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Technical Note

Date: 18/11/2020

Client: Kingston District Council

Subject: Maria Creek – Hybrid Concept Review

1 Introduction

Kingston District Council (KDC) is located approximately 300km to the south-east of Adelaide, South Australia. KDC operates and maintains a number of coastal assets adjacent to the Kingston SE townsite, including the Maria Creek recreational boating facility (boat ramp) and the Kingston Jetty (jetty) shown in Figure 1.

Wavelength Consulting Pty Ltd (Wavelength) developed several concepts to reinstate the boat ramp following significant sand and wrack accumulation within the creek. The background review and findings are presented in the Concept Study (Wavelength, 2020). KDC established a Community Focus Group (CFG) to review the concepts and select a preferred option for progression to detailed design.

Wavelength, at the request of KDC and the CFG, has been engaged to investigate a hybrid of Concept 1 (on-going management) and Concept 2 (extend north and south breakwaters), with the following aims:

- Reducing annual management costs and closures compared to Concept 1, particularly related to seagrass wrack accumulations.
- Reducing capital costs compared to Concept 2.

Layout plans for Concept 1 and 2 are presented in Appendix A.

The Hybrid Concept includes the following elements, presented in Figure 1 on the following page:

- **Southern breakwater:**
    - Repairs and upgrades to the southern breakwater based on Concept 1 approach in Wavelength (2020) and an approximate 60m extension of the southern breakwater. Cross-section based on Concept 2 extension presented in Wavelength (2020).
- **Capital dredging** within three main areas below, with a combined total volume of **~353,000m^3** (in-situ):
    - South Dredge Area: 300,000 m^3 dredge volume to increase the southern breakwater buffer on the southern beach.
    - Channel Dredge Area: 22,500 m^3 dredge volume within the creek and adjacent entrance channel (width of 20m).
    - North Dredge Area: a 30,000 m^3 dredging campaign to increase the northern breakwater buffer.
    - All three areas dredged to a navigable depth of -2.7mAHD
- Placement of the dredged/excavated material on the northern side of the northern breakwater above the 0mAHD contour to a +2mAHD contour.

This Technical Note outlines investigations into the Hybrid Concept, with particular focus on comparison to Concepts 1 and 2 (Appendix A).

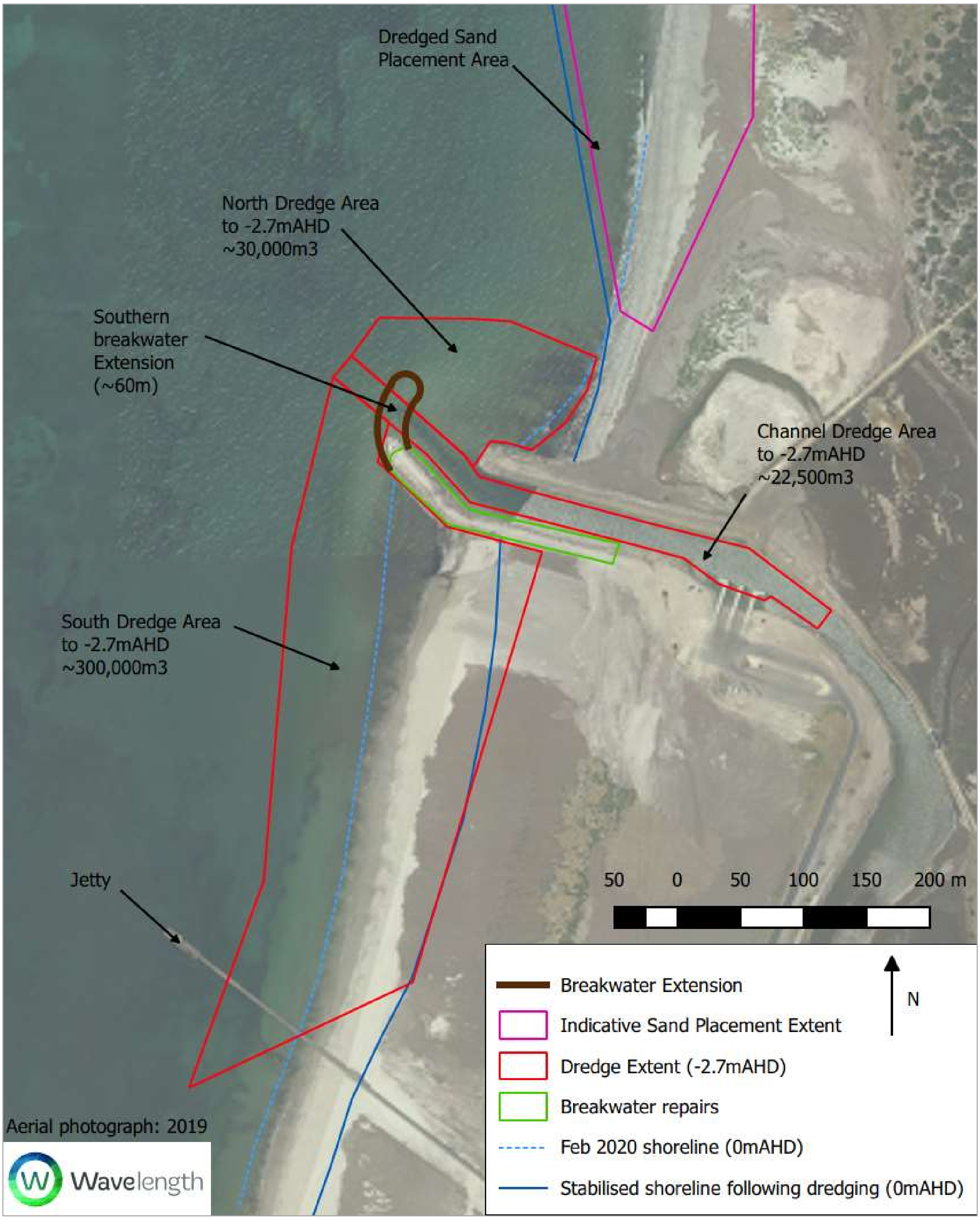


Figure 1: Hybrid Concept layout plan

2 Effectiveness

2.1. Background

The key drivers of the sand and wrack accumulations within the study area were presented previously in Wavelength (2020).

2.2. Boat ramp effectiveness

The Hybrid Concept was modelled by Port and Coastal Solutions (PCS) who established the wave and hydrodynamic model within the original Concept Study (Wavelength, 2020). Modelling results are presented in Appendix B and the assessed level of effectiveness is summarised below:

- **Sand Effectiveness:**
  - As per the other concepts, the Hybrid Concept does not stop sand from accumulating on the southern beach (south of the breakwaters) or allow the sand to naturally bypass the entrance. Therefore, a minimum annual sand bypassing of **30,000 m^3/yr** (up to 50,000 m^3/yr) would be required to keep the entrance channel navigable.
  - The creek remains a net importer of material under the Hybrid Concept, so fine sand is likely to settle out within the entrance channel and at the boat ramp. A sand volume of **5,000 m^3** has been estimated to accumulate in the creek each year.
  - The southern breakwater extension creates a wave shadow on the northern beach, which would trap sediment moving to the south in this area. A sand volume of **2,000 m^3** would need to be removed each year to prevent the northern breakwater from becoming saturated.
- **Wrack effectiveness:**
  - As noted in Wavelength (2020), wrack dynamics are highly complex and are not easy to predict.
  - **Waves:** The breakwater extension would reduce the storm wind and wave exposure in the entrance channel, particularly from south-west to north-west storm conditions (Figure 2). The entrance would remain exposed to winds and waves from north of north-west directions and some wrack is still expected to accumulate within the entrance. However, the volume and frequency of wrack accumulations events are likely to be much lower than with the existing breakwater alignment.
  - **Currents:** Current speeds behind the breakwater extension are expected to remain lower than the existing currents (Figure 3) and are below the 0.06 m/s threshold for remobilization of wrack described in Wavelength (2020). Therefore, wrack is not expected to remobilise into the creek under typical tidal or storm conditions.
  - A wrack volume of **10,000 m^3** has been estimated to accumulate within the creek each year. This is likely to vary depending on the combination of events experienced each year.

The effectiveness results of the Hybrid Concept compared to Concepts 1 and 2 are summarised in Table 1.

Table 1: Maria Creek boat ramp concepts sand and wrack management effectiveness

Concept	Effectiveness of structural change			Indicative annual volumes in creek	
	Sand management		Wrack management	Sand (m^3 in situ)[1]	Wrack (m^3)
	without capital dredging and annual sand bypassing	**with** capital dredging and annual sand bypassing[1]			
Hybrid	X	✓	✓	7,000	10,000
1. On-going management	No structural change	No structural change	No structural change	5,000	30,000
2. Extend north and south breakwaters	X	✓	✓	8,000	5,000

Notes: 1. Effectiveness and volumes based on large capital dredge campaign and on-going sand bypassing of at least 30,000m^3/yr.

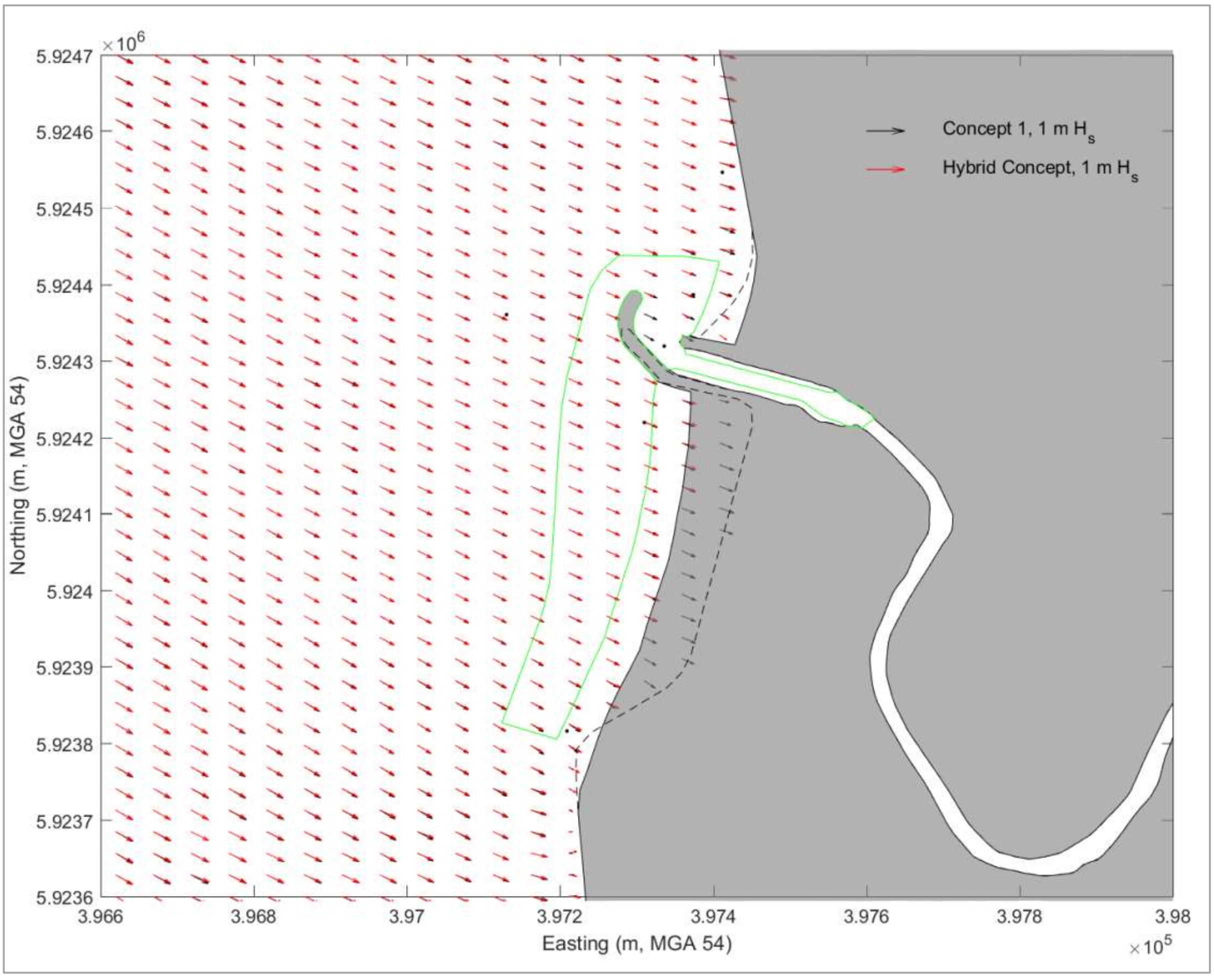


Figure 2: Wave modelling results critical north-west storm

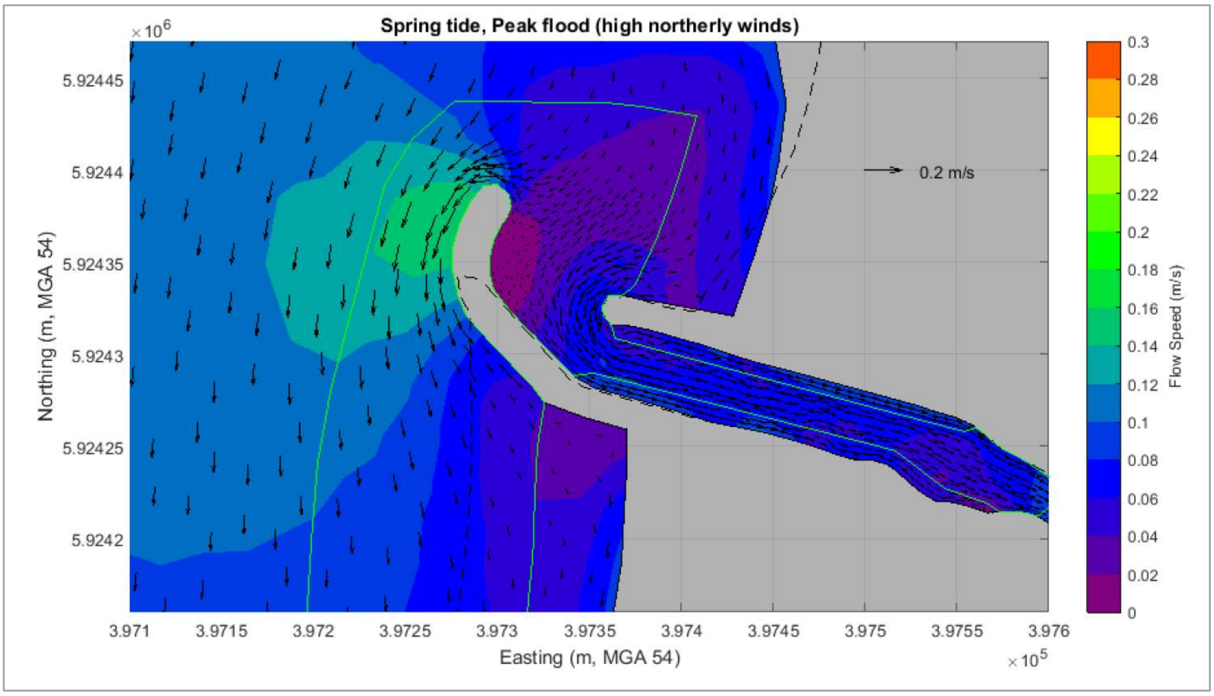


Figure 3: Hydrodynamic (current) modelling results critical northerly winds

2.3. Jetty and Foreshore effectiveness

The following summarises the Hybrid Concept impact on the Jetty and Foreshore:

- **Jetty:** The Jetty shoreline is anticipated to reduce up to 60m under the Hybrid Concept (Figure 1), which is the same as Concept 1 and an improvement of 40m to Concept 2. An additional 240,000 m^3 of sediment would need to be removed over years 2 to 5 to reduce the Jetty beach width an additional 60m (a total improvement of 120m).
- **Foreshore:** Wrack is anticipated to continue to accrete on the southern beach under the Hybrid Concept. Beach wrack volumes are anticipated to be similar to Concept 1, which were in the order of 60,000 m^3 in 2018/19 (Wavelength, 2020).

3 Cost estimate

Order of magnitude capital and recurrent maintenance cost estimates for the Hybrid Concept have been prepared as presented in Table 2 below. These include the estimates for Concepts 1 and 2 and focus on the boat ramp only (i.e. costs do not include additional dredging for improved Jetty shoreline or wrack management noted in Section 2.3).

Net Present Value (NPV) analysis provides an indication of the relative costs of the boat ramp concepts over the design life, considering capital and on-going costs. The cost estimates presented are to be used as a guide only, detailed costings would be developed following selection of option to be progressed to detailed design. Capital and NPV cost breakdowns for the Hybrid Concept is presented in Appendix C.

NPV analysis and cost estimates were developed using the assumptions set out in Section 5.7 of Wavelength (2020).

Table 2: Concept Cost Estimates

Concept	Capital costs			Annual Management			25-year NPV
	Structural changes/ repairs	Dredging *(Volume)*	TOTAL	Sand	Wrack	TOTAL	
Hybrid	$4.8M	$2.8M *(353K m^3)*	**$7.6M**	$389K	$45K	**$434K**	**$14.4M**
1. On-going Mgmt	$3.3M	$2.7M *(335K m^3)*	**$6.0M**	$370K	$135K	**$505K**	**$13.8M**
2. Extend Breakwaters	$9.8M	$1.1M *(135K m^3)*	**$10.9M**	$400K	$30K	**$430K**	**$17.6M**

4 Summary

Key findings of the Hybrid Concept investigations are summarised below:

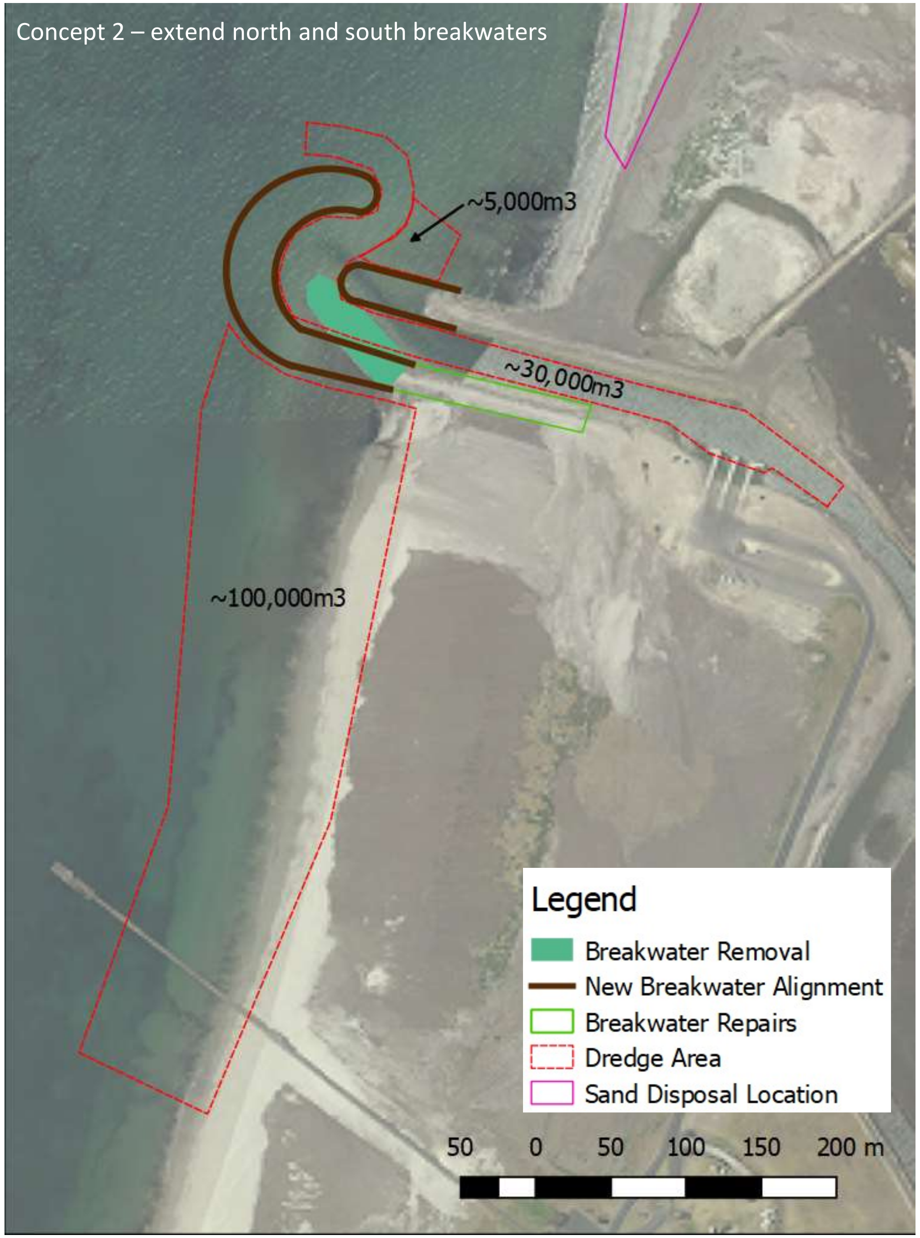
- The Hybrid Concept achieves the high-level aims of the CFG (Section 1) and represents a balanced option between Concepts 1 and 2, as outlined below:
  - Annual management costs of the Hybrid Concept are approximately $70K per year lower than Concept 1 (on-going management approach) and are similar to Concept 2.
  - Capital costs of the Hybrid Concept are ~$3.3M lower than Concept 2 and ~$1.6M higher than Concept 1.
  - The overall 25-year NPV for the Hybrid Concept is approximately $0.6M more than Concept 1. However, this would come with the benefit of a reduced wrack management requirement and entrance channel closures compared to the existing entrance arrangement (Concept 1).
- The Hybrid Concept is expected to have similar impacts on the Jetty shoreline position and beach wrack accumulation to Concept 1.
- Regardless of the concept selected for boat ramp reinstatement, successful operation of the facility is dependent on continued sand and wrack management at a minimum of ~$430K per year. Therefore, careful consideration must be given to securing funding and ensuring resources are available for continued monitoring, approval and execution of the boat ramp management.
- For all concepts, on-going sand bypassing of at least 30,000 m^3 would be required to maintain a navigable entrance. This annual sand management requirement comprises a large portion of the total annual management costs and the following approaches should be investigated in more detail to identify the most cost-effective solution:
  - Trucking.
  - Dredging.
  - Terrestrial bypassing (e.g. Slurrytrak).

5 References

Wavelength, 2020. Maria Creek Sustainable Infrastructure Project - Concept Study. Prepared for Kingston District Council.

Appendix A Concept 1 and Concept 2 Layout Plans

Concept 1 - ongoing management
~10,000m3
~22,500m3
~300,000m3
50 0 50 100 150 200 m



Concept 2 – extend north and south breakwaters
~5,000m3
~30,000m3
~100,000m3
Legend
Breakwater Removal
New Breakwater Alignment
Breakwater Repairs
Dredge Area
Sand Disposal Location
50 0 50 100 150 200 m

Appendix B Hybrid Concept Modelling Results Technical Note (PCS, 2020)

Technical Note

Date:	12th November 2020
To:	Brad Smith
From:	Rachel White
Subject:	Maria Creek – Hybrid Concept
Classification:	Project Related
Version:	1.0

1. Introduction

Wavelength Consulting (Wavelength), on behalf of Kingston District Council (Council), commissioned Port and Coastal Solutions (PCS) to provide data analysis and numerical modelling services to inform the Maria Creek Concept and Design study. The study relates to the management of a boat ramp facility within Maria Creek, which over recent years has incurred untenable maintenance costs. These costs relate to maintaining the integrity of the existing training wall structures and maintaining access following periods of high seagrass wrack and sediment build up in the Creek. Council is seeking to identify a long-term solution that is financially sustainable and can be delivered through an affordable capital solution.

As part of this study, PCS (2020) assessed the implications of a number of design concepts on sediment transport and wrack accumulation using numerical modelling tools to help estimate the ongoing maintenance requirements. Following a review of the findings in PCS (2020), a new design concept was identified for consideration. This technical note summarises the modelling relating to this new design concept. For additional information on the study, including a characterisation of the site (including metocean conditions and a conceptual sediment budget), details of the model setup and performance, the previously assessed design concepts and the results from the assessment of the initial design concepts, the reader should refer to PCS (2020).

2. Hybrid Concept

The hydrodynamic, wave and longshore sediment transport modelling tools developed by PCS (2020) have been applied to assess a concept design which has been proposed by Wavelength as an option to help ease the currently untenable costs associated with maintaining the Maria Creek boat ramp. The concept design considered in this technical note is a hybrid of two design concepts (Concept 1 and Concept 2) previously assessed by PCS (2020) and as such, is referred to herein as the Hybrid Concept.

The key elements of the Hybrid Concept include the following:

- an approximate 60 m extension of the southern breakwater to the north;
- dredging to -2.7 m AHD within Maria Creek and adjacent to the Creek entrance (width of 20 m);
- dredging to -2.7 m AHD extending approximately 100 m to the north of the Creek entrance and approximately 500 m to the south of the Creek entrance; and
- placement of the dredged/excavated material on the northern side of the northern breakwater (above the 0 m AHD contour).

Following dredging, the initial rate of change (i.e. within several months of the completion of the dredging campaign) in the dredged areas is expected to be relatively high until a more stable coastline is achieved. To account for this and to provide an assessment of how the breakwater extension will affect currents and waves once the north and south shorelines have at least partially stabilised and realigned, the bathymetry in the model has been updated to include an approximate 1V:20H slope between the dredged -2.7 m AHD contour and the 0 m AHD (shoreline) contour (i.e. a distance of approximately 50 m).

The hydrodynamic (HD) model mesh of the Hybrid Concept is shown in Figure 1. The Spectral Wave (SW) model mesh was also updated to include the key elements of the Hybrid Concept design, but does not include within the Creek (since this area is sheltered from waves).

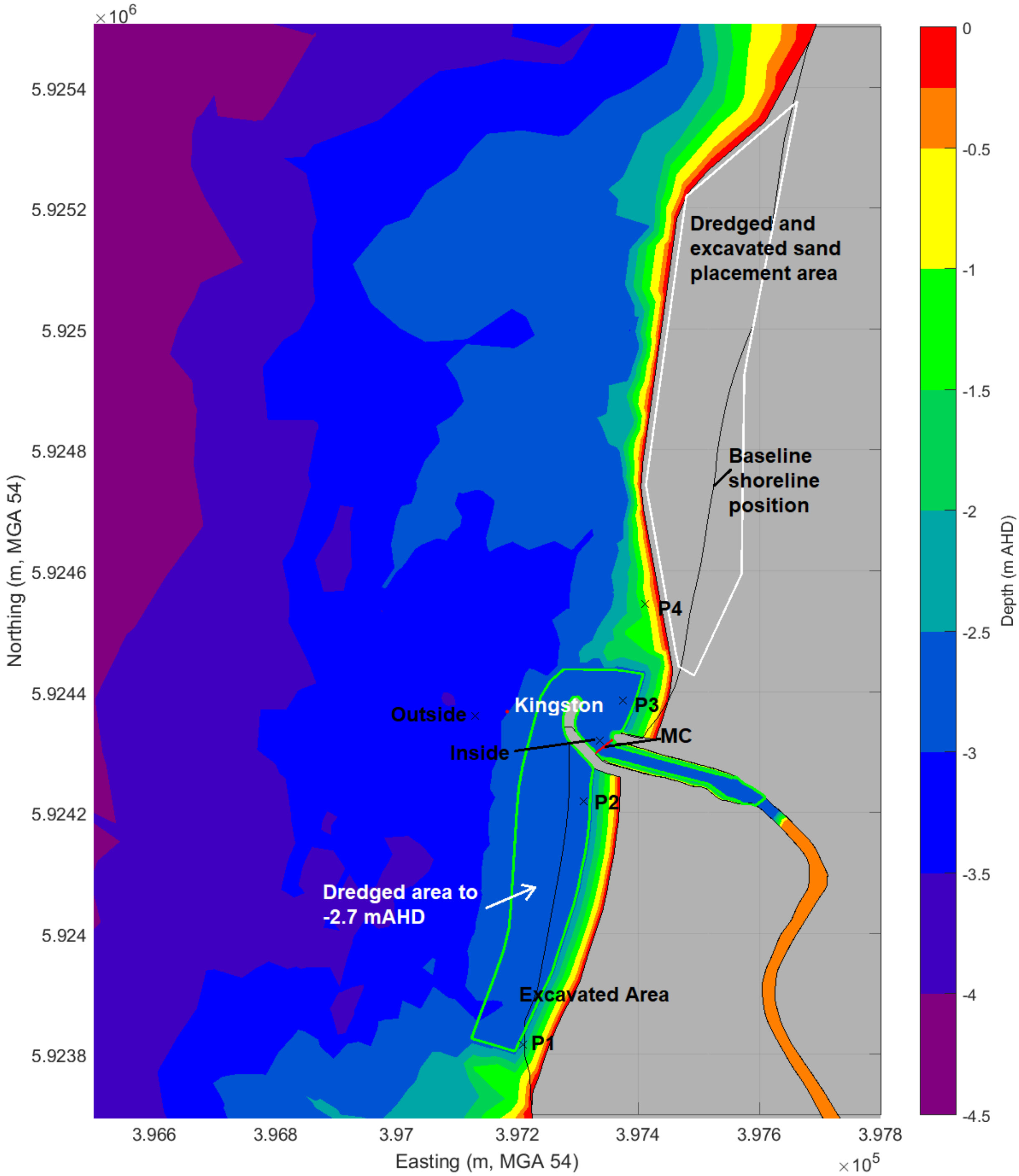


Figure 1. Hybrid Concept: Ongoing management with extension to the southern breakwater.

3. Results

The results from the modelling of the Hybrid Concept are presented in this section. For reference, some results from the previously considered Concept 1 design are also presented. Concept 1 is effectively an ongoing sediment management option (dredging to -2.7 m AHD within the Creek, adjacent to the Creek entrance and to the south of the breakwater) without any changes to the breakwater structure and so comparison between Concept 1 and the Hybrid Concept allows an assessment of the effect of the breakwater extension in the Hybrid Concept to be made.

3.1. Effect on Flows

Timeseries plots of flows outside (at Kingston) and inside Maria Creek (at MC – see Figure 1 for locations) are shown in Figure 2 and Figure 3, respectively. Results show that relative to the Concept 1 design, flows outside of the Creek are largely unchanged, with only a small increase (of around 0.01 m/s, with flows typically remaining slower than 0.2 m/s) and slight reorientation in flows due to the extension of the breakwater. Changes between the flows for the Hybrid Concept and Concept 1 design are also small at location MC within Maria Creek (of the order 0.01 m/s) and tend to vary from tide to tide, most likely as a result of the variable wind conditions.

To show the flows in more detail, map plots of the tidal flows for the Hybrid Concept design are plotted at incremental stages throughout a spring tide during a period of low winds in Figure 4 and Figure 5. Map plots at the time of peak flood are also shown for a spring tide during a period of high northerly winds and a neap tide during a period of high south westerly winds in Figure 6. Additional map plots showing the flows for all tidal states for each wind condition are included in Appendix A (Figure A1 to Figure A4).

The map plots confirm that offshore of the breakwater, flows for the Hybrid Concept are broadly similar to those for Concept 1 (see Appendix B) with only a small acceleration in flows around the offshore edge of the breakwater extension. Shoreward of the breakwater, the maps plots generally show that the flows directly to the north of Maria Creek are reduced compared to Concept 1 as a result of the changes in flow pattern due to the extended breakwater. During the peak flood stage of the tide with high northerly winds the Hybrid Concept has slightly lower flows adjacent to the entrance to Maria Creek compared to Concept 1. In addition, during the peak flood stage of the tide with high south-westerly winds the Hybrid Concept also has lower flows at the entrance to Maria Creek compared to Concept 1 as the breakwater extension stops the eddy from forming adjacent to the entrance. Therefore, the modelling results show that the extended breakwater has the potential to reduce the transport of sediment and seagrass wrack into the Creek relative to Concept 1, particularly during periods of high south westerly winds.

As a result of the breakwater extension there is a small reduction in discharge through the Creek entrance (Figure 7). The change is equivalent to a reduction of approximately 600 m^3 of water flowing into and out of the entrance during a large spring tide which equates to less than a 1% reduction (72,500m^3 for Concept 1 compared to 71,900m^3 for the Hybrid Concept). This small change will not influence the stability of the entrance relative to the longshore transport compared to Concept 1.

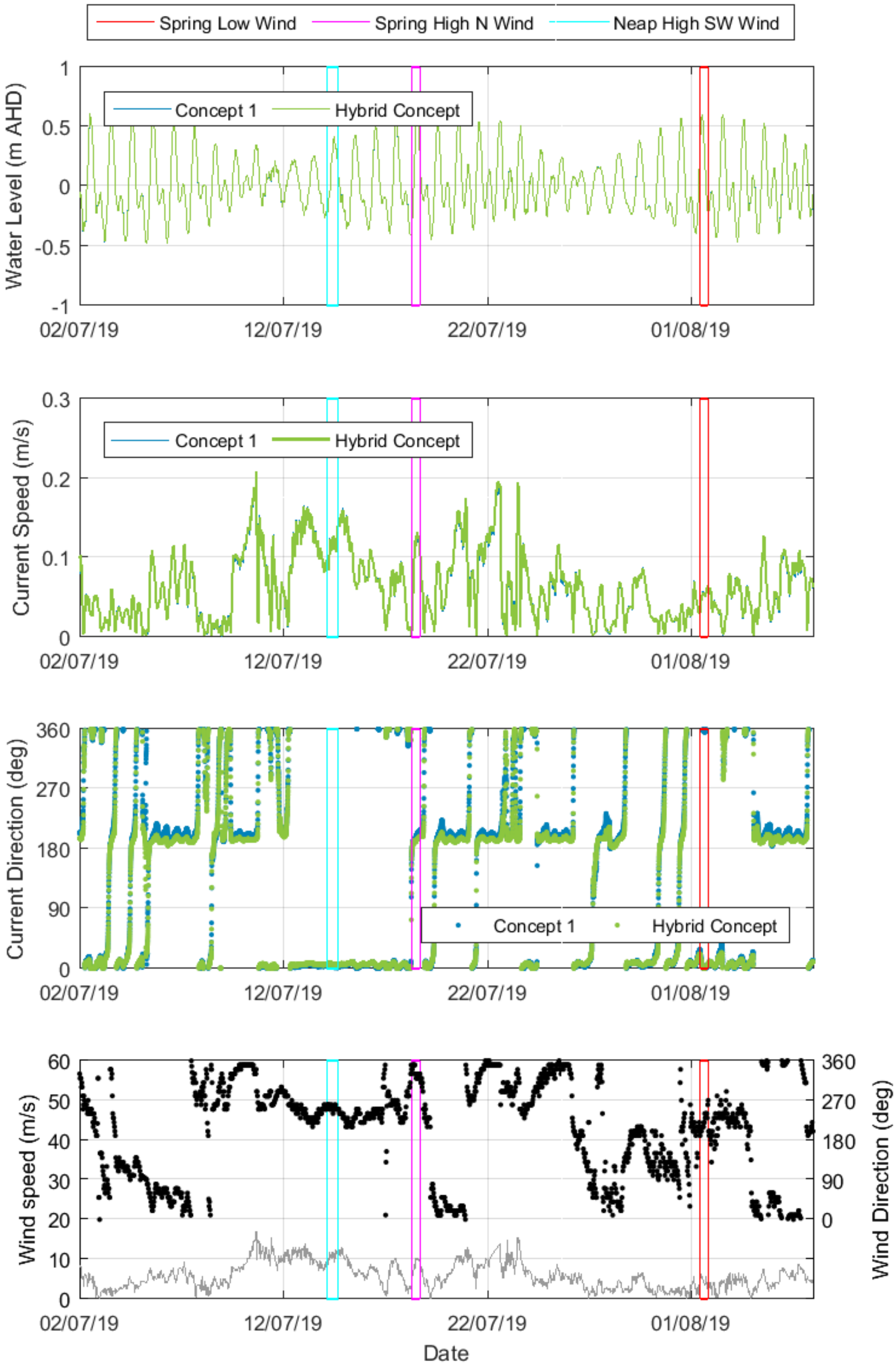


Figure 2. **Timeseries of modelled tidal levels and flows at Kingston for Concept 1 and Hybrid Concept designs.**

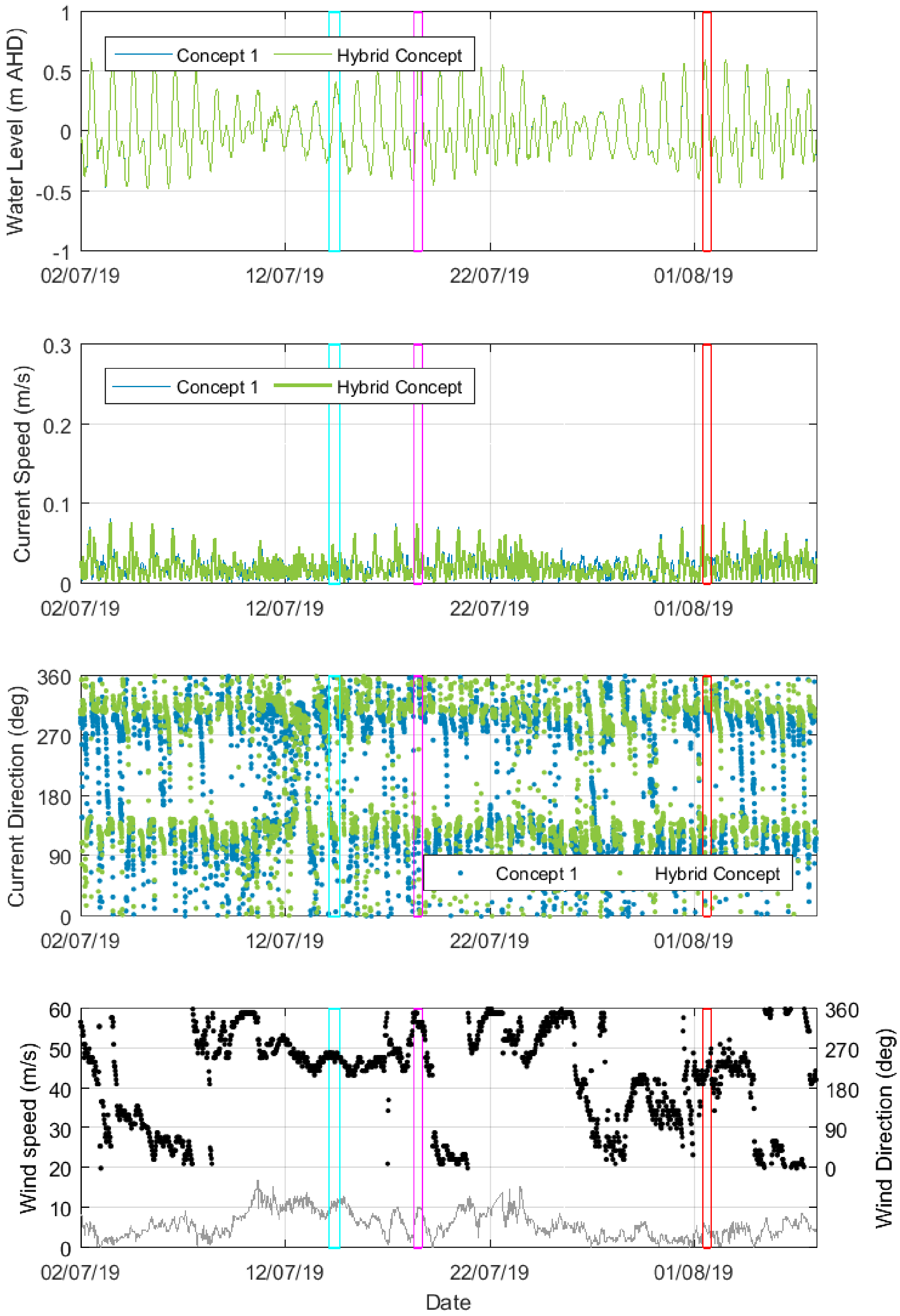


Figure 3. **Timeseries of modelled tidal levels and flows in Maria Creek (in MC) for the Concept 1 and Hybrid Concept designs.**

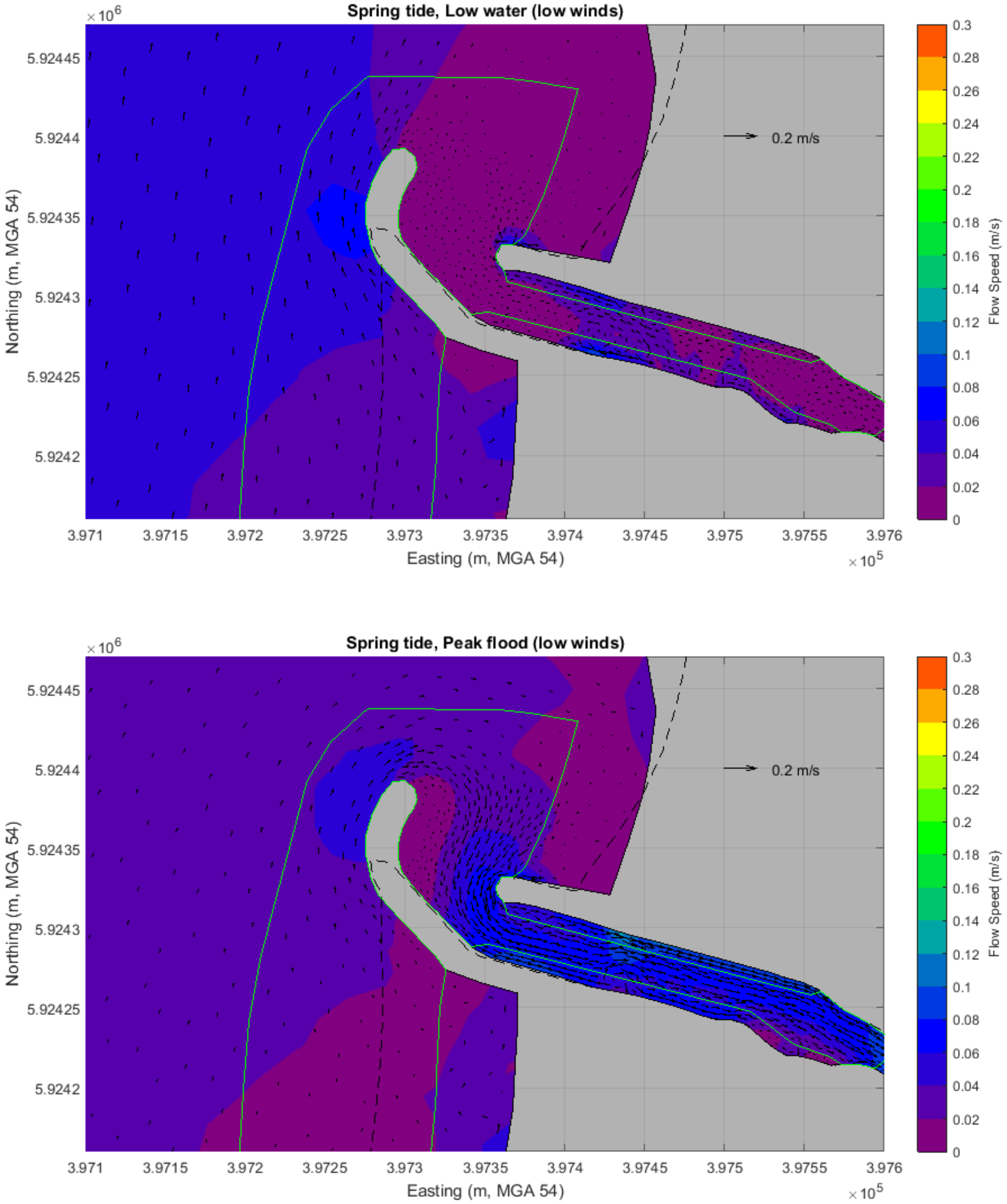


Figure 4. **Modelled tidal current speeds around Maria Creek at low water (top) and peak flood (bottom) for a spring tide with low winds for the Hybrid Concept.**

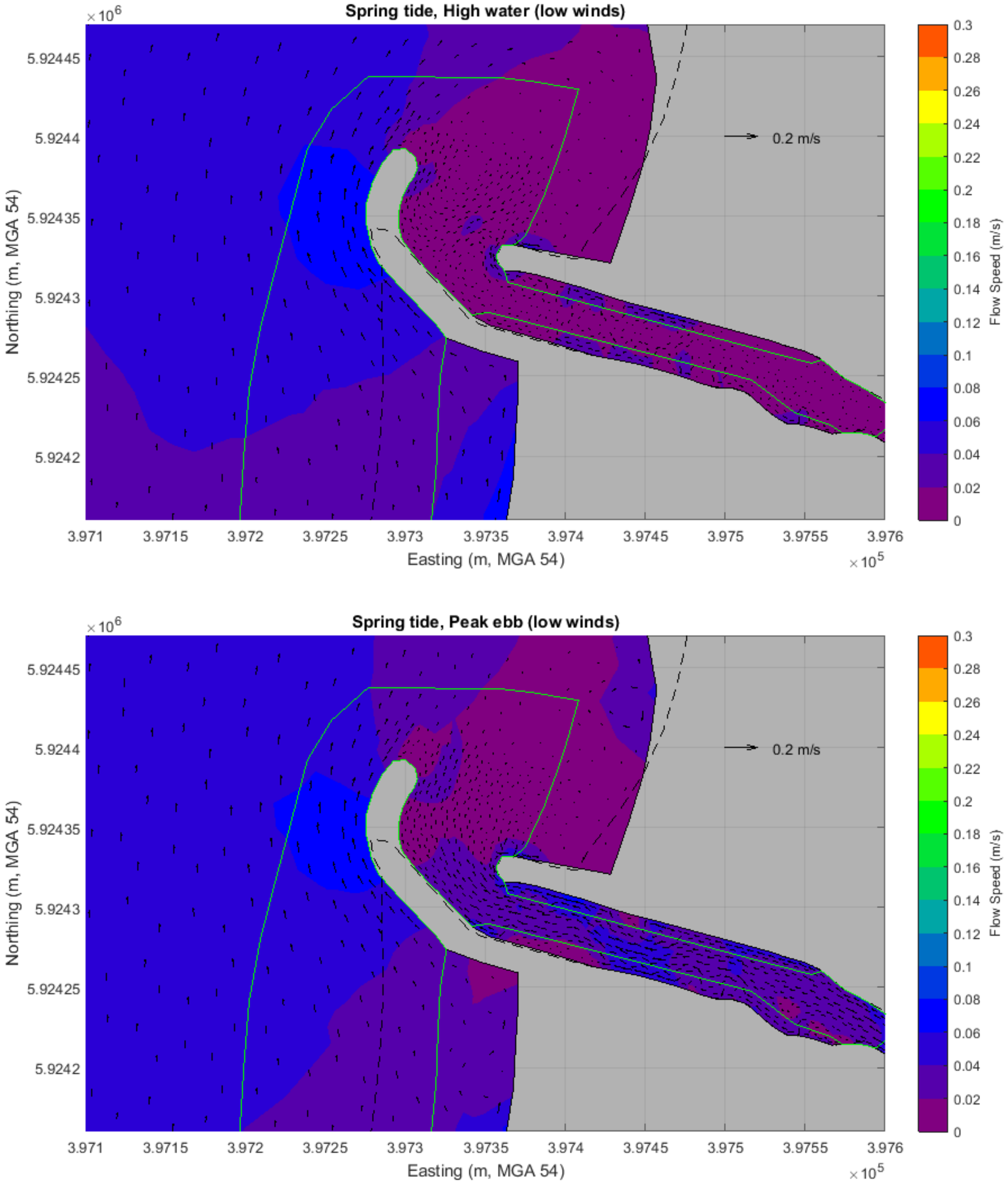


Figure 5. **Modelled tidal current speeds around Maria Creek at high water (top) and peak ebb (bottom) for a spring tide with low winds for the Hybrid Concept.**

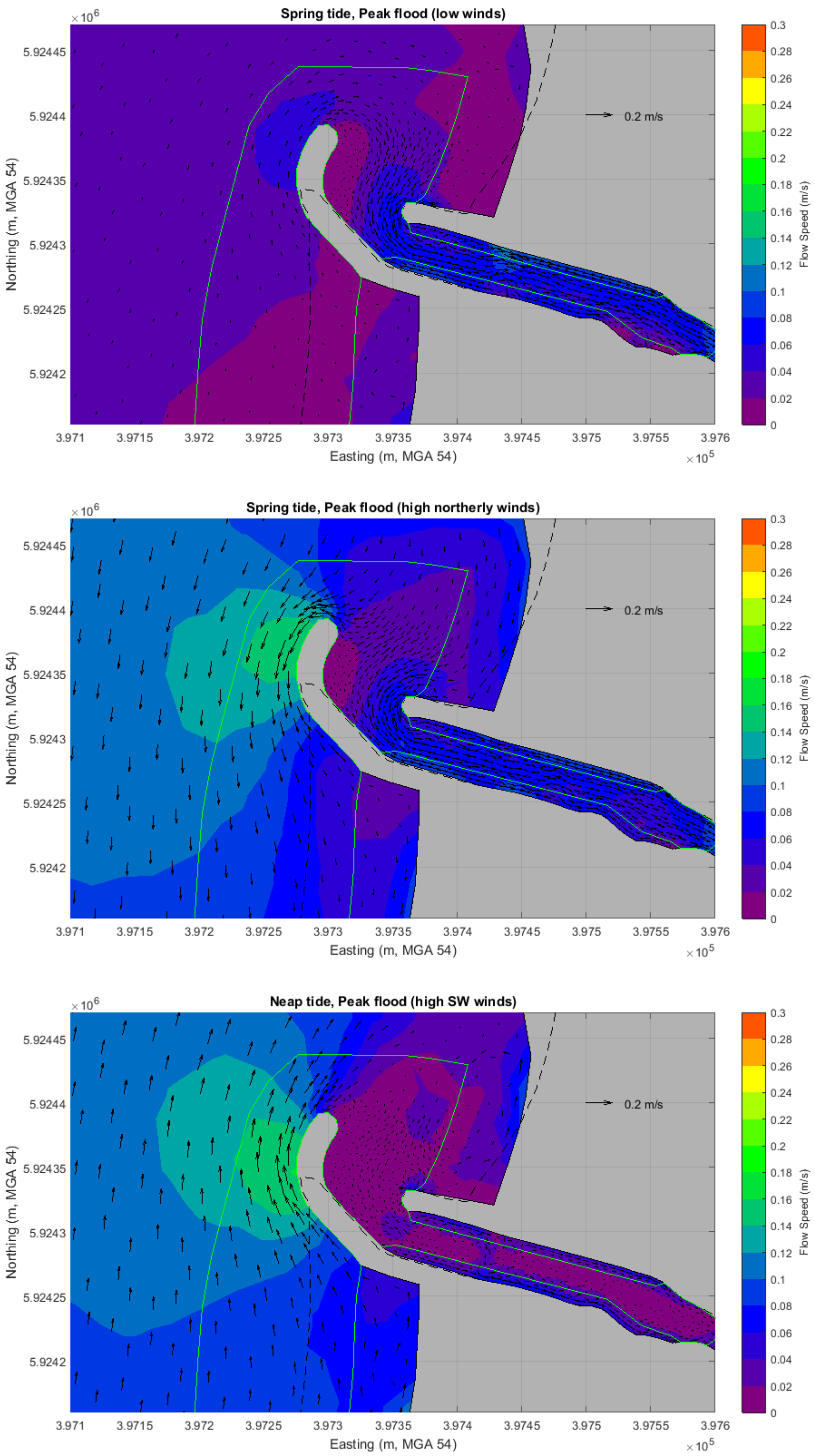
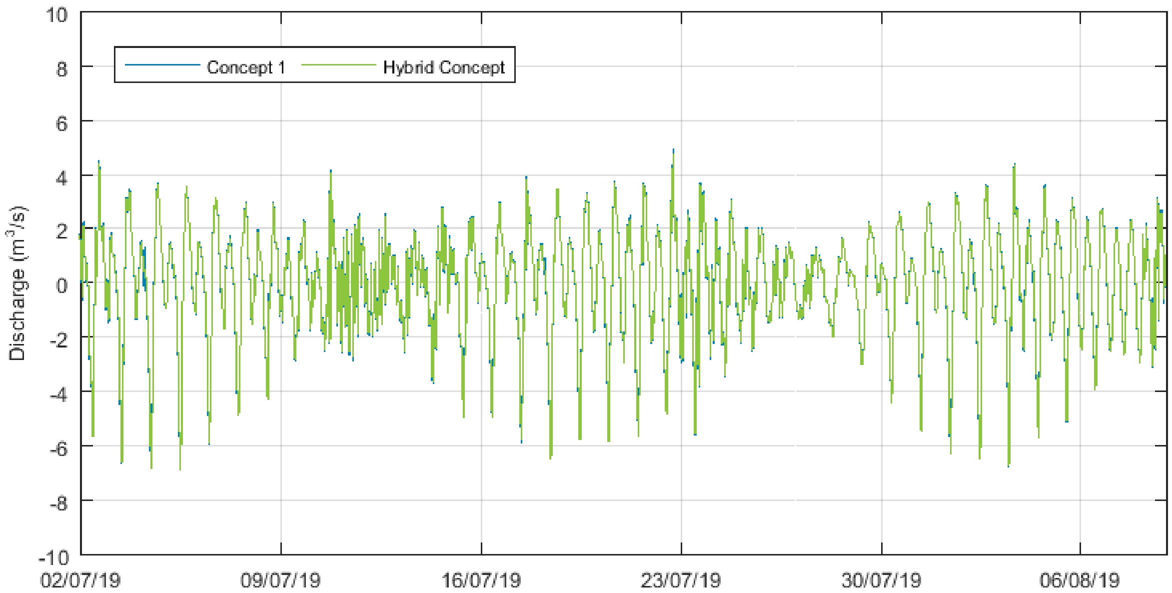


Figure 6. Modelled tidal flows around Maria Creek at peak flood for a spring tide with low winds (top), a spring tide with high northerly winds (middle) and a neap tide with high south westerly winds (bottom) for the Hybrid Concept.



Note: Positive values denote discharge out of Marina Creek and negative values discharge into the Creek.

Figure 7. Modelled discharge through Maria Creek for the Hybrid Concept.

3.2. Effect on Waves

To show how the extended breakwater affects the wave conditions around Maria Creek, vector plots are presented in Figure 8 to Figure 10. These plots show the typical wave conditions for the Hybrid Concept for the following conditions:

- a north-westerly wave event (H_s is 0.44 m[1], less than a 10 in 1 year wave event – Figure 8);
- a westerly wave event (H_s is 0.94 m[1], between a 1 in 1 year and 1 in 5 year wave event – Figure 9); and
- a south-westerly storm (H_s is 0.89 m[1], equivalent to a 1 in 1 year – Figure 10).

The wave events were defined by consideration of the directions of waves at the offshore Cape de Couedic Wave Rider Buoy (since the angle of incidence for waves approaching the coast at Maria Creek covers a relatively narrow band due to the effects of wave refraction across the relatively wide shallow region of Lacepede Bay). Waves from the northwest tend to be duration limited (i.e. the size of waves is limited by the duration for which winds from this direction occur) and therefore resultant waves at Maria Creek are typically small when considered in relation to wave events from other more persistent directional sectors.

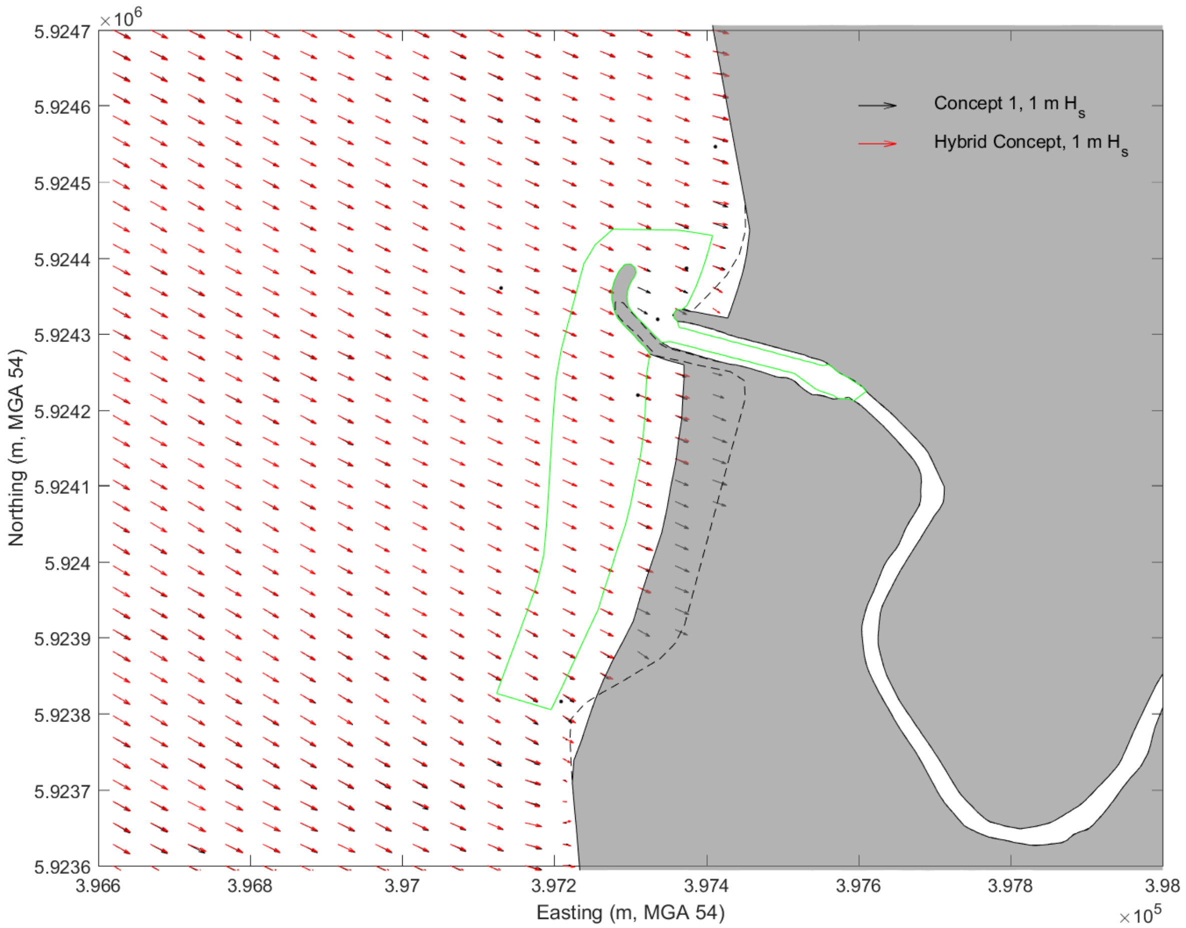
Wave conditions are shown for the Hybrid Concept and Concept 1 to show how the breakwater extension affects the wave conditions, particularly within the Creek entrance where wave sheltering will occur.

The Hybrid Concept results in a number of small changes to the wave conditions relative to the Concept 1 design:

- a small shift in wave direction at the stabilised shoreline locations at both the southern and northern limits of the dredged area. This small directional shift reduces the relative direction at which the waves approach, reducing the potential for wave driven longshore sediment transport; and
- a notable reduction in waves in the lee of the extended breakwater structure, with the largest wave shadow for south-westerly waves.

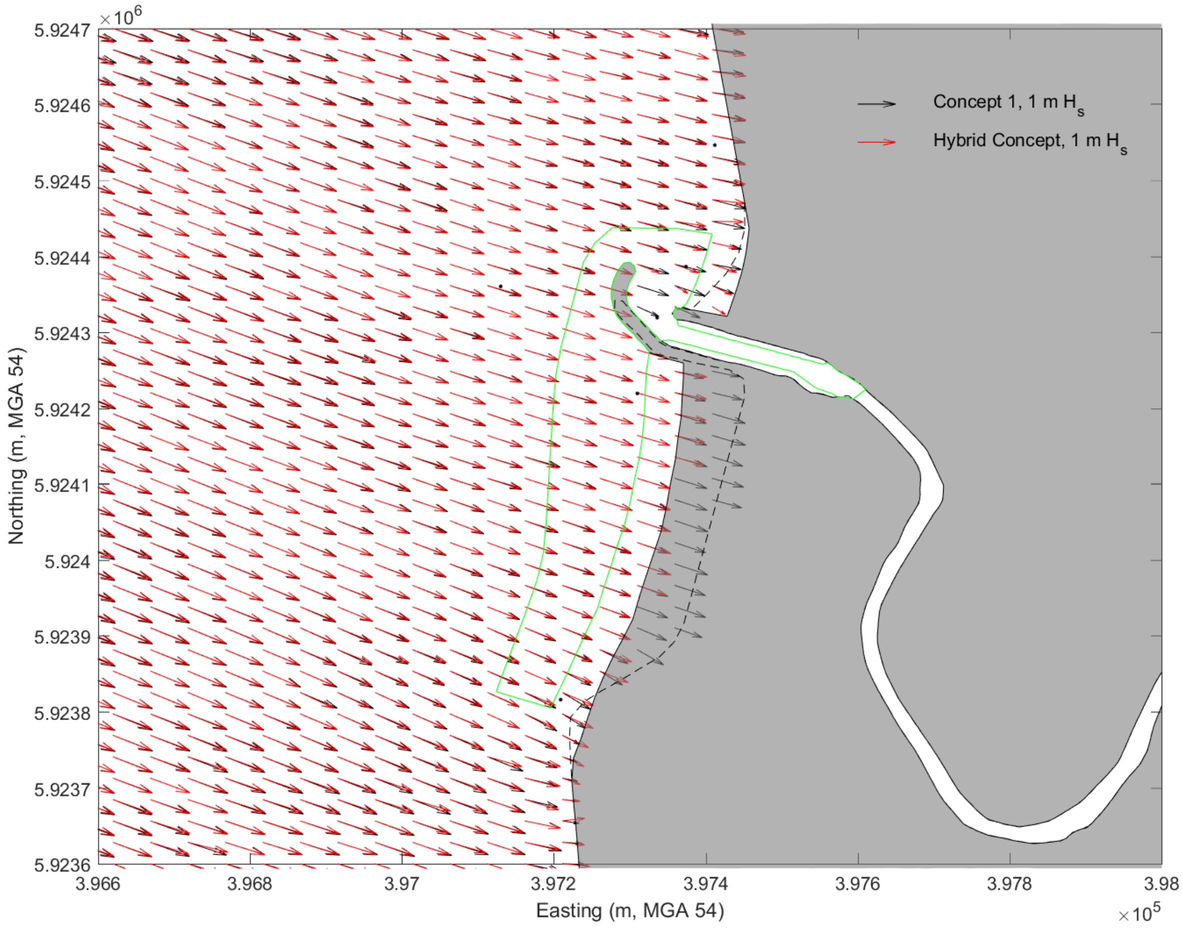
[1] Based on modelled wave height at Maria Creek at the 'Outside' extraction point (see Figure 1).

To further assess the effect of the breakwater extension on the propagation of waves into the Creek a time series of wave conditions within the Creek entrance ('Inside' extraction point – see Figure 1 for location) is shown in Figure 11. A comparison of conditions between the Hybrid Concept and Concept 1 indicates that the extended breakwater reduces wave heights within the Creek by around 80% and the wave energy by a factor of 100 (from around 660 million Joules (J) per year to 9 million J per year).



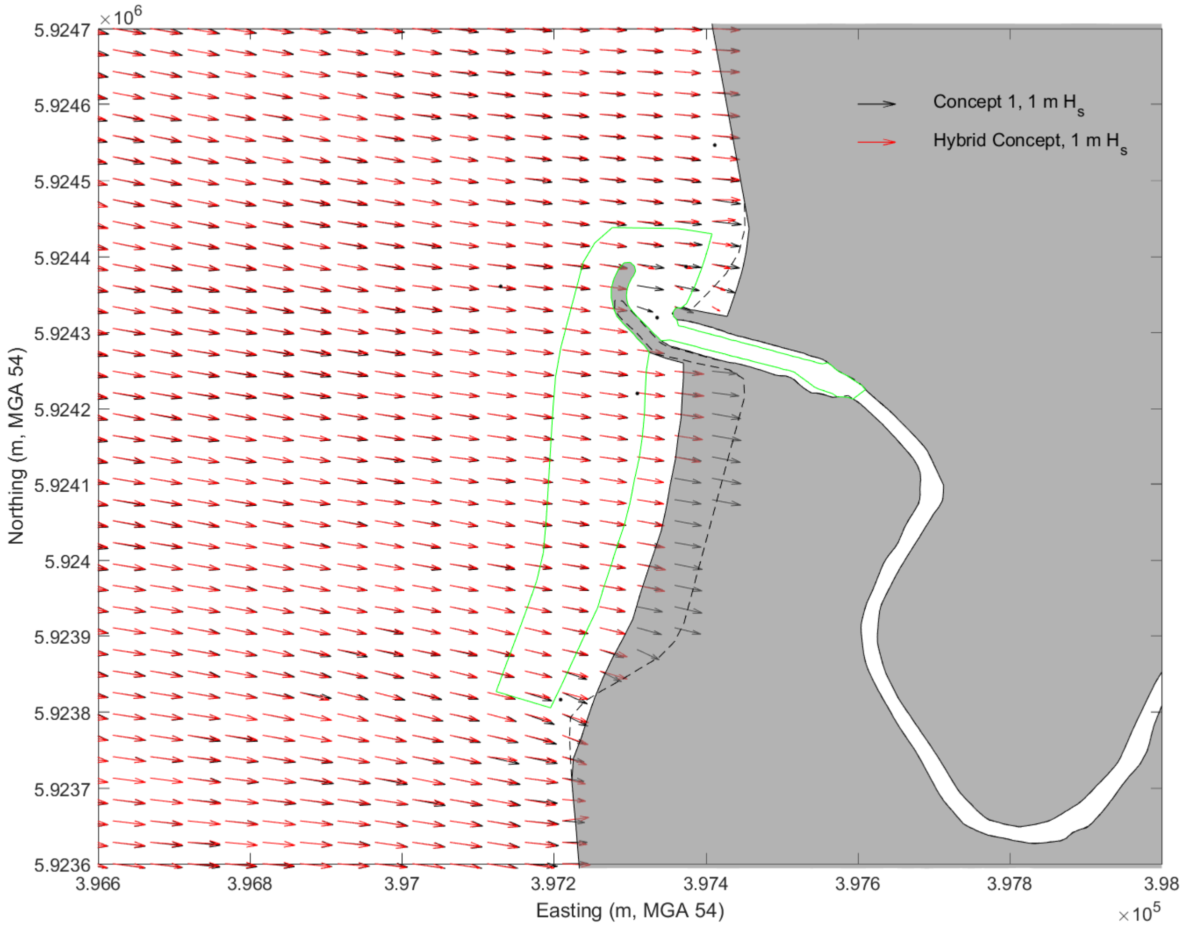
Note: The dashed line shows the location of the coastline for the Concept 1 design.

Figure 8. Modelled wave vectors for waves from the north-west for the Concept 1 and the Hybrid Concept designs.



Note: The dashed line shows the location of the coastline for the Concept 1 design.

Figure 9. Modelled wave vectors for waves from the west for the Concept 1 and the Hybrid Concept designs.



Note: The dashed line shows the location of the coastline for the Concept 1 design.

Figure 10. Modelled wave vectors for waves from the south-west for the Concept 1 and Hybrid Concept designs.

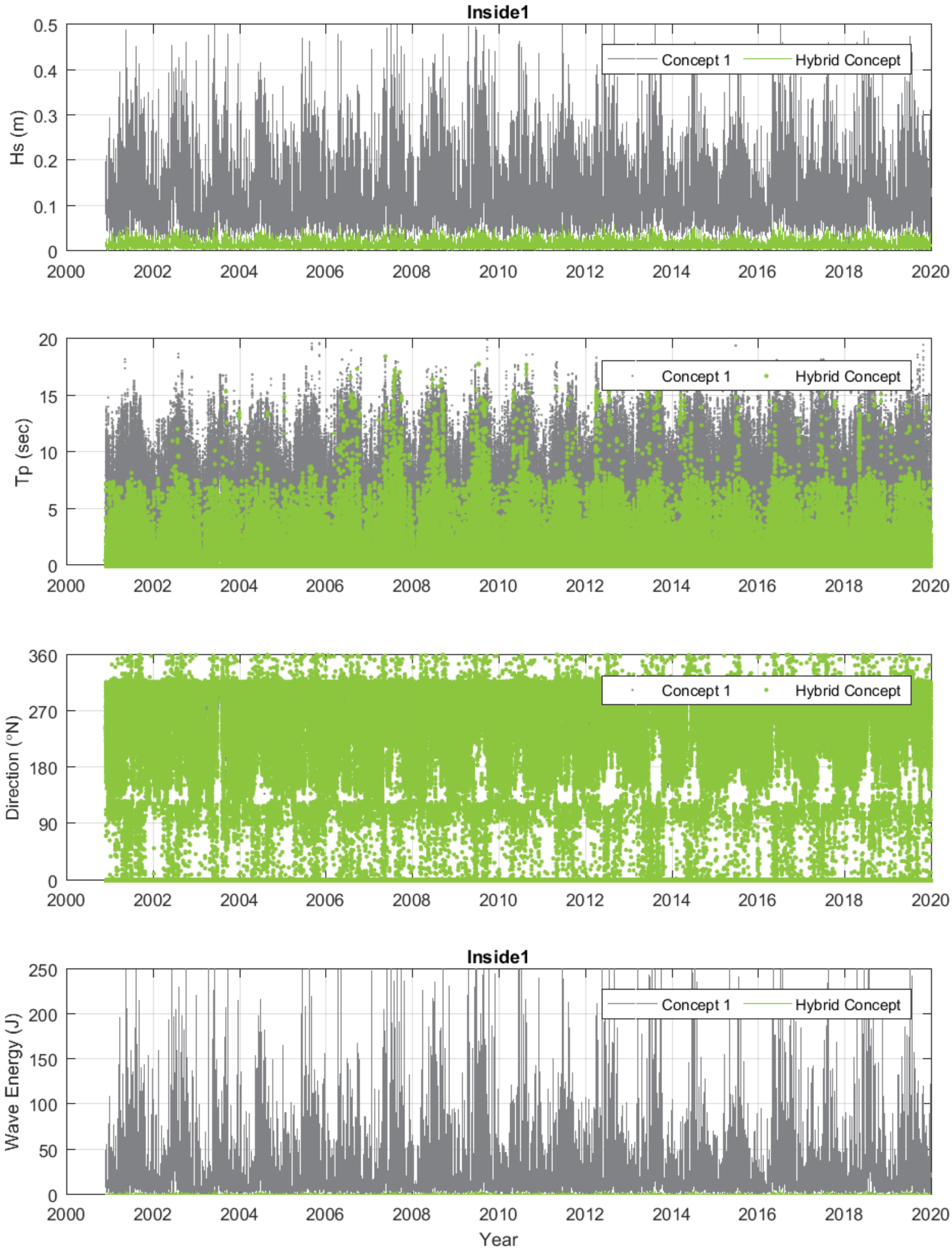


Figure 11. **Timeseries of modelled wave conditions in the Creek Entrance (at 'Inside') for the Concept 1 and Hybrid Concept designs.**

3.3. Effect on Longshore Transport

To assess the effect of the breakwater extension on the longshore drift (especially in the area of wave shadow) and the potential for increased trapping of sand to the north of the Creek, the annual wave driven longshore transport rates for the Hybrid Concept are plotted in Figure 12. Net transport rates are tabulated in Table 1, with results for Concept 1 also included to allow an assessment of the effect of the breakwater extension.

The comparison of wave driven annual net longshore sediment transport rates shows the following:

- the more stabilised shoreline included in the Hybrid Concept to the south of the breakwater results in a reduction in the net transport rate at P1 of approximately 50% compared to the non-stabilised shoreline included in Concept 1;
- net transport at P2 and P4 are very similar for the two concept designs; and
- the northerly transport at P3 is significantly reduced as a result of the wave shadowing effect of the breakwater extension compared to Concept 1, with the Hybrid Concept resulting in a net southerly longshore transport at this point. A reduction in northward transport at P3 was also predicted to occur for the Concept 2 design (which also included a larger breakwater extension and was previously assessed by PCS (2020)). As a result, sediment is likely to accrete adjacent to the northern breakwater to the north of Maria Creek. The effectively unchanged northward transport at P4 suggests that the area of accretion would be limited to a relatively small stretch of the coastline (less than 200 m).

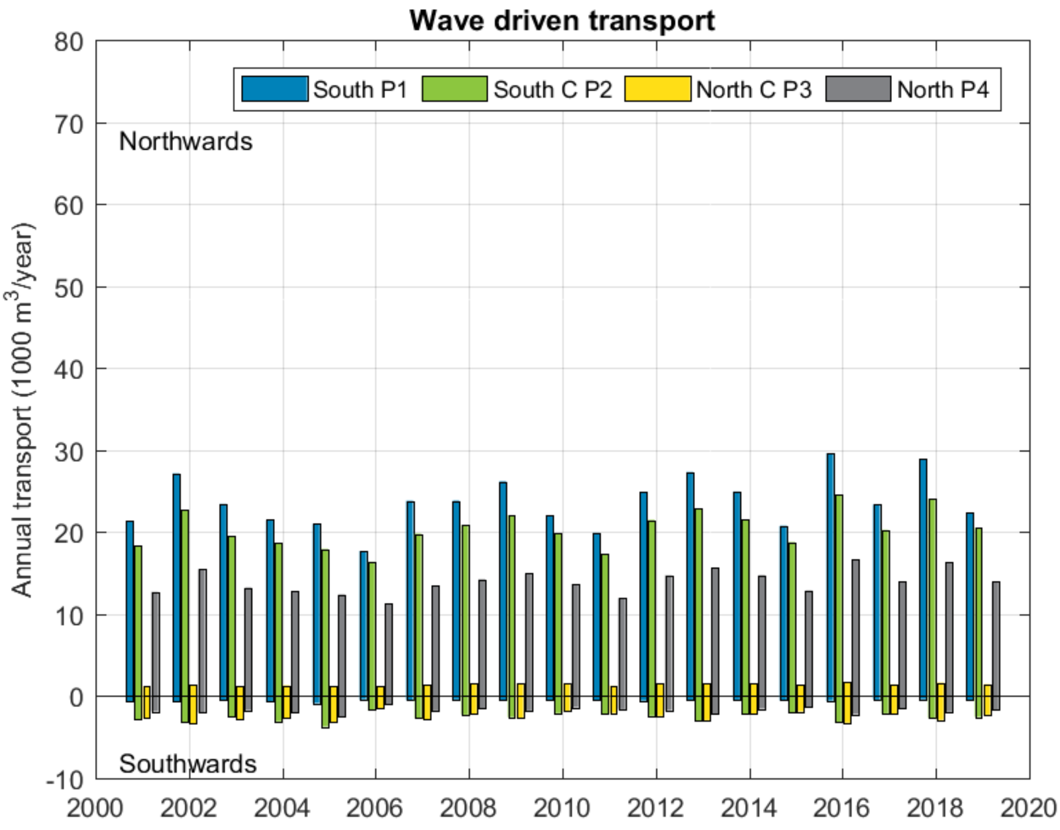


Figure 12. Predicted wave driven annual longshore sediment transport for the Hybrid Concept.

The longshore sediment transport rates are sensitive to the coastline orientation and therefore the difference in shoreline orientation at P3 for the Hybrid Concept and the Concept 1 design could account for some of the difference in net transport at P3. To consider how the net transport at P3 might change for the Hybrid Concept following the build-up of some sediment in this area (and to help separate the effect of the breakwater from local changes in shoreline orientation), the net transport was recalculated at P3 using the same shoreline orientation as adopted for Concept 1. The recalculated net transport at P3 indicated a net northward transport (i.e. positive values) for all years with values ranging from 300 to 1,800 m3 per year and an average of 1,300 m3 per year (compared to an average of 29,000 m3 per year for the Concept 1 net transport rate at P3). This shows that the breakwater extension in the Hybrid Concept results in a reduction in net longshore transport at P3 of more than an order of magnitude compared to Concept 1. This suggests that there would be a build-up of sediment adjacent to the northern breakwater and a potential risk of erosion between P3 and P4 as there is a differential in net longshore transport indicating that additional sediment will be required (i.e. by erosion of the shoreline) until a more stable shoreline orientation is reached.

Table 1. Predicted wave driven annual net longshore sediment transport rates for the Hybrid Concept and Concept 1.

Year	Wave Driven Net Transport (1,000 m^3/year), Kamphuis (1991)							
	P1		P2		P3		P4	
	Concept 1	Hybrid Concept	Concept 1	Hybrid Concept	Concept 1	Hybrid Concept	Concept 1	Hybrid Concept
2001	51	20.7	16.6	15.5	27.2	-1.5	10.5	10.8
2002	63.9	26.5	20.5	19.5	34.7	-2	12.6	13.4
2003	55.2	22.9	18	17	29.4	-1.6	10.8	11.5
2004	51	20.9	16.4	15.5	27.5	-1.4	10.3	10.8
2005	51.7	20.1	15.5	14.2	27.3	-2	9.6	9.9
2006	39.8	17.3	14.8	14.7	22.4	-0.3	10	10.2
2007	56.2	23.3	18.3	17.1	29.4	-1.5	10.9	11.7
2008	54.1	23.4	19.1	18.6	29.1	-0.6	12.2	12.7
2009	60	25.7	20.4	19.5	31.5	-1.1	12.5	13.2
2010	49.2	21.6	18	17.8	26.7	-0.3	11.9	12.3
2011	46	19.4	16.1	15.2	24.1	-0.8	10.1	10.4
2012	56.8	24.3	19.9	19.1	30.3	-0.9	12.7	13.0
2013	64.4	26.9	21.4	19.9	33.8	-1.4	13.3	13.4
2014	56.2	24.5	20	19.4	30.3	-0.6	12.8	13.2
2015	46.5	20.3	16.8	16.8	25.7	-0.5	11.2	11.5
2016	68.9	29.1	22.7	21.4	36.2	-1.6	13.9	14.5
2017	53.6	22.9	18.8	18.1	28.8	-0.7	12.4	12.5
2018	66.3	28.6	22.6	21.4	35.1	-1.3	13.9	14.4
2019	49.9	21.9	17.6	18	28.6	-0.8	11.9	12.3

4. Summary

This technical note has presented an assessment of the effects of a ‘Hybrid Concept’ design on flows and waves in and around Maria Creek. The assessment has compared the results against results for the Concept 1 design, the results of which were reported by PCS (2020). The results from the modelling indicate:

- following the relatively rapid evolution of the shoreline adjacent to the dredged area to the south of Maria Creek to a more stable position post dredging (likely over months to years depending on the occurrence of larger wave heights), the longshore transport in this area is expected to reduce to approximately 50% of the longshore transport rate predicted to occur immediately after dredging;
- it is possible that the potential for wrack to be imported into the Creek for the Hybrid Concept could be reduced relative to Concept 1 due to the reduced tidal current speeds flowing into the Creek (although the flows are still flood dominant in the Creek);
- the breakwater extension provides additional sheltering to the entrance from flows and storm winds and waves, indicating a reduced potential for wrack to be imported into the Creek. However, the flood dominance means that any wrack which is imported is likely to remain within the Creek. As for Concept 1, the sediment import into the Creek would be reduced relative to the baseline case since there is no sand bar available for feed; and
- the additional sheltering of the shoreline directly to the north of the northern training wall afforded by the extension to the southern breakwater is predicted to result in very low longshore transport rates which is likely to result in an increased build-up of sediment in this location.

While there is likely to be a reduction in the transport of wrack and sediment into the Creek for the Hybrid Concept design relative to the Concept 1 design (and the base case), some build-up of sediment in the lee of the breakwaters would still be expected. It is therefore likely that in order to avoid the eventual bypassing of the breakwaters and to maintain the dredged depths within the Creek, some form of sediment management would be required (without which sand bypassing would be likely to result in the formation of a shallow sandbar across the entrance). While the risk of bypassing of the southern breakwater is reduced for the Hybrid Concept design relative to the Concept 1 design, the risk of bypassing of the northern breakwater during periods of southerly longshore transport is increased.

5. References

Kamphuis., J.W., 1991. Alongshore sediment transport rate. Journal of Waterway, Port, Coastal and Ocean Engineering, Vol. 117, 624-640.

PCS, 2020. Maria Creek Concept and Design Study, Numerical Modelling Report, May 2020.

APPENDICES

Appendix A – Additional Plots for the Hybrid Concept Design

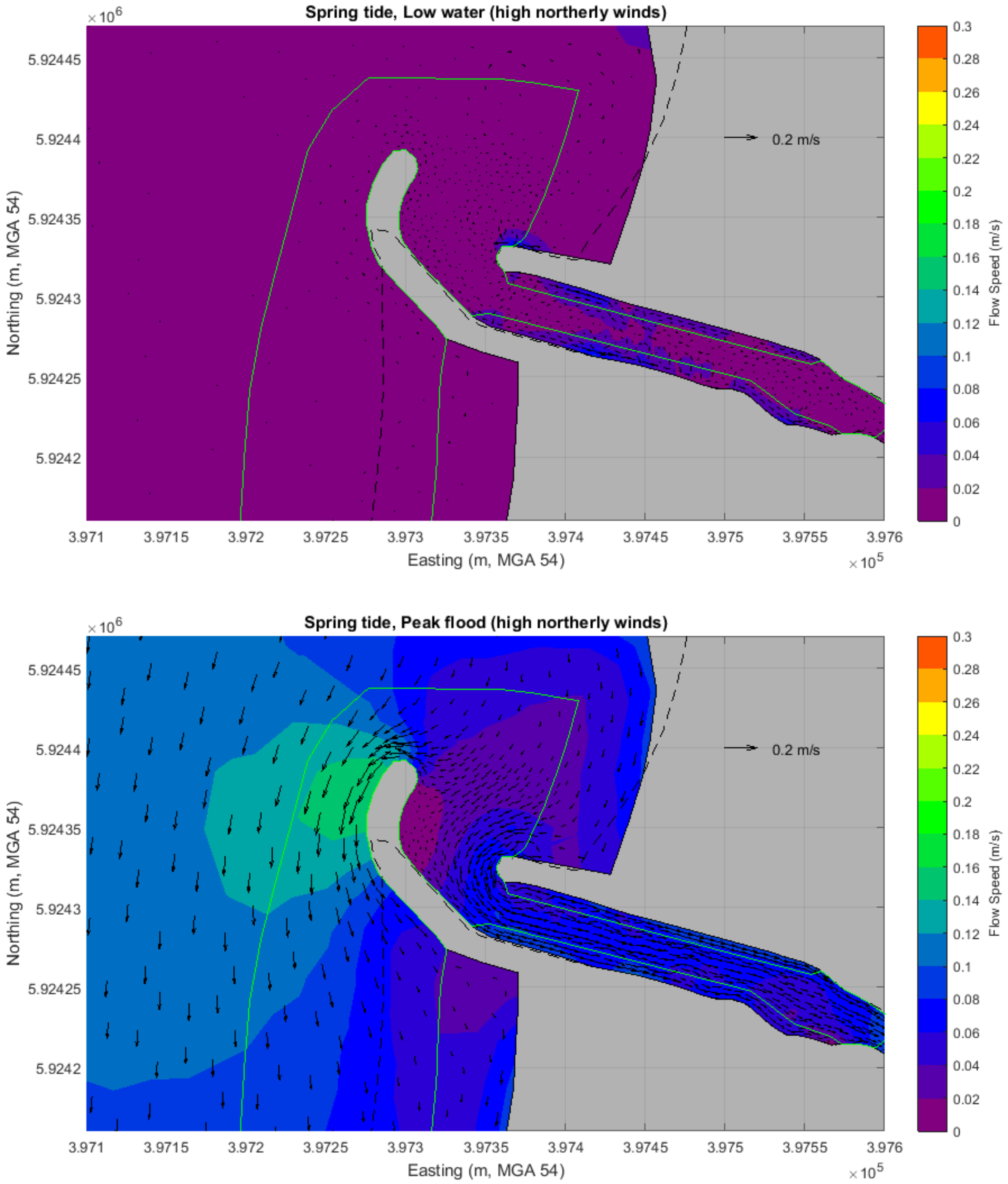


Figure A1. Modelled tidal current speeds around Maria Creek at low water (top) and peak flood (bottom) for a spring tide with high northerly winds for the Hybrid Concept.

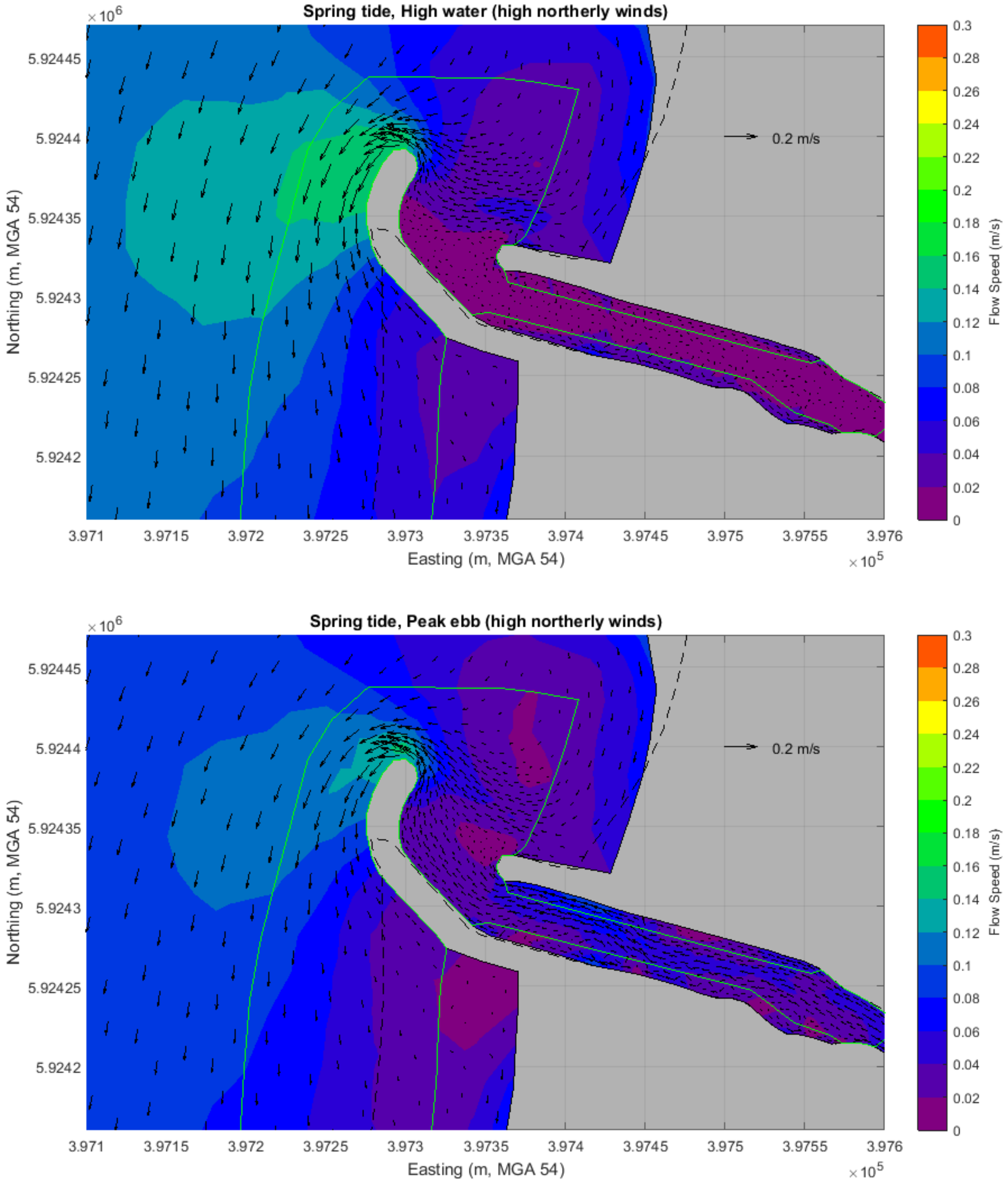


Figure A2. Modelled tidal current speeds around Maria Creek at high water (top) and peak ebb (bottom) for a spring tide with high northerly winds for the Hybrid Concept.

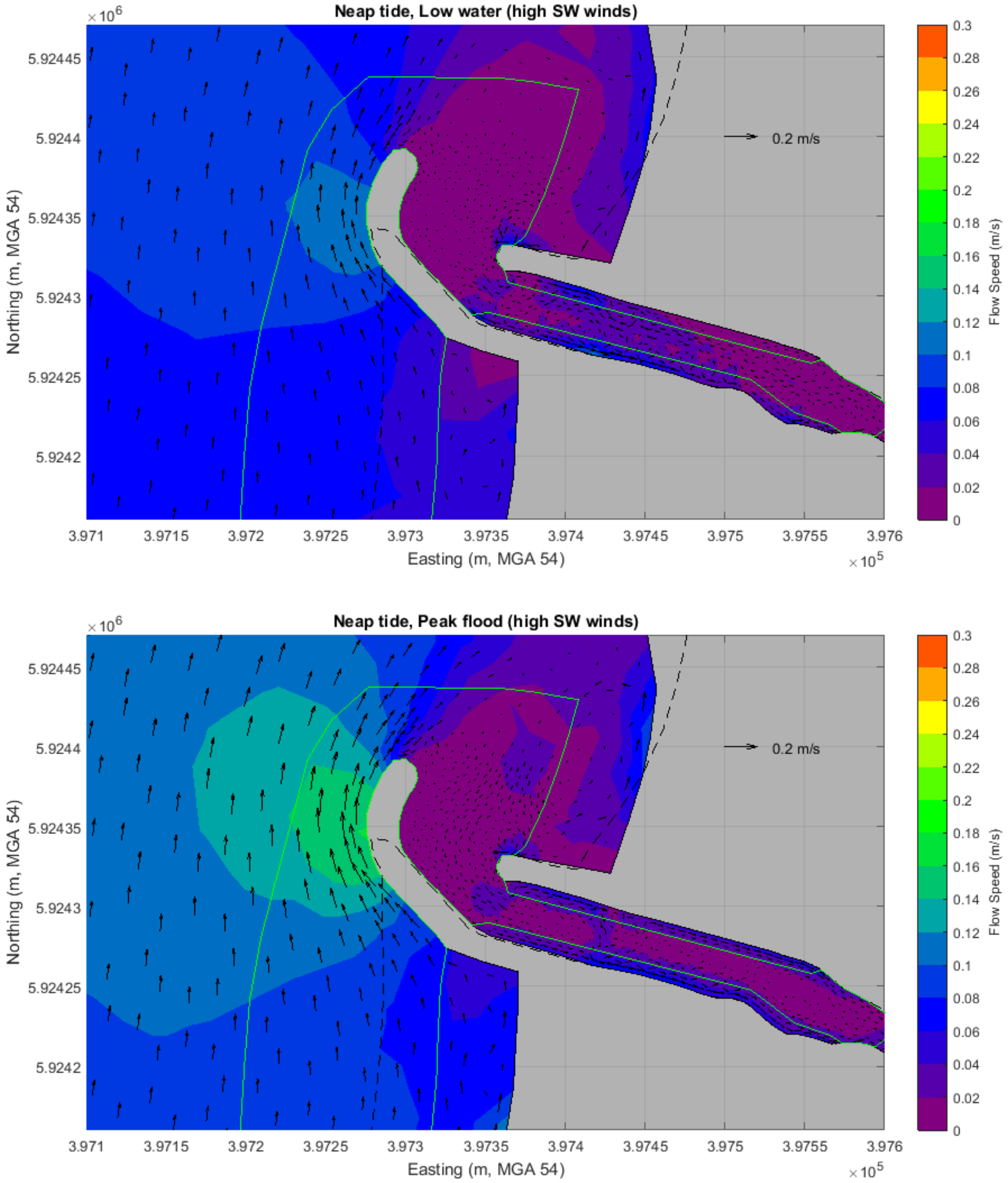


Figure A3. Modelled tidal current speeds around Maria Creek at low water (top) and peak flood (bottom) for a neap tide with high south-westerly winds for the Hybrid Concept.

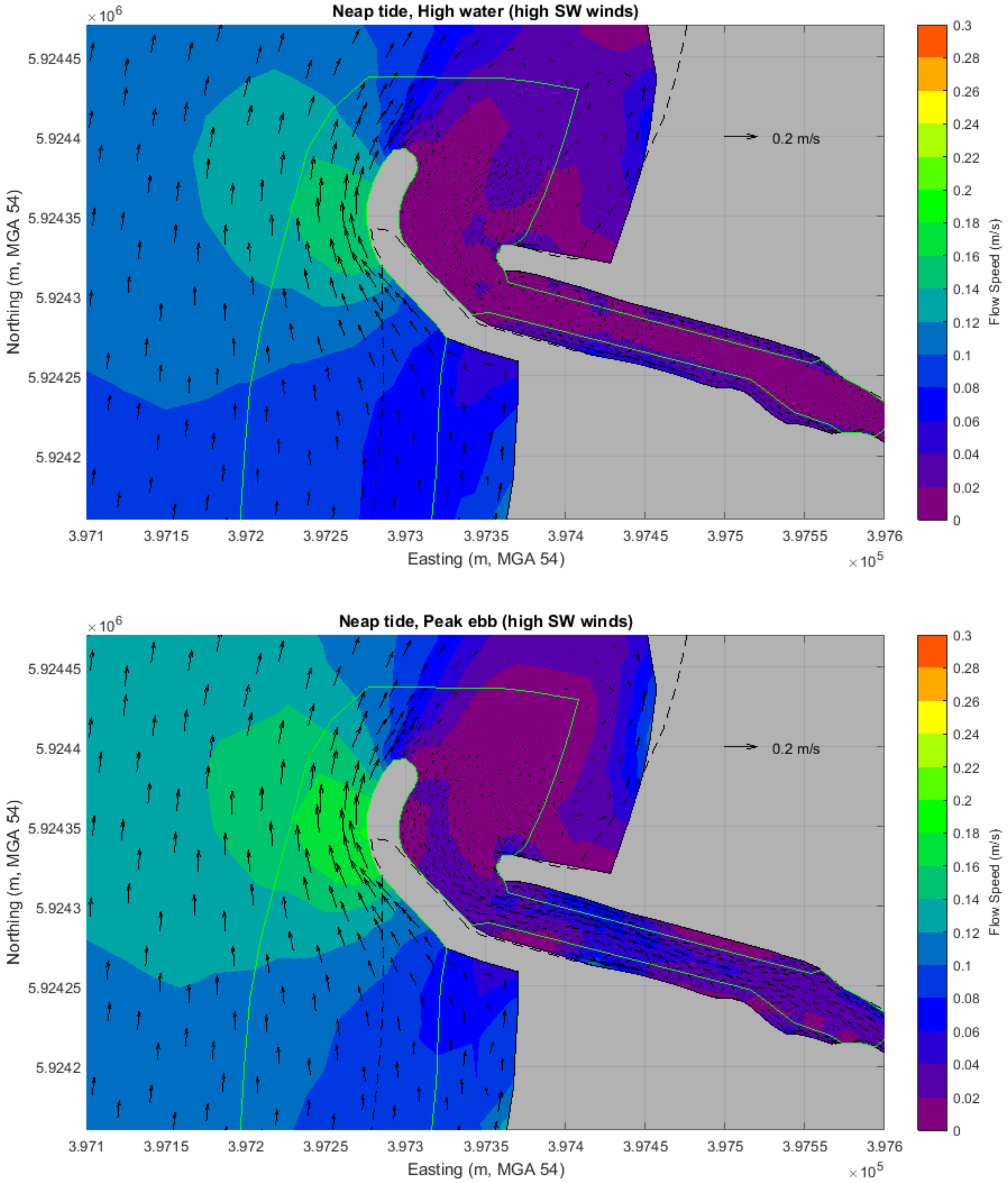


Figure A4. **Modelled tidal current speeds around Maria Creek at high water (top) and peak ebb (bottom) for a neap tide with high south-westerly winds for the Hybrid Concept.**

Appendix B – Plots for the Concept 1 Design

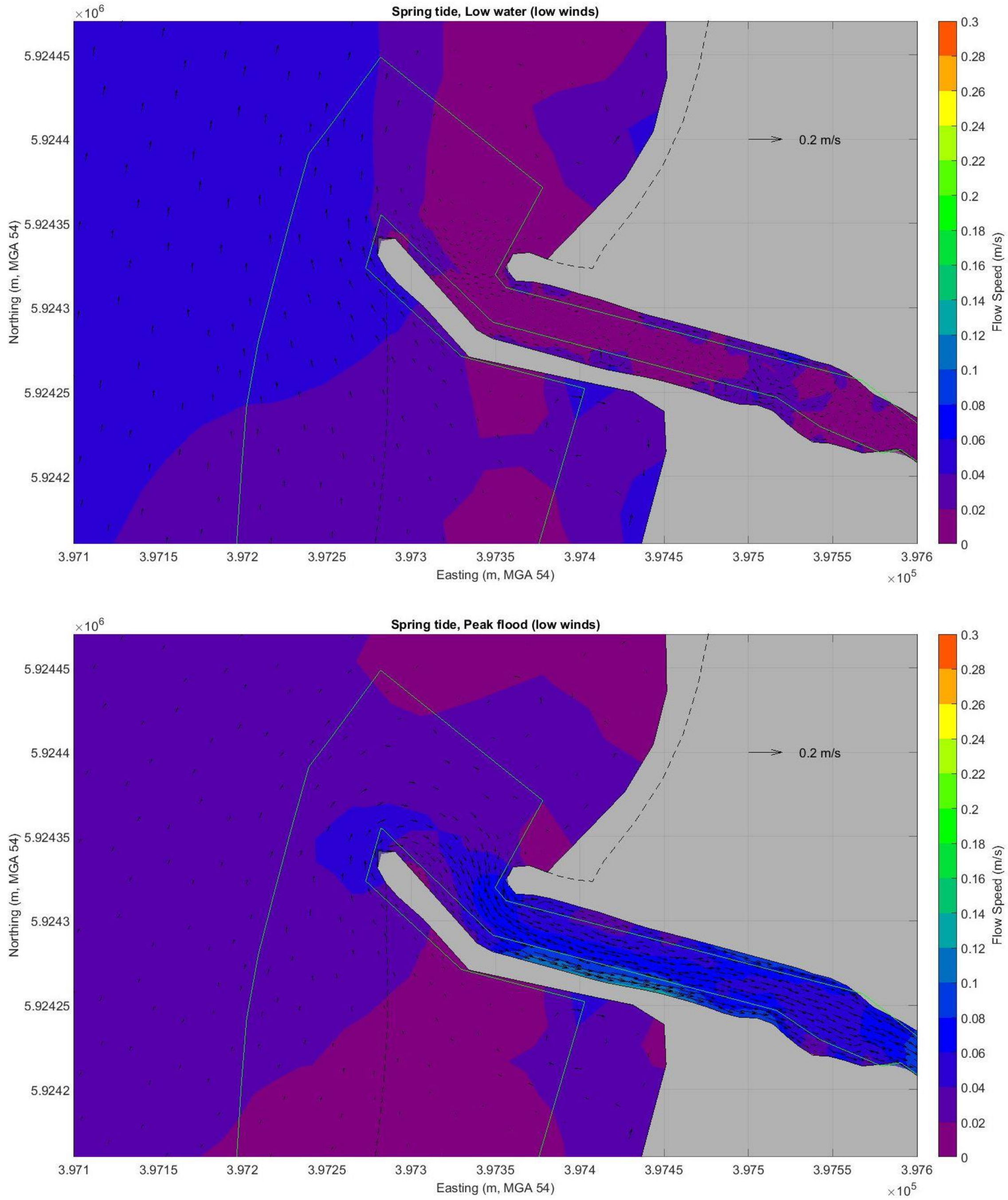


Figure B1. **Modelled tidal current speeds around Maria Creek at low water (top) and peak flood (bottom) for a spring tide with low winds for Concept 1.**

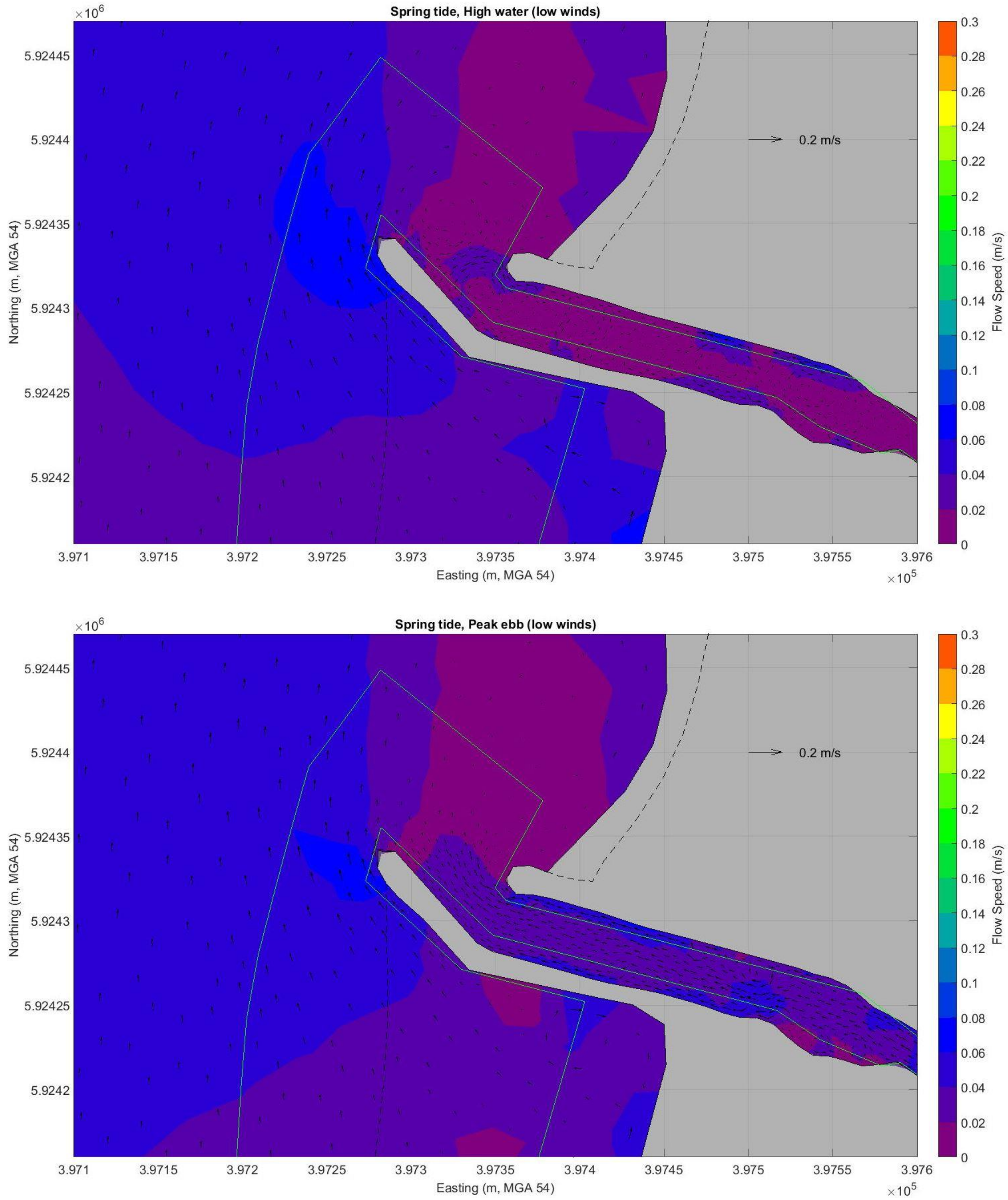


Figure B2. Modelled tidal current speeds around Maria Creek at high water (top) and peak ebb (bottom) for a spring tide with low winds for Concept 1.

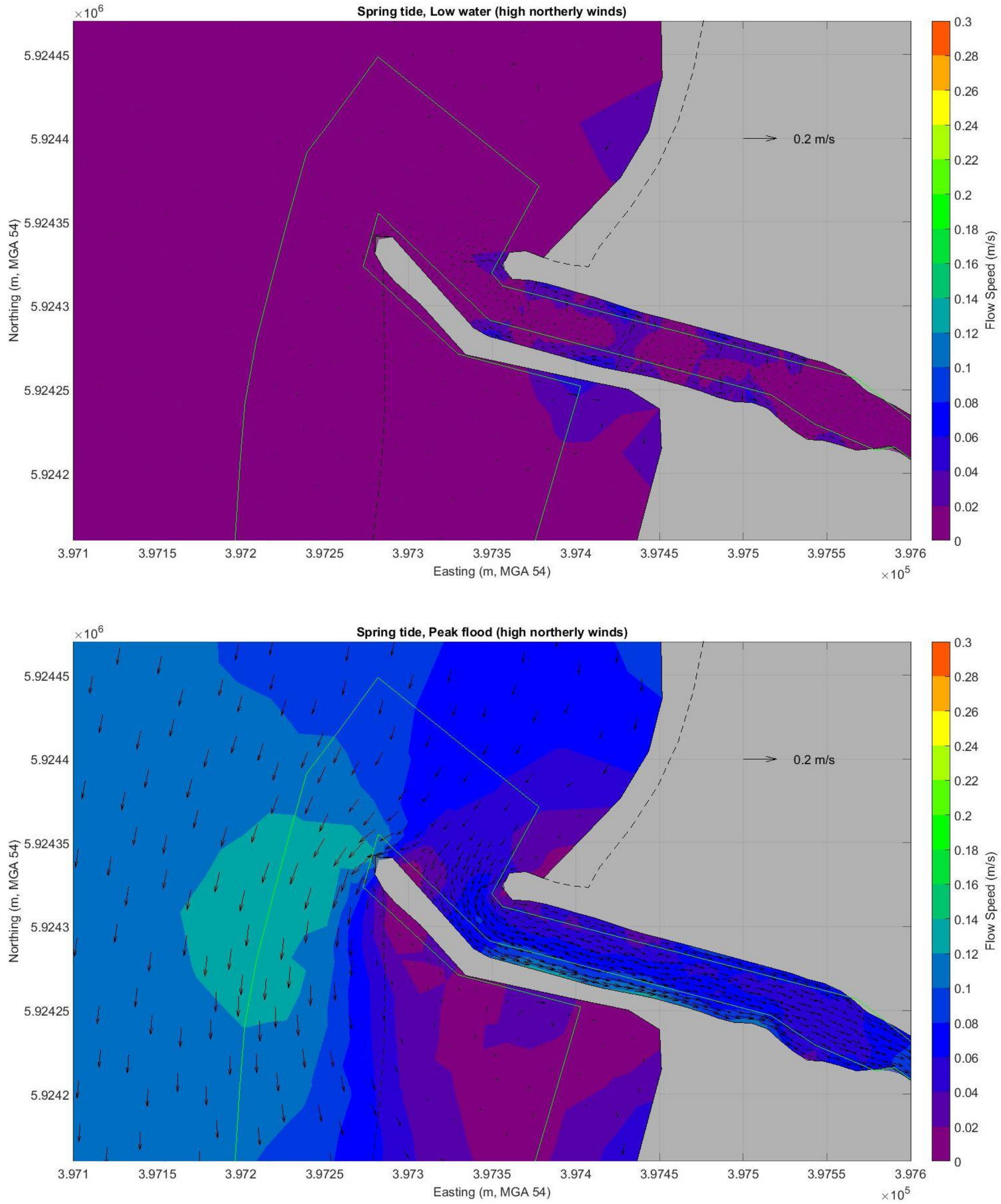
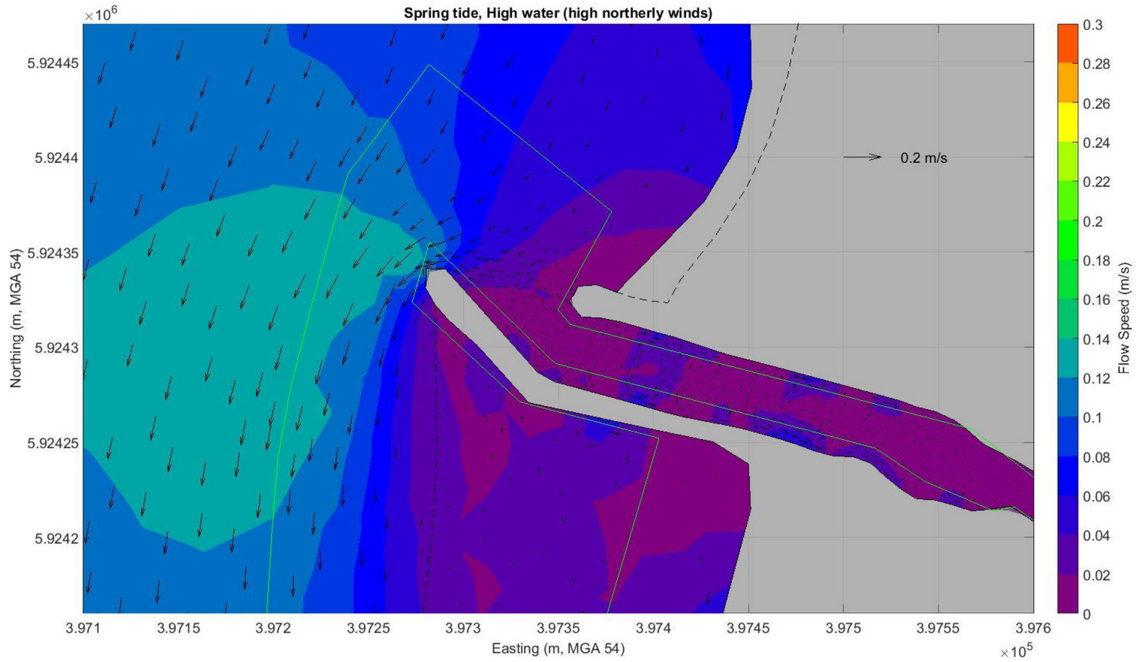


Figure B3. Modelled tidal current speeds around Maria Creek at low water (top) and peak flood (bottom) for a spring tide with high northerly winds for Concept 1.



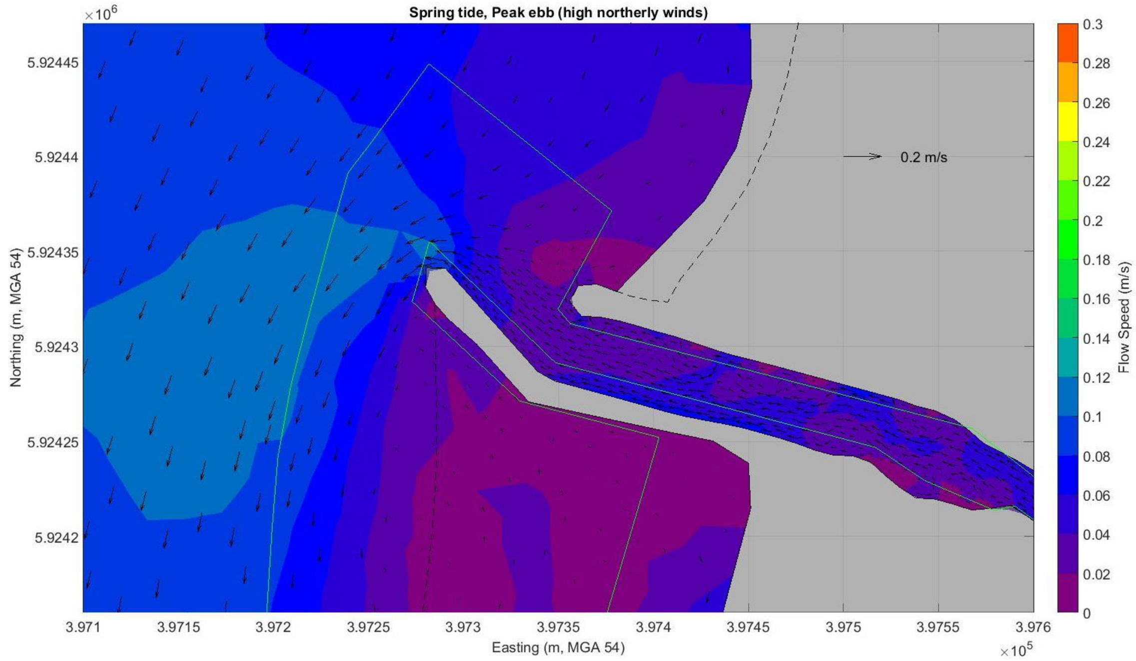
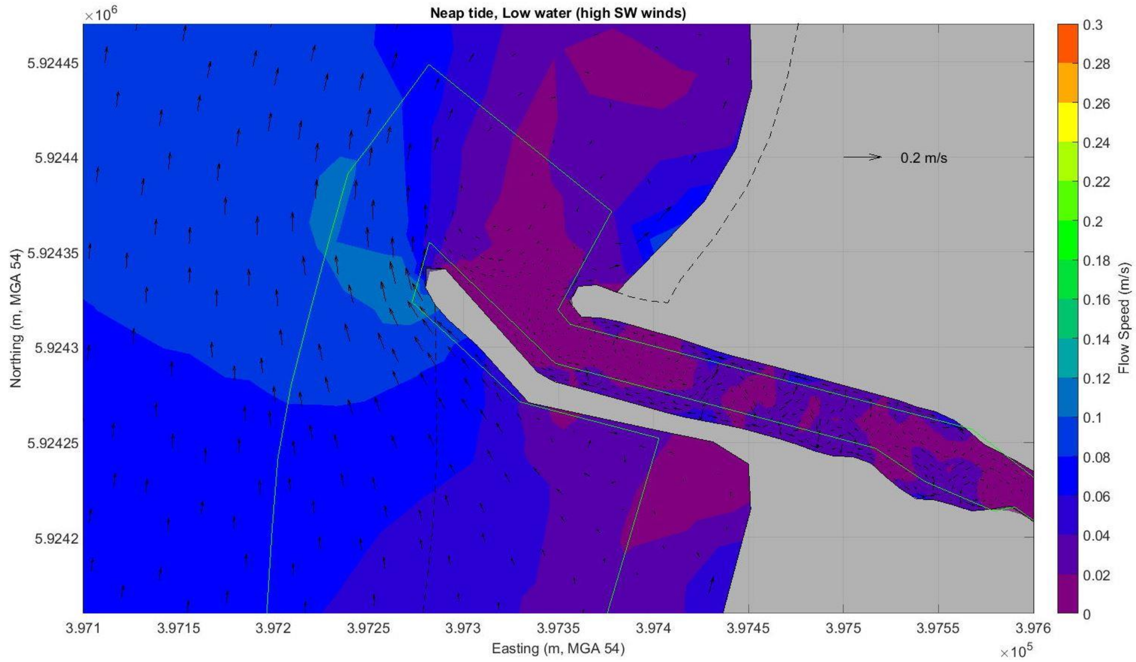


Figure B4. **Modelled tidal current speeds around Maria Creek at high water (top) and peak ebb (bottom) for a spring tide with high northerly winds for Concept 1.**



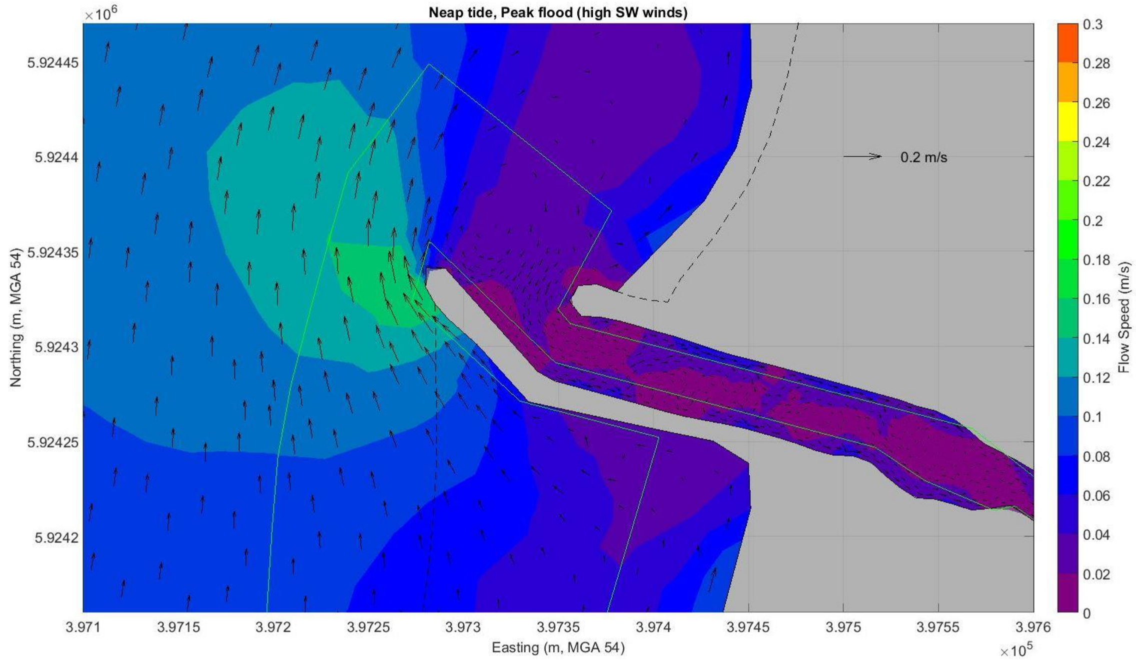


Figure B5. Modelled tidal current speeds around Maria Creek at low water (top) and peak flood (bottom) for a neap tide with high south-westerly winds for Concept 1.

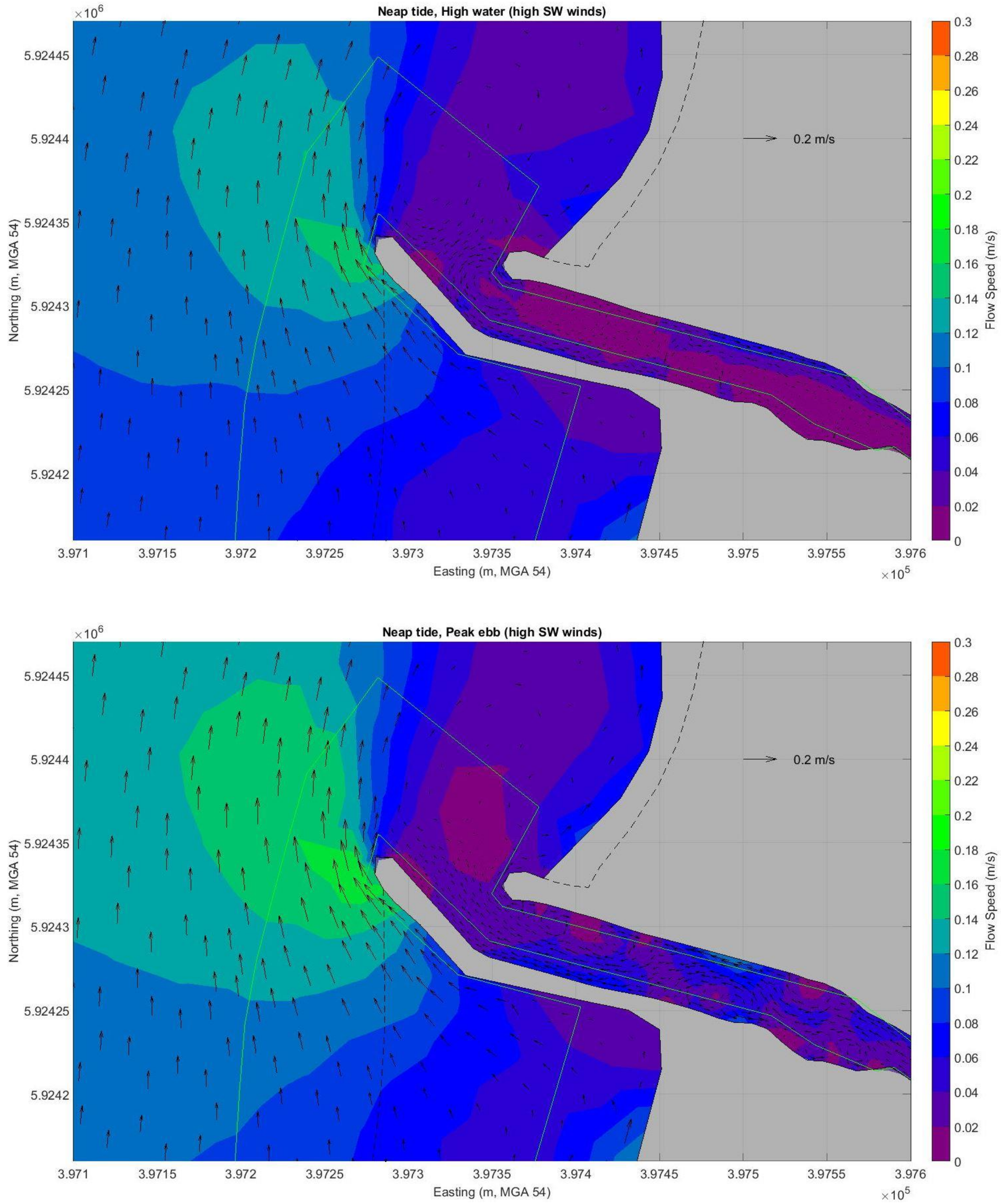


Figure B6. Modelled tidal current speeds around Maria Creek at high water (top) and peak ebb (bottom) for a neap tide with high south-westerly winds for Concept 1.

Appendix C Hybrid Concept capital cost and NPV results

Item No.	Description	Unit	Quantity	Rate, $	Amount, $
1	**Preliminaries**	Item			$ 343,026
2	**South Breakwater Repairs**				
2.1	Remove external armour	t	8,426	$ 30	$ 252,788
2.2	Sort armour	t	8,426	$ 10	$ 84,263
2.3	Supply core	m^3	5,400	$ 47	$ 253,800
2.4	Place core	m^3	5,400	$ 30	$ 162,000
2.5	Supply 6t -8t armour	t	8,269	$ 60	$ 496,125
2.6	Place 6t -8t armour	t	8,269	$ 60	$ 496,125
2.7	Place layer of internal 1.5t armour	t	2,363	$ 50	$ 118,125
2.8	Supply external armour 50m length (3xlayers 1.5t)	t	2,756	$ 55	$ 151,594
2.9	Place external armour 50m length (3xlayers 1.5t)	t	2,756	$ 50	$ 137,813
3	**South Breakwater**				
3.1	Supply Core for breakwater	m^3	6,375	$ 47	$ 299,625
3.2	Place Core for breakwater	m^3	6,375	$ 20	$ 127,500
3.3	Supply 0.5t armour	t	1,890	$ 55	$ 103,950
3.4	Place 0.5t armour	t	1,890	$ 50	$ 94,500
3.5	Supply 6t -8t granite armour	t	5,434	$ 60	$ 326,025
3.6	Place 6t -8t granite armour	t	5,434	$ 60	$ 326,025
	Sub-total (exc preliminaries)				$ 3,430,256
	Construction Total (inc preliminaries)				$ 3,773,282
	Contingency	%		20%	$ 754,656
	Approvals				$ 100,000
	Management	%		5%	$ 188,664
	Project Total (exc GST)				**$ 4,816,602**

Hybrid Concept - Extend Breakwaters NPV

Discount Rate 5

Years from Present	Discount Factor	Item	Nominal Cash Flow				Net Present Value			
			Breakwater Capital	Dredging Capital	BW Mtce	Sand & Wrack	Breakwater Capital	Dredging Capital	BW Mtce	Sand & Wrack
0	1.00000	Hybrid - Capital construction	$ 4,816,602	$ 2,820,000		$ 433,500	$ 4,816,602	$ 2,820,000	$ -	$ 433,500
1	0.95238					$ 433,500	$ -	$ -	$ -	$ 412,857
2	0.90703					$ 433,500	$ -	$ -	$ -	$ 393,197
3	0.86384					$ 433,500	$ -	$ -	$ -	$ 374,474
4	0.82270					$ 433,500	$ -	$ -	$ -	$ 356,642
5	0.78353					$ 433,500	$ -	$ -	$ -	$ 339,659
6	0.74622					$ 433,500	$ -	$ -	$ -	$ 323,484
7	0.71068					$ 433,500	$ -	$ -	$ -	$ 308,080
8	0.67684					$ 433,500	$ -	$ -	$ -	$ 293,410
9	0.64461					$ 433,500	$ -	$ -	$ -	$ 279,438
10	0.61391	Repairs for settlement of rock armour			$ 183,290	$ 433,500	$ -	$ -	$ 112,524	$ 266,131
11	0.58468					$ 433,500	$ -	$ -	$ -	$ 253,458
12	0.55684					$ 433,500	$ -	$ -	$ -	$ 241,389
13	0.53032					$ 433,500	$ -	$ -	$ -	$ 229,894
14	0.50507					$ 433,500	$ -	$ -	$ -	$ 218,947
15	0.48102					$ 433,500	$ -	$ -	$ -	$ 208,521
16	0.45811					$ 433,500	$ -	$ -	$ -	$ 198,591
17	0.43630					$ 433,500	$ -	$ -	$ -	$ 189,135
18	0.41552					$ 433,500	$ -	$ -	$ -	$ 180,128
19	0.39573					$ 433,500	$ -	$ -	$ -	$ 171,551
20	0.37689	Repairs for storm damage			$ 183,290	$ 433,500	$ -	$ -	$ 69,080	$ 163,382
21	0.35894					$ 433,500	$ -	$ -	$ -	$ 155,602
22	0.34185					$ 433,500	$ -	$ -	$ -	$ 148,192
23	0.32557					$ 433,500	$ -	$ -	$ -	$ 141,135
24	0.31007					$ 433,500	$ -	$ -	$ -	$ 134,414
25	0.29530					$ 433,500	$ -	$ -	$ -	$ 128,014
			$ 4,816,602	**$ 2,820,000**	**$ 366,580**	**$ 11,271,000**	**$ 4,816,602**	**$ 2,820,000**	**$ 181,604**	**$ 6,543,225**
							$ 14,361,431			