PORT OTAGO DREDGE DISPOSAL GROUNDS

Monitoring effects of the 2014 disposal at the Heyward Ground on wave dynamics and a proposed dumping plan for Q1-Q2 2015

Prepared for Port Otago Limited

MetOcean Solutions Ltd
www.metocean.co.nz

PO Box 441, New Plymouth, New Zealand
T: 64-6-7585035 E: enquiries@metocean.co.nz

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PO Box 441, New Plymouth, New Zealand
T: 64-6-7585035 E: enquiries@metocean.co.nz

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1. INTRODUCTION

The functional effects of the morphological features of the Heyward Point disposal ground on the local wave dynamics were investigated in a previous report P0140-05a using the nearshore wave models SWAN and CGWAVE, with a particular focus on how they influence the surfing conditions at Whareakeake point. The study provided valuable baseline information on the existing wave processes, which was used to elaborate subsequent disposal plans that would ensure conservation of processes beneficial for surfing (i.e. wave focusing). The report P0140-05a provided a disposal plan for 2014 Q1-Q2 and was followed by report P0140-05b specifying a disposal plan for 2014 Q3-Q4.

The present report includes an assessment of the effects of the disposal completed at Heyward Point from November 2013 to October 2014, based on surveyed bathymetries, and provides a plan for the disposal of up to 130,000 m^3 of sediment over Q1-Q2 2015. The same numerical model simulations undertaken in the previous studies (i.e. P0140-05a,b) have been reproduced here, using the most recent bathymetry of the Heyward Point ground as surveyed at the end of October 2014. The reader is directed to report P0140-05a for a full outline of the methods employed.

2. RESULTS

A bathymetric survey of the Aramoana Beach and Heyward Point disposal grounds in October 2014 provided an updated picture of the seabed morphology following the disposal completed through 2014. The disposal effects on the wave dynamics are assessed in a first part and a plan for the 2015 Q1-Q2 disposal is then proposed.

2.1. Effects of disposal from November 2013 to October 2014

Simulations undertaken in study P0140-05a,b were reproduced using the updated ground bathymetry of October 2014. The November 2013 and October 2014 bathymetries are shown in Figure 2.1.

The recorded disposed volumes throughout the ground (Port Otago Ltd., 2014) are provided in Figure 2.2 and effective total ground volumetric changes over the entire study period are shown in Figure 2.3. The figures show the predominant loading of the existing circular mound area with some additional sediment being disposed along the leeward side of the northwest ridge. Note the differences between recorded and measured changes are due to the progressive morphological adjustments developing during the intervening period.

The total disposed volume over the period is 145,600 m^3 while the measured net volumetric balance of ground area is of around 94,400 m^3. This yields an estimate of the sediment volume dispersion from the ground of approximately 50,000 m^3 over the period (~1 year) and thereby provides a useful empirical indicator of the ground dispersion potential for future disposal planning.

Predicted wave fields over the November 2013 and October 2014 bathymetries are compared in Figure 2.4 andFigure 2.5 for a range of offshore directions. The model consistently predicts a pattern of locally increased wave height (~+20 cm) over and in the lee of the circular mound feature. This can be explained by the shallower mound crest level (9.7 m in 2013, 9.2 m in 2014, see Figure 2.1) focusing more intensely the incoming wave energy. This is however associated with a reduction of the wave heights further in the lee of the mound feature in the direction of Whareakeake point (-5-10cm) which can be attributed to relatively larger wave energy losses by friction during and after the enhanced focusing process over the mound. Absolute wave height reduction along the 6 m contour off the point remain of the order of centimetres for the tested conditions (Figure 2.6) which is within acceptable levels but the overall pattern clearly illustrates the sensitivity of the wave focusing process developing over the ground with respect to the circular mound morphology (i.e. crest level) and how it impacts the resulting wave energy at the Whareakeake surf break.

Note another variation predicted by the model is that the relative build-up of the leeward side of northwest half of the ground (~+0.5 m) generally results in slightly increased wave heights in the lee side directed further east along the coast.

The CGWAVE simulations for idealized surfing conditions (Figure 2.7) confirm that the overall wave focusing process is conserved with a beam of focused wave crests directed to Whareakeake reproduced in both simulations. Wave crest patterns are virtually identical except for a slight reduction of the width of wave crest “beam” directed toward the point.

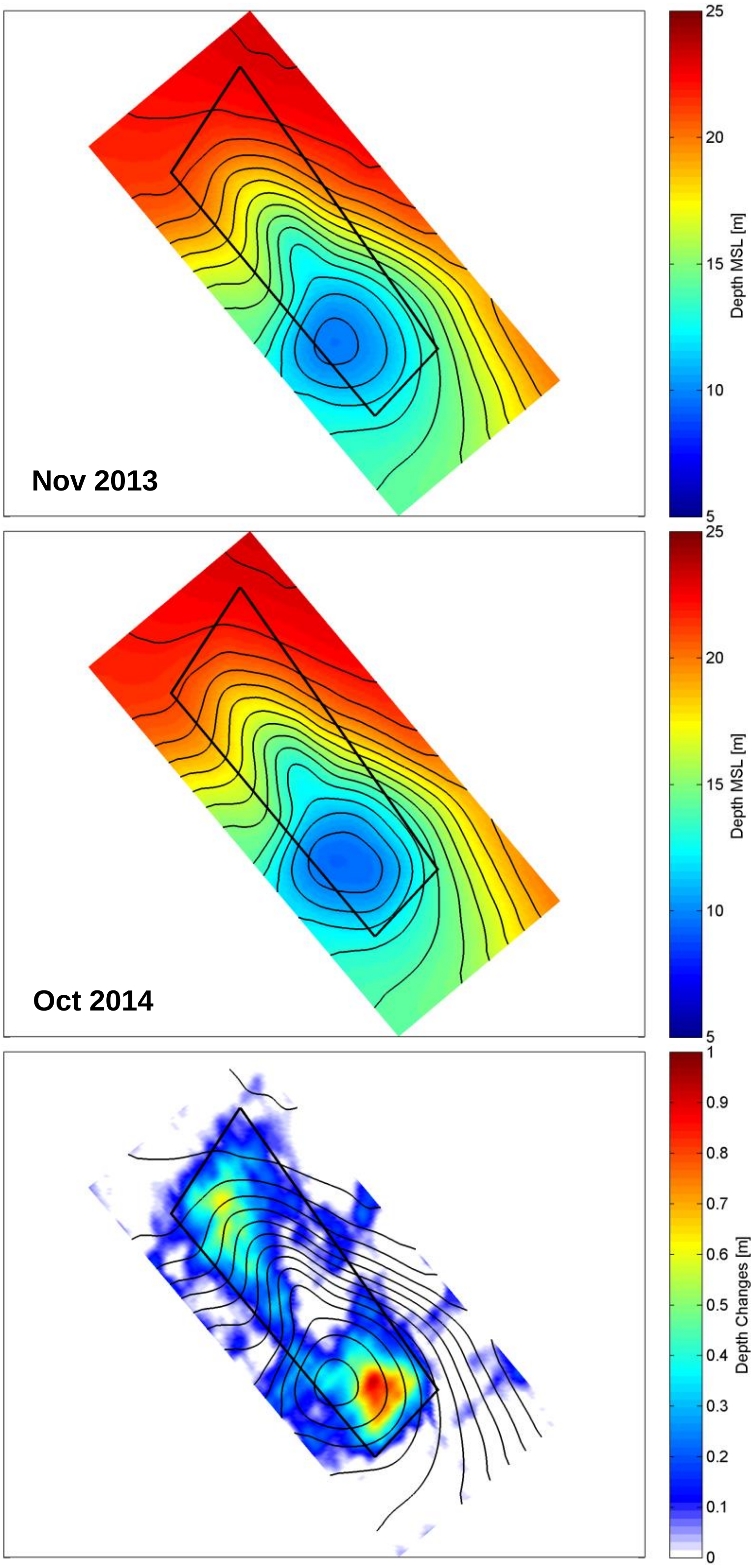

Figure 2.1 Comparison of Nov 2013 (top) and Oct 2014 (middle) bathymetries. The bottom picture shows the depth difference. A positive difference indicates sediment accretion.

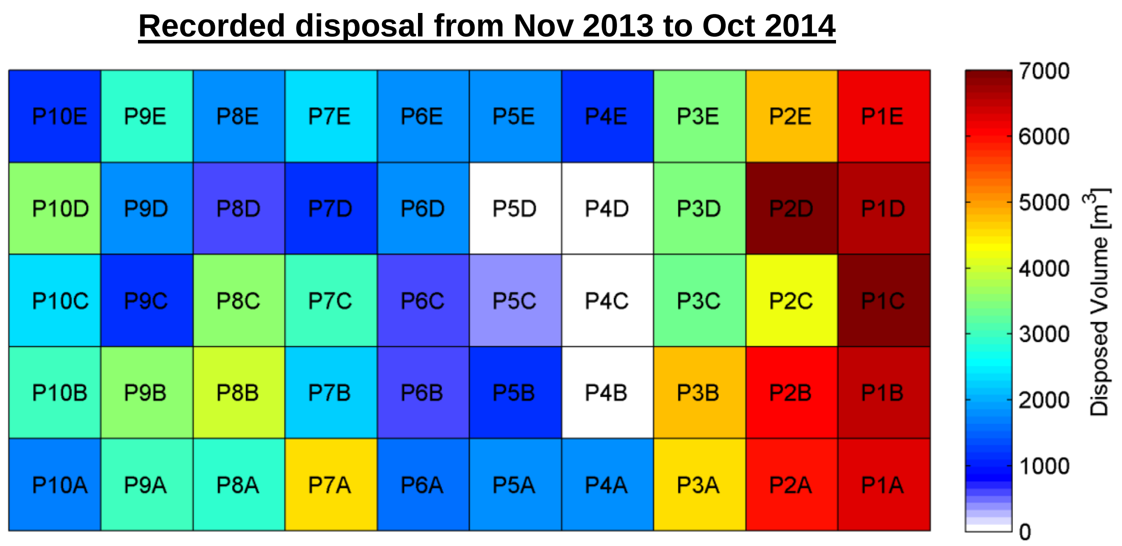

Figure 2.2 Recorded disposal volumes from Nov 2013 to Oct 2014. The total disposed volume over the period is ~ +145600 m^3.

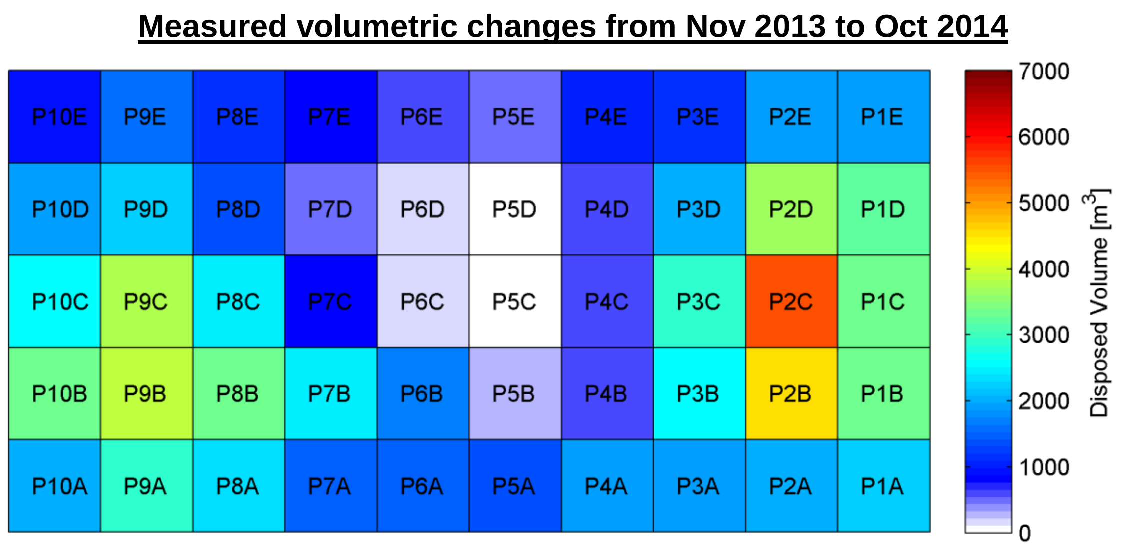

Figure 2.3 Total measured volumetric changes from Nov 2013 to Oct 2014. The net volumetric balance over the period is +94400 m^3.

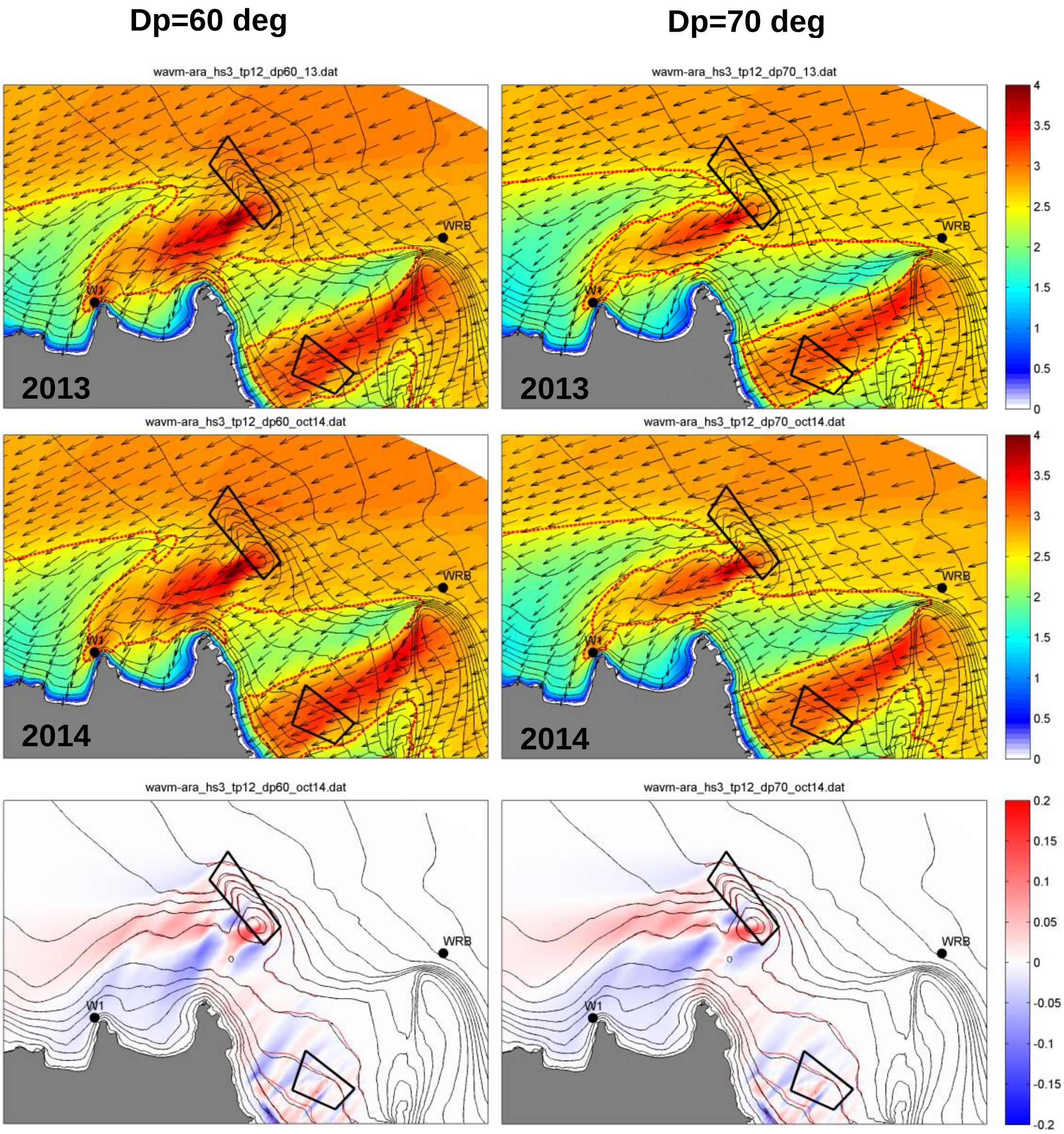

Figure 2.4 Predicted significant wave heights for offshore directions of 60 (left) and 70 (right) degrees over the Nov 2013 (top) and Oct 2014 (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the 2014 bathymetry than over the 2013 bathymetry. 2013 contours are shown in red and 2014 contours are shown in black.

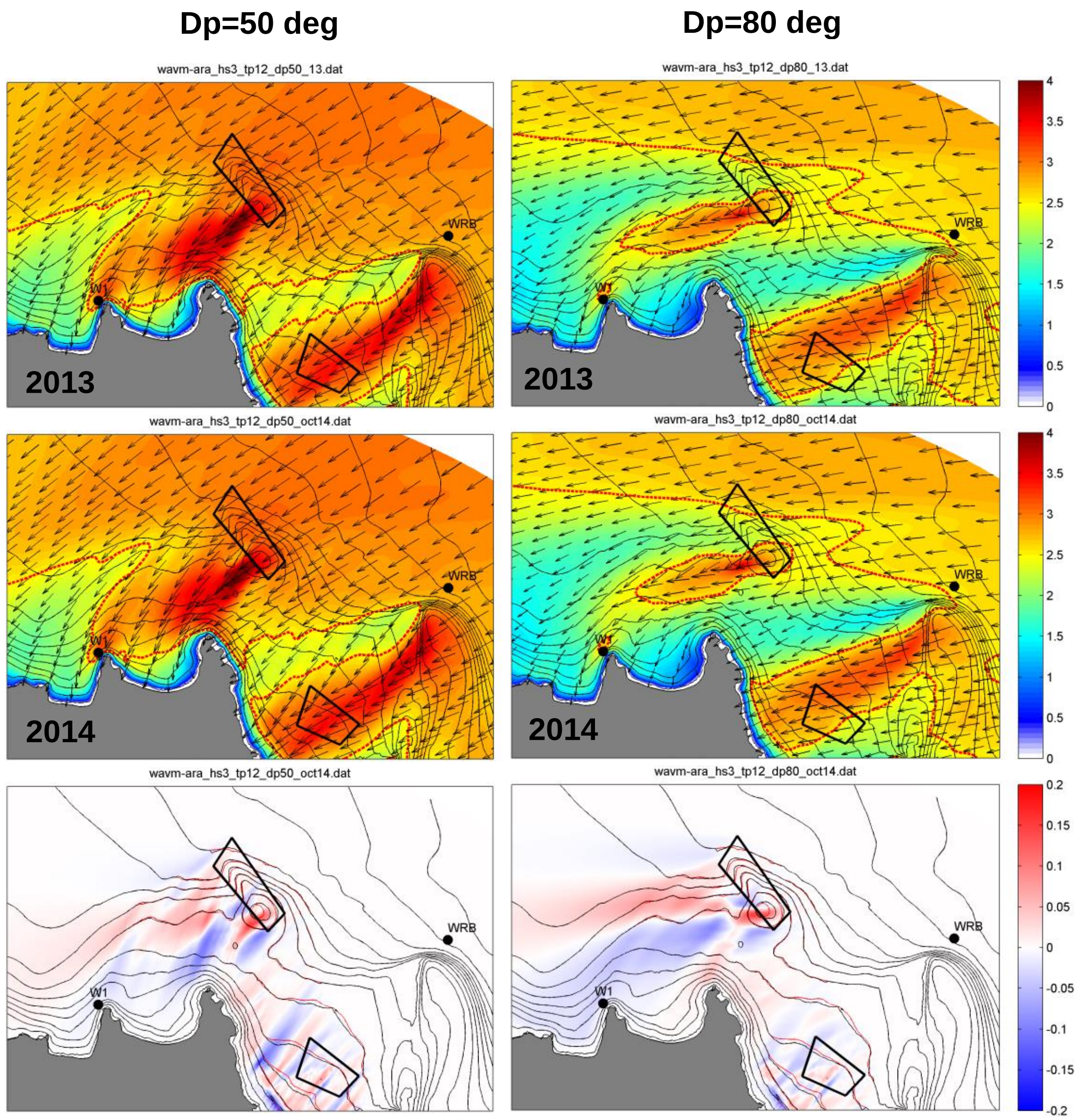

Figure 2.5 Predicted significant wave heights for offshore directions of 50 (left) and 80 (right) degrees over the Nov 2013 (top) and Oct 2014 (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the 2014 bathymetry than over the 2013 bathymetry. 2013 contours are shown in red and 2014 contours are shown in black.

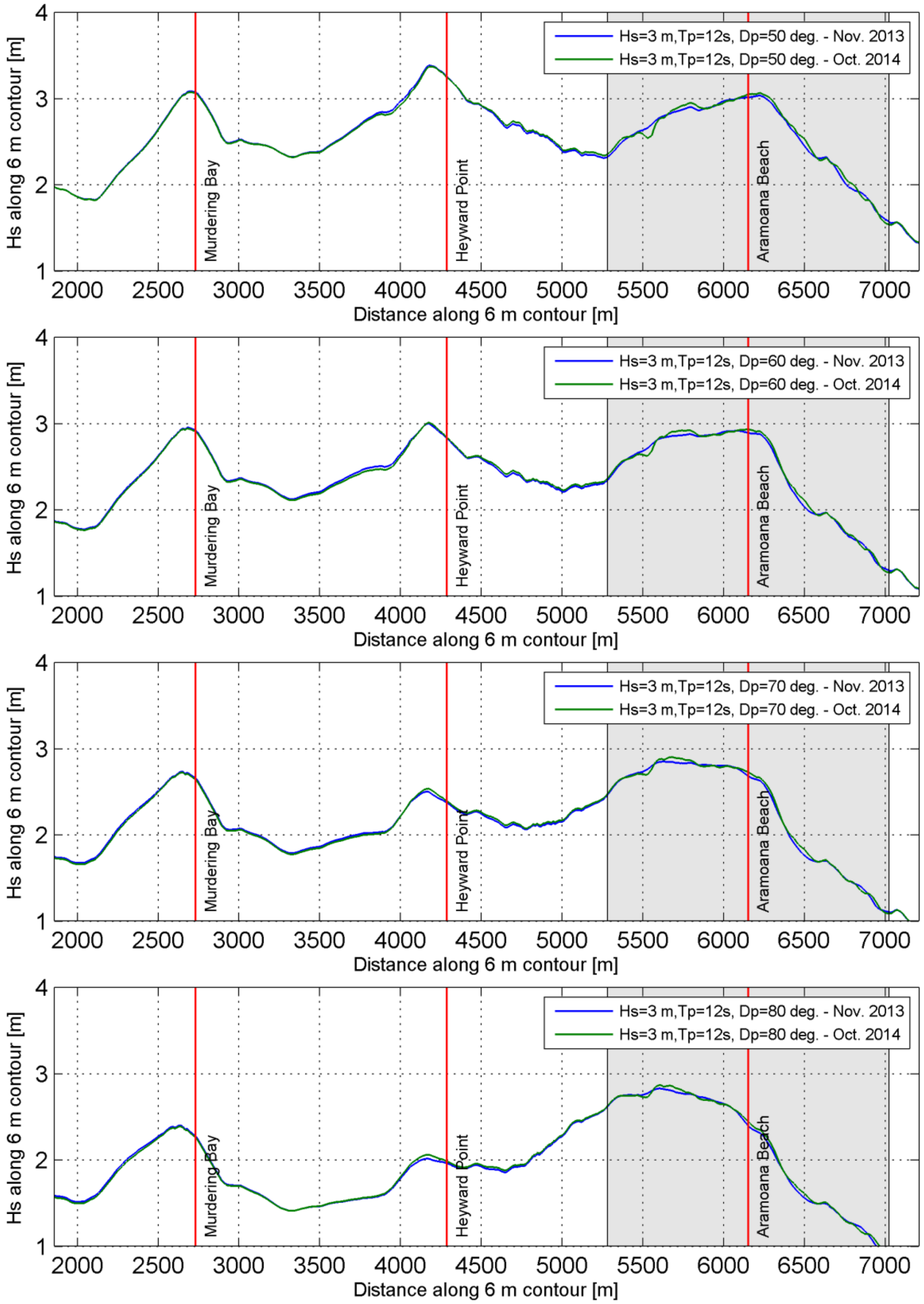

Figure 2.6 Significant wave heights along the 6 m contour for wave incidences of 50, 60, 70, and 80 degrees over the Nov 2013 and Oct 2014 bathymetries.

Table 2.1 Wave conditions at the A0, WRB and W1 sites for all the simulated idealized wave events over the Nov 2013 bathymetry. Significant wave heights (Hs) are in meters, Peak direction (Dp) are degrees, and peak periods (Tp) in seconds.

Nov 2013								
A0 - Site			**WRB - Site**			**W1 - Site**		
Hs (A0)	**Dp (A0)**	**Tp (A0)**	**Hs (WRB)**	**Dp (WRB)**	**Tp (WRB)**	**Hs (W1)**	**Dp (W1)**	**Tp (W1)**
3.0	90	12.0	2.5	88	11.9	2.0	17	11.9
3.0	80	12.0	2.5	84	11.9	2.4	17	11.9
3.0	70	10.0	2.6	72	9.9	2.2	16	10.1
3.0	70	12.0	2.6	76	11.9	2.7	16	11.9
3.0	70	14.0	2.7	84	14.1	2.6	16	14.2
3.0	70	16.0	2.7	84	16.0	2.7	16	16.0
3.0	60	10.0	2.6	64	9.9	2.6	16	10.1
3.0	60	12.0	2.7	68	11.9	2.8	16	11.9
3.0	60	14.0	2.8	68	14.1	3.0	16	14.2
3.0	60	16.0	2.8	72	16.0	3.0	16	16.0
3.0	50	12.0	2.8	60	11.9	2.9	15	11.9
3.0	40	12.0	2.9	52	11.9	2.9	15	11.9

Table 2.2 Wave conditions at the A0, WRB and W1 sites for all the simulated idealized wave events over the Oct 2014 bathymetry. Significant wave heights (Hs) are in meters, Peak direction (Dp) are degrees, and peak periods (Tp) in seconds.

Oct 2014								
A0 - Site			**WRB - Site**			**W1 - Site**		
Hs (A0)	**Dp (A0)**	**Tp (A0)**	**Hs (WRB)**	**Dp (WRB)**	**Tp (WRB)**	**Hs (W1)**	**Dp (W1)**	**Tp (W1)**
3.0	90	12.0	2.5	88	11.9	2.0	17	11.9
3.0	80	12.0	2.5	84	11.9	2.3	17	11.9
3.0	70	10.0	2.6	72	9.9	2.2	16	10.1
3.0	70	12.0	2.6	76	11.9	2.7	16	11.9
3.0	70	14.0	2.7	84	14.1	2.6	16	14.2
3.0	70	16.0	2.7	84	16.0	2.7	16	16.0
3.0	60	10.0	2.6	64	9.9	2.6	16	10.1
3.0	60	12.0	2.7	68	11.9	2.8	16	11.9
3.0	60	14.0	2.8	68	14.1	3.0	16	14.2
3.0	60	16.0	2.8	72	16.0	3.0	16	16.0
3.0	50	12.0	2.8	60	11.9	2.9	15	11.9
3.0	40	12.0	2.9	52	11.9	2.9	15	11.9

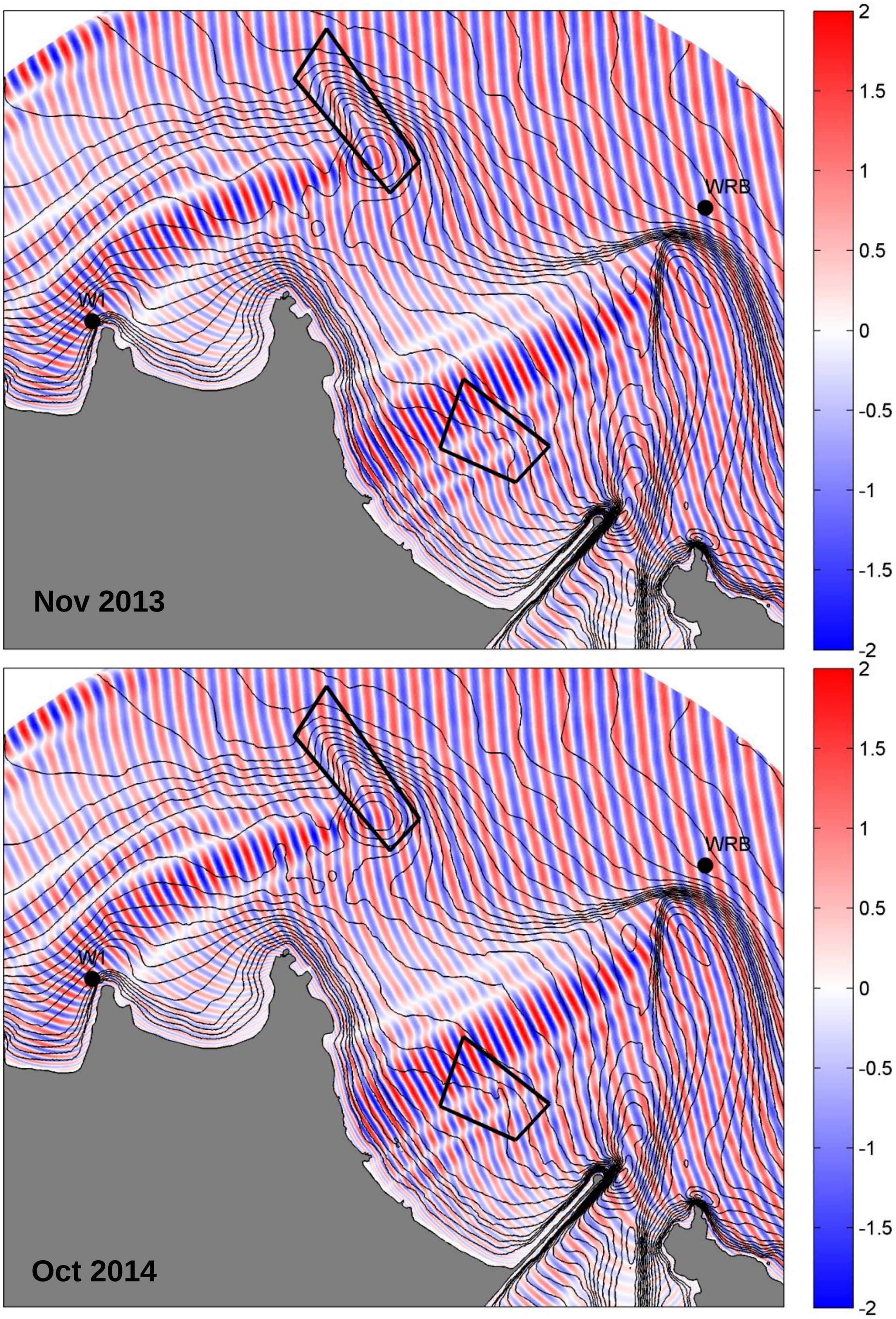

Figure 2.7 Predicted wave crest patterns for a monochromatic surfing wave event Hs=2.6 m Dir=75 deg, Tp=12 sec. over the Nov 2013 (top) and Oct 2014 (bottom) bathymetries.

2.2. Proposed disposal regime for Q1-Q2 2015

The rationale for the 2015 Q1-Q2 disposal plan was to focus the disposal over the circular mound area and reduce the loading of the deeper northwest half of the ground to anticipate the future rock disposal expected during 2015 Q3-Q4 (Port Otago Ltd., pers. communication) that will require these deeper cells. Assuming a total volume of 130,000 m^3 sediment to be disposed over the 6 month period, ~85,000 m^3 were attributed to the 20 south-eastern ground cells (P1 to P4) (Figure 2.8). The actual number of load per cells was adjusted to create a ground bathymetry as smooth as possible, accounting for the previous bathymetric changes (see Figure 2.3). The remaining sediment volume (~45,000 m^3) was spread throughout the rest of the ground relatively homogenously with reduced loads over the northeast-most cells P10 C, D, E and P9 D, E that will receive the rock material over the second half of the year, and very limited volumes over the ridge to prevent any adverse impact of the wave focusing processes as indicated in previous plans (see report P0140-05a, b).

The significant volumes disposed over the circular mound clearly widen the mound feature and raise its crest up to about 8.5 m MSL. This level is shallower than historical levels (i.e. a minimum of 9.2 m was measured in 2010) and should be considered close to the limit level of what can be supported with respect to the wave focusing process developing over the mound and conservation of benefits for surfing. That being, this build-up of the mound is not irreversible and is clearly expected to spread under wave action given the previous modelling (e.g. report P0140-03) as well as historical and recent surveys. This disposal plan, combined with the bi-annual surveys, will provide a good trial to assess the relative dispersion potential of the mound under such an active loading regime.

The proposed disposal plan for 2015 Q1-Q2 is provided in Figure 2.8. An estimate of the post-disposal bathymetry used for the wave modelling was obtained by homogenously spreading the sediment volume to be received in each cell over its surface. The estimated post-disposal bathymetry is compared to the latest surveyed bathymetry of Oct. 2014 in Figure 2.9.

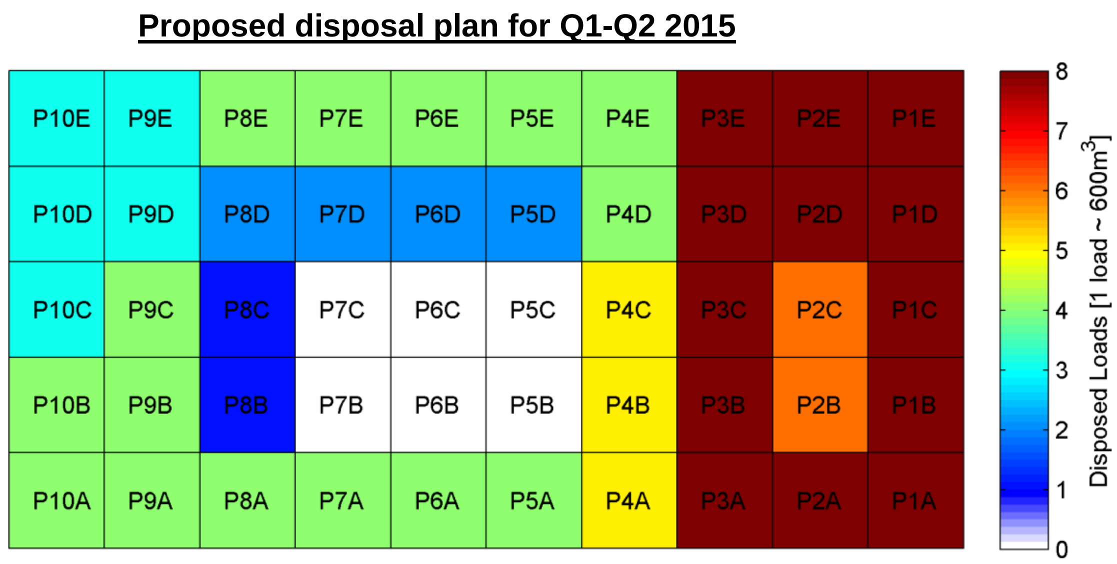

Figure 2.8 Proposed disposal plan for Q1-Q2 2015 totalling ~130,000m^3 of sediment.

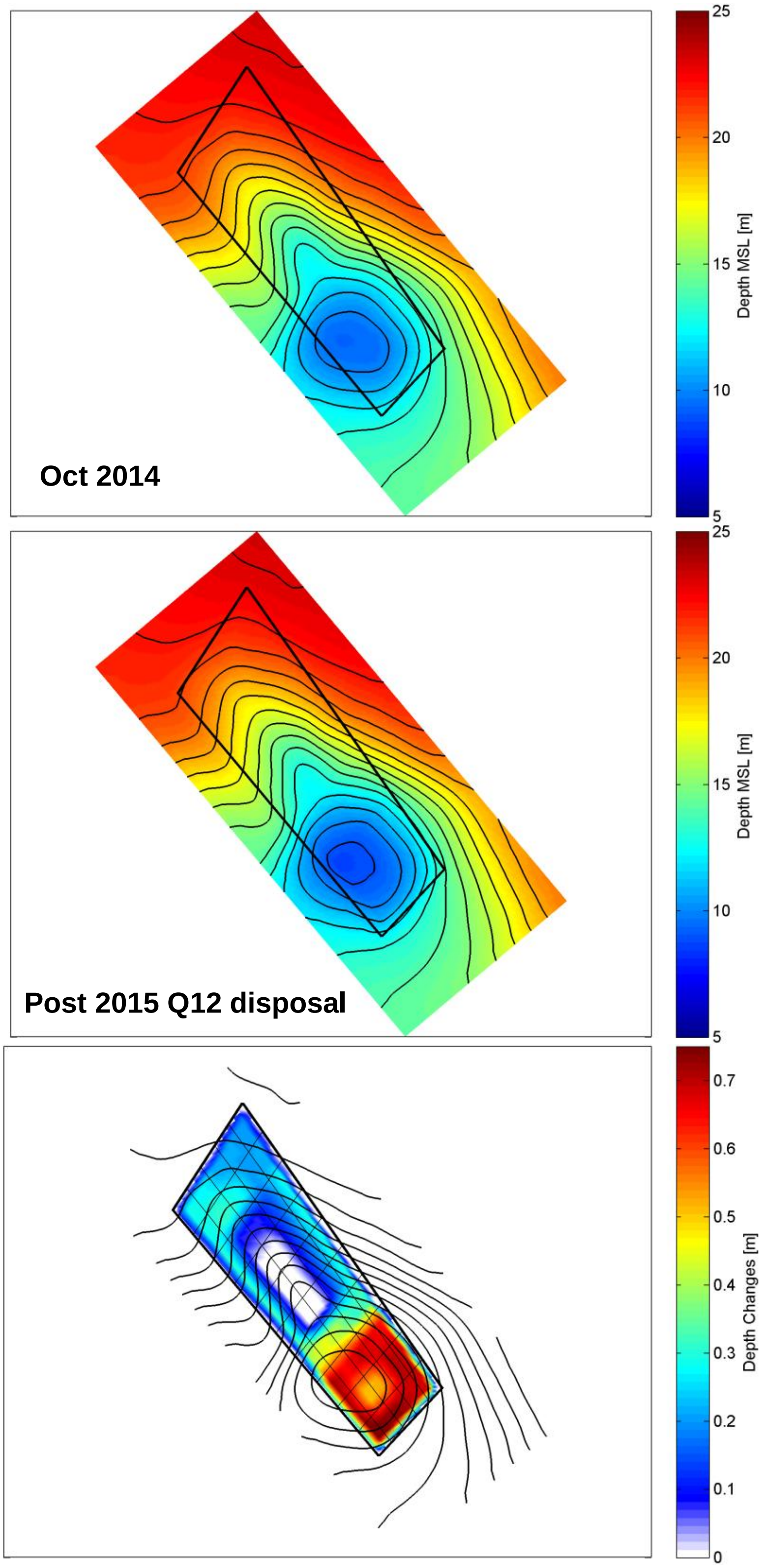

Figure 2.9 Comparison of the Oct 2014 (top) and estimated post Q1-Q2 2015 disposal bathymetries. The bottom picture shows the depth difference. A positive depth difference indicates accretion.

The SWAN simulations reproduced over the post-disposal bathymetry (Figure 2.10 Figure 2.11) yield patterns consistent with these predicted for the 2014 period (Figure 2.4 and Figure 2.5). The larger and shallower post-disposal mound forces more wave focusing and larger wave heights locally but this result in reduced heights further in the lee of the ground and towards Whareakeake point. Absolute wave height reductions off the point are again predicted to be very limited (less than 5 cm, see Figure 2.12) but it is noted they will be cumulative with the previous reduction predicted from Nov 2013 to Oct 2014 (see Figure 2.6).

The CGWAVE simulations suggest the key wave focusing process is conserved over the post-disposal bathymetry (Figure 2.13), however a further reduction of the wave crest "beam" width (~ 50 m) is predicted. Although the relative beam width reduction is small, this feature as well as the cumulative wave height reduction identified above will require particular attention in the next monitoring report at the end of the first half of 2015.

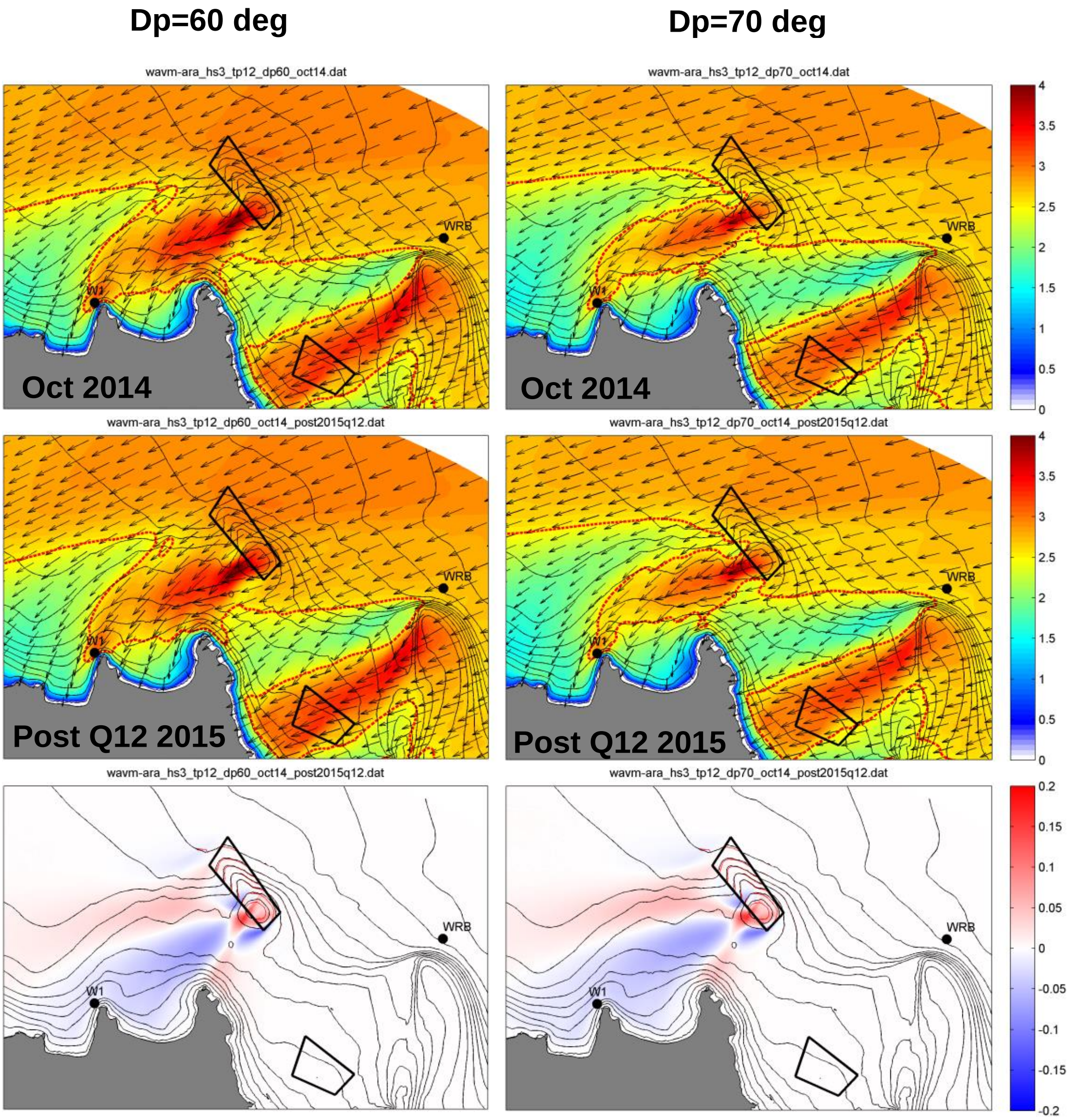

Figure 2.10 Predicted significant wave heights for offshore directions of 60 (left) and 70 (right) degrees over the Oct 2014 (top) and post Q1-Q2 2015 disposal (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the post Q1-Q2 2015 disposal bathymetry than over the Oct 2014 bathymetry. Oct 2014 contours are shown in red and post Q1-Q2 2015 contours are shown in black.

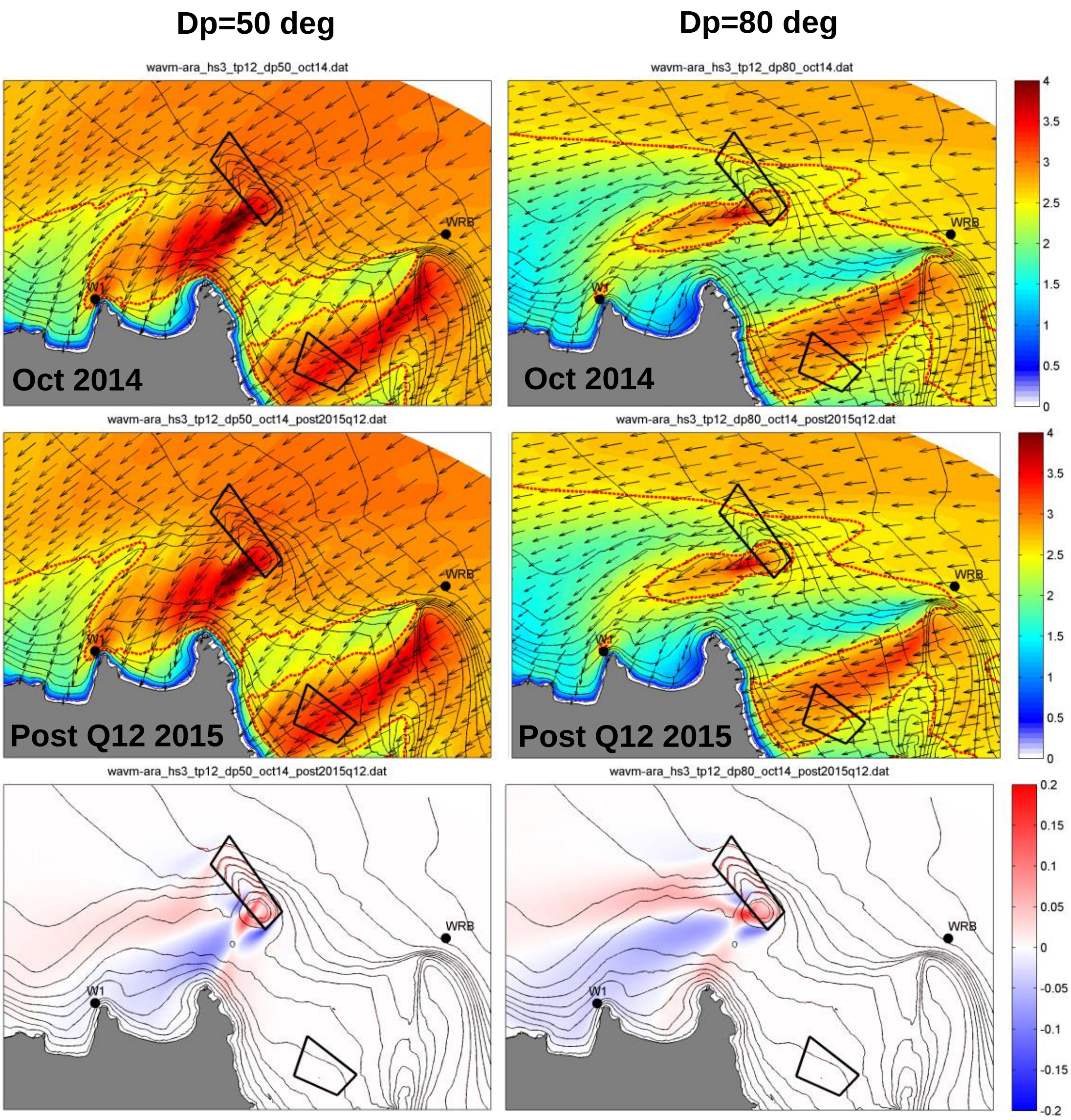

Figure 2.11 Predicted significant wave heights for offshore directions of 50 (left) and 80 (right) degrees over the Oct. 2014 (top) and post Q1-Q2 2015 disposal (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the post Q1-Q2 2015 disposal bathymetry than over the Oct 2014 bathymetry. Oct 2014 contours are shown in red and post Q1-Q2 2015 contours are shown in black.

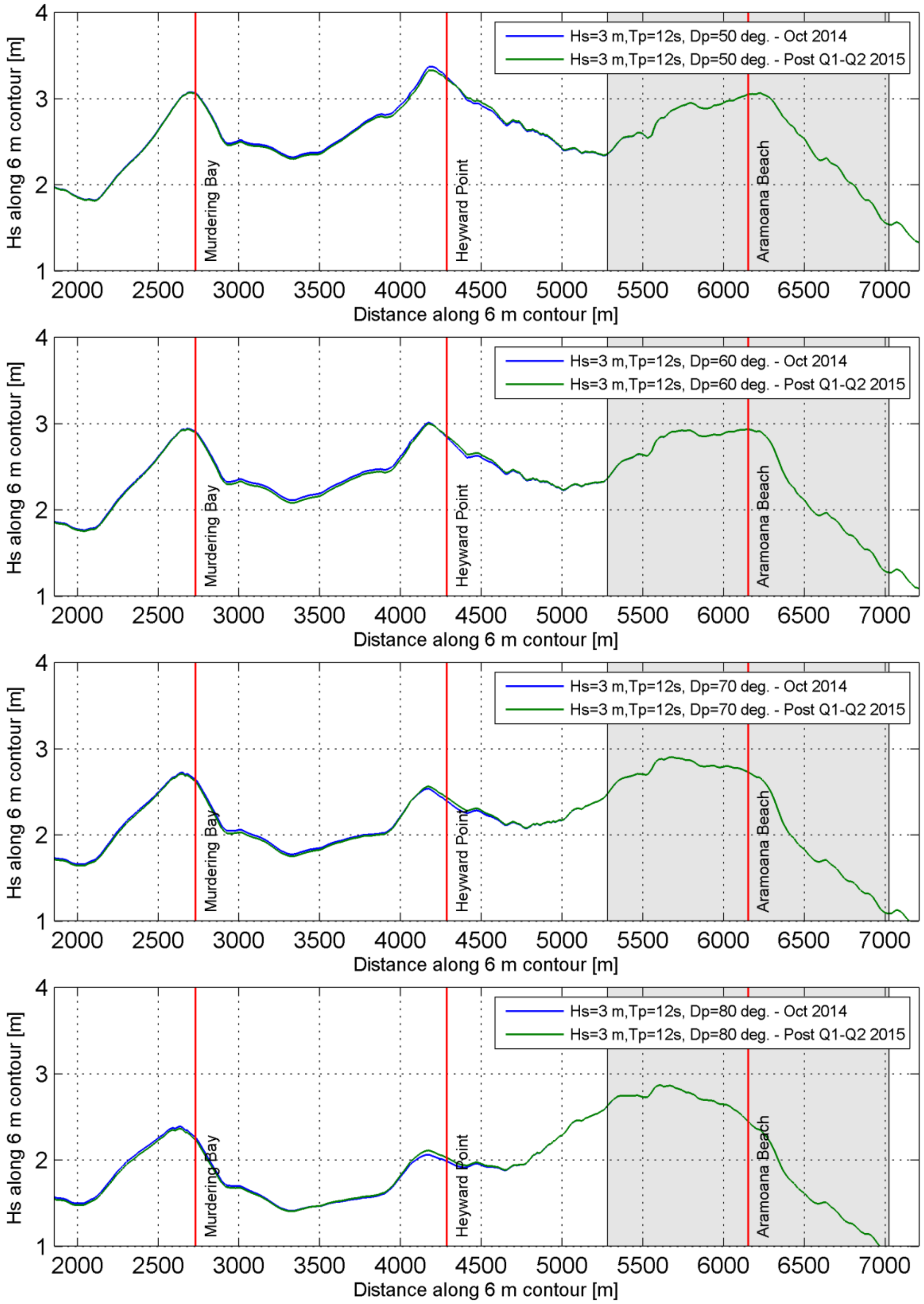

Figure 2.12 Significant wave heights along the 6 m contour for wave incidences of 50, 60, 70, and 80 degrees over the Oct 2014 disposal and post Q1-Q2 2015 disposal bathymetries.

Table 2.3 Wave conditions at the A0, WRB and W1 sites for all the simulated idealized wave events over the estimated post Q1-Q2 2015 disposal bathymetry. Significant wave heights (Hs) are in meters, Peak direction (Dp) are degrees, and peak periods (Tp) in seconds.

Oct 2014 - Post 2015 Q1-Q2										
A0 - Site				**WRB - Site**				**W1 - Site**		
Hs (A0)	**Dp (A0)**	**Tp (A0)**		**Hs (WRB)**	**Dp (WRB)**	**Tp (WRB)**		**Hs (W1)**	**Dp (W1)**	**Tp (W1)**
3.0	90	12.0		2.5	88	11.9		1.9	17	11.9
3.0	80	12.0		2.5	84	11.9		2.3	17	11.9
3.0	70	10.0		2.6	72	9.9		2.2	16	10.0
3.0	70	12.0		2.6	76	11.9		2.6	16	11.9
3.0	70	14.0		2.7	84	14.1		2.6	16	14.2
3.0	70	16.0		2.7	84	16.0		2.7	16	16.0
3.0	60	10.0		2.6	64	9.9		2.6	16	10.1
3.0	60	12.0		2.7	68	11.9		2.8	16	11.9
3.0	60	14.0		2.8	68	14.1		3.0	16	14.2
3.0	60	16.0		2.8	72	16.0		3.0	16	16.0
3.0	50	12.0		2.8	60	11.9		2.9	15	11.9
3.0	40	12.0		2.9	52	11.9		2.9	15	11.9

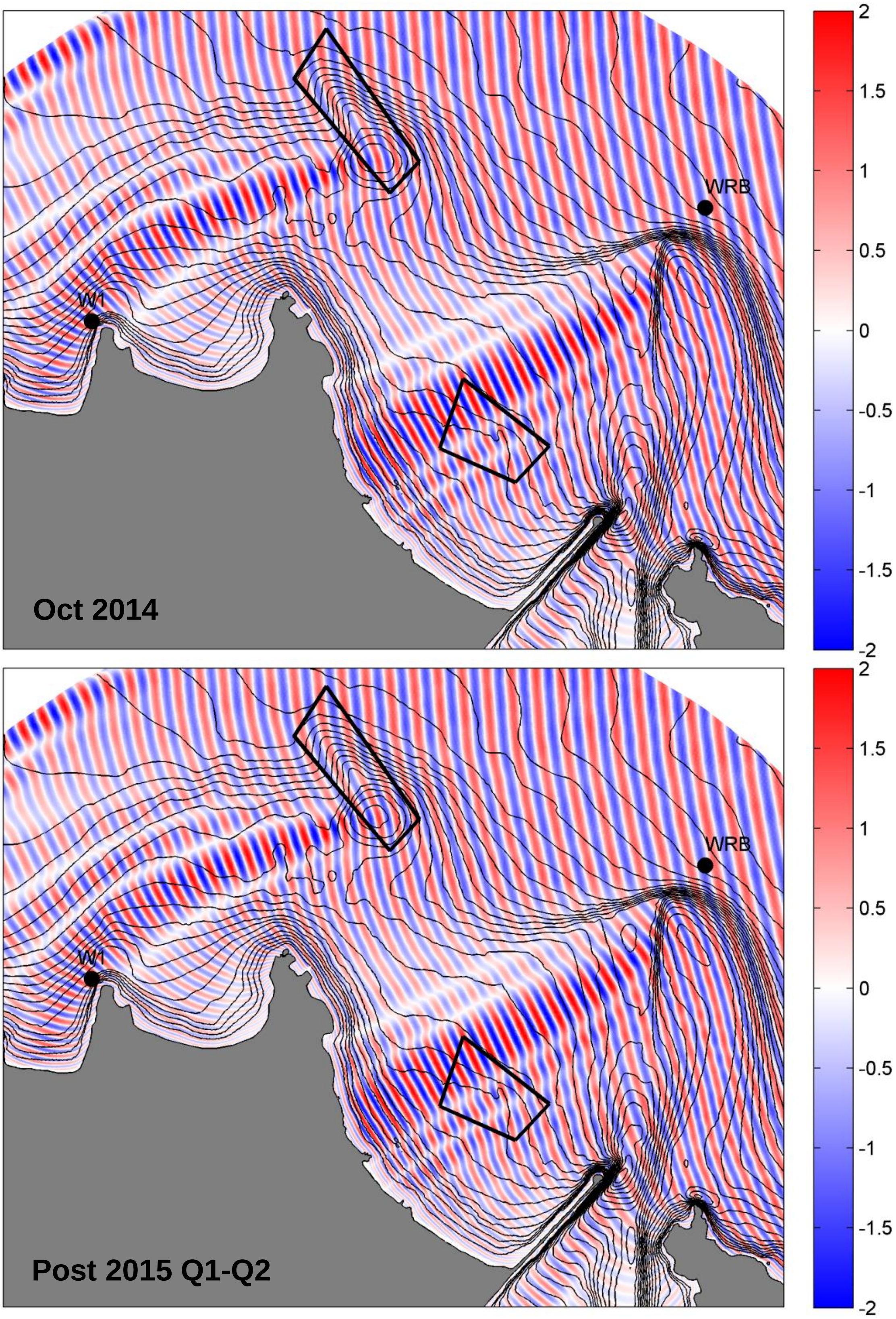

Figure 2.13 Predicted crest patterns for a monochromatic wave event Hs=2.6 m Dir=75 deg, Tp=12 sec., over the Oct 2014 and post Q1-Q2 2015 disposal (bottom) bathymetries.

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