MEMORANDUM

To

From

Date 02 December 2016

Subject Seaspray Sea Level Rise Addendum

The following memo outlines a series of additional modelling scenarios undertaken to assess potential sea level rise impacts on flooding in the township of Seaspray. This work has been undertaken as an addendum to the Seaspray Flood Study (Water Technology, 2016).

1 INTRODUCTION

As part of the recent flood study investigation for Seaspray (Water Technology, 2016), it was determined that under existing conditions catchment derived flows dominate flooding of the township. Subsequent to the study, Water Technology has been requested to further investigate the impact of sea level rise (SLR) on future inundation extents across the township.

2 SCENARIOS

Four simulations were undertaken to determine the impacts of sea level rise on inundation of Seaspray. These were:

1. 1% AEP catchment flows + 0.8 m SLR
2. 1% AEP catchment flows + 10% AEP storm tide elevation
3. 1% AEP catchment flows + 0.8 m SLR + 10% AEP storm tide elevation
4. 1% AEP catchment flows + 0.8 m SLR + 1% AEP storm tide elevation

The original hydraulic model developed for the flood study was utilized in this modelling, with modifications only made to the ocean boundary conditions.

3 BOUNDARY CONDITIONS

The model domain and boundary locations is illustrated in Figure 3-1. Inflow hydrographs were applied to Merriman Creek at the Prospect Road Gauge, and a water level boundary used offshore to represent the tide, mean sea level, and storm surge.

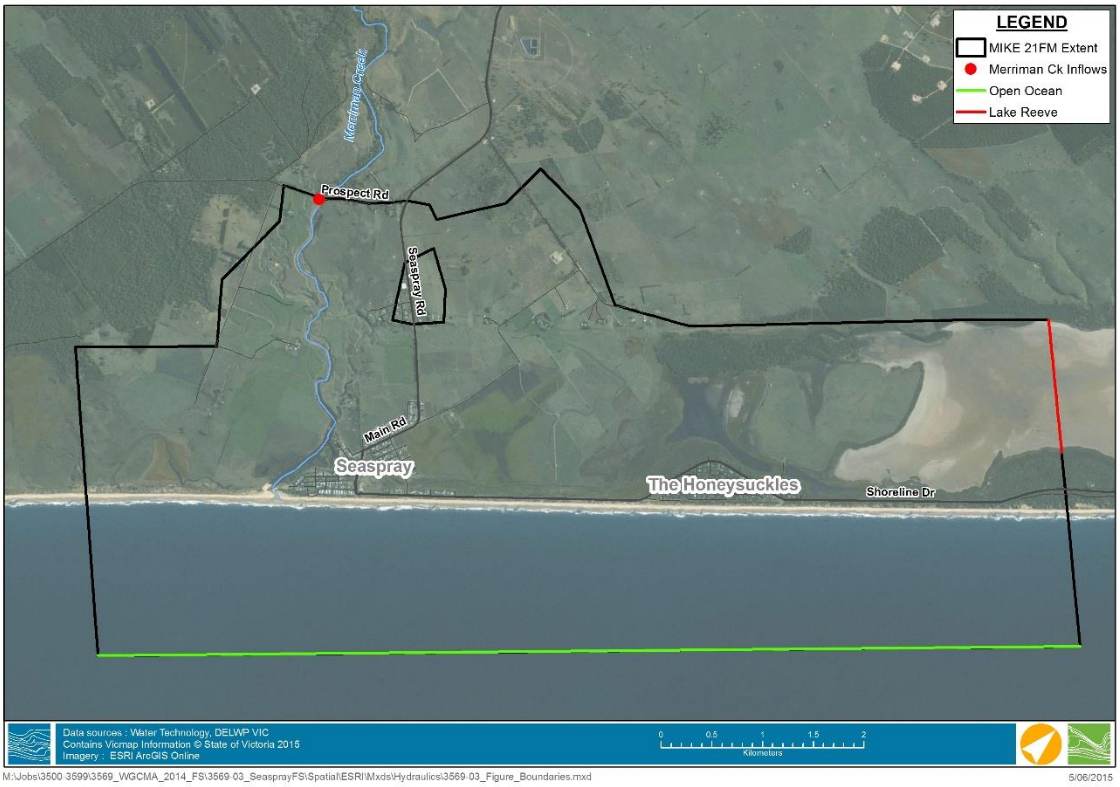

Figure 3-1 Model Boundaries

3.1 Catchment Flows

The hydrograph for the 1% AEP catchment flow derived in the original flood study work was applied for this modelling (Figure 3-2). The hydrograph peaks at around 470 cumecs (40,750 ML/d) 28 to 30 hours into the simulation, coinciding with the peak storm tide.

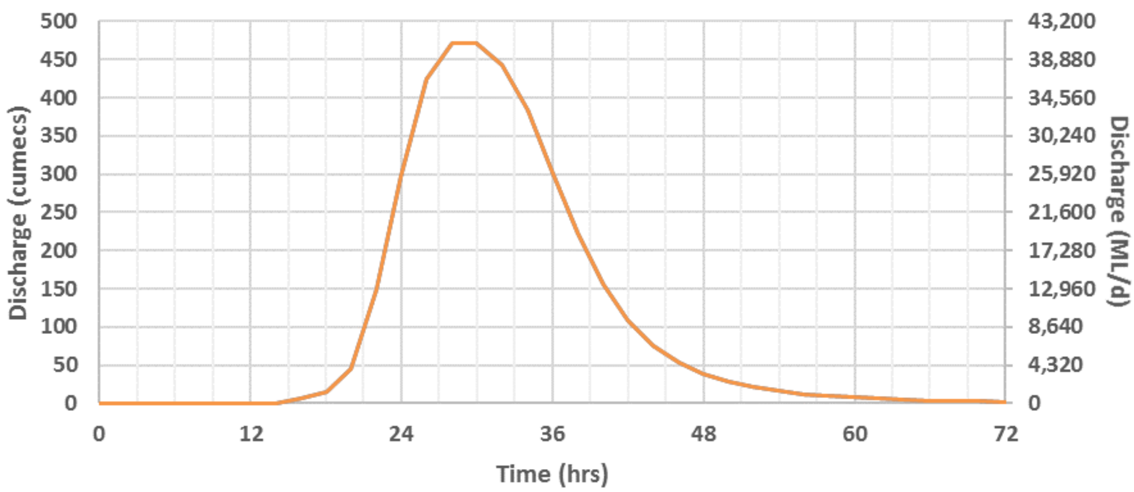

Figure 3-2 1% AEP Inflow Hydrograph

3.2 Lake Reeve

The eastern boundary bordering Lake Reeve had a constant water level equal to the mean sea level applied for these simulations. A mean sea level of 0 m AHD was used for the 10% AEP storm surge simulation, while a mean sea level of 0.8 m AHD was used for the other two simulations to represent mean sea level rise to the end of the century.

3.3 Offshore Boundary

The predicted 10% AEP storm tide at 2100 of 2.33 m AHD and predicted 10% storm surge at 2100 of 1.96 m were adopted from McInnes et. al. (2009), future climate scenario 2 (IPCC 2007 A1F1 scenario in combination with 'high' wind speed scenario). These values are for storm tide and storm surge levels at Seaspray. McInnes (2009) used a 2100 scenario applying a sea level rise increment of +0.82 m rather than the +0.8 m currently recommended for planning purposes in Victoria. For this assessment it is considered that the difference is negligible in terms of potential impact on coastal inundation. We have reported the results using the +0.8 m sea level rise increment to avoid confusion with current planning practice.

The offshore water levels for the three scenarios are illustrated in Figure 3-3.

- Scenario 1 employs a tidal signal raised by 0.8 m to represent the predicted sea level conditions at 2100.
- Scenario 3 combines this tidal signal with a sine curve, representing a storm surge. The peak water level in this scenario is derived from the 10% AEP storm tide level of 2.33 m AHD defined in McInnes et. al. (2009).
- Scenario 2 employs the same water level as Scenario 3 with a vertical shift down of 0.8 m to represent the same storm surge event in the absence of sea level rise. This results in a peak water level approximately 0.3 m higher than the current 10% AEP storm tide. All four scenarios have a peak water offshore water level occurring at the same time, and the same tidal signal underlying the boundary. This allows the impact of sea level rise and storm surge to be directly compared. The peak water level in this scenario (1.51 m AHD) is very similar to that of the current 1% AEP storm tide (1.50 m AHD).
- Scenario 4 combines a tidal signal with a sine curve, representing a storm surge to produce a storm tide peak water level of 2.64 m AHD as defined by McInnes et. al. (2009) for the 2100 1% AEP storm tide. This includes a sea level rise of 0.82 m as with all 2100 projections in McInnes et. al. (2009).

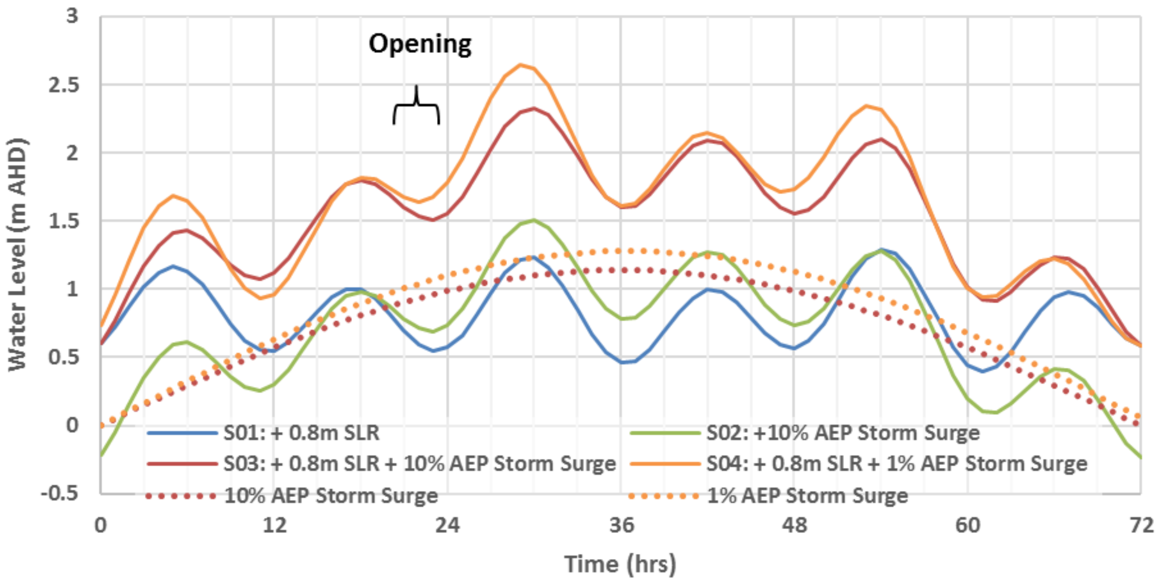

Figure 3-3 Offshore Water Level Boundaries

3.4 Entrance Conditions

Entrance conditions used in this modelling were consistent with design simulations undertaken in the Seaspray Flood Study (Water Technology, 2016). The entrance berm was initially closed with a height of 2.1 m AHD, opening over a 3-hour period to an elevation of 0 m AHD. The opening of the entrance starts from when water levels inside the estuary reach the top of the berm (2.1 m AHD) approximately 20 hours into the simulation. This means that by the time the peak storm tide occurs the entrance is completely open. The same timing for the opening was applied in all three scenarios.

Further details on the effects of entrance condition on flood level is provided in the flood study report.

4 ASSUMPTIONS

A number of simplifying assumptions have been identified in this modelling and are discussed here.

4.1 Entrance Berm Conditions

The same entrance berm conditions were applied for all model simulations, including initial berm height and shape, and rate of opening. The processes and specific geometry of entrance opening and closing are complex, as discussed in the flood study report. The berm is likely to undergo some adjustment in response to mean sea level rise, such as an increase in the mean berm height when closed, or lateral translation of the entrance berm into the estuary. Any such adjustments to berm conditions have not been included in this study.

4.2 Timing of Catchment Flows and Peak Storm Tide Water Level

All scenarios have considered the same timing of both catchment flows and peak storm tide water levels, allow simple comparison between each scenario. Timing of flood and storm tide peaks can vary greatly, however, for the purposes of this modelling the timing has been aligned to match peak catchment flows and storm tide water levels, producing the worst-case timing for each scenario.

4.3 Lake Reeve Water Levels

A constant water level boundary has been applied on the Lake Reeve side for all scenarios. For scenarios 1, 3, and 4, which included a sea level rise assumption of 0.8 m, a constant water level of 0.8 m AHD was applied, while Scenario 2 had a water level of 0.0 m AHD (no sea level rise). The impact of the water level applied at this boundary was minimal, with flood waters reaching Lake Reeve after water levels peak in Seaspray.

5 RESULTS

The results from scenario modelling are discussed in this section. Maximum water surface elevation, depth, and velocity figures for each scenario are presented in Appendix A. The 1% AEP and 0.5% AEP flood extents from the original modelling are included for reference. The original modelling included 1% AEP and 0.5% AEP catchment flow respectively, with the current 1% AEP storm tide at the ocean boundary. The gridded maximum data is also provided along with this memo.

5.1 Scenario 1 – 1% AEP catchment flows + 0.8 m SLR

Scenario 1 resulted in a similar flood extent as the original 1% AEP modelling (Appendix A). This scenario considered a tidal signal raised by 0.8 m to represent sea level rise, resulting in higher water levels offshore and in Lake Reeve prior to the flood event, and a peak water level offshore of 1.23 m AHD following the hydrograph peak. The higher initial water levels appear to have little impact on flood extents, with flood waters only reaching Lake Reeve around the time when the peak of the hydrograph is reaching the entrance meaning the tail water in Lake Reeve has minimal impact on the flooding in Seaspray.

The area north of the floodway is impacted by riverine flooding from the north west around the bottom end of Blind Creek. The floodway is filled from the west, driven by high water levels south of Blind Creek. When the levees on the northern side of the floodway are breached from the north, this leads to a breach on the southern side also, as was observed in the original modelling. The resulting peak water level in the floodway was less than in the 1% AEP design simulation, leading to reduced overtopping of Shoreline Road Levee and water levels east of the caravan park 0.17 m lower. Maximum velocities throughout the model were very similar to the original 1% AEP modelling.

High tides can be expected to exceed 1.50 m AHD approximately 4 time per month with 0.8 m SLR, and these occurrences can be predicted well in advance.

5.2 Scenario 2 – 1% AEP catchment flows + 10% AEP storm tide elevation

Scenario 2 is very similar to the 1% AEP design scenario from the original flood modelling owing to the similarity between peak storm tide levels (Appendix A). This scenario considered a peak offshore water level of 1.51 m AHD, corresponding to the 2100 10% AEP storm tide less sea level rise, while the original modelling considered a peak offshore water level of 1.50 m AHD, corresponding to the existing 1% AEP storm tide.

This slight increase in water level was reflected in the lower section of the river, downstream of Blind Creek where water levels were around 1 to 2 mm higher. There was also a small increase in overtopping of Irving Street levee resulting in water levels being 0.02 m higher.

This scenario differentiates the flooding impacts associated with sea level rise and from storm surge components. Results of this modelling suggest that the absolute tail water level rather than mechanism (sea level rise or storm surge) impacts on flooding in the southern area of Seaspray.

A key difference between these scenarios is the probability and predictability, with a 10% AEP storm tide having a 10% probability of occurring in any one year, while high tides can be expected to exceed 1.50 m AHD approximately 4 time per month by the end of the century with 0.8 m SLR.

5.3 Scenario 3 – 1% AEP catchment flows + 0.8 m SLR + 10% AEP storm tide elevation

Scenario 3 produced significantly greater flood extents and depths through Seaspray than either Scenario 1 or Scenario 2 (Appendix A). It produced significantly more flooding through town than the 1% AEP design catchment flow scenario from the original flood modelling which included the current 1% AEP storm surge. The impact of the increased tail water level tapers from the downstream end up the river. Increases in peak water levels along Trood Street Levee reduce from 0.20 m at the southern end to 0.09 m at the northern end on the outside of the floodway spillway. From the floodway spillway to Futcher street, the increase in peak water level in the floodway reduces from 0.11 m to 0.09 m. East of Futcher Street the increase in peak water level in the floodway remains below 0.06 m.

Flood depths inside the Trood Street Levee increased by 0.50 m, and inside Shoreline Road Levee increased 0.26 m. Most properties south of the floodway were directly impacted by flooding in this scenario and all would have access roads inundated. Flood depths north of the floodway increased by less than 0.05 m with the exception of a small area bordered by the floodway, Futcher Street, and Hansen Street, with an increase of 0.06 m.

Peak flow velocities were around 0.10 m/s slower than the 1% AEP design scenario in the main river channel south of Blind Creek, as could be expected from an increased tail water level. Velocities in the floodway were around 0.10 m/s faster, and the floodway was filled in this case from the spillway rather than from flows entering from the north.

In this scenario breaching of the Irving Street and Shoreline Road Levees was initiated prior to floodwaters overtopping the levees on the northern side of the floodway from the north.

5.4 Scenario 4 – 1% AEP catchment flows + 0.8 m SLR + 1% AEP storm tide elevation

Scenario 4 considered the combined 1% AEP catchment flow combined with a 1% AEP storm tide towards the end of the century with 0.8 m SLR. This scenario resulted in flood extents similar to the design 1% AEP catchment flow (with existing 1% AEP storm tide) north of the floodway, and extents closer to the design 0.5% AEP catchment flow (with existing 1% AEP storm tide) south of the floodway (Appendix A).

The flooding mechanism for this scenario is similar to Scenario 3, with breaching of the levee on the southern side of the floodway initiating prior to catchment flows breaching the levee on its northern side. The opening of the berm at the entrance was initiated by water levels within the estuary reaching 2.1 m as with all the other scenarios considered.

5.5 Comparison of Scenarios

Flood depths and extents resulting from Scenarios 1 and 2 were very similar to each other, and also similar to the 1% AEP design scenario from the original flood modelling which considered a 1% AEP catchment flow combined with the existing sea level 1% AEP storm tide. This main difference is that these results indicates a significant increase in probability of flooding in town towards the end of the century, with high tides alone producing tail water levels equal to the existing 1% AEP storm tide (1.5 m AHD) 4 times a month with 0.8 m SLR.

The similarity between flood extents in Scenarios 1 and 2 suggests that the absolute tail water level rather than mechanism (sea level rise or storm surge) impacts most on flooding in the southern part of Seaspray.

Scenario 3 produced increased flooding compared to Scenarios 1 and Scenario 2, especially in the area south of the floodway. The high water levels resulting from the combined sea level rise and 10% AEP storm tide event to the end of the century will have a significant impact on flooding in Seaspray.

Scenario 4 produces further increased flooding south of the floodway compared to Scenario 3. Flood extents north of the floodway match closely with the original modelling 1% AEP flood event which considered the existing 1% AEP storm tide, while flood extents south of the floodway match more closely with the 0.5%. This shows the impact of tail water conditions are much greater south of the floodway than north.

5.6 Summary

Key finds of this sea level rise flood assessment are as follows:

1. The entire area south of the floodway is considered to be at risk of inundation under a 1% AEP event by the end of the century.
2. Increased tail water levels due to storm surges and sea level rise result in increased flooding of Seaspray township, especially south of the floodway.
3. Any raising of levees associated with the current flood protection arrangements in Seaspray should consider the additional requirements associated with sea level rise and storm tide towards the end of the century. The levees can be designed to be upgraded as sea level rise occurs.

APPENDIX A
FLOOD MODELLING RESULTS

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS