Appendix K
Determination of Wave Energy

1.   Technical Information to be provided with applications for consent

1.1   To demonstrate that a ship will comply with the Wash Rule, resource consent applicants shall submit technical information prepared by a competent professional based on either:

1.1.1   Accepted and properly calibrated computational models, physical models, analytical or empirical analysis allowing for the specific characteristics of the ship concerned and all the relevant operating conditions, navigation tracks, physical effects and conditions within the National Transportation Route; or

1.1.2   Direct measurements specific to the ship concerned covering relevant operating and physical conditions; or

1.1.3   Combinations of the approaches outlined above.

1.2   Wave Energy shall be calculated according to linear wave theory (also known as Airy wave theory), as outlined further below, based on the maximum zero down-crossing wave height and the corresponding zero down-crossing wave period in any Wave Record, as defined further in IAHR (1989).

1.3   Wave Energy shall be determined at a standard depth of 3 metres for sites at which, in the opinion of a competent professional, are not significantly influenced by the effects of diffraction due to bathymetry and objects.

1.4   Applications for consent shall include information detailing the following:

(i)   The Data Recording Device(s) intended for recording ship navigation details;

(ii)   The intended format, mode of transmission and frequency of transmission to the Council of data recorded by the Data Recording Device(s) including any proposed protocols or arrangements for access to the Data Recording Device(s);

(iii)   The intended format, method and location of storage of data generated by the Data Recording Device(s) that is held by the consent holder as archived information including any proposed protocols or arrangements for access to that archived information;

(iv)   The intended maximum Ship Speed through the National Transportation Route including spatial definition of any areas of the National Transportation Route within which maximum Ship Speed is to be varied;

(v)   For applications made under Rule 35.2.7, details of the location, timing, duration and frequency of events for measuring Wave Energy;

(vi)   For applications made under Rule 35.4.2.13, a description of any measures proposed for monitoring the effects of waves generated by the ship on the coastal environment;

(vii)   The International Maritime Organisation number and name of the ship to which the application relates.

2.   Approved Measurement Sites

2.1   For the purposes of assessing compliance with the Wash Rule under any of the methods listed in clause 1.1 above, Wave Energy shall be calculated from assessments and measurements at a minimum of two sites in Tory Channel from the list of the Approved Measurement Sites in Table 1 below. Applicants are free to determine which of the Approved Measurement Sites are to be used, and shall specify in the application which of the Sites have been adopted for assessment purposes. However, applicants shall also ensure that a site from Table 1 is adopted that best represents conditions throughout each area in the National Transportation Route for which particular values of maximum Ship Speed and limits to the navigation corridor are proposed.

2.2   Where an applicant proposes differential speeds for identified areas within the National Transportation Route, the application shall specify which Approved Measurement Sites are proposed to be used to determine the compliant speed for that area. The sites from Table 1 that are specified for this purpose should be representative of conditions within the areas identified in the application.

2.3   Once the representative sites have been determined then the Council's evaluation of the assessments and proposed maximum speed limits and navigation corridors shall be confined to those sites.

2.4   Applicants shall ensure that the analysis of effects at the selected sites covers the full range of ship operating conditions expected to be encountered over the life of the resource consent. Such conditions shall include the full range of tidal flows, navigation paths, and the amount and distribution of hull displacement.

Table 1. Approved Measurement Sites

Channel	Location Description	NZGD2000 Co-ordinates	
Tory Channel	Ngaionui Point West, Arapawa Island	174° 10´.782 E	41° 14´.462 S
	Te Weka Bay	174° 11´.396 E	41° 14´.983 S
	Wiriwaka Point West, Arapawa Island	174° 12´.287 E	41° 14´. 192 S
	Tipi Bay West	174° 17'.001 E	41° 13'.699 S
Queen Charlotte Sound	Picton Point	174° 02'.177 E	41° 15'.283 S
	East Kahikatea	174° 07'.095 E	41° 14'.170 S

3.   Direct measurement of wave properties

3.1   Wave properties used to calculate Wave Energy from a directly measured Wave Record shall be determined according to the following conditions and assumptions:

(a)   Measurements shall be made by, or under the supervision of, a competent professional experienced in the measurement of waves using an appropriate, calibrated wave measurement instrument and accepted data analysis methodologies.

(b)   Measurements shall be made at any of the sites identified in Table 1 above and shall be undertaken only in conditions when those sites are substantially clear of kelp and other obstacles.

(c)   Measurements shall be made in depths of water of between 1 and 5 metres. In order to calculate Wave Energy, the wave properties determined from the Wave Record at the point of measurement shall be transformed to a standard depth of 3 metres using the following methodology or assumptions:

  (i)   Shoaling and refraction analysis to calculate a transformed wave height shall be based on Snell's law assuming that the seabed contours are parallel with the direction of travel of the ship, and that the angle between the wave crests of the waves generated by the ship in deep water and the seabed contours is 55°.

  (ii)   A local water depth of $D + \frac{1}{2}H$, where D is the average water depth and H is the measured wave height applicable to the Wave Record, shall be adopted in the shoaling and refraction analysis for the purpose of calculating group wave celerity and wave length.

  (iii)   The effects of bottom friction, viscous effects and turbulence shall be ignored.

  (iv)   Wave period shall be unadjusted from that determined at the point of measurement.

(d)   Measurements shall be made only under calm conditions which shall be deemed to exist where the Significant Wave Height related to wind and other disturbances (other than the ship under evaluation) at the measurement site does not exceed 0.05 metres based on a Wave Record recorded for a duration of not less than 5 minutes immediately prior to recording ship Wave Energy.

(e)   For the purposes of calculating wave characteristics under this Plan, the density of water shall be taken as 1025 kilograms per cubic metre, the gravitational acceleration shall be taken as 9.806 metres per second squared, and any other physical parameters required shall be those applicable at a temperature of 15°C.

4. Assessment of speed through the water

4.1 The following method is an accepted methodology to determine Ship Speed where an appropriate instrumental approach is not available or where the hull-mounted instruments are faulty.

The speed through the water, V_W, is calculated from the speed over the ground, V_G, according to:

$$V_W = V_G - \lambda x U_T \qquad (1)$$

in which λ is an index that describes the direction of travel of the ship ($\lambda = 1$ for ships travelling towards Picton, and $\lambda = -1$ for ships travelling away from Picton), and U_T is the speed of the tidal stream. The convention for the speed of the tidal stream is that it is positive for the flooding phase (i.e. tide level is rising) and negative for the ebbing phase (i.e. tide level is falling).

For the purposes of calculating the speed of the tidal stream, the Marlborough Sounds is deemed to consist of three zones. Each zone is named after the tidal stream data point marked B, C and D that is located within each zone as shown on Marine Chart NZ 6153. The speed of the tidal stream in each zone is calculated from:

$$U_T = A\cos\left(\frac{2\pi}{12}(t - t_{HT} + t_L)\right) \qquad (2)$$

in which A is the amplitude of tidal stream speed (see Table 2 below), t is the time in hours since midnight, t_{HT} is the time of the nearest high-tide in Wellington, and t_L is the lag between the tidal stream and the high-tide at Wellington (see Table 2 below). The times use for t and t_{HT} must be to a consistent standard, either New Zealand Daylight Saving time (NZDT) or New Zealand Standard time (NZST) depending on the time of year. Equation 2 is a cosine fit to the tidal stream with a semi-diurnal period of 12 hours. The time of high tide is based on the figures published in the New Zealand Almanac (or an equivalent source). The tidal zones, their definitions, and values for the coefficients in equation 2, are given in Table 2 below.

Table 2. Tidal zones and tidal speed parameters that might be adopted to assess speed through the water under Variation 3.

Zone	Description of Limits of Zone	A (knots)	t L (Hour)
B	Zone anywhere in Queen Charlotte Sound, and separated from Tory Channel along latitude 41°14′ S at Dieffenbach Point.	0.3	-0.4
C	Zone in Tory Channel between latitude 41°14′ S at Dieffenbach Point at its western end and longitude 174°18′ E in Tory Channel at its eastern end.	1.8	-0.4
D	Zone near the Heads in Tory Channel located east of longitude 174°18′ E.	6.7	0.0