Project Evaluation of the Impact of Waves Created by Wake Boats on the Shores of the Lakes Memphremagog and Lovering

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EXECUTIVE SUMMARY

The presence of wake boats has been increasing in recent years on water bodies in Quebec. More and more lakefront property owners are concerned about the possible impacts of such boats on lakeshore erosion, including the resuspension of sediment caused by the increase in energy of the waves generated by these types of boats.

The objective of this research was to develop a scientific framework to validate the existence, extent and terms of the impacts of oversized waves wake boats generate by the lake environment in Quebec. The research was made by using lakes Memphremagog and Lovering in collaboration with the SCLL and MCI, and with the service to support communities.

The **main** research **results** are:

- All wake boat passages induce a significant increase in energy contained in the waves before reaching the shore, on average by a factor of 4.

- The impact of wake boat passages is directly and inversely related to the distance between the passage and the shore.

- Of the three different types of waves generated by a wake boat, wake surfing waves are those that cause the greatest impact on their arrival to the shore (1.7 times higher than the waves of a boat moving normally).

- The wake boat passages have a greater impact on the shores with a slope accentuated than those with a gentle slope.

- Our data demonstrates that the energy produced by the wake boat dissipates completely before reaching the banks (and therefore have no significant effect) when the passages of wake boats occur 300 meters or more from shore.

INTRODUCTION

In recent years, new water sports are emerging in water bodies all throughout Quebec. In particular, the popularity of wake boats has been continually increasing on many lakes, including lakes Memphremagog and Lovering, both located in the north of the Appalachian region. Both lakes are important recreational and tourist centers for both residents and for vacationers. The configuration of wake boats can create a reasonably high wave to allow fans to "surf" on the back of the boat or on a wake surfboard or a wakeboard. By wake surfing, the surfer is not attached to the boat, but surfing behind the wake generated by the boat. In the case of wakeboarding, the person behind the boat is attached to it on a board approaching much more a snowboard with breeches.

Other than some research studies, such as those of Hill, Beachler and Johnson (2002), limited to the river Chilkat Alaska, and those Péloquin-Guay (Memory, U. of Montreal, 2013) on the river Batiscan, very few experimental studies have been conducted to rigorously evaluate, and quantitatively measure the potential to accelerate bank erosion, and none were specifically performed using the type of wake boat in lakes. Lakeshores can be an important vector of nutrients to lakes, especially on deforested areas bordering them (Keenan and Kimmins 1993). To date, no regulation circumscribes the use of such craft in relation to their environment impact. Indeed, the only regulation currently in force is that related to Boating Safety, which limits the speed to 10 km/h when the boat is moving at less than 100 m from the shore. In the rest of the lake, the speed limit is 70 km/h (Annexes 2 and 3: Maps Boating regulations of the Government of Québec, MRC Memphremagog 2011; MRC Memphrémagog 2013).

But, each wave created by a boat, or wind, contains a certain amount of energy (turbulent kinetic energy TKE). Part of this energy is dissipated quickly, but a certain amount can reach the banks. It is this energy, which can further contribute to the accelerated bank erosion and the suspension of sediment in place. So far, no relationship was developed to allow the quantitative comparison between the energy induced by the wave train boats and those normally seen.

The objective of this project was to develop a scientific framework for validating the existence, extent and terms of the impacts caused by waves on wake boats on the lake environments in Quebec, based on measurements taken at lakes Lovering and Memphremagog. Three sites in each lake were instrumented in turn, to acquire physical data to quantify the energy induced by the train wake boat waves generate when they reach the shore. In addition, measurements have been taken to assess resuspension of sediment.

METHODOLOGY

Sampling plan

In order to quantify the effect of wake boats on the energy received by the banks, we chose to proceed with a controlled experimental design, that is to say where we can impose configurations and specific paths to the boat. Our protocol allows measurement of the energy generated by the wake boats waves in several combinations of three main factors:

1) The type of movement of the boat, characterized by the speed of the boat, and therefore the type of waves created;
2) the distance from the shore when the boat passes (100, 150 and 200m);
3) the type of shore, following the slope of the shore.

Figure 1 illustrates this sampling plan. For each combination, the measurements were taken twice in order to assess the variability between runs of the same configuration.

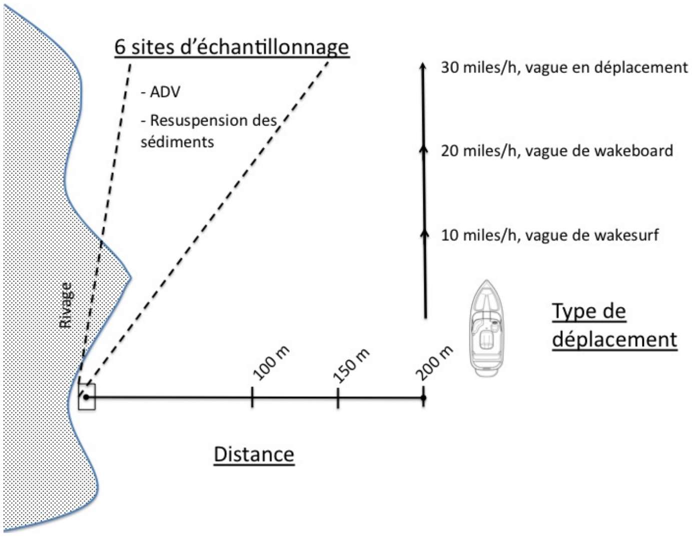


Figure 1. Sampling Plan for the measurement of three different types of displacements and the three distances from shore and six sampling sites.

Types of wake boat movements:

Moving a boat creates different types of waves. In this research, three types of waves have been studied: wake surf waves, wakeboard waves and wake boat waves traveling on the lake. Wake surf waves are created filling one side of the boat's ballast tanks and traveling at a fairly low speed (10 miles/h; 16.1 km/h). For wakeboard waves, both ballasts tanks are filled and the boat is moving at a speed of 20 miles/h (32.2 km / h). When the wake boat moves from one place to another, the average travel speed is 30 miles / hour (48.3 km / h), but it moves, at this time, with empty ballast tanks. The sampling plan was developed to measure the amount of energy that reaches the shore and resuspension of sediment from the bank, according to the three different types of travel (wake surf waves, wakeboarding waves and waves on the move), three distances from shore and six sampling sites (3 per lake Annex 1).

Choice and site characterization - type shore

The choice of sites was to get different types of coastal slope in order to confirm whether the arrival of energy and resuspension of sediments are influenced by the slope of a bank (Sorensen 1997). We sampled Lake Lovering, Lake Memphremagog, and three different sites on each lake (Annex 1) in order to obtain a representative slope gradient of the lakes in the region. Sampling was carried out on 4, 5 and 6 August 2013, between 8 am and 20h.
For each of the sampled sites, shore slope was calculated from maps bathymetric based on the distance between the shore and place into the lake where the water reached a depth of 3.05 m (10 feet units of the bathymetric map).

Slope (m) = 3.05 m / m measured distance

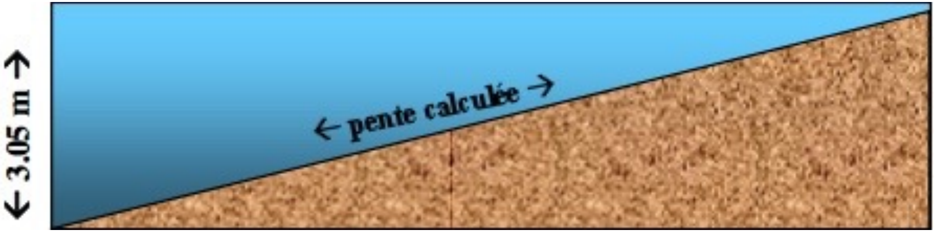
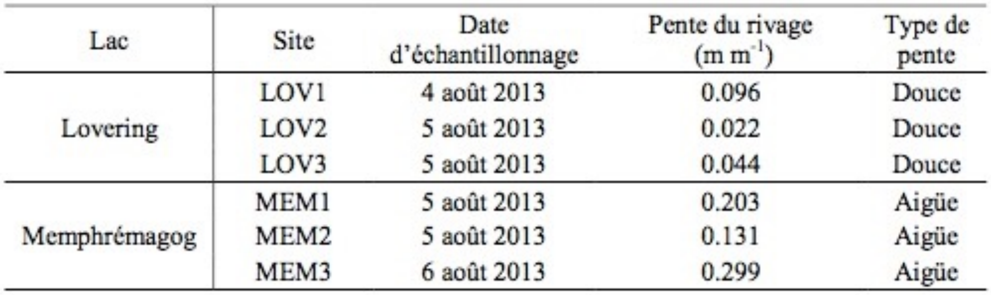


Figure 2. Illustration of the calculation of the slopes of sampling sites coastline

Once the calculated slopes (Table 1), the six sites were separated by acute slope sites (≥0.1 mm^{-1}) Or soft (<0.1 mm^{-1}).

Table 1. Characteristics of the Sampled Sites.



Lac	Site	Date d'échantillonnage	Pente du rivage ($m\ m^{-1}$)	Type de pente
Lovering	LOV1	4 août 2013	0.096	Douce
	LOV2	5 août 2013	0.022	Douce
	LOV3	5 août 2013	0.044	Douce
Memphrémagog	MEM1	5 août 2013	0.203	Aigüe
	MEM2	5 août 2013	0.131	Aigüe
	MEM3	6 août 2013	0.299	Aigüe

Sampling

Sediment resuspension

To measure the sediment resuspension, a water sample was taken before (A) and after (B) of each time a vessel passage occurred at each sampling site. The restoration suspension is the difference in the amounts of suspended sediments measured between both samples (B - A). The base concentration of each site was determined as the first sample taken at that site.

Turbulent kinetic energy

The energy provided by the wave wake boats was measured using a micro-ADV (Acoustic Doppler Velocimeter), which measures the water velocity in the three dimensions and at high frequency (25 times / second; Figure 3).

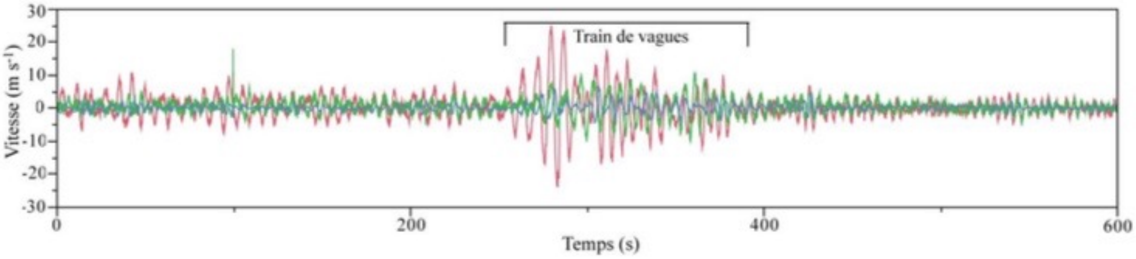


Figure 3. Example representing the speed (ms^{-1}) Dimensions x (red), y (green) and z (blue) measures a period of normal waves, and during the passage of the boat wave (wave train).

The turbulent kinetic energy (TKE "turbulent kinetic energy") contained in a wave (Created by a boat or otherwise) can be calculated by knowing the speed dimension as it passes, according to the equation:

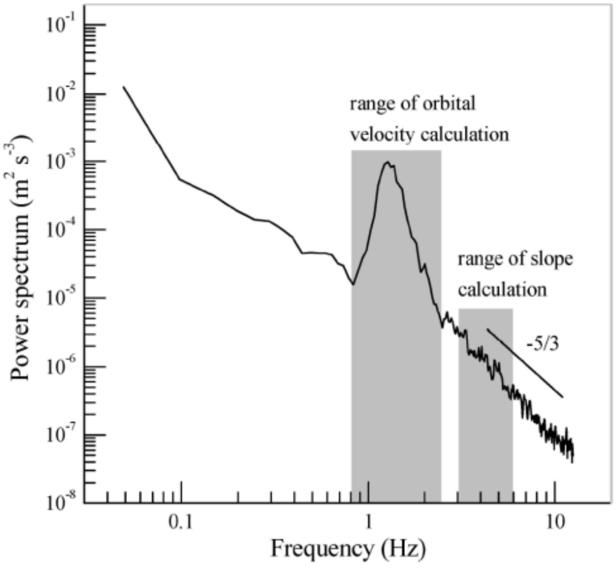
$$TKE = \frac{1}{2}\left(\overline{x^2} + \overline{y^2} + \overline{z^2}\right),$$

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

This type of measurement to estimate the rate of dissipation of energy ("energy dissipation spleen ", ε), which is also a measure of power generation when the system is in equilibrium. These three-dimensional velocity measurements are then decomposed into a power spectrum (Figure 4), the Kolmogorov's theory (1941) provides for the features 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 frequency *f* (Hz), *u*rms can be regarded as the velocity advective average (cm / s) C_f is a constant, and *ε* is the rate of energy dissipation ($m^2 s^{-3}$). One can find the details of this methodology Vachon Meadow & Cole (2010).



(From Vachon, Prairie and Cole, 2010)

Figure 4. Example of power spectrum for the calculation of the energy dissipation

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

Assessment of normal

The impacts on the banks under normal conditions, that is to say without passing boat, were valued using the same device used for energy measurements caused by the passage of wake boats. These data were used to assess the natural impact of waves generated by wind for each site.

Laboratory Analysis

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

Statistical analysis

The protocol BACI (Before-After-Control-Impact) was used as experimental design for statistical analysis (Stewart-Oaten, Murdoch and Parker 1986). This type of sampling compares a site before and after a disturbance, for different types of situations. Here we have compared the difference between the measurements during the passage of waves created by a wake boat, and those in normal conditions for each type of displacements, each distance to shore and at each sampling site. Analyses of variance (ANOVA), comparison medium (t-test) and linear regressions were performed using the JMP software to analyze data.

Study limitations

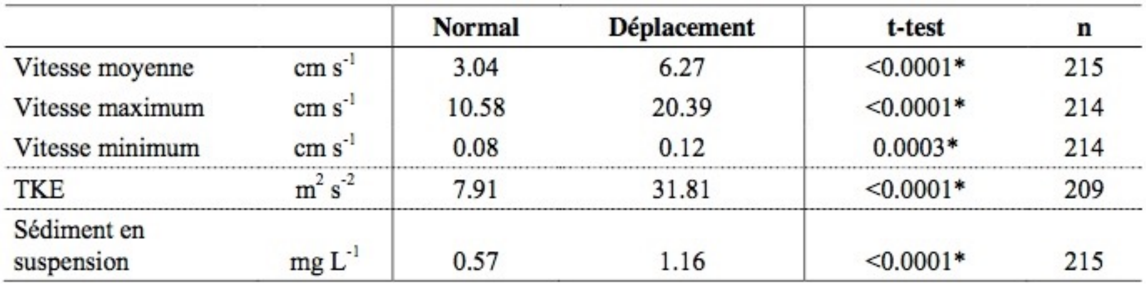
As part of this study, only two lakes were sampled (Memphremagog Lovering) at three sites each. Thus, certain characteristics of lakes in the region are therefore probably not represented in the sampling plan. In addition, three trips by the wake boat, and the typical type of mode that is used in the sampling plan (Wakeboard, wake surf, traveling). In reality, energy experienced by the bank is probably much more varied, because different types of passage, at varying speeds, follow in time. Moreover, in the case of measuring sediment resuspension, results showed smaller amounts of sediment than what we expected and were located very close to the detection limit of the method used. They are not as accurate as desired and should therefore be considered very conservative.

RESULTS AND DISCUSSION

In this study, we analyzed the changes in energy (TKE) and restoration suspension of sediments caused by the waves of wake boats upon arrival to shore, varying the type of movement of wake boats, distance from the shore at which it is located, and the slope of these shores. This section opens with the overall results, that is to say, the results of all types of passage, all distances from shore and all the slopes of the shore, and the six sites combined (ie three to Lovering Lake and the three Lake Memphremagog). In the following, the sections are then presented in the results of the type of wake boat movements (wake surf, wakeboard and away) and thus the type of waves, depending on the distance to shore (100m, 150m, 200m) and following the slopes of coastline. A section also discusses some characteristics of different types of waves produced.

Table 2 shows the average values obtained during the sampling of the two lakes. The results show that the waves created by the wake boat causes increased and significant (on average, 4 times higher) amount of energy (TKE) that reached the shore, compared to normal (ie without passing boat). This general result applies to all types of passage, any distance from shore and all slopes on the combined banks.

Table 2. Comparison of the results in normal conditions and during the passage of a wake boat: speeds (average, maximum, minimum); turbulent kinetic energy (TKE), horizontal energy (ε_x) and vertical (ε_z); suspended sediment.



		Normal	Déplacement	t-test	n
Vitesse moyenne	cm s^{-1}	3.04	6.27	<0.0001*	215
Vitesse maximum	cm s^{-1}	10.58	20.39	<0.0001*	214
Vitesse minimum	cm s^{-1}	0.08	0.12	0.0003*	214
TKE	$m^2 s^{-2}$	7.91	31.81	<0.0001*	209
Sédiment en suspension	mg L^{-1}	0.57	1.16	<0.0001*	215

Note: We considered differences to be significant at $p < 0.05$

Similarly, the passage of a wake boat creates waves carrying a considerable amount of energy that directly induces resuspension of sediments statistically significant in average 2-fold higher than in normal conditions (Table 2), for all types of moving, all distances, and all slopes.

Turbulent kinetic energy (TKE)

Figure 5 shows the results of TKE according to the distance between the passage of the vessel and the shore (100m, 150m, 200m) and the type of transition, or TKE measures for all types of combined passage (Figure 5a), those for the wake surf (10 miles/h, Figure 5b), those for the wakeboard (20 miles/h; Figure 5c) and those for the boat trip (30miles/h; Figure 5d).

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

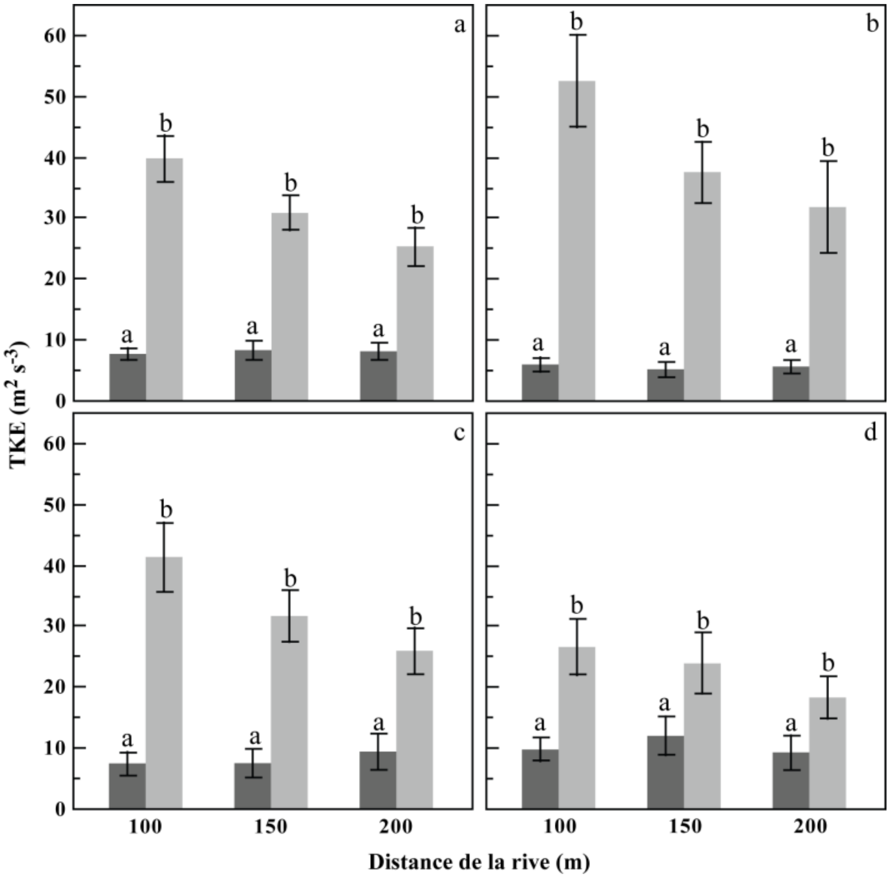


Figure 5. Energy (TKE) present in normal waves (dark gray) and that present in the waves following the passage of a wake boat 100, 150 and 200m from the shore, and the type of transition from boat (a: for all types of passage; b: 10 miles/h; c: 20 miles/h; d: 30miles/h).

Having thus established that all 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 wake boat or the difference between the energy in normal conditions and that measured during the passage of wake boat (TKE wave - normal TKE).

Two types of results are presented here. On the one hand, the additional energy induced is presented following the use made of the boat (wake surf, wakeboarding, traveling), so as speed (10, 20 or 30 miles/h), and depending on the distance of the boat in relation to the bank (a: 100m; b: 150m; c: 200m).

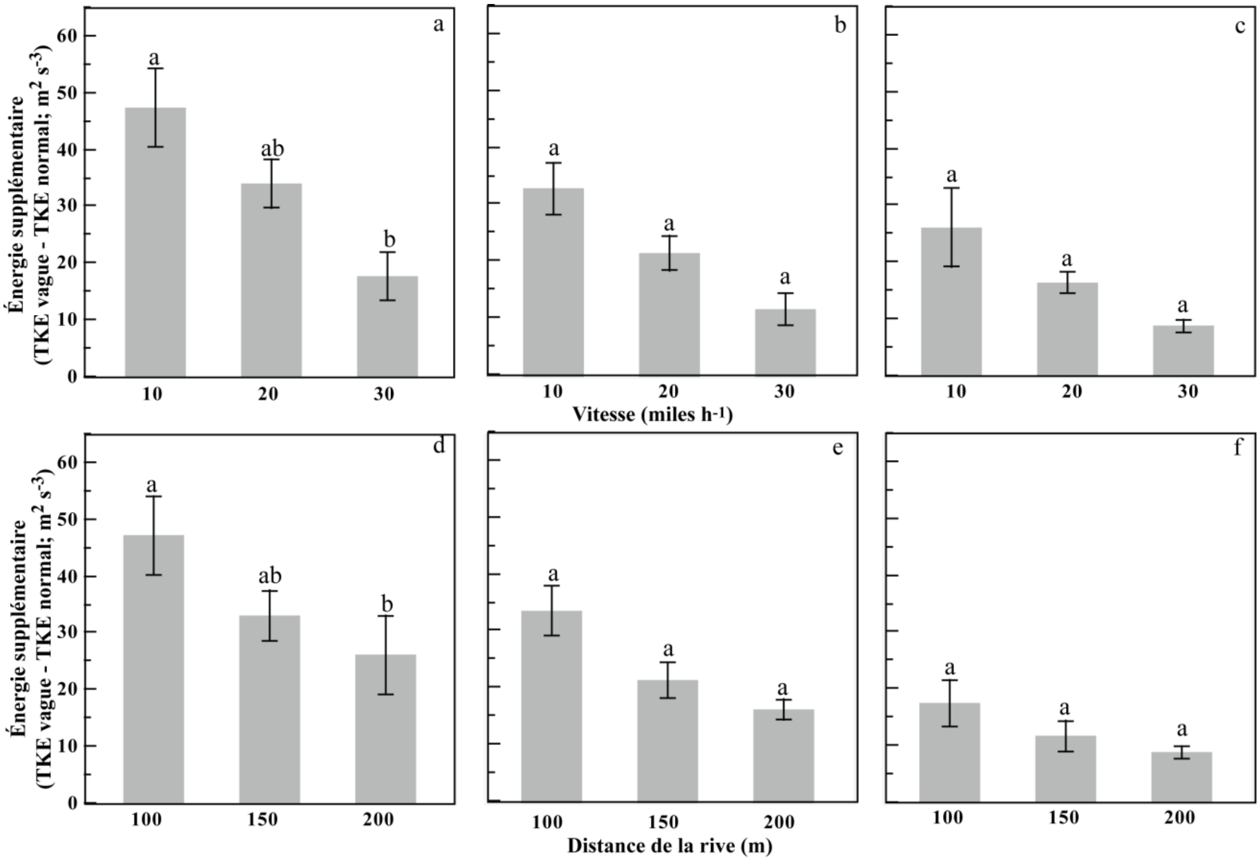


Figure 6. The additional energy induced by the passage of a wake boat (TKE wave - TKE normal) according to the type of passage (10, 20 and 30 miles/h) and the distance to shore (a: 100 m; b:150 m; c: 200m) that is induced depending on the distance to shore (100, 150 and 200m) and the type of passage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

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

This first series of chart compares the effect of different uses of the boat for the same distance from the shore: for example, the impact of the practice of wake surf (10 miles/h) to 100m from the shore (Figure 6a) is much larger than the boat travel (30 miles/h). In fact, the energy created by the wake surf is 1.7 times higher than that produced by the boat movement, despite its speed of 30 miles/hr. In the case of other distances to the shore (Figure b and c), the differences are not significant, although it sees a trend between the distance of 300m and that of 100m.

The second series of graphs in Figure 6 is used to invert the analysis, that is to say compare the amount of additional energy induced depending on the distance to shore (100, 150 and 200m) and on the use of the boat, and therefore according to the speed (d: 10 miles/h; e: 20 miles/h f: 30 miles/h).

This second series of graphs shows that the extra energy induced when the boat passes 100m from the shore is 2 times higher than that induced by a passage 200m. This difference depending on the distance from the shore is significant only in the case of wake surf waves (Figure 6d), although such a trend is observable in wakeboard waves moving (Figure 6e and f).

Sediment Resuspension

Figure 7 shows the amounts of suspended sediment for each distance between the passage of the boat and the shore (100m, 150m, 200m); Figure 7a shows the results for all types combined passage, Figure 7b, those for wake surf waves, Figure 7c, those for wakeboarding waves and Figure 7d, the results for waves traveling.

It is noted in Figure 7, that, in general, the passage of a boat creates a resuspension of sediment significantly higher than that in normal conditions: in the case of the wake surf wave (10 miles/h; Figure 7b) and waves that travel (30 miles/h, Figure 7d), when the boats run 100m or 150m from shore. When the boat passes 200m, there is no more significant changes in the sediment resuspension. These results are contrary to the passages in wakeboard mode (20 miles/h, Figure 7c), where a significant resuspension is shown at 200m, but not at 100m or 150m.

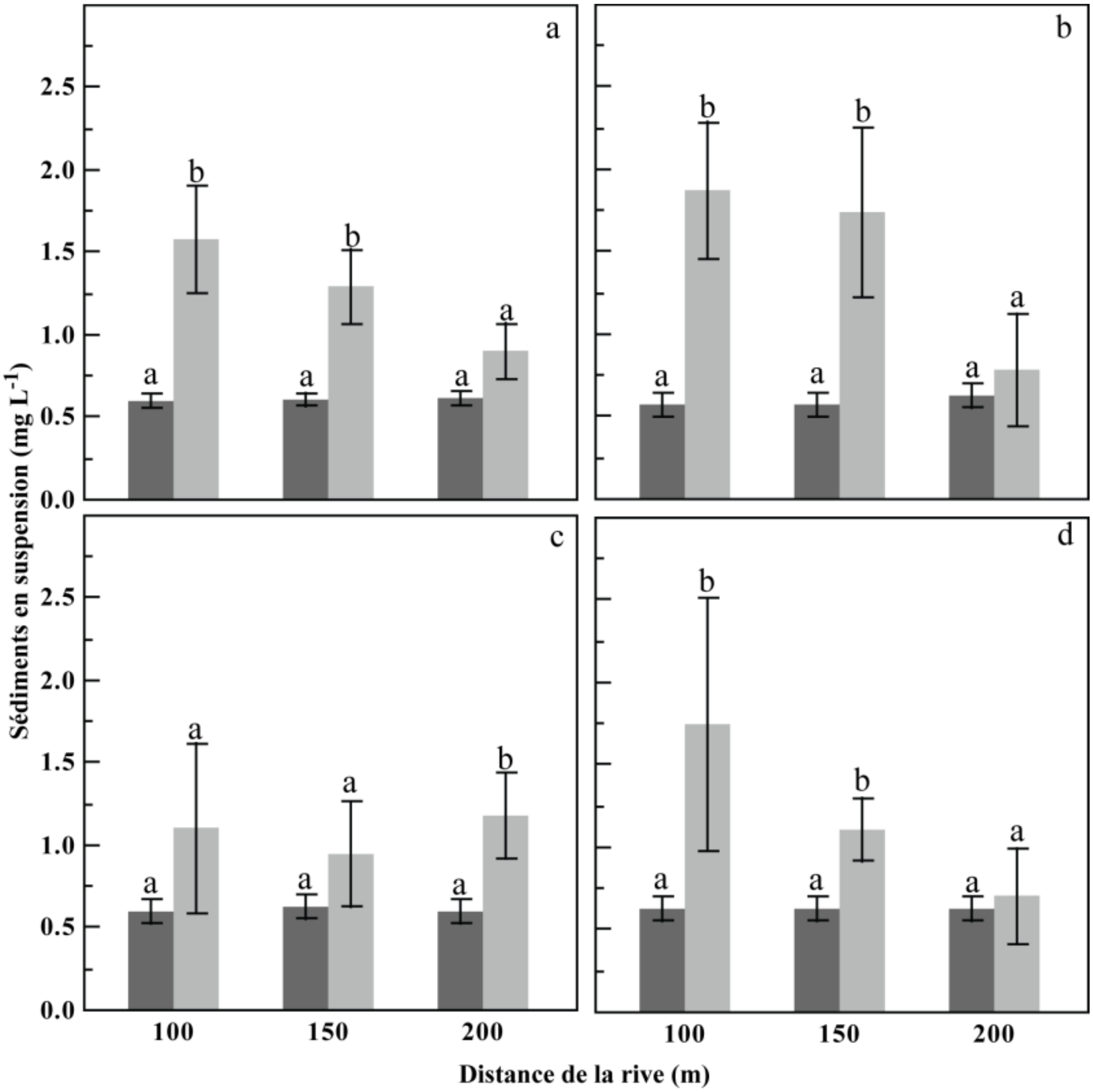


Figure 7. The re-suspension of sediments caused by normal waves (dark gray) and caused by the waves following the passage of a wake boat 100, 150 and 200m depending on the type of transition (A: all kinds of passage; b: 10 miles/h; c: 20 miles/h; d: 30 miles/h).

Note: The same letters above the columns mean that there is no significant difference in effects, between normal conditions and those induced by a wake boat wave pass.

Figure 8 (next page) shows the amounts of sediments suspended in two results shapes. The first set of graphs shows the results for each type of displacement (wake boat: 10 miles/h; wakeboarding: 20 miles/h; traveling 30 miles/h) for a distance of 100m (Figure 8a), a distance of 150m (Figure 8b) and a distance of 200m (Figure 8c). The second series presents the results according to transition away from the shore (100m, 150m and 200m) by type of use of the boat or the wake surf (10 miles/h; Figure 8d), the wakeboard (20miles/h; Figure 8d) and travel (30 miles/h; Figure 8f).

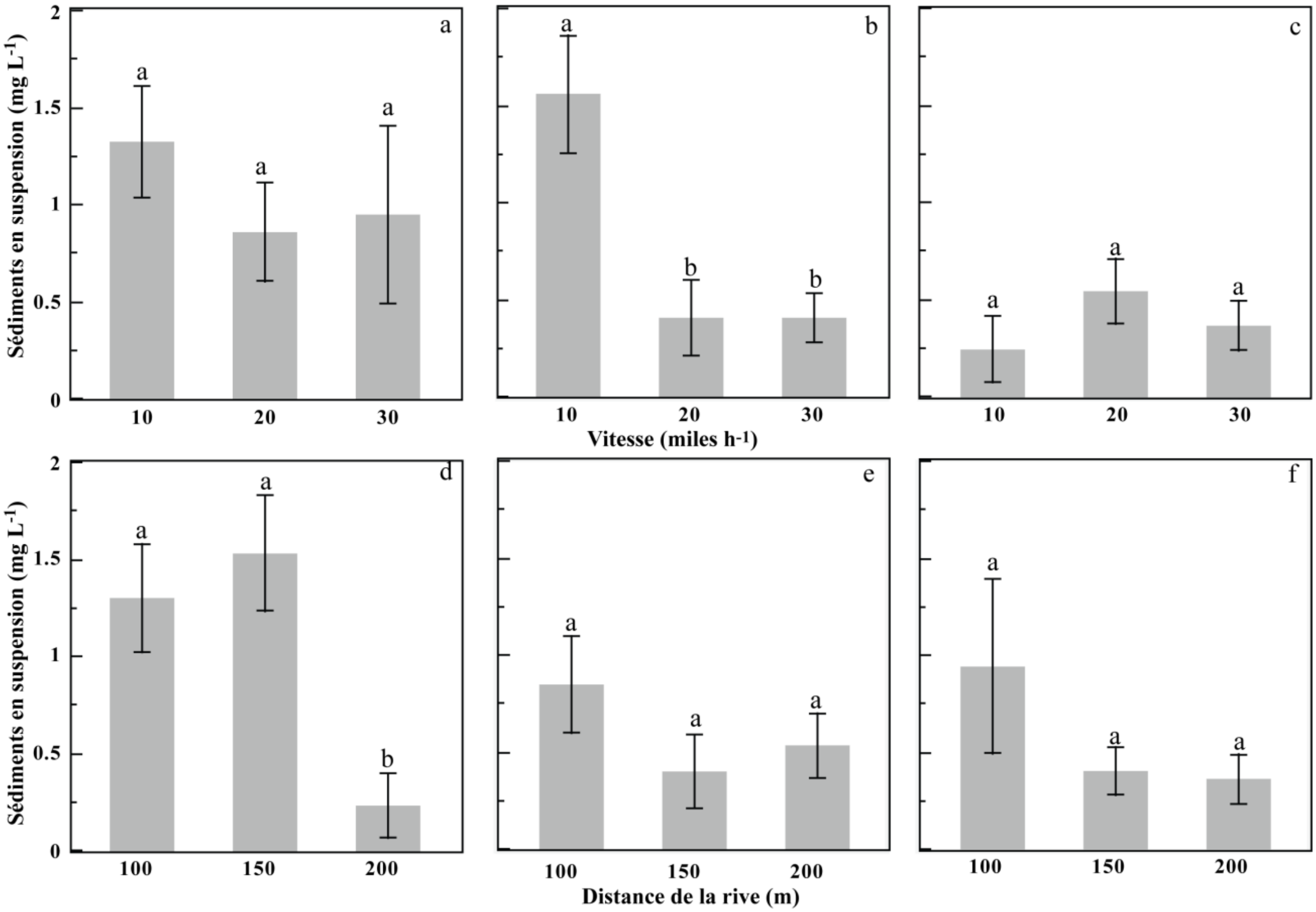


Figure 8. The resuspension of sediments induced depending on the passage (10, 20 and 30 miles/h) and following the pass distance (a: 100 m; B: 150 m; c: 200m) and that induced by distance from the shore (100, 150 and 200 m) and to the type of passage (d: 10 miles/h E: 20 miles/h; f: 30 miles/h).

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

The first set of graphs which compares the effects of resuspension between types displacement, shows that only wake surf waves (10 miles / hr) created at a distance of 150m from the shore (Figure 8b) produces a significantly higher resuspension than the other two types of movement. In the second series of graphs, Figure 8d shows that wake surf waves create a resuspension of sediment at 100 and 150m from the bank, compared to the distance of 200m. The few significant differences among the results, despite apparently different mean values, is due to the high variability of the data, probably due to lack of sensitivity suspended sediment measurements.

Distance from the bank
As can be expected, the amount of energy that reaches the shore decreases when distance is increased by each wake boat passage. Our protocol does not allow us to accurately measure distance from the shore where no energy change is visible on arrival at the shore. However, based on data collected for all types of travel, if there is a linear distance observed between the studied and the effects measured on shore (TKE, Fitness suspension of sediments), it is possible to roughly gauge the distance. The Figure 9 shows the results of these calculations for each measured effect.

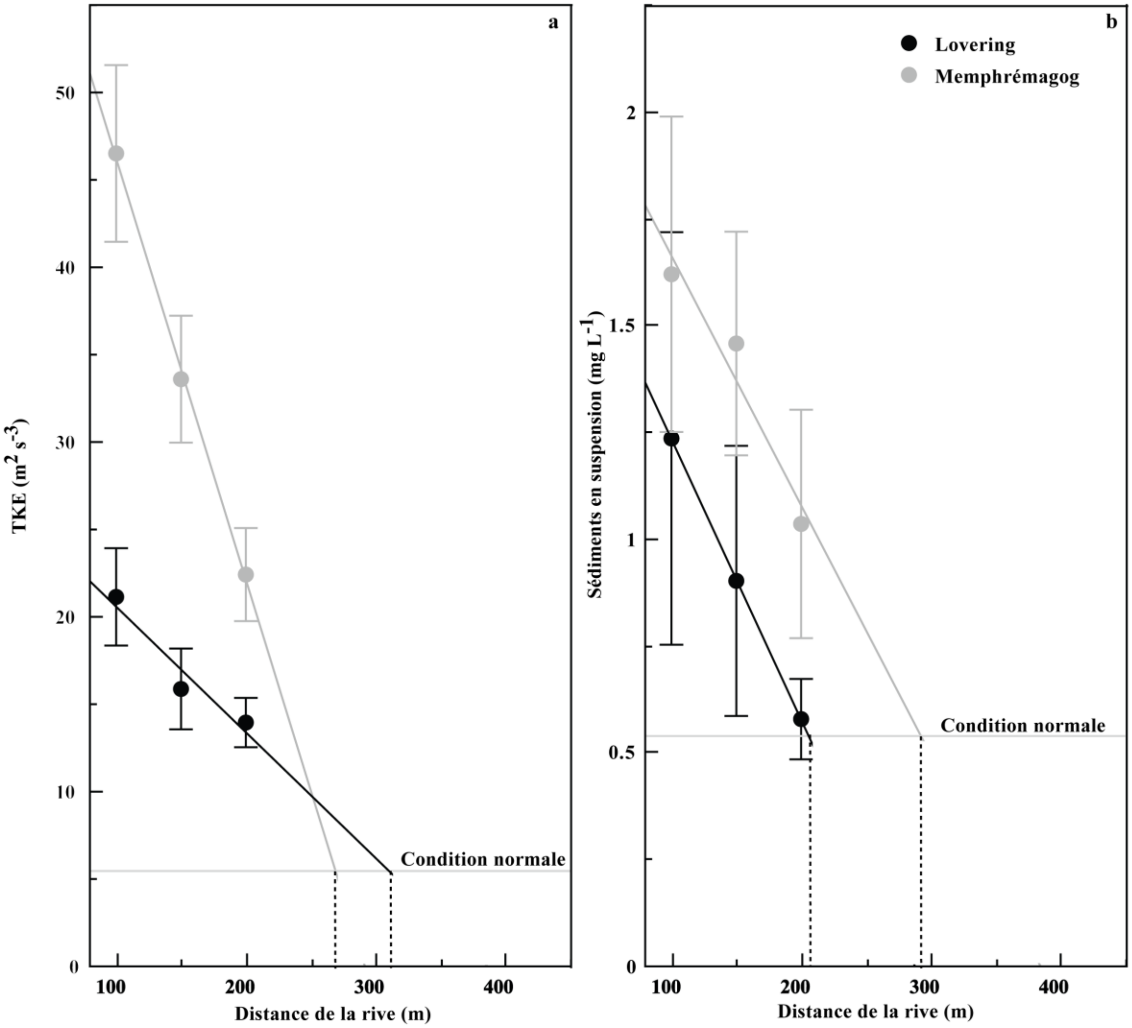


Figure 9. Linear Regression: a)energy (TKE); and, b) suspended sediment, depending on the distance from the shore to the lake Lovering (light gray) and Memphremagog (black).

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

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

We first assessed the passing away of wake boats at which the impact of the wave on the shore is equivalent to normal or 5.5 m^2/s^2 for TKE and 0.57mg/L for suspended sediments. In normal values, and TKE suspended sediments, are represented by a gray horizontal line. On the basis of data of energy (TKE; Figure 9a), travel distances equivalent to the conditions normal is 268m from the shore to Lake Memphremagog and 312m from the shore of Lake Lovering. In the case of suspended sediment (Figure 9b), the distances are estimated 286m (Memphremagog) and 206m (Lovering).

According to our calculations, the distance at which wake boats have similar effects to those in normal conditions is approximately average for the two lakes, 300m from the shore in terms of energy, and 250m from the shore to which is suspended sediment. According to these results, we assume that 300m represents a reasonable distance beyond that the waves generated by wake boats would largely dissipate before their arrival on the banks, and therefore have a negligible effect. On this basis, and if the objective is to eliminate impact on the shoreline that could cause the passages of wake boat we transposed these results on a map for each lake (Memphremagog: 10a; Lovering: Figure 10b), to represent the inland area (dark gray) for wake boats, in the case of legislation restricting their use at a distance of 300m from the shore of lakes.

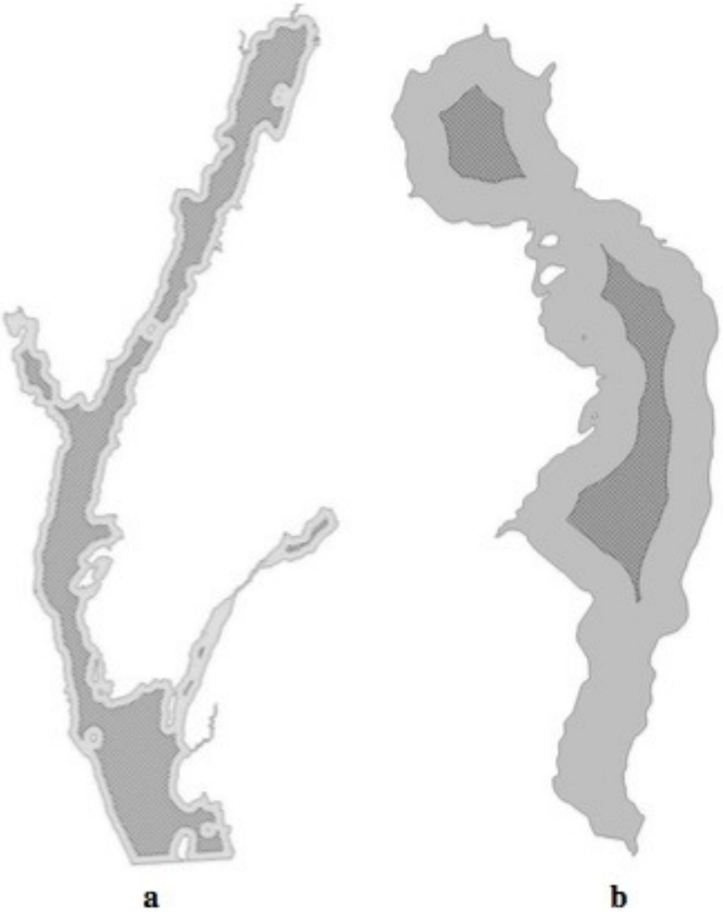


Figure 10. Map of the inland area by wake boats (dark gray) following regulations limiting their activity to more than 300 m from the shore of Lake Memphremagog (a) and Lovering (b).

Impact of the coastal slope of the energy reaching the shore

According to the literature, it is expected that the level of energy that reaches the shore is a function of the slope of the coast. We wanted to test this hypothesis by linking the slopes of the coastline to each site, and measure energy (TKE) under normal conditions and when passing using a wake boat under all types of travel and across all distances.

Our results show that, under normal conditions, the level of energy that happens to a bank with a steep slope (acute: ≥ 0.1 m m^{-1}) is not significantly different from the waves that arrives at the shore with low slope (soft: <0.1 m m^{-1}). That's what this Figure 11a, where we find the energy (TKE) values in normal conditions and with a gentle slope (light gray) vs. an acute slope (dark gray).

When increased energy from the wave that reaches the bank (with the passage of a wake boat), the acute slopes receive a significantly higher energy (Figure 11b). Indeed, when the slope of the coast is acute, the wave meets the bottom coastal area slower and so the wave energy dissipates more slowly. The energy that reaches the shore is then much higher, leading to a greater impact on the resuspension of sediments and possibly on the bank erosion.

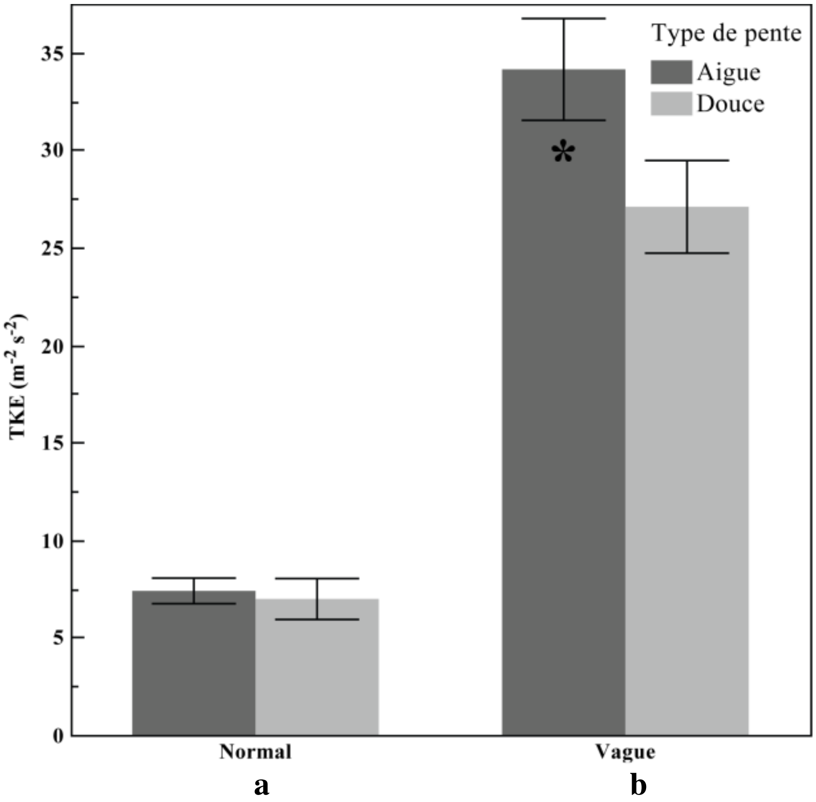


Figure 11. Energy (TKE) that reached the shore between sites with sloping coastline of acute (dark gray), coastal slope (pale gray), for normal waves (a) and that from a wake boat (b).

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

We took over the coastal slope and TKE data to relate them in a regression analysis (next page: Figure 12), under normal conditions (Figure 12a), and when passing a wake boat (Figure 12b). As seen, under normal conditions (Figure 12a), there is little difference between the energy that arrives on a coastline of gentle slope (1st point below, in Figure 12a) and the energy that arrives on a coastline of acute slope (last point, high even figure). With the large amount of energy in the waves caused by the passage of a wake boat (Figure 12b), the impact of the coastal slope is much more important. The effect of waves generated by the wake boat on energy (TKE), to the site that has the coastline with the slope most acute (last point above, Figure 12b) is much larger than for the site that the coastline with the lower slope (1st spot, down even figure).

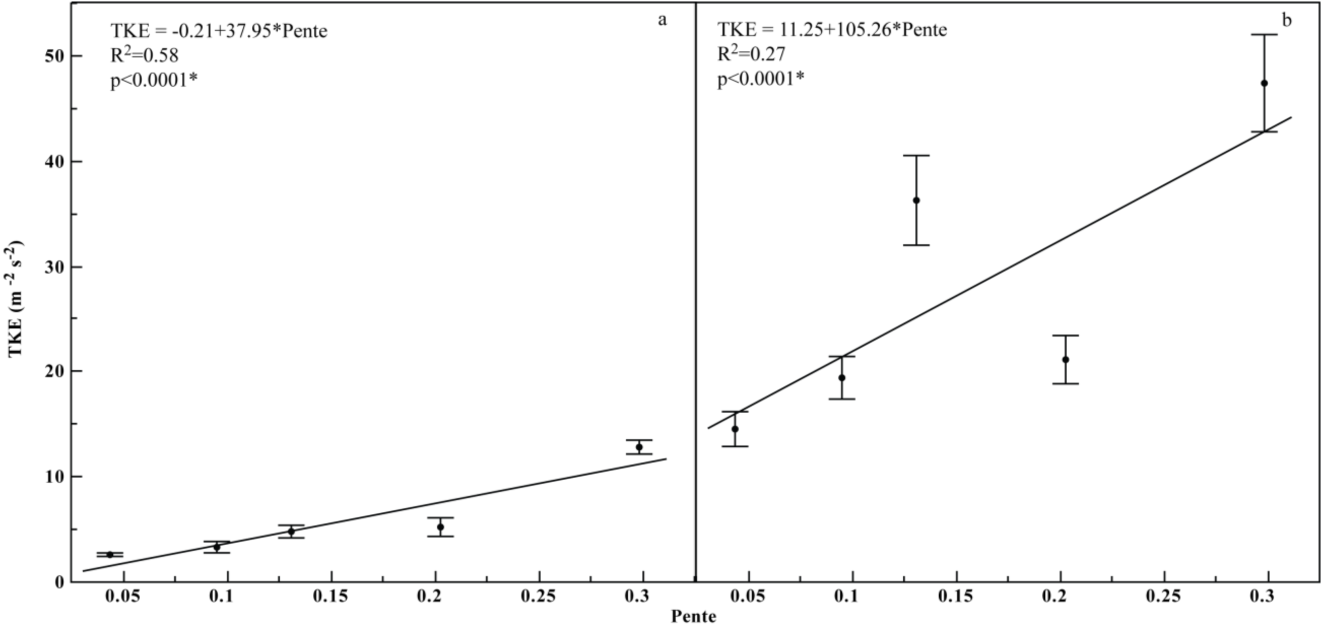


Figure 12. Linear regression between energy (TKE), and the coastal slope: a) normal conditions and b) during the passage of a wave train from a wake boat for 5 sampling sites.

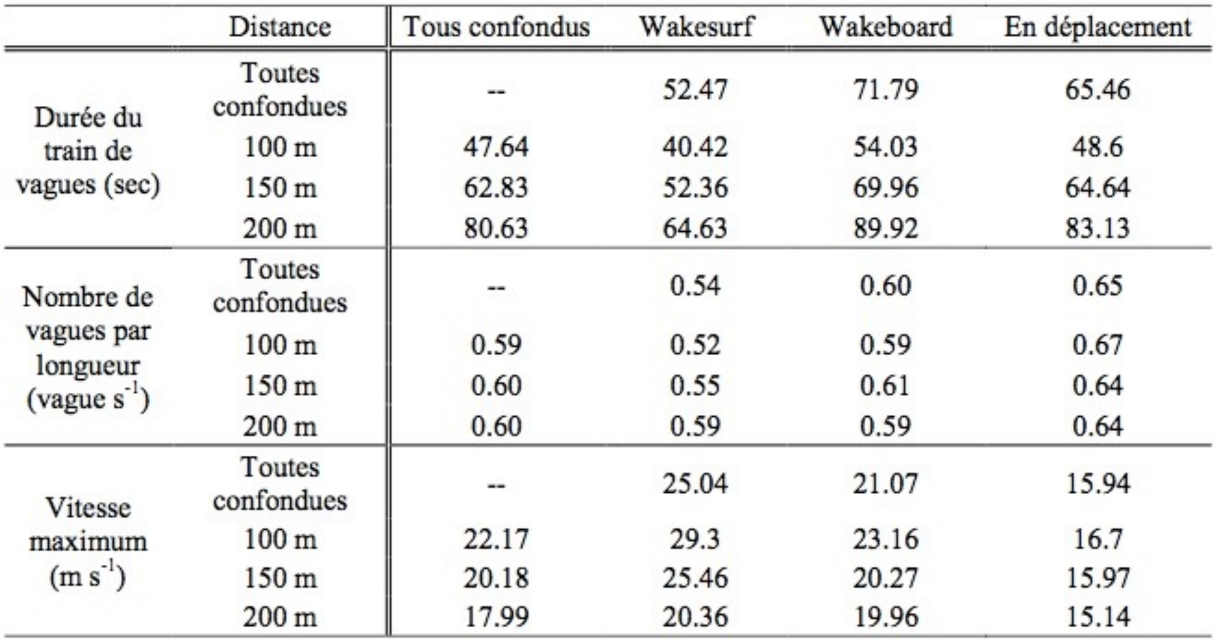
Note : The site LOV2 shoreline slope was eliminated because its very low slope and on a very large length eliminated trends here.

Features waves

In addition to the above information, we characterized the waves and waves of trains, to assess the impact on the banks. According to our results, the train of very short and intense waves created by wake surf is one that has the most impact when it reaches the shore because it contains much more energy (Figures 5 and 6). Indeed, despite an average wave train shorter (52.5 s) and number of waves per second lowest (0.54 s wave $^{-1}$). The speeds maximum damage by waves are the highest (25.0 ms $^{-1}$). Causing a significant suspension of sediment 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 train wakeboard waves is itself much longer in duration (71.8 s) but, despite a sizeable increase in energy (Figure 5) and maximum speed (21.1 ms^{-1}), We have not been able to detect a significant resuspension sediment. The wave train would become too large to have a major impact on sediment.

Table 3. Average duration of the wave train (sec), number of waves per length wave trains and the maximum speed (ms^{-1}) according to the different distances from the edge (100, 150, 200m), and the type of wake boat movement.



	Distance	Tous confondus	Wakesurf	Wakeboard	En déplacement
Durée du train de vagues (sec)	Toutes confondues	--	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
Nombre de vagues par longueur (vague s^{-1})	Toutes confondues	--	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
Vitesse maximum ($m\ s^{-1}$)	Toutes confondues	--	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

Moving wave train at an intermediate period (65.5 s); contains less energy and has a lower maximum speed (15.9 ms^{-1}) than the other two types of trains waves, but it has nevertheless a considerable impact on the bank (Table 3 and 7 and 8). This trend for all three types of waves is the same as the distance from the shore (Table 3). Thus, the number of waves per length of wave train is not based on the distance from the shore ($P > 0.05$). Instead, it is the wake surf waves stream that contains significantly less waves, regardless of the distance from the shore ($p < 0.0001$ * for all three distances all distances considered: Table 3).

The power of a wave train is strongly influenced by the intensity that each of one of the wave components generate and its ability to accumulate.

CONCLUSION

Following this experimental study, it is possible to establish that the type of boat waves that wake boat generates cause considerable impact on the shore as it passes from 100m to the shore, and all passages within 300m significantly add energy to the waves naturally present (Figure 9). In addition, the waves created by a wake boat to make wake surf (1 side ballast tanks filled) are those that have the greatest impact on their arrival at the bank, given the large amount of energy contained in their short wave train, which contains little waves. Given their being much longer waves and containing more waves, wakeboard waves (2 sides filled ballasts) and moving the wake boat (Empty ballasts) have a less severe impact on the shore because the energy is distributed throughout the length of the wave train. Still, we must remember that all boat passages observed in this study carry a significantly greater amount of energy to the shore than in normal conditions.

The energy present in the train of waves created by wake boats causes a resuspension of sediments and probably accelerates bank erosion.

The findings of this research is to eliminate any additional impact on the shore caused by passages of wake boats, and we suggest that the regulation limits passage of such vessels on the lakes wake boats could travel of at least 300m from the banks in order prevent erosion (Figure 9). Inland areas illustrated by the maps in Figure 10 have been established on the basis of this distance of 300m from the banks for the two lakes in the study (Memphremagog: 10a; Lovering: Figure 10b).

REFERENCES

EnvironmentalSciencesSection. 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-Ressources Investigations 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. Environ. rev., vol. 1, p. 121–144.

Kolmogorov, AN. 1941. The local structure of turbulence in incompressible viscous fluid for very large Reynolds numbers. Dokl. Akad. Nauk SSSR, vol. 30, p. 299–303.

MRCMemphrémagog. 2011. Carte de la réglementation nautique au lac Lovering. Gouvernement du Québec. Récupéré le 18 décembre 2013 de http://www.mrcmemphremagog.com/pdf/Patrouille%20nautique/Cartes/Carte%20Lovering-FR.pdf

MRCMemphrémagog. 2013. Carte de la réglementation nautique au lac Memphrémagog. Gouvernement du Québec. Récupéré le 18 décembre 2013 de http://www.mrcmemphremagog.com/pdf/Patrouille%20nautique/Cartes/Carte%20Memph-FR.pdf.

Péloquin-guay, M. 2013. Évaluation de l'effet des vagues de bateau sur les conditions hydrauliques près des berges en milieu fluvial. Université de Montréal.

Sorensen, RM. 1997. Prediction of vessel-generated waves with reference to vessels common to the upper mississippi river system. apport technique, 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.

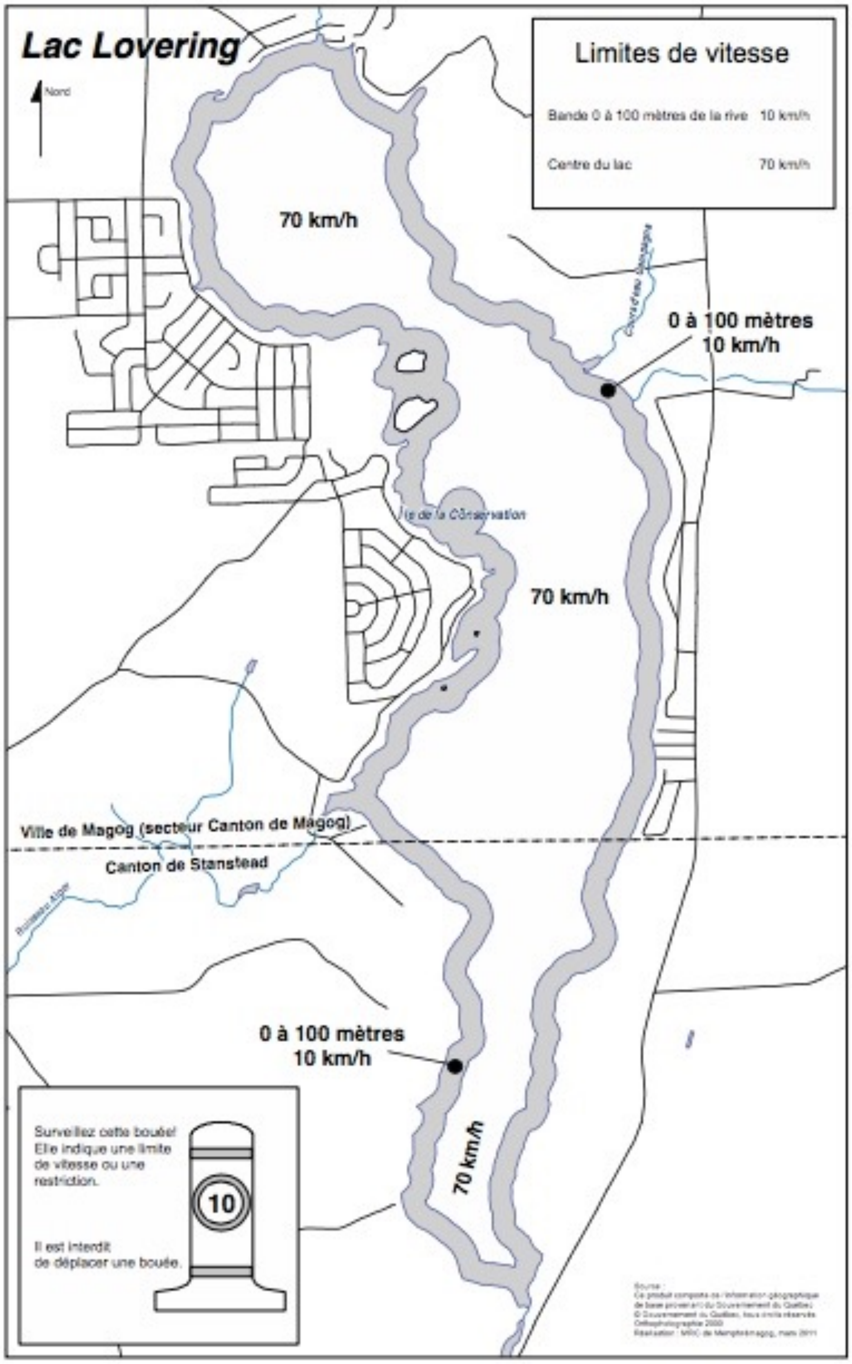
Vachon, D, Prairie, YT and Cole, JJ. 2010. The relationship between near-surface turbulence and gas transfer velocity in freshwater systems and its implications for floating chamber measurements of gas exchange. Limnology and oceanography, vol. 55, no 4, p. 1723–1732.

Wist, HT. 2004. Statistical properties of successive ocean wave parameters. Faculty of engineering sicence and technology, Norvegian university of science and technology.

ANNEXES

Annexe 1. Sites d'échantillonnage dans le lac Lovering et dans le lac Memphrémagog

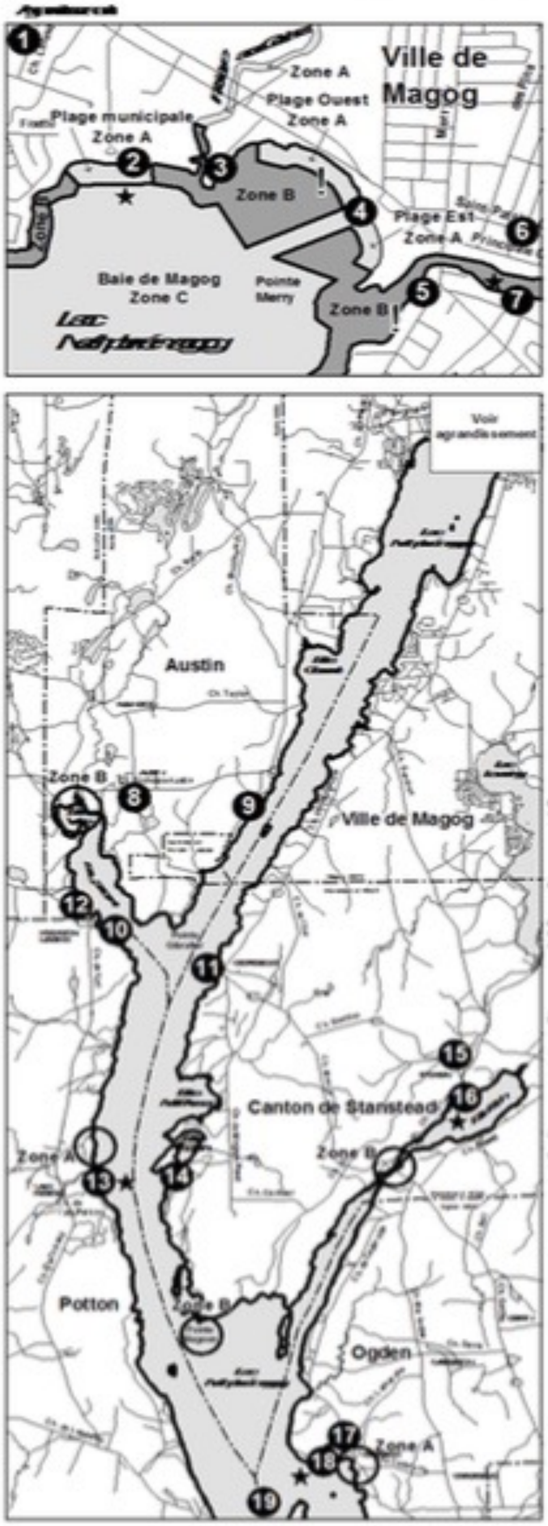
Annexe 2. Carte de la réglementation nautique du lac Lovering



(MRC Memphrémagog 2011)

Annexe 3. Cartes de la réglementation nautique du lac Memphrémagog

Réglementation au lac Memphrémagog



Annexe 3. Tableaux des données brutes des paramètres physiques

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 (m^2 s^{-2})	Epsilon z (m^2 s^{-3})	Nombre de vagues par train	Durée du train de vague (sec)	Nombre/ Longueur (vague s^{-1})
4/8/2013	Lovering	LOV1	Normal	10	100	2,41	21,52	0,04	4,38	3,8E-08			
4/8/2013	Lovering	LOV1	Vague	10	100	6,49	25,81	0,10	33,07	2,2E-07	29,46	62,20	0,47
4/8/2013	Lovering	LOV1	Normal	10	150	1,13	17,33	0,02	0,96	2,2E-08			
4/8/2013	Lovering	LOV1	Vague	10	150	6,02	25,32	0,05	29,52	1,4E-07	43,69	78,88	0,55
4/8/2013	Lovering	LOV1	Normal	10	150	1,23	4,82	0,03	1,12	6,7E-08			
4/8/2013	Lovering	LOV1	Vague	10	150	5,75	19,65	0,12	23,54	6,7E-08	31,83	67,64	0,47
4/8/2013	Lovering	LOV1	Normal	10	200	2,85	10,21	0,06	5,96	6,0E-08			
4/8/2013	Lovering	LOV1	Vague	10	200	5,46	17,09	0,02	21,06	3,3E-08	29,49	53,04	0,56
4/8/2013	Lovering	LOV1	Vague	10	100	6,82	20,54	0,10	33,45	1,6E-07	25,37	51,80	0,49
4/8/2013	Lovering	LOV1	Normal	10	100	1,89	8,53	0,07	2,54	3,3E-08			
4/8/2013	Lovering	LOV1	Vague	10	200	5,03	14,77	0,13	16,87	1,7E-08	43,11	74,84	0,58
4/8/2013	Lovering	LOV1	Normal	10	200	2,28	7,64	0,12	3,89	1,5E-07			
4/8/2013	Lovering	LOV1	Normal	20	200	1,91	8,52	0,02	3,11	1,5E-07			
4/8/2013	Lovering	LOV1	Vague	20	200	4,99	18,88	0,14	18,53	8,0E-08	51,66	90,40	0,57
4/8/2013	Lovering	LOV1	Normal	20	150	2,09	12,40	0,11	3,37	2,1E-07			
4/8/2013	Lovering	LOV1	Vague	20	150	5,48	17,55	0,02	21,90	1,3E-07	38,01	63,36	0,60
4/8/2013	Lovering	LOV1	Normal	20	200	2,01	8,02	0,04	3,12	2,5E-07			
4/8/2013	Lovering	LOV1	Vague	20	200	4,67	19,31	0,07	16,57	1,1E-07	58,45	96,60	0,61
4/8/2013	Lovering	LOV1	Normal	20	100	2,66	7,05	0,04	4,74	2,5E-07			
4/8/2013	Lovering	LOV1	Vague	20	100	6,30	19,08	0,34	29,20	2,1E-07	27,76	51,28	0,54
4/8/2013	Lovering	LOV1	Normal	20	100	1,58	6,38	0,05	1,81	5,4E-08			
4/8/2013	Lovering	LOV1	Vague	20	100	5,84	20,49	0,04	26,12	1,4E-07	37,14	59,84	0,62
4/8/2013	Lovering	LOV1	Vague	20	150	4,47	17,06	0,11	14,98	1,7E-07	66,39	103,28	0,64
4/8/2013	Lovering	LOV1	Normal	20	150	2,38	12,37	0,06	3,86	1,1E-07			
4/8/2013	Lovering	LOV1	Normal	30	150	1,59	5,03	0,07	1,72	9,9E-08			
4/8/2013	Lovering	LOV1	Vague	30	150	3,17	9,14	0,03	6,92	5,0E-08	53,36	81,52	0,65
4/8/2013	Lovering	LOV1	Vague	30	200	3,83	11,47	0,10	10,25	3,3E-08	26,28	38,32	0,69
4/8/2013	Lovering	LOV1	Normal	30	200	1,26	5,64	0,02	1,10	4,4E-08			
4/8/2013	Lovering	LOV1	Normal	30	100	1,61		0,05	10,50	2,4E-07			
4/8/2013	Lovering	LOV1	Vague	30	100	3,78	13,32	0,01	10,26	5,2E-08	22,27	33,40	0,67
4/8/2013	Lovering	LOV1	Normal	30	150	1,55	5,18	0,04	1,62	9,5E-08			
4/8/2013	Lovering	LOV1	Vague	30	150	3,14	11,06	0,04	7,13	9,9E-08	52,16	79,68	0,65
4/8/2013	Lovering	LOV1	Vague	30	100	5,06	14,41	0,08	18,49	8,7E-08	39,36	59,04	0,67
4/8/2013	Lovering	LOV1	Normal	30	100	1,94	8,15	0,00	2,78	9,3E-08			
4/8/2013	Lovering	LOV1	Vague	30	200	3,70	11,51	0,04	10,04	5,8E-08	67,91	99,04	0,69
4/8/2013	Lovering	LOV1	Normal	30	200	1,54	5,75	0,05	1,68	6,1E-08			
5/8/2013	Lovering	LOV2	Normal	10	200	3,95	16,21	0,15	11,76	9,4E-07			
5/8/2013	Lovering	LOV2	Vague	10	200	6,70	21,41	0,05	34,65	3,5E-07	53,90	89,84	0,60

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 ($m^2\ s^{-2}$)	Epsilon z ($m^2\ s^{-3}$)	Nombre de vagues par train	Durée du train de vague (sec)	Nombre/ Longueur (vague s^{-1})
5/8/2013	Lovering	LOV2	Vague	10	100	10,17	28,68	0,13	79,82	1,5E-06	16,06	36,80	0,44
5/8/2013	Lovering	LOV2	Normal	10	100	3,98	12,77	0,09	11,78	3,1E-07			
5/8/2013	Lovering	LOV2	Normal	10	100	3,44	11,16	0,00	8,91	1,9E-07			
5/8/2013	Lovering	LOV2	Vague	10	100	10,65	30,38	0,30	89,23	1,1E-06	16,93	31,04	0,55
5/8/2013	Lovering	LOV2	Normal	10	150	3,26	10,82	0,07	7,86	2,9E-08			
5/8/2013	Lovering	LOV2	Vague	10	150	8,40	28,02	0,04	51,91	4,8E-07	27,26	49,04	0,56
5/8/2013	Lovering	LOV2	Normal	10	200	3,27	11,53	0,09	8,14	5,9E-08			
5/8/2013	Lovering	LOV2	Vague	10	200	8,20	25,64	0,09	49,81	8,2E-08	24,29	46,56	0,52
5/8/2013	Lovering	LOV2	Vague	10	150	7,71	25,43	0,09	43,57	3,0E-07	25,92	46,44	0,56
5/8/2013	Lovering	LOV2	Normal	10	150	3,72	10,84	0,09	9,76	2,1E-07			
5/8/2013	Lovering	LOV2	Vague	20	150	8,10	28,32	0,10	48,36	2,7E-07	31,67	50,80	0,62
5/8/2013	Lovering	LOV2	Normal	20	150	5,00	15,52	0,10	18,12	1,6E-07			
5/8/2013	Lovering	LOV2	Vague	20	200	7,82	31,55	0,23	47,66	1,9E-07	36,85	64,48	0,57
5/8/2013	Lovering	LOV2	Normal	20	200	6,20	20,47	0,09	29,09	1,3E-07			
5/8/2013	Lovering	LOV2	Vague	20	150	8,32	29,10	0,13	52,70	1,8E-07	24,47	41,12	0,60
5/8/2013	Lovering	LOV2	Normal	20	150	5,09	19,96	0,04	19,49	2,2E-07			
5/8/2013	Lovering	LOV2	Normal	20	200	6,09	19,47	0,04	27,84	1,9E-07			
5/8/2013	Lovering	LOV2	Vague	20	200	7,86	25,67	0,14	46,30	2,1E-07	35,13	58,56	0,60
5/8/2013	Lovering	LOV2	Normal	20	100	4,51	16,30	0,07	15,42	6,7E-08			
5/8/2013	Lovering	LOV2	Vague	20	100	8,07	28,93	0,16	50,20	5,4E-07	31,75	50,92	0,62
5/8/2013	Lovering	LOV2	Normal	20	100	4,76	14,83	0,17	16,29	1,8E-07			
5/8/2013	Lovering	LOV2	Vague	20	100	8,51	30,62	0,25	53,98	4,2E-07	24,60	40,40	0,61
5/8/2013	Lovering	LOV2	Normal	30	100	4,94	14,93	0,19	17,60	1,8E-07			
5/8/2013	Lovering	LOV2	Vague	30	100	7,63	19,41	0,36	39,06	1,0E-07	30,23	34,96	0,86
5/8/2013	Lovering	LOV2	Normal	30	200	5,77	17,92	0,04	23,59	1,1E-07			
5/8/2013	Lovering	LOV2	Vague	30	200	6,98	24,98	0,09	35,83	1,0E-07	48,65	74,32	0,65
5/8/2013	Lovering	LOV2	Normal	30	100	5,36	20,25	0,00	21,36	1,3E-07			
5/8/2013	Lovering	LOV2	Vague	30	100	6,85	18,78	0,13	33,32	9,9E-08	47,36	68,08	0,70
5/8/2013	Lovering	LOV2	Normal	30	150	6,92	21,01	0,09	34,48	1,1E-07			
5/8/2013	Lovering	LOV2	Vague	30	150	8,27	22,49	0,05	48,24	1,2E-07	36,15	56,24	0,64
5/8/2013	Lovering	LOV2	Normal	30	150	6,61	22,47	0,04	31,59	1,8E-07			
5/8/2013	Lovering	LOV2	Vague	30	150	8,65	28,30	0,11	55,08	1,4E-07	41,85	65,32	0,64
5/8/2013	Lovering	LOV2	Normal	30	200	6,61	24,82	0,23	31,69	1,0E-07			
5/8/2013	Lovering	LOV2	Vague	30	200	7,68	23,44	0,08	43,63	2,1E-07	31,60	47,40	0,67
5/8/2013	Lovering	LOV3	Vague	10	100	6,18	18,59	0,08	27,96	3,7E-07	35,70	57,52	0,62
5/8/2013	Lovering	LOV3	Normal	10	100	2,55	6,79	0,13	4,50	4,5E-07			
5/8/2013	Lovering	LOV3	Vague	10	150	4,49	17,16	0,04	16,05	1,8E-07	51,30	82,28	0,62
5/8/2013	Lovering	LOV3	Normal	10	150	1,80	6,23	0,02	2,83	1,4E-07			
5/8/2013	Lovering	LOV3	Vague	10	100	5,87	16,87	0,09	25,17	2,0E-07	34,01	54,56	0,62
5/8/2013	Lovering	LOV3	Normal	10	100	1,96	6,67	0,03	2,80	2,2E-08			
5/8/2013	Lovering	LOV3	Vague	10	200	5,19	17,27	0,08	20,14	1,2E-07	50,02	87,88	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 ($m^2 s^{-2}$)	Epsilon z ($m^2 s^{-3}$)	Nombre de vagues par train	Durée du train de vague (sec)	Nombre/ Longueur (vague s^{-1})
5/8/2013	Lovering	LOV3	Normal	10	200	1,97	6,36	0,05	2,94	2,5E-08			
5/8/2013	Lovering	LOV3	Vague	10	200	4,05	16,29	0,05	13,29	2,0E-07	50,08	91,80	0,55
5/8/2013	Lovering	LOV3	Normal	10	200	1,86	6,30	0,09	2,56	8,7E-08			
5/8/2013	Lovering	LOV3	Normal	10	150	1,94	6,56	0,07	2,84	8,7E-08			
5/8/2013	Lovering	LOV3	Vague	10	150	5,24	18,21	0,02	20,82	2,1E-07	45,76	73,08	0,63
5/8/2013	Lovering	LOV3	Vague	20	150	5,01	14,61	0,15		3,6E-07	52,57	84,32	0,62
5/8/2013	Lovering	LOV3	Normal	20	150	1,87	6,58	0,04		1,0E-07			
5/8/2013	Lovering	LOV3	Normal	20	100	2,13	6,10	0,15	2,94	1,8E-07			
5/8/2013	Lovering	LOV3	Vague	20	100	5,15	17,75	0,18	20,19	7,1E-07	44,88	74,80	0,60
5/8/2013	Lovering	LOV3	Vague	20	200	4,24	15,01	0,03	13,16	1,1E-07	66,14	109,32	0,61
5/8/2013	Lovering	LOV3	Normal	20	200	1,88	24,26	0,03	2,73	3,0E-08			
5/8/2013	Lovering	LOV3	Vague	20	150	4,73	17,76	0,04	17,04	3,7E-07	58,45	96,60	0,61
5/8/2013	Lovering	LOV3	Normal	20	150	1,83	5,88	0,08	2,29	2,0E-07			
5/8/2013	Lovering	LOV3	Normal	20	100	1,65	6,68	0,09	1,97	3,2E-08			
5/8/2013	Lovering	LOV3	Vague	20	100	4,52	17,25	0,11	15,78	4,9E-07	53,12	85,20	0,62
5/8/2013	Lovering	LOV3	Normal	20	200	1,79	5,57	0,09	2,35	2,4E-08			
5/8/2013	Lovering	LOV3	Vague	20	200	4,18	15,79	0,04	13,53	9,3E-08	74,75	116,28	0,64
5/8/2013	Lovering	LOV3	Normal	30	150	1,65	5,10	0,03	1,98	4,9E-08			
5/8/2013	Lovering	LOV3	Vague	30	150	3,29	11,33	0,09	7,81	8,2E-08	75,53	110,16	0,69
5/8/2013	Lovering	LOV3	Normal	30	200	1,69	6,33	0,10	2,08	7,9E-08			
5/8/2013	Lovering	LOV3	Vague	30	200	3,07	9,87	0,08	6,96	2,7E-08	86,92	112,40	0,77
5/8/2013	Lovering	LOV3	Vague	30	150	3,37	10,84	0,04	8,26	6,0E-08	73,45	107,12	0,69
5/8/2013	Lovering	LOV3	Normal	30	150	1,93	5,97	0,03	2,81	4,6E-08			
5/8/2013	Lovering	LOV3	Vague	30	100	2,92	8,40	0,02	5,92	5,7E-08	61,34	84,36	0,73
5/8/2013	Lovering	LOV3	Normal	30	100	1,54	6,73	0,01	1,54	2,5E-08			
5/8/2013	Lovering	LOV3	Vague	30	200	3,01	10,27	0,06	6,33	1,7E-07		135,96	
5/8/2013	Lovering	LOV3	Normal	30	200	1,59	4,88	0,02	1,79	9,2E-08			
5/8/2013	Lovering	LOV3	Vague	30	100	3,17	9,69	0,01	7,37	5,6E-08	73,41	91,76	0,80
5/8/2013	Lovering	LOV3	Normal	30	100	1,60	5,28	0,04	1,90	3,1E-08			
5/8/2013	Memphrémagog	MEM1	Normal	10	200	2,07	5,75	0,06	2,83	4,2E-07			
5/8/2013	Memphrémagog	MEM1	Vague	10	200	5,23	22,64	0,06	24,28	1,5E-07	27,87	54,20	0,51
5/8/2013	Memphrémagog	MEM1	Vague	10	150	4,92	16,36	0,07	19,56	4,4E-08	26,33	46,08	0,57
5/8/2013	Memphrémagog	MEM1	Normal	10	150	1,84	6,37	0,02	2,38	1,9E-07			
5/8/2013	Memphrémagog	MEM1	Vague	10	100	5,39	19,46	0,05	23,74	8,2E-08	19,18	41,76	0,46
5/8/2013	Memphrémagog	MEM1	Normal	10	100	2,24	5,82	0,09	3,52	4,0E-07			
5/8/2013	Memphrémagog	MEM1	Normal	10	150	2,50	8,27	0,06	4,20	6,0E-08			
5/8/2013	Memphrémagog	MEM1	Vague	10	150	6,61	22,79	0,25	37,38	5,3E-07	26,89	52,28	0,51
5/8/2013	Memphrémagog	MEM1	Vague	10	200	3,59	12,91	0,06	10,41	1,8E-08	52,11	95,52	0,55
5/8/2013	Memphrémagog	MEM1	Normal	10	200	1,54	7,29	0,01	1,86	3,6E-08			
5/8/2013	Memphrémagog	MEM1	Vague	10	100	7,04	34,66	0,20	49,27	4,2E-07	17,07	33,60	0,51
5/8/2013	Memphrémagog	MEM1	Normal	10	100	1,78	5,94	0,03	2,20	2,1E-07			

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 ($m^2\ s^{-2}$)	Epsilon z ($m^2\ s^{-3}$)	Nombre de vagues par train	Durée du train de vague (sec)	Nombre/ Longueur (vague s^{-1})
5/8/2013	Memphrémagog	MEM1	Normal	20	150	1,81	4,58	0,02	2,25	1,6E-06			
5/8/2013	Memphrémagog	MEM1	Vague	20	150	5,17	16,32	0,26	18,67	4,2E-07	47,87	80,44	0,60
5/8/2013	Memphrémagog	MEM1	Normal	20	200	2,62	11,22	0,19	5,06	1,5E-07			
5/8/2013	Memphrémagog	MEM1	Vague	20	200	4,38	12,65	0,04	13,16	5,0E-07	75,03	116,72	0,64
5/8/2013	Memphrémagog	MEM1	Vague	20	150	5,03	12,38	0,03	17,54	3,8E-07	39,72	64,00	0,62
5/8/2013	Memphrémagog	MEM1	Normal	20	150	3,18	8,80	0,16	7,03	4,2E-07			
5/8/2013	Memphrémagog	MEM1	Normal	20	200	2,12	14,69	0,04	3,01				
5/8/2013	Memphrémagog	MEM1	Vague	20	200	4,48	14,64	0,11	13,97	4,3E-07	72,79	121,32	0,60
5/8/2013	Memphrémagog	MEM1	Normal	20	100	2,32	6,19	0,12	3,70	1,2E-06			
5/8/2013	Memphrémagog	MEM1	Vague	20	100	6,07	19,55	0,11	27,64	1,3E-06	29,39	51,44	0,57
5/8/2013	Memphrémagog	MEM1	Vague	20	100	5,88	22,33	0,07	28,07	6,2E-07	37,69	65,96	0,57
5/8/2013	Memphrémagog	MEM1	Normal	20	100	1,73	6,66	0,08	2,28	8,9E-07			
5/8/2013	Memphrémagog	MEM1	Normal	30	200	3,00	11,38	0,02	6,73	4,6E-07			
5/8/2013	Memphrémagog	MEM1	Vague	30	200	4,78	12,78	0,07	16,14	7,8E-07	37,68	62,80	0,60
5/8/2013	Memphrémagog	MEM1	Vague	30	100	5,01	13,38	0,25	17,21	1,3E-06	22,22	44,44	0,50
5/8/2013	Memphrémagog	MEM1	Normal	30	100		9,66						
5/8/2013	Memphrémagog	MEM1	Vague	30	100	4,63	13,01	0,13	15,64	2,0E-07	32,87	54,32	0,61
5/8/2013	Memphrémagog	MEM1	Normal	30	100	3,27	12,84	0,10	8,98	1,7E-08			
5/8/2013	Memphrémagog	MEM1	Vague	30	150	5,20	14,01	0,17	18,83	7,9E-07	19,05	30,16	0,63
5/8/2013	Memphrémagog	MEM1	Normal	30	150	4,38	9,93	0,12	12,63	3,4E-07			
5/8/2013	Memphrémagog	MEM1	Normal	30	200	2,47	9,36	0,03	4,96	9,4E-07			
5/8/2013	Memphrémagog	MEM1	Vague	30	200	4,13	15,55	0,09	12,74	5,6E-07	52,82	84,72	0,62
5/8/2013	Memphrémagog	MEM1	Normal	30	150	4,58	10,63	0,34	13,89	6,7E-07			
5/8/2013	Memphrémagog	MEM1	Vague	30	150	4,46	12,74	0,11	14,73	5,8E-07	28,17	44,60	0,63
5/8/2013	Memphrémagog	MEM2	Normal	10	100	2,09	6,99	0,08	3,27	2,7E-07			
5/8/2013	Memphrémagog	MEM2	Vague	10	100	8,15	36,25	0,06	67,82	2,4E-06	16,05	29,88	0,54
5/8/2013	Memphrémagog	MEM2	Vague	10	150	8,12	32,63	0,14	61,86	3,1E-07	18,08	35,60	0,51
5/8/2013	Memphrémagog	MEM2	Normal	10	150	2,07	6,72	0,08	3,08	2,5E-07			
5/8/2013	Memphrémagog	MEM2	Normal	10	200	2,16	6,16	0,02	3,18	6,8E-08			
5/8/2013	Memphrémagog	MEM2	Vague	10	200	3,48	11,71	0,02	8,86	9,1E-09	38,78	62,48	0,62
5/8/2013	Memphrémagog	MEM2	Normal	10	200	2,13	8,43	0,04	3,45	3,1E-08			
5/8/2013	Memphrémagog	MEM2	Vague	10	200	6,50	20,04	0,04	35,24	2,1E-08	29,54	48,24	0,61
5/8/2013	Memphrémagog	MEM2	Vague	10	100	7,56	35,70	0,24	62,72	2,5E-06	19,15	36,56	0,52
5/8/2013	Memphrémagog	MEM2	Normal	10	100	1,78	4,34	0,08	2,12	2,4E-07			
5/8/2013	Memphrémagog	MEM2	Vague	10	150	6,71	33,51	0,05	48,93	4,4E-07	20,70	40,32	0,51
5/8/2013	Memphrémagog	MEM2	Normal	10	150	1,90	6,56	0,00	2,60	3,4E-07			
5/8/2013	Memphrémagog	MEM2	Normal	20	150	2,61	6,81	0,04	4,62	7,3E-07			
5/8/2013	Memphrémagog	MEM2	Vague	20	150	7,04	22,82	0,36	36,89	3,2E-07	30,95	51,16	0,61
5/8/2013	Memphrémagog	MEM2	Vague	20	200	6,60	25,18	0,22	33,21	3,6E-07	38,47	67,32	0,57
5/8/2013	Memphrémagog	MEM2	Normal	20	200	2,67	7,50	0,08	4,82	9,3E-07			
5/8/2013	Memphrémagog	MEM2	Normal	20	200	1,50	5,48	0,03	1,69	9,3E-08			

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 $(m^2\,s^{-2})$	Epsilon z $(m^2\,s^{-3})$	Nombre de vagues par train	Durée du train de vague (sec)	Nombre/ Longueur $(vague\,s^{-1})$
5/8/2013	Memphrémagog	MEM2	Vague	20	200	5,19	20,95	0,04	22,22	1,1E-07	45,81	79,52	0,58
5/8/2013	Memphrémagog	MEM2	Vague	20	100	7,66	25,91	0,24	48,80	1,2E-06	21,41	37,16	0,58
5/8/2013	Memphrémagog	MEM2	Normal	20	100	2,19	8,47	0,04	3,73	7,2E-07			
5/8/2013	Memphrémagog	MEM2	Vague	20	150	6,61	21,87	0,16	33,50	4,2E-07	33,86	56,44	0,60
5/8/2013	Memphrémagog	MEM2	Normal	20	150	2,68	7,33	0,14	5,35	1,4E-06			
5/8/2013	Memphrémagog	MEM2	Normal	20	100	2,00	6,56	0,03	3,23	1,2E-06			
5/8/2013	Memphrémagog	MEM2	Vague	20	100	8,06	28,34	0,18	52,53	1,2E-06	20,02	35,04	0,57
5/8/2013	Memphrémagog	MEM2	Normal	30	150	3,97	9,94	0,08	10,56				
5/8/2013	Memphrémagog	MEM2	Vague	30	150	5,31	15,05	0,09	19,51	6,1E-08	30,07	47,60	0,63
5/8/2013	Memphrémagog	MEM2	Normal	30	150	2,74	7,81	0,09	5,12	1,3E-06			
5/8/2013	Memphrémagog	MEM2	Vague	30	150	6,00	14,18	0,10	24,58	9,8E-08	25,06	40,20	0,62
5/8/2013	Memphrémagog	MEM2	Normal	30	100	2,95	8,82	0,05	6,15	1,6E-07			
5/8/2013	Memphrémagog	MEM2	Vague	30	100	6,77	15,11	0,15	30,53	7,4E-07	20,81	30,84	0,67
5/8/2013	Memphrémagog	MEM2	Normal	30	200	3,02	9,98	0,13	6,51	2,9E-07			
5/8/2013	Memphrémagog	MEM2	Vague	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
6/8/2013	Memphrémagog	MEM3	Vague	20	100	9,32	24,54	0,05	60,35	9,4E-07	23,62	42,40	0,56
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	0,57
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	0,59
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	0,60
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	0,51
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	0,65
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	0,67

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

Date de prise d'échantillons	Lac	Site	Periode	Vitesse (miles/h)	Distance de la rive (m)	Sédiments T0 (A) (mg L^{-1})	Sédiments T1 (B) (mg L^{-1})	Remise en suspension (mg L^{-1})
8/4/13	Lovering	LOV1	Normal	20	200	0,4	1,6	1,2
8/4/13	Lovering	LOV1	Vague	20	200	0,4	1,6	1,2
8/4/13	Lovering	LOV1	Normal	20	150	0,4	2,8	2,4
8/4/13	Lovering	LOV1	Vague	20	150	0,4	2,8	2,4
8/4/13	Lovering	LOV1	Normal	30	150	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	30	150	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	20	200	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	20	200	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	20	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	20	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	30	200	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	30	200	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	10	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	10	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	30	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	30	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	20	100	0,4	2,4	2
8/4/13	Lovering	LOV1	Vague	20	100	0,4	2,4	2
8/4/13	Lovering	LOV1	Normal	10	150	0,4	-2,4	-2,8
8/4/13	Lovering	LOV1	Vague	10	150	0,4	-2,4	-2,8
8/4/13	Lovering	LOV1	Normal	30	150	0,4	2	1,6
8/4/13	Lovering	LOV1	Vague	30	150	0,4	2	1,6
8/4/13	Lovering	LOV1	Normal	10	150	0,4	3,2	2,8
8/4/13	Lovering	LOV1	Vague	10	150	0,4	3,2	2,8
8/4/13	Lovering	LOV1	Normal	10	200	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	10	200	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	30	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	30	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	20	150	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	20	150	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	10	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	10	100	0,4	0,4	0
8/4/13	Lovering	LOV1	Vague	10	200	0,4		
8/4/13	Lovering	LOV1	Normal	10	200	0,4		
8/4/13	Lovering	LOV1	Vague	30	200	0,4	0,4	0
8/4/13	Lovering	LOV1	Normal	30	200	0,4	0,4	0
8/5/13	Lovering	LOV2	Normal	30	100	0,6	8,2	7,6
8/5/13	Lovering	LOV2	Vague	30	100	0,6	8,2	7,6
8/5/13	Lovering	LOV2	Vague	20	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	20	150	0,6	0,6	0

Date de prise d'échantillons	Lac	Site	Periode	Vitesse (miles/h)	Distance de la rive (m)	Sédiments T0 (A) (mg L^{-1})	Sédiments T1 (B) (mg L^{-1})	Remise en suspension (mg L^{-1})
8/5/13	Lovering	LOV2	Normal	30	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	30	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	10	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	10	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	30	100	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	30	100	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	10	100	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	10	100	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	20	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	20	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	20	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	20	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	30	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	30	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	10	100	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	10	100	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	20	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	20	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	20	100	0,6	3,4	2,8
8/5/13	Lovering	LOV2	Vague	20	100	0,6	3,4	2,8
8/5/13	Lovering	LOV2	Normal	20	100	0,6	1,8	1,2
8/5/13	Lovering	LOV2	Vague	20	100	0,6	1,8	1,2
8/5/13	Lovering	LOV2	Normal	10	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	10	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	10	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	10	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	30	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	30	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	30	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	30	200	0,6	0,6	0
8/5/13	Lovering	LOV2	Vague	10	150	0,6	0,6	0
8/5/13	Lovering	LOV2	Normal	10	150	0,6	0,6	0
8/5/13	Lovering	LOV3	Normal	30	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	30	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	30	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	30	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	30	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	30	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	10	100	0,3	1,9	1,6
8/5/13	Lovering	LOV3	Normal	10	100	0,3	1,9	1,6
8/5/13	Lovering	LOV3	Vague	20	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	20	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	20	100	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	20	100	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	10	150	0,3	3,5	3,2

Date de prise d'échantillons	Lac	Site	Periode	Vitesse (miles/h)	Distance de la rive (m)	Sédiments T0 (A) (mg L^{-1})	Sédiments T1 (B) (mg L^{-1})	Remise en suspension (mg L^{-1})
8/5/13	Lovering	LOV3	Normal	10	150	0,3	3,5	3,2
8/5/13	Lovering	LOV3	Vague	30	100	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	30	100	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	30	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	30	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	20	200	0,3	1,5	1,2
8/5/13	Lovering	LOV3	Normal	20	200	0,3	1,5	1,2
8/5/13	Lovering	LOV3	Vague	20	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	20	150	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	10	100	0,3	1,5	1,2
8/5/13	Lovering	LOV3	Normal	10	100	0,3	1,5	1,2
8/5/13	Lovering	LOV3	Vague	30	100	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	30	100	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	10	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	10	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	10	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	10	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	20	100	0,3	-1,7	-2
8/5/13	Lovering	LOV3	Vague	20	100	0,3	-1,7	-2
8/5/13	Lovering	LOV3	Normal	20	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Vague	20	200	0,3	0,3	0
8/5/13	Lovering	LOV3	Normal	10	150	0,3	1,5	1,2
8/5/13	Lovering	LOV3	Vague	10	150	0,3	1,5	1,2
8/5/13	Memphrémagog	MEM1	Normal	30	200	1	2,2	1,2
8/5/13	Memphrémagog	MEM1	Vague	30	200	1	2,2	1,2
8/5/13	Memphrémagog	MEM1	Normal	10	200	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	10	200	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	20	150	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	20	150	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	30	100	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	30	100	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	10	150	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	10	150	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	10	100	1	4,2	3,2
8/5/13	Memphrémagog	MEM1	Normal	10	100	1	4,2	3,2
8/5/13	Memphrémagog	MEM1	Normal	10	150	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	10	150	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	10	200	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	10	200	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	20	200	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	20	200	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	30	100	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	30	100	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	20	150	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	20	150	1	1	0

Date de prise d'échantillons	Lac	Site	Periode	Vitesse (miles/h)	Distance de la rive (m)	Sédiments T0 (A) (mg L^{-1})	Sédiments T1 (B) (mg L^{-1})	Remise en suspension (mg L^{-1})
8/5/13	Memphrémagog	MEM1	Vague	30	150	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	30	150	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	30	200	1	-0,2	-1,2
8/5/13	Memphrémagog	MEM1	Vague	30	200	1	-0,2	-1,2
8/5/13	Memphrémagog	MEM1	Normal	20	200	1	3	2
8/5/13	Memphrémagog	MEM1	Vague	20	200	1	3	2
8/5/13	Memphrémagog	MEM1	Normal	30	150	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	30	150	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	20	100	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	20	100	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	20	100	1	1	0
8/5/13	Memphrémagog	MEM1	Normal	20	100	1	1	0
8/5/13	Memphrémagog	MEM1	Vague	10	100	1	2,2	1,2
8/5/13	Memphrémagog	MEM1	Normal	10	100	1	2,2	1,2
8/5/13	Memphrémagog	MEM2	Normal	20	150	0,4	-0,8	-1,2
8/5/13	Memphrémagog	MEM2	Vague	20	150	0,4	-0,8	-1,2
8/5/13	Memphrémagog	MEM2	Normal	10	100	0,4	2,4	2
8/5/13	Memphrémagog	MEM2	Vague	10	100	0,4	2,4	2
8/5/13	Memphrémagog	MEM2	Vague	10	150	0,4	4	3,6
8/5/13	Memphrémagog	MEM2	Normal	10	150	0,4	4	3,6
8/5/13	Memphrémagog	MEM2	Vague	20	200	0,4	2,4	2
8/5/13	Memphrémagog	MEM2	Normal	20	200	0,4	2,4	2
8/5/13	Memphrémagog	MEM2	Normal	20	200	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Vague	20	200	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Normal	10	200	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Vague	10	200	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Normal	30	150	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Vague	30	150	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Normal	10	200	0,4	-0,8	-1,2
8/5/13	Memphrémagog	MEM2	Vague	10	200	0,4	-0,8	-1,2
8/5/13	Memphrémagog	MEM2	Normal	30	150	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Vague	30	150	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Normal	30	100	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Vague	30	100	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Normal	30	200	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Vague	30	200	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Vague	30	100	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Normal	30	100	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Vague	20	100	0,4	2	1,6
8/5/13	Memphrémagog	MEM2	Normal	20	100	0,4	2	1,6
8/5/13	Memphrémagog	MEM2	Vague	20	150	0,4	2,4	2
8/5/13	Memphrémagog	MEM2	Normal	20	150	0,4	2,4	2
8/5/13	Memphrémagog	MEM2	Normal	30	200	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Vague	30	200	0,4	1,6	1,2
8/5/13	Memphrémagog	MEM2	Normal	20	100	0,4	0,4	0

Date de prise d'échantillons	Lac	Site	Periode	Vitesse (miles/h)	Distance de la rive (m)	Sédiments T0 (A) (mg L^{-1})	Sédiments T1 (B) (mg L^{-1})	Remise en suspension (mg L^{-1})
8/5/13	Memphrémagog	MEM2	Vague	20	100	0,4	0,4	0
8/5/13	Memphrémagog	MEM2	Vague	10	100	0,4	4,4	4
8/5/13	Memphrémagog	MEM2	Normal	10	100	0,4	4,4	4
8/5/13	Memphrémagog	MEM2	Vague	10	150	0,4	3,2	2,8
8/5/13	Memphrémagog	MEM2	Normal	10	150	0,4	3,2	2,8
8/6/13	Memphrémagog	MEM3	Vague	30	150	0,7	1,9	1,2
8/6/13	Memphrémagog	MEM3	Normal	30	150	0,7	1,9	1,2
8/6/13	Memphrémagog	MEM3	Normal	20	100	0,7		
8/6/13	Memphrémagog	MEM3	Vague	20	100	0,7		
8/6/13	Memphrémagog	MEM3	Vague	10	200	0,7	3,1	2,4
8/6/13	Memphrémagog	MEM3	Normal	10	200	0,7	3,1	2,4
8/6/13	Memphrémagog	MEM3	Normal	30	100	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	30	100	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Normal	30	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	30	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Normal	30	200	0,7	-0,9	-1,6
8/6/13	Memphrémagog	MEM3	Vague	30	200	0,7	-0,9	-1,6
8/6/13	Memphrémagog	MEM3	Normal	10	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	10	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Normal	30	100	0,7	3,1	2,4
8/6/13	Memphrémagog	MEM3	Vague	30	100	0,7	3,1	2,4
8/6/13	Memphrémagog	MEM3	Normal	20	150	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	20	150	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Normal	20	150	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	20	150	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Normal	10	150	0,7	2,7	2
8/6/13	Memphrémagog	MEM3	Vague	10	150	0,7	2,7	2
8/6/13	Memphrémagog	MEM3	Normal	10	100	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	10	100	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Normal	30	150	0,7	1,5	0,8
8/6/13	Memphrémagog	MEM3	Vague	30	150	0,7	1,5	0,8
8/6/13	Memphrémagog	MEM3	Normal	20	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	20	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Normal	20	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	20	200	0,7	0,7	0
8/6/13	Memphrémagog	MEM3	Vague	20	100	0,7	-1,7	-2,4
8/6/13	Memphrémagog	MEM3	Normal	20	100	0,7	-1,7	-2,4
8/6/13	Memphrémagog	MEM3	Normal	10	100	0,7	3,1	2,4
8/6/13	Memphrémagog	MEM3	Vague	10	100	0,7	3,1	2,4
8/6/13	Memphrémagog	MEM3	Normal	10	150	0,7	1,9	1,2
8/6/13	Memphrémagog	MEM3	Vague	10	150	0,7	1,9	1,2