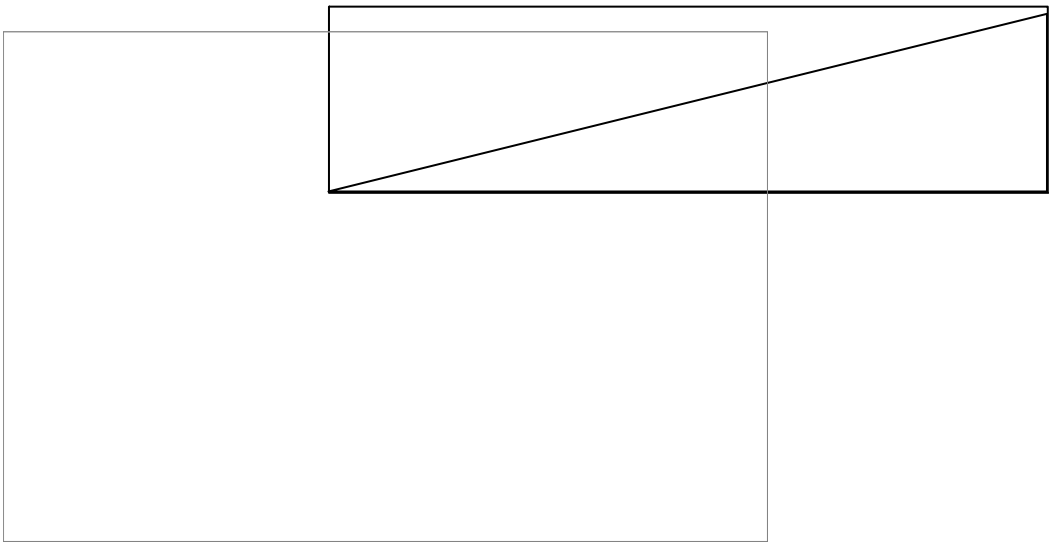
Project evaluation of the impact of the waves created by the type of boats wakeboat on the shore of Lake Memphremagog and Lovering



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EXECUTIVE SUMMARY

The presence of wakeboat type boats has been intensifying over the last few years on Quebec's waterways. More and more lakeside residents are concerned about the potential impact of such boats on lakeshore, including resuspension of sediments caused by increased energy in these waves. .

The objective of this research was to develop a scientific framework to validate the existence, magnitude and modalities of the impacts of oversize waves generated by wakeboats on the lake environment in Quebec. The research was conducted at Lakes Lovering and Memphremagog, in collaboration with SCLL and MCI, and with the support of Community Services.

The **main results** of the research are as follows:

- All wakeboats passages induce a significant increase in the energy contained in the waves that reach the shore, on average by a factor of 4.
- The impact of wakeboat passes is directly and inversely related to the distance between the passage and the shore.
- Of the three different types of waves produced by a wakeboat, the waves of wakesurf are the ones that cause the greatest impact when they arrive at the shore (1.7 times higher than the waves of a boat in normal displacement).
- Wakeboat passes have a greater impact on shorelines with steeper slopes than those with gentle slopes .
- Our data shows that the energy produced by the wakeboat dissipates completely before reaching the banks (and therefore have no significant effect) when the wakeboat passes are 300 m or more from the shore.

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INTRODUCTION

In recent years, new aquatic sports have emerged in Québec's water bodies. In particular, the popularity of wakeboats is constantly increasing in many lakes, including Memphrémagog and Lovering Lakes. Located north of the Appalachian region, these two lakes are important

recreational and tourist centers for both residents and vacationers. The configuration of the wakeboats can create a wave high enough to allow the followers to "surf" at the back of the boat, either on a wakesurf or on a wakeboard. While doing wakesurfing, the surfer is not attached to the boat, but he surfs behind the wake of it on a board very similar to a normal surfboard. In the case of wakeboarding, the person surfs behind the boat, staying attached to it at all times, on a board much closer to a snowboard with slippers.

With the exception of some works, such as those of Hill, Beachler and Johnson (2002), limited to the Chilkat River in Alaska, and those of Péloquin-Guay (Memorial, U. of Montreal, 2013) on the Batiscan River, very few Experimental studies have been conducted to rigorously and quantitatively assess the potential of the boats to accelerate bank erosion, and none have been carried out specifically on wakeboat type boats in lakes. Shoreline erosion can be an important nutrient carrier to lakes, particularly in deforested areas bordering them (Keenan and Kimmins 1993). To date, no regulations govern the use of these boats in relation to their environmental impact. Indeed, the only regulation currently in force is that related to boating safety, which limits the speed to 10 km / h (6.2 mi/hr.) when the boat moves within 100 m of the shore. In the rest of the lake, the speed limit is 70 km / h (43.5 mi/hr} (Appendices 2 and 3: Maps of the nautical regulations of the Government of Quebec, MRC Memphremagog 2011, MRC Memphremagog 2013).

Each wave created by a boat, or by the wind, contains a certain amount of energy (turbulent kinetic energy, TKE). Some of this energy will be dissipated quickly but a certain amount will be able to reach the banks. It is this additional energy that can contribute to accelerated bank erosion and re-suspension of existing sediments. So far, no relationship has been developed to allow the quantitative comparison between the energy induced by the ships.

The objective of this project was to develop a scientific framework to validate the existence, extent and modalities of wave impacts caused by wakeboats on the lake environment in Quebec, based on measurements made at lakes Lovering and Memphremagog. Three sites in each lake were alternately instrumented, to acquire the physical data allowing to quantify the energy induced by the wakeboat wave train that reaches the banks. In addition, measures have been taken to evaluate the resuspension of sediments.

Sampling plan

METHODOLOGY

To properly quantify the effect of wakeboats on the energy received by the banks, we chose to proceed with a controlled experimental plan, that is to say where we can impose specific configurations and trajectories to the boat. Our protocol measures the energy generated by waves of wakeboats according to several combinations of three main factors:

1) the type of displacement of the boat, characterized by the speed of the boat, and thus the type of waves created;
2) the distance from the shore to which the boat passes (100, 150 and 200 m);
3) the type of shore, following the slope of the shore.

Figure 1 illustrates this sample design. For each combination, measurements were taken twice to assess the variability between trials of the same configuration.

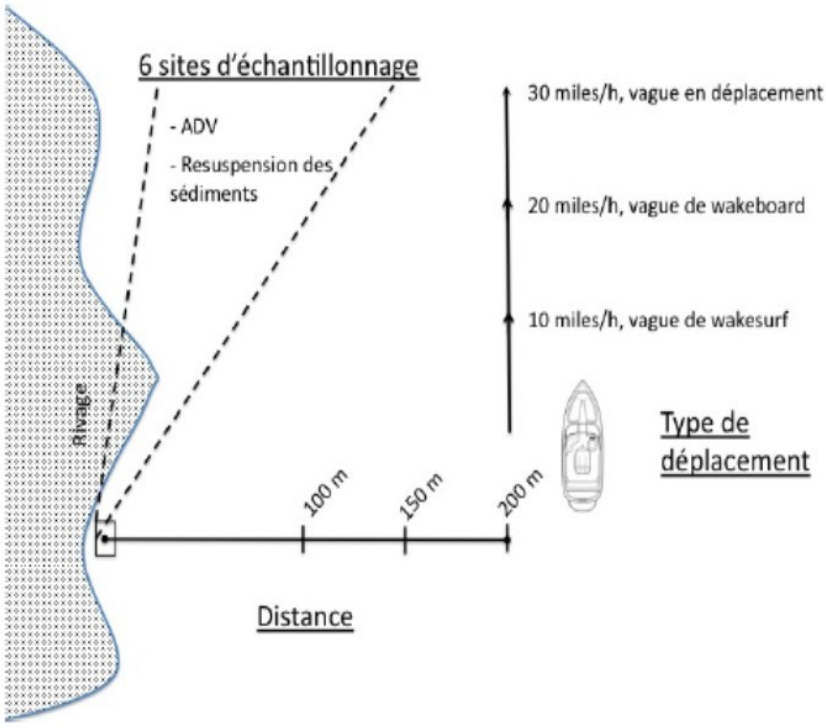


Figure 1. Sampling plan for measuring three different types of displacement at three shoreline distances and at six sampling sites

Wakeboat trip types

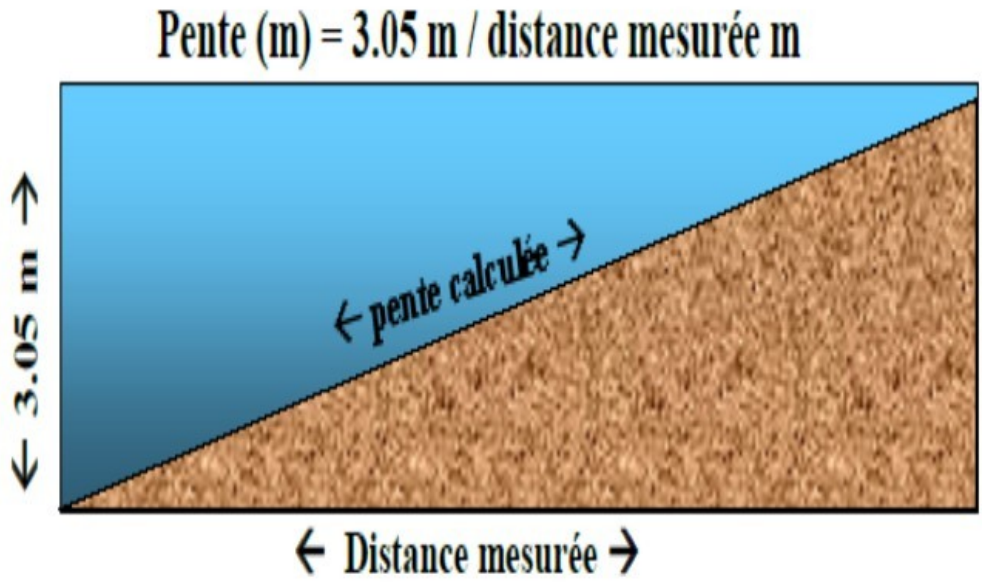
Moving a boat can create different types of waves. In this research, three types of waves were studied: wave surf waves, wakeboard waves and wakeboat waves on the lake. Wakesurf waves are created by filling only one side of the boat's ballasts and sailing at a fairly low speed

(10 mph, 16.1 km / h). In the case of wakeboarding waves, both sides of the ballast are filled, and the boat use moves at a speed of 20 mph (32.2 km / h).

When will wakeboat moves from one place to another, the average speed of movement is 30 miles/h (48.3 km/h), but it moves at this time with these empty ballasts. The sampling plan was developed to measure the amount of energy that arrives at the shoreline and the resuspension of sediments to the shoreline, according to the three different types of movement (wakesurf waves, wakeboard waves and moving waves).), three distances from shore and six sampling sites (3 per lake, Appendix 1).

Choice and characterization of sites - type of shoreline

Site selection was designed to obtain different types of shoreline slope, with the goal of confirming whether the inflow and resuspension of sediments are influenced by bank slope (Sorensen 1997). Lovering and Memphremagog lakes were sampled at three different sites on each lake (Appendix 1) in order to obtain a slope gradient representative of the lakes in the region. The sampling took place on August 4, 5 and 6, 2013, between 8 am and 8 pm For each of the sites sampled, the shoreline slope was calculated from bathymetric charts based on the distance from the shoreline to the location in the lake where the water reached a depth of 3.05 m (10 ft. bathymetric map).



Figuere 2. Illustration of the calculation of coastal slopes of sampling sites

Once the slopes were calculated (Table 1), the six sites were separated into steep-slope sites (0.1 mm $^{-1}$) or soft (<0.1 mm $^{-1}$).

Table 1. Characteristics of sampled sites.

Lake	Site	Dated sampling	Shore slope (mm^{-1})	Type of slope
Lovering	LOV1	August 4, 2013	0096	fresh
	LOV2	August 5, 2013	0022	fresh
	LOV3	August 5, 2013	0044	fresh
Memphremagog	MEM1	August 5, 2013	0203	acute
	MEM2	August 5, 2013	0131	acute
	MEM 3	August 6, 2013	0299	acute

Sampling

Resuspension of sediments

To measure resuspension of sediment, a water sample was taken before (A) and after (B) each of the boat passages at each sampling site. Resuspension represents the difference in the amounts of suspended sediment measured between the two samples (BA). The baseline concentration of each site was established as the first sample collected at this site.

Turbulent kinetic energy

The energy provided by the waves of wakeboats was measured using a micro-ADV (Acoustic Doppler Velocimeter), which makes it possible to measure the speed of water in all three dimensions at a high frequency (25 times / second, Figure 3).

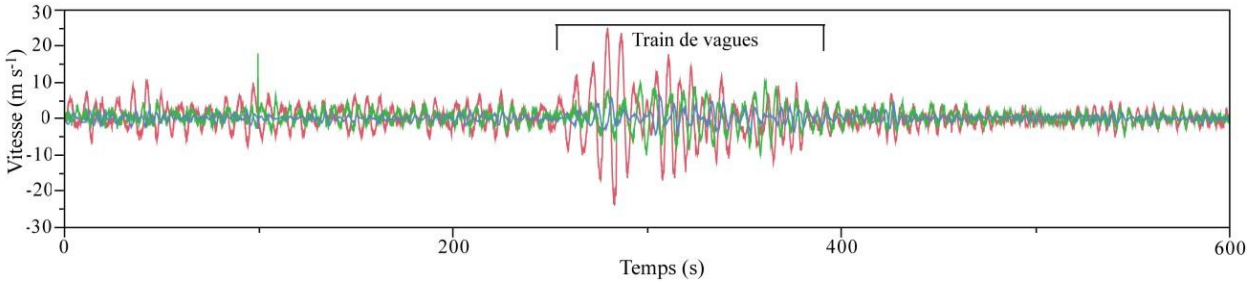


Figure 3. Example representing the speed (ms -1) of the dimensions x (red), y (green) and z (blue) for a period of normal waves, and during the passage of the boat wave (wave train).

Turbulent kinetic energy (TKE) contained in a wave (created by a boat or otherwise) can be calculated by knowing the three-dimensional velocities as it passes, according to the equation :

$$TKE=1/2\ (x^2+y^2+z^2)$$

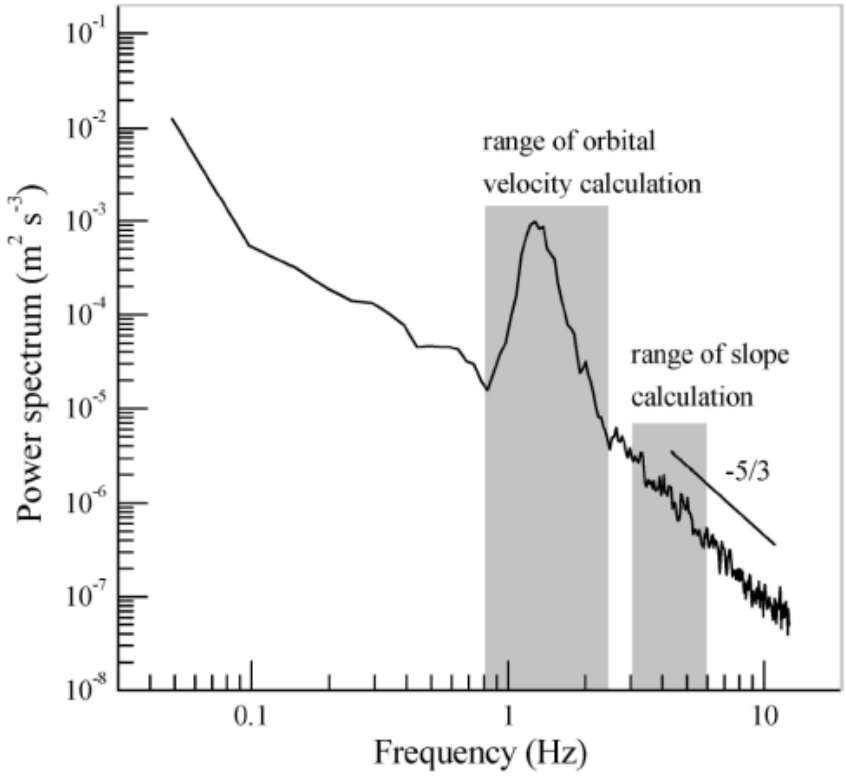
,

where z, y and z are the micro-turbulence velocities measured in the three dimensions (Wist 2004).

This type of measurement makes it possible to estimate the energy dissipation rate (ε) which is also a measure of energy production when the system is in equilibrium. These three-dimensional velocity measurements are then decomposed into a power spectrum (Figure 4) whose Kolmogorov theory (1941) provides the characteristics according to the equation:

$$S(f) = C_f \varepsilon^{2/3} u_{rms}^{2/3} f^{-5/3}$$

where *S (f)* is the spectral density at the frequency *f* (Hz), *u* rms can be considered as the average advective velocity (cm / s), *C f is a constant*, and *ε* is the energy dissipation rate (m 2 s $^{-3}$). Details of this methodology can be found in Vachon, Prairie, & Cole (2010).



(From Vachon, Prairie and Cole, 2010)

Figure 4. Power Spectrum Example for Calculation of Energy Dissipation

Using the maximum peak of the power spectrum obtained for each wave train and dividing it by the sampling frequency (25 / second), we obtain the number of waves present in each wave train. This number of waves is then divided by the length of the wave train (number of waves / wave length) to obtain a number of waves / second for each wave train.

Assessment of normal conditions

Shoreline impacts under normal conditions, ie without boat passage, were assessed using the same device used for energy measurements caused by wakeboat passage. These data made it possible to evaluate the natural impact of the waves generated by the wind and this, for each of the sites.

Laboratory analysis

Water samples taken before and after each boat trip were analyzed in the laboratory. For each sample, a volume of 250 mL of water was filtered through 934-AH RTU filters (Glass Microfiber filters, 47 mm, prewashed and pre-weighed, Whatman) within 72 hours of field sampling. Within 7 days, the filters were dried for one hour in an oven at 103 ° C ± 2 ° C, then kept in a desiccator for 30 minutes to remove all traces of moisture. The filters were finally weighed with a microbalance having an accuracy of 0.0001 g, to obtain the quantity of dry material and thus of sediment contained in the 250 ml water sample. The result was then converted to mg / L (Gray et al 2000, Environmental Sciences Section 1993).

Statistical analyzes

The BACI protocol (Before-After-Impact-Control) was used as an experimental design for statistical analysis (Stewart-Oaten, Murdoch and Parker 1986). This type of sampling makes it possible to compare a site before and after a disturbance, for different types of situation. Here we compared the difference between the wake wave measurements and the normal wave measurements for each type of trip, each shore distance and at each sampling site. Analysis of variance (ANOVA), mean comparisons (t-test) and linear regressions were performed with the JMP software to analyze the data.

Limitations of the study

As part of this study, only two lakes were sampled (Memphremagog and Lovering) at three sites each. Thus, some features of the lakes in the area are therefore unlikely to be represented by the sampling plan. In addition, three typical trips of wakeboat type boats were used in the sampling plan (wakeboard, wakesurf, on the move). In reality, the energy experienced by the shore is probably much more varied, because different types of passage, at variable speeds, follow each other in time.

In addition, in the case of sediment resuspension, the results showed lower sediment levels than expected and were very close to the detection limit of the method used. They are therefore not as accurate as desired and should therefore be considered very conservative.

RESULTS AND DISCUSSION

In this study, we analyzed the variations in energy (TKE) and resuspension of sediments caused by wakeboat waves upon their arrival at the shore, by varying the type of wakeboat movement, the distance from the shore to which it is situated, and the slope of these shores. This section opens with the overall results, that is, the results of all passage types, all shore distances and all shore slopes combined, as well as the six sites combined (ie three at Lovering Lake and three at Lake Memphremagog). In the following sections, the following results are presented according to the type of displacement of the wakeboat (wakesurf, wakeboard and on the move) and thus of the type of waves, according to the distance of the shore (100m, 150m, 200m) (320 ft, 492 ft, 620 ft) and following the slopes of the coast. A section also discusses some characteristics of the different types of waves produced.

Table 2 presents the average values obtained during the sampling in the two lakes. The results show that waves created by the wakeboat cause a significant increase (on average, 4 times higher) and still significant of the amount of energy (TKE) that reaches the shore, compared to normal conditions (ie without passing through boat). This general result applies for all types of passage, all distances from the shore and all shore slopes combined.

Table 2. Comparisons of results under normal conditions and during the passage of a wakeboat: speeds (average, maximum, minimum); turbulent kinetic energy (TKE), horizontal energy (ε x) and vertical energy (ε z); suspended sediment

	Normal	displacement	t-test	n
Average speed cm s^{-1}	3.04	6.27	<0.0001 *	215

Maximum speed	cm s^{-1}	10.58	20.39	<0.0001 *	214
Minimum speed	cm s^{-1}	0.08	0.12	0.0003 *	214
TKE	$m2\ s^{-2}$	7.91	31.81	<0.0001 *	209
Suspended Sediments	mg L^{-1}	0.57	1.16	<0.0001 *	215

Normal displacement t = t estn

Average speed cm s -1

Maximum speed

Minimum speed

TKE

Suspended sediment

Note : We considered the differences to be significant at a threshold of p <0.05

Similarly, the passage of a wakeboat creates waves carrying considerable energy to directly induce a sediment resuspension statistically significant, in average 2 times higher than in normal conditions (Table 2), and this for all types of displacement, all distances and all slopes combined.

Turbulent kinetic energy (TKE)

Figure 5 shows the TKE results from the distance between the boat passage and the shore (100m, 150m, 200m) and the type of passage, ie the TKE measurements for all types of crossing (Figure 5a), for wakesurf (10 miles / hr; (Figure 5b), wakeboarding (20 miles / hr, Figure 5c) and moving ship (30miles / hr, Figure 5d).

Our results show that, for each type of boat passage, regardless of the distance, there was always a significant increase in the amount of energy present in the wakeboat wave train (Figure 5) that reached the shore (pale gray), compared to normal conditions (dark gray).

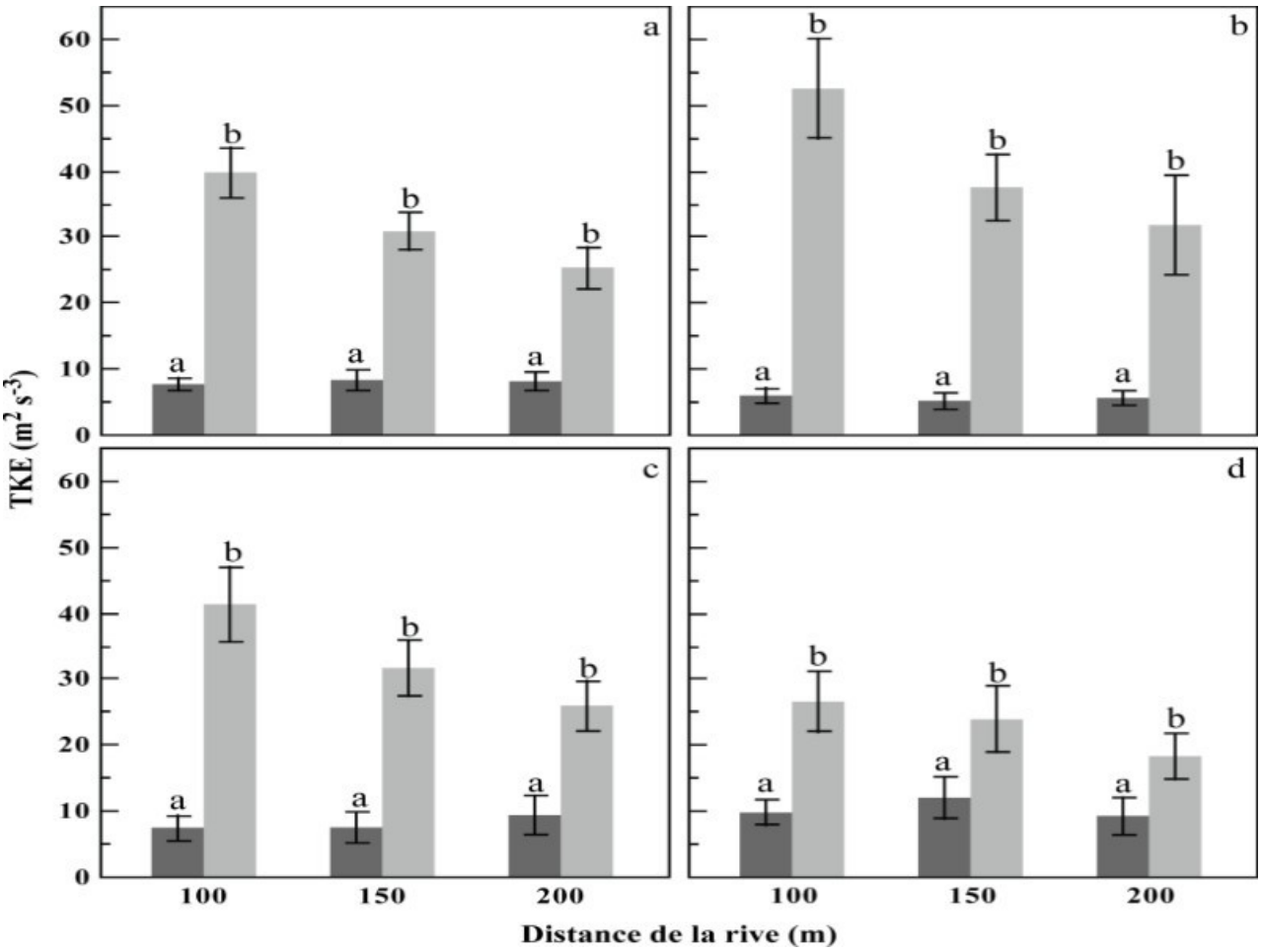


Figure 5. The energy (TKE) present in normal (dark gray) waves and that in waves after the passage of a wakeboat at 100, 150 and 200 m from the shore, and depending on the type of passage of the boat (a: all types of passage combined, b: 10 miles / h, c: 20 miles / h, d: 30miles / h).

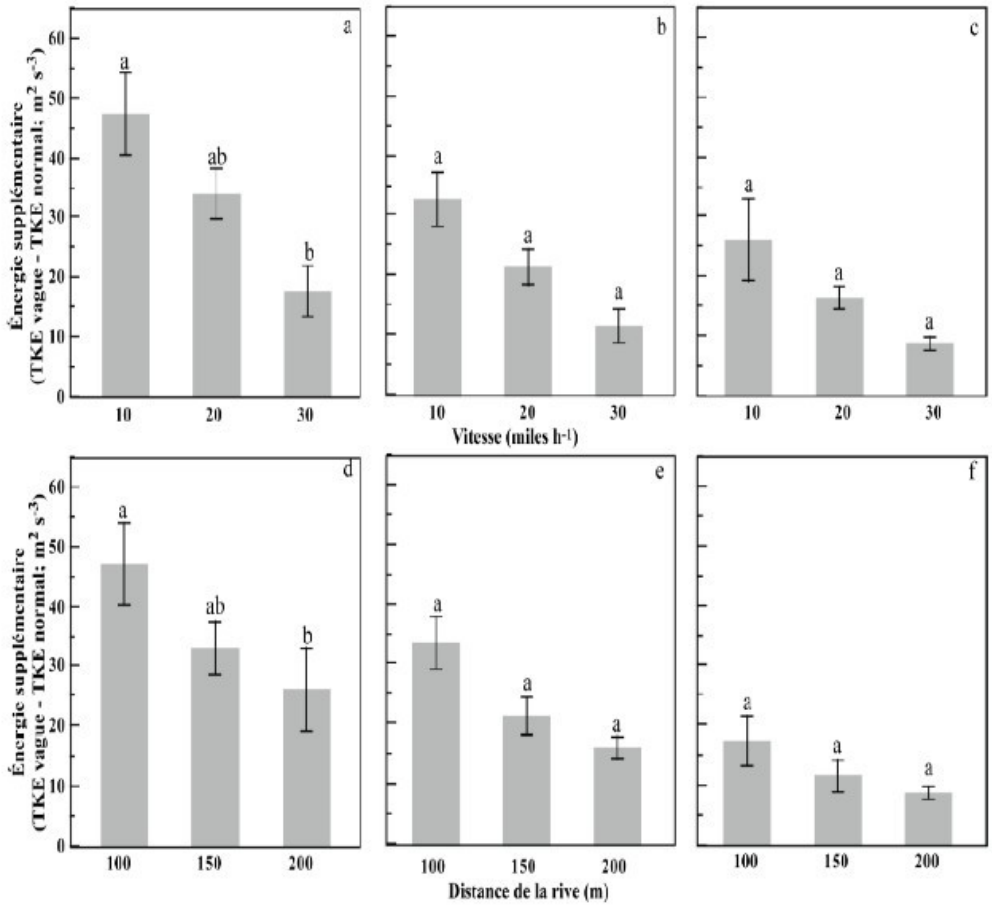
Note : The letters a and b different above the columns mean a significant difference ($p < 0.05$).

Having thus established that all the passages contain a significantly higher energy than under normal conditions, comparisons will be made between the different types of passage and the different distances from the shore.

Figure 6 shows the additional energy induced by the passage of a wakeboat, the difference between the energy in normal conditions and that measured during the passage of the wakeboat (TKE wave - TKE normal).

Two types of results are presented here. On the one hand, the additional energy induced is presented according to the use made of the boat (wakesurf, wakeboard, on the move), and therefore according to its speed (10, 20 or 30 miles / h), and according to the distance of the boat in relation to the shore (a: 100 m, b: 150 m, c: 200 m).

Figure 6. The additional energy induced by the passage of a wakeboat (TKE wave - normal TKE) depending on the type of passage (10, 20 and 30 mph) and the distance to the shore (a: 100 m; b: 150 m; c: 200m) and that induced along the distance to the bank (100, 150 and 200 m) and according to the type of passage (d: 10 miles / h; e: 20 miles / h; f: 30 miles / h).



Note : The letters a and b different above the columns mean a significant difference ($p < 0.05$)

This first series of graphs makes it possible to compare the effect of different uses of the boat for the same distance from the shore: for example, the impact of the practice of wakesurfing (10 miles / h) at 100 m from shore (Figure 6a) is much more important than that of the boat on the move (30 miles / h). In fact, the energy created by the wakesurf is 1.7 times higher than that produced by the boat on the move, despite its speed of 30 miles / h. In the case of other distances to shore (Figure b and c), the differences are not significant, although we see a trend between the distance of 300 m, and that of 100 m.

The second series of graphs in Figure 6 allows to reverse the analysis, ie to compare the amount of additional energy induced by the distance to the bank (100, 150 and 200 m) and according to the use of the boat, and therefore according to its speed (d: 10 miles / h; e: 20 miles / h; f: 30 miles / h).

This second series of graphs shows that the additional energy induced when the boat passes 100 m from the shore is 2 times higher than that induced by a passage to 200 m. This difference according to the distance from the shore is significant only in the case of waves of wakesurf (Figure 6d), although such a tendency is observable during waves of wakeboard and in displacement (Figure 6e and f).

Resuspension of sediments

Figure 7 shows the amounts of sediment resuspended for each distance between the boat passage and the shore (100m, 150m, 200m); Figure 7a presents the results for all types of

crossings combined, Figure 7b, those for wakesurf waves, Figure 7c, those for wakeboard waves and Figure 7d, the results for traveling waves.

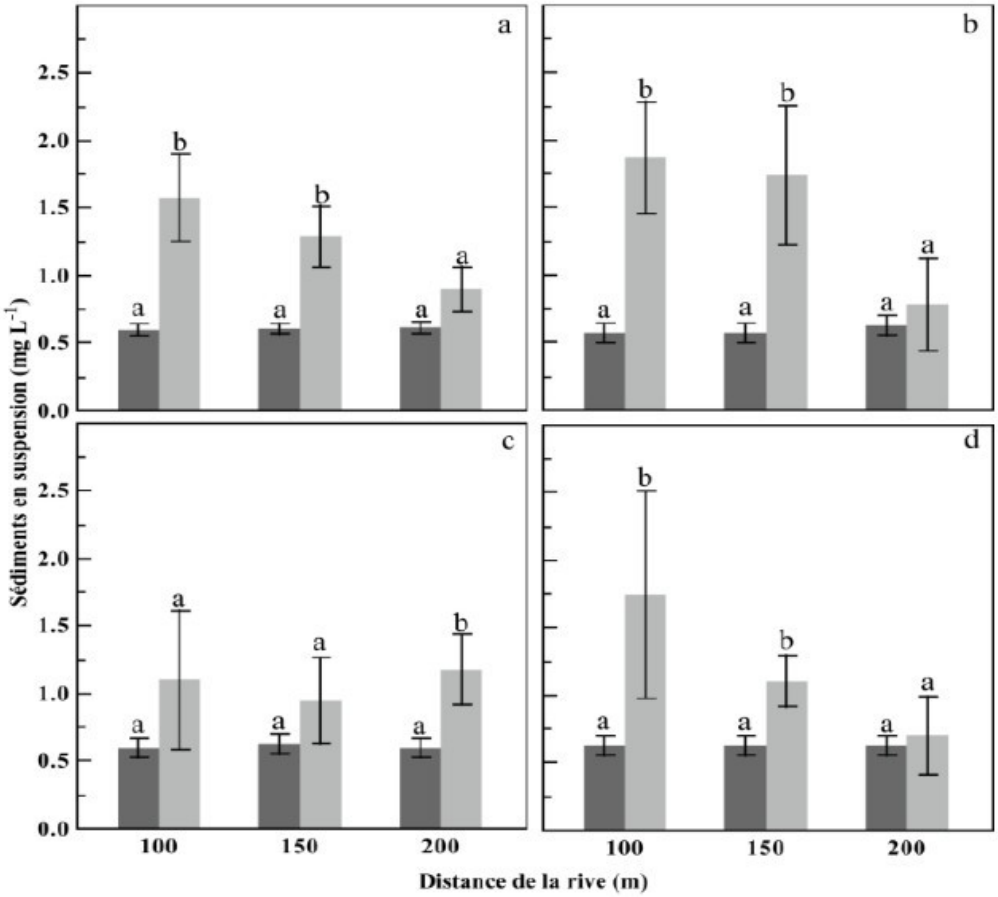


Figure 7 shows that, in general, the passage of a vessel creates a resuspension of sediments that is significantly greater than that under normal conditions: this is the case with waves of wakesurf (10 miles / h, Figure 7b). and moving waves (30 mph, Figure 7d), when boats are traveling at 100m or 150m. from the shore. When the boat passes 200 m, there is no significant change in the resuspension of the sediments. There are contrary results for wakeboard crossings (20 miles / h, Figure 7c), significant resuspension only at 200 m but not at 100m or 150m. **Figure 7. Resuspension of sediments caused by normal waves (dark gray) and caused by waves following the passage of a wakeboat at 100, 150 and 200 m depending on the type of passage (a: all types of passage, b: 10 miles / h, c: 20 miles / h, d: 30 miles / h).**

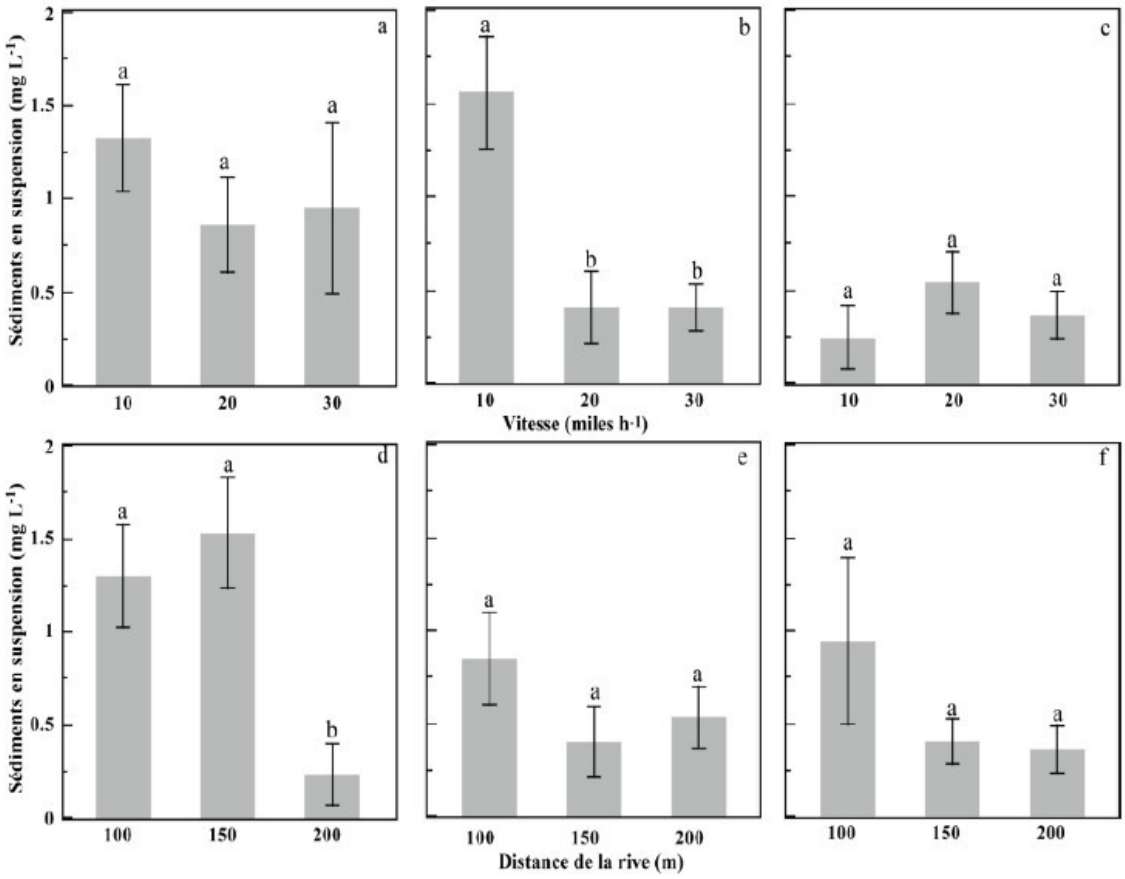
Note : The same letters above the columns mean that there is no significant difference in effects between normal conditions and those caused by wakeboat waves .

Figure 8 (next page) shows the amounts of sediment resuspended in two forms of results. The first set of graphs shows the results for each type of trip (wakeboat: 10 miles / h, wakeboard: 20 miles / h, on the move: 30 miles / h) for a distance of 100m (Figure 8a), a distance of 150m (Figure 8b) and a distance of 200 m. (Figure 8c). The second series presents the results according to the distance of the shoreline (100m, 150 and 200 m) according to the

type of use of the boat, namely wakesurf (10 miles / h, Figure 8d), wakeboard (20miles / h Figure 8d) and on the move (30 mph, Figure 8f).

c: Figure 8. The resuspension of additional sediments induced according to the type of passage (10, 20 and 30 miles / h) and the passage distance (a: 100 m, b: 150 m,200 m) and that induced depending on the distance of the bank (100, 150 and 200 m) and the type of passage (d: 10 miles / h; e: 20 miles / h; f: 30 miles / h;).

Note : The letters a and b different above the columns mean a significant difference ($p < 0.05$)



The first series of graphs, which compare the effects of resuspension between the types of displacement, shows that only waves of wakesurf (10 miles / h) created at a distance of 150 m from shore (Figure 8b) produce a discount. in suspension significantly higher than that of the other two types of displacement. In the second series of graphs, Figure 8d shows that waves of wakesurfing create sediment resuspension greater than 100 and 150 m from the bank, compared to the distance of 200 m. The few significant differences between the results, despite apparently different mean values, can be explained by the large variability of the data, probably due to the lack of sensitivity of suspended sediment measurements.

Distance from the bank

As expected, the amount of energy reaching the shore decreases with the distance of the wakeboat passages. Our protocol did not allow us to precisely measure the distance from the shore where no change of energy is visible on arrival at the shore. However, on the basis of the data recorded for all types of displacement, if the linear trend observed between the distances studied and the effects measured at the shore (TKE, resuspension of the sediments) is prolonged, it is possible to estimate approximate distance. Figure 9 shows the results of these calculations for each measured effect.

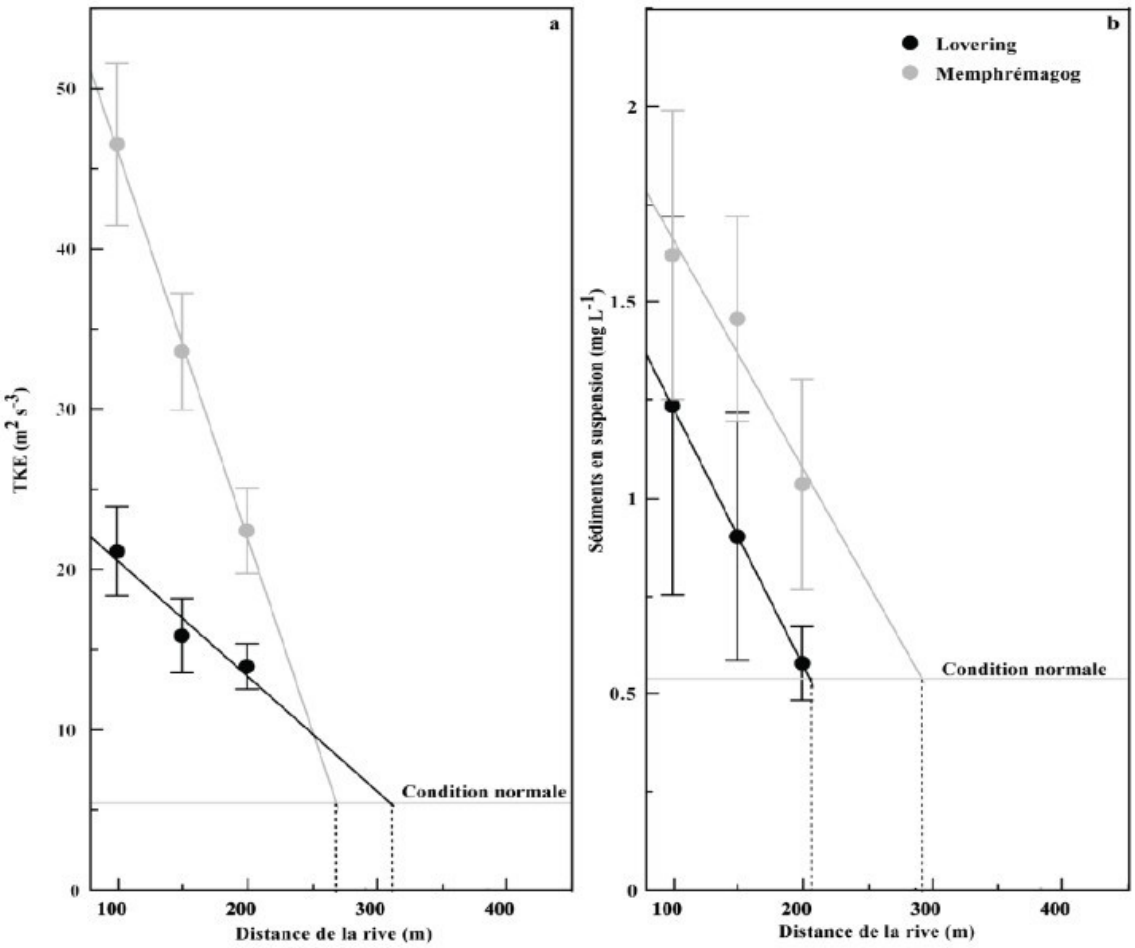


Figure 9. Linear regression of a) energy (TKE) and b) suspended sediment, as a function of shore distance for Lovering (light gray) and Memphrémagog (black) lakes.

Note: The gray horizontal line represents energy level (a) and suspended sediment (b) respectively under normal conditions.

Figure 9 shows the results of the extrapolation of measurements to estimate the distance at which there would be no measurable energy input effects (TKE, Figure 9a) or resuspension of sediment (Figure 9b). In these figures, the results for Lake Lovering are represented by dots and a pale gray line, and those for Lake Memphremagog, in black dots and lines.

We first assessed the wakeboats' wake-up distance at which the impact of the wave on the shore is equivalent to that of normal conditions, ie 5.5 m 2 / s 2 for TKE, and 0.57 mg / L for sediments. in suspension. The normal values of TKE and suspended sediment are represented by a gray horizontal line. On the basis of the energy data (TKE, Figure 9a), the displacement distances equivalent to normal conditions are 268 m from shore for Lake

Memphremagog and 312 m from shore for Lovering Lake. In the case of suspended sediments (Figure 9b), the estimated distances are 286m (Memphremagog) and 206m (Lovering).

According to our calculations, the distance at which the wakeboats would have effects similar to those under normal conditions is approximately, on average for the two lakes, 300 m from the shore in terms of energy, and 250 m from the shore. shore for suspended sediments. Based on these results, we posit that 300 m represents a reasonable distance beyond which the waves generated by the wakeboats would be largely dissipated before their arrival on the banks and would therefore have a negligible effect. On this basis and if the objective is to eliminate any impact on the shoreline that wakeboat passages could cause, we have transposed these results on a map for each lake (next page: Memphrémagog: Figure 10a; Lovering: Figure 10b) , to represent the navigable area (in dark gray) for wakeboats, in the case of a regulation limiting their use at a distance of 300 m from the lakeshore.

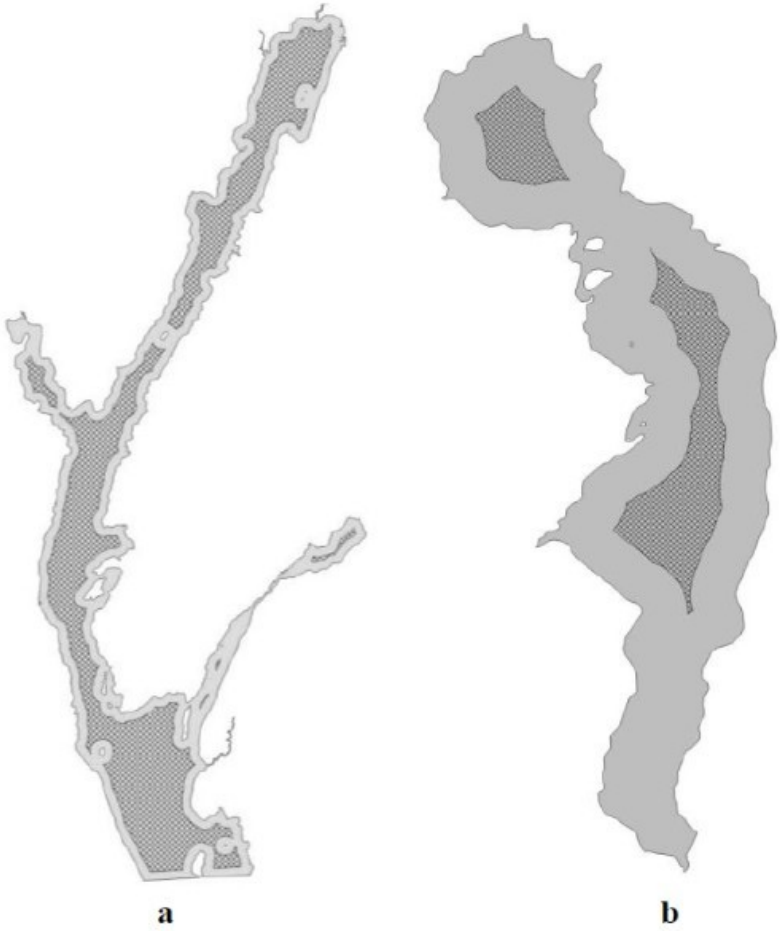


Figure 10. Map of the navigable area by wakeboats (dark gray) following a regulation limiting their activity to more than 300 m from the shores of lakes Memphrémagog (a) and Lovering (b).

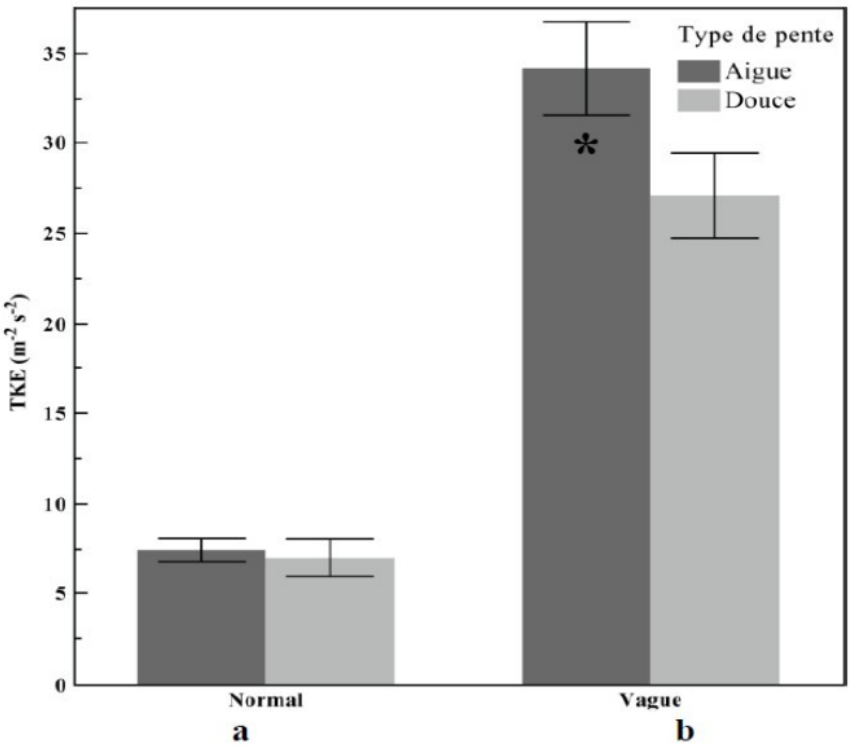
Impact of shoreline slope on energy reaching the shoreline

According to the literature, the level of energy arriving at the shore is expected to be a function of the slope of the coastline. We wanted to evaluate this hypothesis by linking the slopes of the coast of each site with the energy (TKE), measured under normal conditions and then during the passage of a wakeboat, all types of travel combined and all distances combined.

Our results show that, under normal conditions, the energy level that reaches a bank with a steep slope (acute: 0.1 mm -1) is not significantly different from that arriving at the bank with a slight slope (soft: <0.1 mm -1). This is shown in Figure 11a, where energy values (TKE) are found under normal conditions with gentle slope (light gray) and acute slope (dark gray).

On the other hand, when increasing energy reaching the shore (with the passage of a wakeboat), the acute slopes receive a significantly higher energy (Figure 11b). Indeed, when the slope of a coastline is acute, the wave meets less quickly the bottom of the littoral and the energy

of the wave dissipates so less quickly. The energy that arrives at the shore is then much higher, leading to a greater impact on the resuspension of the sediments and possibly on the erosion of the bank.



at b

Figure 11. Energy (TKE) reaching the shoreline for sites with acute (dark gray) or soft (pale gray) slope slope for normal (a) and wakeboat (b) waves.

Note: The asterisk (*) represents the significant increase (p <0.05).

Coastal slope and TKE data were used to relate them in a regression analysis (page 12), under normal conditions (Figure 12a) and when passing a wakeboat (Figure 12b). As seen previously, under normal conditions (Figure 12a), there is little difference between the energy that arrives on a low-slope coastline (1st point down, in Figure 12a) and the energy that arrives on a coastline of acute slope (last point at the top, same figure). On the other hand, with the

large amount of energy present in the waves caused by the passage of a wakeboat (Figure 12b), the impact of the slope of the coastline is much more important. The effect of wakeboat waves on energy (TKE) at the site that has the littoral with the steepest slope (last point at the top, Figure 12b) is much larger than for the site that has the littoral with the most Slow slope (1st point down, same figure).

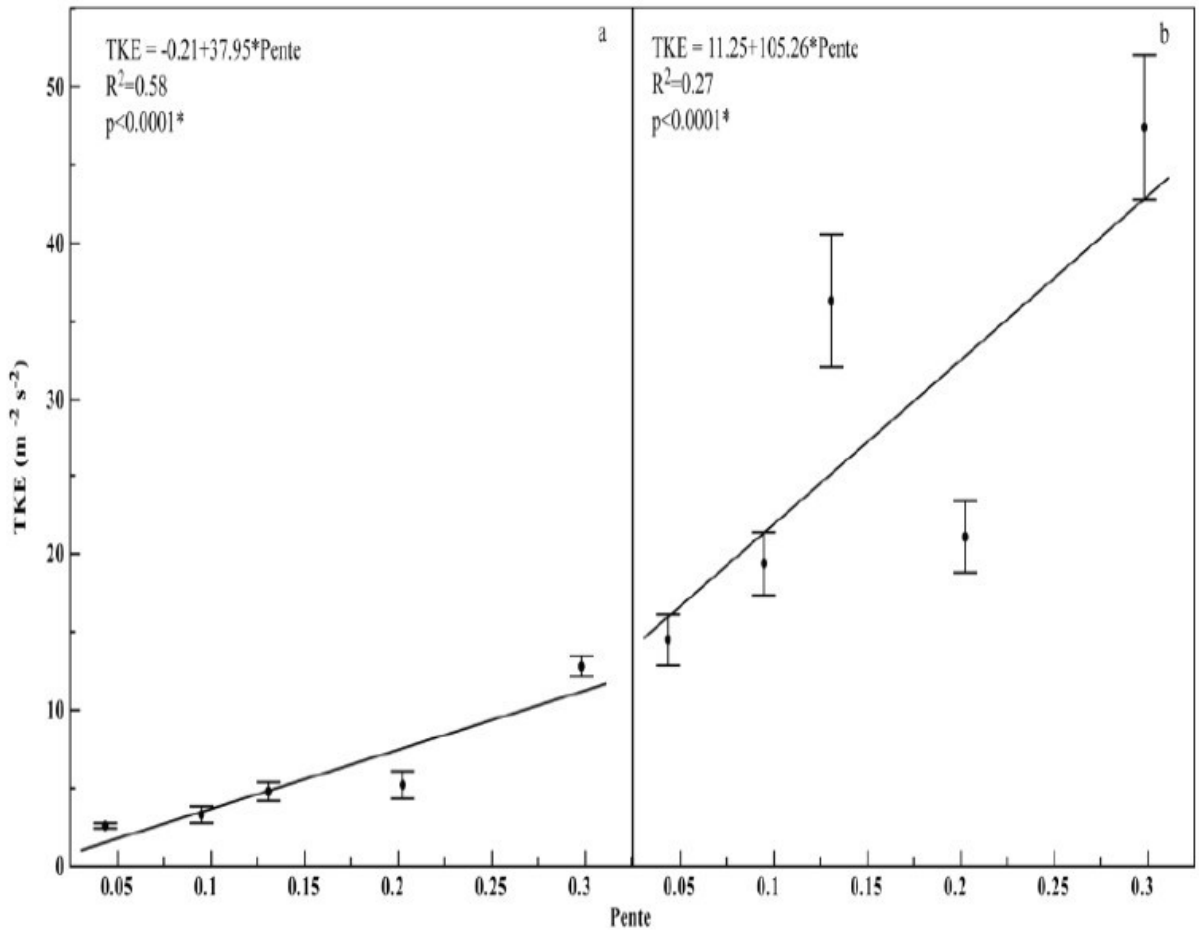


Figure 12. Linear Regression between Energy (TKE) and Shoreline Slope: a) under normal conditions and b) during the passage of a wakeboat wave train for 5 sampled sites.

Note : The LOV2 site has been eliminated from shoreline slope analyzes as its very small and very long slope eliminates the trends observed here.

Characteristics of the waves

In addition to the previous information, we have characterized waves and wave trains, to assess their impact on the shores. According to our results, the very short and intense wakesurf wave train has the most impact when it reaches the shore because it contains much more energy (Figures 5 and 6). Indeed, despite a shorter average wave train duration (52.5 s) and a lower number of waves per second (0.54 wave s -1), the maximum speeds reached by the waves are the highest (25.0 ms -1), causing significant resuspension of sediments during the passage of these waves (Table 3).Indeed, the higher energy is concentrated in a small number of waves, which gives it more power.

The wakeboard wave train is much longer in duration (71.8 s) but, despite a fairly large increase in energy (Figure 5) and maximum speed (21.1 ms -1), we were unable to detect a significant resuspension of sediment. The wave train would become too large to have a major impact on the sediments.

Table 3. Average wave train duration (sec), number of waves per wave train length, and maximum speed (ms -1) for different shore distances (100, 150, 200 m) and the type of displacement of the wakeboat

Distance		All confused	Wakesurf	Wakeboard	Moving
Duration of the wave train (sec)	All confused	-	52.47	71.79	65.46
	100 m	47.64	40.42	54.03	48.6
	150 m	62.83	52.36	69.96	64.64
	200 m	80.63	64.63	89.92	83.13
Number of waves per length (wave s -1)	All confused	-	0.54	0.60	0.65
	100 m	0.59	0.52	0.59	0.67
	150 m	0.60	0.55	0.61	0.64
	200 m	0.60	0.59	0.59	0.64
Maximum speed (ms-1)	All confused	-	25.04	21.07	15.94
	100 m	22.17	29.3	23.16	16.7
	150 m	20.18	25.46	20.27	15.97
	200 m	17.99	20.36	19.96	15.14

The traveling wave train has an intermediate duration (65.5 s); it contains less energy and has a lower maximum speed (15.9 ms -1) than the other two types of wave trains, but it still has a considerable impact on the shoreline (Table 3 and Figures 7 and 8).). This trend for each of the three wave types remains the same depending on the distance from the shore (Table 3). Thus, the number of waves per duration of the wave train is not a function of the distance from the shore ($p > 0.05$). On the other hand, the wakesurf wave train contains significantly fewer waves, regardless of the distance from the shore ($p < 0.0001$ *, for the three distances and all distances: Table 3).

The power of a wave train is thus strongly influenced by the intensity that each of the waves constituting it with the capacity to accumulate.

.**CONCLUSION**

As a result of this experimental study, it is possible to establish that the wakeboat boat passage causes a considerable impact on the shore when it passes 100 m from the shore, and

that all passages within 300 m significantly add energy to naturally occurring waves (Figure 9). In addition, the waves created by a wakeboat to wakesurf (1 side of ballast filled) are the ones that have the greatest impact when they arrive at the shore, given the large amount of energy contained in their short train of waves, which contains few waves. Due to their much longer waves and more waves, wakeboard waves (2 sides of ballasts filled) and the wakeboat (empty ballasts) have a less severe impact on the shore, with the energy distributed throughout the waves. the entire duration of the wave train. Nevertheless, it must be remembered that all the boat passes observed in this study carry a significantly higher amount of energy to shore than in normal conditions.

The energy present in the wave train created by the wakeboats causes a resuspension of the sediments and probably also an accelerated erosion of the banks.

According to the findings of this research and to eliminate any additional impact on the shoreline caused by wakeboat crossings, we suggest that a regulation limit the passage of wakeboat boats on lakes at least 300 m from shore, in order to avoid erosion (Figure 9). The navigable areas illustrated by the maps in Figure 10 were based on this 300m distance from the shorelines for the two study lakes (Memphremagog: Figure 10a; Lovering: Figure 10b).

BIBLIOGRAPHY

Environmental Sciences Section. 1993. ESS Method 340.2: Total Suspended Solids, Mass Balance (Dried at 103-105EC), Volatile Suspended Solids (Ignited at 550EC).

Gray, JR, Glysson, GR, Turcios, LM and Schwarz, GE. 2000. Comparability of suspended sediment concentration and total suspended solids data. US Geological Survey: Water Resources Investigation Report, Vol. 00-4191, No. 1-14.

Hill, DF, Beachler, MM and Johnson, PA. 2002. Hydrodynamic impacts of commercial Jet-boating on the Chilkat river, Alaska.

Keenan, RJ and Kimmins, JPH. 1993. The ecological effects of clear-cutting. About. rev., vol. 1, p. 121-144.

Kolmogorov, AN. The local structure of turbulence in incompressible viscous fluid for very large Reynolds numbers. Dokl. Akad. Nauk SSSR, vol. 30, p. 299-303.

MRC Memphrémagog. 2011. Map of nautical regulation at Lovering Lake. Government of Quebec. Retrieved 18 December 2013 inhttp://www.mrcmemphremagog.com/pdf/Patrouille%20nautique/Cartes/Carte%20Lovering- FR.pdf

MRC Memphrémagog. 2013. Map of nautical regulations at Lake Memphremagog. Government of Quebec. Retrieved December 18, 2013 from http://www.mrcmemphremagog.com/pdf/Patrouille%20nautique/Cards/Carte%20Memph-EN.pdf

Péloquin-guay, M. 2013. Evaluation of the effect of boat waves on the hydraulic conditions near riverbanks in the middle of the river. Montreal university.

Sorensen, RM. 1997. Prediction of Vessel-Generated Waves with Reference to Cells. Technical input, Department of Civil and Environmental Engineering, Lehigh University.

Stewart-Oaten, A, Murdoch, WW and Parker, KR. 1986. Environmental impact assessment: "Pseudoreplication" in time? Ecology, vol. 67, No. 4, p. 929-940.

Vachon, D, Prairie, YT and Cole, JJ. 2010. The relationship between near-surface turbulence and gas transfer velocity in freshwater systems and its implications. Limnology and oceanography, vol.55, No. 4, p. 1723-1732.

Wist, HT. 2004. Statistical properties of successive ocean wave parameters. Faculty of Engineering and Technology, Norvegian University of Science and Technology.

NOTES

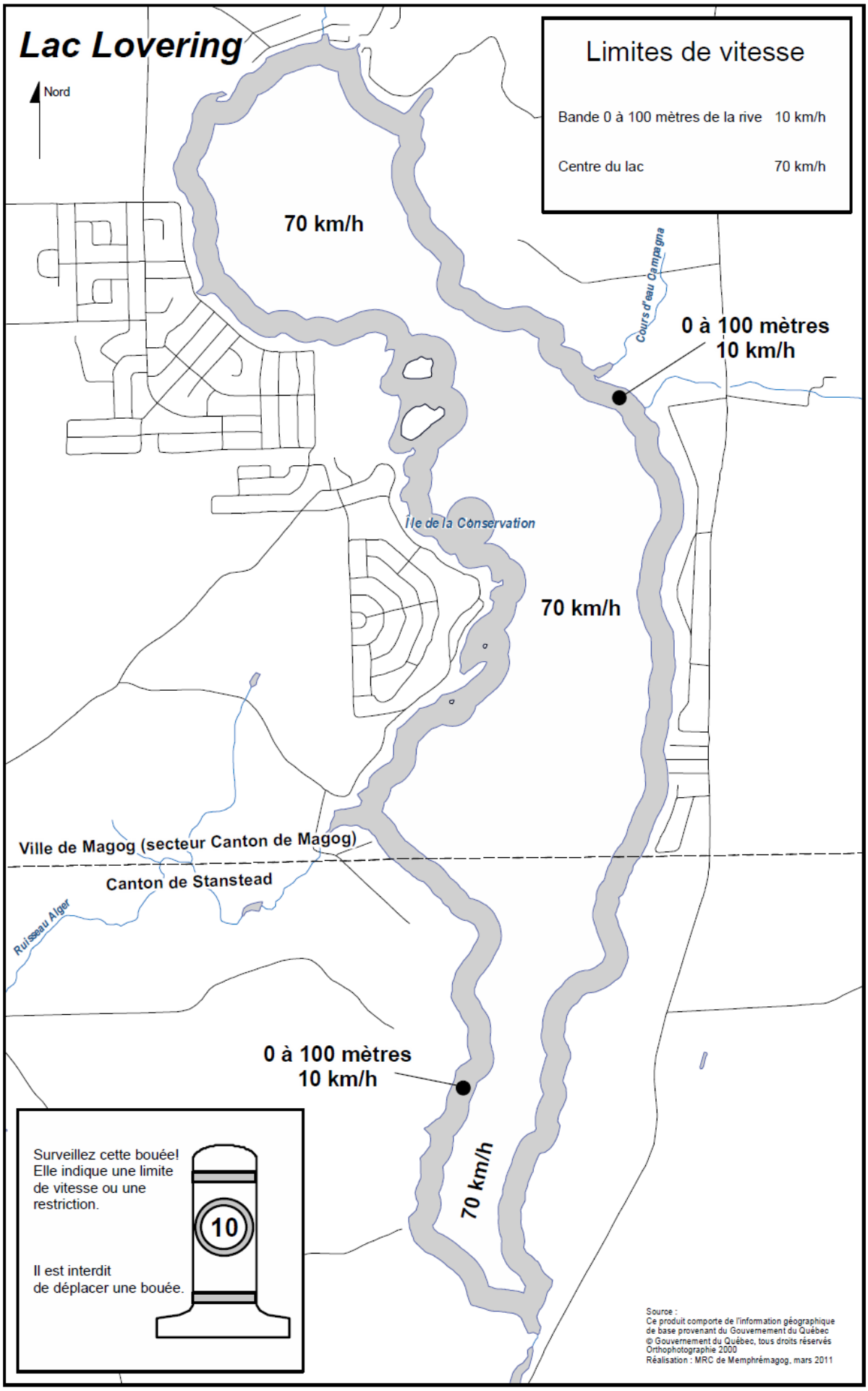
Appendix 1. Sampling sites in Lovering Lake and Lake Memphremagog

Appendix 2. Nautical Regulations Map of Lovering Lake

Appendex 3. Maps of the Lake Memphremagog nautical regulation

Appendix 3. Raw Data Tables of Physical Parameters

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	Average speed (ms -1)	Maximum speed (ms -1)	Minimum speed (ms -1)	TKE (m 2 s -2)	Epsilon z (m 2 s -3)	Number of waves per train	Duration of the wave train (sec)	Number / Length (wave s -1)
08/04/2013	Lovering	LOV1	Normal	10	100	2.41	21.52	0.04	4.38	3,8E-08			
08/04/2013	Lovering	LOV1	Wave	10	100	6.49	25.81	0.10	33,07	2,2nd-07	29.46	62.20	0.47
08/04/2013	Lovering	LOV1	Normal	10	150	1.13	17.33	0.02	0.96	2,2nd-08			
08/04/2013	Lovering	LOV1	Wave	10	150	6.02	25.32	0.05	29,52	1.4E-07	43.69	78,88	0.55
08/04/2013	Lovering	LOV1	Normal	10	150	1.23	4.82	0.03	1.12	6,7E-08			
08/04/2013	Lovering	LOV1	Wave	10	150	5.75	19.65	0.12	23.54	6,7E-08	31.83	67.64	0.47
08/04/2013	Lovering	LOV1	Normal	10	200	2.85	10.21	0.06	5.96	6,0E-08			
08/04/2013	Lovering	LOV1	Wave	10	200	5.46	17.09	0.02	21,06	3.3E-08	29.49	53.04	0.56
08/04/2013	Lovering	LOV1	Wave	10	100	6.82	20.54	0.10	33.45	1.6E-07	25.37	51.80	0.49
08/04/2013	Lovering	LOV1	Normal	10	100	1.89	8.53	0.07	2.54	3.3E-08			
08/04/2013	Lovering	LOV1	Wave	10	200	5.03	14.77	0.13	16.87	1.7E-08	43,11	74.84	0.58
08/04/2013	Lovering	LOV1	Normal	10	200	2.28	7.64	0.12	3.89	1.5E-07			
08/04/2013	Lovering	LOV1	Normal	20	200	1.91	8.52	0.02	3.11	1.5E-07			
08/04/2013	Lovering	LOV1	Wave	20	200	4.99	18,88	0.14	18.53	8,0E-08	51.66	90.40	0.57
08/04/2013	Lovering	LOV1	Normal	20	150	2.09	12,40	0.11	3.37	2,1E-			


Lac Lovering
Nord
Limites de vitesse
Bande 0 à 100 mètres de la rive 10 km/h
Centre du lac 70 km/h
70 km/h
Cours d'eau Campagna
0 à 100 mètres
10 km/h
Île de la Conservation
70 km/h
Ville de Magog (secteur Canton de Magog)
Canton de Stanstead
Ruisseau Alger
0 à 100 mètres
10 km/h
70 km/h
Surveillez cette bouée! Elle indique une limite de vitesse ou une restriction.
Il est interdit de déplacer une bouée.
10
Source :
Ce produit comporte de l'information géographique de base provenant du Gouvernement du Québec
© Gouvernement du Québec, tous droits réservés
Orthophotographie 2000
Réalisation : MRC de Memphrémagog, mars 2011

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	Average speed (ms -1)	Maximum speed (ms -1)	Minimum speed (ms -1)	TKE (m 2 s -2)	Epsilon z (m 2 s -3)	Number of waves per train	Duration of the wave train (sec)	Number / Length (wave s -1)
08/05/2013	Lovering	LOV2	Wave	10	100	10.17	28.68	0.13	79.82	1.5E-06	16,06	36,80	0.44
08/05/2013	Lovering	LOV2	Normal	10	100	3.98	12.77	0.09	11.78	3,1E-07			
08/05/2013	Lovering	LOV2	Normal	10	100	3.44	11.16	0.00	8.91	1,9E-07			
08/05/2013	Lovering	LOV2	Wave	10	100	10.65	30.38	0.30	89.23	1,1E-06	16.93	31,04	0.55
08/05/2013	Lovering	LOV2	Normal	10	150	3.26	10.82	0.07	7.86	2,9E-08			
08/05/2013	Lovering	LOV2	Wave	10	150	8.40	28,02	0.04	51.91	4,8E-07	27.26	49.04	0.56
08/05/2013	Lovering	LOV2	Normal	10	200	3.27	11.53	0.09	8.14	5,9E-08			
08/05/2013	Lovering	LOV2	Wave	10	200	8.20	25.64	0.09	49.81	8,2E-08	24.29	46.56	0.52
08/05/2013	Lovering	LOV2	Wave	10	150	7.71	25.43	0.09	43.57	3.0E-07	25.92	46.44	0.56
08/05/2013	Lovering	LOV2	Normal	10	150	3.72	10.84	0.09	9.76	2,1E-07			
08/05/2013	Lovering	LOV2	Wave	20	150	8.10	28.32	0.10	48.36	2.7E-07	31.67	50.80	0.62
08/05/2013	Lovering	LOV2	Normal	20	150	5.00	15,52	0.10	18.12	1.6E-07			
08/05/2013	Lovering	LOV2	Wave	20	200	7.82	31.55	0.23	47.66	1,9E-07	36.85	64.48	0.57
08/05/2013	Lovering	LOV2	Normal	20	200	6.20	20.47	0.09	29.09	1.3E-07			
08/05/2013	Lovering	LOV2	Wave	20	150	8.32	29,10	0.13	52.70	1,8E-07	24.47	41,12	0.60
08/05/2013	Lovering	LOV2	Normal	20	150	5.09	19.96	0.04	19.49	2,2nd-07			
08/05/2013	Lovering	LOV2	Normal	20	200	6.09	19.47	0.04	27.84	1,9E-07			
08/05/2013	Lovering	LOV2	Wave	20	200	7.86	25.67	0.14	46.30	2,1E-07	35,13	58.56	0.60
08/05/2013	Lovering	LOV2	Normal	20	100	4.51	16,30	0.07	15.42	6,7E-08			
08/05/2013	Lovering	LOV2	Wave	20	100	8.07	28.93	0.16	50.20	5,4E-07	31.75	50.92	0.62
08/05/2013	Lovering	LOV2	Normal	20	100	4.76	14.83	0.17	16.29	1,8E-07			
08/05/2013	Lovering	LOV2	Wave	20	100	8.51	30.62	0.25	53.98	4.2E-07	24.60	40.40	0.61
08/05/2013	Lovering	LOV2	Normal	30	100	4.94	14.93	0.19	17,60	1,8E-07			
08/05/2013	Lovering	LOV2	Wave	30	100	7.63	19.41	0.36	39.06	1.0E-07	30.23	34.96	0.86
08/05/2013	Lovering	LOV2	Normal	30	200	5.77	17.92	0.04	23.59	1,1E-07			
08/05/2013	Lovering	LOV2	Wave	30	200	6.98	24.98	0.09	35.83	1.0E-07	48.65	74.32	0.65
08/05/2013	Lovering	LOV2	Normal	30	100	5.36	20.25	0.00	21,36	1.3E-07			

08/05/2013	Lovering	LOV2	Wave	30	100	6.85	18.78	0.13	33.32	9,9E-08	47.36	68.08	0.70
08/05/2013	Lovering	LOV2	Normal	30	150	6.92	21,01	0.09	34.48	1,1E-07			
08/05/2013	Lovering	LOV2	Wave	30	150	8.27	22.49	0.05	48.24	1.2E-07	36.15	56.24	0.64
08/05/2013	Lovering	LOV2	Normal	30	150	6.61	22.47	0.04	31.59	1,8E-07			
08/05/2013	Lovering	LOV2	Wave	30	150	8.65	28.30	0.11	55,08	1.4E-07	41.85	65.32	0.64
08/05/2013	Lovering	LOV2	Normal	30	200	6.61	24.82	0.23	31.69	1.0E-07			
08/05/2013	Lovering	LOV2	Wave	30	200	7.68	23.44	0.08	43.63	2,1E-07	31.60	47,40	0.67
08/05/2013	Lovering	LOV3	Wave	10	100	6.18	18.59	0.08	27.96	3.7E-07	35,70	57.52	0.62
08/05/2013	Lovering	LOV3	Normal	10	100	2.55	6.79	0.13	4.50	4,5E-07			
08/05/2013	Lovering	LOV3	Wave	10	150	4.49	17.16	0.04	16,05	1,8E-07	51.30	82.28	0.62
08/05/2013	Lovering	LOV3	Normal	10	150	1.80	6.23	0.02	2.83	1.4E-07			
08/05/2013	Lovering	LOV3	Wave	10	100	5.87	16.87	0.09	25.17	2.0E-07	34,01	54,56	0.62
08/05/2013	Lovering	LOV3	Normal	10	100	1.96	6.67	0.03	2.80	2,2nd-08			
0 8/05/2013	Lovering	LOV3	Wave	10	200	5.19	17.27	0.08	20,14	1.2E-07	50.02	87,88	0.57

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	Average speed (ms -1)	Maximum speed (ms -1)	Minimum speed (ms -1)	TKE (m 2 s -2)	Epsilon z (m 2 s -3)	Number of waves per train	Duration of the wave train (sec)	Number / Length (wave s -1)
08/05/2013	Lovering	LOV3	Normal	10	200	1.97	6.36	0.05	2.94	2.5E-08			
08/05/2013	Lovering	LOV3	Wave	10	200	4.05	16.29	0.05	13.29	2.0E-07	50.08	91.80	0.55
08/05/2013	Lovering	LOV3	Normal	10	200	1.86	6.30	0.09	2.56	8,7E-08			
08/05/2013	Lovering	LOV3	Normal	10	150	1.94	6.56	0.07	2.84	8,7E-08			
08/05/2013	Lovering	LOV3	Wave	10	150	5.24	18.21	0.02	20,82	2,1E-07	45.76	73.08	0.63
08/05/2013	Lovering	LOV3	Wave	20	150	5.01	14.61	0.15		3,6E-07	52.57	84.32	0.62
08/05/2013	Lovering	LOV3	Normal	20	150	1.87	6.58	0.04		1.0E-07			
08/05/2013	Lovering	LOV3	Normal	20	100	2.13	6.10	0.15	2.94	1,8E-07			
08/05/2013	Lovering	LOV3	Wave	20	100	5.15	17.75	0.18	20.19	7,1E-07	44.88	74,80	0.60
08/05/2013	Lovering	LOV3	Wave	20	200	4.24	15,01	0.03	13.16	1,1E-07	66.14	109.32	0.61
08/05/2013	Lovering	LOV3	Normal	20	200	1.88	24.26	0.03	2.73	3.0E-08			
08/05/2013	Lovering	LOV3	Wave	20	150	4.73	17.76	0.04	17,04	3.7E-07	58.45	96.60	0.61
08/05/2013	Lovering	LOV3	Normal	20	150	1.83	5.88	0.08	2.29	2.0E-07			
08/05/2013	Lovering	LOV3	Normal	20	100	1.65	6.68	0.09	1.97	3.2E-08			
08/05/2013	Lovering	LOV3	Wave	20	100	4.52	17.25	0.11	15.78	4.9E-07	53.12	85.20	0.62
08/05/2013	Lovering	LOV3	Normal	20	200	1.79	5.57	0.09	2.35	2,4E-08			
08/05/2013	Lovering	LOV3	Wave	20	200	4.18	15.79	0.04	13.53	9,3E-08	74.75	116.28	0.64

08/05/2013	Lovering	LOV3	Normal	30	150	1.65	5.10	0.03	1.98	4.9E-08			
08/05/2013	Lovering	LOV3	Wave	30	150	3.29	11.33	0.09	7.81	8,2E-08	75.53	110.16	0.69
08/05/2013	Lovering	LOV3	Normal	30	200	1.69	6.33	0.10	2.08	7,9E-08			
08/05/2013	Lovering	LOV3	Wave	30	200	3.07	9.87	0.08	6.96	2.7E-08	86.92	112,40	0.77
08/05/2013	Lovering	LOV3	Wave	30	150	3.37	10.84	0.04	8.26	6,0E-08	73.45	107.12	0.69
08/05/2013	Lovering	LOV3	Normal	30	150	1.93	5.97	0.03	2.81	4,6E-08			
08/05/2013	Lovering	LOV3	Wave	30	100	2.92	8.40	0.02	5.92	5,7E-08	61.34	84,36	0.73
08/05/2013	Lovering	LOV3	Normal	30	100	1.54	6.73	0.01	1.54	2.5E-08			
08/05/2013	Lovering	LOV3	Wave	30	200	3.01	10,27	0.06	6.33	1.7E-07		135.96	
08/05/2013	Lovering	LOV3	Normal	30	200	1.59	4.88	0.02	1.79	9,2E-08			
08/05/2013	Lovering	LOV3	Wave	30	100	3.17	9.69	0.01	7.37	5,6E-08	73.41	91.76	0.80
08/05/2013	Lovering	LOV3	Normal	30	100	1.60	5.28	0.04	1.90	3,1E-08			
08/05/2013	Memphremagog	MEM1	Normal	10	200	2.07	5.75	0.06	2.83	4.2E-07			
08/05/2013	Memphremagog	MEM1	Wave	10	200	5.23	22.64	0.06	24.28	1.5E-07	27.87	54.20	0.51
08/05/2013	Memphremagog	MEM1	Wave	10	150	4.92	16.36	0.07	19.56	4.4E-08	26.33	46.08	0.57
08/05/2013	Memphremagog	MEM1	Normal	10	150	1.84	6.37	0.02	2.38	1,9E-07			
08/05/2013	Memphremagog	MEM1	Wave	10	100	5.39	19.46	0.05	23,74	8,2E-08	19.18	41.76	0.46
08/05/2013	Memphremagog	MEM1	Normal	10	100	2.24	5.82	0.09	3.52	4,0E-07			
08/05/2013	Memphremagog	MEM1	Normal	10	150	2.50	8.27	0.06	4.20	6,0E-08			
08/05/2013	Memphremagog	MEM1	Wave	10	150	6.61	22.79	0.25	37,38	5,3E-07	26.89	52.28	0.51
08/05/2013	Memphremagog	MEM1	Wave	10	200	3.59	12.91	0.06	10.41	1,8E-08	52.11	95.52	0.55
08/05/2013	Memphremagog	MEM1	Normal	10	200	1.54	7.29	0.01	1.86	3,6E-08			
08/05/2013	Memphremagog	MEM1	Wave	10	100	7.04	34.66	0.20	49.27	4.2E-07	17.07	33,60	0.51
08/05/2013	Memphremagog	MEM1	Normal	10	100	1.78	5.94	0.03	2.20	2,1E-07			

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	Average speed (ms -1)	Maximum speed (ms -1)	Minimum speed (ms -1)	TKE (m 2 s -2)	Epsilon z (m 2 s -3)	Number of waves per train	Duration of the wave train (sec)	Number / Length (wave s -1)
08/05/2013	Memphremagog	MEM1	Normal	20	150	1.81	4.58	0.02	2.25	1.6E-06			
08/05/2013	Memphremagog	MEM1	Wave	20	150	5.17	16.32	0.26	18.67	4.2E-07	47.87	80.44	0.60
08/05/2013	Memphremagog	MEM1	Normal	20	200	2.62	11.22	0.19	5.06	1.5E-07			
08/05/2013	Memphremagog	MEM1	Wave	20	200	4.38	12.65	0.04	13.16	5,0E-07	75.03	116.72	0.64
08/05/2013	Memphremagog	MEM1	Wave	20	150	5.03	12.38	0.03	17.54	3,8E-07	39.72	64,00	0.62
08/05/2013	Memphremagog	MEM1	Normal	20	150	3.18	8.80	0.16	7.03	4.2E-07			
08/05/2013	Memphremagog	MEM1	Normal	20	200	2.12	14.69	0.04	3.01				
08/05/2013	Memphremagog	MEM1	Wave	20	200	4.48	14.64	0.11	13.97	4,3E-07	72.79	121.32	0.60
08/05/2013	Memphremagog	MEM1	Normal	20	100	2.32	6.19	0.12	3.70	1.2E-06			
08/05/2013	Memphremagog	MEM1	Wave	20	100	6.07	19.55	0.11	27.64	1.3E-06	29.39	51.44	0.57
08/05/2013	Memphremagog	MEM1	Wave	20	100	5.88	22.33	0.07	28.07	6,2E-07	37,69	65.96	0.57
08/05/2013	Memphremagog	MEM1	Normal	20	100	1.73	6.66	0.08	2.28	8,9E-07			
08/05/2013	Memphremagog	MEM1	Normal	30	200	3.00	11.38	0.02	6.73	4,6E-07			
08/05/2013	Memphremagog	MEM1	Wave	30	200	4.78	12.78	0.07	16,14	7,8E-07	37.68	62.80	0.60
08/05/2013	Memphremagog	MEM1	Wave	30	100	5.01	13.38	0.25	17,21	1.3E-06	22.22	44.44	0.50
08/05/2013	Memphremagog	MEM1	Normal	30	100		9.66						
08/05/2013	Memphremagog	MEM1	Wave	30	100	4.63	13,01	0.13	15.64	2.0E-07	32.87	54.32	0.61
08/05/2013	Memphremagog	MEM1	Normal	30	100	3.27	12.84	0.10	8.98	1.7E-08			
08/05/2013	Memphremagog	MEM1	Wave	30	150	5.20	14,01	0.17	18.83	7,9E-07	19.05	30.16	0.63
08/05/2013	Memphremagog	MEM1	Normal	30	150	4.38	9.93	0.12	12.63	3.4E-07			
08/05/2013	Memphremagog	MEM1	Normal	30	200	2.47	9.36	0.03	4.96	9,4E-07			
08/05/2013	Memphremagog	MEM1	Wave	30	200	4.13	15.55	0.09	12.74	5,6E-07	52.82	84.72	0.62
08/05/2013	Memphremagog	MEM1	Normal	30	150	4.58	10.63	0.34	13.89	6,7E-07			
08/05/2013	Memphremagog	MEM1	Wave	30	150	4.46	12.74	0.11	14.73	5,8E-07	28.17	44,60	0.63
08/05/2013	Memphremagog	MEM2	Normal	10	100	2.09	6.99	0.08	3.27	2.7E-07			
08/05/2013	Memphremagog	MEM2	Wave	10	100	8.15	36.25	0.06	67.82	2,4E-06	16,05	29.88	0.54
08/05/2013	Memphremagog	MEM2	Wave	10	150	8.12	32.63	0.14	61.86	3,1E-07	18,08	35.60	0.51
08/05/2013	Memphremagog	MEM2	Normal	10	150	2.07	6.72	0.08	3.08	2.5E-07			
08/05/2013	Memphremagog	MEM2	Normal	10	200	2.16	6.16	0.02	3.18	6.8E-08			
08/05/2013	Memphremagog	MEM2	Wave	10	200	3.48	11.71	0.02	8.86	9,1E-09	38.78	62.48	0.62
08/05/2013	Memphremagog	MEM2	Normal	10	200	2.13	8.43	0.04	3.45	3,1E-08			
08/05/2013	Memphremagog	MEM2	Wave	10	200	6.50	20,04	0.04	35.24	2,1E-08	29.54	48.24	0.61
08/05/2013	Memphremagog	MEM2	Wave	10	100	7.56	35,70	0.24	62.72	2.5E-06	19,15	36.56	0.52

08/05/2013	Memphremagog	MEM2	Normal	10	100	1.78	4.34	0.08	2.12	2,4E-07			
08/05/2013	Memphremagog	MEM2	Wave	10	150	6.71	33.51	0.05	48.93	4.4E-07	20,70	40,32	0.51
08/05/2013	Memphremagog	MEM2	Normal	10	150	1.90	6.56	0.00	2.60	3.4E-07			
08/05/2013	Memphremagog	MEM2	Normal	20	150	2.61	6.81	0.04	4.62	7,3E-07			
08/05/2013	Memphremagog	MEM2	Wave	20	150	7.04	22.82	0.36	36.89	3.2E-07	30.95	51.16	0.61
08/05/2013	Memphremagog	MEM2	Wave	20	200	6.60	25.18	0.22	33.21	3,6E-07	38.47	67.32	0.57
08/05/2013	Memphremagog	MEM2	Normal	20	200	2.67	7.50	0.08	4.82	9,3E-07			
08/05/2013	Memphremagog	MEM2	Normal	20	200	1.50	5.48	0.03	1.69	9,3E-08			

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	Average speed (ms -1)	Maximum speed (ms -1)	Minimum speed (ms -1)	TKE (m 2 s -2)	Epsilon z (m 2 s -3)	Number of waves per train	Duration of the wave train (sec)	Number / Length (wave s -1)
08/05/2013	Memphremagog	MEM2	Wave	20	200	5.19	20.95	0.04	22.22	1,1E-07	45.81	79.52	0.58
08/05/2013	Memphremagog	MEM2	Wave	20	100	7.66	25.91	0.24	48.80	1.2E-06	21.41	37.16	0.58
08/05/2013	Memphremagog	MEM2	Normal	20	100	2.19	8.47	0.04	3.73	7,2E-07			
08/05/2013	Memphremagog	MEM2	Wave	20	150	6.61	21.87	0.16	33.50	4.2E-07	33.86	56.44	0.60
08/05/2013	Memphremagog	MEM2	Normal	20	150	2.68	7.33	0.14	5.35	1.4E-06			
08/05/2013	Memphremagog	MEM2	Normal	20	100	2.00	6.56	0.03	3.23	1.2E-06			
08/05/2013	Memphremagog	MEM2	Wave	20	100	8.06	28.34	0.18	52.53	1.2E-06	20,02	35.04	0.57
08/05/2013	Memphremagog	MEM2	Normal	30	150	3.97	9.94	0.08	10.56				
08/05/2013	Memphremagog	MEM2	Wave	30	150	5.31	15,05	0.09	19.51	6,1E-08	30.07	47,60	0.63
08/05/2013	Memphremagog	MEM2	Normal	30	150	2.74	7.81	0.09	5.12	1.3E-06			
08/05/2013	Memphremagog	MEM2	Wave	30	150	6.00	14.18	0.10	24.58	9,8E-08	25.06	40,20	0.62
08/05/2013	Memphremagog	MEM2	Normal	30	100	2.95	8.82	0.05	6.15	1.6E-07			
08/05/2013	Memphremagog	MEM2	Wave	30	100	6.77	15,11	0.15	30.53	7,4E-07	20.81	30.84	0.67
08/05/2013	Memphremagog	MEM2	Normal	30	200	3.02	9.98	0.13	6.51	2,9E-07			
08/05/2013	Memphremagog	MEM2	Wave	30	200	4.11	11,70	0,07	11,86	1,5E-07	54,98	91,64	0,60
5/8/2013	Memphrémagog	MEM2	Vague	30	100	7,43	24,18	0,23	40,52	1,1E-07	16,86	29,04	0,58
5/8/2013	Memphrémagog	MEM2	Normal	30	100	3,81	13,95	0,09	10,86	1,3E-06			
5/8/2013	Memphrémagog	MEM2	Normal	30	200	2,66	6,73	0,14	4,66	1,1E-06			
5/8/2013	Memphrémagog	MEM2	Vague	30	200	4,01	13,25	0,06	11,77	5,1E-07	63,09	94,64	0,67
6/8/2013	Memphrémagog	MEM3	Vague	10	200	11,09	35,95	0,39		4,5E-07	15,15	29,88	0,51
6/8/2013	Memphrémagog	MEM3	Normal	10	200	3,63	12,52	0,03	9,32	1,0E-07			
6/8/2013	Memphrémagog	MEM3	Normal	10	200	3,73	13,26	0,08	10,30	6,4E-08			
6/8/2013	Memphrémagog	MEM3	Vague	10	200	7,35	28,59	0,04	42,18	2,0E-07	22,03	41,24	0,53
6/8/2013	Memphrémagog	MEM3	Normal	10	150	3,65	14,11	0,07	10,67	2,1E-07			
6/8/2013	Memphrémagog	MEM3	Vague	10	150	8,89	26,88	0,08	58,74	1,1E-06	20,33	33,68	0,60
6/8/2013	Memphrémagog	MEM3	Normal	10	100	4,34	12,23	0,02	13,07	5,5E-07			
6/8/2013	Memphrémagog	MEM3	Vague	10	100	11,79		0,25			10,99	24,04	0,46
6/8/2013	Memphrémagog	MEM3	Normal	10	100	3,95	11,26	0,09	11,15	5,1E-07			
6/8/2013	Memphrémagog	MEM3	Vague	10	100	10,32	30,13	0,09	83,96	4,8E-06	14,27	25,32	0,56
6/8/2013	Memphrémagog	MEM3	Normal	10	150	4,21	16,18	0,09	12,52	4,7E-07			
6/8/2013	Memphrémagog	MEM3	Vague	10	150	12,09	39,60	0,21		1,7E-06	11,11	22,96	0,48
6/8/2013	Memphrémagog	MEM3	Normal	20	100	5,06	16,63	0,28	18,94	1,5E-06			
6/8/2013	Memphrémagog	MEM3	Vague	20	100	11,28	23,66		81,75	2,1E-06	6,00	9,60	0,63

6/8/2013	Memphrémagog	MEM3	Normal	20	150	6,81	18,52	0,23		1,7E-06			
6/8/2013	Memphrémagog	MEM3	Vague	20	150	8,26	22,45	0,27	47,69		32,59	55,44	0,59
6/8/2013	Memphrémagog	MEM3	Normal	20	150	6,01	19,64	0,18		1,2E-06			
6/8/2013	Memphrémagog	MEM3	Vague	20	150	7,16	23,02	0,19	37,53	3,6E-07	55,48	92,48	0,60
6/8/2013	Memphrémagog	MEM3	Normal	20	200	4,73	12,86	0,09	16,05	1,9E-06			
6/8/2013	Memphrémagog	MEM3	Vague	20	200	6,92	19,41	0,16	32,54	1,1E-06	46,44	93,04	0,50
6/8/2013	Memphrémagog	MEM3	Normal	20	200	4,22	12,14	0,04	12,62	4,4E-07			
6/8/2013	Memphrémagog	MEM3	Vague	20	200	7,47	20,46	0,15	38,93	9,5E-07	37,39	65,44	0,57

Date de prise d'échantillons	Lac	Site	Période	Vitesse (miles/h)	Distance de la rive (m)	Vitesse moyenne (m s-1)	Vitesse maximum (m s-1)	Vitesse minimum (m s-1)	TKE (m2s-2)	Epsilonz (m2s-3)	Nombre de vagues par train	Durée du train de vague (sec)	Nombr Longue (vague 1)
6/8/2013	Memphrémagog	MEM3	Vague	20	100	9,32	24,54	0,05	60,35	9,4E-07	23,62	42,40	0,5
6/8/2013	Memphrémagog	MEM3	Normal	20	100	4,29	12,59	0,03	13,00	8,5E-07			
6/8/2013	Memphrémagog	MEM3	Vague	30	150	7,79	25,95	0,16	45,06	5,6E-07	28,71	50,24	0,5
6/8/2013	Memphrémagog	MEM3	Normal	30	150	4,25	8,81	0,14	12,89	2,4E-06			
6/8/2013	Memphrémagog	MEM3	Normal	30	100	4,38	16,56	0,19	14,48	3,8E-07			
6/8/2013	Memphrémagog	MEM3	Vague	30	100	8,18	25,11	0,04	47,33	1,2E-06	21,28	36,20	0,5
6/8/2013	Memphrémagog	MEM3	Normal	30	200	3,74	10,22	0,24	9,55	7,3E-07			
6/8/2013	Memphrémagog	MEM3	Vague	30	200	6,41	18,95	0,10	27,01	4,2E-07	46,96	78,28	0,6
6/8/2013	Memphrémagog	MEM3	Normal	30	200	4,99	23,96	0,22	15,81	6,4E-07			
6/8/2013	Memphrémagog	MEM3	Vague	30	200	6,15	17,90	0,19	25,59	1,0E-06	40,03	77,84	0,5
6/8/2013	Memphrémagog	MEM3	Normal	30	100	3,76	10,94	0,08	10,04	3,0E-07			
6/8/2013	Memphrémagog	MEM3	Vague	30	100	8,35	25,62	0,34	51,91	1,4E-06	23,35	35,76	0,6
6/8/2013	Memphrémagog	MEM3	Normal	30	150	4,20	11,85	0,15	13,45	2,8E-06			
6/8/2013	Memphrémagog	MEM3	Vague	30	150	6,64	16,61	0,14	29,18	7,0E-07	41,87	62,80	0,6

Annexe 4. Tableaux des données brutes des valeurs de sédiments en suspension

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	T0 (A) sediments (mg L -1)	T1 (B) sediments (mg L -1)	Resuspension (mg L -1)
08/04/13	Lovering	LOV1	Normal	20	200	0.4	1.6	1.2
08/04/13	Lovering	LOV1	Wave	20	200	0.4	1.6	1.2
08/04/13	Lovering	LOV1	Normal	20	150	0.4	2.8	2.4
08/04/13	Lovering	LOV1	Wave	20	150	0.4	2.8	2.4
08/04/13	Lovering	LOV1	Normal	30	150	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	30	150	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	20	200	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	20	200	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	20	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	20	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	30	200	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	30	200	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	10	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	10	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	30	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	30	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	20	100	0.4	2.4	2
08/04/13	Lovering	LOV1	Wave	20	100	0.4	2.4	2
08/04/13	Lovering	LOV1	Normal	10	150	0.4	-2.4	-2.8
08/04/13	Lovering	LOV1	Wave	10	150	0.4	-2.4	-2.8
08/04/13	Lovering	LOV1	Normal	30	150	0.4	2	1.6
08/04/13	Lovering	LOV1	Wave	30	150	0.4	2	1.6
08/04/13	Lovering	LOV1	Normal	10	150	0.4	3.2	2.8
08/04/13	Lovering	LOV1	Wave	10	150	0.4	3.2	2.8
08/04/13	Lovering	LOV1	Normal	10	200	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	10	200	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	30	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	30	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	20	150	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	20	150	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	10	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	10	100	0.4	0.4	0
08/04/13	Lovering	LOV1	Wave	10	200	0.4		
08/04/13	Lovering	LOV1	Normal	10	200	0.4		
08/04/13	Lovering	LOV1	Wave	30	200	0.4	0.4	0
08/04/13	Lovering	LOV1	Normal	30	200	0.4	0.4	0
08/05/13	Lovering	LOV2	Normal	30	100	0.6	8.2	7.6
08/05/13	Lovering	LOV2	Wave	30	100	0.6	8.2	7.6
08/05/13	Lovering	LOV2	Wave	20	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	20	150	0.6	0.6	0

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	T0 (A) sediments (mg L -1)	T1 (B) sediments (mg L -1)	Resuspension (mg L -1)
08/05/13	Lovering	LOV2	Normal	30	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	30	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	10	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	10	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	30	100	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	30	100	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	10	100	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	10	100	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	20	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	20	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	20	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	20	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	30	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	30	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	10	100	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	10	100	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	20	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	20	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	20	100	0.6	3.4	2.8
08/05/13	Lovering	LOV2	Wave	20	100	0.6	3.4	2.8

08/05/13	Lovering	LOV2	Normal	20	100	0.6	1.8	1.2
08/05/13	Lovering	LOV2	Wave	20	100	0.6	1.8	1.2
08/05/13	Lovering	LOV2	Normal	10	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	10	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	10	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	10	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	30	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	30	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	30	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	30	200	0.6	0.6	0
08/05/13	Lovering	LOV2	Wave	10	150	0.6	0.6	0
08/05/13	Lovering	LOV2	Normal	10	150	0.6	0.6	0
08/05/13	Lovering	LOV3	Normal	30	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	30	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	30	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	30	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	30	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	30	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	10	100	0.3	1.9	1.6
08/05/13	Lovering	LOV3	Normal	10	100	0.3	1.9	1.6
08/05/13	Lovering	LOV3	Wave	20	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	20	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	20	100	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	20	100	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	10	150	0.3	3.5	3.2

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	T0 (A) sediments (mg L -1)	T1 (B) sediments (mg L -1)	Resuspension (mg L -1)
08/05/13	Lovering	LOV3	Normal	10	150	0.3	3.5	3.2
08/05/13	Lovering	LOV3	Wave	30	100	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	30	100	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	30	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	30	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	20	200	0.3	1.5	1.2
08/05/13	Lovering	LOV3	Normal	20	200	0.3	1.5	1.2
08/05/13	Lovering	LOV3	Wave	20	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	20	150	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	10	100	0.3	1.5	1.2
08/05/13	Lovering	LOV3	Normal	10	100	0.3	1.5	1.2
08/05/13	Lovering	LOV3	Wave	30	100	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	30	100	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	10	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	10	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	10	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	10	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	20	100	0.3	-1.7	-2
08/05/13	Lovering	LOV3	Wave	20	100	0.3	-1.7	-2
08/05/13	Lovering	LOV3	Normal	20	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Wave	20	200	0.3	0.3	0
08/05/13	Lovering	LOV3	Normal	10	150	0.3	1.5	1.2
08/05/13	Lovering	LOV3	Wave	10	150	0.3	1.5	1.2
08/05/13	Memphremagog	MEM1	Normal	30	200	1	2.2	1.2
08/05/13	Memphremagog	MEM1	Wave	30	200	1	2.2	1.2
08/05/13	Memphremagog	MEM1	Normal	10	200	1	1	0
08/05/13	Memphremagog	MEM1	Wave	10	200	1	1	0
08/05/13	Memphremagog	MEM1	Normal	20	150	1	1	0
08/05/13	Memphremagog	MEM1	Wave	20	150	1	1	0
08/05/13	Memphremagog	MEM1	Wave	30	100	1	1	0
08/05/13	Memphremagog	MEM1	Normal	30	100	1	1	0
08/05/13	Memphremagog	MEM1	Wave	10	150	1	1	0
08/05/13	Memphremagog	MEM1	Normal	10	150	1	1	0
08/05/13	Memphremagog	MEM1	Wave	10	100	1	4.2	3.2
08/05/13	Memphremagog	MEM1	Normal	10	100	1	4.2	3.2
08/05/13	Memphremagog	MEM1	Normal	10	150	1	1	0
08/05/13	Memphremagog	MEM1	Wave	10	150	1	1	0
08/05/13	Memphremagog	MEM1	Wave	10	200	1	1	0
08/05/13	Memphremagog	MEM1	Normal	10	200	1	1	0
08/05/13	Memphremagog	MEM1	Normal	20	200	1	1	0
08/05/13	Memphremagog	MEM1	Wave	20	200	1	1	0
08/05/13	Memphremagog	MEM1	Wave	30	100	1	1	0
08/05/13	Memphremagog	MEM1	Normal	30	100	1	1	0
08/05/13	Memphremagog	MEM1	Wave	20	150	1	1	0

08/05/13	Memphremagog	MEM1	Normal	20	150	1	1	0

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	T0 (A) sediments (mg L -1)	T1 (B) sediments (mg L -1)	Resuspension (mg L -1)
08/05/13	Memphremagog	MEM1	Wave	30	150	1	1	0
08/05/13	Memphremagog	MEM1	Normal	30	150	1	1	0
08/05/13	Memphremagog	MEM1	Normal	30	200	1	-0.2	-1.2
08/05/13	Memphremagog	MEM1	Wave	30	200	1	-0.2	-1.2
08/05/13	Memphremagog	MEM1	Normal	20	200	1	3	2
08/05/13	Memphremagog	MEM1	Wave	20	200	1	3	2
08/05/13	Memphremagog	MEM1	Normal	30	150	1	1	0
08/05/13	Memphremagog	MEM1	Wave	30	150	1	1	0
08/05/13	Memphremagog	MEM1	Normal	20	100	1	1	0
08/05/13	Memphremagog	MEM1	Wave	20	100	1	1	0
08/05/13	Memphremagog	MEM1	Wave	20	100	1	1	0
08/05/13	Memphremagog	MEM1	Normal	20	100	1	1	0
08/05/13	Memphremagog	MEM1	Wave	10	100	1	2.2	1.2
08/05/13	Memphremagog	MEM1	Normal	10	100	1	2.2	1.2
08/05/13	Memphremagog	MEM2	Normal	20	150	0.4	-0.8	-1.2
08/05/13	Memphremagog	MEM2	Wave	20	150	0.4	-0.8	-1.2
08/05/13	Memphremagog	MEM2	Normal	10	100	0.4	2.4	2
08/05/13	Memphremagog	MEM2	Wave	10	100	0.4	2.4	2
08/05/13	Memphremagog	MEM2	Wave	10	150	0.4	4	3.6
08/05/13	Memphremagog	MEM2	Normal	10	150	0.4	4	3.6
08/05/13	Memphremagog	MEM2	Wave	20	200	0.4	2.4	2
08/05/13	Memphremagog	MEM2	Normal	20	200	0.4	2.4	2
08/05/13	Memphremagog	MEM2	Normal	20	200	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Wave	20	200	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Normal	10	200	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Wave	10	200	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Normal	30	150	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Wave	30	150	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Normal	10	200	0.4	-0.8	-1.2
08/05/13	Memphremagog	MEM2	Wave	10	200	0.4	-0.8	-1.2
08/05/13	Memphremagog	MEM2	Normal	30	150	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Wave	30	150	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Normal	30	100	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Wave	30	100	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Normal	30	200	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Wave	30	200	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Wave	30	100	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Normal	30	100	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Wave	20	100	0.4	2	1.6
08/05/13	Memphremagog	MEM2	Normal	20	100	0.4	2	1.6
08/05/13	Memphremagog	MEM2	Wave	20	150	0.4	2.4	2
08/05/13	Memphremagog	MEM2	Normal	20	150	0.4	2.4	2
08/05/13	Memphremagog	MEM2	Normal	30	200	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Wave	30	200	0.4	1.6	1.2
08/05/13	Memphremagog	MEM2	Normal	20	100	0.4	0.4	0

Date of taking samples	Lake	Site	Period	Speed (miles / h)	Distance from shore (m)	T0 (A) sediments (mg L -1)	T1 (B) sediments (mg L -1)	Resuspension (mg L -1)
08/05/13	Memphremagog	MEM2	Wave	20	100	0.4	0.4	0
08/05/13	Memphremagog	MEM2	Wave	10	100	0.4	4.4	4
08/05/13	Memphremagog	MEM2	Normal	10	100	0.4	4.4	4
08/05/13	Memphremagog	MEM2	Wave	10	150	0.4	3.2	2.8
08/05/13	Memphremagog	MEM2	Normal	10	150	0.4	3.2	2.8
08/06/13	Memphremagog	MEM 3	Wave	30	150	0.7	1.9	1.2
08/06/13	Memphremagog	MEM 3	Normal	30	150	0.7	1.9	1.2
08/06/13	Memphremagog	MEM 3	Normal	20	100	0.7		

08/06/13	Memphremagog	MEM 3	Wave	20	100	0.7		
08/06/13	Memphremagog	MEM 3	Wave	10	200	0.7	3.1	2.4
08/06/13	Memphremagog	MEM 3	Normal	10	200	0.7	3.1	2.4
08/06/13	Memphremagog	MEM 3	Normal	30	100	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	30	100	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Normal	30	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	30	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Normal	30	200	0.7	-0.9	-1.6
08/06/13	Memphremagog	MEM 3	Wave	30	200	0.7	-0.9	-1.6
08/06/13	Memphremagog	MEM 3	Normal	10	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	10	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Normal	30	100	0.7	3.1	2.4
08/06/13	Memphremagog	MEM 3	Wave	30	100	0.7	3.1	2.4
08/06/13	Memphremagog	MEM 3	Normal	20	150	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	20	150	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Normal	20	150	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	20	150	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Normal	10	150	0.7	2.7	2
08/06/13	Memphremagog	MEM 3	Wave	10	150	0.7	2.7	2
08/06/13	Memphremagog	MEM 3	Normal	10	100	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	10	100	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Normal	30	150	0.7	1.5	0.8
08/06/13	Memphremagog	MEM 3	Wave	30	150	0.7	1.5	0.8
08/06/13	Memphremagog	MEM 3	Normal	20	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	20	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Normal	20	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	20	200	0.7	0.7	0
08/06/13	Memphremagog	MEM 3	Wave	20	100	0.7	-1.7	-2.4
08/06/13	Memphremagog	MEM 3	Normal	20	100	0.7	-1.7	-2.4
08/06/13	Memphremagog	MEM 3	Normal	10	100	0.7	3.1	2.4
08/06/13	Memphremagog	MEM 3	Wave	10	100	0.7	3.1	2.4
08/06/13	Memphremagog	MEM 3	Normal	10	150	0.7	1.9	1.2
08/06/13	Memphremagog	MEM 3	Wave	10	150	0.7	1.9	1.2