DEPARTMENT OF PUBLIC WORKS, N.S.W.

HARBOURS AND RIVERS BRANCH

MANLY HYDRAULICS AND SOILS LABORATORY

HAWKESBURY RIVER - THE EFFECT OF SPEEDBOAT ACTIVITIES
ON BANK EROSION

by

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Investigation Sponsored by the
Maritime Services Board, N.S.W.

Report No. 106.
This investigation was made at the request of the Maritime Services Board of N.S.W. That Board is responsible for the control of navigation in N.S.W. waterways, which includes the regulation of water skiing activities. The Department was asked to investigate the effects of wave action on the banks of the Hawkesbury River to determine the relative erosive effects of water skiing, wind and floods.

The investigations were carried out at the Hydraulics laboratory of the Department of Public Works, by Mr. E.J. Lesleigher, B.E., under the supervision of Mr. A.H. Lucas, B.E., Supervising Engineer in charge of the laboratory, and under the direction of Mr. C.D. Floyd, B.E., A.M.I.E. Aust., Inspecting Engineer, Investigation.

Although the relative effects of wind and speed boats in generating waves have been established for the Hawkesbury River no quantitative measure of the rate of erosion has been established. This is apparently slight and would vary with location.

Quantitative information could be obtained but would require a lengthy and detailed program of field data collection which would be outside the scope of this investigation.

This report is issued under the authority of Mr. R.A. Johnson, LL.B., Director of Public Works.

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HAWKESBURY RIVER: THE EFFECT OF SPEEDBOAT ACTIVITIES ON BANK EROSION.

Abstract

This investigation, carried out at the request of the Maritime Services Board of N.S.W. was aimed at finding the magnitude of the erosive action of waves caused by water skiing activities. Comparison with the effect of wind induced waves is made. The testing program included wave measurement during many controlled speedboat runs in the Manly Reservoir using both an outboard and inboard powered vessel.

1. Statement of the Problem

For a number of years there has been quite an amount of conjecture regarding river bank erosion, and its cause, on the Hawkesbury River. Fig. 1 is a plan showing part of the area in question. Many opinions have singled out the increasing water skiing activities and speedboat traffic as a major cause of bank erosion.

In order to have some concrete evidence on which to base negotiations, the present testing program was entered into. As part of the investigation, one year's wind records from the nearby Richmond Airport were analyzed and wind wave theory applied to find the magnitude, duration and direction of wind waves in the river reaches where skiing is carried out.

Inspection of the area reveals the immense action that flooding has in erosion and causing subsequent bank failures due to saturation of the soil in the banks.

2. Testing Procedure

In order to obtain a comprehensive coverage of wave measurement for speedboats, several typical craft would be required. In the present testing program two speedboats were used. The first, used for the major proportion of testing, was a 13 ft. long, "planing" type hull powered by a 35 H.P. outboard motor. This vessel weighing 5 cwt. is considered typical of the lighter speedboats used for water skiing purposes. Other craft
used for such activities have similar, perhaps longer, planing type hulls with higher powered outboard motors. The second craft was a 15 ft. long, displacement type hull powered by a 130 H.P. inboard motor. This boat, typical of the many inboard vessels in use today, weighed 12 cwt. The latter vessel was not used extensively, but mainly for a comparison with the former.

The wave recorder used consisted of a float actuated pen moving on a revolving chart. The recorder was installed approximately 20 ft. from the shore in about 2'6" depth of water. The investigation was carried out in the reservoir contained by Manly Dam.

The path of the speedboat was maintained parallel to the shore and in one direction. Runs were made at distances of 25 feet, 50 feet and 100 feet from the recorder at a number of speeds. Speeds were measured by timing over a measured distance.

One series of tests was carried out to determine the variation in wave height caused by turning craft. Although it was difficult to maintain the speedboat on a fixed diameter turn, measurements were made with the vessel moving at fixed speeds in circles, the circumference of which approached to a minimum of 25 ft. from the recorder.

A number of passes were made at each speed so that the final results would be the average of several repeats of each phase.

3. Results of the Investigation

From the many wave records obtained for boats passing at a number of speeds and various distances from the recorder, mean values of the maximum wave height were found and used for plotting purposes.

A wave train considered to be typical is shown expanded and enlarged in Fig. 2. The waves are first felt as low and long; steepness increases and three or four higher waves pass followed by somewhat irregular small waves. The number of waves propagated by one pass seemed to vary between about four and fourteen, however in the majority of cases there are six to eight waves containing three to four pronounced waves in the middle of the train. It is thought that speed and distance from the
recorder may have some bearing on the number of waves formed, however as this particular feature was unimportant for this investigation, the thought was not pursued.

A feature which may have bearing on the relative waves formed by passes at 25 ft, 50 ft. and 100 ft. from the recorder is the interference of bow and stern waves. A vessel moving through the water sets up a train of bow waves and also a train of stern waves. These waves moving out at different directions to the boat's path interfere causing larger or smaller waves depending upon the frequency and phasing of the two trains. The distance from the boat's path at which interference takes place, being somewhat constant, would thus have some effect on the 25, 50 and 100 ft. wave trains.

Fig. 3 is a graph of the maximum wave heights caused by the two speedboats used, plotted against boat speed and the ratio of boat speed to the square root of the length \( V/L^2 \). The ratio, \( V/L^2 \), perhaps provides a better application of the graphs to other speedboats of different lengths. It will be noticed that the heavier inboard vessel causes much larger waves than the outboard. Also peak heights of 9.0 inches and 6.8 inches respectively are produced. For the slow moving boat, waves are small, and increase with a slight increase in speed until the peak is reached. Further increase in speed causes the wave height to decrease fairly uniformly; at these speeds the boats tend to lift out of the water, so causing less displacement. It is felt that the peak wave height occurs at a particular speed due to building up caused by interference of the bow and stern waves. Before this the interference evidently results in a varying degree of annulment.

Fig. 4 shows the effect of loading of the lighter speedboat. The difference is quite marked especially at the speed producing the peak wave height. This effect would depend on the initial weight of the craft, and so the difference would not be as great for larger, heavier speedboats. Further, at skiing speeds, the increase in wave height caused by more persons on board, even for the light speedboat, is not very great.
The effect of the distance of travel of the waves is shown in Fig. 5. These graphs show that the waves flatten to some extent during travel—a feature which would be expected. Although one boat only was used in this section of the testing, it is reasonable to believe a similar trend would exist for other speedboats. The second graph of Fig. 5 is a re-arrangement of the first.

When speedboats turn, there appears to be a build up in wave height. Fig. 6 shows that this is the case for high speeds. There it is seen that for low speeds (possibly up to 10-12 m.p.h.) the waves are reduced when a boat turns until the turning diameter increases to approximately 250 ft. For higher speeds (above 15 m.p.h.), there is an increase in wave height when the boat turns in diameters less than approximately 200 ft. This section of the tests was carried out under difficulties which include, first, variation of speed due to turning and, second, the difficulty of maintaining a constant circular course of a fixed diameter at a fixed distance from the recorder. Consequently Fig. 6 should only be used as a guide, although a substantial one.

The wave period was found to be larger for the larger speedboats to be expected because of the larger waves so produced. In this case the average period for each train varies with boat speed, however for the peak wave conditions the period is approximately 1.6 to 1.8 seconds. For the lighter vessel, the waves usually have a period ranging between 1.0 and 1.6 seconds.

Waves propagated by a skier alone were measured. These waves although dependent on the skier's weight and speed, are quite small. The average maximum height being 1.25 inches. These waves would no doubt add to the boat waves (and subtract from, under some conditions); however the addition would only be a small proportion of the measured 1.25 inches as the wave formation is dependent upon volume increase.
4. Energy Dissipation Considerations

Waves are a means of transfer of energy. The amount of energy depends upon wave length and the wave height squared. How much of this energy is dissipated when the wave strikes the shore depends on the slope of the shore. On a very flat shore, the wave breaks and energy is dissipated in this way. On the other hand when the wave reaches a vertical bank the wave is reflected and much less energy is lost on the shore. In most cases the waves meet banks which cause them to break; and even when the banks are steep a continual movement of waves against the banks, decreases the energy reflection and so a large amount of energy is consumed.

(i) Speedboat Waves

Using a large speedboat powered by an inboard motor (a vessel considered to be typical of the majority of speedboats) it was found that the maximum wave height experienced at the recorder from passes 50 ft. away was 9 inches. This occurred at a speed of 9.5 m.p.h. At speeds less or greater than 9.5 m.p.h., the wave heights were less. At skiing speeds (say greater than 20 m.p.h.) the maximum wave heights were found to be approximately 7 inches and from previous consideration, a skier behind such a boat would cause a negligible addition to these wave heights. 50 ft. is somewhat closer than a speedboat normally approaches river banks.

From a smaller boat powered by an outboard motor (a vessel representing a lesser proportion of speedboats) the maximum wave was 6.8 inches from a pass 50 ft. from the recorder. The boat contained two persons and was travelling at 7 m.p.h.

Having details of the maximum wave height at skiing speeds and using this as average, it was decided to gather statistics of the number of speedboat passes at a point considered to be the busiest and at a time at which traffic was at a maximum. On February 9, 1964 (Sunday) with a temperature of 81°F, the number of boats passing a fixed point in York Beach in one hour was 79. This count, made at a time when traffic was a
maximum is considered as a very good basis for computations to find the worst conditions. Eight boats were being used on this occasion.

Considering a wave train to contain seven waves, the maximum being seven inches high it was estimated that such would contain approximately 30\% of the energy of seven waves seven inches high.

\[
\text{Wave Height, } H = 7'' = 0.58 \text{ ft.}
\]
\[
\text{Wave Period, } T = 1.70 \text{ sec.}
\]
\[
\text{Wave Energy, } E = Y L H^2 / 8 = 62.4 \times 14.8 \times 0.34 = 39.3 \text{ lb ft. per wave/ft. length.}
\]
\[
\text{Where } Y = \text{ unit weight of water (lb/ft}^3) = 62.4 \text{ lb ft. per wave/ft. length.}
\]
\[
\text{Maximum train energy } = 0.30 \times 7 \times 39.3 = 82.5 \text{ lb ft. per wave/ft. length.}
\]

Assuming each boat pass to expend 82.5 lb ft. of energy onto each one ft. length of shore, a skiing day of 8 hours duration, the number of such days per year being 104, and the number of speedboat passes 79 per hour then

\[
\text{Total Energy per year } = 8 \times 79 \times 104 \times 82.5 \text{ lb ft. per wave/ft. length} = 2.12 \text{ K Watt hours/ft. length.}
\]

(ii) Wind Induced Waves

In order to compute the wind waves for a particular river stretch, it is required to know the fetch, F, and the wind velocity, U. Reference was made to an excellent paper on the subject by Bretschneider (Coastal Engineering, 1958, page 31, figures 1A, 2 and table 1). Using Richmond Airport wind records for 1961, average velocities, their duration in hours per day and their direction were found.

Consultation of a plan of the river (fig. 1) reveals that the maximum fetch for the wind generated waves to be 3000 yd. In general the fetch maximum is 1000 to 2000 yards.

Inspection on October 9, 1963 revealed very minor lower bank erosion in small sections of Clarence Reach (fetch 1000 yd., direction N.E.), Swallow Rock Reach (fetch 2000 yd. S.W. direction), Lower
Crescent Reach (fetch 2000 yd, S.S.W. direction), Wilberforce Reach (fetch 3000 yd, N or S winds) and Sackville Reach (3000 yd, S.W. or N.E. winds), possibly caused by water lapping against bank bared by floods.

Below is a summary of the computed energy which would be dissipated due to wind waves at the ends of a number of these reaches where skiing is carried out.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Wind Direction</th>
<th>Wave Details (maximum)</th>
<th>Energy per ft. per year</th>
<th>Kilowatthours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Height (ft.)</td>
<td>Period (sec)</td>
<td>Length (ft.)</td>
</tr>
<tr>
<td>Clarence</td>
<td>NE</td>
<td>0.51</td>
<td>1.42</td>
<td>10.35</td>
</tr>
<tr>
<td>Swallow Rock</td>
<td>SW</td>
<td>0.83 &amp; 0.62</td>
<td>1.86 &amp; 1.69</td>
<td>17.6 &amp; 14.6</td>
</tr>
<tr>
<td>Lower Crescent</td>
<td>SW</td>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>Wilberforce</td>
<td>S</td>
<td>0.79</td>
<td>1.94</td>
<td>19.2</td>
</tr>
<tr>
<td>Sackville</td>
<td>SW</td>
<td>1.01 &amp; 0.74</td>
<td>1.07 &amp; 1.89</td>
<td>21.9 &amp; 18.2</td>
</tr>
</tbody>
</table>

TABLE 1. Wind Wave Characteristics

(iii) Flood Erosion

During the passage of a large flood, energy is lost by frictional resistance of the bed and banks. The actual head loss can be computed and the corresponding power loss so found. From such a computation using a 30 ft. flood at Windsor the energy loss per foot length, is estimated to be approximately 4,000 kilowatt hours. Flood energy is also lost through turbulence and boat but it is estimated that the greater loss would be in frictional drag at the bed and banks. If one assumes that frictional drag accounts for half the loss and that one quarter of this is lost on the rougher banks then a conservative estimate finds that 500 kilowatt hours per foot length is lost during the passage of a medium size flood. Assuming the wind and speedboat wave affects over a 5 ft. tide range and the flood over a 50 foot height of bank, the comparable energy dissipation per foot length of bank is 50 kilowatt hours during one such flood. This energy is dissipated along the entire bank length, but is obviously more severe at bends. Comparison of this figure with those of speedboat and wind waves reveals that the passage of one such flood dissipates energy equivalent to many years of skiing and wind action.
An effective means of comparison of the effect of speedboat and wind waves and flood erosion is a measure of the maximum power that can be released against a one foot length of bank by those agencies. This involves the reduction of the total energy figures by the time factors involved. Table 2 is a summary of relative powers impinging on the bank. It would be normal to expect that erosion of a given material would occur at a particular power (P). At powers greater than P, erosion will occur and the actual rate of erosion, \( \frac{dS}{dP} \), would be expected to increase as the power became greater. From this, Table 2, would indicate that the erosion action of flooding with respect to either of the other effects would be greater than the actual ratios of power.

<table>
<thead>
<tr>
<th>Reach</th>
<th>Wind Waves</th>
<th>Speedboat Waves Max. Power</th>
<th>Flood Max. Power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>at position of Max. Traffic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(HP)</td>
<td>(HP)</td>
<td>(HP)</td>
</tr>
<tr>
<td>Clarence</td>
<td>0.021</td>
<td>0.042</td>
<td>0.93</td>
</tr>
<tr>
<td>Swallow Rock</td>
<td>0.093</td>
<td>0.093</td>
<td></td>
</tr>
<tr>
<td>Lower Crescent</td>
<td>0.053</td>
<td>0.087</td>
<td></td>
</tr>
<tr>
<td>Wilberforce</td>
<td>0.087</td>
<td>0.153</td>
<td></td>
</tr>
</tbody>
</table>

**Table 2. Comparison of Maximum Power Impingements**

5. Conclusion

The investigation has shown that the maximum measure of the energy dissipated against banks of the Hawkesbury River due to waterskiing activities, is in the order of 2 to 2.5 kilowatt hours per year on each foot length of bank; and that the maximum height of speedboat waves is of the order of 3 to 10 inches.

One comment which many observers might be heard to make is "But speedboat waves are usually much larger than 8 to 10 inches; I have seen 18 inch waves on a number of occasions." The author would immediately question such an observation. He and all others engaged in the measurement of the speedboat waves were startled to discover that waves which appeared "enormous" were much less than one foot high. The author then is prompted to issue a warning that one's judgment on the height of an observed wave be treated with great suspicion, as the human senses in this case have a universal tendency to grossly overestimate.
It would be a very rare occasion for a speedboat of the type used for water skiing purposes to produce waves of greater height than 12 inches, under normal usage.

The table shows that the energy dissipated against banks by wind induced waves to be of the same order as that from speedboat waves. However, in Wilberforce Reach a relatively high value was found. It should be remembered that the wind energy is only dissipated at its maximum along a limited length of bank, at the end of a reach, and in the intermediate portions of the reaches the energy would be considerably less.

Inspection of the Hawkesbury between Windsor and Sackville has revealed that bank erosion is widespread. It is evident that flooding is by far the greatest single cause of this erosion. This is substantiated by the fact that such erosion is prevalent in non-water skiing areas. Also the higher bank areas are eroded and slides caused by bank saturation during flooding is common in these areas; trees washed out by floodwaters leave large areas of bank open to scour.

Inspection of the Hawkesbury in areas subject to erosion, reveals a general absence of obvious marked wind wave erosion eventhough the lapping against open sandy banks does cause localised minor bank "indentations" at water level. A few of the local identities were consulted regarding their general visual observations of wind waves in the area. It was their opinion that Wilberforce Reach was more open to wind waves than others (this was borne out by computation - see table on page 9). Also, as a guide, the Shire Engineer at Wilberforce expressed the view that wind waves "would not be severe enough to swamp a small dinghy". Further, Mr. McLachlan, the owner of a large property at the north end of Wilberforce Reach said that he sees "white tops" on waves caused by a strong southerly wind occasionally, however such occurrences are rare and not prolonged. These opinions agree with the findings, before summarised, that wind wave effects are not appreciable. Floods sometimes even occur well grassed areas where wind effects do not aggravate the situation.

Consequently, in the opinion of the author, it is concluded that the contribution of water skiing activities to bank erosion is
perhaps more appreciable than wind wave influences, because, of course, the energy is released along the whole bank length. However these factors are of minor magnitude when compared with the huge forces of nature released by the very large river discharges during flooding. Further any undermining tendency of speedboat waves appears to be of only minor importance, as such action is very slow and insignificant when it is considered that, in a few days, the passage of a flood causes damage of tremendously greater magnitude. Inspection of the banks, shows general erosion from high areas right down to the water level and there is no particular place where erosion is greatest.

6. Recommendations

The program of tests carried out has been comparatively brief but suitably scientific for the purpose in mind. That is, to find the relative erosive effect of speedboat waves on the Hawkesbury River. In the author’s opinion the results point to the recommendation, that speedboat activities need not be restricted, as detrimental erosive effects are negligible. Water skiing activity in N.S.W. is probably at its greatest on the Hawkesbury River. Consequently it is unlikely that such activity would be the cause of bank erosion on other waterways in the State, provided the soils are similar. Wind action however, could be far greater than the wave action due to skiing at other places where the fetch is larger.

It is recommended that where speeds are restricted on waterways for wave reduction, there be some consideration given to the limits in the light of figure 3; where it is seen that speedboats travelling at 7 to 10 m.p.h. (6 to 9 knots) cause maximum wave heights.

This investigation does not supply enough information to determine the relative amounts of power dissipation in wave making, eddy loss and friction loss. Such could be attempted with wave measurements from a large number of boats. Neither can quantitative amounts of soil, eroded by a particular wave energy, be obtained without actual study of the material in a flume under wave action. This work could be an introduction to further investigation along these lines and the results
would be of academic and practical interest. The resultant recommendation therefore would be that if power considerations are required a further investigation be undertaken using several boats (because of the effect of shape characteristics) with several horsepower ratings (because of the obvious effect power changes would have).
Skiiing Areas: Wilberforce Reach & Downstream

FIGURE 1.

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HAWKESBURY RIVER
WATER SKIING AREAS

SCALE: 1 inch = 1
Period 20 sec
Period 18 sec
Period 16 sec

Wave
Travel
Time
(Seconds)

Note: The vessel covering this wave was the 6ft. inboard powered speedboat, travelling at 10 mph 50 ft. from the recorder.

FIGURE 2

DEPARTMENT OF PUBLIC WORKS M.S.W.
HARBOURS & RIVERS BRANCH
TYPICAL SPEEDBOAT WAVE TRAIN

E.J.L. 3-2-64
REVISED
J. M. MAIN
DIRECTOR OF PUBLIC WORKS

EJL
PRINCIPAL ENGINEER

SCALE: 43
Inboard (see note)

Max. Wave Height (inches)

Boat Speed (m.p.h.)

FIGURE 3.

Note:
1. Both vessels loaded full crew on board.
2. The inboard vessel was 15 ft long, weight 12cwt, and was powered by a 150 HP motor.
3. The outboard vessel was 15 ft long, weight 12cwt, and was
powered by a 95 HP motor.
4. Both vessels were driven at 50 ft distance from the wave recorder.
Note 1: These measurements were taken using a 13 ft. boat powered by a 35 hp outboard travelling 50 ft. from the wave recorder.
Note: These tests were done using the light, outboard powered, speedboat.
FIGURE 6.

Note: These tests were done using the light, outboard, powered speedboat.
1. The speeds shown were taken on a straight course. On turn on a curve, the actual speed would be lower than indicated.
2. The curves are for use with a quiet approach speed.
3. The boat was driven so as to be 25 km/hr from the recession.

SPEEDBOAT WAVES. VARIATION CAUSED BY A TURNING VESSEL.