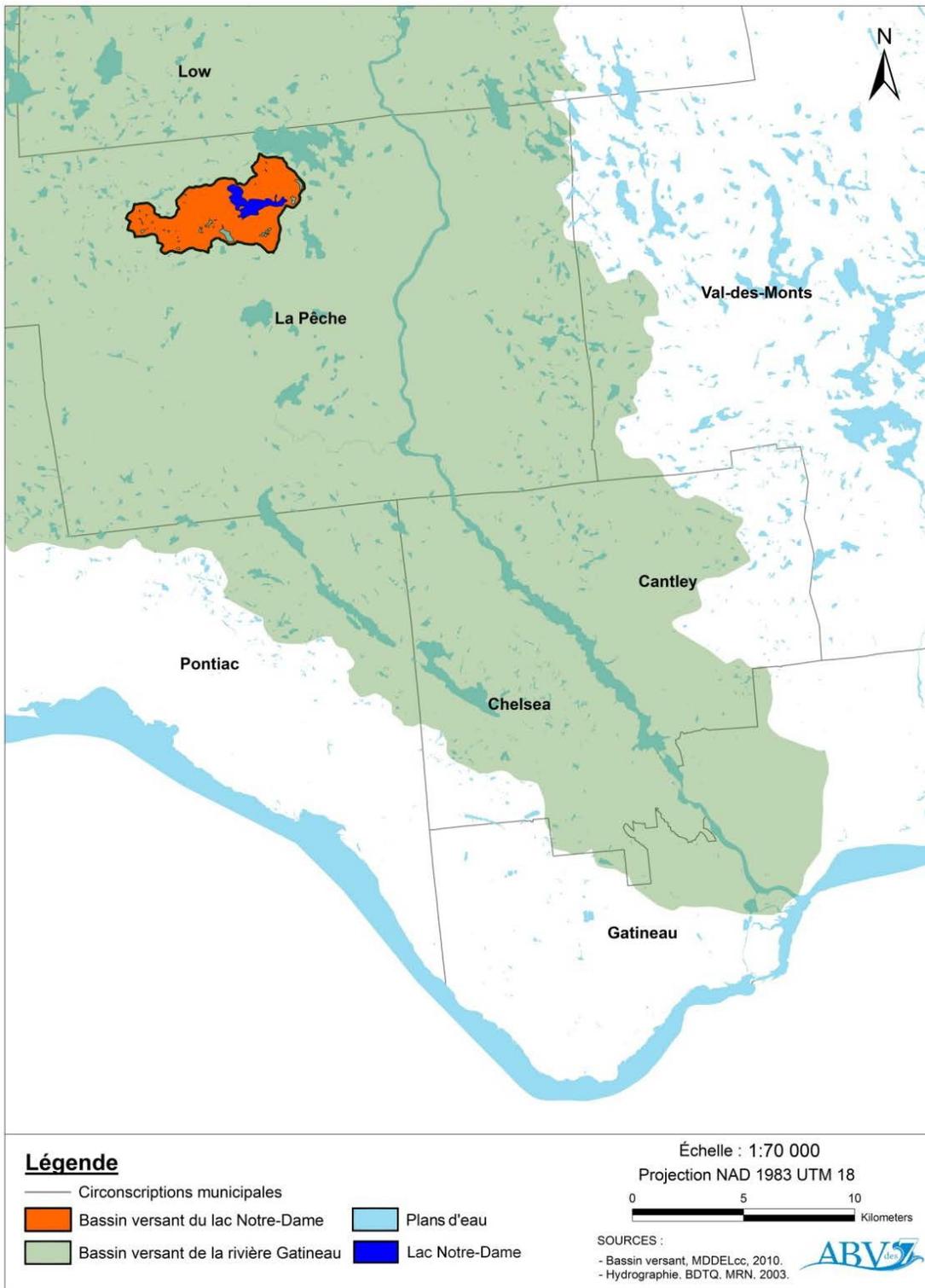


Figure 12. Location map of the Lac Notre-Dame watershed

3.1.2 Portrait and history of Lac Notre-Dame

Notre-Dame and Usher Lakes Association

The Association des lacs Notre-Dame et Usher was created in 2004 and has a seven-member Board of Directors. Its mission is to promote, protect and preserve the water quality of the lakes and their watersheds to ensure their continued use by all. The Association pursues several objectives, including :

- "Acquire knowledge about the functioning of the two lakes and their ecosystems in order to promote their preservation and protection;
- Encourage the development of lake restoration and protection programs in line with appropriate management techniques and strategies;
- Monitor all factors that may have a negative impact on lake water quality and implement measures to maintain and improve the environment of the lakes and their watersheds" [Association des lacs Notre-Dame et Usher, 2005].

Recreational and tourism activities

The lake is bordered by private residences and has no public access to the water. There is no public beach and no campsite on or near the lake. There is, however, a private beach used by non-riparian property owners on the Domaine de l'Archevêque. What's more, the municipal road leading to the peninsula is often used illegally by outside boat owners. In fact, although the municipality has installed blocks to prevent boat launching, users still manage to make an access ramp. What's more, Chemin des Générations (formerly Symons Trail) leads directly to the lake and serves as an access ramp for nearby property owners. A single youth camp, Camp Kalalla, welcomes young people aged between 7 and 15 for a few weeks during the summer, but its activities have drastically declined in recent years (Ottawa CGIT Committee, 2014). The only activities listed are motorboat touring, water skiing, sailing, kayaking, canoeing, swimming and fishing.

Population and septic systems

Lac Notre-Dame boasts 143 homes, 56 of them permanent and 87 seasonal. These homes were built in the following years: 24 before 1960; 24 between 1961 and 1980; 44 between 1981 and 1990; 23 between 1991 and 2000; 20 between 2001 and 2010; and 8 between 2011 and 2013. Some homes have had their septic systems replaced, while others are still relatively old.

3.1.3 Land use

The five types of land use are grouped into two groups according to the type of input, whether natural or anthropogenic (Table 4).

Table 4. Land use categories in the Lac Notre-Dame watershed

Type input	Type land use	Watershed area (ha)
Natural	Forest	2 910,92
	Wetlands	309,27
	Water	615,19
Anthropogenic	Sparsely populated (residential and recreational)	4,00
	Agricultural land	12,24
	Other	1,62

The watershed is mainly covered by forest (around 75%), and to a lesser extent by wetlands (8%) and bodies of water (nearly 16%). There is very little agricultural activity, and the level of anthropization, linked to the occupation of the territory by residences or infrastructures, is low (0.10%) (figures 13 and 14).

Characterization of the riparian strip of Lac Notre-Dame and delineation of Eurasian watermilfoil beds

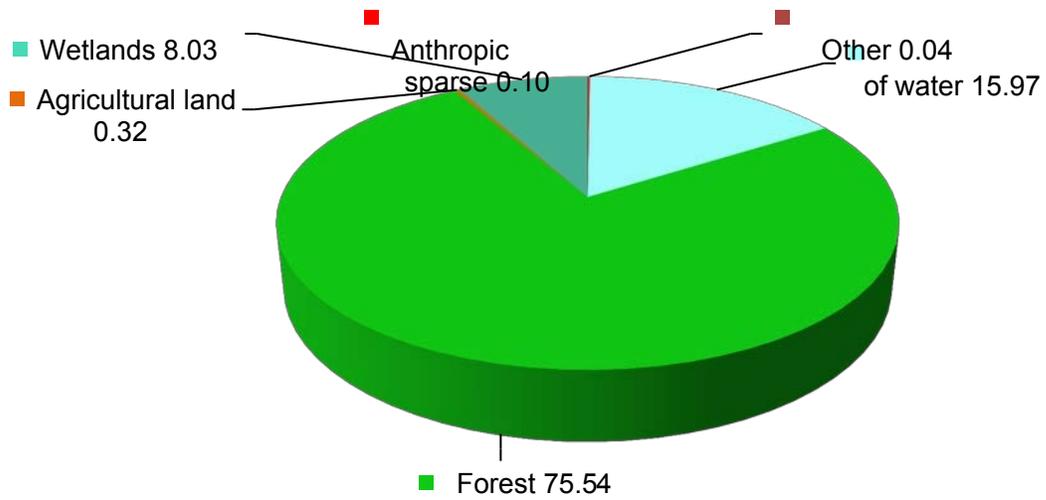


Figure 13. Relative importance of different types of land use in the Lac Notre-Dame watershed

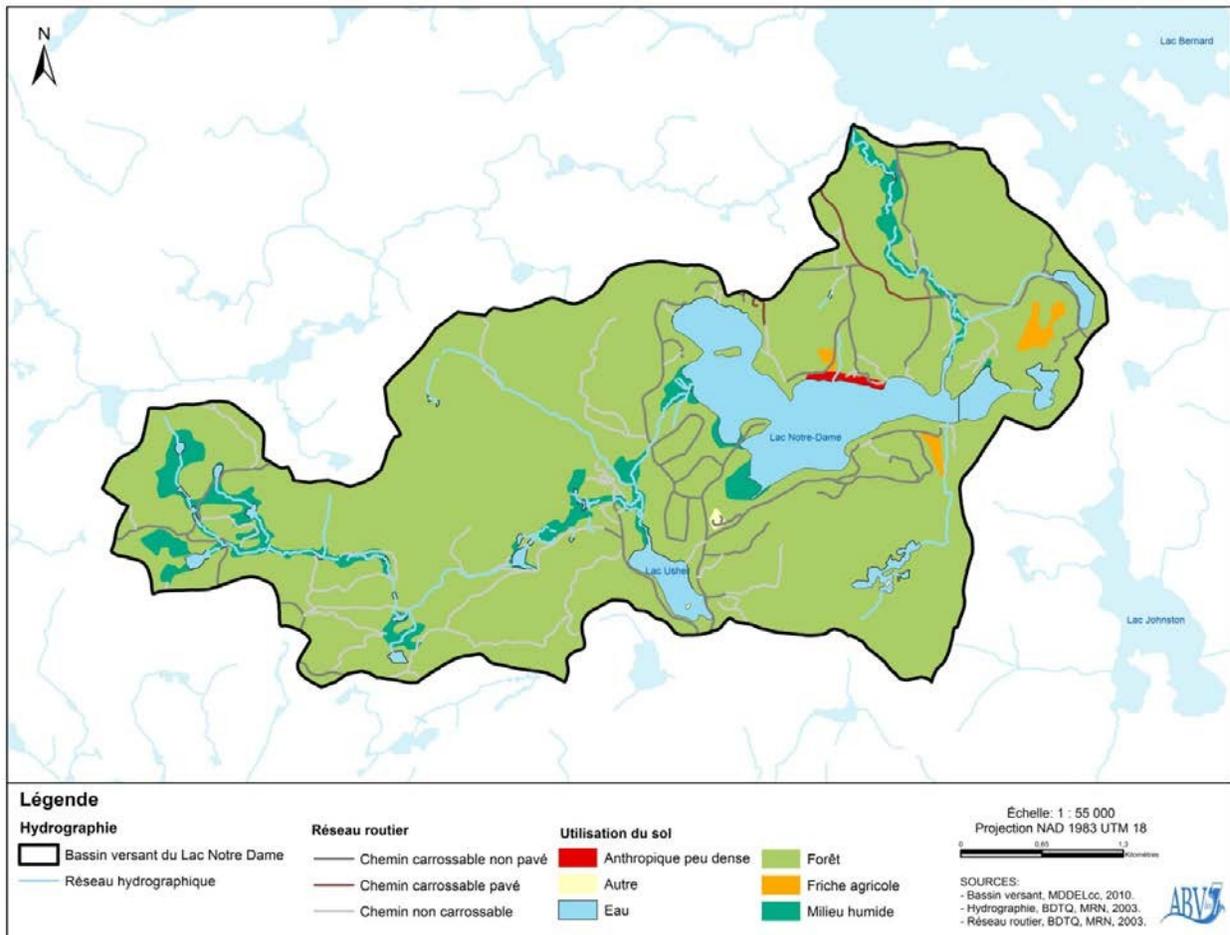


Figure 14. Land use map of Lac Notre-Dame watershed

3.1.4 Road network

In terms of road infrastructure, Lac Notre-Dame residents have access to the southern part of the lake via chemin du lac Notre-Dame, which becomes chemin Shaw, then chemin du Renard. In the northern part, there's chemin de la Ferme Malone. Numerous paved and unpaved roads line the perimeter of the lake, most of them to the southwest (Figure 14). Of all the roads included in the watershed, only the road leading to the peninsula is part of the 15-metre riparian buffer.

3.2 Riparian buffer characterization

The Lac Notre-Dame riparian zone comprises 42 homogeneous zones. For each zone, the land use category and type of development were identified. Sections 3.2.1 and 3.2.2 present the results of this characterization.

Based on this information, riparian zones were classified according to the percentage of natural vegetation they contain (section 3.2.3). Sections 3.2.4 and 3.2.5 then provide information on the level of shoreline degradation.

Finally, a summary of information is presented in section 3.2.6.

3.2.1 Land use categories

During the survey, only three categories of land use were identified: natural, inhabited or frequented, and infrastructure (Figure 15).

Characterization of the riparian strip of Lac Notre-Dame and delineation of Eurasian watermilfoil beds

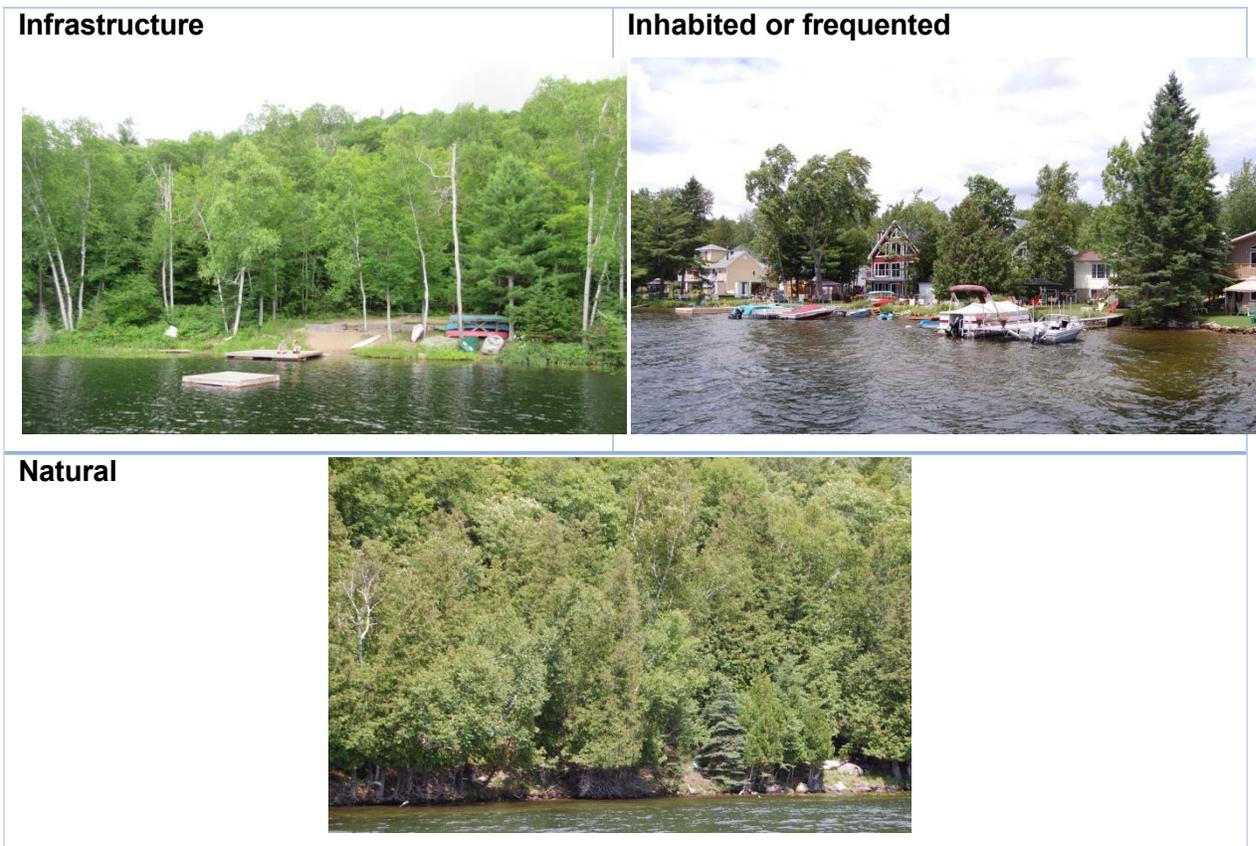


Figure 15. Examples of the three riparian zone land use categories at Lac Notre-Dame

Figure 16 shows their relative importance. More than half of the lake's circumference is inhabited, making it a lake with considerable anthropogenic pressure.

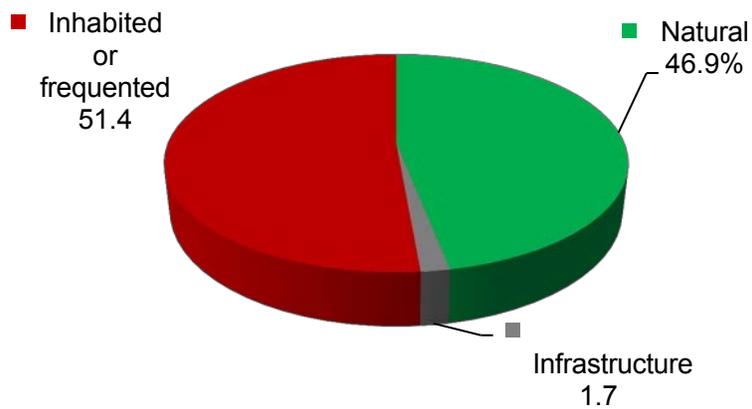


Figure 16. Relative importance of land use categories in the Lac Notre-Dame riparian zone.

The map below shows the homogeneous land-use zones at Lac Notre-Dame by category (Figure 17).

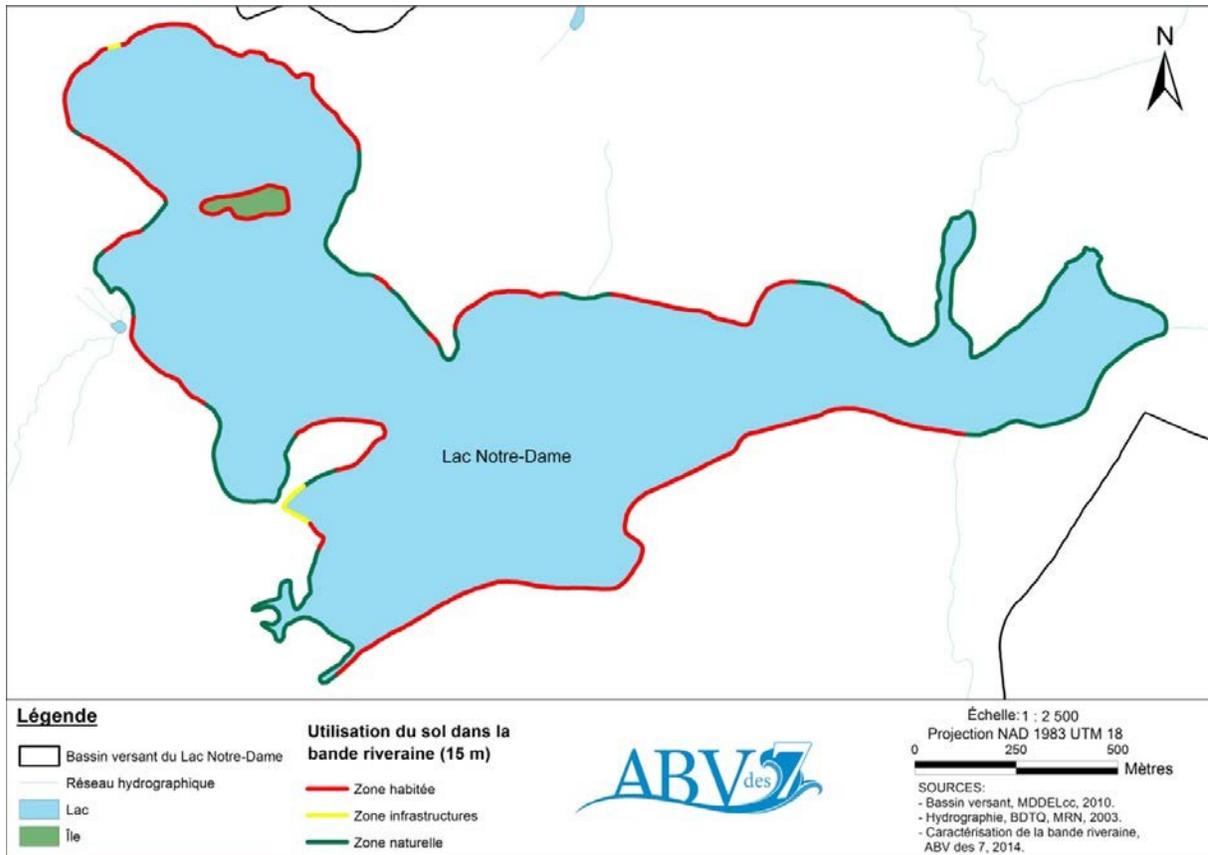


Figure 17. Location of homogeneous land-use zones at Lac Notre-Dame by category

3.2.2 Types of layout

Three types shoreline development and shoreline degradation have been identified at Lac Notre-Dame (Figure 18).

Inert materials



Ornamental vegetation



Natural vegetation



Figure 18. Examples of the three types riparian buffer development and shoreline degradation at Lac Notre-Dame

The riparian strip of Lac Notre-Dame is mostly composed of natural vegetation (82%) (Figure 19).

Characterization of the riparian strip of Lac Notre-Dame and delineation of Eurasian watermilfoil beds

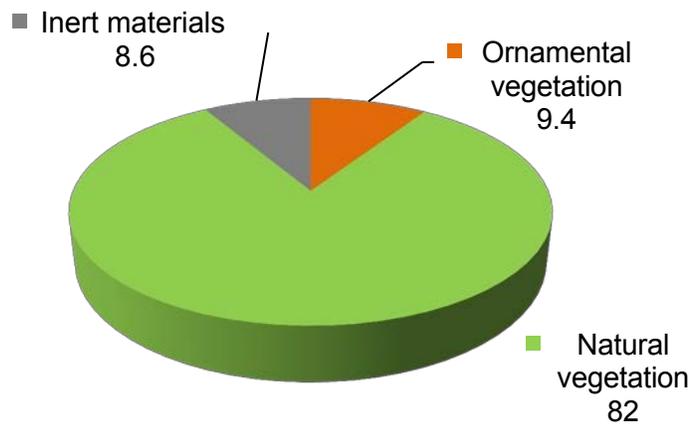


Figure 19: Relative importance of riparian zone development and shoreline degradation at Lac Notre-Dame

A riparian buffer composed of more than 80% natural vegetation is favorable for maintaining the environmental, social and economic benefits it provides. As a general rule, lawn-type ornamental vegetation and inert materials encourage water runoff and pollution of water bodies.

3.2.3 Design classes

According to management classes based on the percentage of natural vegetation, of the riparian buffer is made up of plant species (trees, shrubs, herbaceous plants), which cover 80 to 100% of the surface area of the areas studied (Table 5 and Figure 20).

Table 5. Lake Notre-Dame riparian buffer management class percentages

Management class by percentage of natural vegetation	Percentage of total riparian buffer strip
A - 80 to 100	83,03 %
B - 60 to < 80%	5,35 %
C - 40 to < 60	1,32 %
D - 20 to < 40	4,36 %
E - 0 to < 20	5,94 %

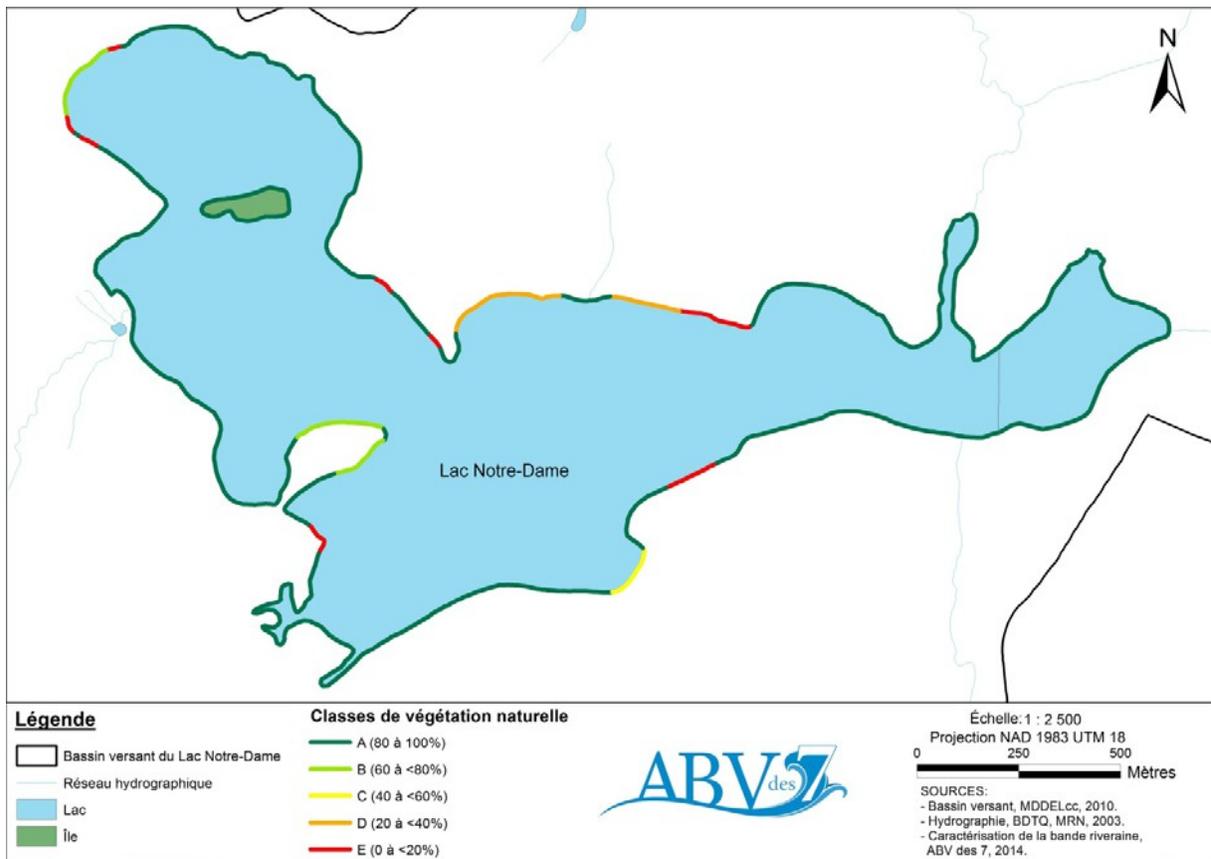


Figure 20. Location of Lac Notre-Dame riparian buffer sections by natural vegetation management class

The areas with the greatest human impact are mostly found on the north-central shore of the lake. This should be the preferred location for actions to preserve and restore the riparian buffer zone.

3.2.4 Shoreline degradation

Table 6 shows the percentages of shoreline degradation according to the three categories of land use present at Lac Notre-Dame. Overall, the shoreline is disturbed along 8.1% of its length. The presence of bare soil and erosion sites represents 2.5% of the shoreline, while the presence of low walls and fills represents 5.6%.

Table 6. Percentage of shoreline degradation according to the three categories of land use present at Lac Notre-Dame

Land use category	Types of shoreline degradation	
	Bare soil and erosion focus	Low walls and embankments
Inhabited or frequented	2,2 %	5,6 %
Infrastructure	0,3 %	0,0 %
Natural	0,0 %	0,0 %
Subtotal	2,5 %	5,6 %
Total disturbance	8,1 %	

Bare soil along the shoreline increases the risk of erosion and pollution (e.g. pollutants, sediments, nutrients). Low walls and embankments can concentrate runoff, cause erosion and contribute to phosphorus inputs.

3.2.5 Shoreline degradation classes by percentage of disturbed shoreline

Overall, the riparian strip of Lac Notre-Dame is only slightly disturbed (less than 20% of the shoreline is disturbed over more than 90% of its length) (Table 7). The less disturbed the shoreline, the greater the lake's natural protection against erosion, eutrophication and water warming.

Disturbances are mainly concentrated in the north-central and southern areas (Figure 21). Riparian buffer restoration could be carried out in these areas.

Table 7. Percentage of riparian strip according to shoreline disturbance classes

Shoreline degradation class by percentage disturbed shoreline	Percentage of total riparian buffer strip
A -< 20	92,37 %
B - 20 to< 40	0 %
C - 40% to< 60%	0,83 %
D - 60 to< 80%	3,07 %
E - > 80 %	3,73 %

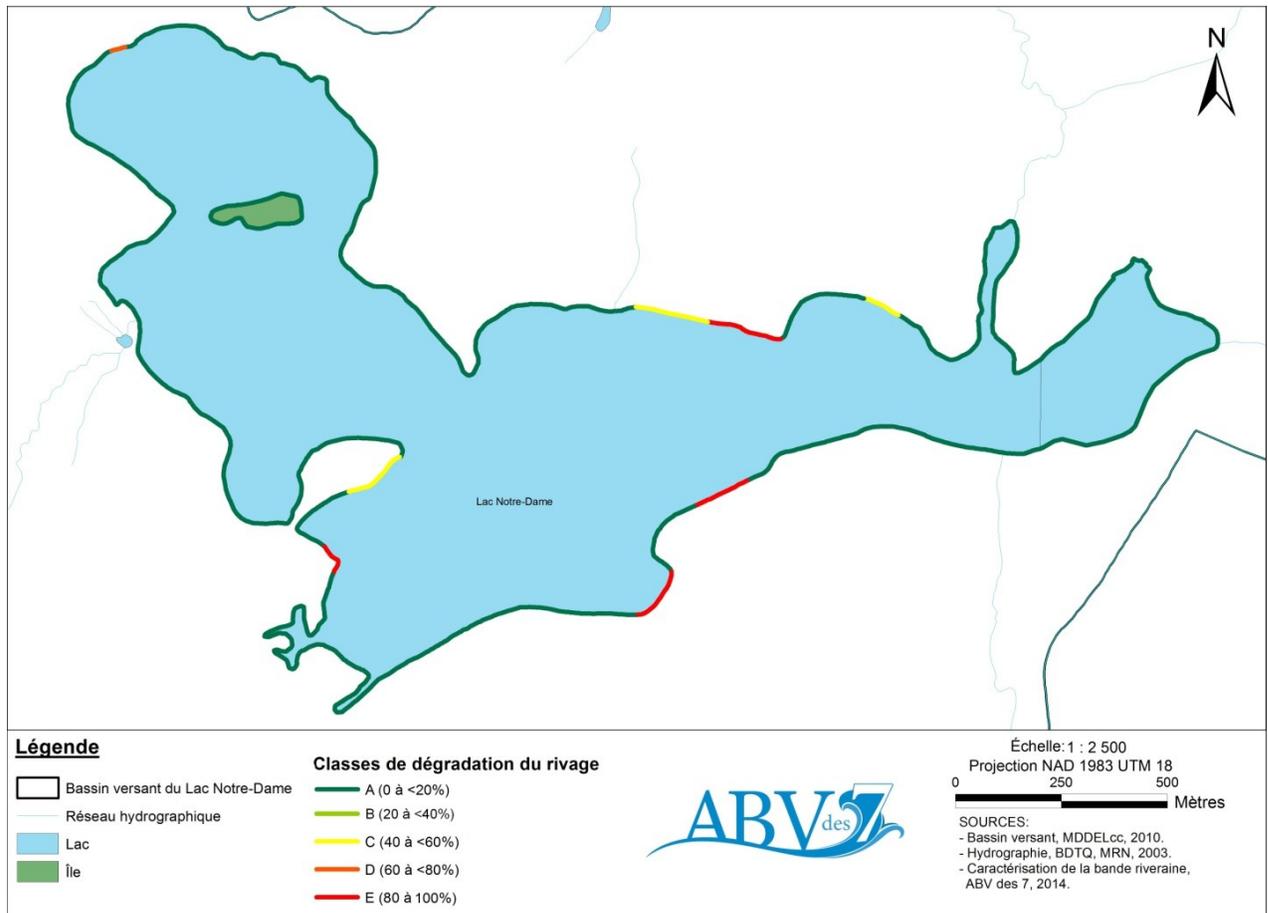


Figure 21. Location of Lac Notre-Dame riparian buffer sections according to their shoreline degradation class

3.2.6 Information summary

Compiling the information on land use (natural, inhabited or infrastructure) and the types of development present in the riparian buffer strip, we can see that in the natural land use category, natural vegetation is dominant (95.90%) and inert materials (rocks) represent 4.10%. In addition, inhabited areas comprise natural vegetation, which leads to 30% land use that erosion and runoff ornamental vegetation (lawns) and inert materials. The same applies to infrastructure zones, where inert materials account for 24.70% and natural vegetation for 75.30% (Table 8 and Figure 22). It is interesting to note, however, that there is no ornamental vegetation in the infrastructure zones.

Table 8. Importance of riparian buffer development and degradation by land use category at Lac Notre-Dame.

Types of development and degradation	Land use categories		
	Natural	Inhabited	Infrastructure
Natural vegetation 	95,90 %	70,00 %	75,30 %
Ornamental vegetation 	0,00 %	18,00 %	0,00 %
Inert materials 	4,10 %	12,00 %	24,70 %
Total	100 %	100 %	100 %

Characterization of the riparian strip of Lac Notre-Dame and delineation of Eurasian watermilfoil beds

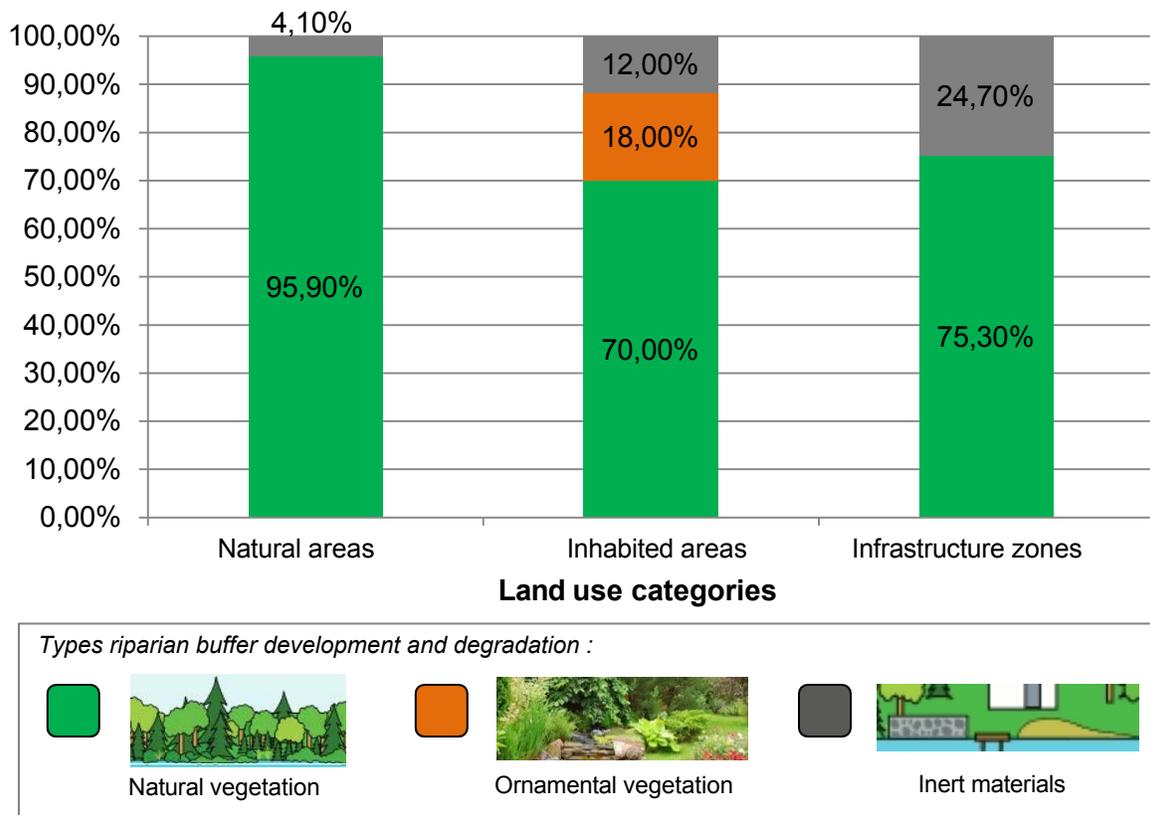


Figure 22: Importance of riparian buffer development and degradation by land-use category for Lac Notre-Dame.

3.3 Beaver issues

3.3.1 The beaver population

Beavers thrive in wooded areas and in wet habitats along streams and rivers. Topography is an important factor in the establishment of colonies (preference for streams with a gradient of less than 3%).

Beavers are mainly found around the lake, in marshy areas. Indeed, beavers generally build their lodges directly in the lake (figure23).



Figure 23. Presence of a beaver lodge in a marshy bay at Lac Notre-Dame

The potential causes of the beaver's presence in the Lac Notre-Dame watershed are related its habitat preferences:

- Wetlands (swamps, etc.) or ;
- Low gradient for a watercourse (less than 3%);
- The body of water in which the beaver settles must be in direct proximity to a wooded area for feeding and for building (dams, lodges, etc.);
- Environments with few predators.

3.3.2 Consequences

The beaver must be able to enjoy respect for its environmental niche. Indeed, beavers create ecosystems that are essential to the aquatic environment through the biodiversity they maintain. Their ponds ensure the diversity of aquatic plants, help regulate the flow of rivers, provide watering places for mammals and sites for the development of new species.

feeding grounds for birds that feed on invertebrates or fish. Table 9 shows the general impacts of beavers.

Table 9: Natural impacts of beavers

Creation wetland ecosystems: When a river is transformed into a pond by the construction of a dam, the water speed is altered. As a result, species (fauna and flora) that thrive in flowing water (insect larvae, etc.) will be replaced by species that thrive in stagnant water.
Dead trees, flooded by rising water, serve as perches for birds
The combined effect of several dams helps to regulate the flow of larger upstream rivers during periods of high water levels. droughts or when there are thunder showers
The first species to benefit from this increase in stream productivity is the brook trout. In addition to increasing the amount of food available, beaver ponds provide resting, shelter and wintering areas. Other species also benefit from the beaver's presence: catfish, pike and bass.
Beaver ponds also attract many species waterfowl, such as wood ducks and black ducks, as well as a number of passerines and insectivores that depend on these environments for feeding, reproduction and breeding. rest
Changes to the plant communities of ponds and adjacent shorelines benefit certain large mammals. Moose and white-tailed deer feed on aquatic vegetation and the abundance of young shoots that emerge following establishment of a beaver colony. Bears, on the other hand, seek out the wild fruits that abound in these new clearings
Transformation of forest ecosystems: beavers mainly cut down hardwood trees on land, which has a negative impact on the environment. transforms the forest into a coniferous forest
Beavers use their tails to stir up suspended matter in the water, which can lead to sedimentation. clog spawning grounds for certain fish (lake trout)
Public safety problems: damage to infrastructure (flooding, blocked roads, etc.).
Impacts on recreational tourism activities (reduction in the population of certain fish prized for sport fishing in due to changes in the water level, blocked or flooded trails...)

3.3.3 Conclusion

The beaver is a species whose constructions can have an impact on the environment. According to the Association, the beaver's presence on Lac Notre-Dame has a significant and negative impact on the lake's water quality. In fact, they found that high water analysis results were linked to the presence of beavers, since they were carried out near their habitat. In addition, beavers are thought to be responsible for

the increase in organic matter and present in the lake as they build dams and huts and cut down trees in the riparian strip.

3.4 The problem Eurasian water milfoil

3.4.1 Overview of the situation at Lac Notre-Dame

Milfoil beds in Lac Notre-Dame were delineated on September 3, 2014. According to Paul Hamilton, an expert from the Musée de la Nature, Eurasian water milfoil was introduced into Lac Notre-Dame some twenty years ago. The only herbarium mapping carried out prior to this project dates back to 2004, and was done by hand (Figure 24).

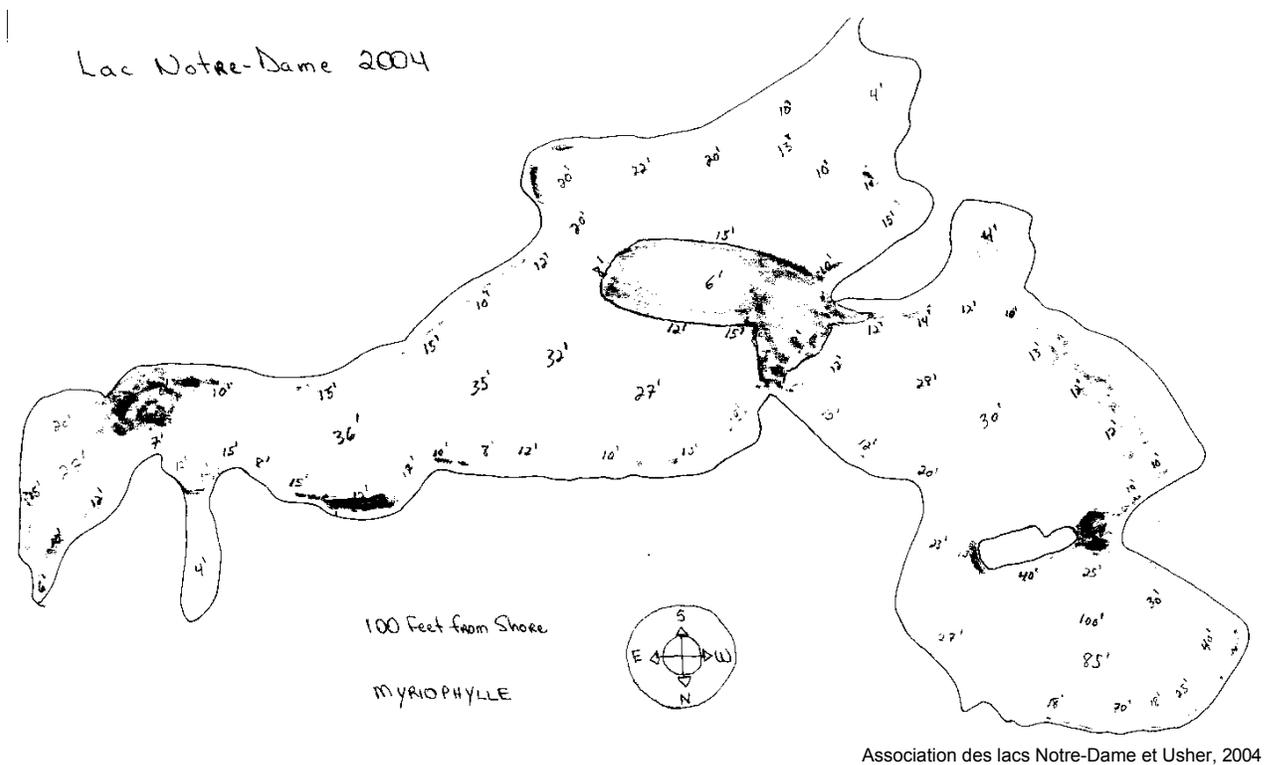


Figure 24. Location of Eurasian watermilfoil beds on Lac Notre-Dame in 2004

This map shows that Eurasian watermilfoil was widespread throughout the lake. Figure 25 shows the state of the beds ten years later, in 2014.

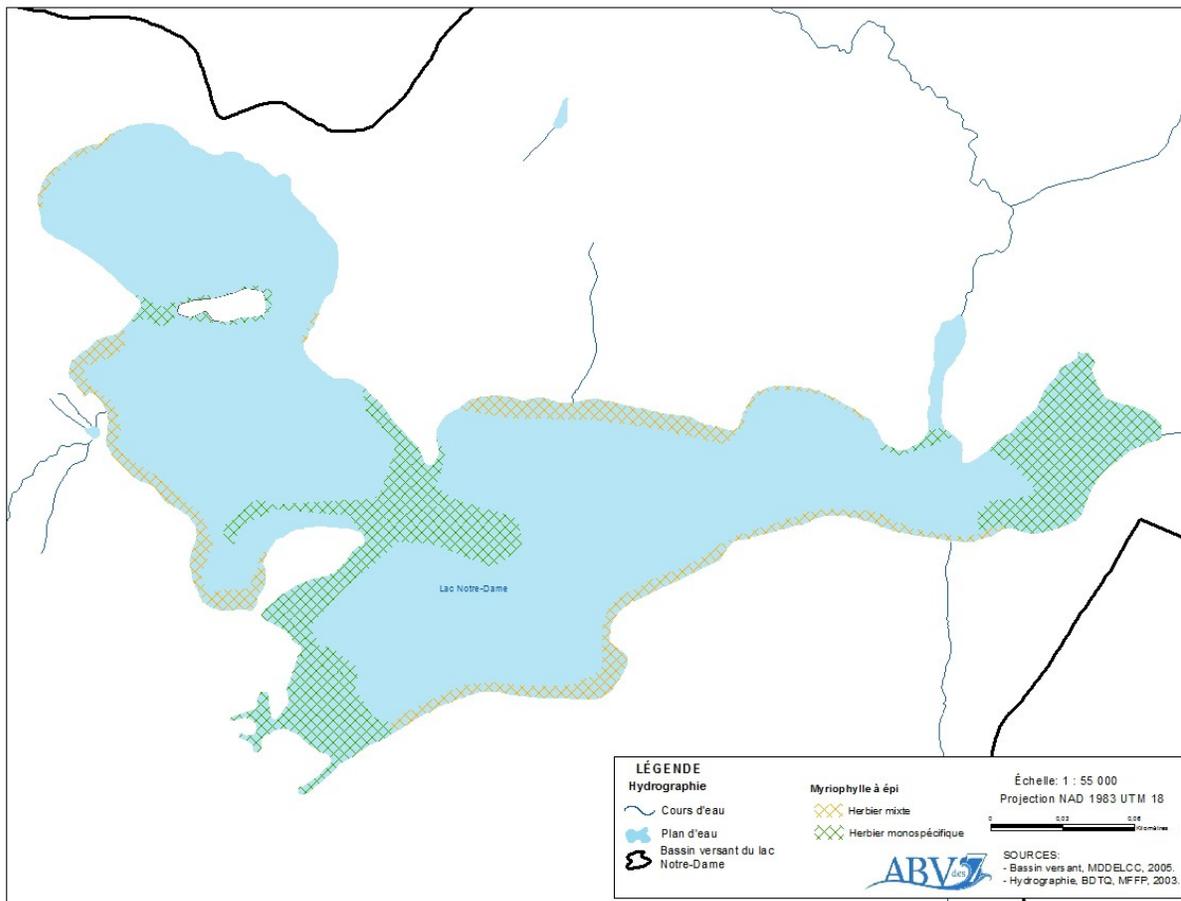


Figure 25. Location of mixed and monospecific Eurasian watermilfoil beds

This map shows watermilfoil is still present and has spread since 2004. The map shows the distribution of monospecific and mixed milfoil beds on Lac Notre-Dame. The plant's distribution represents approximately 38.96 hectares of the lake's surface area. Given that the lake has a surface area of 146.46 hectares, Eurasian watermilfoil beds account for more than a quarter (26.6%) of the lake's total surface area.

Meadows can be divided into two sub-categories. Either mixed meadows, i.e. milfoil meadows including native species, or monospecific meadows, i.e. milfoil meadows with no native plants (Figure 26).

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

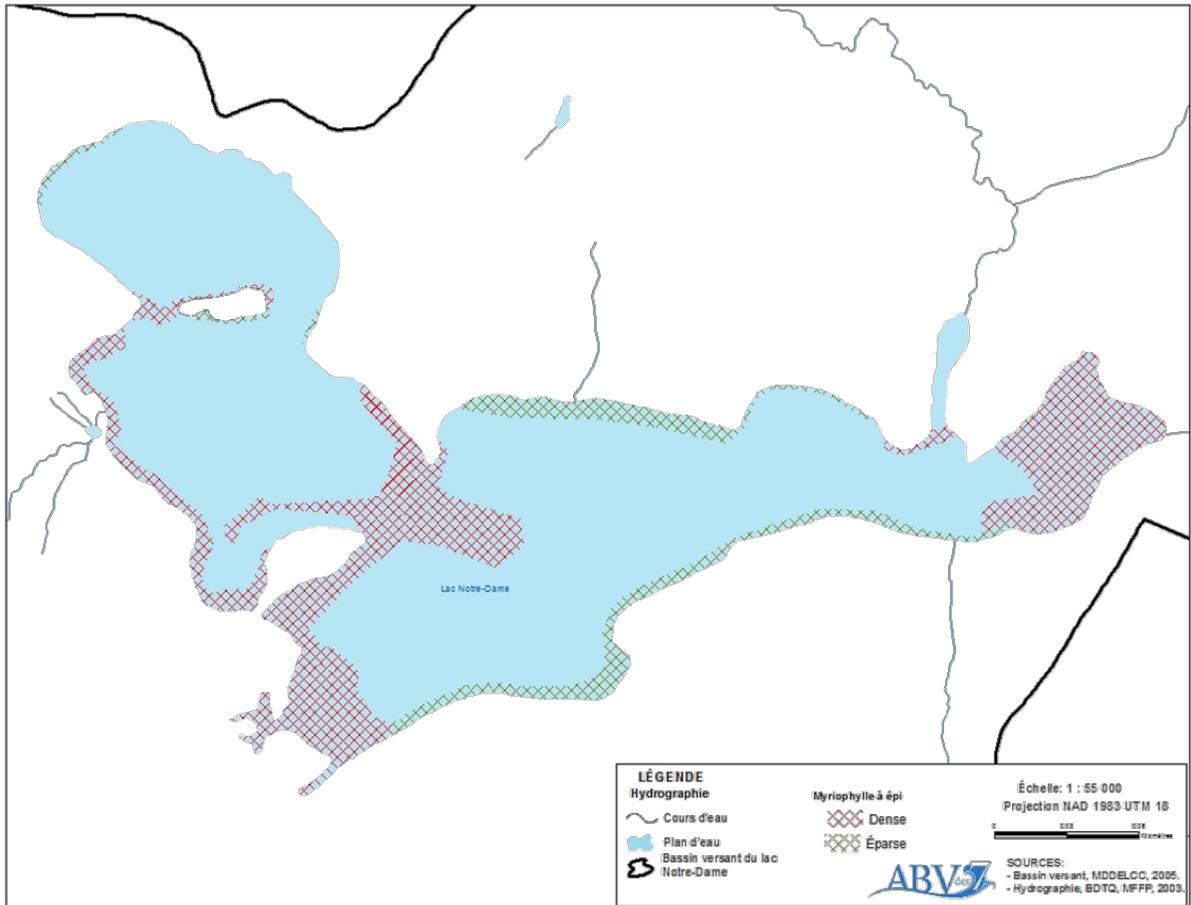


Figure 26. Location of dense and sparse Eurasian watermilfoil beds

The following table illustrates some of the data from the mapping carried out in 2014 according to seagrass type.

Table 10. Classification, area and percent cover of Eurasian watermilfoil beds at Lac Notre-Dame in September 2014.

Type herbarium	Total (ha)	Density	Area (ha)	Percentage seagrass cover	Percentage lake capping
Monospecific	27,71	Dense	27,39	70,3 %	18,7 %
		Clairsemé	0,32	0,8 %	0,2 %
Mixed	11,25	Dense	3,26	8,4 %	2,2 %
		Clairsemé	7,99	20,5 %	5,5 %
Total	38,96	N/A	38,96	100 %	26,6 %

Using the data in Table 9, we can see that seagrass beds are predominantly monospecific and dense. Mixed meadows are mostly sparse. This suggests that mixed meadows are the first stage in the evolution of the invasive plant in the lake. The plant quietly establishes itself among the native species, displacing them and taking over the entire area to create dense monospecific meadows.

It is important to consider the degree of accuracy of this data. Several external variables can influence the accuracy of such mapping. During the field trip, a GPS was used to delimit the seagrass beds. This tool has an accuracy of between three and five metres. Furthermore, since the seagrass beds were located from a canoe with the aid of an Aqua-Scope II, it is possible that the seagrass beds are actually larger than the mapping indicates, given that visibility is influenced by the weather during the field trip and the transparency of the water.

3.4.2 Possible control methods

When it comes to Eurasian water milfoil in a lake, there's often talk of how to eradicate it. However, after several years of research and trials, it is still impossible to eradicate Eurasian water milfoil from a lake once it has been introduced. That's why it's so important to prevent the spread of this invasive plant and protect Eurasian watermilfoil-free lakes. One way to prevent or delay the spread of Eurasian water milfoil, or any other exotic aquatic species, is by

invasive species from lake to lake is boat washing. The ABV des 7 has produced various awareness-raising materials on this problem of lake-to-lake transmission of invasive alien species. Figure 27 illustrates an awareness panel to be posted at boat landings that includes the steps involved in boat washing.



Figure 27. Awareness and instruction signs for boat washing

The plant also spreads within a lake, naturally through the plant itself, but also through motorboat traffic in milfoil-infested areas. So, in addition to encouraging boat washing, it's important to emphasize to users of an affected body of water that they shouldn't drive watermilfoil beds. By avoiding these areas, it is possible slow the spread of the plant in non-infested areas.

Once Eurasian water milfoil has established itself in a lake, it is still not possible to eradicate it. However, we can try to control it using a variety of mechanical, physical, chemical and biological techniques. The MDDELCC has produced a summary of all possible control methods. This document is Appendix 2 to the Environment Quality Act (EQA). The table contents of this appendix is presented Appendix B of this report (MDDELCC, 2014e). However, for the purposes of this project, a quick summary of the various techniques and methods is developed in the following sections.

Please note that before carrying out any project, you must contact the people in charge at the MDDELCC to confirm whether or not you need to obtain a certificate of authorization under the LQE. Eurasian watermilfoil control methods fall into four categories: mechanical, physical, chemical and biological.

3.4.2.1 Mechanical techniques

Mechanical techniques include any action that acts directly on Eurasian watermilfoil plants, such as mowing and grubbing.

Mowing is carried out using a tool that cuts the aerial part of the plant, but never touches the roots. This technique can be compared to hair-cutting for Eurasian water milfoil. As a result, the exercise has to be repeated several times during the same summer season, and requires several volunteers each time. What's , a certificate of authorization is required to carry out this activity in a lake.

Manual removal by divers is a method that seems to be very effective when properly executed. This method can be very costly, as deep-seated plants have to be removed by scuba diving. Also, it's important to remove one plant at a time in order to remove the entire root system and avoid creating fragments of Eurasian watermilfoil. This method is costly in terms of time, money and energy, especially dealing with large weed beds. In addition, it is important to consider that when the phosphorus concentration in a lake is high, the lake is not large, or the quantity of plants to be removed is large, there may be an undesirable effect to the removal. When a plant is uprooted, the sediment becomes suspended particles, releasing the phosphorus trapped in the sediment. This release of phosphorus could create conditions conducive to the proliferation of cyanobacteria, resulting in the appearance of a blue-green algal bloom.

However, when these methods are used to control Eurasian water milfoil, it is essential to ensure that no fragments escape to prevent the plant from spreading into the lake. To achieve this, floating barriers or a surveillance team must be set up around the site to recover floating fragments.

3.4.2.2 Physical techniques

Physical techniques involve attacking the plant in relation to a physical characteristic, such as oxygenating the water, reducing light levels with burlap or freezing the plants over winter.

Aeration systems to oxygenate the water have long been a recommended method of controlling Eurasian water milfoil. In fact, such systems are already in place at Lac Notre-Dame. However, over the years, scientists seem to disagree with the effectiveness of this method. According to the merchants, this method is revolutionary, and according to the scientists, this method is useless. In fact, biologists have found that oxygenating the water column has no significant effect on Eurasian water milfoil beds, since these plants have very large roots, which means that the lake's oxygen concentration has no effect on them. Furthermore, oxygen injection could have the effect of preventing thermal stratification in lakes (Figure 5). This could prevent the natural equilibrium of a lake and could harm the wildlife species present. Phosphorus naturally settles to the bottom of a lake and accumulates in the sediments. Aeration of the hypolimnion may release phosphorus trapped in the sediment into the water column and prevent sedimentation. The concentration of phosphorus in the water column could become higher. This phenomenon is the opposite of the desired effect. This method is risky, very expensive in terms of equipment, maintenance and repair, and has no guarantee of success.

The use of benthic fabric, either burlap or geotextile, is a relatively new method. It was first tested in Ireland by a university researcher on an exotic and invasive aquatic plant, *Lagarosiphon major* (Caffrey *et al.*, 2010). In this study, the researcher found that jute fabric, unlike geotextile fabric, is biodegradable and allows native plants to grow through the fabric. As a result, the balance of the aquatic ecosystem can return to normal. ABV des 7 replicated this experiment at Lake Pémichangan in 2012. After three years of burlap installation at Lake Pémichangan, the results are similar those obtained in this study. Native plants grow through the burlap, Eurasian watermilfoil grows very little and the burlap decomposes quietly (Figure 28).

The advantage of using jute fabric is that it's biodegradable, so there's no need to remove it year for cleaning, as is case with geotextile fabrics.



Source: ABV des 7, 2013

Figure 28. Underwater photo of burlap with native plants

Winter freezing involves lowering the water of a body of water so that Eurasian water milfoil plants come into contact with the winter frost, causing them to die. However, this technique is difficult to implement in a lake the size of Lac Notre-Dame, especially as the water level in this lake is not controlled by a dam.

3.4.2.3 Chemical techniques

From 1970 to 1990, certain herbicides, mainly 2,4- dichlorophenoxyacetic acid (2,4-D), were used to control or eradicate Eurasian watermilfoil (Denis-Blanchard and Carignan, 2013). Any use of herbicides or algaecides is strictly prohibited in lakes in Quebec under the pesticide management code (MDDELCC, 2014b).

Another chemical technique, which can be used under certain conditions, is to capture phosphorus, the nutrient that limits the growth of aquatic plants. To achieve this, iron salts or alum can be applied to absorb the nutrients. For phosphorus, one company has developed a product called Phoslock™ which, according to toxicity studies, poses a very low risk to humans and the aquatic ecosystem (Davies, 2011). Furthermore, the same study mentions that

that Phoslock™ would deliver significant improvements to water quality and the ecosystem as a whole through phosphorus reduction (Davies, 2011). This product is being observed in many parts of the world, including Ontario. This chemical traps phosphorus at the bottom of the lake, improving water quality and reducing the amount of algae and aquatic plants in the lake.

3.4.2.4 Biological techniques

Biological techniques often involve introducing herbivorous fish species, macro-invertebrates (aquatic insects), bacteria or toxic or competitive plants. However, all these methods are risky, since they involve introducing something that does not exist in the ecosystem affected by Eurasian water milfoil. It is impossible to predict the reaction of the introduced species to its new environment. Even if you introduce a herbivorous fish, you can't predict whether it will eat only Eurasian water milfoil or only native species.

Research has been carried out in Quebec on the larva of a species of aquatic weevil native to North America (*Euhrychiopsis lecontei*) that appears to feed on Eurasian watermilfoil (Denis-Blanchard and Carignan, 2013). In fact, this biological technique for controlling Eurasian watermilfoil was tested on Lac Supérieur in the MRC des Laurentides for a period of six years, between 2005 and 2010. The results of this project were inconclusive (Comité consultatif en environnement de la municipalité de Lac-Supérieur, 2013). Studies have shown that sunfish (*Lepomis gibbosus*) consume adult weevils and can rapidly deplete the population, reducing the chances of success of biological control of Eurasian watermilfoil (Lavoie, 2010). In Lake Superior, the sunfish population is very large, which may explain why this project was unsuccessful, as the weevil population was not large enough (Lavoie, 2010).

3.4.3 Actions taken by local residents

The Association has been very active on the Eurasian watermilfoil issue ever since the plant was first discovered. Indeed, members of the Association contacted an expert from the Museum of Nature, Mr. Paul Hamilton. This expert took part in an information session with the owners, where he was able to talk about his experience with the plant.

experience with Eurasian water milfoil. He also presented the various possible control methods, with the advantages and disadvantages of each. As a result, the members of the Association decided to set up a pilot project for mowing the lake. In May 2005, the Association obtained a certificate authorization from the MDDELCC for the project entitled "*Eurasian watermilfoil control program through summer and fall cutting at Lac Notre-Dame, municipality of La Pêche*". Copies of the certificate of authorization and permit from the MFFP can be found Appendix C of this report. This pilot project involved mowing Eurasian watermilfoil using mowing equipment attached to a pontoon and a team of volunteers collecting Eurasian watermilfoil fragments in the water. This project turned out to be more laborious than anticipated, and required the participation of volunteers on a regular basis. According to Association president Jacqueline Lambert-Madore, these two factors made the project unviable in the long term. As a result, the Association is encouraging residents to carry out manual mowing, which does not require a certificate of authorization, during the summer months. According to Ms. Lambert-Madore, manual mowing weakens the seagrass beds, allowing native plants to recolonize. This finding corroborates what Mr. Hamilton concluded in his study (Danard and Hamilton, 2004).

In addition, some shoreline residents have installed underwater aerators to control Eurasian water milfoil growth. The purpose of these aerators is to increase the concentration of dissolved oxygen in the water, which could have the effect of reducing Eurasian watermilfoil growth. These installations are the result of initiatives by a few local residents.

The Association has also distributed information leaflets on good and bad practices regarding Eurasian water milfoil and lake water quality. This information also forms part of the agenda for membership renewal at each Annual General Meeting (AGM). The AGM is held at the beginning of each July. What's more, at the AGM, the Association distributes pamphlets produced by the various ministries concerned (MFFP and MDDELCC) to make shoreline residents aware of any changes they may have observed concerning the presence of new aquatic plants or invasive aquatic fauna such as the zebra mussel. According to Ms Lambert-Madore, a major problem encountered is that the majority of owners are vacationers, and are only present at the lake during the summer months. And so..,

the Association has a very limited period in which to reach them and raise their awareness.

3.4.4 Conclusion

It's difficult to choose a good control method that will be effective and not too costly. However, Lac Notre-Dame needs a helping hand to slow the evolution of Eurasian water milfoil, as the plant can further invade the lake, transforming sparse, mixed-grass beds into dense, monospecific ones. Based on the situation at Lac Notre-Dame, ABV des 7 recommends focusing efforts on the source of the problem, i.e. phosphorus inputs. In parallel with these efforts, benthic blankets (ideally made of jute) would be an excellent alternative for certain priority areas of the lake.

3.5 Water quality results and analysis

Sections 3.4.1 to 3.4.3 present data and analysis related to *E. coli* and total phosphorus. Transparency is then discussed in section 3.4.3, and the various physico-chemical measurements taken by ABV des 7, including dissolved oxygen, temperature, pH and conductivity, are offered and interpreted in sections 3.4.6 and 3.4.7.

3.5.1 Faecal coliforms (*E. coli*)

Faecal coliforms are bacteria of faecal origin found in the digestive tract of humans and animals. The species most frequently associated with this bacterial group is *E. coli* (80-90% of faecal coliforms detected) (INSPQ, 2003). They are used in water quality analyses as indicators of fecal pollution.

The MDDELCC uses a classification based on fecal coliform content to assess whether water quality is sufficient for recreational use (table 11).

Table 11. Classification of water quality for recreational use.

Water quality	Faecal coliforms/ 100 ml	Permitted uses
Excellent	0-20	All recreational uses permitted
Good	21-100	All recreational uses permitted
Poor	101-200	All recreational uses permitted
Wrong	Over 200	Bathing and other direct contact with compromised water
Very bad	More than 1000	All recreational uses compromised

Source: Taken from MDDELCC, 2014b.

The figure below shows the evolution of *E. coli* concentrations a seven-year period for the nine sampling points presented in figure 4 of section 2.2.1.

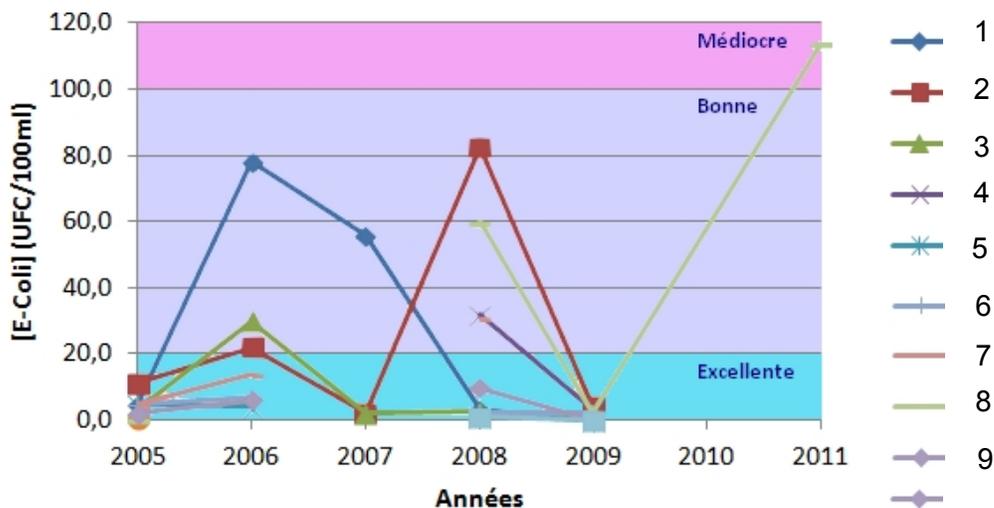


Figure 29. Changes in *E. coli* concentration (CFU/100 ml) in Lac Notre-Dame from 2005 to 2011

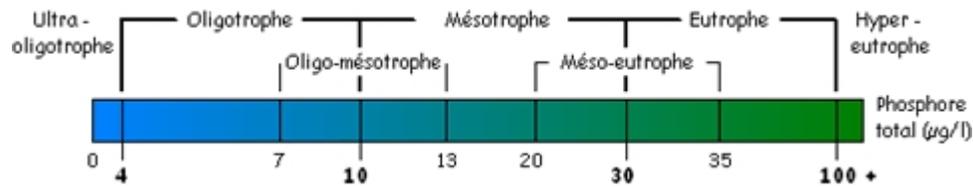
Sampling data show excellent to good water quality, except at sampling station 8 in 2011, which showed poor water quality.

3.5.2 Total phosphorus

Phosphorus is an essential mineral for the growth of aquatic plants and algae. It can be naturally introduced into aquatic ecosystems via

erosion of the watershed substrate and subsequent runoff. Phosphorus also comes from artificial sources via human inputs, such as chemical or natural fertilizers, domestic wastewater (septic systems), phosphate-containing cleaning products, forest cutting creating erosion and sediment transport, unvegetated riparian buffers, and poorly managed roadside drainage ditches.

A lake's phosphorus concentration defines its trophic status (Figure 30). A lake is considered eutrophic if it exceeds a total phosphorus concentration 0.03 mg/l.



Source: MDDELCC, 2014a

Figure 30. Diagram of trophic level ranking of lakes according to total phosphorus

The following figure shows the evolution of total phosphorus concentrations over seven years for the various sampling points on Lac Notre-Dame.

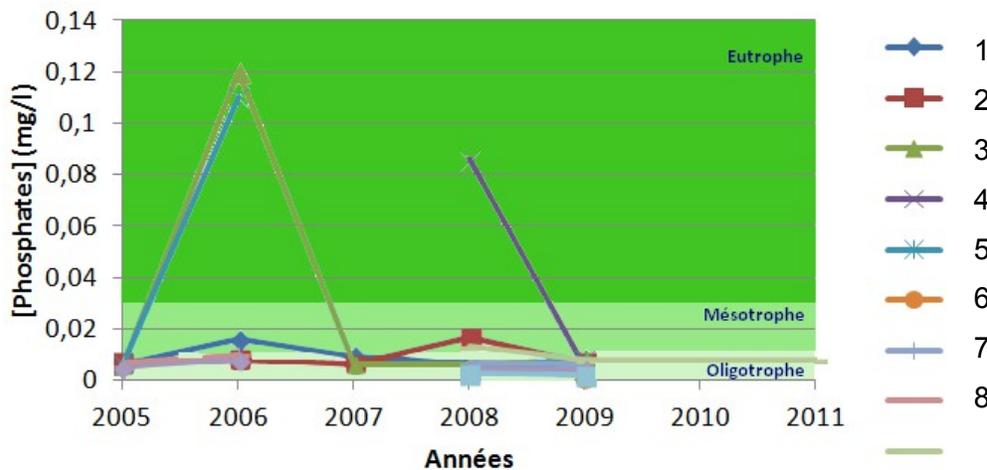


Figure 31. Changes in total phosphorus concentration (mg/l) in Lac Notre-Dame from 2005 to 2011

Most samples show oligotrophic to mesotrophic water. Only samples taken at sampling stations 3 and 5 in 2006 and station 4 in 2008 showed eutrophic water. Two increases in trophic level are visible, one in 2006 and one in 2008. It would therefore appear that eutrophication was a problem in both years. To locate these stations, please refer to figure 4 in section 2.2.1.

In addition, during the characterization of the riparian strip in July 2014, the ABV des 7 team noted the presence of outdoor fireplaces in the riparian strips. These fireplaces were often on the ground and had no ash collection tanks. When it rains, or simply blows in the wind, the ashes can be washed into the lake, representing a considerable source of phosphorus. It is therefore important to equip outdoor fireplaces with tanks to collect ashes after each use, thus preventing them from ending up in the lake.

3.5.3 Joint analysis of changes in fecal coliform and total phosphorus concentrations

It should be mentioned at the outset that Figures 32 and 33 are based averages of existing data for each year. The number and date of measurements differ from year to year, and many data are missing. These irregularities increase the imprecision of the data, but a few trends can be discerned from these figures.

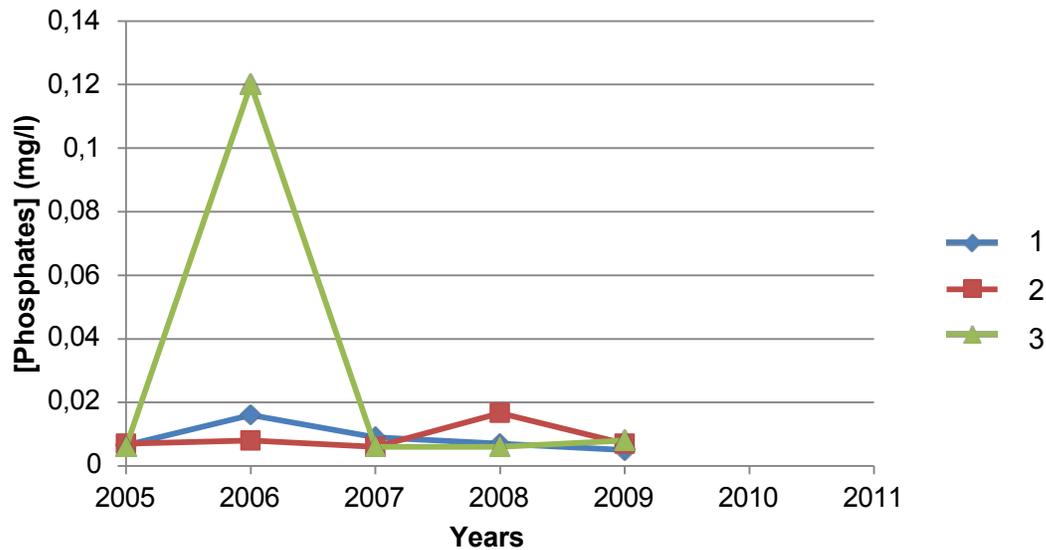


Figure 32. Trends in total phosphorus concentration (mg/l) for sampling stations 1, 2 and 3 at Lac Notre-Dame from 2005 to 2011.

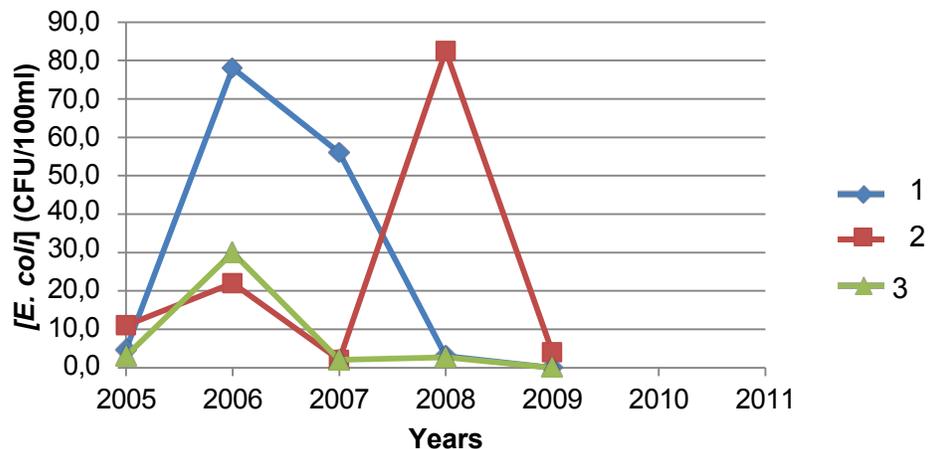


Figure 33. *E. coli* concentration trends (CFU/100ml) for sampling stations 1, 2 and 3 at Lac Notre-Dame from 2005 to 2011.

Firstly, a concentration peak was observed in 2006 for the *E. coli* and total phosphorus parameters, at the majority of sampling stations. Stations 1 and 3 have the highest data in this respect.

Then, another concentration peak seems to emerge in 2008. However, a significant lack of data between 2006 and 2008 makes it impossible to conclude on a general trend in phosphorus concentration. In fact, both parameters were

analysed for all years (between 2006 and 2009) only for sampling station 2. If we disregard the two measurements with very high data compared to the others, we can observe a downward trend *E. coli* concentrations and a stabilization in phosphate concentrations.

Sampling stations 1, 2 and 3 are the most important on the lake, as they are located at the mouths of the main tributaries, including Usher Lake (station 1). However, no water quality data is available for Usher Lake for the years 2006 and 2008.

Samples were also taken by the association on June 5 and July 23, 2013. The sampling points showed total phosphorus concentrations ranging from 0.005mg/l to 0.011mg/l, with an average of 0.008mg/l for samples taken in June. In July, concentrations ranged from 0.006mg/l to 0.039mg/l, with an average of 0.015mg/l. These results place the entire body of water at mesotrophic level. The lake is no longer considered oligotrophic, so there is a trend towards eutrophication.

Fecal coliform concentrations were highly variable from point to point and from date to date. For samples taken in June, all showed concentrations of 2 CFU/100ml or less, indicating excellent water quality. For samples taken in July, only 16 of the 26 samples showed excellent water quality, with four (4) samples indicating good water quality and six (6) indicating poor water quality.

Data provided by the municipality of La Pêche

The municipality of La Pêche conducts its own water quality monitoring. It has provided results for the years 2008 to 2013 (Figures 34 and 35).

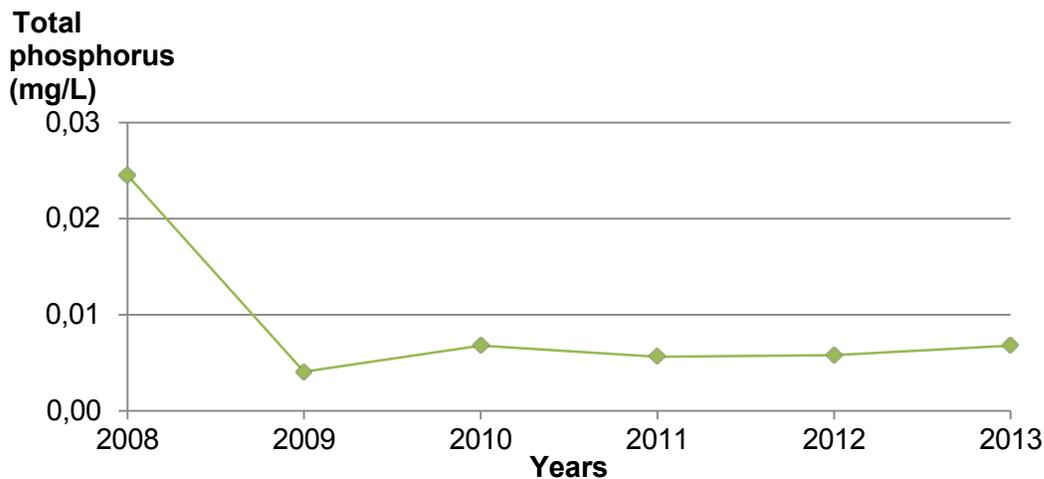


Figure 34. Changes in total phosphorus concentration in Lac Notre-Dame from 2008 to 2013

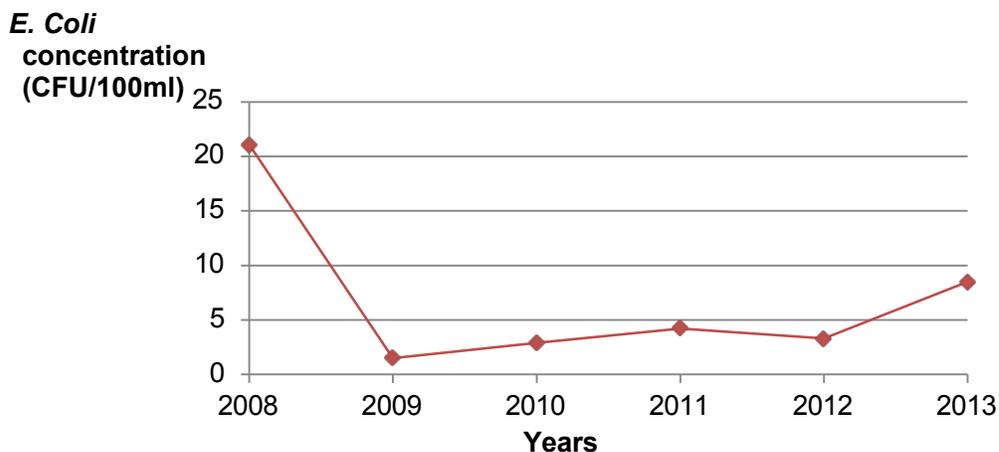


Figure 35. Changes in *E. coli* concentration in Lac Notre-Dame from 2008 to 2013

As with the data provided by the lake association, an increase in phosphorus and *E. coli* concentrations is visible for 2008. Concentrations then drop drastically. Overall, from 2009 to 2010, there was a slight increase in concentrations. Nevertheless, the lake as a whole remains oligotrophic and has excellent water quality. These results are not consistent with those obtained by the Association. However, the locations and number of sampling points are not the same between the Association and the municipality, which may explain the difference in results. In both cases, the increase in trophic level is very slight. The water quality of Lac Notre-Dame remains to be monitored.

3.5.4 Water transparency

Water transparency is also an indicator of the trophic level of the water body (table 12).

Table 12. Trophic level classes of lakes with corresponding water transparency values

Trophic level		Average transparency (m)
Main class	Secondary class	
Ultraoligotrophic		>12
Oligotrophic		12 - 5
	Oligo-mesotrophic	6 - 4
Mesotrophic		5 - 2,5
	Meso-eutrophic	3 - 2
Eutrophic		2,5 - 1
Hypereutrophic		<1

Source: Modified from MDDELCC, 2014a.

The Association des lacs Notre-Dame et Usher carried out transparency measurements with a Secchi disk on June 27 and September 30, 2013. On average, transparency 4 m in June and 5 m in September, placing the lake at an oligo-mesotrophic to mesotrophic level. This concurs with the values total phosphorus concentrations obtained by the Association and underlines the slight eutrophication of the water body.

3.5.5 Dissolved oxygen and temperature

ABV des 7 took measurements of saturation and dissolved oxygen concentration, as well as temperature as a function of depth, on July 17, 2014, i.e. during a period of thermal stratification. Figures 36 and 37 illustrate this evolution.

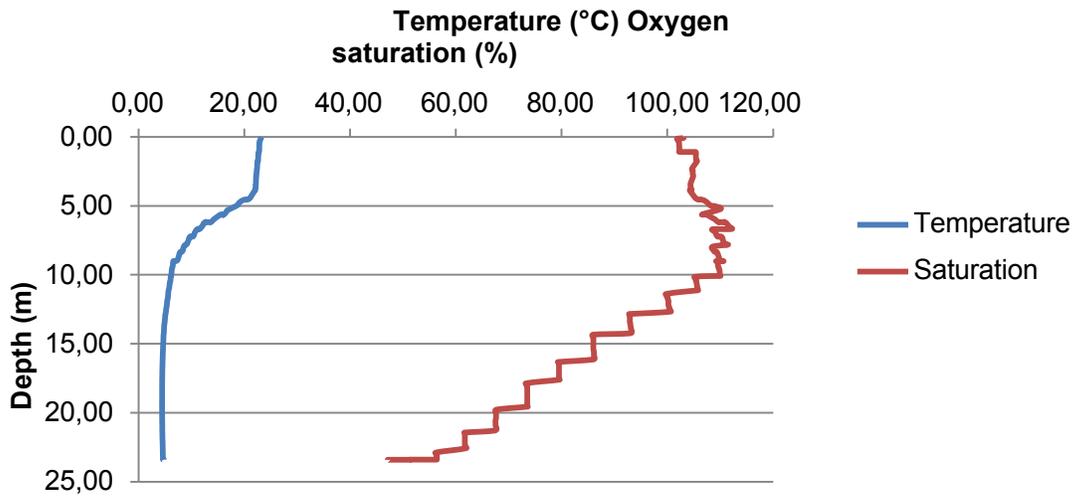


Figure 36. Changes in temperature and dissolved oxygen saturation as function of depth at Lac Notre-Dame

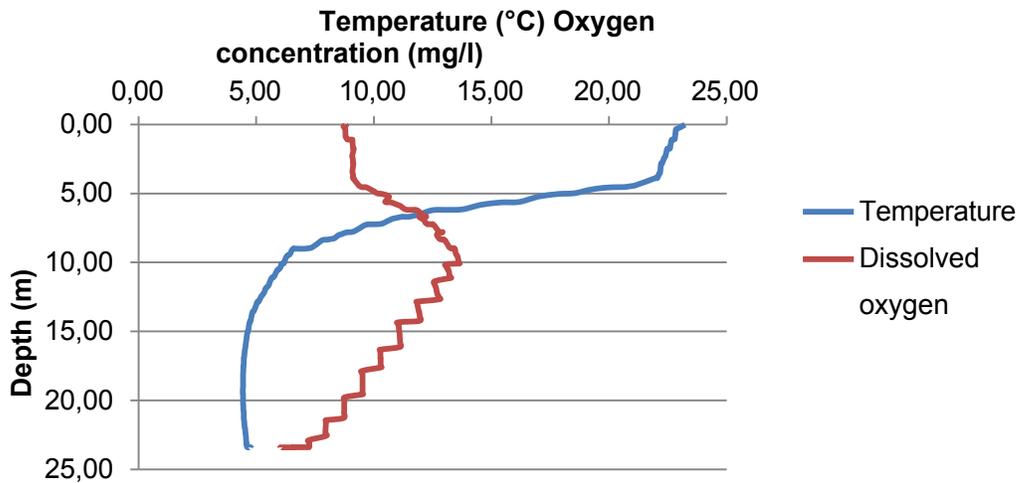


Figure 37. Changes in temperature and dissolved oxygen concentration as a function of depth at Lac Notre-Dame

Thermal stratification is visible. The first three meters have a temperature above 22°C (epilimnion), then the temperature drops significantly between three and eleven meters depth (thermocline) to stabilize between 4°C and 5°C in the deepest part of the water column (hypolimnion). With increasing depth, oxygen content and saturation decrease in the epilimnion, increase in the thermocline and then drop significantly in the hypolimnion.

The MDDELCC has issued theoretical minimum values to ensure aquatic life as a function of water temperature. These theoretical values were compared with those observed at Lac Notre-Dame (Table 13).

Table 13. Comparison of oxygen concentration and saturation values obtained at Lac Notre-Dame with theoretical values provided by MDDELCC for the survival of aquatic organisms

Water temperature (°C)	Average dissolved oxygen concentration (mg/l)		Average oxygen (%)	
	Theoretical* values	Observed values	Theoretical* values	Observed values
0-5	8	8,73	54	67,76
5-10	7	13	54	106,02
10-15	6	11,87	54	109,99
15-20	6	10,28	54	107,93
20-25	5	9,03	57	104,16

*Source: MDDELCC, 2014c.

For each temperature range, the oxygen concentration and saturation values observed were higher than the theoretical values. No anoxia problems were identified during this data collection. However, this is the average of oxygen concentration and saturation over the desired temperature range. The values taken separately show a concentration and saturation rate of less than 8mg/l and 54% in the last meter of depth. Although this is not cause for concern, a further measurement at the end of thermal stratification (mid-August to mid-September) would reveal whether the lake is suffering from anoxia in the hypolimnion. It is therefore important to monitor measurements of dissolved oxygen concentration and saturation.

3.5.6 Conductivity and pH

➤ Conductivity

The average conductivity of Lac Notre-Dame is 0.340 mS/cm (Figure 38). To estimate the average specific conductivity of a lake, it's best to consider the value measured at one metre depth, i.e. around 0.130 mS/cm. Although specific conductivity varies little with depth, an increase can be observed at

this depth. Under normal circumstances, conductivity in freshwater should be less than 0.200 mS/cm.

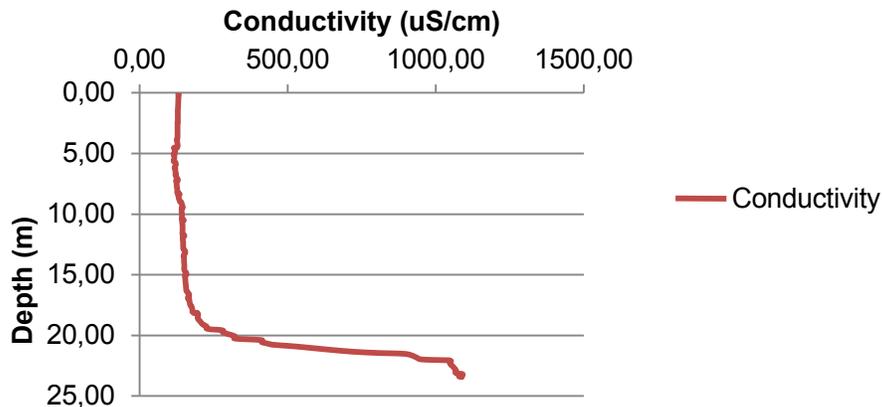


Figure 38. Changes in conductivity as a function of depth at Lac Notre-Dame

Conductivity decreases slightly in the epilimnion (up to 6.19 m), then increases gradually and then drastically in the last few metres. Conductivity can be affected by the presence of de-icing salts and sand caused by the erosion of unpaved roads. In the riparian zone of Lac Notre-Dame, only the road leading to the presqu'île is included in the 15-metre riparian zone.

➤ pH

The pH value is expressed on a scale of 1 to 14, with 1 being the most acidic and 14 the most basic, and neutrality ranging from 7. The aquatic ecosystem in a lake can be greatly influenced by pH. It must be in the neutral zone, i.e. between 6 and 9, to survive. The pH of Lac Notre-Dame was measured on July 17, 2014 and is shown in Figure 39.

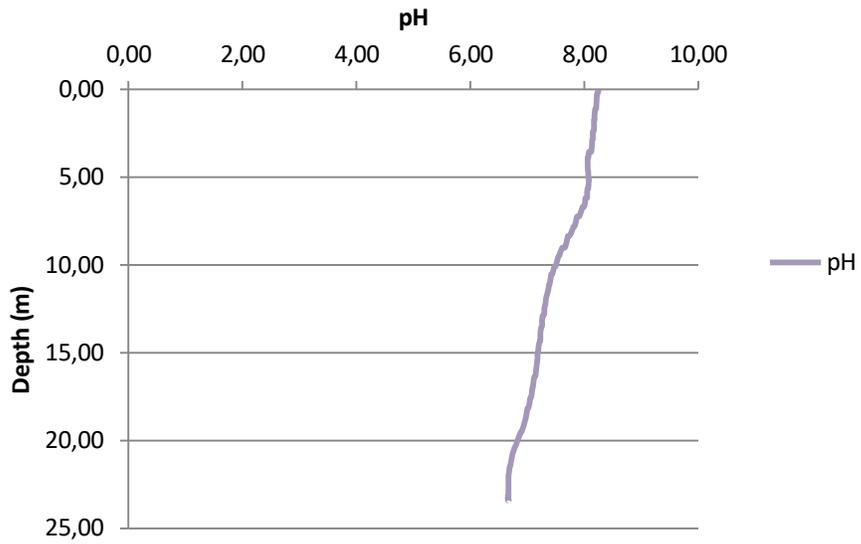


Figure 39. Changes in conductivity as a function of depth at Lac Notre-Dame

Values range from 8.25 at the surface to 6.66 at depth. The pH values are therefore within the range recommended by the MDDELCC for the protection of aquatic life.

4 Summary of information and recommendations

4.1 Potential phosphorus inputs

As mentioned in section 3.4.2, phosphorus is a limiting factor for the growth of aquatic plants and algae. For this reason, lake eutrophication depends on phosphorus inputs. These inputs may be of natural or anthropogenic origin (table 14).

Phosphorus is the main nutrient responsible for eutrophication in lakes. In the Lac Notre-Dame watershed, phosphorus can come from a variety of natural and anthropogenic sources.

Table 14. Sources of phosphorus in the Lac Notre-Dame watershed

Naturally occurring phosphorus	Wetlands
	Erosion and runoff
	Release of phosphorus stored in lake-bottom sediments
	Forestry inputs
	Atmospheric inputs
	Animal manure and decomposition of organic matter
Anthropogenic phosphorus	Non-vegetated riparian buffer Erosion of exposed soils and lack of vegetation cover along the lakeshore. Ornamental vegetation (grass) or inert materials in the riparian strip (15m) represent 30% of the inhabited riparian strip of Lac Notre Dame.
	Anthropogenic development around the lake
	Possible non-standard septic discharge
	Use of phosphate-rich household products Fertilizers for lawn and plant care Use of non-biodegradable and phosphate-containing soaps and detergents

4.2 Recommendations

Table 15 provides recommendations for maintaining and protecting the water quality of Lac Notre-Dame. It should be noted that the proposed actions are not listed in order of priority.

Table 15. Recommendations for maintaining and protecting water quality in Lac Notre-Dame

Recommendation	Findings and actions	
<p>1. Apply current shoreline protection regulations</p>	<p>Report</p>	<p>The vast majority of the lake's riparian strip is made up of natural vegetation, regardless of the type of land use category (natural, inhabited or frequented, infrastructure).</p>
	<p>Action</p>	<p>Municipality of La Pêche -The municipality of La Pêche needs to develop a strategy for enforcing its shoreline regulations. The bylaw in force since 2009 in the MRC des Collines-de-l'Outaouais requires shoreline property owners to plant a 5-metre strip of vegetation along the banks of lakes and watercourses. -The municipality of La Pêche could adopt a stricter bylaw on shoreline protection.</p>
<p>2. Revegetation of the Lac Notre-Dame riparian buffer strip</p>	<p>Report</p>	<p>Although the majority of the riparian buffer strip is made up of natural vegetation, the areas that are devoid of it are severely so.</p>
	<p>Action</p>	<p>Municipalité de la Pêche/Association des lacs Notre-Dame et Usher The Association and the municipality must work to implement revegetation projects for non-conforming buffer strips.</p>
<p>3. Controlling the beaver population</p>	<p>Report</p>	<p>Beavers are a problem for Lac Notre-Dame, as they increase the lake's phosphorus and <i>E. Coli</i> concentrations. <i>Coli</i> in the lake. It can also be a vector for the spread of Eurasian water milfoil.</p>
	<p>Action</p>	<p>Municipalité de la Pêche/Association des lacs Notre-Dame et Usher Trap beavers or hire a trapper to control their population.</p>
<p>4. Controlling Eurasian watermilfoil proliferation</p>	<p>Report</p>	<p>More than a quarter (26.6%) of Lac Notre-Dame's surface area is affected by watermilfoil.</p>
	<p>Action</p>	<p>Municipalité de la Pêche/Association des lacs Notre-Dame et Usher Working together to implement projects that control the spread of</p>

Recommendation	Findings and actions	
		plant in the lake. One of the control methods recommended for the lake is the installation of burlap in priority areas.
5. Continue water quality analysis	Report	The lake water quality monitoring carried out by the municipality and the Notre-Dame and Usher Lakes Association enables us to assess the situation on an annual basis, and to identify and implement corrective measures where necessary.
	Action	<p>Municipalité de la Pêche/Association des lacs Notre-Dame et Usher</p> <p>-Continued sampling and analysis of lake water at the same stations and using the same methodology by the same organizations year after year.</p> <p>Take dissolved oxygen measurements at the pit during the ice-free period (May to October) to check whether the lake oxygen at the end of thermal stratification.</p>
6. Continue detailed monitoring septic tank condition	Report	The Municipality of La Pêche monitors septic systems on its territory. It applies the <i>Règlement sur l'évacuation et le traitement des eaux usées des résidences isolées</i> (LQE, 2002).
	Action	<p>Municipality of La Pêche</p> <p>Follow up on this issue and consider the possibility of adopting a more restrictive municipal by-law if necessary.</p>
7. Educate local residents about good water protection practices	Report	Some residents may behave in ways that are harmful to the environment. The Association raises public awareness in this regard.
	Action	<p>Association des lacs Notre-Dame et Usher</p> <p>Through its website, pamphlets and articles, the Association could: inform shoreline residents about the impact of fertilizer and pesticide use on the environment and suggest alternatives; encourage them to use phosphate-free cleaning ; encourage them to install buckets to collect ashes from their outdoor fireplaces; and any other actions aimed at limiting nutrient or pollutant inputs to the lake.</p>



5 CONCLUSION

Following a characterization of the riparian zone, water quality and the presence of Eurasian water milfoil, Lac Notre-Dame shows several signs of eutrophication.

The parameters studied for this project have highlighted a number of problems and possible solutions.

Characterization of the riparian strip showed that the majority of riparian strip use is divided between natural (47%) and inhabited (). However, when vegetation type is taken into account, natural vegetation occupies the vast majority of the riparian strip, with a percentage of 70%. This can be explained by the large number of homes around Lac Notre-Dame, which have preserved the natural vegetation in the riparian strip. Thus, the shoreline degradation class according to the percentage of disturbed shoreline is in class A (<20%) and the other significant values are in classes D (60 to <80%) and E (<80%) with a representation of 3% and 4% respectively.

As far as water quality is concerned, the results vary depending on who took the samples, and not all the stations are the same. However, we can still conclude that Lac Notre-Dame is oligo-mesotrophic in the trophic level classification of lakes based on total phosphorus and water transparency. In addition, the ABV des 7 observed a slight lack of oxygen at depth during measurements.

Finally, Lac Notre-Dame shoreline residents have to contend with the increasing presence of Eurasian watermilfoil in lake. watermilfoil is present in over a quarter (26%) of the lake's surface area, and most of these beds are well-established, monospecific and dense. The lake's recreational and tourism uses and water quality are compromised by this invasive species.



REFERENCES

- ABV des 7 (2014). Eurasian watermilfoil. In ABV des 7. *Aquatic invasive species*. <http://abv7.org/administration/content/UserFiles/File/Especes%20aquatiques%20envahissantes/myriophylleaepi.pdf> (Page consulted on October 21, 2014).
- Association des lacs Notre-Dame et Usher (2005). Statuts. In Lac Notre-Dame. *Documents*. http://www.lacnotredame.org/Association_-_Statuts.pdf (Page consulted on October 21, 2014).
- Association des lacs Notre-Dame et Usher (2004). Bathymetric Map. In Association des lacs Notre-Dame et Usher. *Map*. <http://lacnotredame.org/html/map.html> (Page consulted on October 15, 2014).
- Caffrey, J. M., Millane, M., Evers, S. Moran, H. and Butler, M. (2010). A novel approach to aquatic weed control and habitat restoring using biodegradable jute matting. *Aquatic Invasions*, vol. 5, no. 2, p. 123-129.
- Advisory Committee on the Environment of the Municipality of Lac-Supérieur (2013). Rapport du Comité consultatif en environnement de la municipalité de Lac-Supérieur portant sur l'étude des lacs et sur la consultation publique et recommandations en vue de l'établissement d'une politique d'usage et de gestion de nos plans 'eau. In Municipalité de Lac-Supérieur. *Municipal Council*. <http://www.muni.lacsuperieur.qc.ca/pdf/Rapport-CCE-avril-2013.pdf> (Page consulted on October 10, 2014).
- Danard, R. J., Hamilton, P. B. (2004) The control of *Myriophyllum spicatum* (Eurasian Watermilfoil) in the Rideau canal. Research Division, Canadian Museum of Nature. Technical report 2004/2: 1-141.
- Davies, S. (2011). Phoslock Risk Assessment: An overview of risks to the aquatic environment associated with the use of Phoslock. In Phoslock Europe GmbH. *Publications*. http://www.phoslock.eu/media/7503/Phoslocks_Risk_Assessment_April_2011.pdf (Page accessed October 18, 2014).
- Institut national de santé publique du Québec (INSPQ) (2003). Fecal coliforms. In INSPQ. *Publications*. <http://www.inspq.qc.ca/pdf/publications/198-cartableeau/ColiformesFecaux.pdf> (Page consulted on October 24, 2014).
- Lavoie, M. (2010). L'utilisation du charançon pour le contrôle biologique du myriophylle à épis, Master's thesis, Université de Montréal, 86 p. <http://www.archipel.uqam.ca/2790/> (Page consulted on November 21, 2014).
- Environment Quality Act*, R.S.Q., c. Q-2.
- MDDELCC (2014a). The Voluntary Lake Monitoring Network: Methods. In MDDELCC. *Water*. <http://www.mddelcc.gouv.qc.ca/eau/rsvl/methodes.htm> (Page consulted on October 21, 2014).

- MDDELCC (2014b). Code de gestion des pesticides. *In* MDDELCC. *Water*.
<http://www.mddelcc.gouv.qc.ca/eau/recreative/qualite.htm> (Page consulted on
September 3, 2014).
- MDDELCC (2014c). Water quality and recreational uses. *In* MDDELCC. *Water*.
<http://www.mddelcc.gouv.qc.ca/eau/recreative/qualite.htm> (Page consulted October 2,
2014).
- MDDELCC (2014d). Surface water quality criteria. *In* MDDELCC. *Water*.
http://www.mddelcc.gouv.qc.ca/eau/criteres_eau/index.asp (Page consulted on October
15, 2014).
- MDDELCC (2014e). Guide d'analyse des projets d'intervention dans les écosystèmes
aquatiques, humides et riverains assujettis à l'article 22 de la Loi sur la qualité de
l'environnement. Appendix 2- Methods controlling aquatic plants and algae. *In*
MDDELCC. *Water*.
<http://www.mddelcc.gouv.qc.ca/eau/rives/annexe2.pdf> (Page consulted on October 2, 2014)
- MDDEP and CRE Laurentides (2007). Protocole de caractérisation de la bande riveraine. *In*
MDDELCC. *Water*. http://www.mddelcc.gouv.qc.ca/eau/rsvl/bande_riveraine.pdf (Page
consulted August 12, 2014).
- Ottawa CGIT Committee (2014). *Welcome to Camp Kalalla*. <http://kalalla.com/> (Page
consulted on October 21, 2014).
- RAPPEL (2012). Eutrophication (lake aging). *In* RAPPEL. *Lac*.
[http://www.rappel.qc.ca/services-et-produits/informations-
techniques/lac/eutrophisation.html](http://www.rappel.qc.ca/services-et-produits/informations-techniques/lac/eutrophisation.html) (Page consulted on October 21,
2014).

APPENDIX A

Table A.1 Description of riparian buffer sections on Lac Notre-Dame.

Section no.	Description	Photos taken by ABV des 7
1	Inhabited area. The presence a turtle was noted.	
2	Infrastructure zone. Beach for local residents.	
3	Natural zone.	
4	Inhabited area with lawn.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
5	Natural zone.	
6	Inhabited area.	
7	Inhabited area. There is a natural area between each dock.	
8	Natural zone.	
9	Inhabited area. Presence of access to the shoreline, which are sources of erosion.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
10	Natural zone.	
11	Inhabited area. Lawn and beaver lodge. Natural vegetation between infrastructures.	
12	Inhabited area. Private island. A cabin is present within the 15 m riparian strip. Many rocks and conifers under which vegetation does not develop.	
13	Natural area. Only one dock present.	
14	Inhabited area. A house on a gravel-covered slope, a hotbed of erosion. Ornamental vegetation.	

1/2

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
		 <p style="text-align: right;">2/2</p>
15	Inhabited area. Outdoor fireplace and low wooden wall.	
16	Inhabited area. Presence of a dwelling within 15 m of the riparian strip on the bank and a low wall.	 <p style="text-align: right;">1/2</p>

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
		 <p style="text-align: right;">2/2</p>
17	Natural zone.	
18	Infrastructure zone. Access road.	
19	Inhabited area. Riprap on the bank.	
20	Natural zone.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
21	Inhabited area. Presence of a beach that constitutes a focus of erosion.	
22	Inhabited area. Presence of erosion.	
23	Inhabited area. Presence of a beach that constitutes a focus of erosion.	
24	Inhabited area. Presence of erosion sites and human infrastructures.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
25	Inhabited area. Riprap on the bank.	
26	Inhabited area. Presence of a terrace on the . The owner must destroy this structure. Destruction has begun, but is not yet complete. Presence of erosion.	 
27	Inhabited area. Only one house present.	
28	Natural area. Bay invaded by Eurasian water milfoil.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
29	Inhabited area.	
30	Natural zone.	
31	Inhabited area. Boat launch. Two cottages within 15 m of shoreline.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
32	Inhabited area. Riprap on the bank along the entire section.	
33	Inhabited area.	
34	Natural zone. Lots of natural vegetation, but only one dock, unused and unlaunched.	
35	Inhabited area. Presence of a beach that constitutes a focus of erosion. Several outdoor fireplaces and a dwelling within 15 m of the riparian buffer strip.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
36	Natural zone.	
37	Inhabited area. Presence of Eurasian water milfoil.	
38	Natural zone.	
39	Inhabited area. Presence of a dock.	
40	Inhabited area. Rocks on the ground.	

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

Section no.	Description	Photos taken by ABV des 7
41	Inhabited area.	
42	Inhabited area. Presence of riprap and docks.	



APPENDIX B

Annexe 2 Méthodes de contrôle des plantes aquatiques et des algues

TABLE DES MATIÈRES DU TABLEAU DES MÉTHODES

Type de contrôle	Méthode de contrôle	Page
MANUEL	Arrachage, coupe ou raclage manuel	3
MÉCANIQUE	Coupe ou fauchage mécanique	4
	Moissonneur	5
	Arrachage	6
	Scarifiage ou fraises rotatives	7
	Agitateur à sédiments	8
	Dragage mécanique ou par aspiration du fond (hydraulique)	9
	Aspirateur de fond avec plongeur	10
PHYSIQUE	Aération de l'hypolimnion en activant la circulation de l'eau (éolienne)	11
	Aération de l'hypolimnion par apport d'oxygène	12
	Recouvrement temporaire ou permanent des sédiments (membrane)	13
	Colorant et opacifiant	14
	Ecrans de surface, barrières flottantes	14
	Baisse du niveau d'eau et assèchement	15
	Évacuation sélective des eaux hypolimniques	16
	Hausse du niveau d'eau	16
	Filtration	16
	Sonication (procédé employant des ultrasons)	17
CHIMIQUE	Augmentation de l'écoulement (effet « chasse d'eau »)	18
	Travaux de récréation du lit d'un cours d'eau	18
	Farine de quartz et tube biocatalyseur (technologie « Plocher »)	19
	Paille d'orge	19
	Ozonation	20
BIOLOGIQUE	Herbicides (dont les algicides)	21
	Adsorbant de nutriments (sels de fer ou d'alun)	22
	Craie (chaux) et autres éléments minéraux à base de carbonate de calcium	23
	Manipulation de la chaîne trophique – zooplancton consommateurs de phytoplancton	24
	Manipulation de la chaîne trophique – poissons herbivores consommateurs de macrophytes	25
	Manipulation de la chaîne trophique – poissons herbivores consommateurs de phytoplancton	26
	Manipulation de la chaîne trophique – macro-invertébrés aquatiques consommateurs de macrophytes	27
	Agents pathogènes des algues ou des plantes aquatiques (virus, bactérie, champignon)	28
	Bio-augmentation (injection de bactéries aérobies)	29
Introduction de plantes allopathiques	30	
Introduction de plantes indigènes compétitrices	30	
Îles flottantes artificielles	31	



APPENDIX C

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

MUNNEAG 7

Ministère du
Développement durable,
de l'Environnement
et des Parcs

Québec 

Gatineau, le 3 mai 2005

CERTIFICAT D'AUTORISATION

Association des lacs Notre-Dame et Usher
37, chemin Sullivan
La Pêche (Québec) J0X 1A0

N/Réf. : 7430-07-01-00893-00
200108859

Objet : Programme de contrôle du myriophylle à épis par une coupe
estivale et automnale au lac Notre-Dame, municipalité de La Pêche

Mesdames,
Messieurs,

À la suite de votre demande de certificat d'autorisation datée du 5 février 2005,
j'autorise, conformément à l'article 22 de la Loi sur la qualité de l'environnement
(LRQ, chapitre Q-2), le titulaire ci-dessus mentionné à réaliser le projet décrit
ci-dessous :

Programme de contrôle du myriophylle à épis par une coupe
estivale et automnale au lac Notre-Dame, municipalité de
La Pêche.

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

CERTIFICAT D'AUTORISATION

- 2 -

N/Réf. : 7430-07-00893-00
200108859

Le 3 mai 2005

Les documents suivants font partie intégrante du présent certificat d'autorisation :

- Demande de certificat d'autorisation adressée au ministère du Développement durable, de l'Environnement et des Parcs concernant le programme de contrôle du myriophylle à épis par une coupe estivale et automnale au lac Notre-Dame, municipalité de La Pêche, datée du 23 février 2005 et signée par Mme Jacquelin Lambert-Madore, présidente, 1 page et 10 annexes.

En cas de divergence entre ces documents, l'information contenue au document le plus récent prévaudra.

Le projet devra être réalisé et exploité conformément à ces documents.

En outre, ce certificat d'autorisation ne dispense pas le titulaire d'obtenir toute autre autorisation requise par toute loi ou tout règlement le cas échéant.

Pour le ministre,



MD/DD/jr

Marc Dubreuil,
Directeur régional de l'analyse
et de l'expertise de l'Outaouais

Characterization of the riparian strip of Lac Notre-Dame and delineation of Eurasian watermilfoil beds

Ministère des
Ressources naturelles,
de la Faune
et des Parcs

Québec

AUTORISATION

(L.R.Q., c. C-61.1, article 128.7)

COURRIER CERTIFIÉ LC 042 599 400

Gatineau, le 23 mars 2005

Madame Jacqueline Lambert-Madore
Association des lacs Notre-Dame et Usher
37, chemin Sullivan
La Pêche (Québec) J0X 1A0

N/Réf. : 9023-6.5.91
Contrôle du myriophylle à épis par une coupe estivale et
autumnale au lac Notre-Dame, municipalité de La Pêche.

Madame,

En vertu des pouvoirs qui me sont conférés par la Loi sur la conservation et la mise en valeur de la faune (L.R.Q. c. C-61.1), j'autorise madame Jacqueline Lambert-Madore, à effectuer ou à faire effectuer pour le compte de l'Association des lacs Notre-Dame et Usher, dans l'habitat du poisson, l'activité suivante aux conditions ci-après mentionnées :

Endroit de réalisation :

Municipalité de La Pêche / MRC des Collines-de-l'Outaouais
Canton de Masham
Lac Notre-Dame
45°44'00" lat. N. - 76°01'00" long. O.
Carte topographique 31F/09

Description des activités autorisées :

Contrôle du myriophylle à épis par une coupe estivale et automnale au lac Notre-Dame, municipalité de La Pêche.

Conditions d'autorisation :

- Les travaux devront être conformes à la description fournie dans la *Demande d'autorisation pour activité dans un habitat faunique* du 23 février 2005;
- Effectuer les travaux de façon à minimiser la mise en suspension de sédiments dans le lit du lac Notre-Dame;
- Le requérant devra informer les riverains du lac Notre-Dame de la mise en place de ce projet pilote et de son déroulement;
- Le requérant devra effectuer un suivi des effets de l'opération de fauchage sur les plantes aquatiques;

...2

Characterization of the riparian strip of Lac Notre-Dame
and delineation of Eurasian watermilfoil beds

2

- Ne pas manipuler de l'huile ou de l'essence à moins de 60 m de la ligne naturelle des hautes eaux du lac Notre-Dame;
- Le cas échéant, les conditions de la présente autorisation devront être ajoutées au cahier des charges du (des) contracteur(s) et transmis au surveillant des travaux afin que la protection des habitats et des espèces soit considérée dans l'évaluation des coûts des travaux et prise en compte directement par ceux qui feront les travaux;
- Le requérant ou le promoteur doit permettre, à toute heure raisonnable, aux employés du ministère des Ressources naturelles et de la Faune, de pénétrer sur le terrain public ou privé où les travaux de la présente autorisation s'effectuent ou ont été effectués, afin de s'assurer du respect des conditions de la présente autorisation;
- Une copie de la présente autorisation ainsi que de tout autre document requis dans le cadre de l'exécution des travaux (ex : plans et devis) devra être disponible sur les lieux en tout temps lors de la réalisation des travaux afin que toute personne habilitée (contremaître, inspecteur, etc.) puisse les consulter;
- La Direction de l'aménagement de la faune devra être avisée 48 heures avant le début des travaux, en communiquant avec Madame Monique Peck au (819) 772-3434, poste 217. Le bureau de Gatineau de la Direction de la protection de la faune devra aussi être avisé par télécopieur au (819) 246-1966;
- Si le requérant ou le promoteur ne peut pas respecter une de ces conditions pour certaines raisons, entre autres à la suite d'événements incontrôlables, il devra obligatoirement communiquer avec le responsable du dossier, Monsieur Daniel Toussaint, au ministère des Ressources naturelles et de la Faune [au (819) 772-3434, poste 248] avant de débiter ou de continuer les travaux pour que ce dernier puisse analyser la situation et, le cas échéant, modifier l'autorisation;
- La présente autorisation ne dispense pas le titulaire d'obtenir toute autre autorisation requise par toute loi ou tout règlement, le cas échéant.

Le directeur de l'Aménagement de la faune
de l'Outaouais,



Jean Fink

c.c. : Direction de la protection de la faune