IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	resource consent applications and Notices of Requirement by the Bay of Plenty Regional Council to undertake the proposed Kaituna River Re-diversion and Ongatoro / Maketū Estuary Enhancement Project

STATEMENT OF EVIDENCE OF JAMES DAHM

INTRODUCTION

Qualifications and experience

1. My full name is James Dahm and I am an environmental consultant specialising in coastal processes and management. I am a Director of Eco Nomos Ltd and a member of the Focus Resource Management Group.

2. I hold a M.Sc. in Earth Sciences from the University of Waikato specialising in coastal processes, coastal change and sedimentation. I am a member of the Coastal Education and Research Foundation and the New Zealand Coastal Society and a member and trustee of the Dunes Trust of New Zealand.

3. I have 31 years work experience in applied coastal science and management, including:

   (a) Authoring and co-authoring over 400 reports on applied coastal science and management – particularly addressing coastal hazard assessment and mitigation/management, restoration of coastal ecosystems and vegetation, estuarine sedimentation, dynamics of various river and tidal entrances, sand extraction, and origin and Holocene development of beach systems;

   (b) Being involved as either a principal designer or peer reviewer for a wide range of coastal management measures including over a hundred coastal restoration projects (dunes, coastal cliffs, estuaries), coastal setbacks and associated controls, beach nourishment in both sandy and mixed sand-gravel beach systems, a cobble/boulder beach protection system, coastal retreat, and a wide range of siteand property-specific coastal hazard mitigation and/or protection strategies and measures;

(c) Initiating community-based dune restoration (Beachcare/Coastcare) and playing a significant role in development of restoration methodologies/guidelines for this work;

(d) Being part of design teams involved in various large-scale projects including estuarine restoration, estuary entrance training works, beach nourishment, marinas, harbour development, and various engineering structures;

(e) Auditing and reviewing (e.g. for resource consenting and peer review purposes) a wide range of coastal management works and structures in respect to coastal processes and environmental impacts.

(f) Contributing to various regional and national guidelines for coastal hazard assessment and management; and

(g) Sitting on hearings as a Commissioner - including on proposals for sand extraction, coastal revetment, coastal walkway and tidal power.

4. I have also worked extensively with river and lake environments - including river bank and lakeshore erosion assessment and management; assessment and management of bridge, pier, abutment and general scour; flood and flood level assessments; and design of a major tailrace excavation.

5. Over the last two decades, my work in the above areas (including management of coastal hazards) has particularly focused on working with nature to the extent practicable and the restoration of coastal ecosystems – reflecting changes in national and other policy away from the traditional engineering/protection paradigm in coastal management.

Scope of Evidence

6. I have been involved in the Project since early 2012, when I was involved to assist with peer review of the alternatives report (at Tab B, Volume 1 of the AEE) and the ongoing modelling, and to provide input on aspects related to coastal processes and change.

7. In addition, I have assessed and prepared reports addressing the potential effect of the Project on:

(a) shoreline erosion risk around the margin of the Maketu estuary and along the Kaituna River edges (herein referred to as the erosion memo);[1] and

(b) the Te Tumu entrance and bar (herein referred to as the navigation memo).[2]

8. These assessments are based on the DHI modelling, previous reports and historical information on the area, previous experience working on the Department of Conservation's 1996 partial re-diversion, and various empirical and geomorphic models and relationships from the coastal processes literature.

9. My evidence will cover:

(a) The existing environment of the upper and lower estuary (see Figure 1 for locations), and the effects of the earlier diversion works in shaping that environment;

(b) The potential effects of the Project on coastal erosion and estuarine sedimentation in:

(i) the lower estuary, Maketu township foreshore, and the Maketu spit;

(ii) the upper estuary, including Papahikahawai Island, the diversion channel, and the lower River; and

(c) Where necessary, proposed mitigation measures.

10. Matters related to the effect of the Project on Te Tumu Cut (aka Te Tumu entrance or Kaituna River mouth) are covered in the evidence of Dr Martin Single.

11. I will also provide comments on the submissions as they relate to the scope of my evidence. Other witnesses also provide comments on the submissions relevant to their areas of expertise and project involvement. I have been involved in several of the submitter meetings.

12. I have read and am familiar with the section 42A report and the proposed set of consent conditions and will refer to these where relevant to my evidence.

13. Lastly, I have read the Code of Conduct for Expert Witnesses in the Updated Environment Court Practice Note (2014) and agree to comply with the Code. This evidence is within my area

[1] Memorandum to Pim de Monchy and Steve Everitt: Effects on Coastal and Riverbank Erosion and Morphology, June 2014, at Tab B Volume 2 of the AEE).
[2] Memorandum to Pim de Monchy, Steve Everitt, and Stephanie Brown dated 11 February 2015, prepared jointly with DHI and reviewed by Dr Martin Single.

of expertise, except where relying on the evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

EXECUTIVE SUMMARY

14. The original diversion of the Kaituna River from the estuary in 1956 led to a considerable increase in flood tide inflows, a significant decrease in river and tidal outflows, and decreased fluvial sediment supply to the estuary. These changes:

    (a) Caused extensive sedimentation and expansion of the flood tide delta in the lower estuary; seriously exacerbating erosion of adjacent shorelines and also leading to ongoing periodic breaching of the Maketu Spit;

    (b) Contributed (along with decreased freshwater inflows) to extensive loss of intertidal wetlands (particularly rushland) and associated bed level lowering in the central and upper regions of the estuary. The wetland loss caused serious erosion along the landward margin of Papahikahawai Island and led to increased exposure of upper estuarine shorelines to wave and current erosion during extreme sea level events;

    (c) Significantly reduced flushing in the upper estuary; leading to ongoing and significant accumulation of organic matter in the upper estuary and along the margin of Papahikahawai Island. This has led to serious anoxic sediment conditions in many sheltered areas of the estuary (see evidence of Mr Keith Hamill for further details of these conditions and associated ecological effects).

15. The Project will markedly increase river flows through the estuary, significantly decrease flood tide inflows and lead to outflow dominated sediment transport throughout much of the estuary. These changes:

    (a) Will significantly decrease flood tide sedimentation in the lower estuary and, in my view very likely reduce the size of the flood tide delta over time. The reason for my view on this matter is that extensive research on flood- and ebb-tide delta systems in sandy estuaries indicates that gross morphology is significantly influenced by patterns of net sediment transport. This reduction in size of the flood tide delta will markedly decrease erosion risk around the shorelines of the lower estuary and, over time, the frequency of spit breaching.

    (b) Will increase the flushing of organic sediments from the estuary, improving sediment quality in this area over time.

(c) Are not likely to affect (either increase or decrease) shoreline erosion in the upper estuary. However, the Project may facilitate future restoration of rushland with human intervention (see my earlier erosion report and evidence of Mr Roger MacGibbon) and this would provide increased shelter and erosion protection to adjacent shorelines.

16. Peak velocities in the diversion channel are relatively low and are unlikely to cause severe bank erosion. Nonetheless, the proposed erosion protection works in the most vulnerable areas are appropriate risk management given the potential consequences of any severe erosion.

17. River bank erosion within the existing Kaituna River will either be unaffected or (downstream of the diversion channel) slightly decreased.

LOWER ESTUARY – EXISTING ENVIRONMENT AND EFFECT OF 1956 DIVERSION

18. For the purposes of this evidence, the lower estuary is defined as the area including the enlarged flood tide delta and adjacent shorelines – as shown Figure 1, Attachment A to my evidence.

19. The coastal morphology and processes in this area were significantly modified by the diversion of the Kaituna River from the estuary in 1956. It is now a markedly changed environment.

20. Prior to diversion, most of the estuary tidal prism was infilled by river flows; which also augmented ebb discharges on outgoing tides. At this time, outflows were highly dominant over inflows (similar to the existing lower Kaituna River and Te Tumu Cut situation) and the flood tide delta in the lower estuary was a relatively minor feature (Figure 2– top photo).

21. Following the diversion of the river through Te Tumu Cut, flood tide inflows through the estuary entrance markedly increased to compensate for the loss of river flows. This significantly changed the balance between inflows and outflows and caused significant expansion of the flood tide delta and associated sedimentation in the lower harbour (Figure 2 – lower photo).

22. The increased tidal inflows extended the channel along Beach Road to the area fronting Park Road and the expansion of the ebb tide delta pushed this tidal channel hard against the shoreline (Figure 2). This caused severe erosion along the foreshore of the town, particularly along the front of Park Road. By 1963, the wide sandy beach that previously occurred along the seaward margin of Park Road had been lost and rock protection had been placed to prevent further erosion. Over the following years, continued expansion of

the flood tide delta also pushed tidal channels close to the shoreline between Park Road and the marae; causing erosion in this area by the 1980's and leading to rock protection also being placed along much of this shoreline length up to near the marae.

23. The expansion of the flood tide delta following diversion of the river from the estuary has also caused periodic severe erosion along the landward margin of the Maketu Spit adjacent to the lower estuary (e.g. Figure 2 – see lower photo). These periods of erosion have even led to breaching of the spit on at least two occasions (1979 and 1994) (e.g. Figure 3). The spit breaches cause significant but temporary changes to the pattern of channel and banks in the lower estuary (Figure 3). Following the breaches, the entrance slowly migrates eastwards back to its original position and the pattern of channel and banks inside the estuary recovers; with this process taking at least 4-5 years following the breaches in 1979 and 1994.

24. In contrast, prior to diversion of the river from the estuary, the spit was typically consistently very wide in areas adjacent to the lower estuary (e.g. see top photo in Figure 2 – typical of condition shown also by other photos taken prior to the diversion).

25. Accordingly, the morphology of the lower harbour and the adjacent shorelines has been significantly modified since the 1956 diversion; largely as a consequence of the significant increase in flood tidal inflows and associated flood tide delta expansion and sedimentation.

26. Ongoing severe adverse effects are also evident – with upstream expansion of the flood tide delta presently causing severe erosion along the landward margin of the spit (Figure 4). This could lead to a further spit breach in coming years. Any breaching is most likely to occur during a severe storm event with elevated sea levels and storm-wave overtopping.

27. The location of the present erosion of the spit is further upstream than in the case of any of the other breaches since the river was diverted. Accordingly, a breach in the present area of severe spit erosion may cause more significant disruption of inner harbour morphology than has occurred previously. It may also take a longer time for the estuary entrance to migrate eastwards to its original position following any breach in this location. The reason the flood tide delta is presently causing spit erosion much further upstream is not clear but it may indicate progressive ongoing expansion of the flood tide delta up the harbour over time.

POTENTIAL EFFECTS OF THE PROJECT ON THE LOWER ESTUARY

28. Modelling by DHI indicates that the area of the flood tide delta is presently dominated by flood tide (i.e. upstream) directed sediment transport leading to ongoing expansion of this feature (see top diagram in Figure 5). The modelling also indicates the strong cross-

channel component of net sediment transport in the area where the spit is presently being narrowed by erosion (Figure 5) – illustrating the processes resulting in expansion of the flood tide delta forcing the main tidal channel closer to the spit. This increases nearshore currents adjacent to the spit and results in increased erosion of the foreshore under the combination of local wind waves and tidal currents. The modelling also indicates areas of strong flood tide directed transport within parts of the main channels (see upstream areas of the main channel in top diagram of Figure 5 in Attachment A).

29. In contrast, once the proposed partial re-diversion back into the estuary has been implemented, the modelling predicts that the lower harbour will be dominated by ebb-directed sediment transport in most areas including large areas of the flood tide delta (see bottom diagram in Figure 5). Moreover, remaining areas of flood-tide directed sediment transport will be markedly reduced in most areas; including most areas of the flood tide delta (Figure 5).

30. These changes reflect the increased outflows and decreased flood tidal inflows that will accompany the proposed re-diversion.

31. These significant changes are very likely to give rise to marked morphologic change over time – as the pattern of flood- and ebb-tide dominated sediment transport has a significant effect on the morphology of sandy harbours and flood tide deltas.

32. The exact morphologic outcome of the hydrodynamic and consequent sediment transport changes is difficult to predict. However, given the significance of the changes in net sediment transport (Figure 5), the direction of morphologic change over time is very likely to move the harbour morphology back towards the morphology that occurred prior to the diversion. In particular, the changes are very likely to reduce the expanded flood tide delta – partly reversing the effects on the earlier diversion.

33. The re-diversion is unlikely to completely restore the morphology that prevailed before the 1956 diversion as it only diverts part of the river back through the estuary. Nonetheless, the significant and widespread nature of the changes in net sediment transport indicates that the consequent morphologic changes are likely to be significant and readily observable over time. The reasons for this are outlined in more detail my earlier erosion report. However, in simple terms, extensive research indicates that on sandy coasts the gross morphology of inlet-delta systems (i.e. entrances and associated flood and ebb tide deltas) is strongly influenced by the pattern of net sediment transport.

Beach Road

34. The modelling by DHI (2014) indicates that the proposed Kaituna River re-diversion will significantly reduce the dominance of flood-tide residual sediment transport in the channel fronting the Beach Road rock wall, with some areas of the channel even becoming ebb-dominated (Figure 5).

35. Again, the exact morphologic outcomes are difficult to predict but the expected changes could include some reduction in the depth and extent of the channel adjacent to Beach Road and some movement of this channel away from the shoreline at the township end. The changes are therefore not likely to increase scour along the edge of the rock protection along Beach Road.

36. In the more seaward areas of the channel, the modelling predicts a change from flood- to ebb-directed net sediment transport (Figure 6 below). Accordingly, there may be a slight increase in channel depths here but these are unlikely to be of sufficient magnitude to significantly affect the rock protection. Nonetheless, monitoring is proposed to confirm this (see Proposed Condition 28 and discussion of the Beach Road foreshore below). Similarly, any changes in tidal current velocities will have no adverse effect on the stability of the structure; which is designed for the much higher energy wave conditions periodically experienced - associated with refracted storm waves propagating into the harbour through the entrance during storms with elevated sea levels. These storms are the only events likely to damage the rock wall and they will be unaffected by the Project. However, if the increased outflows widen the entrance (which may occur, as suggested by the peer reviewers, given the close relationship between tidal prism and entrance dimensions as established by extensive research) then that may slightly increase wave propagation into the lower harbour. Accordingly, the proposed monitoring is appropriate.

Foreshore of main township (Park Road Area)

37. Prior to the diversion of the river from the estuary in 1956, this foreshore was fronted by a wide sandy beach and shallow intertidal areas (see top photo in Figure 3). This wide sandy beach was dynamic (being exposed to ocean waves propagating through the estuary entrance at higher stages of the tide) but was evident in all available aerial photos prior to the diversion (including vertical and oblique aerial photos dating from 1939, 1948, 1953 and 1955). Records from the time also indicate it was a popular sheltered area for children to swim. The relative stability and permanence of the wide high tide beach led to the local community raising and grassing landward parts of the area to enhance recreation.

38. Following the 1956 diversion, the increased flood tide inflows formed a channel along the foreshore and this channel also moved landward as the flood tide delta expanded (Figure 3). This resulted in rapid erosion of the foreshore in the years immediately following the 1956 diversion at Te Tumu. This severe erosion eventually led to rock protection being placed to protect the eroding foreshore and township – rock protection being evident in aerial photos dating from at least 1963. The erosion and the placement of the rock protection resulted in loss of the beach along the foreshore.

39. The modelling indicates that the proposed partial re-diversion will significantly reduce inflows and flood tide directed sediment transport. Over time, this is likely to reduce the size of the expanded flood tide delta and the forces which formed and hold the present channel against the shoreline.

40. While the final morphology is difficult to predict, resultant changes are likely to include shallowing and reduced erosional forces along the foreshore. It is not clear if the reduction in the flood tide delta and flood tide inflows will be sufficient to restore a sandy beach seaward of the present rock protection – particularly as the existing rock protection is close to the seaward edge of the high tide beach that existed prior to diversion of the river from the estuary. However, the changes are very likely to increase the potential for softer options and enhanced beach amenity – even though full restoration of a high tide beach (if desired by the community) might still require some retreat of the rock protection. Monitoring is proposed to measure the changes over time (see Proposed Condition 28 and discussion in paragraphs 63 to 68 below).

Town foreshore – 733 Maketu Road to Marae

41. Prior to the 1956 diversion, this shoreline was characterised by a sandy beach fronted by a shallow intertidal flat, with shallow low tide channels located some distance further offshore.

42. Following diversion, aerial photographs indicate that the ongoing expansion of the flood tide delta into the estuary (accompanying the marked increase in flood tide inflows) gradually pushed a tidal channel close to the shoreline. This process is also well shown by the sediment transport residuals in this area (see top diagram in Figure 5). This exacerbated shoreline erosion, eventually leading to various forms of protection works being placed along much of the shoreline; extending eastwards to about the marae.

43. The DHI modelling indicates that the proposed re-diversion will significantly reduce flood-tide directed sediment transport in the areas immediately offshore from this shoreline (see bottom diagram in Figure 5). This is likely to markedly reduce the forces which presently hold the channel against the shoreline. Therefore, while the final morphologic outcome is

difficult to predict, the direction of change is likely to be back towards the morphology that prevailed before the 1956 diversion. Over time, it is probable that the channel will move further offshore over time and that erosion forces along the shoreline will reduce.

44. Accordingly, the re-diversion is likely to provide increased opportunities in the future for beach and dune restoration and for the use of soft approaches for the management of coastal erosion. Depending on the scale of the natural changes, it may be possible to even remove some of the existing hard protection structures over time following the re-diversion. Monitoring is proposed to measure these changes and enable early identification of opportunities for restoration of natural values and/or removal of hard structures.

Town foreshore – southern areas

45. Prior to the diversion, this area of shoreline was extensively protected by large areas of rushland located immediately offshore (see Figure 2). Little to no loss of this rushland is evident in aerial photographs pre-dating the 1956 diversion (Park, 2014).

46. Following the diversion, significant progressive loss of rushland occurred over the following decades. There are now only minor isolated remnants left along the area immediately offshore from the shoreline. A new equilibrium now appears to have been reached with no further significant loss of rushland in recent years (Park, 2014).

47. The loss of the rushland offshore from the shoreline has exposed most of the shoreline to wave action at higher stages of the tide. However, this area of shoreline is relatively sheltered and only exposed to locally-generated, fetch-limited waves. Field inspection indicates that present-day erosion processes are relatively minor.

48. The only moderate erosion occurs towards the extreme southern end of the township where concrete and other rubble has been placed along the boundary of residential properties (Figure 6). In this area, the stream discharging from the township flows directly along the seaward edge of private properties and appears to exacerbate wave erosion. It is not clear to what extent this present stream alignment relates to the 1956 diversion. However, prior to the diversion there was dense estuarine wetland (particularly rushland) in this area and the wetland directed the stream offshore and then towards the main estuary (Figure 2). Accordingly, it seems probable that the wetland loss arising from the diversion has contributed to the changed stream alignment and consequent erosion.

49. The impact of the partial re-diversion on coastal erosion along this shoreline will primarily depend on whether or not the re-diversion encourages rushland recovery. The DHI modelling suggests the re-diversion will result in some minor lowering of salinities in this area. There is also likely to be increased input of suspended sediment, particularly during

high river flows (floods and freshes). However, it is not clear whether these changes will be sufficient to promote rushland recovery in this area. In particular, field inspection suggests that bed levels may now be too low for saltmarsh and other higher elevation wetland vegetation (e.g. sarcocornia, salt meadow) over significant areas of the intertidal flats. Even if the re-diversion encourages some recovery of elevation over the intertidal flats (which is not certain), this may take some time to occur. Therefore, significant natural recovery of rushland immediately following the re-diversion seems unlikely.

50. However, there is potential in the longer term for the project to enable wetland recovery through human intervention following the re-diversion as discussed in my earlier erosion memo and the various work by Mr MacGibbon. Accordingly, in the longer term, the project may well help facilitate wetland recovery with associated erosion protection benefits.

Maketu Spit adjacent to lower estuary

51. This distal end of the spit adjacent to the lower harbour (Figure 4) was consistently wide prior to the 1956 diversion; with no sign of any severe erosion along the landward margin despite the fact that the full river flowed through the estuary at that time (Figure 2).

52. However, following the diversion, expansion of the flood tide delta has periodically caused severe erosion along the landward margin of the spit, leading to breaching of the spit on at least two occasions (1979 and 1994).

53. A further period of flood tide delta expansion is presently occurring, causing severe erosion and narrowing of the spit in the area approximately 600-800 m from the entrance (Figure 4) and this may lead to further breaching of the spit in the next few years. Modelling by DHI indicates the present dominance of flood tide directed sediment transport over the flood tide delta (Figure 5); this sediment transport driving the upstream expansion of the flood tide delta. The modelling also indicates strong cross-channel residual (i.e. net) sediment transport directions directly opposite the present spit erosion (Figure 5). This confirms that that the expansion of the flood tide delta is acting to push the tidal channel nearer the spit shoreline in this area.

54. The modelling indicates that the proposed partial re-diversion will markedly reduce flood tide directed sediment transport over most of the flood tide delta and will reverse net sediment transport directions (i.e. give rise to ebb-directed net transport) along the main channel margin of the flood tide delta (see bottom diagram in Figure 5).

55. Accordingly, it is likely that the proposed re-diversion will stop the ongoing expansion of the flood tide delta and, over time, will gradually erode and reduce the size of this feature. It is difficult to accurately predict the reduction in size of the delta over time but it is likely to be

significant given the marked reduction in flood tide directed net sediment transport and the significant increase in outflow-directed net sediment transport (see Figure 5).

56. It is not clear however if the benefits of the proposed re-diversion will occur in time to prevent the present erosion developing into a spit breach. DHI (2014) note that the proposed re-diversion may even slightly exacerbate spit erosion for a period immediately following implementation; as there will initially be a small increase in both flood and ebb velocities adjacent to the spit until the flood tide delta reduces in size, particularly during extreme flood events.

57. It is my opinion that any effects of those small changes on spit erosion are likely to be minor and the influence of the re-diversion on the present erosion will eventually be positive; reducing nearshore velocities and erosion as the channel and flood tide delta dimensions adjust to the altered sediment transport residuals.

58. However, the timescale for these benefits is hard to reliably predict. I would expect the re-diversion to eliminate flood tide delta expansion almost immediately; since effects on the hydrodynamics and sediment transport will obviously be almost immediate. Full reduction in the size of the enlarged flood tide delta to a smaller size in equilibrium with the altered current flows and sediment transport may however take several years or even 1-2 decades; though I would expect useful reduction within 1-2 years in areas adjacent to the main channel (i.e. areas of high sediment transport).

59. In my view, whether the re-diversion will prevent the present erosion developing into a spit breach will depend critically on how soon the Project can be implemented and how much further the spit is eroded and narrowed before the re-diversion occurs. If the re-diversion is delayed for some years allowing the spit to be seriously narrowed by ongoing erosion, then a breach may occur during a major storm before the re-diversion, during commissioning or even after full commissioning.

60. In view of the uncertainties around this area, monitoring of the erosion is proposed (see Condition 28 and discussion in paragraphs 63 to 68 below) together with appropriate adaptive management.

SUMMARY OF EFFECTS IN THE LOWER ESTUARY

61. Over time, the proposed re-diversion is likely to significantly reduce erosion along the shorelines adjacent to the lower harbour due to the marked reduction in flood tide delta expansion and size that will accompany the changes in hydrodynamics and sediment transport. These benefits will be particularly evident along:

(a) The foreshore of Park Road and the township through to (and including) the marae where protection works may eventually be able to be removed and a high tide beach restored.

(b) The landward edge of Maketu spit. In this area, periods of severe erosion and periodic spit breaching are likely to be markedly reduced in both frequency and severity; and possibly even eliminated in the future.

62. Overall, the effects on coastal erosion in the lower harbour will be either positive (most areas) or neutral (southern areas of township through to Maketu Road). However, there are uncertainties related to some areas where adverse effects may be experienced (e.g. spit erosion; depths in the boat access channel). Accordingly, monitoring is proposed with appropriate mitigation depending on the results of this work (see following paragraphs).

PROPOSED MONITORING IN THE LOWER ESTUARY

63. Given the uncertainty in relation to both spit erosion and morphologic response of shorelines around the lower harbour, monitoring of the spit erosion is proposed, together with bed level and shoreline monitoring along Beach Road, the boat ramp access channel and the foreshore of the township up to and including the marae (see Proposed Condition 28).

64. The proposed monitoring of the present spit erosion will enable appropriate mitigation work to be considered in the unlikely event that the re-diversion does significantly exacerbate erosion for a period. The practicality and nature of any appropriate action will depend on conditions prevailing at the time.

65. The initial survey work should extend from at least 10 metres landward of the existing shoreline out to the edge of the main channel (or at least to spring low tide). Subsequent surveys need only extend from the toe of the erosion scarp out to the edge of the main channel (or spring low tide). Existing aerial photographs will provide appropriate information on existing time-averaged erosion rates which can be used for comparison with the monitoring results.

66. The proposed monitoring along Beach Road will ensure early warning in the event of any significant scour along the seaward toe of the existing protection works. Two transects are proposed along this shoreline and should be adequate. These will need to be well located and include a transect fronting the more seaward areas of the protection works – the most likely area where scour and adverse effects might occur.

67. Monitoring of depths in upper reaches of the boat ramp channel is proposed as the significant reduction in flood tide inflows anticipated could affect depths in parts of this channel. Appropriate mitigation action will depend on the nature and scale of any effects indicated by the monitoring.

68. The monitoring proposed along the front of the township is expected to show a movement towards shallowing and beach recovery over time rather than any aggravation of erosion risk. Nonetheless, the monitoring will enable the benefits to be better quantified and will help highlight opportunities for recovery of natural shoreline features (e.g. beaches and dunes) and removal of hard structures as they arise.

EXISTING ENVIRONMENT OF THE UPPER ESTUARY AND IMPACTS OF 1956 DIVERSION

69. Papahikahawai Island can be broadly subdivided into two geomorphic units:

(a) Elevated sand dunes along the seaward side of the island; and

(b) Low-lying peaty soils and sands along the landward side of the island (see Figure 8 and Figure 9).

70. Elevated sand dunes extend along most of the seaward side of the island (separated from the Maketu spit by Papahikahawai Creek) but are most notable at the northern end where they commonly rise to elevations of 3-5 m above mean sea level, with maximum elevations up to about 7.5 m (Figure 9). In central and southern areas of the island, the dunes are much lower – with typical maximum heights of about 1.5 m above mean sea level (Figure 9).

71. The low-lying area of peaty soils and sands occur along the landward half of the island (Figure 8); where elevations are typically 0.5-1 m above mean sea level (Figure 9). These low-lying areas were originally part of the extensive area of estuarine and freshwater wetlands (largely rushlands) that occurred prior to the 1956 diversion; originally extending from the sand dunes of Papahikahawai Island southwards to the main river channel (Figure 10). Following the diversion of the river in 1956, large areas of these wetlands were progressively lost over time (Park, 2014).

72. This extensive loss of wetlands is likely to have been caused by various mechanisms; including increased salinity (particularly affecting freshwater wetlands) and bed level lowering following the 1956 diversion. These mechanisms are discussed in my earlier erosion memo.

73. The erosive retreat of the low-lying wetlands composing the landward side of Papahikahawai Island was only arrested when Maori landowners constructed a sand bund/stopbank along the estuarine margin of the wetlands (Figure 11) in the 1970's. This bund, vegetated largely (though not exclusively) in pampas (Figure 11), is slowly eroding and acts both as erosion protection and as a stopbank for the remnant wetland and low-lying areas of Papahikahawai Island. All of the rushland seaward of the bund had largely been eliminated by 2011 apart from isolated patches; with only around 0.3 ha remaining of the 71 ha present prior to diversion of the river from the estuary (Park, 2014). If the sand bund had not been constructed, it is likely that erosion would have largely eliminated the remaining low-lying wetlands and eroded Papahikahawai Island back to the high dunes along the seaward margin.

74. The remnant low-lying areas of Papahikahawai Island protected by the bund are largely drained and used as grazing (Figure 8) but there are also some remnant wetland areas (e.g. see top photo in Figure 11 and evidence of Mr Roger MacGibbon).

75. Seaward of the bund, the only significant areas of rushland remaining are isolated patches (some quite large) formed on the elevated beach immediately seaward of the slowly eroding bund (Figure 12). Further seaward on the adjacent intertidal flats – there is now only a small isolated (and eroding) patch of rushland remaining from the extensive areas that occurred prior to the diversion (Figure 12). Elsewhere, bed levels over the intertidal flats are now well below the elevations required for native maritime rush species such as sea rush and oioi.

76. Wave washed algae deposits also occur in a band along the front of the sand bund (Figure 11), typically underlain by anoxic muddy sediments (Figure 14). Large areas of organic accumulation and anoxic sediments are also evident in other areas of the upper harbour as discussed in the evidence of Mr Keith Hamill. The accumulation of these materials indicates a significant reduction in natural flushing since diversion of the river from the estuary.

77. Causeways/bunding and drainage have also resulted in loss of significant areas of intertidal and vegetated wetland from the estuary as discussed in the evidence of Mr Roger MacGibbon.

78. Overall, since the 1956 diversion, the upper harbour has experienced significant wetland loss (due to erosion, bed level lowering, salinity changes, causeways and drainage/reclamation) and extensive accumulation of organic material and anoxic sediments (due to reduced flushing).

POTENTIAL EFFECTS OF THE PROJECT ON THE UPPER ESTUARY

79. The modelling indicates that the proposed re-diversion will significantly increase freshwater inflows and ebb dominated sediment transport in the middle- and upper-harbour, including over the intertidal flats adjacent to Papahikahawai Island (Figure **15**).

80. This widespread increase in ebb-dominated sediment transport in the upper harbour is very likely, over time, to improve the flushing from the estuary of algal accumulations and associated anoxic, organic mud.

81. This flushing will be assisted by wave stirring associated with fetch-limited, locally-generated wind waves which will aid entrainment and dispersal of the algae by the outwards dominated flows. While local wind waves are typically very low, the velocities and turbulence associated with these is sufficient to entrain sediments – particularly as the tide rises and falls over the areas.

82. The scale of the improvement is difficult to reliably predict but, in my opinion, the scale of the current changes indicated by the modelling is such that significant flushing of these materials from the harbour is likely over time.

83. Therefore, over time, reduced algal accumulations are likely over the intertidal flats. This should also reduce (and possibly even eliminate) the supply of wave-washed algae to the Papahikahawai Island shoreline (Figure 18). The increased outflow currents, together with wave stirring should also assist in the dispersal of the band of algae accumulated along the shoreline and the underlying anoxic muddy sediments.

84. The effect of the proposed re-diversion on sediment supply and recovery of original bed levels is less clear. Existing bed levels over the intertidal flats adjacent to Papahikahawai Island are now typically well (>0.2 m) below those required for maritime rushland. Accordingly significant sediment input would be required to restore habitat suitable for the recovery of this ecosystem.

85. DHI (2014) note that the proposed re-diversion may increase sediment supply from the river to the estuary, particularly during floods – which they believe could lead to some deposition in the upper estuary during flood flows. I concur with this opinion, particularly in respect to coarser sediments (e.g. coarse silts and fine sands) that may be carried into the upper estuary in suspension during flood flows and then settle out as velocities decrease (i.e. as the diversion enters the wider harbour). In my view, this would be a beneficial effect given the sediment loss and bed level reduction that has occurred since the 1956 diversion. However, even if this beneficial effect occurs, I doubt that the sediment supply will be

sufficient to restore bed levels over the intertidal flats to the elevations required for maritime rushland; and almost certainly not over short periods (i.e. several years).

86. The primary reason for this is that the proposed re-diversion is not likely to carry anything like the volumes of suspended sands and coarse silts that used to occur during floods when the entire river flowed through the estuary. The bulk of these sediments are likely to remain in the Kaituna River with only a small portion carried into the estuary by the proposed re-diversion.

87. It is also uncertain whether the relatively low velocities and turbulence levels in the diversion channel will be sufficient to carry significant volumes of coarser sediments that might settle within the harbour. It is more probable that most of the sediment carried into the estuary by the re-diversion will be suspended muds; most of which are likely to remain in suspension and be discharged from the estuary. Accordingly, even if some deposition occurs, it is likely to require a long time (e.g. many decades or more) to restore bed levels to those required for maritime marsh.

88. Monitoring of the effects of the diversion on the upper estuary is recommended, including:

(a) Monitoring of organic and associated sediment accumulations to confirm the effects of the proposed re-diversion on the dispersal and removal of these contaminants.

(b) Monitoring of bed levels and sediment characteristics to better assess/confirm the effect of the proposed re-diversion on these properties.

89. This monitoring is important not only to assess and confirm the effects of the re-diversion on these aspects but also to assess whether additional action will be required (in the shorter or longer term) to restore ecological health and function in the upper estuary.

Papahikahawai Island

90. The re-diversion is not likely to have a significant beneficial effect on erosion of Papahikahawai Island as it is not likely to result in recovery of the rushland or other ecosystems which originally composed/protected this shoreline because:

(a) As discussed in the evidence of Mr MacGibbon, the re-diversion is unlikely to reduce salinities sufficiently to allow restoration of large areas of freshwater/palustrine wetlands.

(b) Existing bed levels over these intertidal flats are now well below the elevations required for maritime rushland (e.g. sea rush and oioi) to establish.

91. As noted in the preceding section, while there is a possibility that the re-diversion will facilitate some sediment deposition in the upper estuary it is unlikely that this deposition will be sufficient to facilitate significant recovery of bed levels in the short-medium term. Therefore, significant natural rushland recovery is unlikely to occur in the short-medium term and so the estuarine margin of Papahikahawai Island is likely to remain vulnerable to erosion.

92. Accordingly, erosion protection for Papahikahawai Island will require the existing sand bund to be retained in the interim. Removal of the bund would result in the low-lying lands behind this feature being progressively eroded. This would restore estuarine wetlands but probably open intertidal flats rather than rushland; which the Maori landowners have indicated would not be acceptable (Mr Pim de Monchy, pers. comm.).

93. It is unlikely that erosion of the bund will be significantly altered (i.e. increased or decreased) by the project as this erosion largely relates to wave erosion during extreme sea levels and these processes will be relatively unaffected. Nonetheless, as a precaution, a condition is proposed requiring monitoring of erosion in the vicinity of the island (see Condition 28.1 and discussion of monitoring in paragraphs 116 to 119 below).

94. I have recommended that the Regional Council continue to look into other options to manage erosion risk which may, in the future, better provide for the ecological and natural character objectives of the Project than the existing bund. Various such options are discussed in my earlier report on erosion and the various work by Mr MacGibbon. This work should, and I understand will, be conducted in partnership with the owners of Papahikahawai Island as part of a separate Biodiversity Management Plan. While not directly part of the Project itself, the initiatives undertaken as part of the Project are intended to facilitate and enable this kind of outcome in the future.

95. In terms of erosion risk to the ocean (northern) side of Papahikahawai Island, I concur with the assessment of Mr Ben Tuckey that increased flows arising in this area (e.g. as a consequence of the removal of the existing causeways and the diverted river flows) (Figure 15) are not likely to cause serious bank erosion in this area.

Southern margin – stopbanks

96. The stopbanks along the southern estuary margin encroach close to the existing estuary margin and over former estuarine areas. Accordingly, they are vulnerable to erosion and, historically, have been subject to severe erosion.

97. In particular, file notes record severe stopbank erosion during the Wahine storm of 9-10 April, 1968 during which sea levels in Maketu were higher than had previously been

recorded. A report by the (then) Tauranga County engineer dated 24 April 1968 records serious erosion of the stopbank face reducing the top width to an average of only “2 feet” (i.e. about 0.6 m) over a length of “58 chains” (i.e. about 1.1-1.2 km). Diagrams accompanying the file notes indicate the damage extended from the middle to the upper estuary.

98. Murray (1978) also notes stopbank erosion in some areas in May 1977 resulting in various “corrective” measures, including dumping of rocks and logs and the planting of spartina. He also notes that spartina had been planted next to another area of stopbank in the mid-estuary in 1972 to prevent erosion.

99. It is probable that serious erosion such as the Wahine storm relates to the combination of extreme sea levels and the penetration of some storm wave energy into the estuary (probably in the form of longer period infragravity waves or surges). The present stopbank protection works have been designed to accommodate 1% AEP sea and river flood events with a margin for safety and uncertainty.

100. The significant loss of intertidal wetlands from the upper estuary following the 1956 diversion (discussed in preceding sections and in more detail by Park, 2014) is likely to have contributed to the erosion through increased wave energy in this area. The loss of the river flows would also contribute (at higher stages of the tide) to the penetration of storm-swell energy into the estuary.

101. As noted above, the proposed re-diversion is not likely to result in recovery of significant rushland or bed levels over the existing intertidal flats of the upper harbour. The works are therefore not likely to significantly reduce erosion forces along the shoreline.

102. The increased river/tidal velocities accompanying the proposed re-diversion are too low to cause any significant erosion of the banks and therefore the diversion is also not likely to significantly aggravate any erosion of the banks. Therefore, the proposed diversion is not likely to have any significant effect on the severity of the erosion accompanying future storm events.

103. Overall, the Project is likely to be neutral in respect to erosion hazard along this shoreline.

104. In the longer term, there would be benefit in setting the stopbank further landward from the estuary margin and restoring saltmarsh and other natural vegetation or features to enhance erosion protection. However, this is outside the scope of the present project.

Diversion Channel

105. This area includes the banks along the full length of the re-diversion channel (i.e. the new cut, Ford Island, the bend adjacent to the Corbett land, and the enlarged Ford's Cut channel).

106. Modelling of water velocities through this channel by DHI indicate that velocities are relatively low even during flood situations, with peak velocities in the new diversion channel and the enlarged Fords Cut averaging less than 1.5 m/s (except immediately downstream of the culverts). The highest velocities also occur near the channel centre rather than the margins, except near bends. These velocities are unlikely to promote significant erosion of the channel banks.

107. Nonetheless, as a precaution the construction report proposes that rock protection is placed along the southern bank of the new channel to protect the stopbank, with a 5 m berm also placed between the top of the channel and the stopbank (see Section 2.6 of Waterline, 2014). In my opinion, this is appropriate risk management.

108. The construction report (Waterline, 2014) also proposes as a precaution the placement of rock protection on the outside banks of the minor bends in the new channel and the banks adjacent to the culvert structures. I support this approach.

109. In my opinion, the remaining unprotected banks of the diversion channel are at low risk from significant erosion. Periodic inspection of the unprotected banks should be conducted as a precaution.

Kaituna River and entrance

110. The modelling indicates that Kaituna River flows upstream of the diversion channel are not significantly changed. Accordingly, there is not likely to be any aggravation of erosion in this area.

111. In the areas downstream of the diversion channel, the river flows are decreased due to the partial diversion. Accordingly, any existing river erosion issues in this area are likely to be either unaffected or slightly decreased – probably the former as most erosion occurs at high river flows when the effect of the diversion will be less pronounced.

112. The Kaituna River stopbank is rock armoured upstream from the river mouth and this area has suffered damage in past extreme events, due to storm waves penetrating up the river. Particularly serious damage occurred during the Wahine storm. File notes report that the rock works slumped at numerous locations between the mole and a distance of about 140

m upstream, as well as several “very minor” slumps beyond that. These events relate to the combination of extreme sea levels and storm wave action and the proposed diversion will have no significant adverse effects on this risk.

113. The effects of the proposed re-diversion on the river entrance (i.e. Te Tumu Cut) including limiting bar depths were assessed in the modelling (DHI, 2014) and a review of these findings using geomorphic models and well-tested empirical procedures (Eco Nomos and DHI, 2015). This work concluded that the proposed re-diversion would have no measurable effects on bar depths and navigability at low and mean flows (the conditions of concern to submitters). These conclusions were supported in the peer review by Dr Martin Single. These various matters are covered in detail in Dr Single’s evidence and are therefore not repeated here.

SUMMARY OF EFFECTS IN THE UPPER ESTUARY

114. Overall, the proposed partial re-diversion:

(a) Will significantly increase outflows and enhance the dominance of outflows over inflows in sediment transport in the upper estuary. Over time, this is very likely to enhance flushing and removal or organic accumulations in the upper harbour and enhance ecological health - as also discussed by Mr Hamill

(b) May result in some minor increased sediment deposition in the upper estuary over time; but this deposition is not likely to be adequate to restore original bed levels and associated rushland in the short to medium term.

(c) Is not likely, in itself, to be adequate to restore protective rushland over the intertidal flats adjacent to Papahikahawai Island. Accordingly, retention of the existing sand bund will be required to protect wetlands and other low-lying land behind this bund.

(d) Is not likely to have any significant positive or negative effects on shoreline erosion in the upper harbour.

(e) Is not likely to aggravate bank erosion within the Kaituna River.

115. Overall, effects of the Project on physical processes in the upper estuary are therefore either positive (improved flushing of organic matter and contaminants) or neutral (shoreline erosion) and so no additional mitigation is required.

PROPOSED MONITORING IN THE UPPER ESTUARY

116. Monitoring of erosion and bed levels is proposed for the shoreline of Papahikahawai Island and over the adjacent intertidal flats (see Proposed Condition 28.1). In my opinion, the four transects proposed will be adequate, with careful selection of the location of the proposed monitoring transects. The initial transects surveys should include the full width of the bund and also extend at least 20 m landward of the bund. Subsequent surveys need only extend from the estuarine face or toe of the bund. The permanent markers for the transects should be accurately positioned so they can be re-established if lost.

117. It is also recommended that work be conducted to obtain information on rates of erosion prior to the diversion – to provide "before" measurements as a basis for assessing the effects of the diversion. It is important to appreciate that erosion of the bund is episodic during extreme events and that there will some lengthy periods in which little to no erosion occurs. Accordingly, good information on episodic events and time-averaged rates prior to the re-diversion will be required to properly assess/interpret the results of the proposed monitoring. These "before" measurements are probably best achieved by shoreline change analysis using available historic photography since the bund was installed. This approach would provide the most reliable indication of the time-averaged rates prior to the re-diversion. I have recommended the addition of a new condition requiring this.

118. In my opinion, there would also be value in extending the transects across the intertidal flats to the main channel to monitor bed levels over time. This would help assess any trends for bed level erosion or sedimentation over time. I have proposed amendments to Proposed Condition 28 accordingly.

119. If no significant changes in erosion or bed levels are observed in the first three years after the re-diversion, there is provision for review of the monitoring including reduction in frequency (e.g. once every 5-10 years but with provision for additional surveys after notable extreme events) and/or offshore extent (proposed Condition 26).

RESPONSE TO SUBMISSIONS

120. I have considered the submissions that have raised issues relating to the scope of my role in the Project.

Dr Chris Richmond and Maketu Ongatoro Wetland Society Inc (MOWS)

121. Dr Chris Richmond, who project-managed the earlier small re-diversion, supports the applications. However, he expresses concern that the Project does not seek consents to excavate part of the flood-tide-delta and use the sand to reinforce the inner margins of the

spit. Concern in respect to spit erosion and the need for additional mitigation measures is also raised in the separate submission by MOWS.

122. I was one of the technical experts involved in the team advising Dr Richmond on these matters at the time of the earlier application. The recommendation for spit reinforcement at that time reflected the fact that the diversion at that time was relatively small (and in fact was further decreased by the terms of the resource consent granted). We did not believe it would be sufficient to prevent ongoing expansion of the flood tide delta and associated spit breaching. Accordingly, additional reinforcement of the spit was proposed.

123. In contrast, the proposed partial re-diversion is much larger. It is clear from the modelling that this re-diversion will very significantly alter sediment transport in the lower harbour and particularly the forces driving periodic expansion of the flood tide delta and consequent spit breaching (see Figure 5). For the reasons discussed earlier, it is my view that the proposed re-diversion alone will be sufficient to mitigate (and probably even eventually eliminate) the risk of flood tide delta expansion and associated spit breaching. Accordingly, no additional mitigation is required on this occasion.

124. In regard to potential short-term aggravation of the erosion by the proposal, raised by MOWS, this matter has been discussed above (paragraphs 51 to 60). As noted in that discussion, any adverse effect is likely to be minor and short term; with the long term effects on spit erosion likely to be extremely positive. Nonetheless, the Applicant has proposed a condition (Proposed Condition 28.2) addressing monitoring of the erosion and consideration of appropriate mitigation action in the unlikely event that the Project is found to be aggravating the erosion.

Western Bay of Plenty District Council

125. The Western Bay of Plenty District Council (WBoPDC) notes that in view of the uncertain morphological outcomes on the channels in the vicinity of Beach Road, Park Road and town foreshore areas, the consents should provide for dredging of the channels if required to maintain existing seawalls/protection structures or maintain access to the boat ramp.

126. In my opinion, it is very unlikely that the channel will move significantly towards the protection structures and, even it was to do so, dredging and sand placement would probably be only a temporary solution. Monitoring is proposed along Beach Road and the township foreshore (see Proposed Condition 28.4 and discussion above at paragraphs 66 to 68). The details of appropriate mitigation action are best decided if the monitoring indicates that re-diversion aggravates risk to the protection works.

127. In relation to the boat ramp, it is noted in my earlier erosion report that the decreased flood tide inflows may adversely impact on depths within the boat ramp access channel (particularly upper areas nearer the ramp) over time – though this is uncertain. In my opinion, the concern is best addressed by monitoring bed levels in the access channel as is proposed in Condition 28.4(c). In the event that depths are significantly impacted, it is not clear that dredging would necessarily be the best option and other options may be more appropriate. Accordingly, appropriate mitigation is best addressed at the time.

128. The WBoPDC also recommends that, as opportunities arise, the consent holder should actively pursue the removal of hard structures and encourage replacement with soft options. As discussed earlier in this evidence, it is my opinion that many of the existing hard structures were only required as a direct consequence of the 1956 diversion and that opportunities for removal of these structures and/or restoration of natural beach and dune values may well arise given the potential positive effects of the re-diversion. I agree with the WBoPDC submission that these opportunities should be actively pursued as they arise. The WBoPDC and BoPRC have agreed that any opportunities for restoration are best achieved by other means such as through a biodiversity management plan or riparian initiatives.

Mr Eion Harwood

129. Mr Eion Harwood, who has long-standing experience with the upper estuary, expresses concern in his submission that there will not be sufficient current in the upper- and mid-sections of the estuary to flush out the anoxic sediments. His concerns relate to the fact that the diversion will only occur during incoming tides, when the velocities in the diverted flow will be reduced by seawater entering through the Maketu Estuary. Mr Harwood is concerned that the Project may even result in the anoxic mud in the upper- to mid-estuary being spread into mid and lower areas.

130. I appreciate the reasons for Mr Harwood's concerns and acknowledge that it may appear counter-intuitive to expect increased scour; given that the diversion occurs during an incoming tide when velocities in the estuary will be damped by opposing tidal inflows through the Maketu Entrance. However, it is important to appreciate that it is the residual (i.e. net) sediment transport over the full tidal cycle that is significant. It is quite clear from the modelling that, over a full tidal cycle, the Project will result in a significant increase in both the magnitude and spatial extent of outwards-dominated residual sediment transport in the upper and middle harbour relative to the present situation (Figure **15**). This means that, over a full tidal cycle, materials suspended by waves and currents will tend to be moved downstream and out of the harbour. In my opinion, wave suspension of the contaminants

will also be particularly important as this will facilitate dispersal by the markedly altered water flows.

131. Accordingly, as discussed earlier, it is very likely that the Project will result in improved flushing of contaminants from the upper harbour over time and it is my opinion that the concerns expressed by Mr Harwood are unlikely to eventuate.

132. Mr Harwood also expresses concern that the Project will increase sedimentation in the upper harbour due to the extra river flow. As noted by Mr Tuckey, this is not likely to be the case during typical river flows when the only sediment will be fine suspended muds that are likely to remain in suspension and be flushed right through the harbour. However, as discussed by Mr Tuckey and earlier in this evidence, there is potential for coarser sediments to be carried with the diverted flows during floods and higher flows and some of these materials may deposit in the upper harbour. Nonetheless, as discussed earlier (paragraphs 85 to 89 above) this is not likely to be significant.

133. It is also important to distinguish between sedimentation in the upper harbour associated with natural sediments (e.g. river-derived fine sands and coarse silts) and that related to anoxic muds associated with algal decomposition. As is evident from Mr Hamill's evidence, the latter (i.e. the anoxic organic sediments) are clearly a significant problem. However, any natural sedimentation from river-derived sediment is more likely to be beneficial. As discussed in my earlier erosion report, there is evidence that bed level lowering following the 1956 diversion contributed to the significant rushland loss. The present lowered bed levels over the intertidal flats adjacent to Papahikahawai Island are generally too low at present for maritime rushland (e.g. oioi, sea rush) to re-establish. Accordingly, any sedimentation associated with deposition of coarse silts and fine sands may well be beneficial – over time helping to re-establish bed levels more suited to recovery of maritime rushland. However, as discussed earlier in this evidence any such beneficial effect is likely to be very slow and to occur only periods of many decades or even longer; with human intervention is likely to be required if it is desired to restore maritime rushland in the interim.

134. Mr Harwood also notes that he is not sure that reduced erosion will be one of the benefits of the proposal. However, as discussed earlier, the original 1956 diversion significantly increased erosion around the lower harbour due to expansion of the flood tide delta. As also discussed earlier, it is very clear from the modelling that the proposed re-diversion will significantly reduce the size of the flood tide delta over time and this is very likely to reduce erosion on the shorelines around the lower estuary, as discussed in detail in my evidence above.

SECTION 42A REPORT

135. I have read the sections of the Officers Report that relate to my evidence, (particularly Section 11.6) and the relevant proposed conditions (Condition 28 and 23.4(b)).

136. I concur with the assessment in Section 11.6 of the Officers Report.

137. I also support the recommended monitoring conditions but have recommended various changes to the wording of these conditions and added some additional recommendations. In all cases, these changes accept or expand on the monitoring requirements proposed by the Officers Report. In some cases, the wording has also been modified to ensure the proposed monitoring is effective in achieving the purposes outlined in this evidence. In no cases have the changes reduced the monitoring recommended by the Officers Report.

CONCLUSION

138. It is my opinion that the proposed partial re-diversion will largely have positive or neutral effects on shoreline erosion and estuary morphology. The areas in which there are uncertainties and the potential for (typically minor) adverse effects have been addressed by proposed monitoring. This monitoring will allow for appropriate mitigation action to be taken if required.

139. Accordingly, overall, it is my opinion that, subject to compliance with the recommended conditions, the Project will result in acceptable effects on shoreline erosion.

Jim Dahm

17 April 2015

Figure 1: Aerial photograph of Ongatoro / Maketu Estuary showing key locations referred to in text

Figure 2: View of lower estuary in April 1939 prior to diversion of river from the estuary (top) and in November 1959 (bottom) shortly after the diversion. Note the markedly enlarged flood tide delta in the lower photo.

Figure 3: Aerial photograph from December 1979 showing lower harbour area shortly after a spit breach.

Figure 4: Recent (July 2013) aerial photograph showing erosion along the landward margin of the spit with associated narrowing.

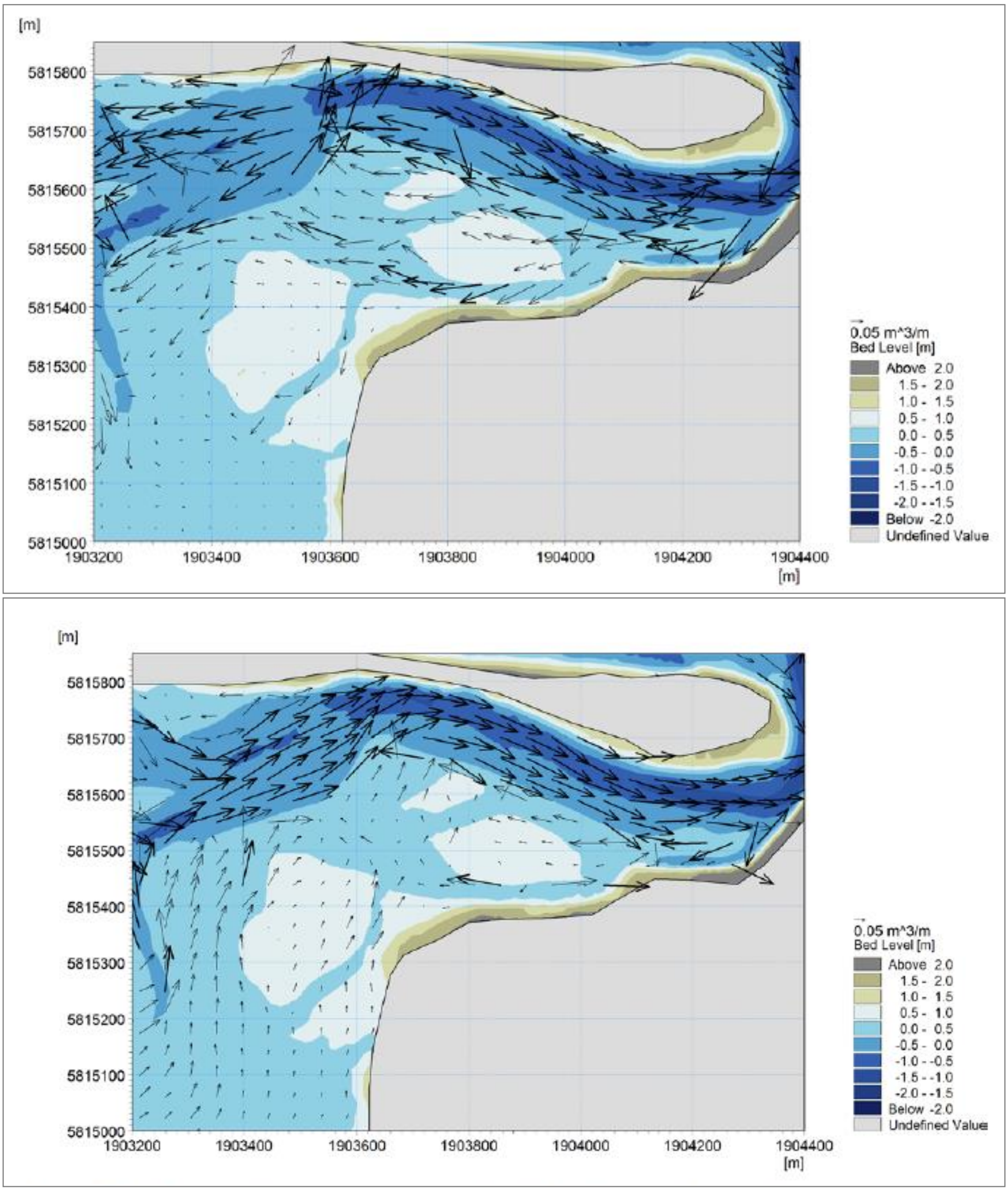

Figure 5: Directions of residual (i.e. net) sediment transport in the lower harbour under present conditions (top diagram) and with the proposed diversion (bottom diagram)

Figure 6: View of eastern end of township foreshore towards Maketu Road – showing concrete and other rubble placed to reduce erosion.

Figure 7: Chenier island features offshore from the southern shoreline of the township – with saltmarsh remnants and other maritime wetland and riparian vegetation communities.

Figure 8: View of Papahikahawai Island looking north from near the centre of the island - showing the high dunes to seaward (right and foreground) and the low-lying peats and sands bordering the estuary (top left)

Figure 9: LiDAR survey data for Papahikahawai Island and adjacent areas.

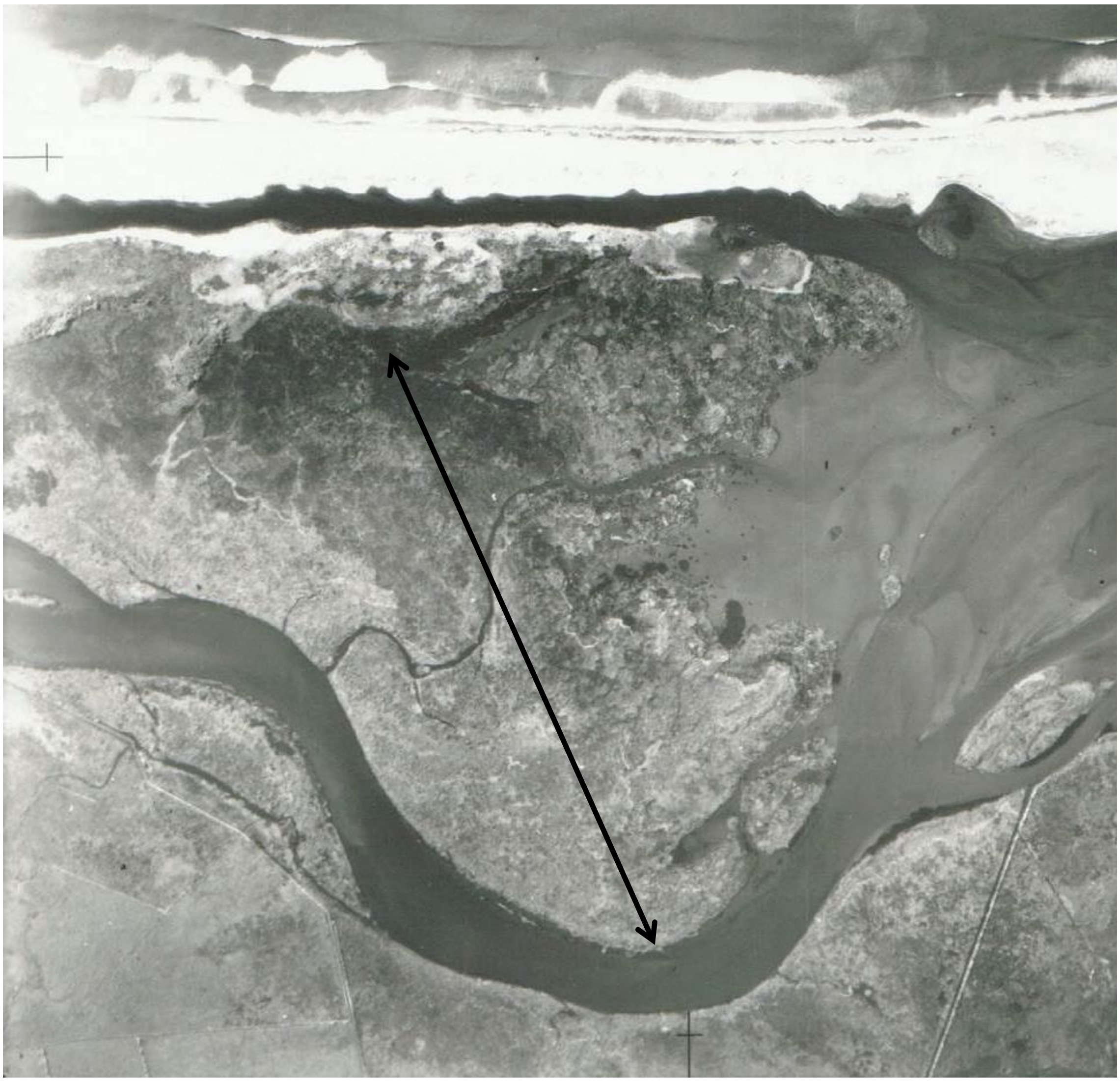

Figure 10: View of the upper estuary in April 1939 - showing the extensive areas of estuarine and freshwater wetlands (arrowed) that used to occur on the landward side of the island.

Figure 11: View of sand bund (densely vegetated with pampas) along the landward margin of Papahikahawai Island. Top photo shows the remnant wetland and drained wetland areas protected by the bund while the bottom photo shows a typical view along the estuarine margin. Note also the dense accumulation of wave washed organic materials over the beach (bottom photo) – with anoxic sediments underlying these materials.

Figure 12: Area of maritime rushland along the estuarine margin of Papahikahawai Island. The rushland has developed on the elevated beach seaward of the sand bund. Various similar patches occur along the beach in front of the bund. Note that the beach face is also covered in wave washed organic materials and anoxic sediments.

Figure 13: Isolated small remnant of rushland (oioi) on the intertidal flats seaward of Papahikahawai Island. This small patch is the only significant remnant

Figure 14: Anoxic sediments typical of those which occur along the estuarine margin of Papahikahawai Island

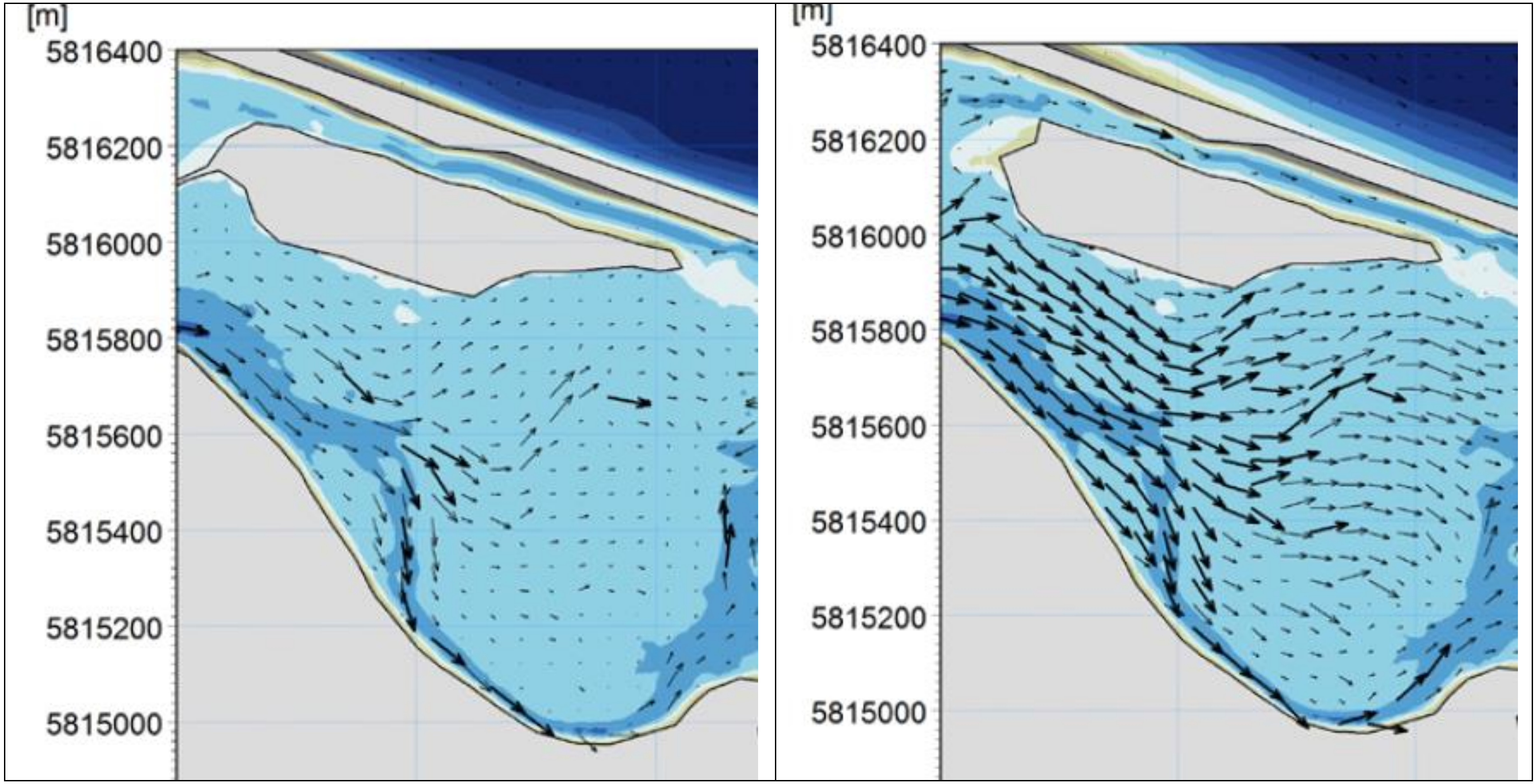

Figure 15: Residual (net) sediment transport rates and directions within the estuary for the existing situation (left) and with the proposed re-diversion (right). The sediment residuals are those that occur during mean river flow over a neap-spring cycle. (Figures provided by DHI from their modelling reported in DHI, 2014. Transport rates are low and arrows have been scaled so that differences can be seen).