Before a Board of Inquiry
Transmission Gully
Notices of Requirement and Consents

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under:	the Resource Management Act 1991
in the matter of:	Notices of requirement for designations and resource consent applications by the NZ Transport Agency, Porirua City Council and Transpower New Zealand Limited for the Transmission Gully Proposal
between:	**NZ Transport Agency** *Requiring Authority and Applicant*
and:	**Porirua City Council** *Local Authority and Applicant*
and:	**Transpower New Zealand Limited** *Applicant*

Statement of evidence of Dr Sharon Betty De Luca (Marine ecology) for the NZ Transport Agency and Porirua City Council

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Dated: 27 January 2012

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STATEMENT OF REBUTTAL EVIDENCE OF DR SHARON BETTY DELUCA FOR THE NZ TRANSPORT AGENCY AND PORIRUA CITY COUNCIL

INTRODUCTION

1 My full name is **Dr Sharon Betty De Luca.**

2 I have the qualifications and experience set out at paragraphs 2 to 5.6 of my statement of evidence in chief, dated 17 November 2011 (*EIC*).

3 I repeat the confirmation given in my EIC that I have read, and agree to comply with, the Code of Conduct for Expert Witnesses (Consolidated Practice Note 2011).

4 I confirm that I am authorised to give this evidence on behalf of NZ Transport Agency.

5 In this statement of rebuttal evidence, I:

5.1 Respond to the evidence of Helen Anne Kettles, on behalf of Director General of Conservation

5.2 Make a minor correction to a paragraph in my evidence in chief.

6 The fact that this rebuttal statement does not respond to every matter raised in the evidence of submitter witnesses within my area of expertise should not be taken as acceptance of the matters raised. Rather, I rely on my evidence in chief and this rebuttal statement to set out my opinion on what I consider to be the key marine ecology matters for this hearing.

7 For the purposes of this evidence, I will refer to the NZ Transport Agency (*the NZTA*) Project[1] and the Porirua City Council (*PCC*) Project[2] collectively as the "Transmission Gully Project" (and hereafter, *the TGP* or *the Project*).

SUMMARY OF EVIDENCE

8 The evidence prepared by Ms Kettles has not caused me to depart from the opinions and conclusions expressed in my evidence in chief. I re-confirm the conclusions reached in my evidence in chief.

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1 The 'NZTA Project' refers to the construction, operation and maintenance of the Main Alignment and the Kenepuru Link Road by the NZTA.

2 The 'PCC Project' refers to the construction, operation and maintenance of the Porirua Link Roads (being the Whitby Link Road and the Waitangirua Link Road) by PCC.

DOC EVIDENCE

9 In the paragraphs below, I address the issues raised in the evidence in chief of Helen Kettles, on behalf of the Director General of Conservation, that are within my area of expertise.

Linkage between benthic invertebrates and bird and fish feeding and habitat use

10 As per the Marine Ecology Expert Conferencing Joint Report to the Board of Inquiry[3], more detailed information on habitat use by fish and birds[4] is provided in Table A and Table B, **Appendix A**. The following paragraphs are a summary of that information.

11 The Porirua Harbour contains a high diversity of marine and freshwater fish that use the shallow, sheltered, warmer harbour waters for feeding and and/or spawning at various life stages. Invertebrates such as crabs, shrimp, worms, shellfish, small crustaceans, amphipods, in addition to plankton and fish, which are abundant throughout the intertidal and shallow subtidal areas of the Pauatahanui Inlet, form the diet of most of these fish. Some species of fish, such as trevally, yellow-eyed mullet and flounder spend time in harbours and bays during their juvenile life stages. A greater proportion of the fish species known to be present use the harbour in their adult life stage compared to the juvenile life stage (Table A).

12 The estuarine/coastal birds that feed on invertebrates within the Pauatahanui Inlet include NZ pied oystercatcher, pied stilt, Northern NZ dotterel, banded dotterel, reef heron, variable oystercatcher, royal spoonbill, white-faced heron, Eastern bar-tailed godwit, wrybill and pectoral sandpiper. Primarily these birds feed on molluscs, crustacean, worms and crabs (Table B).

Assessment of effects on saltmarsh

13 Ms Kettles raises in paragraph 25 of her evidence in chief that there was little assessment of potential effects on saltmarsh in my evidence in chief. The primary reason for this is that saltmarsh is largely outside the marine/estuarine areas that may be adversely affected by the Project. A more in-depth discussion of salt marsh is provided in Technical Reports 10 and 11.[5]

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[3] Paragraph 7.

[4] See also rebuttal evidence of Dr Bull.

[5] Sections 4.9.1, 5.2, 6.2.1, 6.4 Technical Report 6: Terrestrial Habitat & Species Description and Values Report;

Sections 3.1.2, 3.1.5, 5.3, Appendix 10F Technical Report 10: Marine Habitat & Species Description & Values Report;

Sections 5.3.2, 5.9.4, 6.7, 10.1.7, 12.5 Technical Report 11: Ecological Impact Assessment.

Threshold deposition areas under baseline conditions

14 Ms Kettles stated in her evidence in chief difficulties in interpreting the modelling output information[6] and raised that baseline sediment deposition has not been presented as effects threshold areas as it has been for the "with Project" scenario[7]. In order to provide better understanding of the Project, the areas of benthic habitat affected under baseline conditions have been mapped as threshold areas[8] and the area affected calculated (Table 1). The area of benthic habitat receiving threshold deposition[9] during the rainfall events included in my evidence are presented below (Table 1), both as baseline and due to the Project only. Where there is negative deposition due to the Project, this means that these areas are spared in the with Project scenario.

15 Table 1, Figures 15A to 17B (as set out in **Appendix B**), and Figures 3A to 5B (attached to my evidence in chief), show that for the 2 year events small areas of intertidal habitat receive threshold deposition due to the Project during the maximum earthworks scenario (0.2 ha is the largest intertidal area affected). Significant larger areas are affected under baseline conditions. Larger areas are affected subtidally during maximum earthworks, but these are predominantly in the central subtidal basins, where ecological values are low. All 2 year events have been assessed as having low to very low significance of impact[10].

16 The 10 yr events in the Horokiri stream catchment show a similar pattern, with large areas affected under baseline conditions (Figures 18 to 20 (as set out in Appendix B). During the maximum earthworks scenario small areas intertidally are affected by threshold deposition (some areas are spared), and greater areas affected subtidally (Table 1, and Figures 6 to 8 of my evidence in chief). Similarly, these events have been assessed as having low significance of impact.[11]

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6 Paragraphs 34 and 38.

7 Paragraph 52

8 Figures 15A to 22 in Appendix B.

9 The term "Threshold Deposition" in the context of my evidence refers to the deposition of terrigenous sediment above potential effects thresholds for benthic marine invertebrates based on the current literature i.e. 5-10mm of deposited sediment may adversely affect sensitive species, >10mm of deposited sediment may affect a wider range of species and potentially affect community composition.

10 Table 11.61, Technical Report 11.

11 There is an error in Table 11.62, Technical Report 11. The Assessment of Impact Magnitude for 10 year events in the Horokiri Stream catchment is stated incorrectly as low, where it should have been stated as negligible.

17 Ms Kettles raises in paragraph 37 of her evidence in chief that 1.1ha of intertidal habitat receives 5-10mm deposition during a 10 year event in the Horokiri catchment with southerly winds under the maximum earthworks scenario. This is correct, but should be considered along with the 0.8ha of benthic habitat that would under baseline conditions receive >10mm of sediment (and therefore affect a larger number of species than the deposition of 5-10mm), but under the with Project scenario this area is spared, resulting in a net increase in benthic habitat deposition of only 0.3ha (Table 1).

18 The 10 yr event in the Duck/Pauatahanui catchments with northerly winds and the 10 yr event in the Kenepuru/Porirua catchments with southerly winds result in larger areas of intertidal habitat receiving threshold sediment deposition under baseline conditions (Table 1 and Figures 21 to 22 in Appendix B). Under the maximum earthworks scenario, due to more substantial areas of high value intertidal habitat receiving threshold deposition, the 10 year event in the Duck and Pauatahanui catchments (northerly wind) is considered to have high significance of impact, where the 10 year event in the Kenepuru and Porirua catchments (southerly wind) is considered to have moderate significance of impact.

Table 1: Area of benthic habitat receiving threshold deposition (ha)

	Intertidal		**Subtidal**	
	5-10mm	**>10mm**	**5-10mm**	**>10mm**
2 Year (Both Inlets)				
Southerly - Baseline	32.0	1.2	33.4	8.4
Southerly - Deposition due to maximum earthworks	0.2	0.0	5.3	2.0
Northerly - Baseline	1.4	1.1	32.9	7.8
Northerly - Deposition due to maximum earthworks	0.1	0.1	3.4	0.7
Calm - Baseline	5.3	2.1	26.0	12.9
Calm - Deposition due to maximum earthworks	0.2	0.1	5.9	1.2
10 Year (Pauatahanui Inlet only)				
Horokiri Southerly - Baseline	2.0	1.9	64.6	32.4
Horokiri Southerly - Deposition due to maximum earthworks	1.1	-0.8	-3.4	0.2
Horokiri Northerly - Baseline	1.9	2.8	60.2	24.4
Horokiri Northerly – Deposition due to maximum earthworks	-2.3	-1.7	13.7	6.5
Horokiri Calm - Baseline	4.1	2.1	47.3	33.7
Horokiri Calm – Deposition due to maximum earthworks	0.2	0.1	7.7	7.5
Duck Northerly - Baseline	2.1	1.4	47.6	44.4
Duck Northerly - Deposition due to maximum earthworks	3.9	0.0	-1.0	3.4

10 Year (Onepoto Arm only)				
Kenepuru Southerly - Baseline	1.2	0.1	26.4	20.4
Kenepuru Southerly - Deposition due to maximum earthworks	1.8	1.0	-5.4	1.3

Q50 Rainfall / Wind Events

19 Further hydrodynamic modelling of extreme rainfall/wind events was agreed in the marine ecology expert witness caucusing.[12] A Q50 in the Duck/Pauatahanui catchments (with a Q2 elsewhere) with northerly winds, and a Q50 in the Kenepuru/Porirua catchments (with a Q2 elsewhere) with southern winds have accordingly been modelled during the maximum earthworks open scenario. It is worth noting that when heavy rainfall is predicted the site will be shut down and stabilised as best as is able, but this is not reflected in the modelling, which assumes that this stabilisation does not occur.

20 SKM have produced a map series for the two Q50 events (see **Appendix C**). Figures 50Yr-3D-TA 01 and 50Yr-3D-TA 02 show the difference in sediment deposition between the baseline and the peak earth works, 3 days after the peak of the storm event. Figures 50Yr-3D-TA 03 through to 06 show the baseline sediment deposition (in brown) with the areas of sedimentation that are pushed to within the 5mm and 10mm effects thresholds due to the Project.

21 Figures 50Yr-3D-TA 03-06 show that a large proportion of the Onepoto Arm receives sediment in a baseline Q50 event with southerly winds, and an even larger proportion of the Pauatahanui Inlet receives sediment in a baseline Q50 event with northerly winds. My evidence in chief stated at paragraph 84 that under a baseline Q50 event "an extremely large volume of sediment would be deposited in Porirua Harbour, smothering most, if not all of the organisms and resulting in highly significant adverse effects on marine ecological values".

22 Now that the two Q50 events have been modelled, I consider that my statement in paragraph 84 of my evidence in chief over states the situation. Not all of the benthic habitat of the two inlets is affected by sedimentation under baseline Q50 events and therefore not most or all benthic organisms would suffer adverse effects, as stated in my evidence in chief. It seems from the figures provided by SKM that perhaps one-third of the Onepoto Arm receives deposited sediment, and around one-third to a half of the Pauatahanui Inlet. Deposition in both inlets is primarily, but not exclusively, in the central subtidal basin areas, which have lower

[12] Paragraph 15, Expert Conferencing Joint Report to the Board of Inquiry, 8 December 2011.

ecological values compared to intertidal and shallow subtidal habitats.

23 From the Project during maximum earthworks, the harbour receives an additional 660 tonnes of sediment with a Q50 in the Kenepuru/Porirua catchments and southerly winds and 1384 tonnes of sediment with a Q50 in the Duck/Pauatahanui catchments with northerly winds. Figure 13 and 14 in Appendix C show the areas of benthic habitat that are pushed into the two effects threshold deposition areas. It can be clearly seen in these figures that the effect of the Q50 is a pushing outwards of sediment from the baseline sediment deposition pattern. Small areas of deposition occur in intertidal habitats, with most occurring subtidally. Table 2 below contains the additional areas of benthic habitat in Porirua Harbour predicted to receive sediment above threshold depths. Additional intertidal benthic habitat affected is less than 0.7 ha in the Pauatahanui Inlet, and less than 0.5 ha in the Onepoto Arm. Subtidally, less than 4.8 ha is affected in the Pauatahanui Inlet and less than 3.3 ha in the Onepoto Arm (Table 2).

Table 2: Additional threshold sediment deposition in Q50 events modelled due to the Project during maximum earthworks.

	Duck/Pauatahanui		**Kenepuru/Porirua**	
Deposition Thresholds	**Intertidal**	**Subtidal**	**Intertidal**	**Subtidal**
5-10mm	0.32 ha	2.06 ha	0.37 ha	1.41 ha
>10mm	0.35 ha	2.67 ha	0.05 ha	1.86 ha

24 In paragraph 84 of my evidence in chief I state that the “additional sediment discharged to the harbour in a Q50 event from Project related open earthworks would make a negligible contribution to the adverse effects that would occur under baseline conditions”. I remain confident in my conclusion. Furthermore, I consider the adverse effects on the marine ecological values of the Porirua Harbour due to the Project are less in the two Q50 events modelled compared to the corresponding Q10 events, due to the large baseline volume of sediment discharged under baseline conditions.

25 Total suspended sediment (TSS) within the harbour under the two Q50 events modelled follows a similar pattern to that of the Q10 and Q2 events, with low concentrations of sediment at three days post the peak of the storm event. Negligible difference in TSS is evident between the baseline and peak construction scenarios. An additional 1 ha of the Pauatahanui Inlet has a concentration of TSS

50-100g/m^3 due to the Project at 3 days post the peak of the Q50 in the Duck/Pauatahanui Inlet, with 1 ha less affected at 0-50 g/m^3. Effects on marine ecological values of TSS arising from the Q50 storm event due to the Project are considered to be negligible.

26 Similarly, in a smaller rainfall event, such as a Q20, the volume of sediment discharged to the harbour (and therefore concentration of TSS) would be expected to lie somewhere between a Q10 and Q50 rainfall event. Given that TSS is not expected to have adverse effects on marine ecological values in either of these two rainfall events, based on the scenarios modelled, it is not expected that adverse effects would occur during a Q20 rainfall event.

Ration Stream

27 In response to concerns raised by Ms Kettles in her evidence in chief regarding sediment contribution from Ration Stream[13], a Q10 event has been modelled in this catchment, in conjunction with a Q10 in the Pauatahanui and Duck catchments and a Q2 elsewhere[14]. Ms Malcolm states in her rebuttal evidence that the earthworks staging used for this modelling scenario is 3.2km open in the Ration catchment, 0km open in the Pauatahanui catchment and 1.0km open in the Duck catchment.

28 Ms Malcolm presents in her rebuttal evidence a discussion of the additional sensitivity analyses undertaken in relation to sediment yield in the Pauatahanui catchment. Ms Malcolm concludes that the sensitivity analysis suggests reducing the baseline sediment yield from 4426 tonnes to 2631 tonnes. Whilst the modelling of a Q10 in the Ration, Pauatahanui and Duck catchments mentioned in paragraph 27 above does not include earthworks in the Pauatahanui catchment, Ms Malcolm considers that a reduction in the baseline sediment yield in the Pauatahanui catchment, in conjunction with the sediment discharged from Ration stream during a Q10 event run as a further modelled scenario, can be used as a valid surrogate for understanding the effects on the harbour of a reduction of baseline sediment yield in the Pauatahanui catchment. This is because sediment discharged from Ration Stream is likely to be deposited in similar locations to the sediment discharged from the Pauatahanui Stream[15]. I consider the effects on marine ecological values from these modelled scenarios in the paragraphs that follow.

29 For clarification, the additional modelled scenarios are:

- Q10 in the Ration, Duck, Pauatahanui catchments with northerly, southerly and calm wind conditions, under baseline and during peak construction (6 modelling runs).

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13 Ms Kettles evidence in chief, paragraphs 62-71.

14 Ms Malcolm, Rebuttal Evidence.

15 Ms Malcolm, Rebuttal Evidence.

- Q10 in the Ration, Duck, Pauatahanui catchments with northerly winds only, using a reduced baseline sediment yield figure, under baseline and during peak construction (2 modelling runs).

Table 3: Additional threshold sediment deposition in Q10 events modelled in Ration, Pauatahanui and Duck catchments (ha).

	Intertidal		**Subtidal**	
	5-10mm	**>10mm**	**5-10mm**	**>10mm**
10 Year (Pauatahanui Inlet only)				
Ration, Pauatahanui, Duck - Calm - Baseline	7.3	8.9	39.3	62.5
Ration, Pauatahanui, Duck - Calm - Deposition due to maximum earthworks	0.5	0.4	4.8	5.6
Ration, Pauatahanui, Duck - Northerly- Baseline	6.6	1.9	51.0	50.9
Ration, Pauatahanui, Duck - Northerly - Deposition due to maximum earthworks	0.7	0.4	6.4	4.8
Ration, Pauatahanui, Duck – Southerly - Baseline	9.2	3.3	48.6	65.2
Ration, Pauatahanui, Duck - Southerly - Deposition due to maximum earthworks	0.9	0.5	3.5	8.3
10 Year with reduced baseline sediment yield in Pauatahanui catchment (Pauatahanui Inlet only)				
Ration, Pauatahanui, Duck - Northerly- Baseline	4.2	0.9	46.5	39.7
Ration, Pauatahanui, Duck - Northerly - Deposition due to maximum earthworks	0.9	0.3	8.9	4.7

30 Table 3 presents the baseline and Project related sediment deposition broken down by intertidal/subtidal and sediment threshold (5-10mm and >10mm). This data has also been mapped (see Figures 23-30 in **Appendix D**). I consider each modelled scenario as follows.

31 In the calm wind baseline scenario (without Project), extensive areas of high value intertidal habitat extending from the mouth of the Pauatahanui Stream receive sediment above threshold depths (i.e. 7.3 ha receives 5-10mm sediment depth and 8.9 ha receives >10mm sediment depth) constituting a significant adverse effect. Subtidally, a total of approximately 100ha receives sediment above threshold depths (i.e. 39.3 plus 62.5 ha) (Table 3 and Figure 27, Appendix D). The same rainfall and wind event causes a further 0.5 ha and 0.4 ha of high value intertidal habitat, and 4.5 ha and 5.6 ha

of subtidal habitat to receive threshold sediment deposition due to the Project during peak construction (Table 3 and Figure 23, Appendix D). The additional sediment deposition in the intertidal and shallow subtidal areas is small, particularly in comparison with the baseline. I consider the additional adverse effects on the marine ecological values due to construction of the Project under the modelled rainfall and wind event to be insignificant.

32 In the northerly wind baseline scenario, large areas of high value intertidal habitat around the mouth of Duck Creek and Pauatahanui Stream receive sediment above threshold depths (i.e. 6.6 ha receives 5-10 mm sediment depth and 1.9 ha receives >10 mm sediment depth) which would have significant adverse effects on benthic ecological values. Subtidally, under baseline conditions, similar to the calm wind scenario, approximately 100 ha receives sediment above threshold depths (see Table 3 and Figure 28, Appendix D). Sediment deposition under the same scenario, due to the Project, results in small areas of intertidal habitat receiving above threshold sediment deposition (i.e. 0.7 ha receives 5-10mm and 0.4 ha receives >10mm). Subtidally, due to the Project, 6.4 ha and 4.8 ha receives sediment above threshold depths (Table 3 and Figure 24, Appendix D). I consider the additional adverse effects caused by sediment deposition due to the Project are insignificant.

33 In the southerly wind baseline scenario, as per the calm and northerly scenario, vast areas of high value intertidal habitat adjacent to Duck Creek, Pauatahanui Stream and between Ration and Horokiri Streams receive sediment above threshold depths (i.e. 9.2 ha receives 5-10mm and 3.3 ha receives >10mm). The effects of the baseline sediment deposition on intertidal marine ecological values are significant. High value shallow subtidal habitat and lower value central subtidal basins also receive significant sediment under the baseline (i.e. approximately 114 ha in total) (Table 3, Figure 28, Appendix D). Due to the Project, the additional sediment deposited, expands the areas affected under baseline conditions to a small degree in the intertidal habitat (i.e. an increase of 0.9 ha in the 5-10mm threshold and an increase of 0.5 ha in the >10mm threshold). Subtidally, a further 11.8 ha receives sediment above threshold depths (Table 3 and Figure 25, Appendix D). Given the ecological values present in the intertidal and subtidal habitat of the Pauatahanui Inlet, I do not consider the additional sediment deposition due to the Project would cause significant adverse effects.

34 The reduced baseline sediment yield modelling runs (baseline and with Project, under northerly winds) indicate an additional 0.1ha of intertidal habitat and 2.4 ha of subtidal habitat receives sediment at threshold depths due to the Project (Table 3 and Figure 26, Appendix D). I do not consider that the reduced baseline sediment yield alters my assessment of the same storm.

35 When earthworks are open in the Pauatahanui catchment, and a Q10 storm occurs, using the reduced baseline sediment yield, the additional sediment discharged to harbour is estimated to be 100 tonnes which is significantly less than the additional 578 tonnes modelled to discharge from Ration Stream in the scenario above[16]. Given that sediment arising from Ration Stream and Pauatahanui Stream is likely to deposit in similar parts of the intertidal and subtidal habitats[17], I consider the additional effects of the reduced baseline sediment yield in the Pauatahanui catchment during maximum open earthworks in the Pauatahanui catchment to be negligible.

36 In summary, I consider the adverse effects on marine ecological values attributable to the Project, based on the additional modelling of Q10 events that has been carried out in the Ration, Duck and Pauatahanui catchments, to be of low significance.

Increasing the sediment yield estimate in the Kenepuru catchment

37 An increase in the sediment yield estimate (during the maximum earthworks open scenario and allowing for fill sites) relating to Project construction in the Kenepuru catchment was made following revised estimates prepared by Ms Malcolm[18]. A Q10 in the Kenepuru and Porirua catchments, with southerly winds was modelled again with this increased sediment yield. The baseline sediment yield remaining as per the original modelling run.

38 The baseline sediment deposition is shown in Table 4 and Figure 22 (Appendix B), and the Project related sediment deposition is shown in Table 4 and Figure 31 (**Appendix E**). There is no difference between the intertidal areas affected in the “with Project” scenario reported in Table 1 and that reported below in Table 4, and negligible difference in the subtidal areas. The increase in the sediment yield estimate relating to Project construction has negligible effect on the areas of benthic habitat that receive sediment during this rainfall event. My assessment of this event remains the same i.e. adverse effects of moderate significance due to the deposition in intertidal habitats which have moderate ecological values.

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[16] Ms Malcolm, rebuttal evidence.

[17] Ms Malcolm, rebuttal evidence.

[18] Ms Malcolm, rebuttal evidence.

Table 4: Threshold sediment deposition in a Q10 event with southerly winds, modelled in Kenepuru and Porirua catchments with increased sediment yield under the with Project scenario (ha).

	Intertidal		Subtidal	
	5-10mm	>10mm	5-10mm	>10mm
10 Year with increased sediment yield during construction (Onepoto Arm only)				
Kenepuru & Porirua - Southerly - Baseline	1.2	0.1	26.4	20.4
Kenepuru & Porirua - Southerly- Deposition due to maximum earthworks	1.8	1.0	-5.1	1.6

Peak Earthworks point

39 Ms Kettles raises concerns regarding the peak earthworks period, particularly in relation to Rations Stream[19]. This is considered in the rebuttal evidence of Mr Edwards, paragraphs 24-27.

Wide margin of error in modelling results

40 Ms Kettles raises in paragraph 42 of her evidence in chief that Dr Fisher reported a +/-50% margin of error in the accuracy of the harbour modelling. Mr Roberts responds to this in his rebuttal evidence paragraph 12-13.

Resuspension of sediment

41 Ms Kettles raises concerns in paragraphs 43 and 44 of her evidence in chief regarding redistribution of sediment during sediment moving wind events. Mr Roberts responds to this in his rebuttal evidence paragraph 17.

Net Change

42 In paragraph 48 of Helen Kettles evidence in chief, Ms Kettles states that not all intertidal areas are homogenous, and that variation in ecological value is therefore not considered in using a net change approach to assessment of sediment deposition. I accept that not all intertidal areas are homogenous, and that in the Pauatahanui Harbour there are areas that have higher values than other areas. However, in order to simplify the complex and detailed data informing my assessment, I have conservatively assumed that all of the intertidal habitat is of high value.

43 I consider this approach to be practical and reasonable, as gaining an understanding of the variability of intertidal habitat value throughout the harbour would be excessively time consuming and prohibitively expensive, and would be unlikely to significantly affect the assessment of effects.

[19] Ms Kettles, Evidence in Chief, Paragraphs 65 and 66.

44 In paragraph 53 of Ms Kettles' evidence in chief, she refers to the grey areas mapped on figures 3A-11B in my evidence in chief showing sediment deposition and loss, as having been previously impacted by sediment deposition and the sediment subsequently removed. This is incorrect. The grey areas are areas that would receive sediment deposition under the baseline situation, but when the same rainfall event occurs during peak earthworks, these grey areas that would have received sediment are spared, and do not receive sediment deposition. Therefore, assuming all intertidal and near shore subtidal benthic habitat has high value, the areas spared can be deducted from the areas that receive sediment. Similarly, assuming all central subtidal basin habitat in the Pauatahanui Inlet has low value; spared areas can be deducted from the areas receiving sediment.

Harbour Resilience

45 Ms Kettles states the Pauatahanui Inlet is only capable of supporting approximately half the number of cockles that existed in 1976. I agree that the estimated population of cockles is approximately half of that detected in 1976, but a lower estimated population does not directly imply lower carrying capacity of the Inlet. The last four surveys of the cockle population show a clear trend of increasing population, which is a positive sign for the ecological health of the Inlet.

46 I have plotted the cockle abundance data collected by the Guardians of Pauatahanui Inlet in 2010, on the Q10 Duck/Pauatahanui (with northerly wind) sediment threshold plot, as requested by Helen Kettles (Figure 12, **Appendix F**). This figure shows a moderate abundance of cockles in intertidal areas that may receive some sediment deposition during this particular extreme rainfall event adjacent to Duck Creek, Motukaraka West, and Pauatahanui Stream ($25/0.1m^2$) and a high abundance at Bromley ($40/0.1m^2$) to the north-east of Duck Creek. Therefore, as per my assessment, deposition of sediment in these areas is considered to be an adverse effect of high significance.

47 Ms Kettles refers to the intertidal monitoring carried out in the Porirua Harbour by Robertson & Stevens (2010). They concluded that the benthic invertebrate community, as in previous years, was dominated by a broad range of sensitive species, with large numbers and elevated abundances of cockles and wedge shells. Robertson & Stevens (2010) further conclude that the invertebrate community is "relatively healthy and diverse but is prone to loss of sensitive species if there is a shift towards increased muddiness and/or nutrient enrichment". The authors report sediments are dominated by sand (80-89%), with 7-15% mud content. I conclude from the Robertson & Stevens (2010) report that the benthic community is diverse, healthy and dominated by sensitive organisms and the sediment mud content is low.

Short-term Effects

48 Ms Kettles states in paragraph 12 of her evidence in chief that I acknowledge that there will be ecologically significant short term catastrophic impacts on localised habitat in Pauatahanui Inlet (referring to my paragraph 104). This is somewhat incorrect as I do not use the word catastrophic, nor do I consider it appropriate in this situation. I state in paragraph 104 of my evidence in chief that "the additional effects of the Project on sediment deposition in the harbour, should either of the specific Q10 events identified occur, whilst comprising a small proportion of the total sediment deposition occurring, remain of moderate to high significance given the value of the habitat that may be affected".

Cumulative Effects

49 Ms Kettles states that the cumulative effects of multiple rainfall events have not been assessed[20].

50 Repeated deposition of sediment on the same area of benthic habitat can have cumulative adverse effects on marine organisms. The scale of adverse effect depends on the benthic community present, the depth, area and duration of deposition and the time interval between deposition events. Recovery from a deposition event occurs along a continuum, with opportunistic and tolerant species recolonising initially, followed over time by the more sensitive species and those with a longer life cycle. Small events occur frequently but with small effects and rapid recovery.

51 My assessment states that the Q2 events modelled do not have significant adverse effects on marine ecological values. Events smaller than a Q2, whilst likely to occur more frequently, are similarly predicted to not cause significant adverse effects on marine ecological values.

52 The probability of a Q2 event occurring at least once in a single year is 39%. The likelihood of a Q2 event occurring at least once during the 6 year construction period is 95%[21]. The likelihood of multiple Q2 events occurring close together (i.e. within one to two months) has not been calculated. However, Q2 events occur on average, one every two years. Therefore, it is likely the probability of repeated Q2s occurring within one year within the 6 year construction period is very low.

53 I consider that the cumulative effects of smaller, more frequent events (such as the Q2) depositing sediment on the same area of benthic habitat to be negligible given the likelihood of repeated identical events within a short time frame and the likelihood of

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[20] Paragraph 13 c. and 61 of evidence in chief of Ms Kettles.

[21] Table 15.35, page 114, Technical Report 15

repeated events having identical characteristics thereby affecting the same exact area of benthic habitat.

54 It is worth remembering that the modelling undertaken and my assessment is based on the maximum earthworks scenario, i.e. the peak of construction activity within a particular catchment. The scale of activity across the Project will not be uniform and can be expected to increase and then decrease from the peak activity. This provides context for my assessment and during off peak construction times (for the majority (~75%) of the construction period) the effects will be less than what I have assessed.

Mitigation

55 Ms Kettles states in paragraph 106 of her evidence in chief that there is no mitigation offered to compensate for the potential effects of sedimentation of the Pauatahanui Inlet. I assume Ms Kettles is referring to the long-term accumulation of sediment within the Inlet, rather than acute rainfall events. No mitigation is proposed for the additional long-term accumulation of sediment within Porirua Harbour because it has not been identified as a significant adverse effect in the ecological impact assessment[22]. The contribution of the Project to the accumulation of sediment within the harbour is minimal compared to the baseline situation and has negligible additive adverse effects.

56 As stated in Technical Report 11[23], the focus throughout the Project development and assessment stages has been on the avoidance and minimisation of sediment entering the marine environment, rather than mitigation. Avoidance and minimisation is proposed through the erosion and sediment control measures, the revegetation of riparian margins, retirement of land, controls on maximum areas of open earthworks, and procedures for stabilising earthworks sites particularly when a large rainfall is predicted.

57 However, compensation, in the form of offset mitigation, is proposed if significant short-term adverse effects arising from the discharge of sediment during rainfall events are detected[24]. As stated in my evidence in chief, this is because once sediment is deposited in marine environments; measures to remove the sediment typically create more disturbance than benefit. The type and quantum of the offset mitigation is to be agreed between NZTA, relevant regulatory authorities and community groups, if significant adverse are shown

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22 See Table 11.64, Technical Report 11.

23 See Section 10.1, page 122, Technical Report 11.

24 A revision to condition M.7 will be required to provide for this off-set mitigation as it may not be possible, in acute events, to 'implement appropriate contingency plans and/or remedial measures' as the condition currently provides. Rather there may need to be off-set mitigation to compensate for the sediment deposition. I understand that Ms Rickard is working on revisions to the conditions and this will be addressed.

to have occurred. The offset mitigation should be commensurate with the degree of adverse effect actually detected[25]. Given that adverse effects are only potential at this stage, it is not reasonable to specify the offset mitigation required. Such compensation could align with the actions and goals contained within Porirua Harbour and Catchment Strategy and Action Plan.

NZCPS

58 Ms Kettles in her evidence in chief raises concern with my discussion on the relevant policies within the NZCPS.[26] Ms Rickard has responded to Ms Kettles concerns in her rebuttal evidence in paragraph 58.12.

Correction of a typographic error in my evidence in chief.

59 Paragraph 100 in my evidence in chief refers to a confidence interval around the 12% probability of the 10 year event occurring in the Duck/Pauatahanui catchments during peak construction. The confidence interval is quoted as 4% to 13%, which is incorrect. The correct confidence interval is 4% to 23%.[27]

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Dr Sharon Betty De Luca
27 January 2012

[25] See paragraph 123 of my evidence in chief, and paragraph 20 of the Expert Conferencing Joint Report to the Board of Inquiry – Marine Ecology.

[26] See paragraphs 76-95 of Ms Kettles evidence in chief.

[27] Appendix 11.M to Technical Report 11.

APPENDIX A: BIRD AND FISH HABITAT USE AND DIET

Table A: Porirua Harbour - fish diet and habitat use

SPECIES		HABITAT	DIET
Lamprey	*Geotria australis*	As juveniles spend time in freshwater (~ 4 years) before migrating to the sea. As adults this species can be found close to the coast.	n/a
Rig	*Mustelus lenticulatus*	Not usually found in shallow areas - more suited to open water up to depths of 200m (Doak 2003).	n/a
Elephant fish	*Callorhynchus nilii*	n/a	n/a
Eagle ray	*Myliobatis tenuicaudatus*	Most abundant over sand or mud substrate. Congregate in shallow bays in summer.	Bottom feeders. Feed on urchins, shellfish and crabs (Doak 2003).
Kahawai	*Arripis trutta*	Abundant in coastal waters; form large schools in-shore in summer during spawning. In winter, kahawai migrate to deeper off-shore waters (Doak 2003).	Juvenile stage eats plankton; adult stage eats small school fishes (e.g., yellow-eyed mullet, pilchards, piper and whitebait) along with shrimps, swimming crabs and krill (Doak 2003).
Yellow-eyed mullet	*Adrichetta forsteri*	Juveniles spend time in estuaries. As they mature some will remain in estuaries while others extend to harbours and sheltered bays. Form large schools in sheltered water (Doak 2003).	Scoop mud and digest the organic matter. Also eat planktonic crustaceans.
Pilchard	*Sardinops neopilchardus*	Mid to surface dwelling species as adults. Heavy concentrations in sheltered bays. School with yellow-eyed mullet (Doak 2003).	n/a
Anchovy	*Engraulis australis*	Likes sheltered bays.	n/a
Garfish	*Hemirhamphus ihi*	Live in brackish waters (Doak 2003).	n/a
Smelt	*Retropinna retropinna*	Occupies streams. Sensitive to pollutants. Species is both diadromous and non-diadromous.	n/a
Pipefish	*Syngnathus norae*	This species can be found amongst seagrass beds.	n/a
Long-snout pipefish	*Stigmatophora longirostris*	Lives in depths of a few metres. Common in Wellington harbour. Can quite often be found in kelp (Doak 2003).	n/a
Seahorse	*Hippocampus abdominalis*	Sheltered in-shore waters, harbours, estuaries and seaweed habitats (Doak 2003).	Feed on small crustaceans and plankton found in the kelp beds that they occupy (Doak 2003).
Blue mackerel	*Scomber australasicus*	Found below schools of jack mackerel and kahawai (Doak 2003).	Eat plankton and small pelagic fish (like jack mackerel and kahawai, the species that they school with) (Francis 1988).
Jack mackerel	*Trachurus novaezelandiae*	Common in shallow harbours and bays (Doak 2003). Form schools in mid-water and can also be found around oceanic islands and reefs (Francis 1988).	Eat plankton and small pelagic fish (Francis 1988).
Barracouta	*Thyrsites atun*	Range from shallow inshore areas to depths of 200m. Generally exist in cooler waters (Doak 2003).	n/a
Trevally	*Caranax georgianus*	Juvenile trevally form large schools for safety. As they mature the larger adults split off from the school and form smaller groups around rocky headlands (Doak 2003).	Prefer krill and plankton, when food is scarce they sift out worms and small crustaceans from the substrate (Doak 2003).
Tarakihi	*Nemadactylus macropterus*	This species spawn in open water where the larvae drifts in currents then hatch after three days. As adults, the cooler winter water temperatures bring them inshore (50m to 100m).	Feed on invertebrates (mostly tube worms).
Snapper	*Pagrus auratus*	Lives in multiple habitats and can live in depths to 200 m. Older snapper leave the group and become solitary (Doak 2003).	Opportunistic feeders - diet includes about 100 different species. Main food is crustaceans (especially crabs, tube worms and urchins) (Doak 2003).
Blue moki	*Latridopis ciliaris*	Juveniles live in shallower waters (<10m) and can be found under rock ledges but commonly reside over sand flats. Adults move to deeper water (<30m) over sand canyons (Doak 2003). Adults form large schools and make annual migrations along the east coast of New Zealand to the only spawning ground near Gisborne (Francis 1988).	Adults eat crabs, crustaceans, shellfish and worms which they suck from the substrate (Francis 1988).
Warehou	*Seriolella brama*	Adults are mainly found on the west coast of the south island. Generally a deep water fish. Adults form schools over the continental shelf, while juveniles for small schools in harbours and bays (Francis 1998).	Adults eat planktonic salps, jellyfish, crustaceans and squid. Juveniles are thought to eat small crustaceans (Francis 1988).
Grey mullet	*Mugil cephalus*	Surface dwelling, coastal species. Found in harbours, mangroves and estuaries (Doak 2003).	n/a

Red cod	*Pseudophysis bacchus*	Shallow water dweller that is active at night. Hides in caves and crevices by day (Doak 2003). Are known to form large schools over sand or mud (Francis 1988).	Uses sensory barbels below their jaw to detect invertebrates and small fish in sand/mud (Francis 1988).
Rock cod	*Lotella rachinus*	Spends the day sheltered in caves and crevices (Doak 2003).	Feed on crabs, shrimps, octopus and small fishes (Doak 2003).
Gurnard	*Cheilidorichthys kumu*	Feeds over sand or mud to depths of 150m. Not usually seen in shallow bays (Doak 2003).	n/a
Spotty	*Pseudolabrus celidotus*	As juveniles, this species stays close to kelp forests for protection from predators. As they mature they spread out to find their own territories. Once they reach adult maturity, this species will occupy inshore reef flats, harbour wharves and tidal rivers (Doak 2003).	Eat a wide variety of food. Juveniles eat small crustaceans, adults eat crabs, hermit crabs, bivalves, gastropods, brittlestars and worms (Francis 1988).
Banded parrotfish	*Pseudolabrus fucicola*	As juveniles, this species stays amongst kelp beds for defence. Once they reach adult maturity, this species will stay amongst kelp beds but seek deeper water (Doak 2003).	Small hard shelled animals (limpets, chitons, crabs, shellfish, etc).
Sandflounder	*Rhombosolea plebeia*	This species spawns inshore during spring. The juvenile stage is spent in harbours and estuaries. Adults use substrate as shelter. Camouflage plays a big part of defence (Doak 2003).	Eats invertebrates found in the substrate (worms, small fishes, crabs and shrimps) (Doak 2003).
Yellowbelly flounder	*Rhombosolea leporina*	Adults occupy shallow water. They are most abundant in harbours, estuaries and muddy bays.	n/a
New Zealand sole	*Peltorhamphus novaezeelandiae*	Prefers depths of <100m.	n/a
Dwarf common sole	*Peltorhamphus latus*	n/a	n/a
Striped stargazer	*Leptoscopus macropygus*	Adults inhabit coastal estuaries and tidal rivers (Doak 2003).	Fish of various sizes and crabs (Doak 2003).
Spotted stargazer	*Genyagnus novaezelandiae*	Adults ambush prey by settling into the sandy substrate (Doak 1991).	Crabs and small fishes (Doak 1991).
Cockabully	*Gobiomorphus cotidianus*	Found throughout a range of habitats including lake and wetland margins, streams and rivers (Parkinson & Cox 1990).	Feeds on freshwater insects, crustaceans, snails and small fish.
Robust blenny	*Trypterygion robustum*	n/a	n/a
Grahams gudgeon	*Grahamichthys radiatus*	Adults prefer sheltered bays.	n/a
Brown trout	*Salmo trutta*	Spawn in freshwater, upstream. Juveniles occupy freshwater courses. Adults generally occupy freshwater but have been found in the sea. Species occurs south of Auckland where water temperatures are suitable for egg development (Parkinson & Cox 1990).	n/a
Conger eel	*Conger verrauxi*	Occupy same areas for long lengths of time. Prefers caves/crevices for shelter. Restricted to the bottom via their swim bladders. Important role in regulating reef fishes (Doak 2003).	Nocturnal feeders. Feed on crustaceans and small reef fishes (Doak 2003).
Shortfin eel	*Anguilla australis*	Adults occupy lower elevations of streams, wetlands, rivers and lakes. Have high tolerances to temperatures and oxygen concentrations.	Insect larvae, worms, water snails, fish.
Longfin eel	*Anguilla dieffenbachii*	Occupy higher elevations of streams, wetlands, rivers and lakes.	Start off eating the same as the shortfin eel then progress to freshwater crayfish and even ducklings.
Whitebait (giant kokopu)	*Galaxias argenteus*	Coastal species. Likes slow-slowing waters such as lakes (Parkinson & Cox 1990).	Terrestrial insects - cicadas and spiders.
Whitebait (banded kokopu)	*Galaxias fasciatus*	Juveniles are sensitive to suspended sediments and are primarily a coastal species. Adults like in small tributaries with overhead canopies. Can also be found in urban streams (Parkinson & Cox 1990).	n/a
Whitebait (inanga)	*Galaxias maculatus*	Adults occupy rivers, streams, lakes and swamps near the coast. Can be seen shoaling in open water. Not good at climbing obstacles so stay coastal (Parkinson & Cox 1990).	n/a

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Francis, M., (1988). *Coastal Fishes of New Zealand A Diver's Identification Guide*. Heinemann Reed, Auckland, New Zealand.

Parkinson, B., Cox, G., (1990). *A Field Guide to New Zealand's Lakes and Rivers*. Random Century New Zealand Ltd, Auckland, New Zealand.

Table B: Porirua Harbour - estuarine bird diet and habitat use

SPECIES		CONSERVATION STATUS		DIET	HABITAT USE
NZ pied oystercatcher	*Haematopus finschi*	Native	Declining	Mainly molluscs and worms, occassionally insects, sea anemones and small fish (Marchant & Higgins 1993). Diet is mainly molluscs (esp. bivalves), estuarine worms, earthworms and insect larvae (esp. grass grub), but other small fish are taken (Heather & Robertson 2000).	Widely distributed throughout NZ. Mainly found in estuaries, mudflats and beaches (Medway 2002).
Pied stilt	*Himantopus h. leucocephalus*	Native	Declining[SO]	Diet is mainly aquatic and terrestrial invertebrates (Heather & Robertson 2000).	Common in freshwater wetlands, tidal estuaries, marine mudflats and harbours. Feeding behaviours vary with habitats (Moon 2002).
Northern NZ dotterel	*Charadrius obscurus aquilonius*	Endemic	Nationally Vulnerable[CD]	Feed on a wide range of marine invertebrates; particularly sandhoppers. When feeding on mudflats they eat crabs (Moon 2002).	Generally restricted to beaches, river mouths and estuaries of northern New Zealand. Few individuals have been recorded on west coast southern North Island (Medway 2002).
Banded dotterel	*Charadrius b. bicinctus*	Endemic	Nationally Vulnerable[RR]	Marine invertebrates and freshwater insects and their larvae. In wet pastures they eat earthworms. Have also been observed eating small fruits from plant foliage (Moon 2002).	Occupy a wide range of habitats; estuaries, sandy beaches, stream mouths, coastal lakes, ponds, salt marshes, coastal farmland, airports and ploughed fields. Mostly found in the South Island but during December to July flocks up to several hundred can be found around the NZ coast (Medway 2002).
Reef heron	*Egretta sacra sacra*	Native	Nationally Vulnerable[SO St]	Small fish including eels and flounder, crabs, molluscs (Heather & Robertson 2000).	Rocky coasts, mangrove estuaries, tidal streams (Medway 2002).
Variable oystercatcher	*Haematopus unicolor*	Endemic	Recovering	Mainly molluscs, worms, crabs, other small invertebrates and small fish. Sometimes feeds on earthworms and insect larvae in coastal fields after heavy rain (Medway 2002).	Mudflats, estuaries, beaches. Widely distributed throughout NZ (Medway 2002).
Royal spoonbill	*Platalea regia*	Native	Naturally Uncommon[Inc RR SO Sp]	Feed on invertebrates and fish along with frogs (Moon 2002).	Distributed thorughout mainland New Zealand when not breeding. Located on tidal mudlfats, muddy estuaries and sometimes on margins of freshwater lakes (Medway 2002).
White-faced heron	*Ardea novaehollandiae*	Native	Not Threatened[SO]	Diet is fish, frogs and tadpoles, aquatic and pasture insects; spiders, earthworms and mice (Heather & Robertson 2000).	Common throughout New Zealand in lowland areas. Occupy mudflats, estuaries, rocky shores, harbours, lagoons, lake margins, riverbeds, farms and parks (Medway 2002).
Eastern bar-tailed godwit	*Limosa lapponica baueri*	Migrant	Migrant[SO]	Diet consists of marine worms, crustaceans and molluscs found in soft mud (Moon 2002).	Arrives to New Zealand mid-September and depart March-April. Can be found throughout NZ in estuaries with broad intertdial mudlfats and sandflats, harbours, sandy coasts and inlets, (Medway 2002).
Pectoral sandpiper	*Calidris melanotos*	Vagrant	Vagrant[SO]	Feed mainly of freshwater aquatic insects and their larvae (Moon 2002).	Favour coastal freshwater pools and lagoons. Only a small number of this species visit New Zealand annually (main breeding grounds are Canada, Alaska and northern Siberia) (Moon 2002).

QUALIFIERS		
QUALIFIER	STANDS FOR	STATUS
CD	Conservation Dependent	Unchanged
DP	Data Poor	Unchanged

EF	Extreme Fluctuations	Unchanged
EW	Extinct in the Wild	Unchanged
OL	One Location	Unchanged
RF	Recruitment Failure	Unchanged
SO	Secure Overseas	Unchanged
TO	Threatened Overseas	Unchanged
St	Stable	Changed
De	Designated	Added
IE	Island Endemic	Added
Inc	Increasing	Added
PD	Partial Decline	Added
RR	Range Restricted	Added
Sp	Sparse	Added
HI	Human Included	Removed
RC	Recovering	Removed

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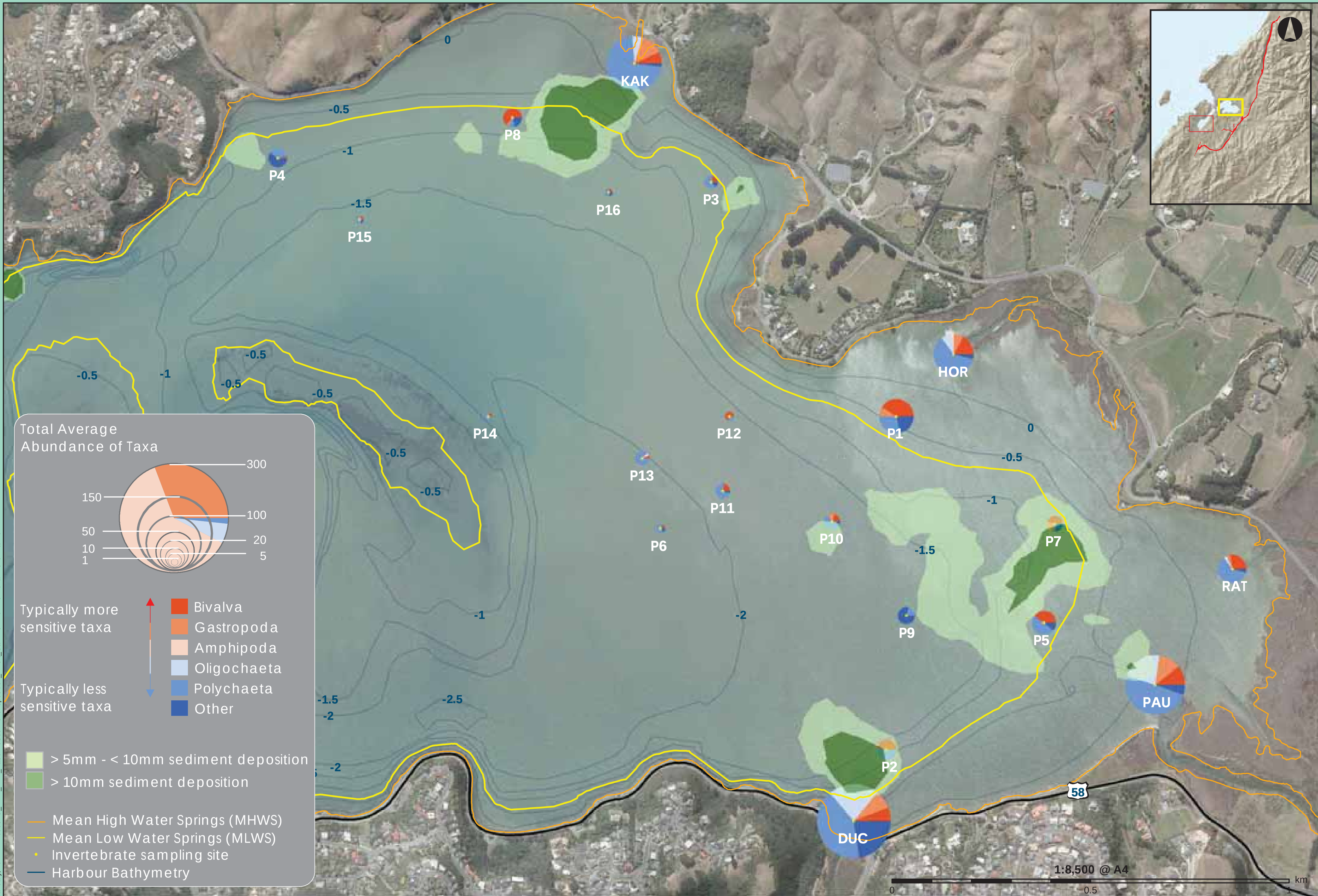
Heather, B., & H. Robertson (2000). *The field guide to the birds of New Zealand*. Penguin books, Auckland, New Zealand.

Medway, D.G., (2002). *Sea and Shore Birds of New Zealand*. Reed Books, Auckland, New Zealand.

Moon, G., (2002). *A Photographic Guide to Birds of New Zealand*. New Holland Publishers, Auckland, New Zealand.

APPENDIX B: BASELINE SEDIMENT DEPOSITION THRESHOLD MAPS



January, 2012 W09034G_MAR_2YR_BaselineSedimentDeposition_Invert_CalmA3.mxd

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TRANSMISSION GULLY

PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

2 yr event in all catchments modelled, calm wind, 3 days post peak of storm

15A

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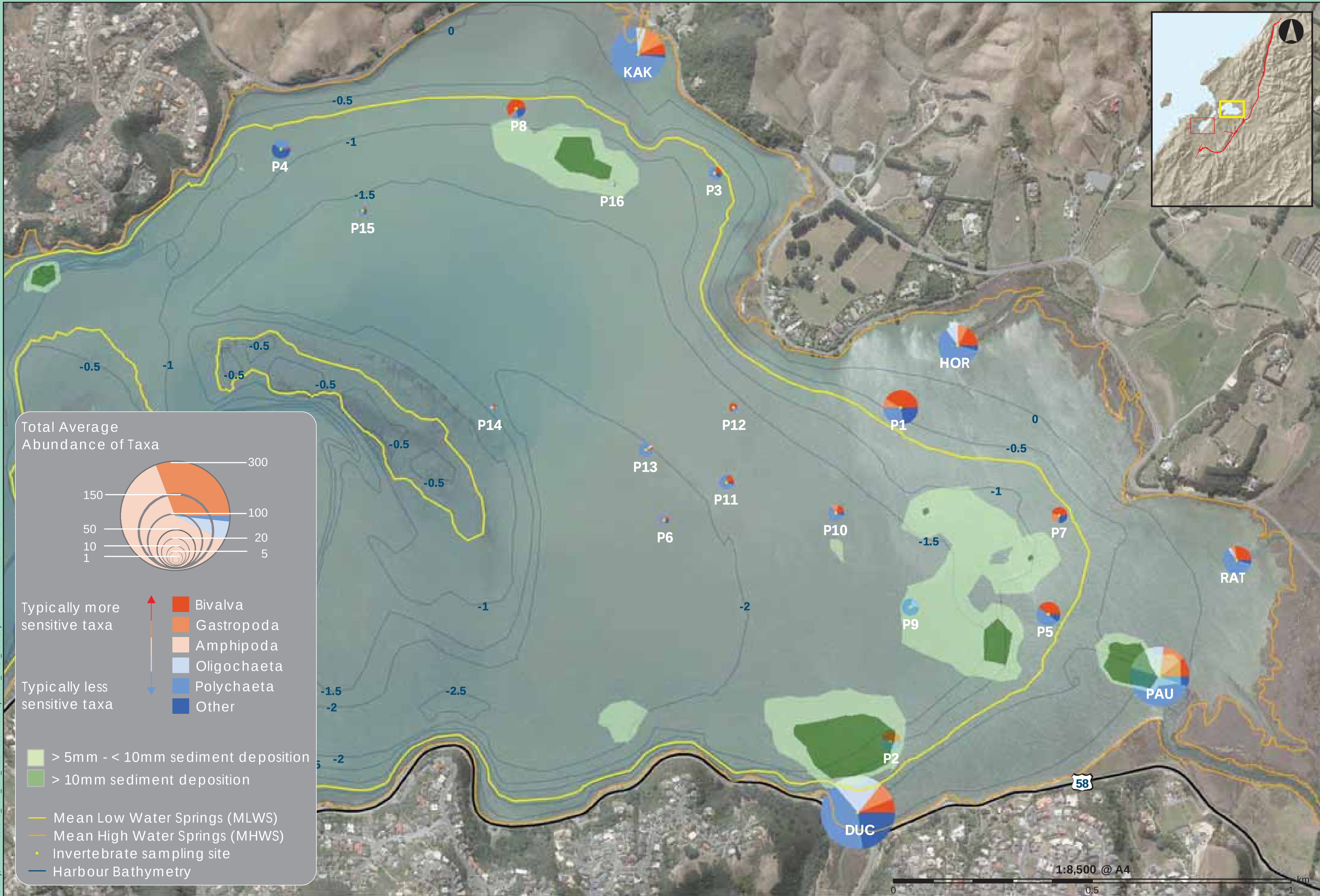
TRANSMISSION GULLY - ONEPOTO ARM

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

2 yr event in all catchments modelled, calm wind, 3 days post peak of storm

15B



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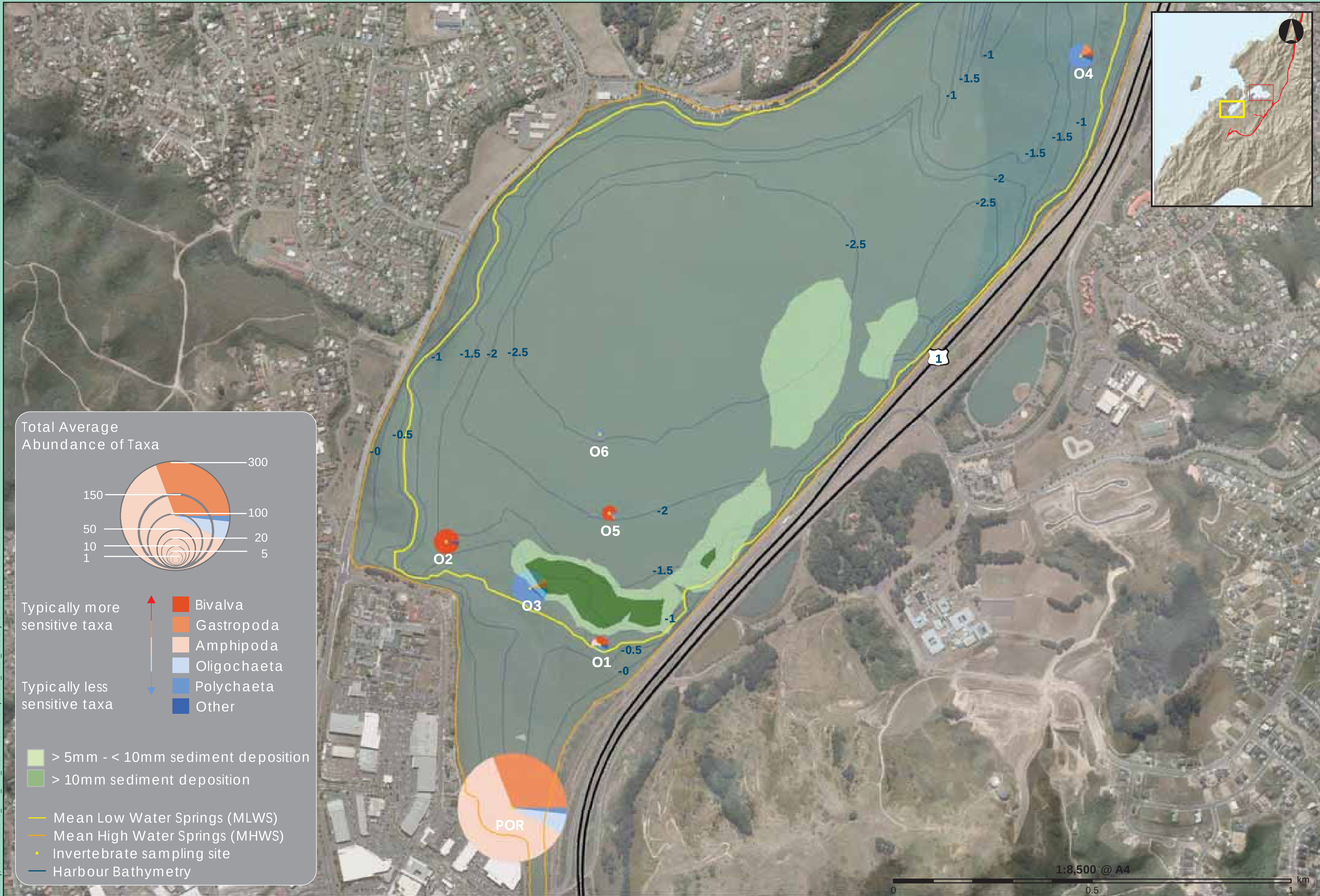
TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

2 yr event in all catchments modelled, northerly wind, 3 days post peak of storm

16A



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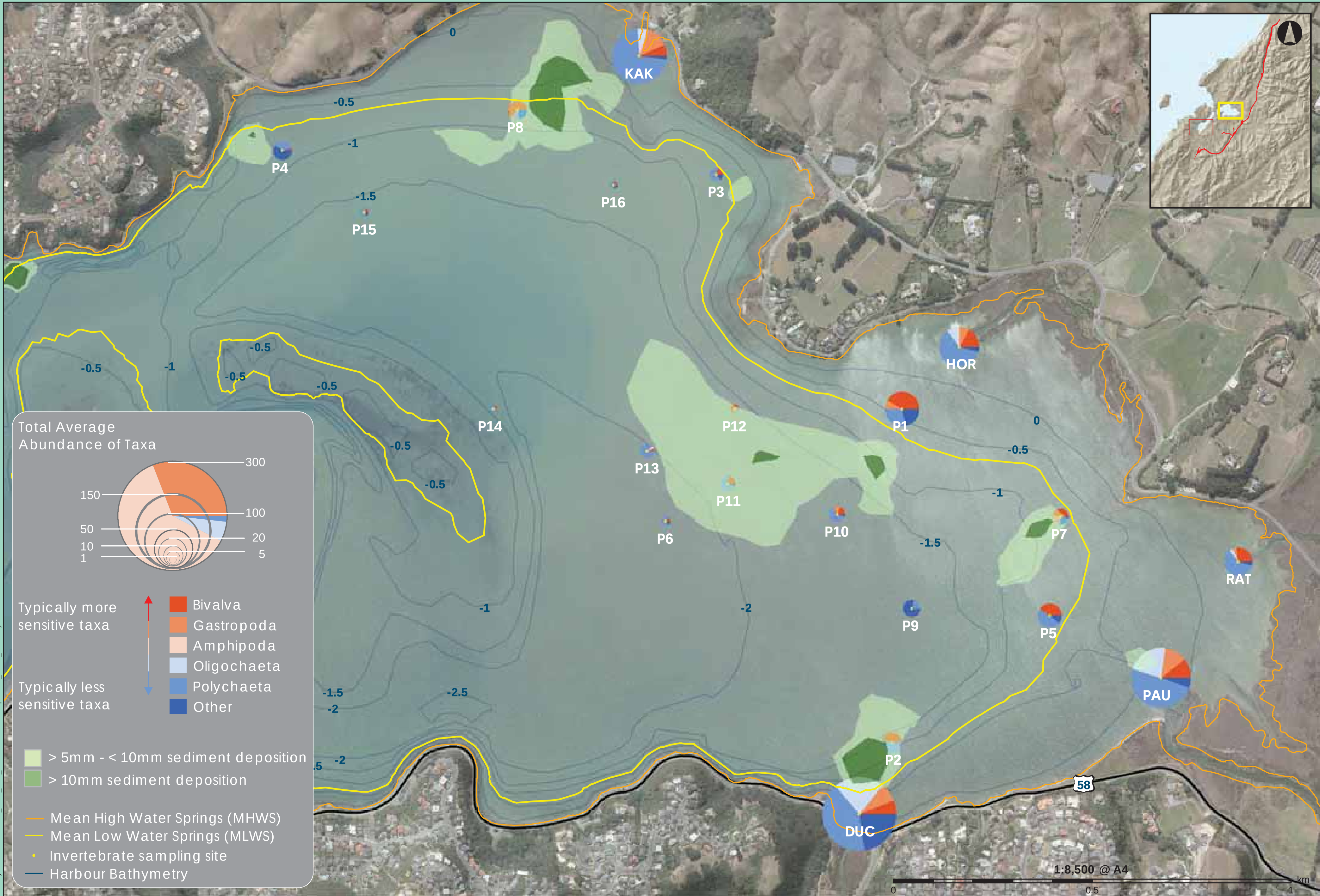
TRANSMISSION GULLY - ONEPOTO ARM

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

2 yr event in all catchments modelled, northerly wind, 3 days post peak of storm

16B



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TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

2 yr event in all catchments modelled, southerly wind, 3 days post peak of storm

17A

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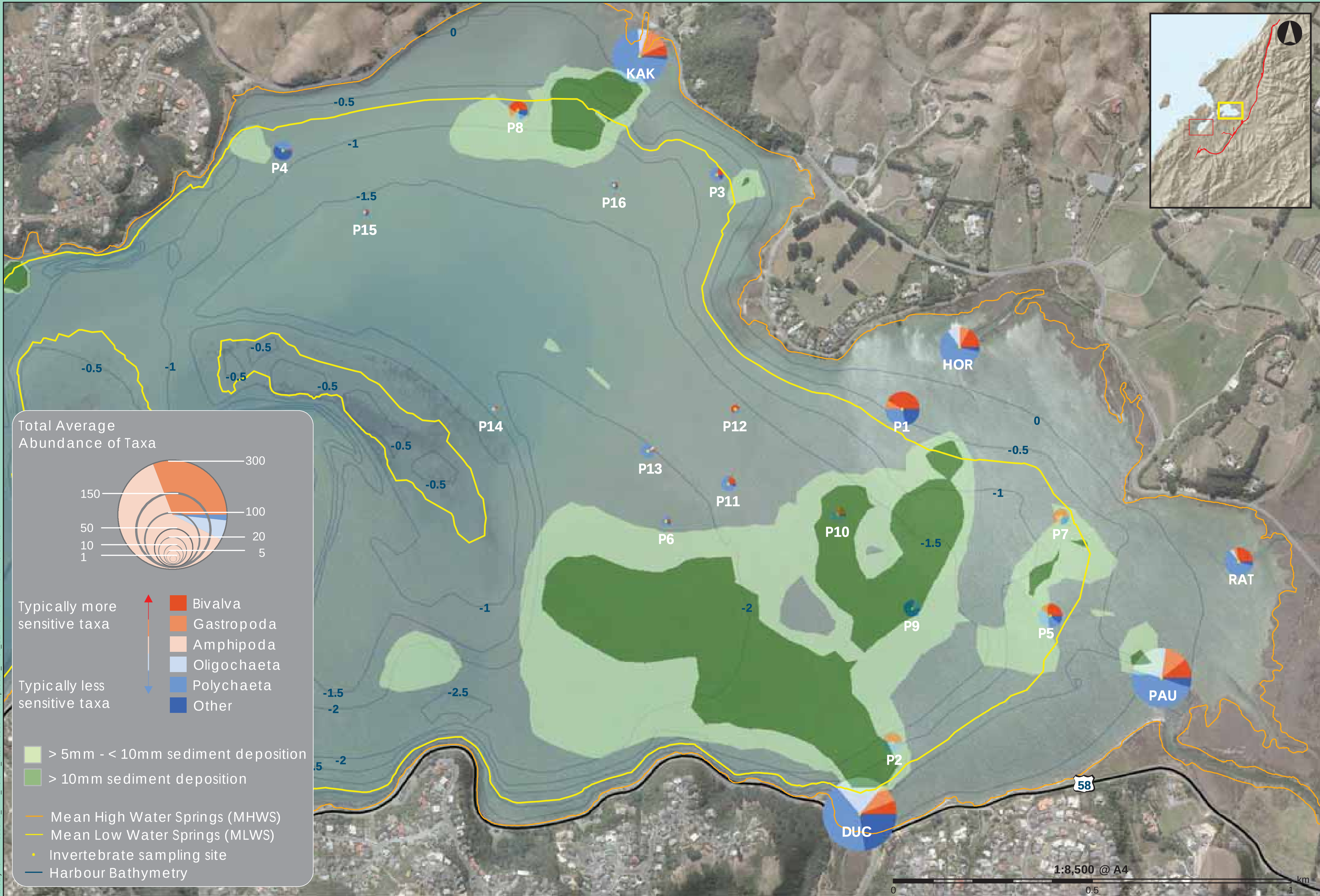
TRANSMISSION GULLY - ONEPOTO ARM

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

2 yr event in all catchments modelled, southerly wind, 3 days post peak of storm

17B



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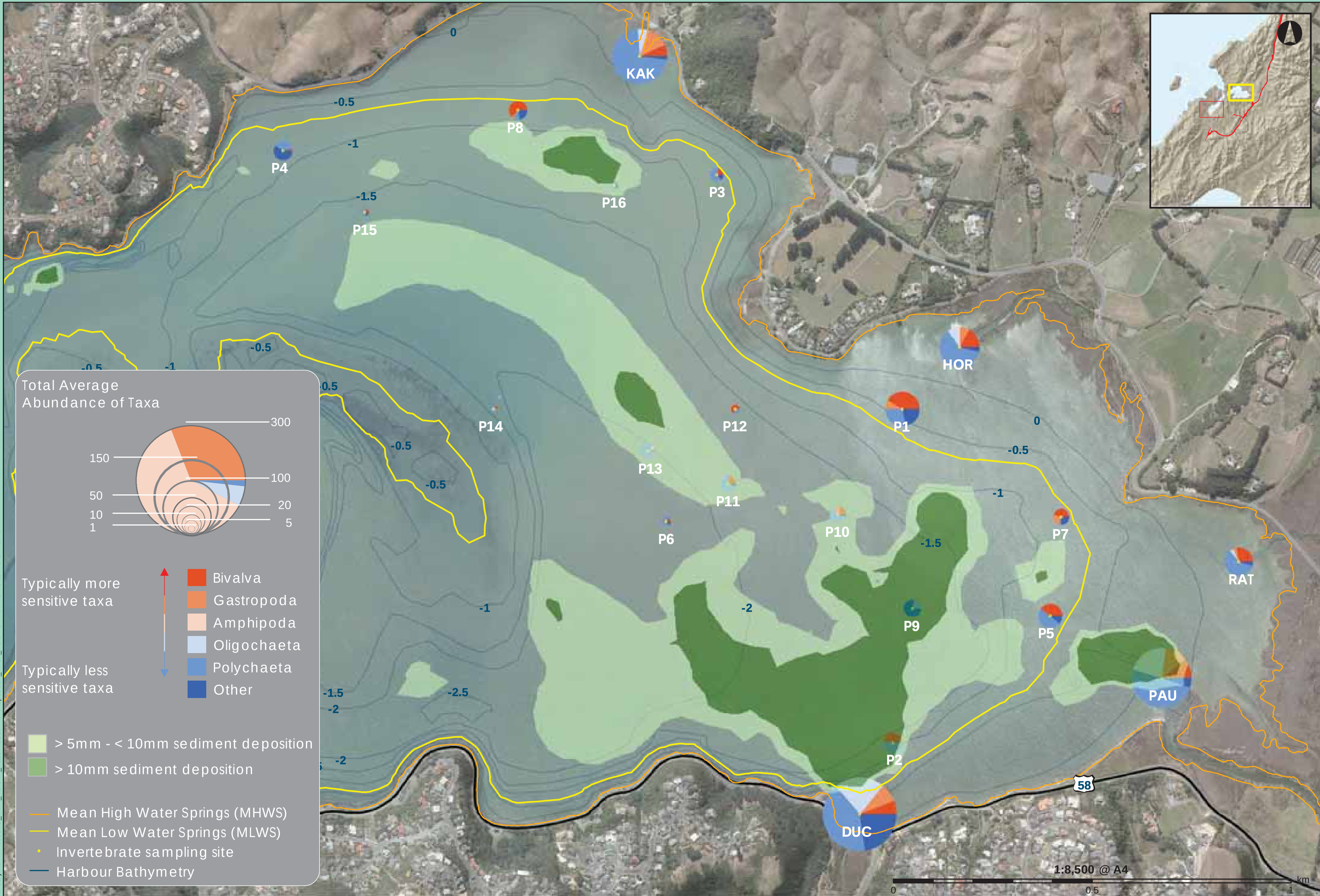
TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 year event in Horokiri, calm wind, 3 days post peak of storm



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TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 year event in Horokiri, northerly wind, 3 days post peak of storm

January 012 W09034G_MAR_Horokiri_BaselineSedimentDeposition_Invert_SoutherlyA3_10yr.mxd © Boffa Miskell Ltd 2011

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INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 year event in Horokiri, southerly wind, 3 days post peak of storm

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INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 yr event in Duck/Pauatahanui, northerly wind, 3 days post peak of storm

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION
10 yr event in Kenepuru/Porirua, southerly wind, 3 days post peak of storm

APPENDIX C: Q50 EVENT FIGURES

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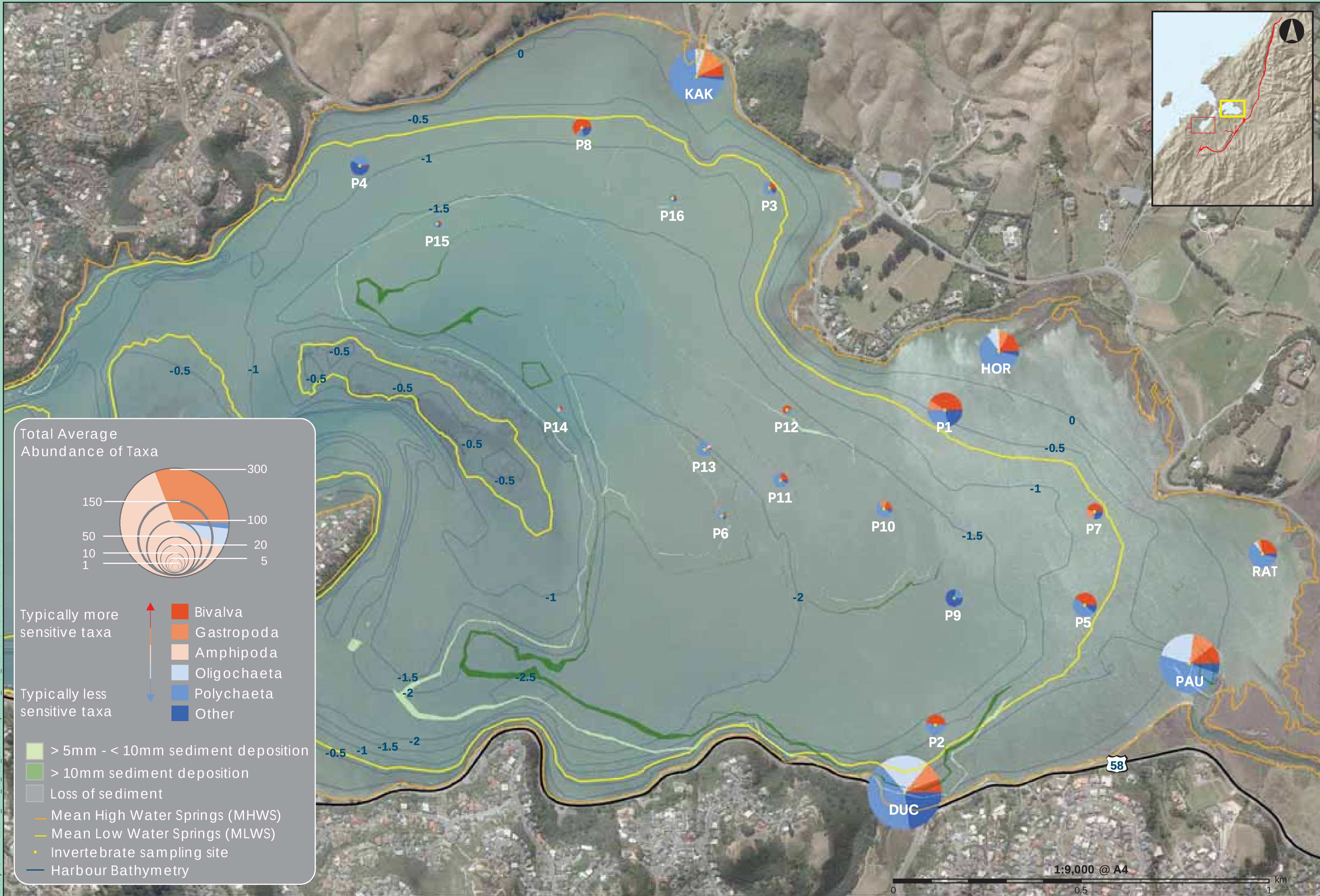
INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

50 yr event in Kenepuru/Porirua, southerly wind, 3 days post peak of storm



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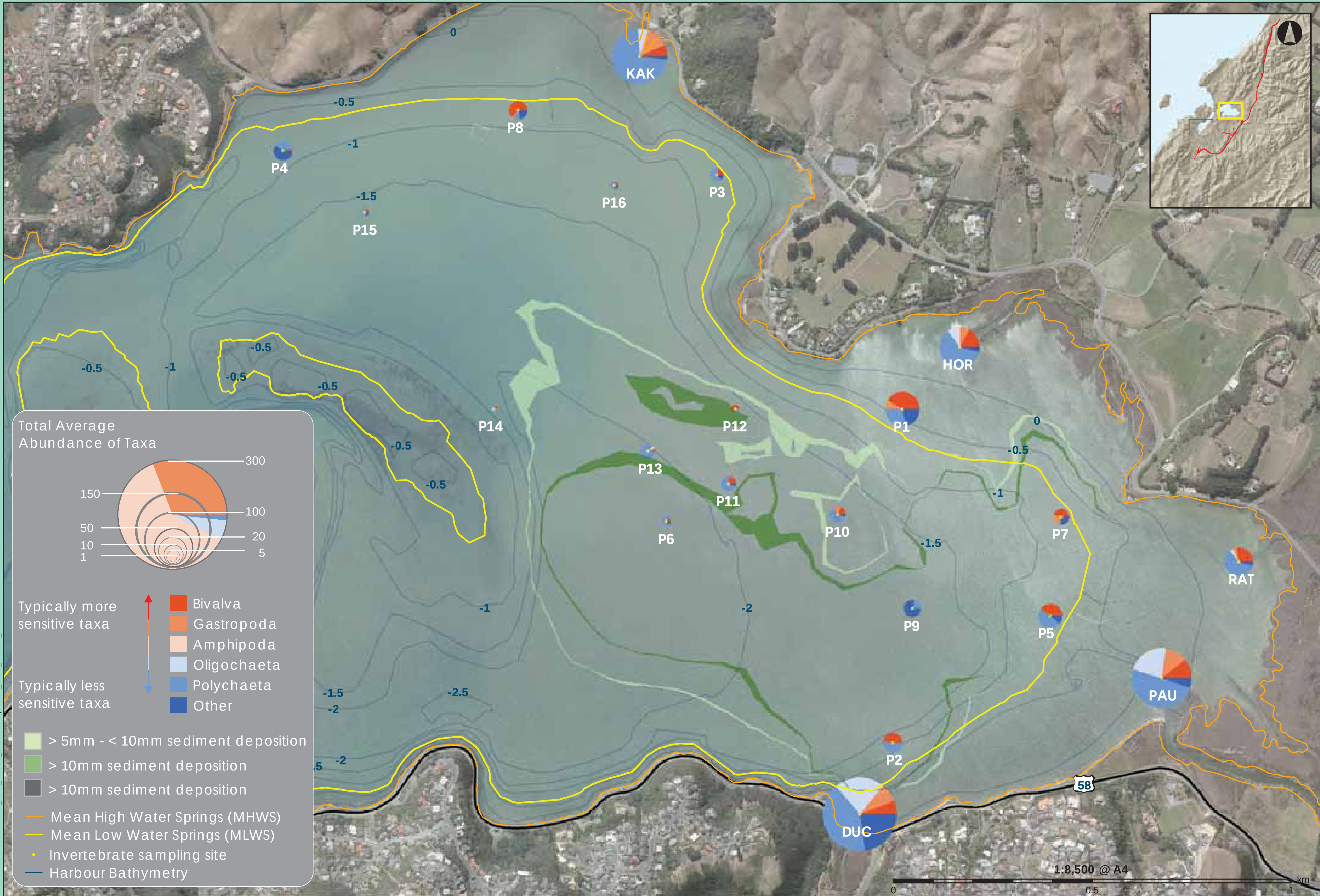
TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

50 yr event in Duck/Pauatahanui, northerly wind, 3 days post peak of storm

14

APPENDIX D: FIGURES SHOWING DEPOSITION OF SEDIMENT ABOVE THRESHOLD DEPTH DURING Q10 EVENTS IN RATION, PAUATAHANUI AND DUCK CATCHMENTS (FIGURES 23-30).



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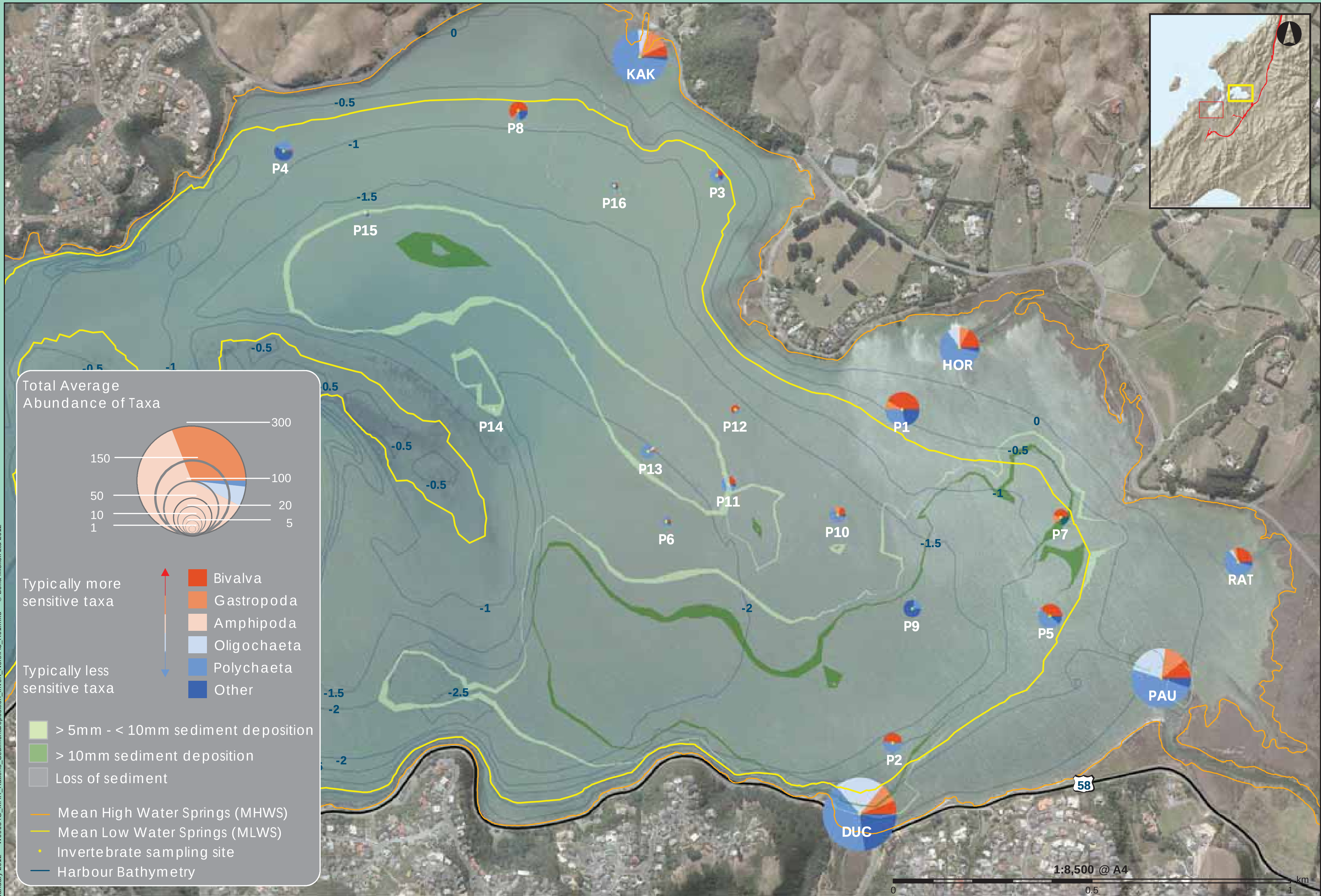
TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

10 year event in Ration/Duck/Pauatahanui, calm wind, 3 days post peak of storm



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TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

10 year event in Ration/Duck/Pauatahanui, northerly wind, 3 days post peak of storm

January 2012 W09034G_MAR_Rations_SedimentDeposition_Invert_SoutherlyA3.mxd

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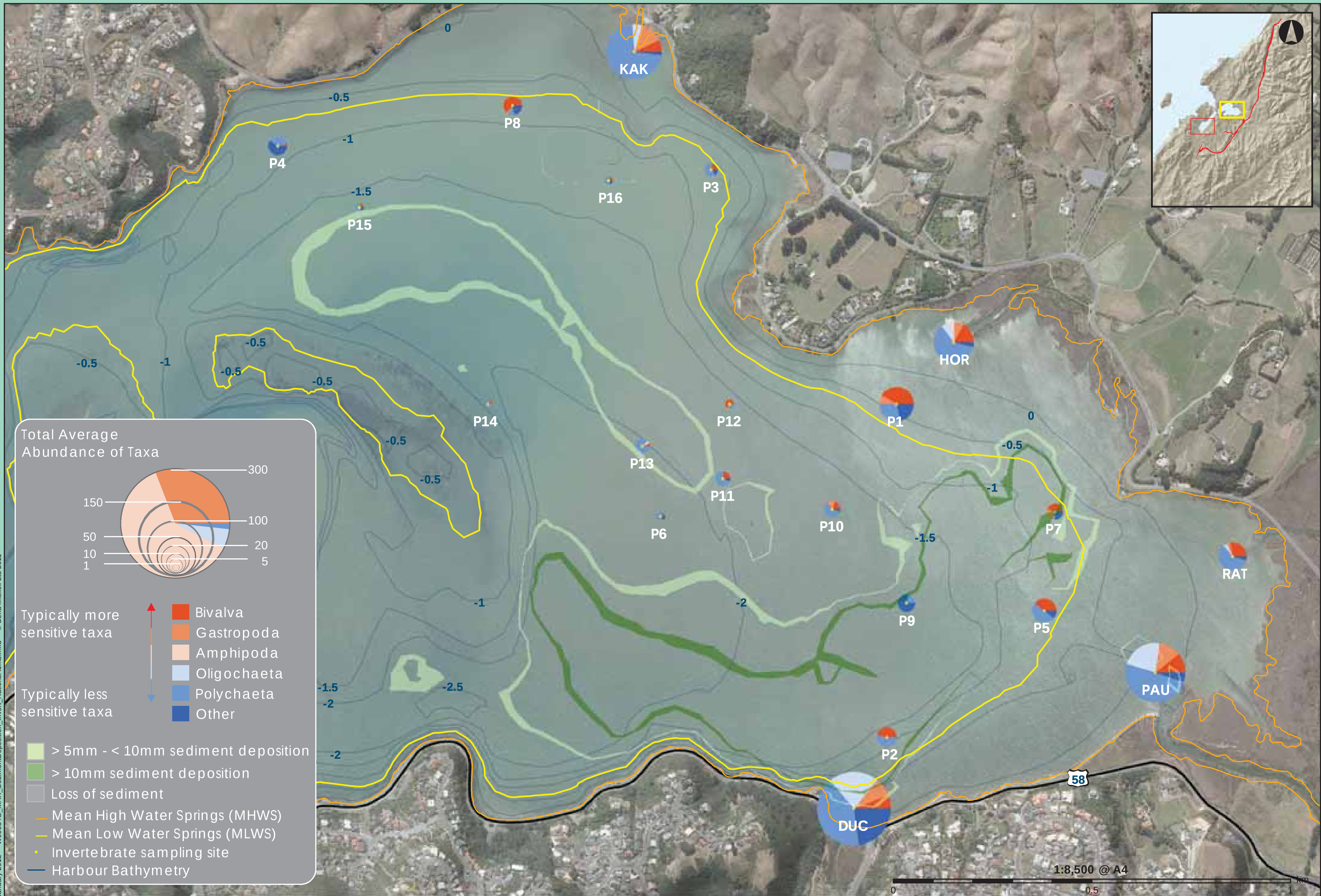
INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

10 year event in Ration/Duck/Pauatahanui, southerly wind, 3 days post peak of storm



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TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

10 yr event in Ration/Duck/reduced Pauatahanui, northerly wind, 3 days post peak of storm

January 2012 W09034G_MAR_Rations_BaselineSedimentDeposition_Invert_CalmA3.mxd

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TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 year event in Ration/Duck/Pauatahanui, calm wind, 3 days post peak of storm

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TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 year event in Ration/Duck/Pauatahanui, northerly wind, 3 days post peak of storm

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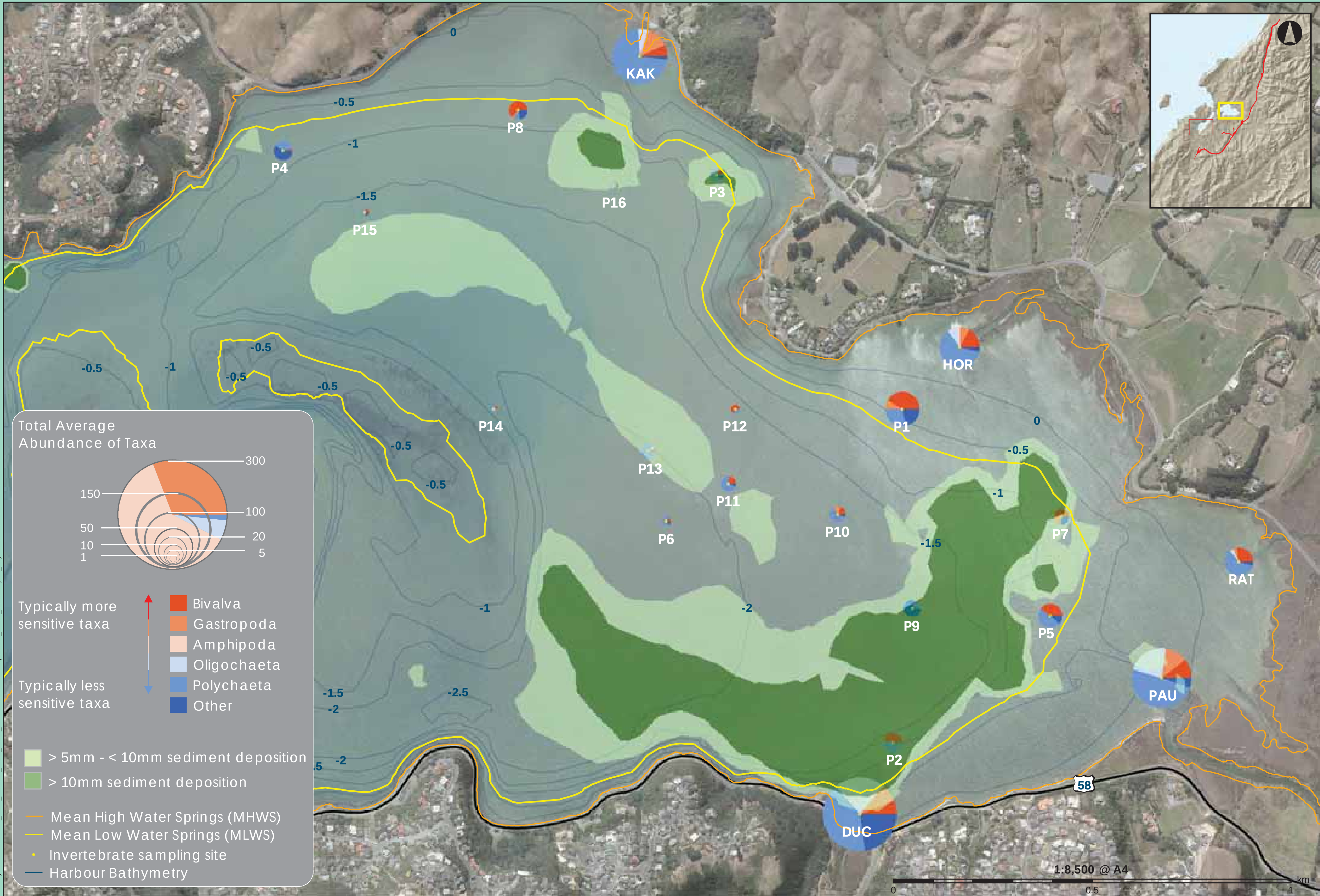
TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 year event in Ration/Duck/Pauatahanui, southerly wind, 3 days post peak of storm



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NZ TRANSPORT AGENCY
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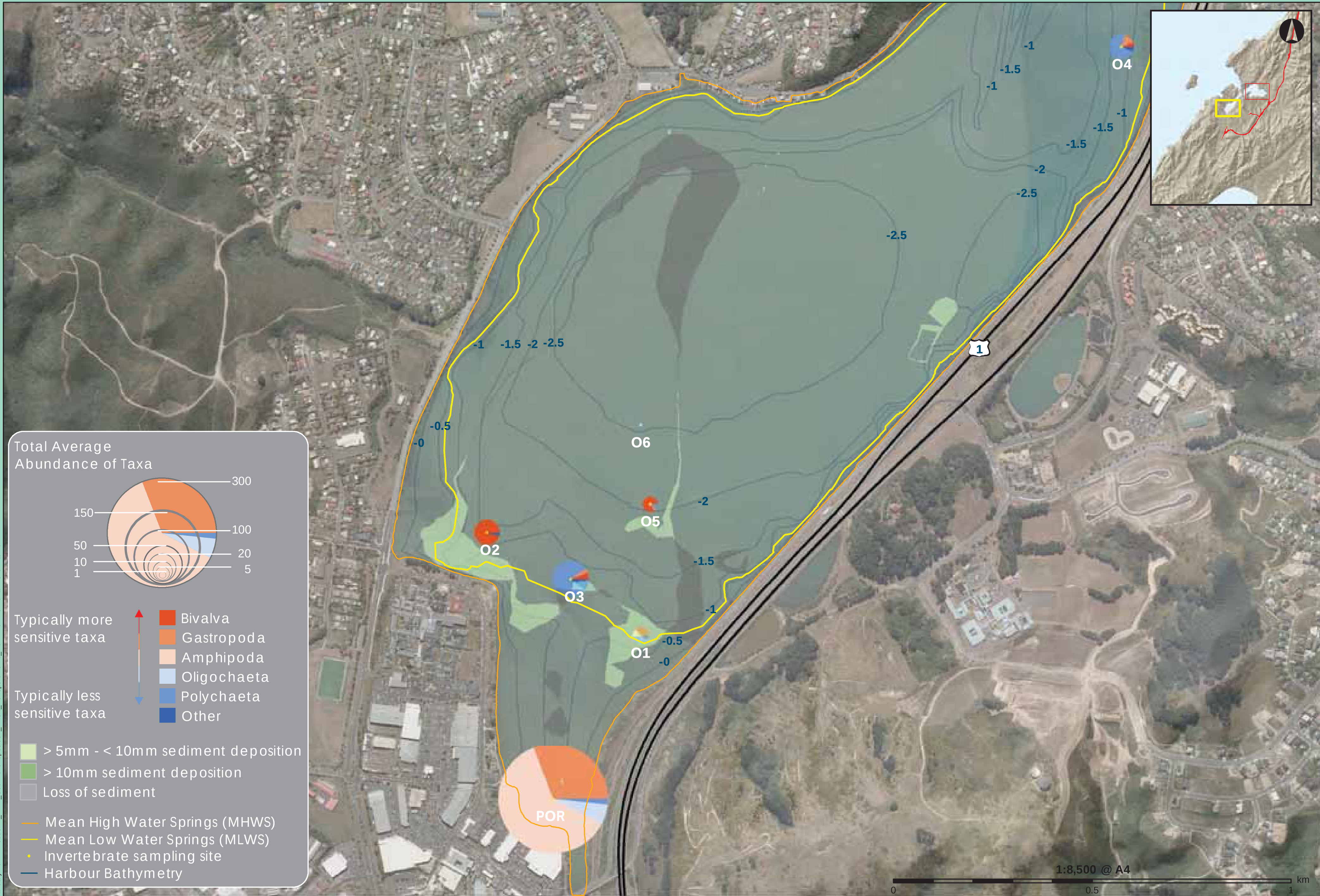
TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND BASELINE THRESHOLD SEDIMENT DEPOSITION

10 year event in Ration/Duck/reduced Pauatahanui, northerly wind, 3 days post peak of storm

APPENDIX E: FIGURE 31 - SHOWING DEPOSITION OF SEDIMENT ABOVE THRESHOLD DEPTH DURING A Q10 EVENT IN KENEPURU AND PORIRUA CATCHMENTS WITH REVISED SEDIMENT YIELD DURING CONSTRUCTION



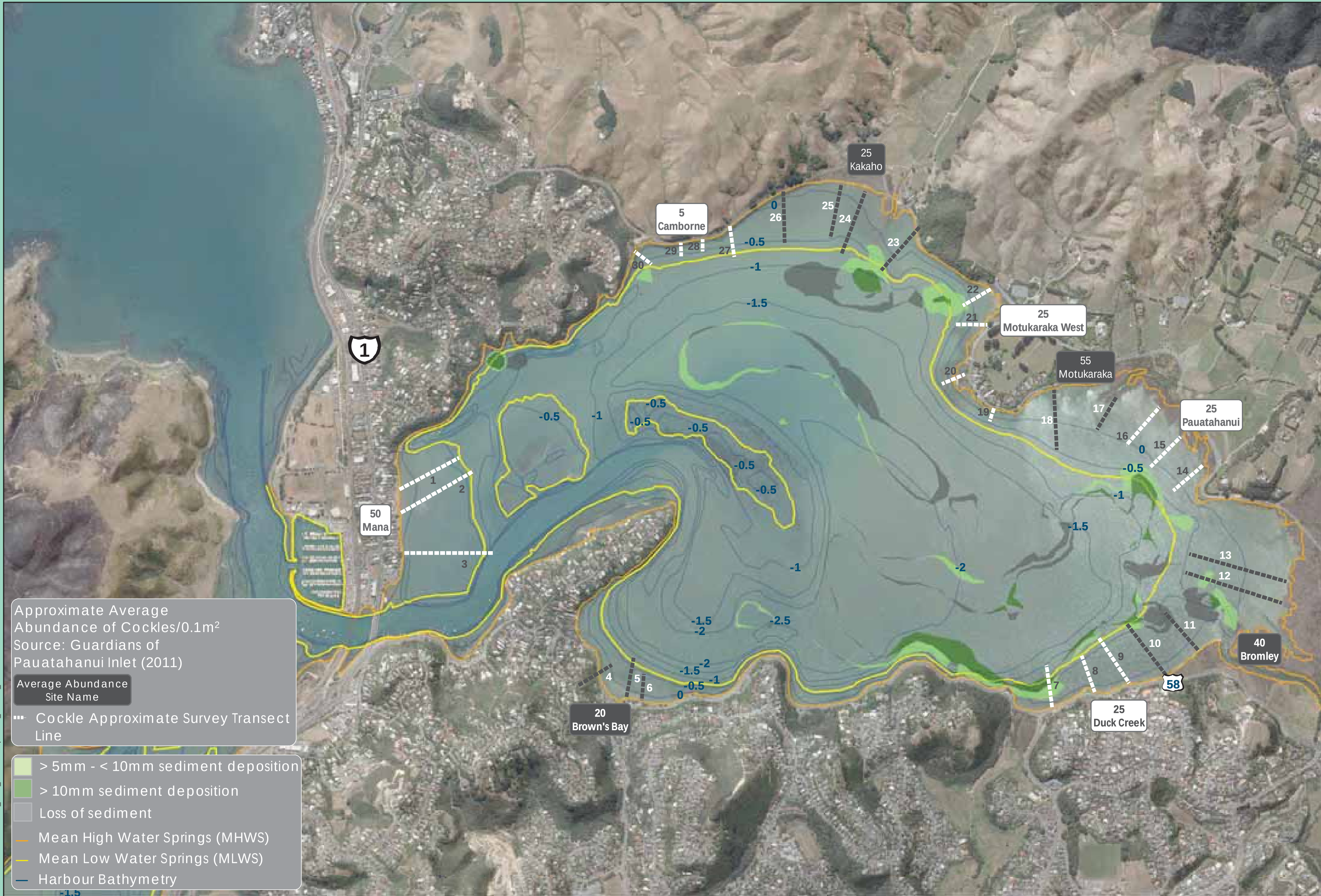
Boffa Miskell NZ TRANSPORT AGENCY WAKA KOTAHI

TRANSMISSION GULLY - ONEPOTO ARM

INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

10 yr event in Kenepuru/Porirua, (increased construction sediment yield), southerly wind, 3 days post peak of storm

APPENDIX F: COCKLE ABUNDANCE FIGURE



November 2011 W09034A_MAR_SedimentDeposition_Cockles_DuckA3mb.mxd © Boffa Miskell Ltd 2012

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TRANSMISSION GULLY - PAUATAHANUI INLET

INVERTEBRATE ABUNDANCE AND THRESHOLD SEDIMENT DEPOSITION

10 yr event in Duck/Pauatahanui, northerly wind, 3 days post peak of storm