PORT OTAGO DREDGE DISPOSAL GROUNDS

Monitoring effects of the Q1-Q2 2015 disposal at the Heyward Ground and proposed dumping plans for Q3-Q4 2015 at Heyward and Aramoana Grounds

Prepared for Port Otago Limited

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1. INTRODUCTION

This report builds upon the previous series of disposal planning documents (i.e. P0140-05a,b,c) that provide the monitoring and planning of dumping activities for Port Otago. This adaptive management process aims to preserve the wave focusing processes and associated surfing benefits from the morphology of the disposal grounds.

The functional effects of the morphological features of the Heyward disposal ground on the local wave dynamics were investigated in 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. That 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). That report specified a dumping plan for 2014 Q1-Q2 and was followed by report P0140-05b and P0140-05c specifying the dumping plans for Q3-Q4 2014 and Q1-Q2 2015, respectively.

The present report includes an assessment of the effects of the dumping in the Heyward ground from October 2014 to May 2015, based on the latest surveyed bathymetries, and provides plan for the upcoming disposal of up to 100,000 m^3 of sediment over Q3-Q4 2014. In contrast with previous dumping plans which concerned only the Heyward ground, the present plan proposes a split of the sediment load between the Heyward and Aramoana grounds. The reason for this is twofold; i) the capacity of the Heyward ground is close to maximum without having a negative effect on the wave focussing morphology and ii) there is an opportunity to study the potential positive effects on the surfing wave conditions by virtue of constructing a shaped mound of 50,000 m^3 at the Aramoana ground.

The same SWAN and CGWAVE simulations as undertaken in study P0140-05a,b,c have been reproduced here, using the most recent bathymetry of the Heyward Point ground and vicinity (May 2015) as well as estimated bathymetry post 2015 Q3-Q4 disposal.

Aramoana Beach, in the lee of the Aramoana disposal ground, experiences high-quality surfing waves primarily due to strong wave refraction over the tip of submerged offshore ebb delta and the resultant wave-phase separation that occurs (MSL, 2012). Disposal activities within the Aramoana ground require special attention because it is located in the swell corridor between the offshore wave refraction feature and the beach surf zone. Additional modelling focusing on the wave propagation over and in the lee of Aramoana ground was therefore undertaken. Two disposal options are presented, including a trial wave-focusing mound that aims to examine the efficacy of shaped dumping activities to provide positive benefits to the surfing wave conditions.

Readers are directed to report P0140-05a for a detailed description of the numerical methods used in this study.

2. MONITORING RESULTS

A bathymetric survey of the Aramoana Beach and Heyward Point disposal grounds in May 2015 provided an updated picture of the seabed morphology following the disposal that was undertaken since October 2014.

2.1. Heyward ground wave dynamics

The simulations undertaken in study P0140-05a,b,c were reproduced here using the updated ground bathymetry from the survey in May 2015. The October 2014 and May 2015 bathymetries and depth changes are shown in Figure 2.1. The sediment volumes disposed in the Heyward ground for the entire period (i.e. October 2014 to May 2015) and for the period January 2015 to May 2015 (i.e. Q1-Q2 2015) are provided in Figure 2.2 and Figure 2.3 respectively.

The proposed disposal plan for Q1-Q2 2015 and the effective volumetric changes are shown in Figure 2.4 and Figure 2.5. These figures show the predominant loading of the existing circular mound area with some additional sediment being disposed along the sides of the northwest ridge (A and E box lines). The mound loading raised its crest from ~9.2 m, MSL in Oct 2014 to ~ 8.5 m MSL in May 2015.

The recorded sediment disposals are generally consistent with the proposed loading plan. However it appears that the region P3D/P3E received a larger number of loads compared to surroundings cells, which eventually created a small spur in the north side of the circular mound (see Figure 2.1). Likewise, it appears that column 9 (northwest side of the ground) received more loads than originally planned. Close attention to the load placement is needed in future to avoid any further discontinuities developing in the design morphology and management of the ground.

Note there are differences between recorded and measured changes in the ground, and as per the interpretation from the previous reports, these are likely due to the progressive morphological adjustments developing during the study period.

The total disposed volume over the period is 145,800 m^3 while the measured net volumetric balance of ground area is 115,200 m^3. This yields a dispersion of approximately 30,000 m^3 over a 7-month period, which is consistent with the estimate of an annual dispersion rate of around 50,000 m^3 that was obtained in the report P0140c.

Predicted wave fields over the October 2014 and May 2015 bathymetries are compared in Figure 2.6 and Figure 2.7 for a range of offshore wave directions. As observed in the previous reports, 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 (9.2 m in October 2014, 8.5 m in May 2015, see Figure 2.1) focusing more intensely the incoming wave energy. This is again associated with a slight reduction of the wave heights in the lee of the mound in the direction of Whareakeake point (i.e. 5-10 cm reduction). The absolute wave height changes along the 6 m depth contour off the point remains of the order of centimetres for the tested conditions (Figure 2.8) which is considered to be less than significant. 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.

These results clearly illustrate the sensitivity of the wave focusing process developing over the ground with respect to the circular mound morphology (i.e. crest level, mound morphology) and how it can impact the resulting wave energy arriving at the Whareakeake point surf break.

CGWAVE simulations for an idealized surfing event (Figure 2.9) show that the general wave focusing process is conserved with a clear beam of focused wave crests directed to Whareakeake point reproduced in both the October 2014 and May 2015 runs. However, besides modulation the of wave energy magnitude (e.g. Figure 2.6, to Figure 2.8), the present results shows that the shallower mound of May 2015 results in a relative reduction of the focused wave energy “beam” (620 m in Oct 2014 versus 550 m in May 2015 in 6 m water depth). Furthermore, for the wave period tested, the offset in wave crests within the beam relative to the sides are also reduced in May 2015, thus resulting in a beam not as sharply defined as in the October 2014 bathymetry in which the mound was wider and more circular.

Although these results are obtained for an idealized monochromatic wave event with a unique direction, the predicted reduction of the width of the focused wave energy beam can be interpreted as a potential reduction of the optimal swell windows for which the wave focusing over the Heyward ground will benefit surfing at Whareakeake Point.

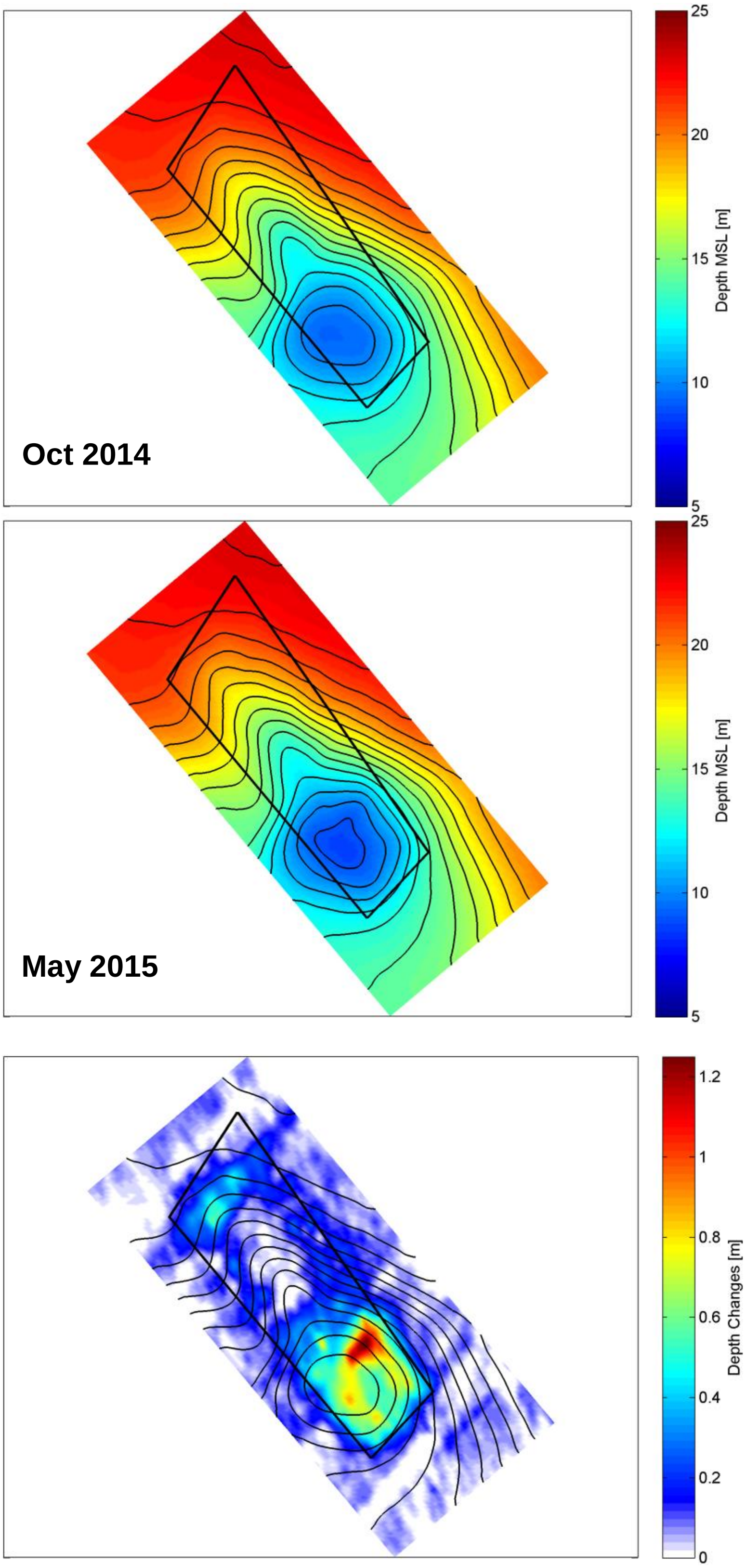


Figure 2.1 Comparison of Oct. 2014 (top) and May 2015 bathymetries. The bottom picture shows the depth difference. A positive difference indicates sediment accretion.

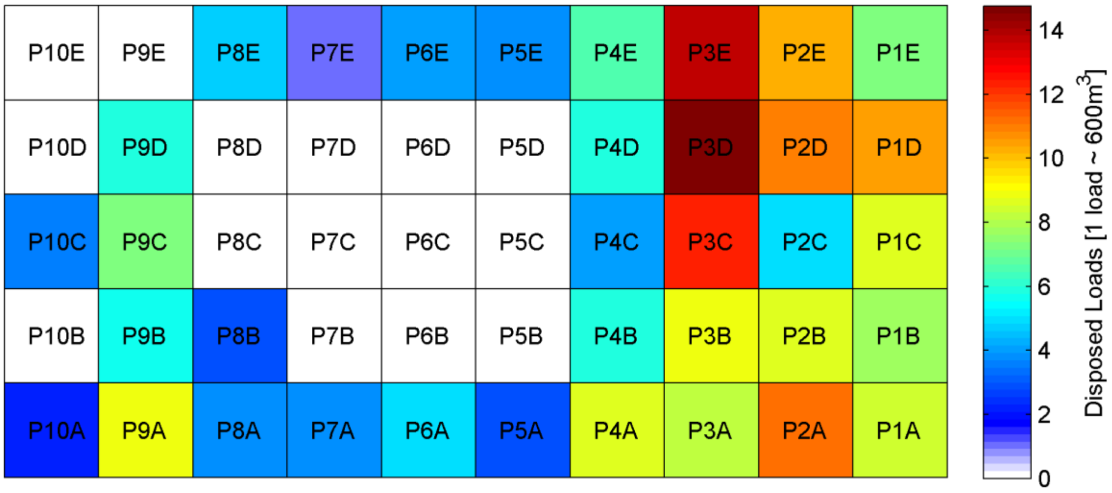


Figure 2.2 Recorded disposal volumes from October 2014 to May 2015. The total disposed volume over the period is 145,815 m^3.

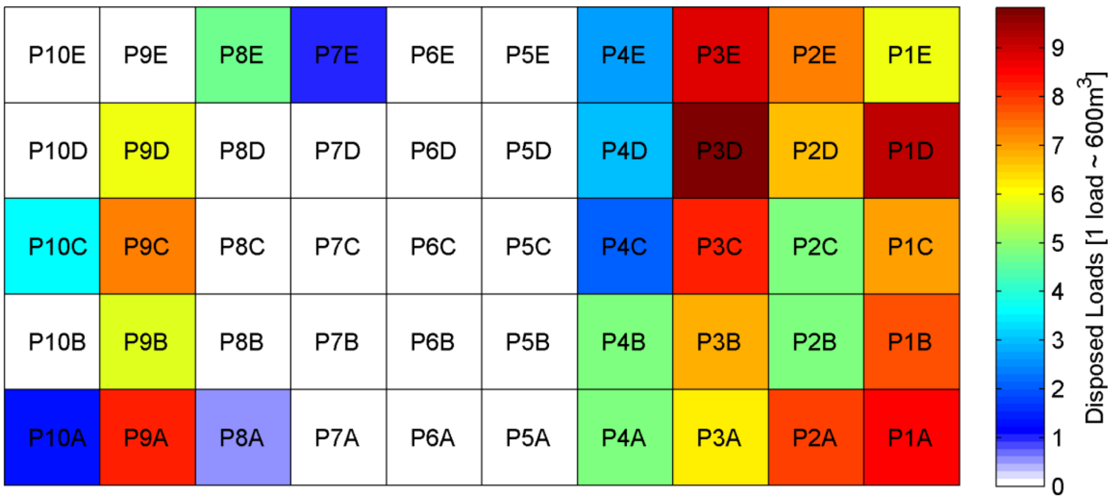


Figure 2.3 Recorded disposal volumes from January 2015 to May 2015. The total disposed volume over the period is 99,215 m^3.

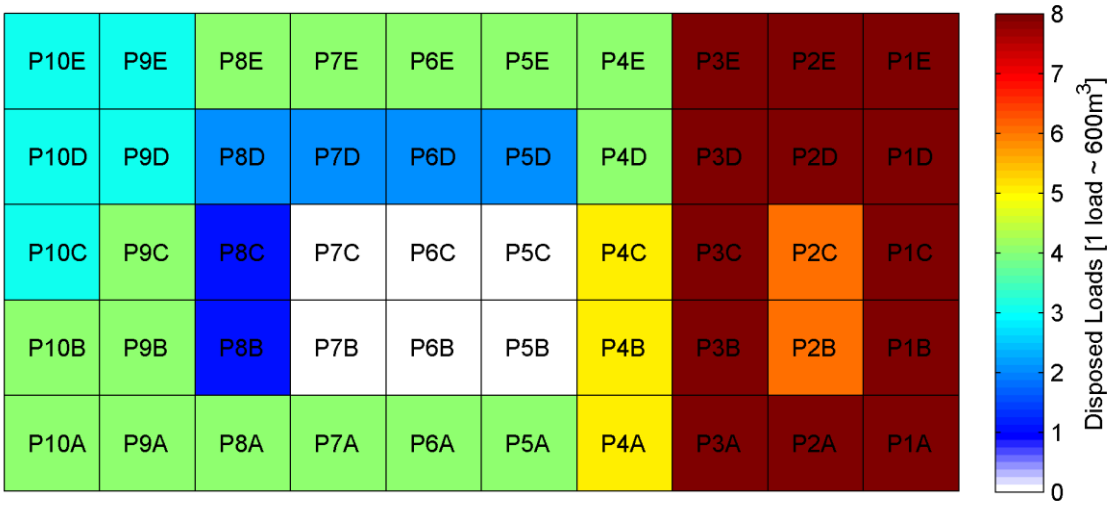


Figure 2.4 The disposal plan for 100,000 m^3 provided for Q1-Q2 2015 in report P0140c.

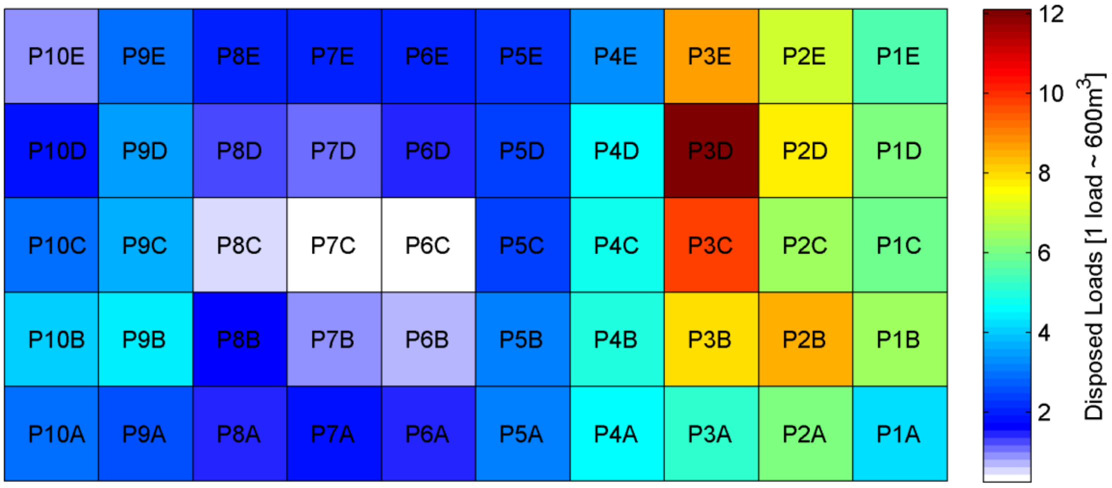


Figure 2.5 Total measured volumetric changes from October 2014 to May 2015. The net volumetric balance over the period is 115,200 m^3.

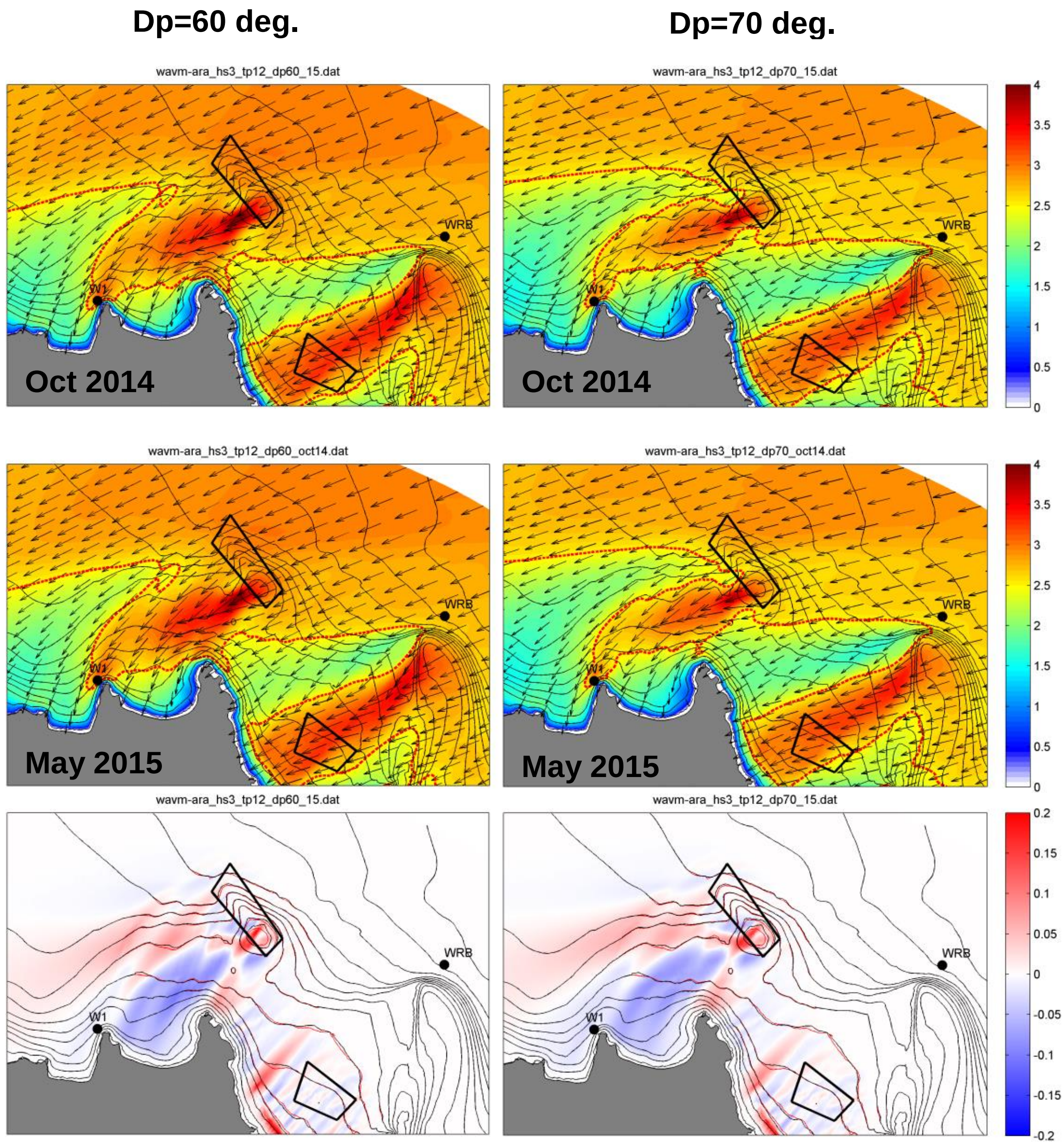


Figure 2.6 Predicted significant wave heights for offshore directions of 60 (left) and 70 (right) degrees over the October 2014 (top) and May 2015 (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the 2015 bathymetry than over the 2014 bathymetry. 2014 contours are shown in red and 2015 contours are shown in black.

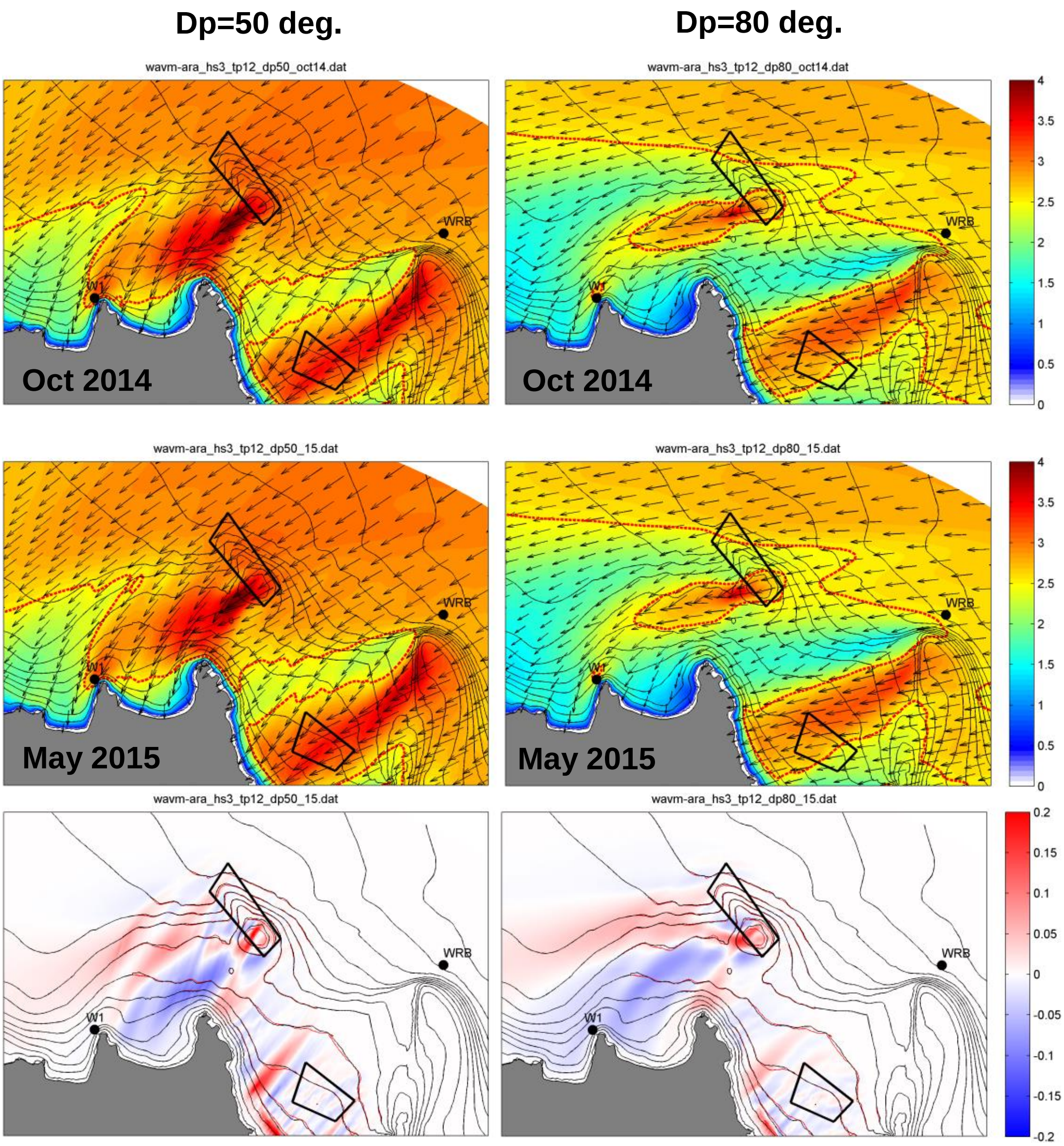


Figure 2.7 Predicted significant wave heights for offshore directions of 50 (left) and 80 (right) degrees over the October 2014 (top) and May 2015 (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the 2015 bathymetry than over the 2014 bathymetry. 2014 contours are shown in red and 2015 contours are shown in black.

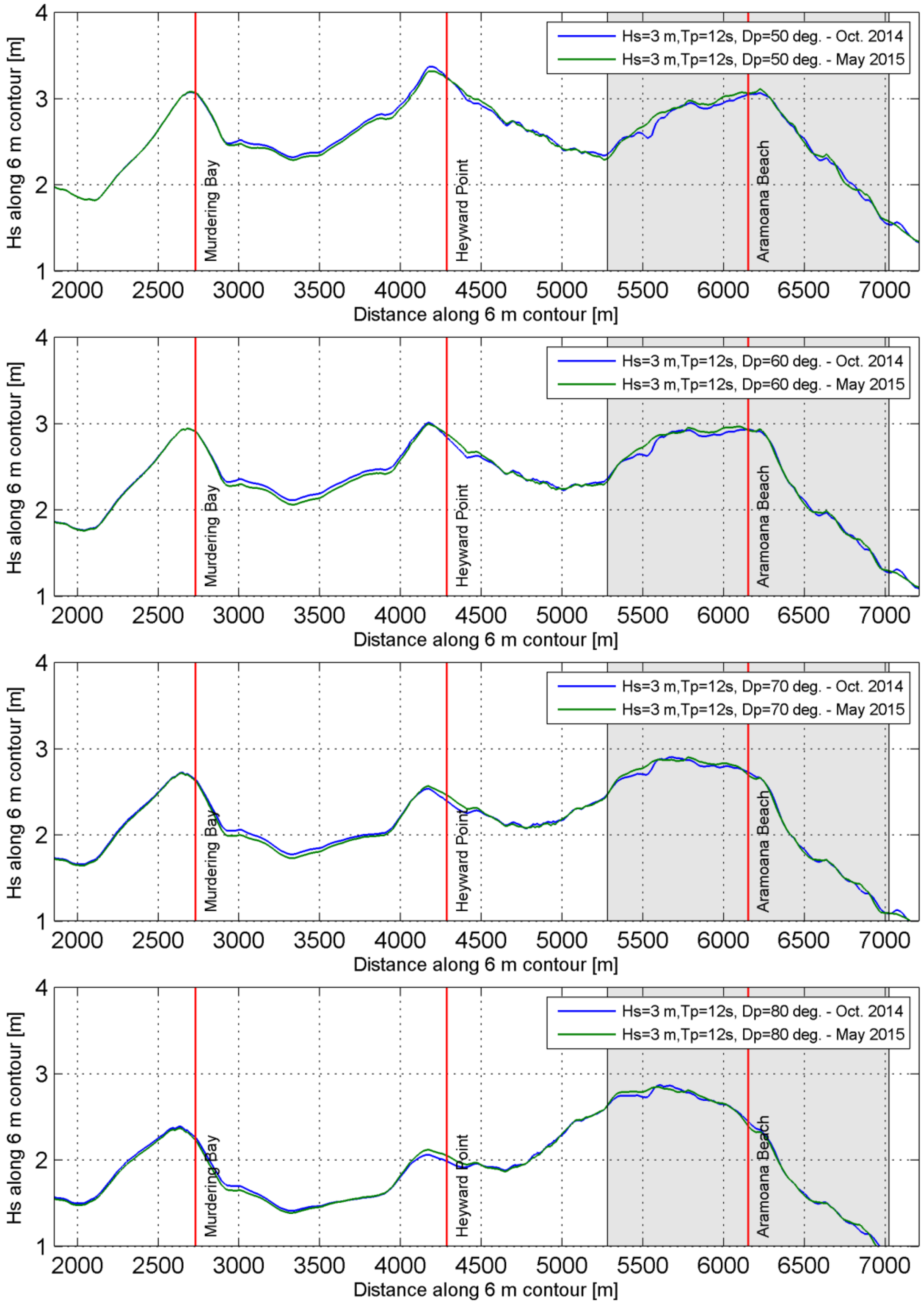


Figure 2.8 Significant wave heights along the 6 m depth contour for wave direction incidences of 50, 60, 70, and 80 degrees over the October 2014 and May 2015 bathymetries.

Table 2.1 Wave conditions at the A0, WRB and W1 sites for all the simulated idealized wave events over the October 2014 bathymetry. Significant wave heights (Hs) are in meters, Peak direction (Dp) are degrees, and peak periods (Tp) in seconds.

Oct 2014 - Measured								
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

Table 2.2 Wave conditions at the A0, WRB and W1 sites for all the simulated idealized wave events over the May 2015 bathymetry. Significant wave heights (Hs) are in meters, Peak direction (Dp) are degrees, and peak periods (Tp) in seconds.

May 2015 - Measured								
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	10.1
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

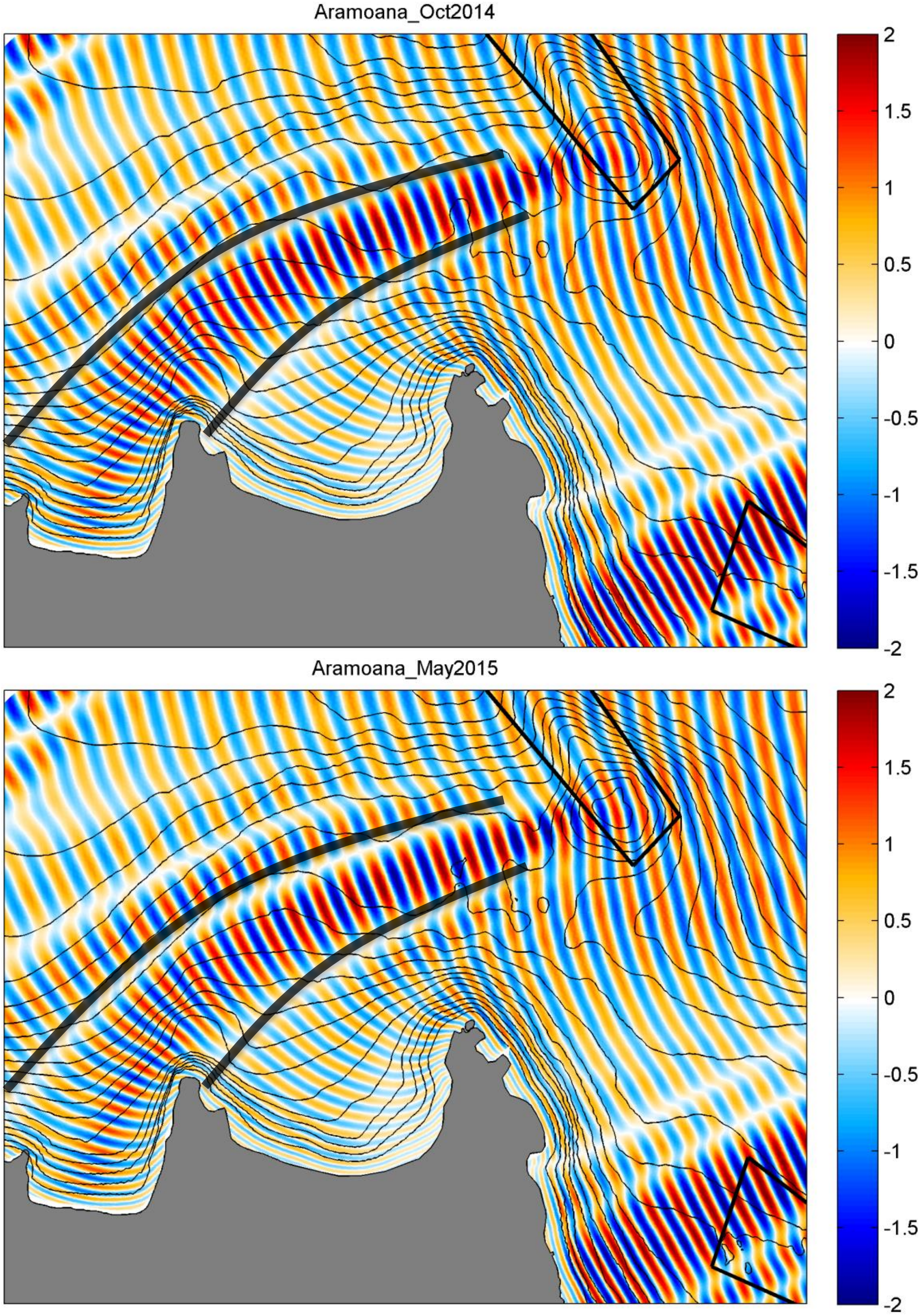


Figure 2.9 Predicted wave crest patterns for a monochromatic surfing wave event Hs=2.6 m Dir=75 deg, Tp=12 sec. over the Oct. 2014 (top) and May 2015 (bottom) bathymetries. The black curves are added to show the relative reduction of the beam of focused waves in May 2015.

3. PROPOSED DISPOSAL REGIME FOR Q3-Q4 2015

Results of the previous section suggest that the cumulative effects of the previous disposals in the Heyward ground are starting to exhibit measurable effects on the wave dynamics, and further deposition needs to be carefully considered within the context of the effects on the surf quality and long term capacity of this area to receive sediment. Accordingly, it is proposed to reduce the disposal volume for Q3-Q4 2015 to 50,000 m^3 to allow the mound morphology to re-equilibrate, and place the remaining 50,000 m^3 in the Aramoana ground. Details of the proposed plan are provided in the following sections.

3.1. Heyward ground plan

The disposal plan for Q3-Q4 2015 includes a reduction of the total load to 50,000 m^3 to allow the circular mound morphology to be re-established. With respect to the sediment repartitioning, the circular mound in southeast section of the ground will receive ~20,000 m^3 and the northwest third receives a similar volume. Here the loading of the mound does not increase its current crest level, which remains at ~8.5 m MSL. The remaining sediment volume (~10,000 m^3) is placed in the middle third of the ground along the A and E lines to avoid any growth of the existing spur (see Figure 3.1).

It is expected that disposal of ~12,000 m^3 of rock material from the channel is required in Q3-Q4 2015. Rock material will be static once disposed of, effectively capping the underlying mobile sediments. Therefore, it is proposed to place this material in the deepest cells of the ground to limit effects on wave refraction (P8E, P9E, P10E, P9D, P1010D and P10C).

The proposed disposal plan is shown on Figure 3.1; an estimate of the post-disposal bathymetry used for the SWAN and CGWAVE 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 May 2012 in Figure 3.2.

The SWAN wave model simulations reproduced over the post-disposal bathymetry (Figure 3.3 and Figure 3.4) yield patterns consistent with these predicted for the October 2014 to May 2015 period (Figure 2.6, Figure 2.7). The predicted changes are very small, of the order +-0.1 m in the vicinity of the mound and insignificant at Whareakeake. The CGWAVE simulations over the May 2015 and post Q3-Q4 disposal bathymetries are included in Figure 3.6 and show very similar patterns.

The port dredging requirements for Q3-Q4 2015 may include a volume of silt, up to 35,000 m^3. To accommodate this volume in addition to the 50,000 m^3 of sandy material it is proposed to place this material in the northwest corner, on top of the rocky material. This operation will need to be supported by an interim bathymetric survey and an update of the disposal plan to be sure that detrimental morphological changes are not created.

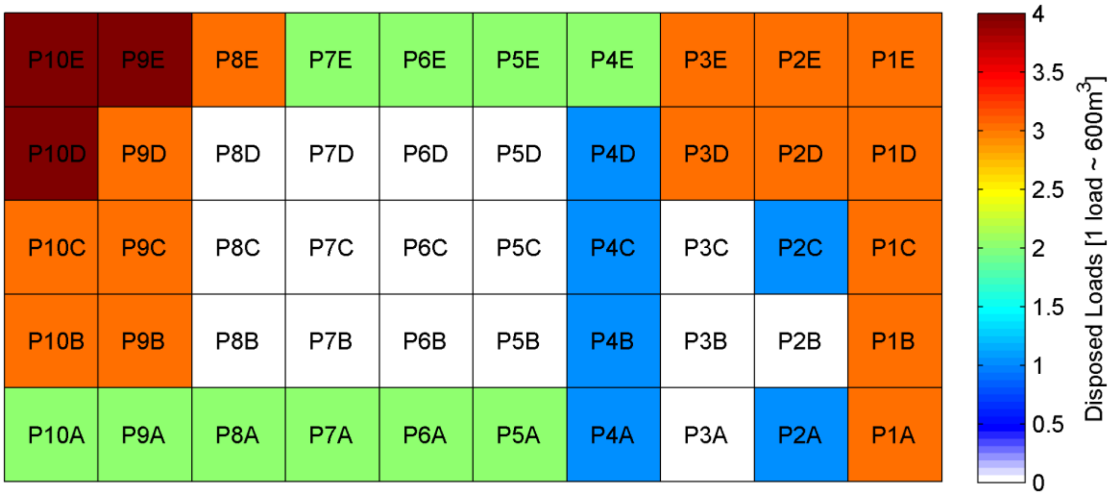


Figure 3.1 Proposed disposal plan for Q3-Q4 2015 at the Heyward ground, featuring 50,000 m^3 of sandy sediments. Rock material (up to 12,000 m^3) should go in cells P8E, P9E, P10E, P9D, P1010D and P10C.

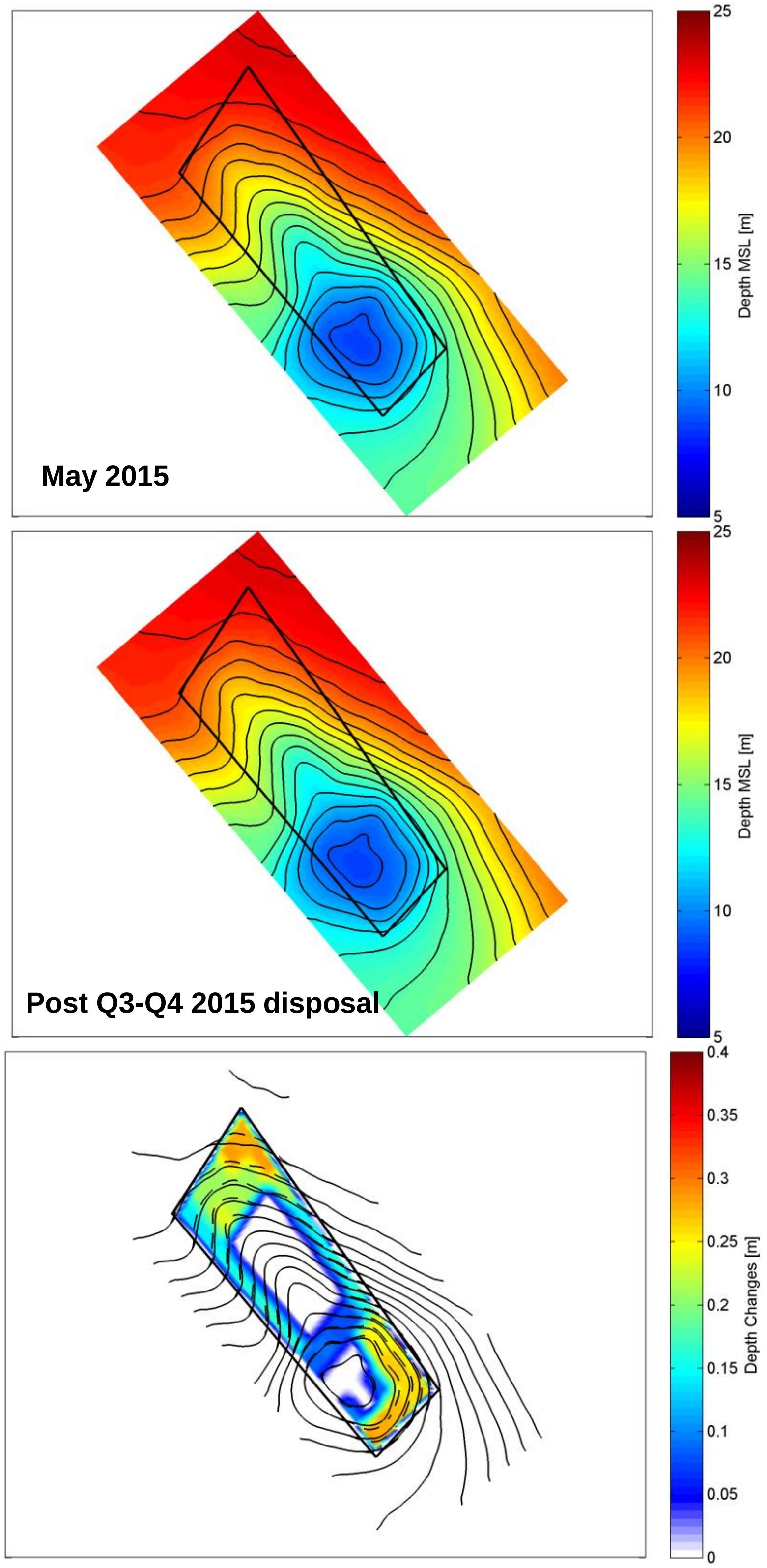


Figure 3.2 Comparison of the May 2015 (top) and estimated post Q3-Q4 2015 disposal bathymetries. The bottom picture shows the depth difference. A positive depth difference indicates accretion.

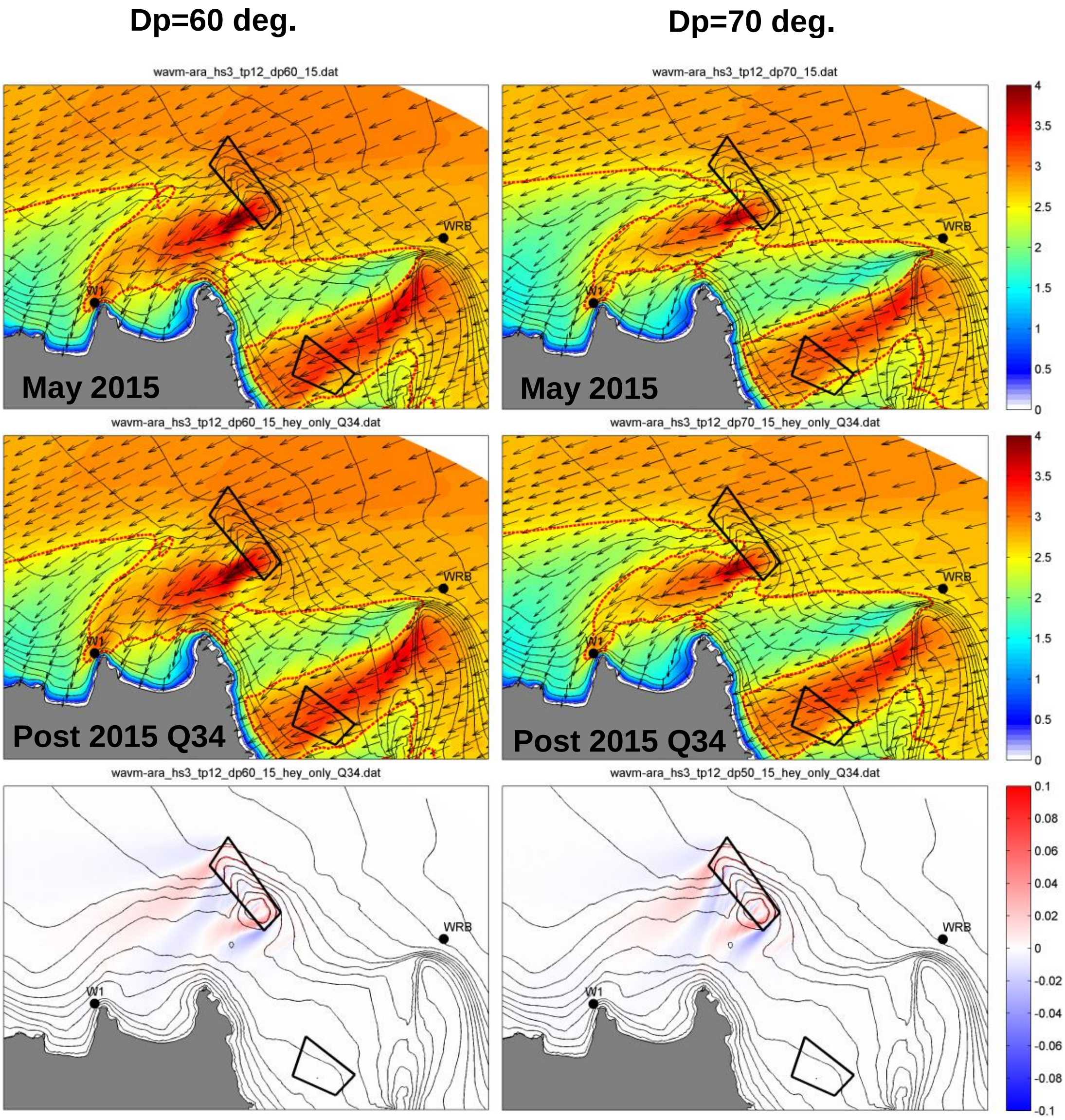


Figure 3.3 Predicted significant wave heights for offshore directions of 60 (left) and 70 (right) degrees over the May 2015 (top) and post Q3-Q4 2015 disposal (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the post Q3-Q4 2015 disposal bathymetry than over the May 2015 bathymetry. May 2015 contours are shown in red and post Q3-Q4 2015 contours are shown in black.

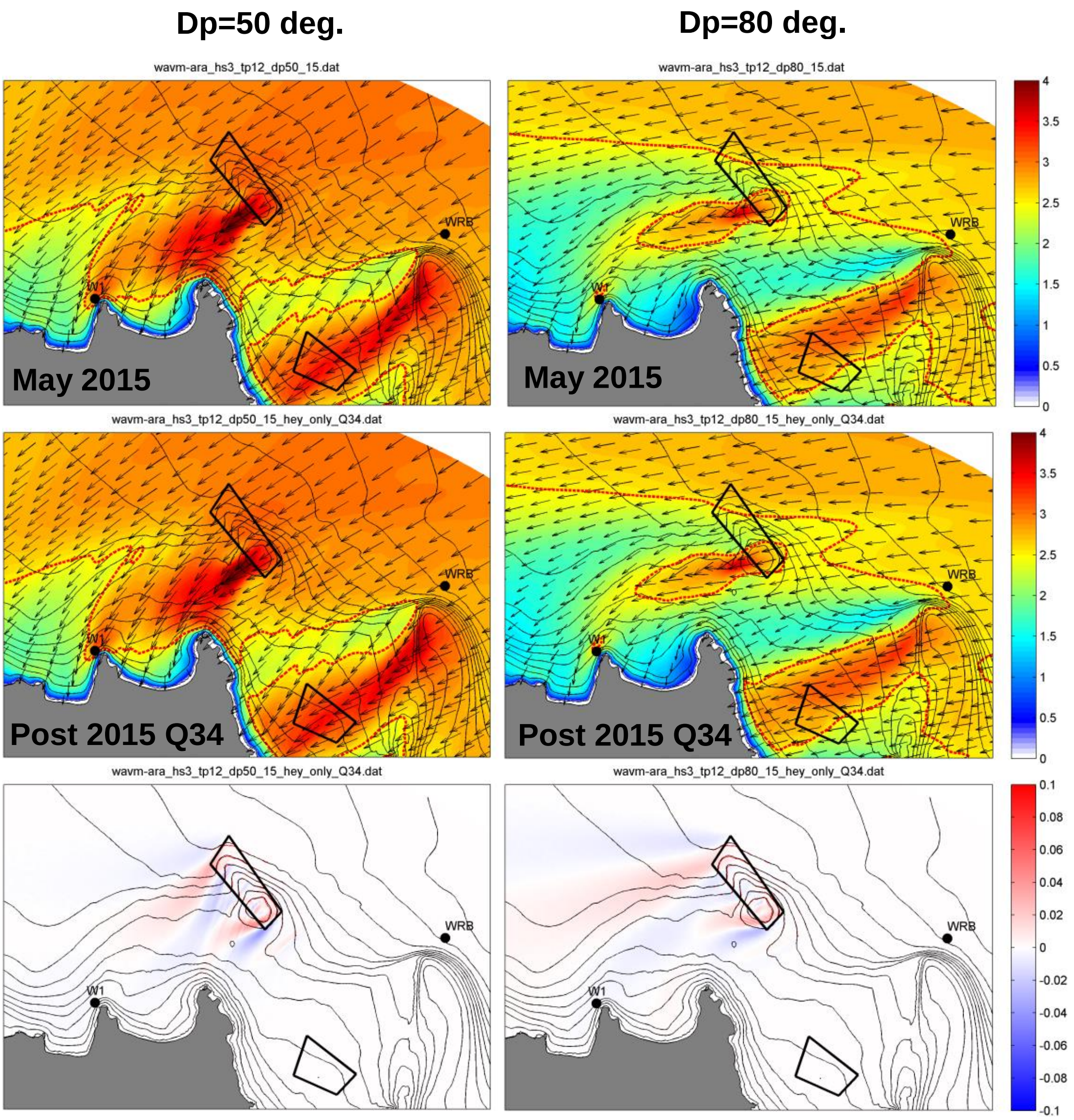


Figure 3.4 Predicted significant wave heights for offshore directions of 50 (left) and 80 (right) degrees over the May 2015 (top) and post Q3-Q4 2015 disposal (middle) bathymetries and differences (bottom). The dotted red line is the 2.5 m wave height contour (top, middle). In difference maps (bottom), positive values indicate wave height larger over the post Q3-Q4 2015 disposal bathymetry than over the May 2015 bathymetry. May 2015 contours are shown in red and post Q3-Q4 2015 contours are shown in black.

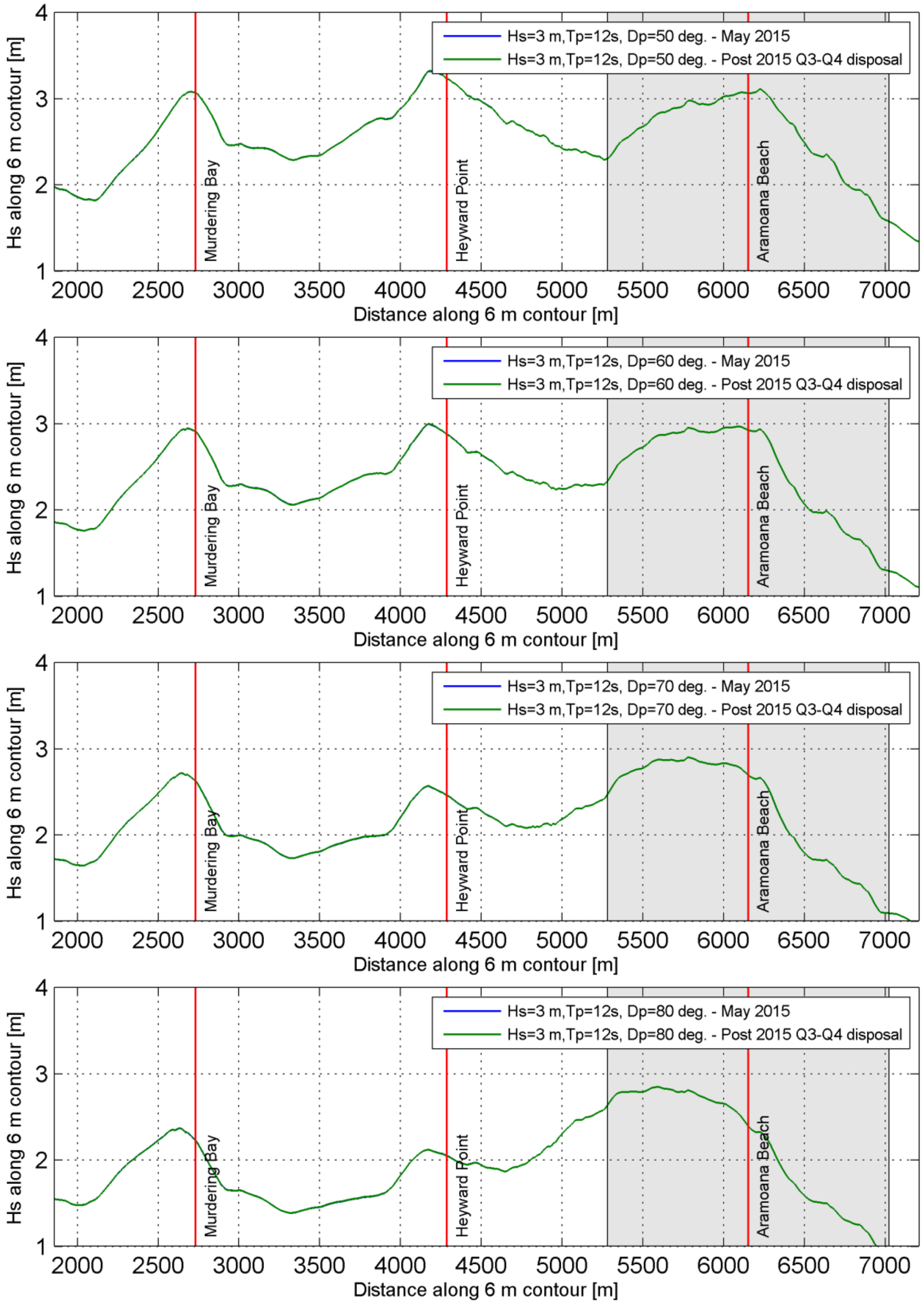


Figure 3.5 Significant wave heights along the 6 m depth contour for wave direction incidences of 50, 60, 70, and 80 degrees over the May 2015 disposal and post Q3-Q4 2015 disposal bathymetries.

Table 3.1 Wave conditions at the A0, WRB and W1 sites for all the simulated idealized wave events over the estimated post Q3-Q4 2015 disposal bathymetry. Significant wave heights (Hs) are in meters, Peak direction (Dp) are degrees, and peak periods (Tp) in seconds.

Post Q3-Q4 2015 disposal								
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	10.1
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

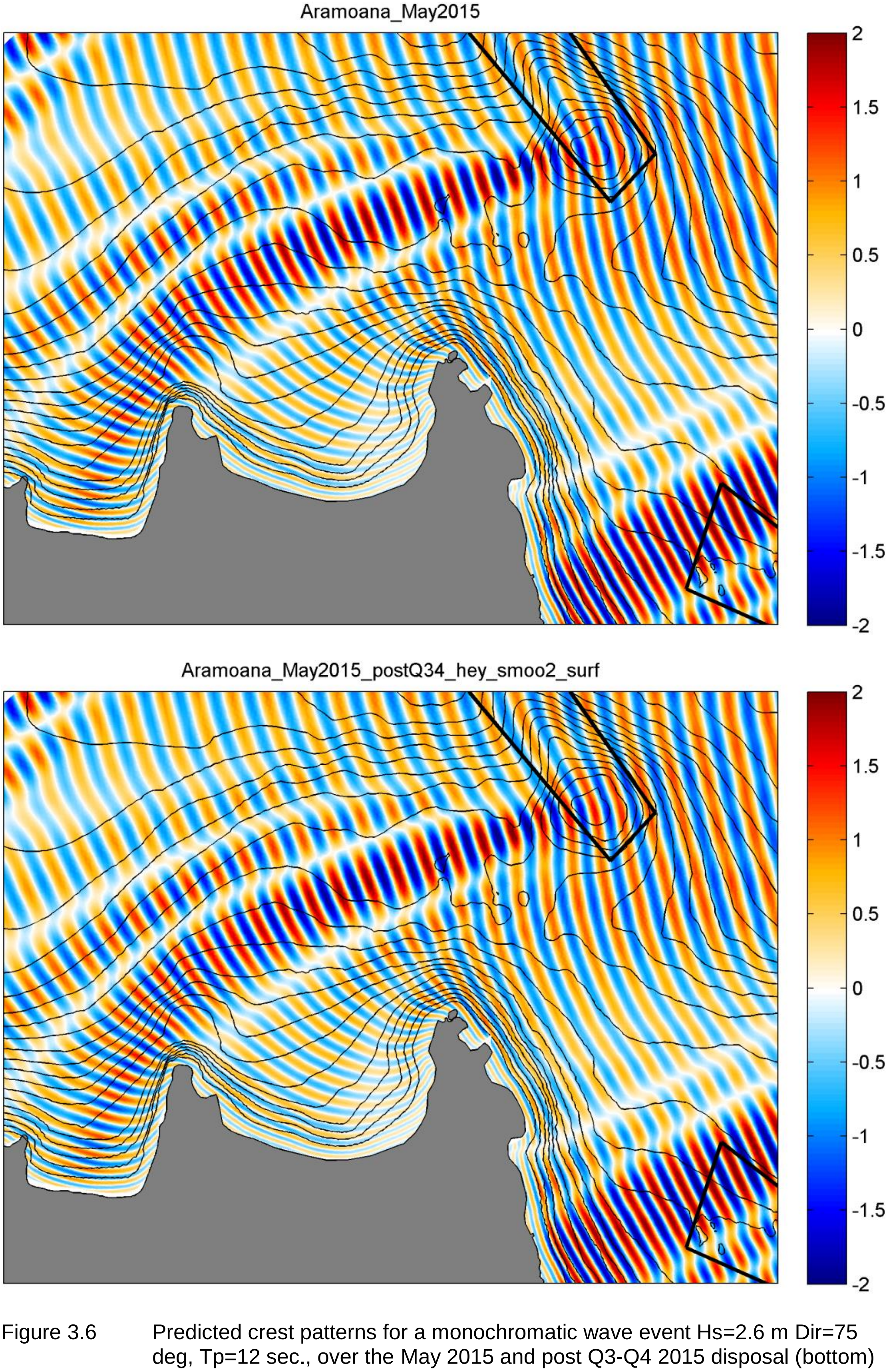


Figure 3.6 Predicted crest patterns for a monochromatic wave event Hs=2.6 m Dir=75 deg, Tp=12 sec., over the May 2015 and post Q3-Q4 2015 disposal (bottom) bathymetries.

3.2. Aramoana ground plan

The Aramoana ground has been subject to active sediment disposal over the previous 20 years, with some 100-200,000 m^3 per year disposed here in the initial years. This deposition has bathymetric signatures that are visible in historical near-shore contours presented in Figure 3.7 (2002-2007). From 2008-2009 onwards, very little spoil has been placed at Aramoana, and the dumped sediments have progressively migrated onshore and fed the near-shore beach system (see report P0140-03). This response can also be seen in Figure 3.7 with a progressive offshore translation of the 5, 6, 7 m contours from 2010-2014. Interestingly though, the 2015 contours are consistently shifted onshore by 20-30 m relative to the 2014 positions. This onshore translation suggests a relaxation of the sedimentary system following many years of regular deposition.

Complete cessation of dumping at Aramoana in the last two years has allowed the surfing wave dynamics to be monitored with the view to developing a base line for future effects assessments. For Q3-Q4 2015 it is proposed that 50,000 m^3 of clean sandy sediments is placed in the ground to test the efficacy of a shaped mound to enhance surf conditions on the beach. Such an offshore wave focusing structure can potentially produce a wave height gradient along the beach and / or introduce localise phase-shifting of the wave crests, both of which have the potential to improve surfability on a planar beach.

Accordingly, a range of wave model tests were undertaken to examine height, orientation, length and width. The optimum morphology was found to be a structure that is 350 m and 50 m wide and 3 m high, located along the south-eastern margin of the ground and some ~800 m from the shore. The predicted effects of this feature on the wave climate are presented in Figure 3.9. The mound aims to improving surfing conditions in the central beach, in the general vicinity of the carpark (under most swell directions). Here the wave heights are typically lower than the beach to the northeast, and this location will not interfere with the primary swell corridor that exists in the direct lee of the offshore bar.

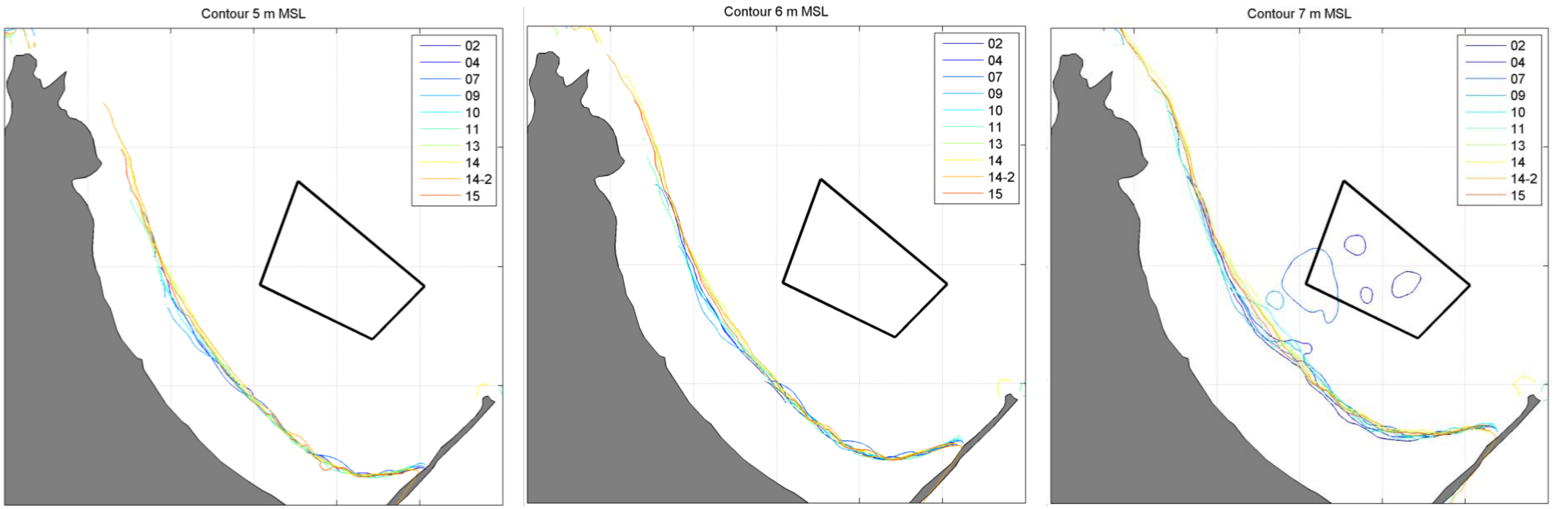


Figure 3.7 Historical bathymetric contours at 5, 6,and 7 m MSL from 2002 to 2015.

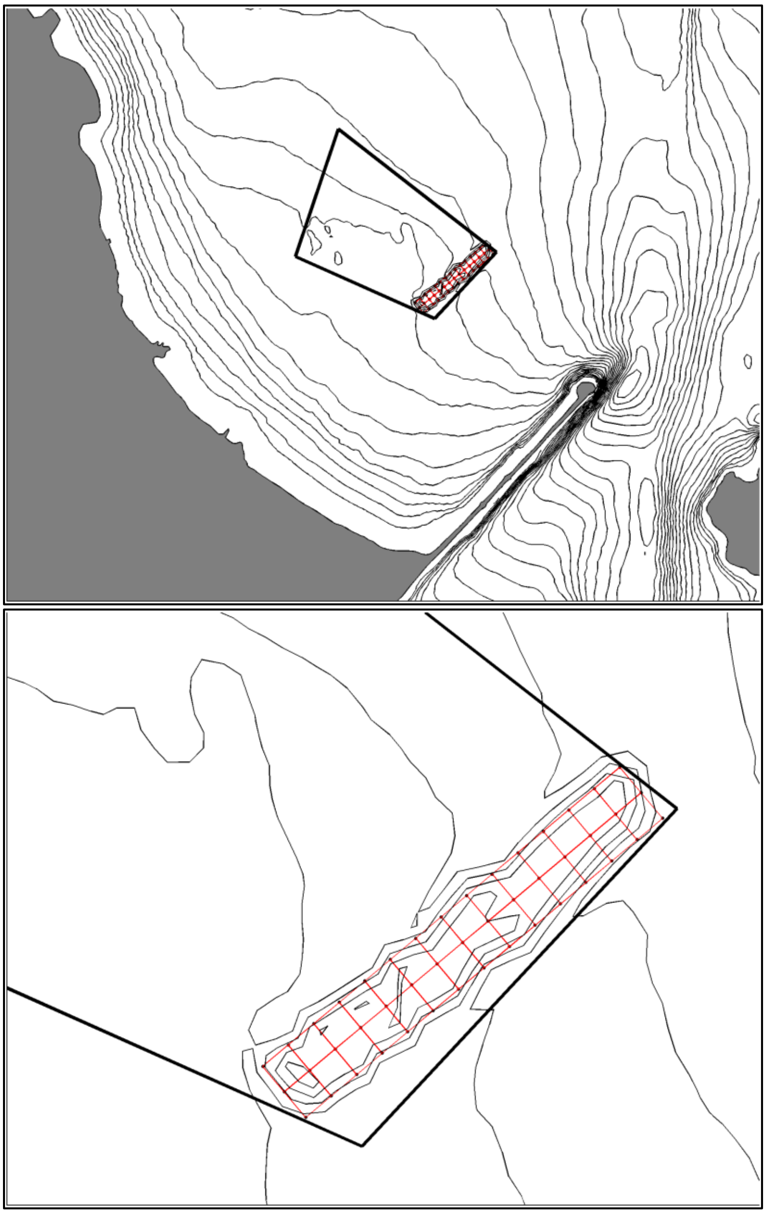
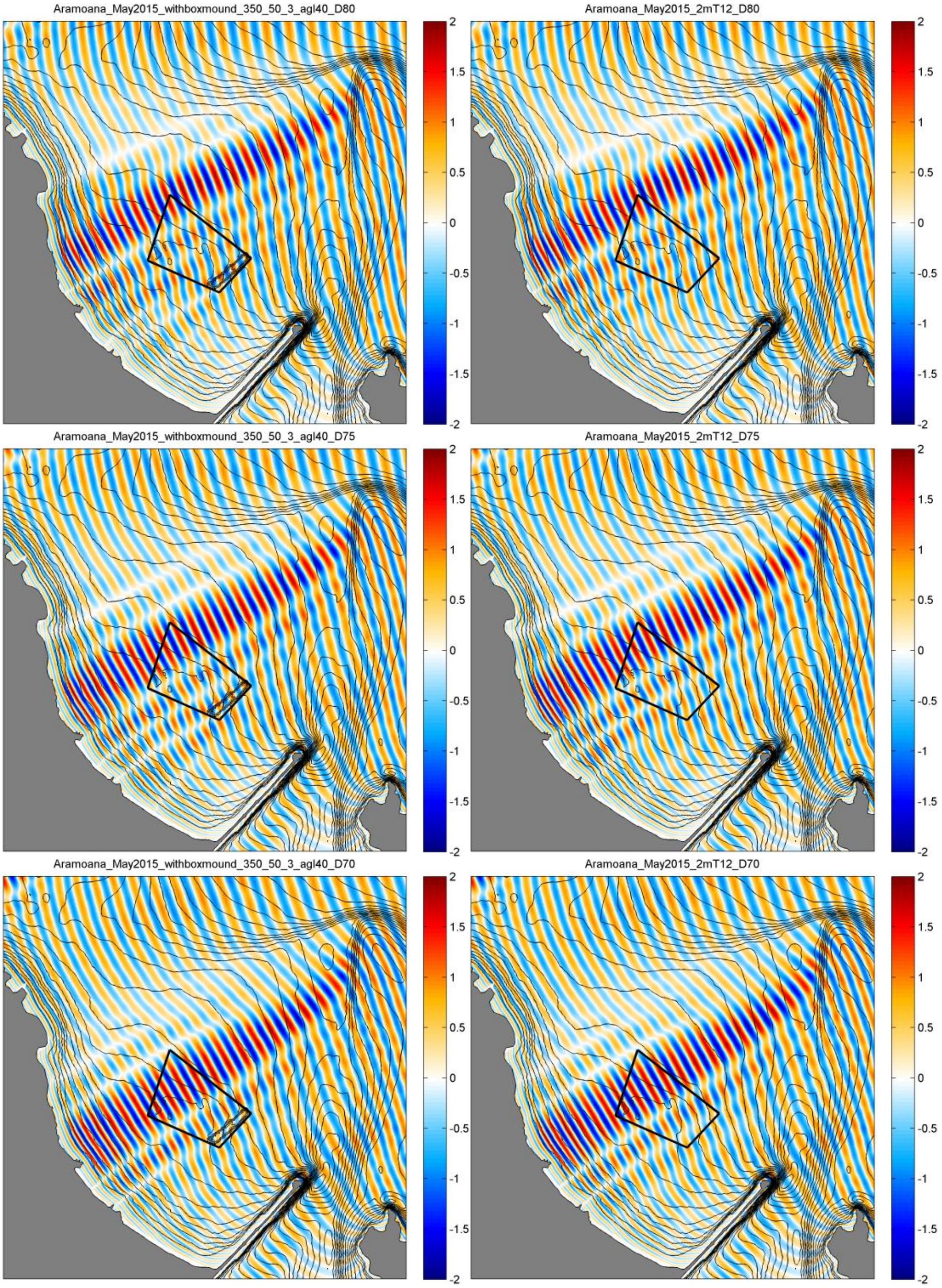


Figure 3.8 Position of the proposed trial focusing mound. The mound is 350 m long by 50 m wide and 3 m high and is located ~800 m from the shore. Each cell is 25 m by 25 m and should receive ~1800 m^3 (~3 New Era loads).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-2

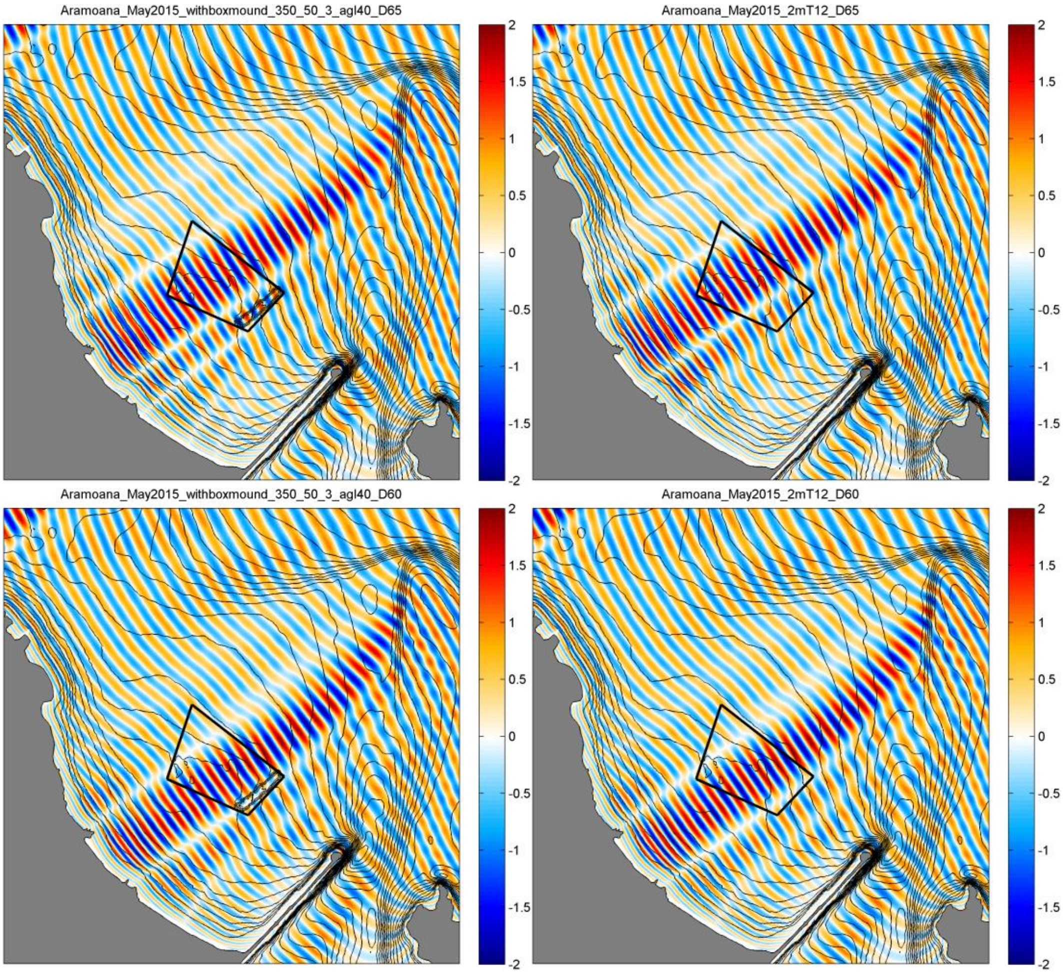

Figure 3.9 Simulated wave crest patterns for monochromatic wave events for the May 2015 bathymetry with and without the focus mounds (Hs=2m, Tp=12s, Dpm=80,75,70,65,60 degT).

4. RECOMMENDATIONS

The dumping plan for the Heyward ground for 2015 Q3-Q4 has a reduction to 50,000 m^3 and specific placement of rocky material in the deepest cells. Also, in Q3-Q4 the port may have the requirement to deposit up to 35,000 m^3 of silty material dredged from the berth pockets. To accommodate this volume, an interim bathymetric survey and analysis will be required to ensure the ground can accommodate the material and specify the best cells to place the material. Further, the view of the Working Group was that is preferable to place this silty material in the deepest cells to minimize the possible connection with the coast. It was also recognized that rock material should not be place on top of silt to avoid capping. Therefore, the Q3-Q4 plan needs to either separate the timing of deposition of rock and silt, or place the materials in separate cells.

The Q3-Q4 dumping plan provides for 50,000 m^3 to be placed in the Aramoana ground, in a specifically shaped mound. This mound would be created in a concentrated dumping effort, and surveyed immediately after construction, then at 3-monthly intervals to monitor the morphological outcomes.

A new bathymetric survey of the entire coastal area is required as soon as possible, preceding mound construction at Aramoana, and including Taharoa and Whareakeake and the offshore bar. Data coverage and density to be confirmed with the modeling team before commencement.

5. REFERENCES

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