BEFORE THE HEARING PANEL

AT HAMILTON

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of the Proposed Waikato Regional Plan Change 1 Waikato and Waipā River Catchments
AND	
IN THE MATTER	of Variation 1 to the Proposed Waikato Regional Plan Change 1 Waikato and Waipā River Catchments

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STATEMENT OF EVIDENCE IN CHIEF OF DR HUGH ALLISTER ROBERTSON

FOR THE DIRECTOR-GENERAL OF CONSERVATION

TOPICS: B2, B3, B4, B5

15 February 2019

Department of Conservation

Private Bag 3072
HAMILTON

Ph 07 838 5687

Email vtumai@doc.govt.nz

Counsel Acting: Victoria Tumai

Submission number: 71759

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Introduction

1. My full name is Hugh Allister Robertson.

2. I hold the position of Principal Science Advisor-Freshwater in the Aquatic Unit, Department of Conservation. I have been in this role since October 2008.

3. I am presenting this evidence for the Director-General of Conservation in relation to protecting and restoring the values of wetland ecosystems through addressing water quality pressures in the Waikato and Waipā catchments. The evidence covers all wetlands within the proposed Plan Change 1 (PC1) boundary, with specific focus on Whangamarino Wetland given the significance of this site.

Qualifications and experience

4. I have a PhD in wetland ecology from Deakin University, Melbourne, Australia (2007), and a BSc Hons (first class) from Otago University (1999).

5. My PhD thesis was entitled 'Environmental Water Requirements of Isolated Floodplain Wetlands' and investigated the ecological functioning of wetland systems.

6. I have 18 years of experience in the field of freshwater ecology in New Zealand and Australia, in both a research and wetland management capacity. This includes expert knowledge of the impacts of land use change and water resource development on wetland ecosystems.

7. Prior to working for the Department of Conservation I worked for the NSW Department of Environment and Climate Change (2006-2008) where I was responsible for providing technical input to catchment water sharing plans. I also worked for the regional government in South Australia (2005-2006) determining the environmental water requirements (water allocation) to maintain the ecological values of wetlands.

8. I was appointed New Zealand's National Science & Technical (STRP) Focal Point for the Ramsar Convention on Wetlands in 2008. In this role

I provide scientific advice to the NZ Government on the status of wetlands of international importance, which includes Whangamarino Wetland, and the sustainable management of wetlands in general.

9. I was an invited expert (2013-2015) for the Ministry for the Environment on the Wetlands Panel to develop recommendations on wetlands attributes and associated catchment policy in association with the Government's Freshwater Reforms during the development of the NPS Freshwater Management.

10. I am currently an invited expert (for the Ministry for the Environment and Statistics NZ) on the Freshwater Domain Technical Advisory Group, providing advice on freshwater measures and attributes for national SOE reporting under the Environmental Reporting Act 2015.

11. I was the lead author of the wetlands chapter in the NZ Freshwater Science Society publication *Advances in New Zealand Freshwater Science*. The chapter was titled: 'Wetland biodiversity, ecosystem processes and management' (Robertson et al. 2016).

12. I am the scientific lead for the Department of Conservation's (**the Department**) Arawai Kākāriki wetland restoration programme, that includes Whangamarino Wetland. In this role, I lead development of ecological monitoring and reporting that is used by the Department to report on the state and trend of natural values at Whangamarino Wetland. I also lead and provide scientific guidance for technical investigations and research projects at Whangamarino Wetland.

13. I am a member of the New Zealand Freshwater Sciences Society and the National Wetland Trust, and a past member of the Society of Wetland Scientists and Australian Limnological Society.

Code of Conduct

14. While this is not an Environment Court hearing, I have read the Environment Court "Code of conduct for expert witnesses", and I agree to abide by it. I have prepared this Statement in accordance with that Code. I confirm that my evidence is within my area of expertise. I have not omitted to consider any material facts known to me that alter or detract from the opinions I express in this Statement. I have

acknowledged the material used or relied on in forming my opinions and in the preparation of this Statement.

Summary

15. This evidence covers freshwater wetlands within the proposed Plan Change 1 (**PC1**) area, with specific focus on Whangamarino Wetland given the significance of this site.

16. In my opinion, the significant values and uses of freshwater wetlands will not be adequately protected or restored in the Waikato and Waipā River catchments by the proposed PC1. Put simply, insufficient attention has been afforded to wetlands when setting freshwater objectives and in the development of water quality attributes and targets.

17. The total area of wetlands within PC1 is 15,817 ha. Protecting and restoring the ecosystem heath, natural character and mahinga kai values and uses of wetlands should be a primary focus of PC1. However, the lack of technical consideration of wetlands in the stated objectives and attributes I consider to be a critical gap in PC1.

18. The absence of clear objectives, attributes and targets for wetlands, and the inadequacy of water quality targets for Whangamarino Wetland (e.g. no target for Total Phosphorus in contributing sub-catchments) means there is little, if any, technical certainty that wetland ecosystems will be adequately protected or restored in PC1. As it stands, the development and implementation of policies and rules, cannot be directly related back to achieving a measurable water quality target for wetlands.

19. In response to this substantial gap in the acknowledgement of wetlands, my evidence describes and sets out the following changes that are needed to PC1, specifically: **(1)** additional values and uses for wetlands, **(2)** objectives for protecting and restoring the values and uses of wetlands, including amendments to the objective for Whangamarino, (**3**) attributes (relating to water quality) for protecting and restoring wetland ecosystem health, **(4)** the establishment of a Whangamarino Wetland

FMU, **(5)** narrative targets for wetlands, and **(6)** numeric water quality targets for the Whangamarino Wetland FMU

20. The operative Waikato Regional Plan (**WRP**) provides very limited direction for addressing water quality impacts on wetlands. There are no policies or implementation methods within the WRP that seek to reduce or avoid the impacts of nutrient and sediment inputs on Waikato wetlands. I therefore disagree with the S42A Officer's report that suggests sections 3.1 and 3.7 of the WRP are sufficient for protecting the ecosystem health of wetlands.

21. To be effective, the WRP needs to define the key water quality attributes that affect wetland ecosystem health and mahinga kai. Based on national and international understanding of wetland ecosystems, these attributes are: **(1)** phosphorus, **(2)** nitrogen, **(3)** sediment and **(4)** hydrological regime (as an attribute that directly influences water quality effects). Recommended narrative targets for these attributes are presented in my evidence.

22. It would be desirable to have specific values, attributes and numeric targets defined separately for all priority wetland complexes in PC1, rather than taking a general approach in defining narrative targets. However, in the absence of WRC data for many wetlands in PC1 this is not possible. Adoption of narrative targets however will provide the framework from which policies, and rules and other methods, can be appropriately developed to address water quality pressures on wetlands in the Waikato and Waipā catchments.

23. The exception to applying narrative targets is for Whangamarino Wetland. Whangamarino is internationally significant for its ecological values and is one of New Zealand's most well-studied ecosystems. Its international significance is acknowledged in PC1 and there is comprehensive water quality, hydrological and ecological data from which to base targets on.

24. In my opinion Whangamarino Wetland is an Outstanding Freshwater Body. This is based on the guidance provided by the Ministry of the Environment (MfE 2017b), the WRCs own guidance on fresh water bodies and wetlands to be included in the identification of outstanding

freshwater bodies and significant values of wetlands (Section 8B, Operative WRPS), and due to the highly significant values that Whangamarino supports.

25. Whangamarino Wetland is at high risk of irreversible degradation (incl. shifts in species composition, loss of representative wetland types) if water quality is not improved. It is necessary for water quality attributes and numeric targets to be specifically defined in PC1 to ensure the significant values of Whangamarino Wetland are protected. At present, the water quality targets listed in Table 3.11-1 for Whangamarino sub-catchments are inadequate. For example, they do not include Total Phosphorus or sediment both of which have an adverse effect on indigenous species in Whangamarino Wetland.

26. My evidence summarises the relationship between wetland values and water quality attributes at Whangamarino Wetland. Based on this, I present proposed 10, 20 and 80-year numeric targets for Total Phosphorus (TP), Total Nitrogen (TN) and Total Suspended Solids (TSS) Load for sub-catchments contributing to Whangamarino Wetland.

27. Within the framework of PC1, the most appropriate method to apply specific numeric targets for Whangamarino Wetland, in my view, is through the adoption of a Whangamarino Wetland FMU. Considering the guidance provided by the Ministry for the Environment (MfE 2016), establishment of a Whangamarino Wetland FMU is reasonable and necessary given that: (1) Whangamarino is of international significance, (2) there is a high risk of irreversible degradation of significant wetland values (Figure 1), (3) a different suite of water quality attributes is required to protect the significant values of Whangamarino, over and above those proposed in Table 3.11-1, (4) technical understanding and monitoring data is sufficient to define the current state of the Whangamarino FMU, and the FMU can be accurately delineated, and (5) in the absence of a Whangamarino FMU, the sub-catchment targets in Table 3.11-1 will not achieve the intent and purpose of PC1.

28. I disagree with the S42A report conclusion that '*Due to insufficient monitoring data available to determine the current state of Whangamarino Wetland, absence of guidance on wetland attributes in the NPS-FM and limited understanding of wetland systems, it was*

considered the determination of meaningful numerical limits would be impracticable at this time' (para 489). In my opinion, there is sufficient data on the current state of Whangamarino Wetland (incl. water quality data collected by WRC since 2002, sedimentation analysis by NIWA, nutrient/sediment modelling by Jacobs NZ Ltd) and adequate national and international understanding of how water quality affects wetland health. In other parts of PC1 additional attributes not required by the NPS-FM have been proposed to achieve the Vision & Strategy for the Waikato River.

29. At the conclusion of each section of my evidence, I recommended specific amendments to PC1 that address the gaps relating to wetlands.

Figure 1. Discoloured water flowing into Whangamarino Wetland from Lake Waikare via the Pungarehu Canal and Stream.

Scope of Evidence

30. I have been asked to provide evidence in relation to the following matters:

    - Protecting and restoring wetlands under PC1
    - Significance of wetlands across the Waikato region (B2 S.42a officer's report)
    - Significance of Whangamarino Wetland (B2)
    - Reasons for classifying Whangamarino Wetland as an Outstanding Water Body (B2)
    - The intrinsic values and uses of wetlands (B2)
    - Catchment impacts on the ecosystem health of wetlands (B3)
    - Catchment impacts on the ecosystem health of Whangamarino Wetland (B3)
    - Objective in PC1 for for Whangamarino Wetland (B4)
    - Objectives for wetlands (B4)
    - Whangamarino Freshwater Management Unit (B5)
    - Attributes for wetlands (B5)
    - Attributes and numeric targets for Whangamarino Wetland (B5)

Material Considered

31. Key documents and information I have used in preparing this evidence are:

    - Proposed PC1
    - Vision and Strategy for the Waikato River
    - NPS Freshwater Management (MfE 2017a)

- A Guide to the National Policy Statement for Freshwater Management 2014 (MfE 2017b)
- A Guide to Identifying Freshwater Units (MfE 2016)
- Operative Regional Policy Statement
- Operative Waikato Regional Plan
- S42A Officer's Report, and associated amendments to PC1
- Whangamarino Wetland sediment monitoring report (PDP 2018)
- Water quality data for sub-catchment tributaries of Whangamarino Wetland (LAWA website, WRC monitoring data)
- Wetland soil nutrient data and wetland vegetation data for Whangamarino Wetland (DOC monitoring data)
- SOURCE catchment modelling report for Whangamarino Wetland (Lockyer 2015)
- Sedimentation analysis for Whangamarino Wetland (Gibbs 2009, Reeve et al. 2010, Reeve 2015)

Protecting and restoring wetlands under PC1

32. The proposed PC1 puts forward a suggested framework to protect and restore the Waikato and Waipā river catchments by reducing discharges of nutrients, sediment and microbial pathogens to rivers, lakes and wetlands.

33. For PC1 to be effective, key water quality attributes that affect wetland ecosystem health, and other values and uses (e.g. mahinga kai), need to be defined. Ideally these attributes would be spatially defined for all priority freshwater ecosystems (refer evidence of Ms McArthur, para 28). However, if data is limited, a general or narrative approach to setting water quality targets can be applied, including for wetlands.

34. As it stands, water quality attributes that affect wetland values have not been determined for PC1. It appears to have been assumed that the sub-catchment water quality targets proposed for rivers will be adequate in safeguarding wetland ecosystems and species.

35. S42A reporting officer's consider that no additional direction is required for wetlands in PC1 given they are already covered by the existing provisions in the WRP, especially sections 3.1 and 3.7 that relate to wetlands (para 472).

36. However, the WRP provides a very limited framework for addressing water quality impacts on wetland values (except at a high level). As a consequence, there are no policies or implementation methods within the WRP that seek to reduce or avoid the impacts of nutrient and sediment inputs on Waikato wetlands. I therefore disagree with the S42A Officer's report that suggests sections 3.1 and 3.7 of the WRP are sufficient to protect the ecosystem health of wetlands. PC1 is the place to address water quality impacts on wetlands as it is addressing targets for water quality within the Waikato and Waipā River catchments.

37. At a fundamental level, the influence of nitrogen, phosphorus and sediment on wetland functioning seems to have been overlooked in PC1. Freshwater wetlands by definition exist because of the fresh water they receive from surface water, groundwater or rainfall (Johnson & Gerbeaux 2004). Freshwater sources, including runoff, are the primary vector for water contaminants including nutrients and sediment (Mitsch & Gosselink 2007).

38. It is recognised that under the NPS-FM, the NOF (MfE 2017a) only provides national attributes and values for lakes and rivers. But this does not mean that setting of additional attributes cannot occur[1]. In PC1, a decision has been made to include some additional attributes (e.g. Clarity, TN at limited sites, TP at limited sites) as they are relevant to achieving the Vision and Strategy for the Waikato River. The same approach can apply for wetlands.

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[1] Establishing other attributes is provided for by Policy CA2 of the NPS-FM (MfE 2017a)

39. In my opinion, further consideration of wetlands in PC1 is required before it can be assured that the significant values of wetlands will be protected.

Current extent and significance of wetlands across the Waikato region

40. Geospatial mapping of wetlands in New Zealand (FENZ Geodatabase, Ausseil et al. 2008) indicates that only 10%[2] of freshwater wetlands now remain throughout New Zealand. Nationally, the total extent of inland wetlands (not coastal) is 250,000 ha. Within the Waikato, only 8.9% of freshwater wetlands remain (Ausseil et al. 2008).

41. The total area of natural freshwater wetlands in the PC1 geographical area is 15,817 ha, with the Lower Waikato FMU having the largest extent of wetlands. In comparison the total area of lakes in PC1 is only 6022 ha (refer evidence of Dr Phillips). Figure 2 below illustrates the distribution and extent of wetlands in the Lower Waikato FMU.

42. Approximately 41% (by area) of wetlands in the PC1 geographical area are administered by The Department of Conservation as public conservation land (6538 ha). While these wetlands are legally protected as part of the public conservation estate, they are often situated within catchments where land use is predominantly agriculture, or forestry, with the wetland areas subject to high risk of degradation from nitrogen, phosphorus and sediment contamination, in addition to drainage and altered flood frequency.

43. There are approximately 140 wetlands in the PC1 geographical area (mean area = 93 ha, median area = 13 ha). The extent of wetlands in the PC1 geographical area is highly depleted, and therefore, the significance of remaining wetlands for protecting biodiversity and natural character is high (van der Zwan & Kessels 2017).

44. An integrated ranking of the biodiversity priorities for the Waikato Region, which included wetlands (Leathwick 2016), indicates that many of the remaining of the Lower Waikato FMU are of the highest priority for

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[2] Compared to the extent of wetlands prior to human settlement of New Zealand

the indigenous biodiversity (Figure 3), a key component of ecosystem heath (MfE 2017a).

45. The 2017 SNA report for the Waikato District (van der Zwan & Kessels 2017) further recognises the international and national significance of wetlands, particularly in the Lower Waikato FMU (Figure 4).

46. There is a high degree of consistency between the FENZ wetland mapping (Ausseil et al. 2008), biodiversity priorities (Leathwick 2016), the SNA assessment of significant habitats (van der Zwan & Kessels 2017) and the priority ecosystems described within the Waikato Conservation Management Strategy 2014-2024 (DOC 2014). This consistency indicates that protecting and restoring the significance values of remaining wetlands is recognised as one of the key issues to address within the Waikato Region.

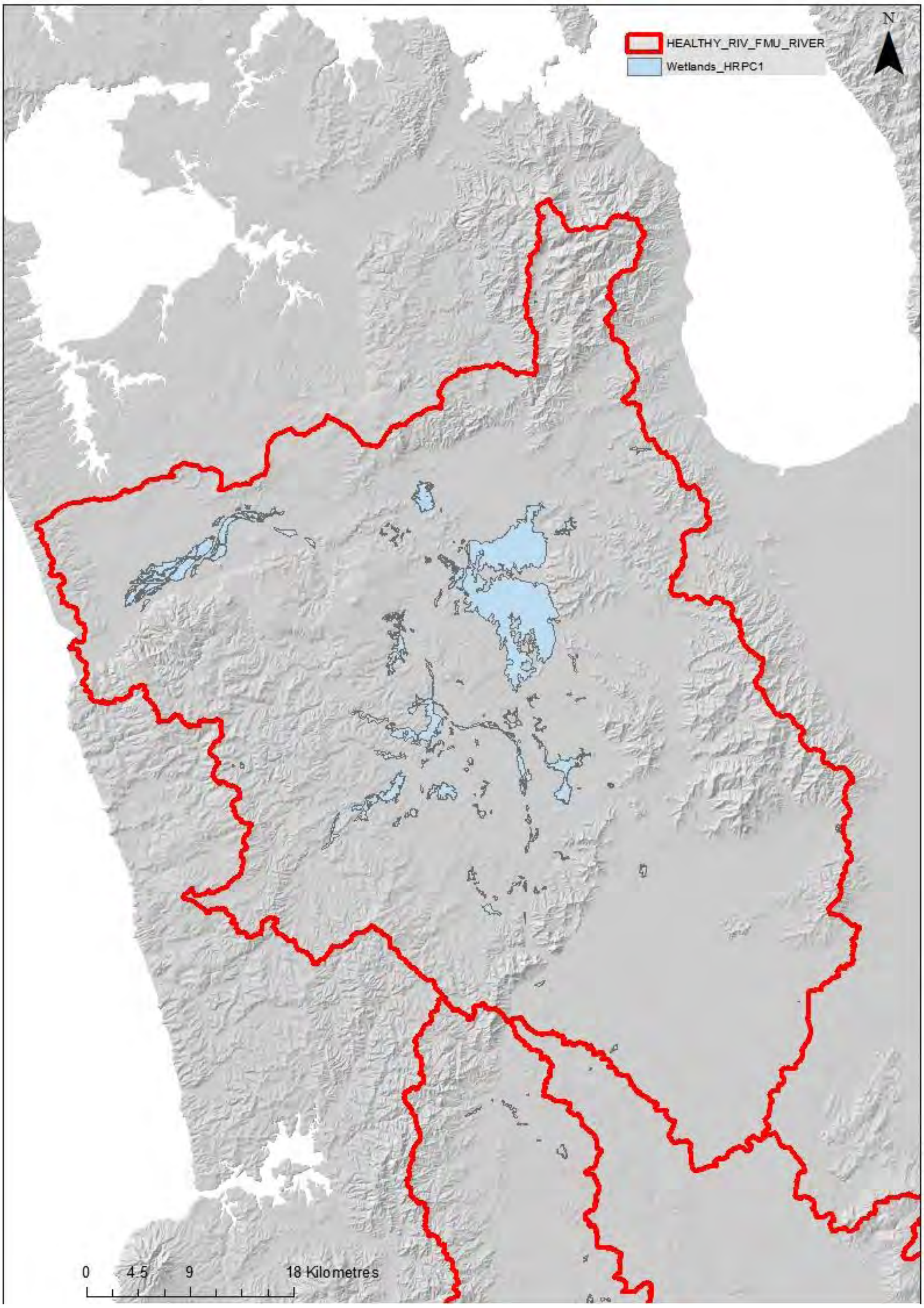


Figure 2. Extent of freshwater wetlands in Lower Waikato FMU. Freshwater wetlands are depicted as blue polygons. Red lines are the FMU boundaries. Source data: FENZ Geodatabase.

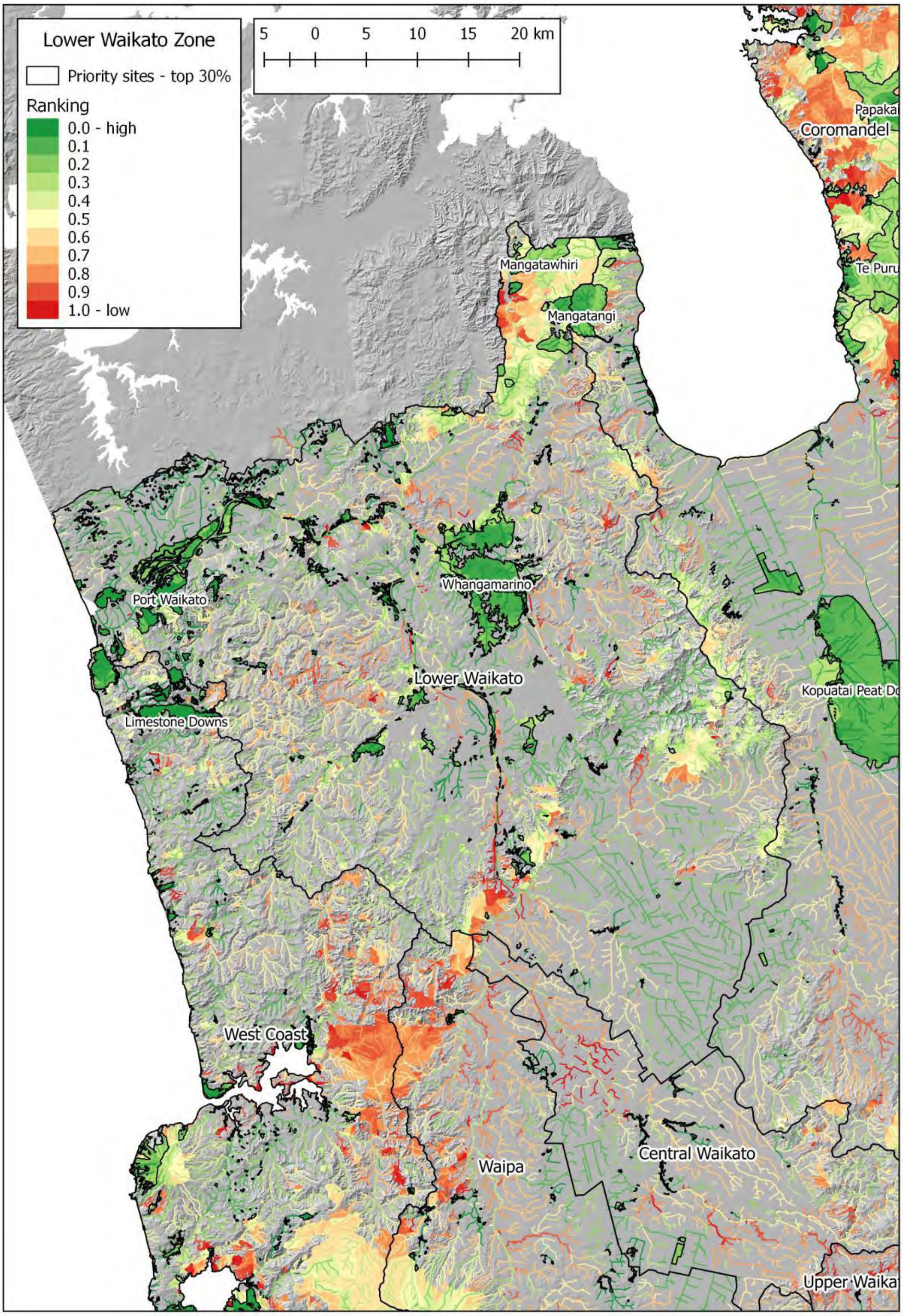


Figure 3. Integrated biodiversity ranking and prioritisation for the Waikato region. Green polygons depict high ranking sites include a number of Lower Waikato wetlands (as well as other habitats). Source: Leathwick (2016)

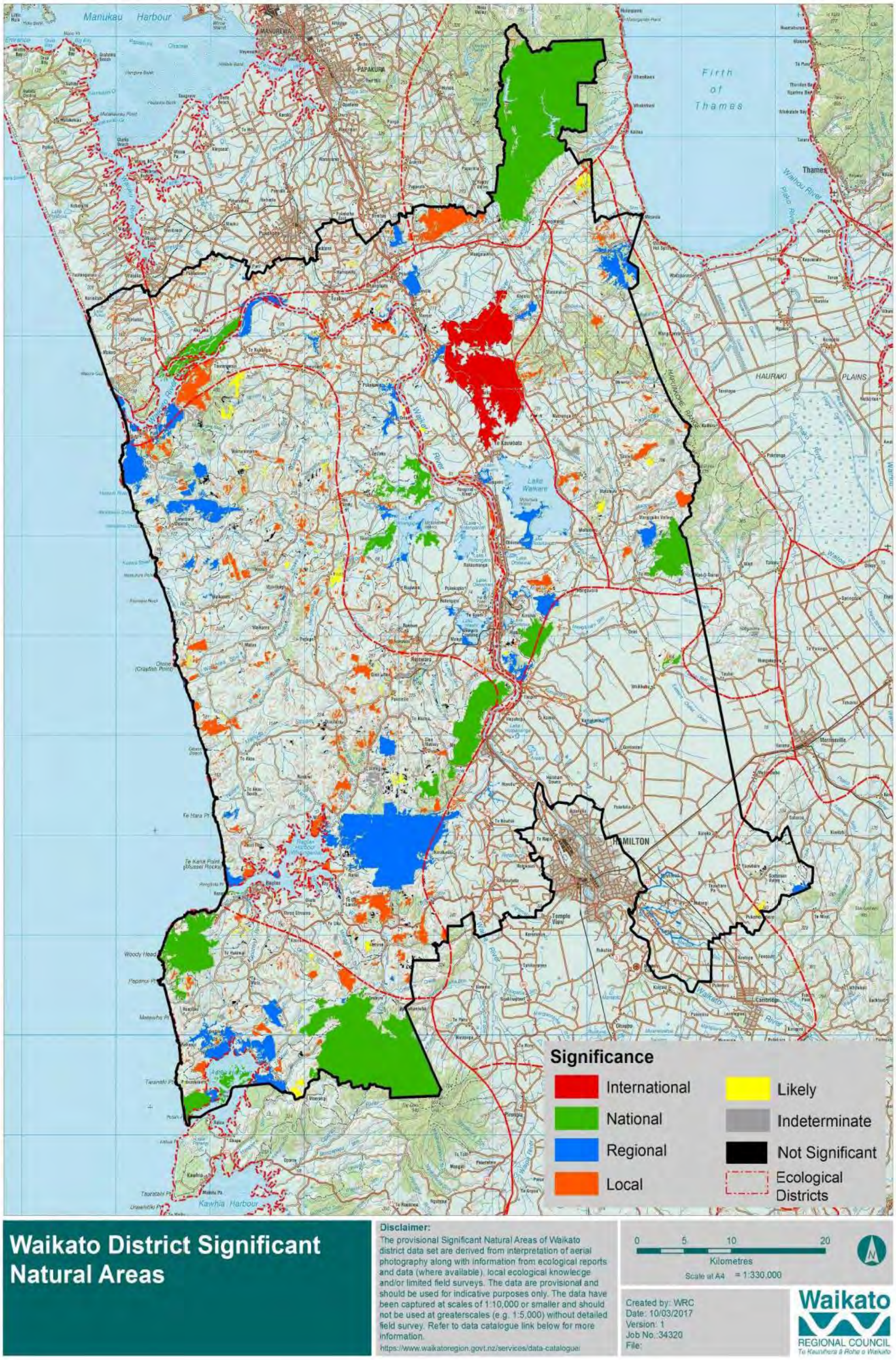


Figure 4. Significant natural areas of the Waikato District. Source: van der Zwan & Kessels (2017)

47. The predominant wetland types that occur within the PC1 geographical area are swamp and bog and to a lesser degree marsh (Table 1 and Figure 5).

Table 1. Extent of wetland types in the PC1 geographical area

Wetland type	Area	Proportion	Susceptibility to elevated nutrient and sediment inputs
Bog	4871 ha	30.8 %	Very High
Marsh	1279 ha	8.1 %	High
Swamp	9595 ha	60.7 %	High
Other	72 ha	0.5 %	-
Total	15,817 ha	100 %	

48. The bog wetland type is characterised by soils with relatively low nutrient status and a wetland flora and fauna that has adapted to low levels of nutrient and sediment input (Johnson & Gerbeaux 2004, Clarkson et al. 2004, Blyth 2011, Blyth et al. 2013).

49. Bogs are typically rainfed, relatively acidic and are disconnected from inputs of surface water. However, within the Waikato changes in land use resulting in drainage of wetlands and the development of water infrastructure (e.g. flood schemes) has resulted in a number of bogs becoming influenced by catchment processes, such as Whangamarino and Moanatuatua (Shearer 2007, Blyth 2011). Objectives for the management of nutrients and sediment in PC1 therefore should extend to bogs to protect and restore their low fertility values and to avoid shifts in vegetation and habitat types that occurs with increased fertility and discharge of nutrients and sediments.

50. The swamp wetland type, which accounts for approximately 60% of all wetlands in PC1 region is characterised by surface water inputs (Johnson & Gerbeaux 2004). Swamps are often termed ‘minerotrophic’. They have higher nutrient status due to direct linkages with river and/or lake surface water inputs that transport mineral soils, including nutrients. This hydrological process makes swamps and marshes less acidic, compared to bogs.

51. The minerotrophic character of swamps, and their association with rivers, streams and riverine lakes makes this wetland type particularly vulnerable to nutrient enrichment and sedimentation. Swamps are natural deposition environments, but their natural function can be altered if nutrient concentrations or sediment loads increase.

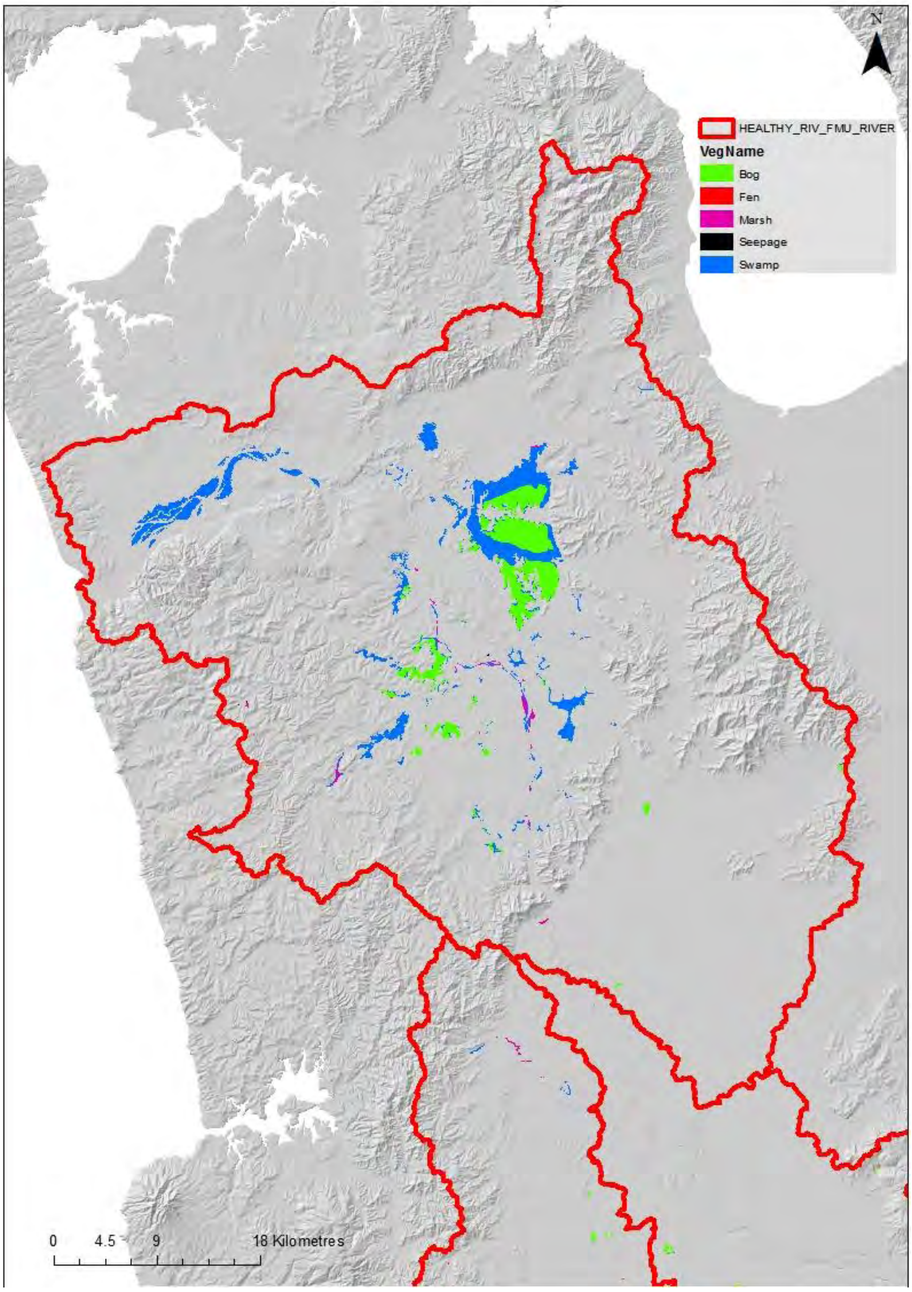


Figure 5. Wetland types of Lower Waikato FMU

52. The significant ecological values of a number of wetlands in the PC1 region (Figure 4) have been described in report '*Significant natural areas of the Waikato District: terrestrial and wetland ecosystems* (van der Zwan

& Kessels (2017) and the Directory of New Zealand Wetlands (Cromarty & Scott 1996).

53. The significant natural areas report indicates that significant wetlands in the Waikato District include both indigenous dominated wetlands and modified and induced wetlands (where invasive species have established). However, the report notes that modified wetlands still provide important habitat for many threatened species, such as Australasian Bittern, Marsh Crake, Black Mudfish and Giant Kokopu (van der Zwan & Kessels (2017).

54. The importance, status and pressures on the Waikato's wetlands was also summarised by the Waikato Regional Council in the report *'The health of the Waikato River and catchment'* (Environmental Waikato 2008). It noted that wetlands in the region provide significant habitat for many threatened species. This report also stated: *"All these remaining wetland areas [in the Waikato River catchment] are highly vulnerable to drainage, damage by pest plants and animals,* ***sedimentation and nutrient runoff****.*" [emphasis added]

55. Across the PC1 Geographical Region, some of the largest and significant wetlands are: Opuatia Wetland, Moanatuaua, Whangamamarino Wetland, Waikato River delta wetland and the swamps associated with lowland lakes (Waikare, Whangape, etc). A review of literature indicates that all of these wetlands have are identified as being susceptible to impacts associated with water quality decline (Table 2).

Table 2. Summary of some of the regionally, nationally and internationally significant wetlands within the PC1 Geographical Area

Wetland	**Area (ha)**	**Key values**	**Susceptible to water quality impacts**
Opuatia	950	Large bog and swamp, rare species	**Yes** (Browne et al. 2005)
Moanatuatua	115	Remnant bog	**Yes** (Clarkson et al. 1999, Shearer 1997)
Whangamarino	7000	Ramsar site,	**Yes**

		threatened species	(Blyth 2011, Shearer 1997)
Waikato River Delta wetland	1500	Unique wetland landform, rare species	**Yes** (Environment Waikato 2008, Cromarty & Scott 1996)
Waikato swamps (Whangape, Waikare, etc)	>1000	Remnant swamp, rare species	**Yes** (Cromarty & Scott 1996)

Significance of Whangamarino wetland

56. Whangamarino Wetland refers to the ~7000 ha wetland complex situated on the floodplain of the Lower Waikato River. Whangamarino comprises extensive freshwater wetlands (bog, fen, swamp, marsh) and is fed by the Pungarehu Stream, Whangamarino River and Maramarua River (Figure 6). In addition to the natural rivers that flow into Whangamarino, the wetland receives inflows from Lake Waikare via the Pungarehu Canal.

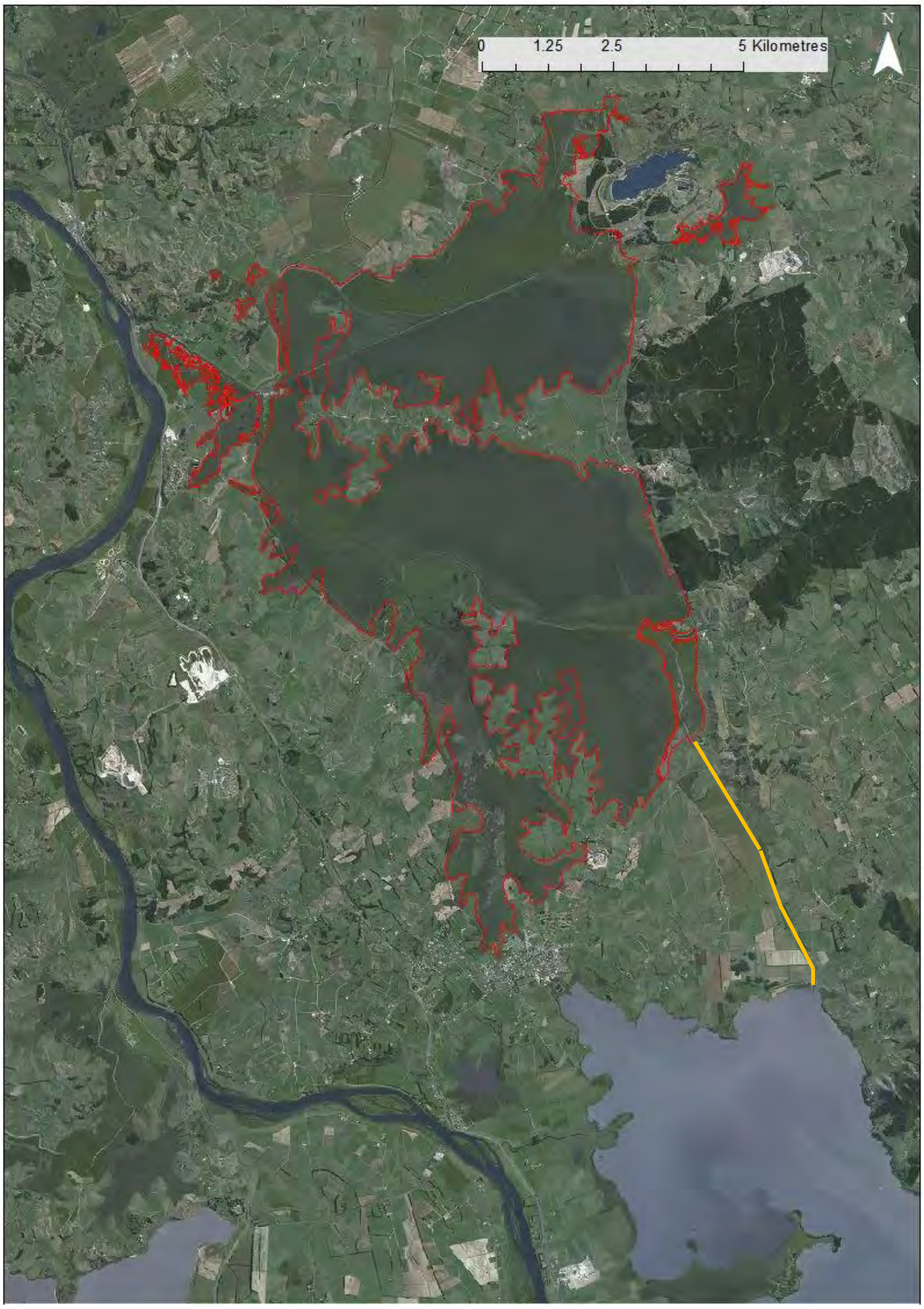


Figure 6. Location and extent of Whangamarino Wetland

57. Whangamarino Wetland includes land administered by the Department of Conservation, land owned by Fish & Game, and private land. Approximately 5,000 ha of Whangamarino Wetland is administered by the Department of Conservation as a Government Purpose (Wetland Management) Reserve under the Reserves Act 1977.

58. The Whangamarino Wetland Ramsar site (wetland of international importance) was officially designated in 1989. The Ramsar site encapsulates both the public conservation land administered by the Department of Conservation and Fish & Game owned land.

59. Protecting the significant values and uses of Whangamarino is a national priority for the Department of Conservation. One of the main objectives of the Arawai Kākāriki wetland restoration programme at Whangamarino is *to maintain or enhance water regimes, water quality and the condition of wetland habitat*. Whangamarino is also a priority site in the Waikato Conservation Management Strategy 2014-2024 (DOC 2014).

60. The significance of Whangamarino wetland is acknowledged in PC1. In the reason for adopting Objective 6 it is stated "*Objective 6 seeks to recognise the significant value of Whangamarino Wetland, a Ramsar site of international importance, and the complexity of this wetland system. It seeks to recognise that the bog ecosystems (which are particularly sensitive to discharges of contaminants) need protection over time. The effort required to restore Whangamarino Wetland over 80 years is considerable and as a minimum needs to halt and begin to reverse the decline in water quality in the first 10 years. This objective describes how wetland restoration needs to be supported by restoration of the Lower Waikato Freshwater Management Unit sub-catchments that flow into Whangamarino Wetland*".

61. Protecting the ecological significance of Whangamarino Wetland appears to be one of the primary goals for PC1. Whangamarino is the second largest bog and swamp complex in the North Island and one of the best remaining and largest examples of this wetland type in New Zealand. It contains extensive and diverse wetland habitats that forms a

highly significant ecological sequence across marsh, swamp, fen and bog wetland types (Figure 7).

62. Whangamarino is a national stronghold for many threatened species. It meets the Ramsar Criteria 2, 3, 4 and 6 (Denyer & Robertson 2016) because of its significance for nationally threatened and at-risk species. It supports the largest known population of the Australasian bittern ('nationally critical') in New Zealand (20% of the national population), and is an important site for spotless crake, North Island fernbird and black mudfish. Whangamarino Wetland also provides habitat for inanga *Galaxias maculatus* which is classified as 'At Risk, Declining' (Dunn et al. 2018). Fish surveys (Lake et al. 2011) have also recorded other species of whitebait, including Banded Kokopu *Galaxias fasciatus*.

Figure 7. Aerial photograph of Whangamarino showing the ecological sequence of Swamp-Fen-Bog wetland habitat in association with the Whangamarino River.

63. A number of threatened plants have also been recorded in the wetland including the water milfoil *Myriophyllum robustum*, the swamp helmet orchid *Corybas carsei* and the club moss *Lycopodiella serpentina*.

Notably, Whangamarino is the only location in New Zealand where *Corybas carsei* is currently known to occur.

64. The intrinsic ecological values contribute to Whangamarino meeting 5 of the 9 Ramsar criteria for international significance (Appendix 1) and 7 of the 8 criteria for ecological significance in the WRPS (Appendix 2).

65. A principal reason why Whangamarino Wetland is internationally significant is because it is an outstanding example of a wetland characteristic of its biogeographical region (Ramsar Criterion 1). It meets Criterion 1 because of its large size, the relatively intact (indigenous dominated) ecological sequences of marsh, swamp, fen, and bog (the main wetland types), and the diversity of aquatic habitats it provides for indigenous species. Whangamarino contains approximately 1812 ha of bog habitat, 1908 ha of fen habitat, 736 ha of marsh habitat and 2249 ha of swamp habitat.

66. However, the extent of representative bog habitat dominated by sedges and wirerush has declined significantly since 1963 (from covering 53% of the wetland in 1963 to only 35% in 2014, Reeves 2015). The decline in bog extent is due to impacts associated with changes in catchment land use and altered hydrology (Blyth 2011). The ecological condition of the swamp, fen and marsh wetland types has also declined over the past 50 years (Reeves 2015). This is due to high volumes of sediment and nutrients entering the wetland system, coupled with an altered hydrological regime[3] (Blyth 2011). For example, there has been a substantial loss of native sedgelands dominated by *Carex gaudichaudiana* and increased abundance of invasive plant species (Reeves 2015), such as *Glyceria maxima* and *Persicaria* species.

67. Maintaining and restoring the ecological health of Whangamarino Wetland is required to ensure the internationally important values of the

[3] the Lower Waikato flood control scheme diverts flood water from Lake Waikare into Whangamarino Wetland.

site, recognised under the Ramsar Convention, are sustained and protected.

Classifying Whangamarino Wetland as an Outstanding Freshwater Body

68. The National Policy Statement for Freshwater Management (NPS-FM 2014) defines "Outstanding freshwater bodies" as those water bodies identified in a regional policy statement or regional plan that have outstanding values, including ecological, landscape, recreational and spiritual values.

69. The operative WRPS states (section 8.2.1) that the '*Waikato Regional Council, through a values setting process, shall identify outstanding fresh water bodies and significant values of wetlands. The process to inform the identification of outstanding freshwater bodies and the significant values of wetlands will include consideration of the values of those fresh water bodies and wetlands that are in section 8B and the uses and associated values of those freshwater bodies that are in section 8A.*'

70. Accordingly, PC1 presents an appropriate planning process for Outstanding freshwater bodies to be recognised in the updated WRP in accordance with the direction provided under the WRPS (8.2.1) and to address the adverse effects of use and development, including sediment and nutrients.

71. The submission of the Director-General identified several waterbodies that should be considered outstanding under the NPS-FM framework, which included Whangamarino Wetland.

72. In relation to Whangamarino Wetland, the submission of the Director-General is in alignment with the WRPS. Section 8B includes Whangamarino in the list and map of those '*Fresh water bodies and wetlands to be included in the identification of outstanding freshwater bodies and significant values of wetlands as stated in Method 8.2.1*'.

73. While there is no standardised method for determining whether a waterbody is 'outstanding' in New Zealand there are a range of ecological criteria that can be adopted. I agree with the evidence of Ms

McArthur that when considering outstandingness under the NPS-FM objectives (A2 and B4) 'the contribution of a particular waterbody to regional or national ecological values and the potential for the regional or national range and breadth of ecological values to be "irreparably diminished" if the values in a waterbody are not protected' is particularly relevant (refer evidence of Ms McArthur, para 67).

74. In my opinion, Whangamarino Wetland can be readily identified as an outstanding fresh water body under the NPS-FM 2014, consistent with section 8B of the Operative WRPS. It is outstanding because:

- if the natural character or ecosystem heath of Whangamarino were diminished, this would represent a decline in significant wetland values at a national and international scales, which is likely to be irreversible.

- the wetland is an internationally significant site for the protection of nationally critical threatened species, such as the Australasian Bittern

- large areas of the sensitive raised bog remain in relatively pristine condition (good water quality, indigenous dominance, natural ecological processes) and it is one of the best global examples of a restiad raised bog.

75. Identification of Whangamarino as an outstanding freshwater body in PC1 is important because NPS-FM Objective A2 specifically requires the maintenance and improvement of water quality to protect their significant values, as well as the significant values of wetlands. To implement Objective A2 appropriately for Whangamarino, PC1 needs to go further and ensure targets for all important water quality attributes will achieve its protection. This includes additional attributes that are not currently provided for in Table 3.11-1 of PC1. I suggested that this warrants the use of a separate FMU to protect its significant values.

76. In summary, I recommend that Whangamarino Wetland is recognised as an outstanding freshwater body in PC1.

Intrinsic values and uses of wetlands in PC1

77. The proposed PC1 includes the health and mauri of the water (ecosystem health) and the health and mauri of the environment (natural form and character) as intrinsic values. The intrinsic values have been developed to be all encompassing, covering the range of freshwater systems and freshwater management units including wetlands.

78. The current description of ecosystem health is focused on linking clean fresh water to protecting and restoring different groups of freshwater species, such as vegetation, macroinvertebrates and native fish.

79. The ecosystem heath definition would benefit by considering existing literature that established definitions of ecological integrity in New Zealand. Schallenberg and others (2011) defined freshwater ecological integrity as having four components: these are *nativeness, pristineness, diversity* and *resilience* (Schallenberg et al. 2011). Lee et al. (2005) also developed a definition of ecological integrity. One of the key aspects of their framework is the inclusion of the *'maintenance of ecosystem processes*'.

80. Considering this literature, I recommend that a further component of ecosystem heath is included in PC1. That is *'Clean fresh water supports the natural ecological functioning of river, wetland, lake and estuarine ecosystems*'.

81. The definition of ecosystem heath in PC1 also refers to the role of wetlands and floodplains in 'water purification'. This water purification function of wetlands is more suited to a use value, not an intrinsic value. It may be interpreted that the use of wetlands to capture nutrient and sediment contaminants from land use runoff is consistent with achieving an ecosystem health outcome. Given accumulation of high levels of nutrient and sediment is detrimental to wetland ecosystem health (refer paragraphs 89-103), I recommend that water purification is deleted from ecosystem health as an intrinsic value and included under 'commercial, municipal and industrial use' or 'primary production' as a use value.

82. PC1 provides a definition of natural form and character that does not encapsulate the full intent of natural form and character as defined under the NPS-FM (MfE 2017a) and other statutory documents (e.g. NZCPS).

The notified value of natural form and character also omitted wetlands, even though wetlands as with any other natural ecosystem will contribute to this intrinsic value.

83. I recommend that a further component of natural form and character is included in PC1 to be consistent with the intent of the NPS-FM.

84. The notified version of PC1 did not include wetlands under the 'Mahinga kai' use values. In the book, Te Reo o re Repo (Taura et al. 2017), it is stated '*Repo (wetlands), also known as reporepo, poharu, and roto, are regarded by Māori as taonga with historical, cultural, economic, and spiritual significance. Repo can also be reservoirs for mātauranga (knowledge), wellbeing, and utilisation. They are mahinga kai (food gathering sites) used by local marae (Māori social and cultural centres), whānau (families), hapū (subtribes), and iwi (tribes), and provide significant habitats for a range of taonga (culturally important) plants, animals, fish, birds, reptiles, insects, and micro-organisms. In addition, many repo contain a variety of culturally important medicinal plants for rongoā (Māori medicinal use).* The S42A officer's report recommends a revision to the Mahinga kai use value so that wetlands are recognised. I support this proposed amendment as wetlands are recognised as critical sites for food gathering.

85. As notified, PC1 does not recognise the 'human health-recreation' use value for wetlands. S.42a officer's also do not recommend making changes to the value to recognise recreation. However, across New Zealand, and within the Waikato, wetlands are a site frequently used for recreation. Community use wetlands for hunting (e.g. duck hunting in Whangamarino Wetland), for kayaking and for fishing (e.g. tuna). The evidence of Mr David Klee (Fish & Game) provides information on the use of wetlands for recreation. An amendment to PC1 is required to recognise the 'human health-recreation use values of wetlands.

86. PC1 provides a definition of the 'mitigating flood hazards' use value that recognises the infrastructure that is in place to protect land and assets from flooding. In addition to river engineering, the natural capital of wetlands in mitigating flood impacts should be recognised as well as the impact flood storage can have on wetland values. This is particularly relevant in terms of protecting the significant values of Whangamarino

Wetland. I acknowledge that flood storage is one of the ecosystem services Whangamarino Wetland provides, albeit an engineered one. It is also important to recognise how the use of the wetland for flood control impacts on other values, such as ecosystem health and mahinga kai.

87. I recommend that a further component of mitigating flood hazards is included in PC1. That is, '*Lakes, wetlands and estuaries provide natural infrastructure that mitigate flood impacts, recognising that altered flood regimes can impact on intrinsic values and uses'*.

88. I recommend that the values and uses section of PC1 is amended so that:

- *Ecosystem heath* includes reference to 'the natural ecological functioning of river, wetland, lake and estuarine ecosystems'.
- *Ecosystem health* excludes reference to '~~water purification~~' and this aspect is shifted to a use value
- *Natural form and character* includes better reference to the NPS-FM definition.
- '*Mahinga kai'* includes reference to 'wetlands'
- *Mitigating flood hazards* includes reference to 'natural infrastructure that mitigate flood impacts, recognising that altered flood regimes can impact on intrinsic values and uses'

Catchment impacts on the ecosystem health of wetlands

89. Understanding water quality impacts on the ecosystem health of wetlands, and Whangamarino Wetland, is necessary for setting objectives in PC1.

90. Verhoeven et al. (2006) published a summary article on *Regional and global concerns over wetlands and water quality*. In this, they noted: *Water quality in many stream catchments and river basins is severely impacted by nutrient enrichment as a result of agriculture. Water-resource managers worldwide are considering the potential role of riparian zones and floodplain wetlands in improving stream-water quality, as there is evidence at the site scale that such wetlands are*

efficient at removing nutrients from through-flowing water. ***However, recent studies have highlighted disadvantages of such use of wetlands, including emissions of greenhouse gases and losses of biodiversity that result from prolonged nutrient loading*** [emphasis added].

91. Further, Verhoeven et al. (2006) noted: *'Nutrient inputs to ecosystems have increased over the past century in many parts of the world. The resulting nutrient enrichment often has significant effects, including increased productivity, higher rates of nutrient leaching and shifts in the dominance, and composition, of species',* and they also summarised, *'Wetlands that are characterized by low productivity and high plant diversity dominated by slow growing, nutrient-conserving species shift to systems dominated by large, fast-growing helophytes following a strong increase in nutrient-loading rates.'*

92. The critical nutrients that Verhoeven et al. (2006) focused on were **nitrogen** and **phosphorus**. As for lake systems, these are the nutrients that directly influence the primary productivity of vascular and non-vascular vegetation. The diagram below (Figure 8) illustrates the typical N and P cycle in wetlands.

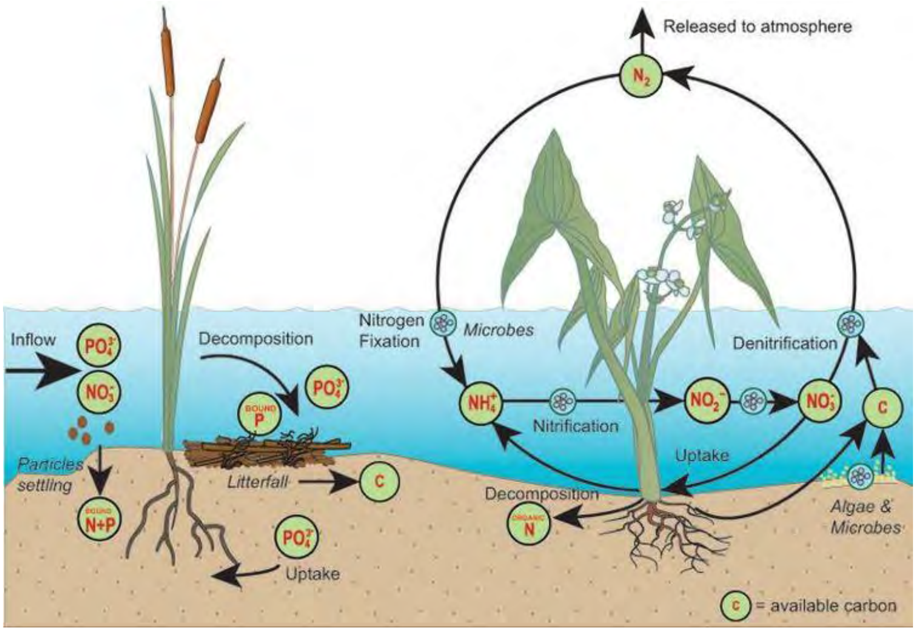
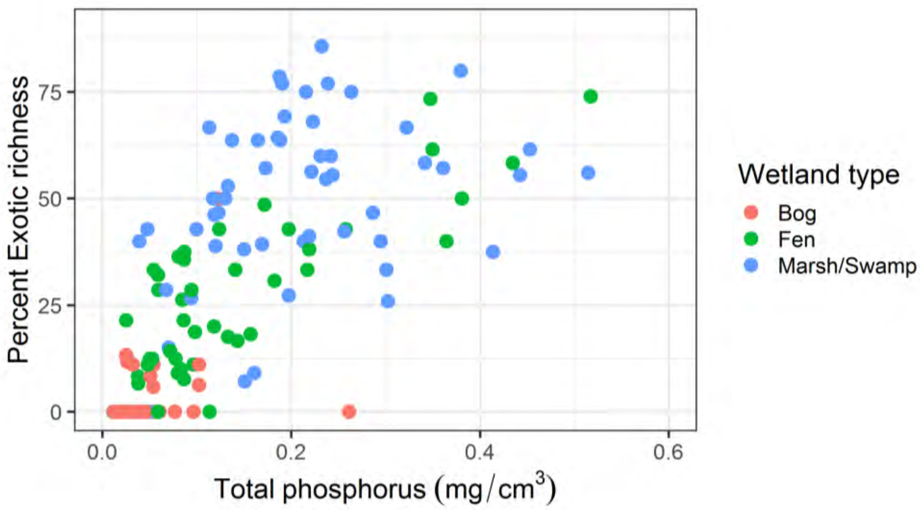


Figure 8. Simplified conceptual diagram of the nitrogen and phosphorus cycle in wetlands. Source: Wetlands Initiative

93. Scientific literature summarising the role of nutrients in New Zealand wetlands has also been published. Appendix II of the Handbook for Wetland Condition Monitoring (Clarkson et al. 2004), for example, provides an overview of the impact of elevated nutrients on wetland vegetation. It states: '*Changes in nutrient loads into wetlands increase soil nutrient concentrations, causing shifts in species composition because species vary in their ability to cope with different nutrient availabilities*. It also notes that '*changes in soil chemistry and soil nutrient content are widely used to monitor inputs of dissolved and particulate nutrients into wetlands. Dissolved nutrients in standing water can be used in deeper wetlands, and in these habitats can often be interpreted in similar ways to nutrient monitoring programmes in lake and river ecosystems*.'

94. Research I have led on nutrient-plant relationships at three significant wetlands in New Zealand (Whangamarino, O Tu Wharekai, Awarua) supports the findings of Clarkson et al. (2004). Increased levels of soil TN and soil TP were found to correlate with an increase in exotic plant species richness (Figure 9A, 9B), indicating the susceptibility of wetlands to elevated nutrients.



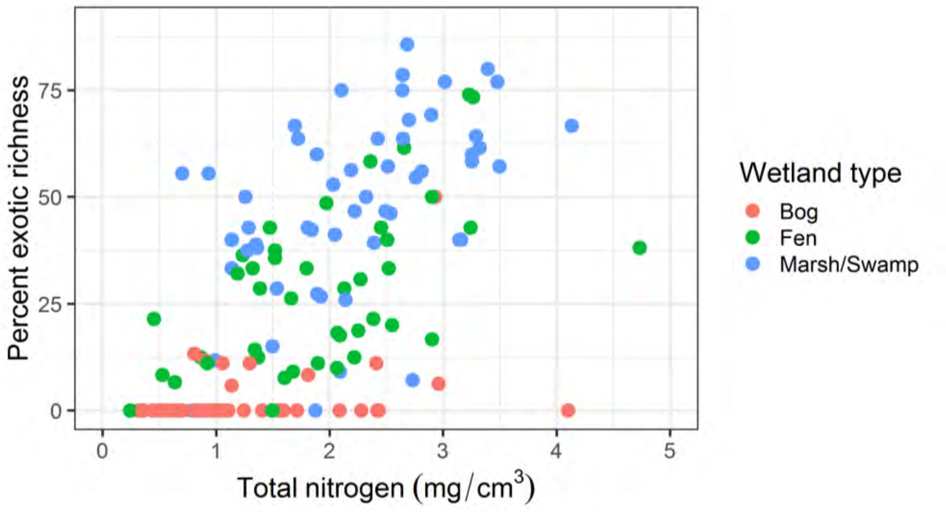


Figure 9: Relationship between soil total phosphorus **(A)** and soil total nitrogen **(B)** and the richness of exotic wetland plants in three New Zealand wetlands (Whangamarino, O Tu Wharekai, Awarua). Source: DOC.

95. Appendix II of the Handbook (Clarkson et al. 2004) goes on to describe the degree of N versus P limitation in New Zealand wetlands. The key conclusion is that across New Zealand wetlands bogs tend to be P limited (high N:P ratios), while swamps can be N or P limited (lower N:P ratios) depending on the particular site in question, its local hydrogeology and the degree of catchment land use change.

96. And in summary, Clarkson et al. (2004) state '*Nutrient enrichment (eutrophication) can dramatically alter vegetation composition, health, and habitat value in wetlands, and is arguably second only to hydrological disturbance as a cause of loss of wetland condition in New Zealand. Point source discharges of nutrients and diffuse nutrient run-off are widely recognised as important problems affecting lake and river ecosystems, but their effects on wetland ecosystems have received less attention*.

97. In my opinion, it is critical that PC1 includes Nitrogen (TN) and Phosphorus (TP) as key attributes for maintaining the ecosystem health of wetlands.

The other important driver of ecosystem heath in wetlands, in relation to water quality, is sedimentation. Clarkson et al. (2004) summarised the effects of sedimentation as follows: '*Runoff of suspended sediments into* *wetlands (i) can cause direct smothering of desirable vegetation in shallow wetlands; and (ii) reduces light penetration in standing water. In both cases, sedimentation is usually associated with increased loads of organic matter that increase soil and water respiration, causing the habitat to become more anaerobic and often resulting in vegetation decline and fish kills*. *Sediment input may be accompanied by nutrient enrichment, because most anthropogenic sediments in New Zealand have an associated nutrient load.'*

98. One of the most well-monitored wetlands for sediment processes and sedimentation in New Zealand is Whangamarino. There has been a substantial increase in the rate of sediment accumulation in low-lying areas of the wetland over the past 50 years (Reeve et al 2010, Gibbs 2016). The photograph below illustrates the build-up of fine-medium size sediment on the wetland soils and vegetation in Whangamarino Wetland (Figure 10). This directly effects the natural character and ecosystem health of Whangamarino by smothering native vegetation and increasing habitat disturbance that favours invasive plant species.

Figure 10. Sediment deposition in swamp wetland habitat in Whangamarino Wetland

99. Although Figure 10 presents an extreme example, I would expect other swamp wetlands in the PC1 region that receive inputs of

surface water with high levels of suspended sediment to also be subject to increased rates of sediment deposition.

100. There is a broad range of international scientific literature that have reported on sediment impacts on wetland ecosystem heath. Increased sedimentation in general;

- reduces plant seedling establishment (e.g. Mahaney et al. 2005, Jurik et al. 1994)
- reduces biomass of wetlands plant (e.g. Ewing 1996)
- favours growth of invasive plant species (e.g. Mahaney et al. 2005)
- reduces water clarity – adversely affecting fish, visual feeding native birds (e.g. Boubee et al. 1997)
- increases the inputs of phosphorus, as particulate P bound to sediment (Mitsch & Gosselink 2007)

101. As per above for nutrients, it is critical that PC1 includes sediment as a key attribute for maintaining the ecosystem health of wetlands.

102. My recommendation to include nutrients and sediment as key attributes is supported from research at Waikato wetlands, including Opuatia wetland (Browne et al. 2005), Moanatuatua (Clarkson et al. 1999) and Whangamarino (Blyth 2011). These studies all conclude that addressing water quality was critical to protect the ecological health of these wetlands.

103. Further, the Waikato Regional Council report on the state of the Waikato catchment (*The health of the Waikato River and catchment'*) noted for wetlands that *''Decline in habitat and water quality due to excess run-off of sediment and nutrients'* was a key pressure. It added 'this *can occur through inappropriate use of surrounding land in a catchment (e.g. pine forest drawing water away from ground water systems leaving depleted water supply, or poorly managed farming practices causing sediment and/or fertiliser runoff), or by loss of vegetation in the surrounding catchment (including harvesting of*

plantation forest close to wetlands) causing erosion and subsequent runoff of excess sediment directly into wetlands. Sedimentation threatens not only plant communities but also breeding areas for native fish (e.g. black mudfish)' (Environmental Waikato 2008).

Catchment impacts on Whangamarino Wetland

104. One of the conclusions of the S42A Officer's report (para 489) is that there is insufficient data on Whangamarino Wetland from which to determine attributes and set numeric targets, and consequently there is insufficient data to adopt a Whangamarino Freshwater Management Unit (FMU). I disagree with these conclusions.

105. Over the past 10 years, there has been a concerted effort in monitoring, investigations and modelling that provides a well-developed understanding of the physico-chemical and ecological status of Whangamarino Wetland and its contributing water sources.

106. It is clear from site assessment (Figure 10), photographs (Figure 1), monitoring data and catchment modelling that Whangamarino Wetland is over-allocated in terms of water quality (nutrients, sediment, clarity).

107. WRC has in place surface water quality monitoring for the main Whangamarino tributaries, as part of regional State of the Environment monitoring (e.g. Whangamarino River Island Block Rd) and for consent monitoring (Pungarehu canal). A summary of monitoring data is presented in Table 3.

Table 3. Summary of water quality monitoring data for primary surface water tributaries for Whangamarino Wetland. Source: LAWA accessed 7 February 2019, except Pungarehu Canal (WRC data, PDP 2018)

Monitoring site	**TP Median Conc. (mg/m3)**	**TN Median Conc. (mg/m3)**	**Clarity (m)**	**TSS Annual Load (T/yr)**
Matahuru Stm Waiterimu Road Below Confluence	91	1430	0.33	na

Waerenga Stm SH2 Maramarua	42	1100	0.86	na
Whangamarino River Jefferies Rd Br	85	1150	0.4	na
Mangatangi River SH2 Maramarua	62	530	0.51	na
Whangamarino River Island Block Rd	131	1960	0.21	na
Pungarehu Canal at Waerenga Rd or Farm Bridge	138	3000	~0.2	Mean TSS load 1980-2012 approx. 22,000 T/yr.[4] TSS load in 2017 was 27,000 T/yr

108. Hydrological (GOLDSIM, Lockyer 2015a) and catchment water quality models have also been developed (SOURCE model, Lockyer 2015b) and applied to calculate nutrient and sediment contaminant loads for Whangamarino Wetland (Table 4).

Table 4. Nutrient and sediment loads to Whangamarino Wetland as calculated from SOURCE catchment modelling (Lockyer 2015b).

Sub-catchment	**TP annual load (T/yr)**	**TN annual load (T/yr)**	**TSS annual load (T/yr)**
Whangamarino/ Waerenga	10	142	22600
Maramarua	14	149	15400
Pungarehu Canal/Stream	22.5	391	22850

109. More recent monitoring of sediment concentrations and loads in the Pungarehu Canal has also been undertaken by WRC that provides up to date estimate of sediment load (PDP 2018). This indicates the

[4] WRC are actively monitoring this site to refine the estimate.

annual sediment load from the Pungarehu Canal can be in the order of 27,000 T/yr (based on 2017 data).

110. The nutrient concentrations (Table 3) and nutrient and sediment loads (Table 4) are very high compared to other sites in New Zealand, and the Waikato. Summary statistics in the LAWA website indicate loads of sediment and nutrients are in the worst 25% of all lowland sites of New Zealand (LAWA accessed 7 February 2019). The poor water quality of Lake Waikare for TN and TP (NOF D band) and poor water quality in inflowing Matahuru sub-catchment also contributes directly to water quality issues in Whangamarino Wetland.

111. There is good understanding of the impact of nutrients and sediments on wetland ecosystem health from ecohydrological research (Blyth 2011) and ongoing wetland monitoring by the Department of Conservation. Figure 11 provides a spatial illustration of the variation in wetland soil TP concentration. Areas of elevated TP are associated with the swamp wetland types that occur at low-lying elevations.

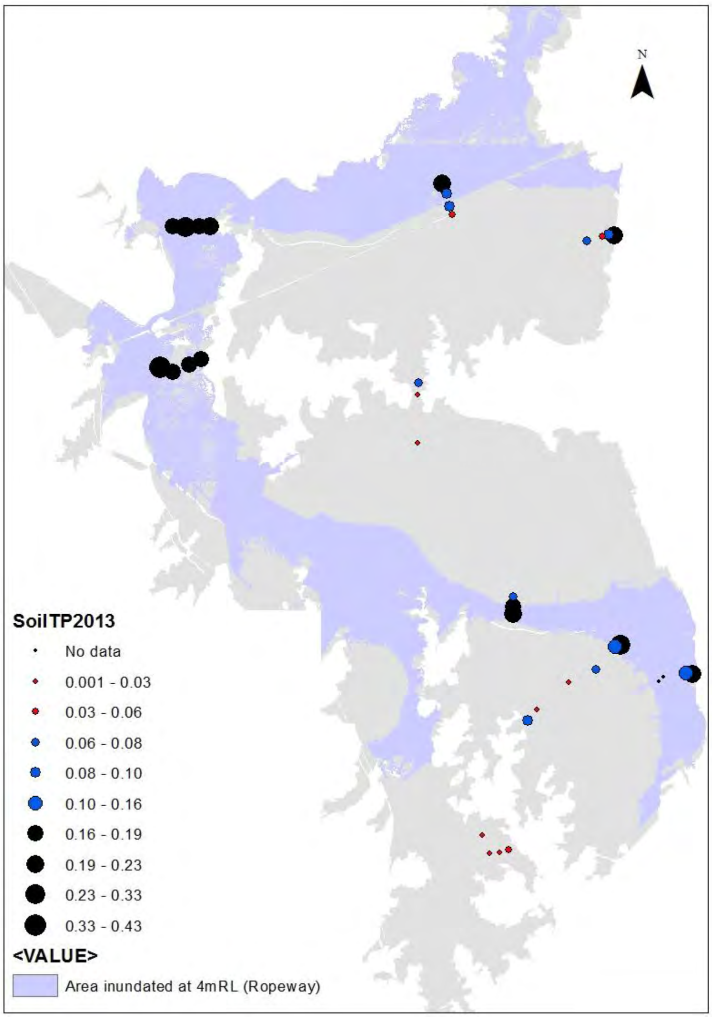


Figure 11: Variation in wetland soil Total Phosphorus (mg/cm^3) in Whangamarino Wetland. Areas shaded darker depict lower-lying habitat (<4m above sea level) that are associated with the swamp wetland type.

112. There is a clear relationship between nutrient status and plant community composition at Whangamarino (Blyth 2011). High levels of TN and TP are directly associated with a reduction in native species richness (Figure 12) and a reduction of indigenous vegetation dominance (e.g. Figure 13).

113. Elevated nutrient levels in Whangamarino Wetland also create environmental conditions that benefit the establishment of Yellow-flag Iris, Alligator Weed and other highly invasive wetland plants, at the expense of other species.

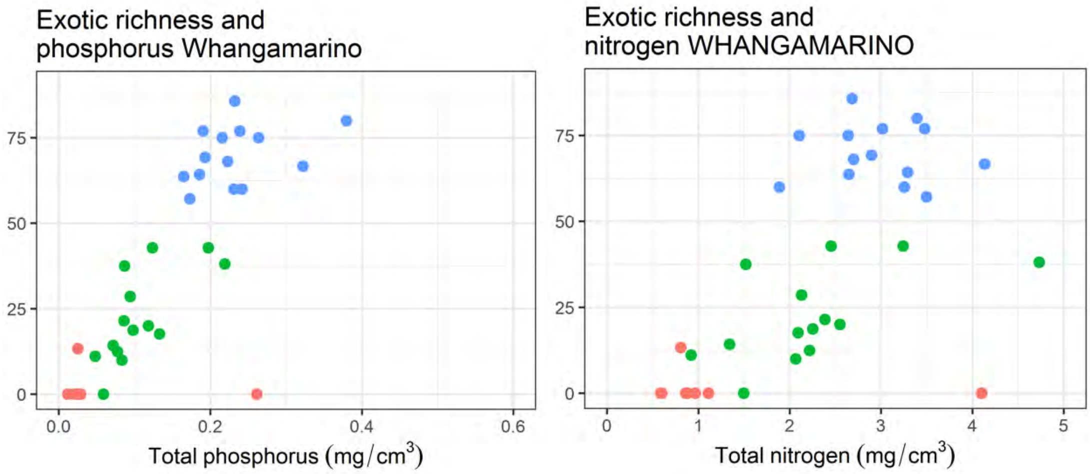


Figure 12: Relationship between soil total phosphorus **(A)** and soil total nitrogen **(B)** and the richness of exotic wetland plants in Whangamarino. Source: DOC.

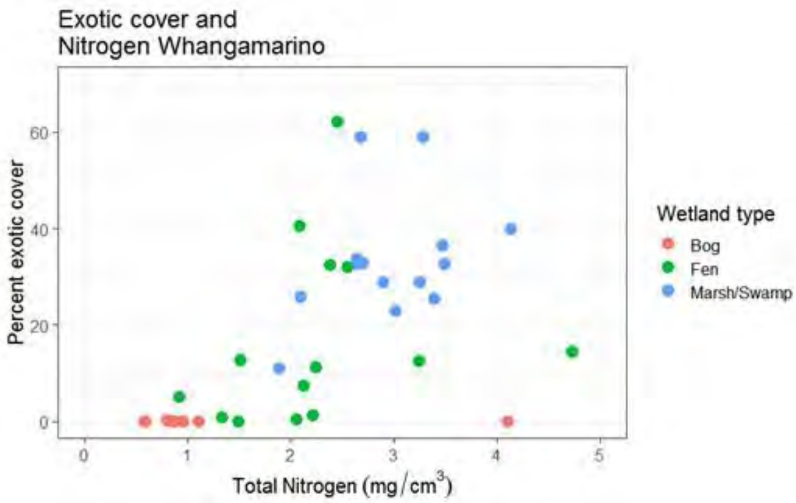


Figure 13: Relationship between soil total nitrogen and the abundance (%cover) of exotic wetland plants in Whangamarino Wetland. Source: DOC.

114. Invasive species such as Alligator Weed have an opportunistic life-history, in that they undergo rapid growth and decomposition in response to changing environmental conditions, characterised by a rapid nutrient cycling strategy (Bassett et al. 2012). Whereas native sedges (e.g. *Carex* species) typically have slower growth and decomposition.

115. Given the high load of nutrients entering Whangamarino Wetland, and the clear linkage between nutrients and ecosystem health, TN

and TP are both considered critical water quality attributes for inclusion in PC1 for Whangamarino.

116. Compound-specific isotope (CSSI) analysis and sediment dating have also been undertaken at Whangamarino providing scientifically robust information on sediment sources and sedimentation rates (Gibbs 2009, Reeve et al 2010, Gibbs 2016).

117. Figure 14 shows the change in sedimentation rates in Whangamarino Wetland over the past ~100 years. Samples sites were near the confluence of the Pungarehu Stream and Whangamarino River. The contemporary sediment accumulation rates in the swamp wetland types (Core 2C, 3C, 5C) is ~15mm/yr. Historically sediment accumulation rates were 2.9mm/yr.

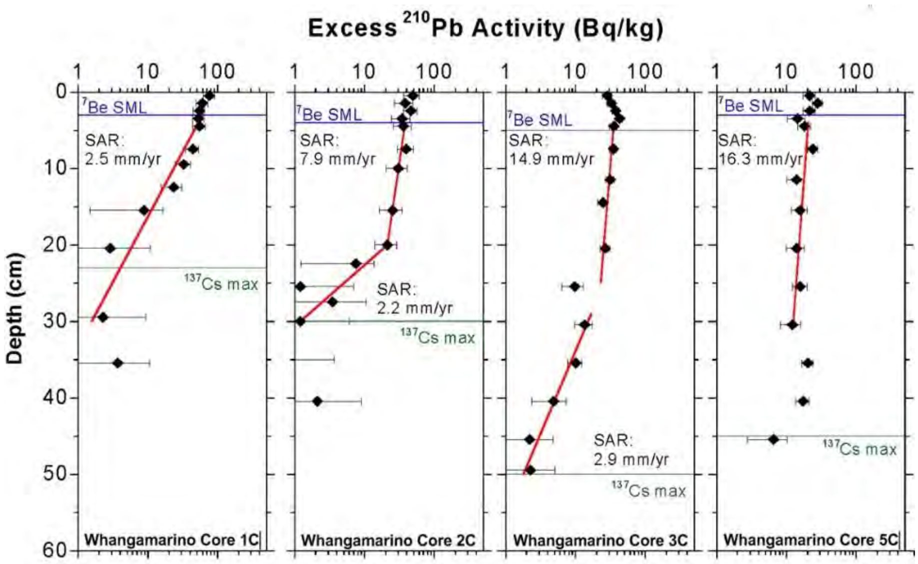


Figure 14: Variation in the sediment accumulation rate (mmy/yr) in Whangamarino Wetland. Cores 2C, 3C and 5C are from swamp wetland type. Core 1C is from fen wetland type that is less susceptible to changes in sediment deposition. Source: Reeve et al. 2010.

118. The high sediment deposition rates will contribute directly to (1) the high concentrations of TP (particulate P is bound to sediment) observed in the wetland soils, (2) reduced germination and growth of susceptible native wetland plants, and (3) poor water clarity (as fine sediment can be resuspended).

119. High concentration of suspended sediment is also a water quality issue at Whangamarino. Suspended solid concentrations and turbidity are highly correlated (Figure 15).

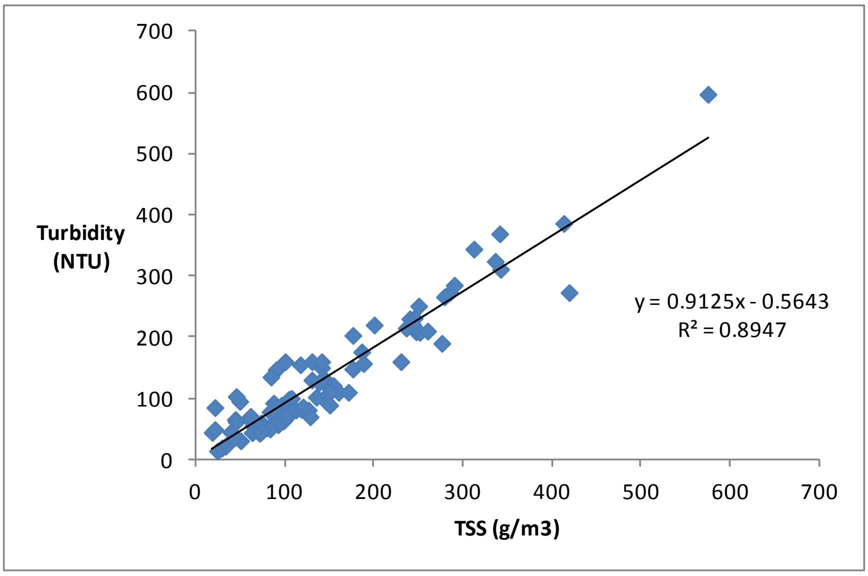


Figure 15. Relationship between Total Suspended Solids (g/m3) and Turbidity (NTU) from the Pungarehu Canal monitoring site. Source: WRC monitoring data 1995-2013.

120. Based on WRC monitoring data, the median suspended sediment concentration for the Pungarehu Canal is approximately 110 g/m3. The median turbidity is approximately 95 NTU. Maximum suspended sediment and turbidity recorded from the Pungarehu Canal is often in excess of 200 g/m3 and 200 NTU, respectively. The median (5 year) turbidity of the Whangamarino River at Island Block Road is 33 NTU (Source: LAWA website, accessed 7 February 2019).

121. The poor water clarity will impact on in-stream aquatic fauna, such as freshwater fish. The fish community of Whangamarino Wetland was surveyed in 2007 and 2008 (Lake et al. 2011). Native freshwater fish species included: Black mudfish, Inanga, Shortfin eel, Longfin eel, Banded Kokopu, Common Bully, Redfin Bully and Common Smelt.

122. Banded Kokopu (Boubee et al. 1997, Rowe & Dean 1998), Inanga (Cavanagh et al. 2014) and Black mudfish (Hicks & Barrier 1996) are vulnerable to high levels of suspended sediment. Research on the

habitat requirements of Black Mudfish in the Waikato region (Hicks & Barrier 1996) concluded that Black Mudfish were adversely affected by high turbidity and favour wetland habitats with low levels of anthropogenic disturbance. Research on Banded Kokopu (Boubee et al. 1997, Rowe & Dean 1998) and Inanga (Cavanagh et al. 2014) indicates these species can be impacted when turbidity levels are >20 NTU.

123. Given the high levels of sediment entering Whangamarino Wetland, and the impact of deposited and suspended sediment on ecosystem health (wetland and instream fauna), I consider that water clarity (NTU or visual clarity (m)) and sediment load (TSS load) are both critical water quality attributes for inclusion in PC1 for Whangamarino.

124. Sediment load is particularly critical, in addition to concentration, given the effect flood events (e.g. Figure 16) have on sediment processes in Whangamarino Wetland.

Figure 16. Flood event in Whangamarino, photograph taken from Falls Road.

125. In summary, there is widespread understanding of water quality impacts on wetland ecosystem health, including for Whangamarino Wetland, these impacts are:

- Nutrient enrichment increases primary productivity leading to loss of indigenous dominance, increased exotic species richness and decline in natural character and ecological health
- Increased sedimentation causes habitat disturbance, including smothering wetland plants and contributes to loss of indigenous dominance and increased exotic species richness
- Poor water clarity reduces the quality of habitat for indigenous species
- Further, hydrological change (increased flooding, drainage) often exacerbates nutrient and sediment impacts.

Objective in PC1 for Whangamarino wetland

126. PC1 includes a specific Objective for Whangamarino Wetland. Objective 6 has two elements (a and b), these are:

a) Nitrogen, phosphorus, sediment and microbial pathogen loads in the catchment of Whangamarino Wetland are reduced in the short term, to make progress towards the long term restoration of Whangamarino Wetland; and

b) The management of contaminant loads entering Whangamarino Wetland is consistent with the achievement of the water quality attribute^targets^ in Table 3.11-1.

127. The S42A Officers report makes two recommendations on Objective 6. These are (1) retain the Objective as per original text, and (2) delete Objective 6 in its entirety. The latter recommendation is the preferred option stated in the report, because it is considered that Objectives 1 and 3 are sufficient for Whangamarino Wetland.

128. I do not agree with the suggestion that Objectives 1 and 3 will adequately protect and restore the significant values of Whangamarino Wetland.

129. In relation to Objective 1, the long-term targets in Table 3.11-1 have been developed for river systems and not for Whangamarino Wetland. The attributes in Table 3.11-1 do not include water quality attributes that are known to be currently impacting on ecosystem health – specifically Total Phosphorus, Total Nitrogen or Total Suspended Sediment Load.

130. Similarly, for Objective 3, the short-term targets relate to achieving outcomes in river systems, not for Whangamarino Wetland.

131. Objectives 1 and 3 are also not adequate, because they do not provide any greater level of protection for Whangamarino, which in my opinion is necessary given the internationally significant values it contains, and the high level of risk that these values are presently subject to.

132. Consequently, my recommendation is that Objective 6 is retained in PC1. Amendments to Objective 6 are also proposed so that the Objective encompasses all attributes required to protect and restore Whangamarino's significant values.

I recommend that Objective 6 is retained in PC1 and amended so that an integrated approach is taken reduce the adverse impact of nitrogen, phosphorus and sediment on Whangamarino Wetland, such that the short, medium and long-term targets outlined in both Table 3.11-1 **and** Table X[5] are achieved. I support the proposed amendments outlined by Ms Kissick for this objective.

[5] Refer to Appendix 6 for proposed new Table. The details of this table are presented in paragraphs 159-169.

Objective for wetlands

133. At present PC1 is primarily focused on setting targets for river sub-catchments and lakes. Insufficient attention has been afforded to wetlands when setting objectives and in the development of attributes and targets.

134. Protecting and restoring the ecosystem heath, natural character and mahinga kai values and uses of wetlands should be a primary focus of PC1. However, the lack of technical consideration of wetlands in the stated objectives is considered a critical gap in PC1.

135. The absence of clear objectives or attributes for wetlands means there is little, if any, technical certainty that wetland ecosystems will be adequately protected or restored from water quality impacts through the policies and rules proposed in PC1. As it stands, the development and implementation of policies and rules, cannot be directly related back to achieving a specific objective for wetlands.

136. Where this will be critical, is when making decisions on land-use development that is likely to adversely affect water quality in a wetland but does not have an anticipated impact at the sub-catchment level on a river system. If PC1 has a specific objective for wetlands that requires nitrogen, phosphorus and sediment to be minimised and avoided, then specific Implementation actions can be put in place to ensure this occurs.

137. It was highlighted in the S42A report, at paragraph 490, that '*with regards to other wetlands, the Section 32 Report anticipates that future plan changes will need to address wetlands and the need for FMUs relating to specific wetlands*.'

138. I agree with this statement in part, in that I agree that work is needed to collate data on the current state of wetlands to enable the development of numeric targets in future. However, the missing element in PC1 is an objective that sets in train a course of action to fill this data gap over the next 5-10 years. But the lack of data in itself does not mean that narrative or descriptive objectives for wetlands

cannot be set now, that provide better direction (than is currently in the WRP or in PC1) for addressing water quality issues on wetlands.

139. I recommend that a new separate objective for all wetlands is defined in PC1. That is:

- *By 2026, policies and methods are implemented that safeguard the ecosystem health of all wetlands by specifically minimising and avoiding the impact of nitrogen, phosphorus and sediment on natural wetlands, and associated hydrological drivers of water quality decline, including a programme for benchmarking and setting numeric targets for wetland attributes*

Whangamarino Freshwater Management Unit

140. Considering the guidance provided by the Ministry for the Environment on Freshwater Management Units (FMU) (MfE 2016), establishment of a Whangamarino Wetland FMU is reasonable and necessary given that:

    - Whangamarino is of international significance
    - There is a high risk of irreversible degradation of significant wetland values (see Figure 1)
    - A different suite of water quality attributes is required to protect the significant values of Whangamarino, over and above those proposed in Table 3.11-1 for river ecosystems
    - Technical understanding and monitoring data is sufficient to define the current state of the Whangamarino FMU, and the FMU can be accurately delineated
    - In the absence of a Whangamarino FMU, the sub-catchment targets in Table 3.11-1 will not achieve the intent and purpose of PC1.

141. I disagree with the conclusion in the S42A officers report (para 489) that '*Due to insufficient monitoring data available to determine the*

current state of Whangamarino Wetland, absence of guidance on wetland attributes in the NPS-FM and limited understanding of wetland systems, it was considered the determination of meaningful numerical limits [targets] *would be impracticable at this time*'.

142. I disagree with the S42A officers report because, in my opinion,

- there is sufficient data on the current state of Whangamarino Wetland,
- there is national and international guidance on water quality attributes that effect wetland health, and
- in other parts of PC1, to ensure the Vision and Strategy is achieved, additional attributes not required by the NPS-FM have been adopted

143. Appendix 3 presents the proposed sub-catchments to be included in the Whangamarino FMU as recommended by Dr Dave Campbell (University of Waikato) during CSG workshops. I endorse this map, as it accurately delineates the sub-catchments that contribute surface flows of nutrients and sediment to Whangamarino Wetland, including those conveyed via the Pungarehu Canal from Lake Waikare. These sub-catchments are listed in Table 5 and redrawn in Figure 17.

144. Overall, the boundary I propose for the Whangamarino FMU (Figure 17-B) is consistent with the sub-catchments that have been delineated in PC1 (Map 3.11-2) and the associated Table 3.11-1.

145. The one exception is the 'Waikato at Mercer' sub-catchment (#9). In PC1 this large sub-catchment has been mapped to include the Maramarua River which is one of the three main tributaries of Whangamarino (Figure 17-A). This issue can be easily rectified by splitting the Waikato at Mercer sub-catchment so that all Whangamarino Wetland sub-catchments are contained within the FMU (Figure 17-B). The eastern section of the Waikato at Mercer sub-catchment is most appropriately combined with the Whangamarino River at Island Block Road sub-catchment.

146. All of the proposed Whangamarino FMU sub-catchments (Table 5) have active water quality monitoring by WRC.

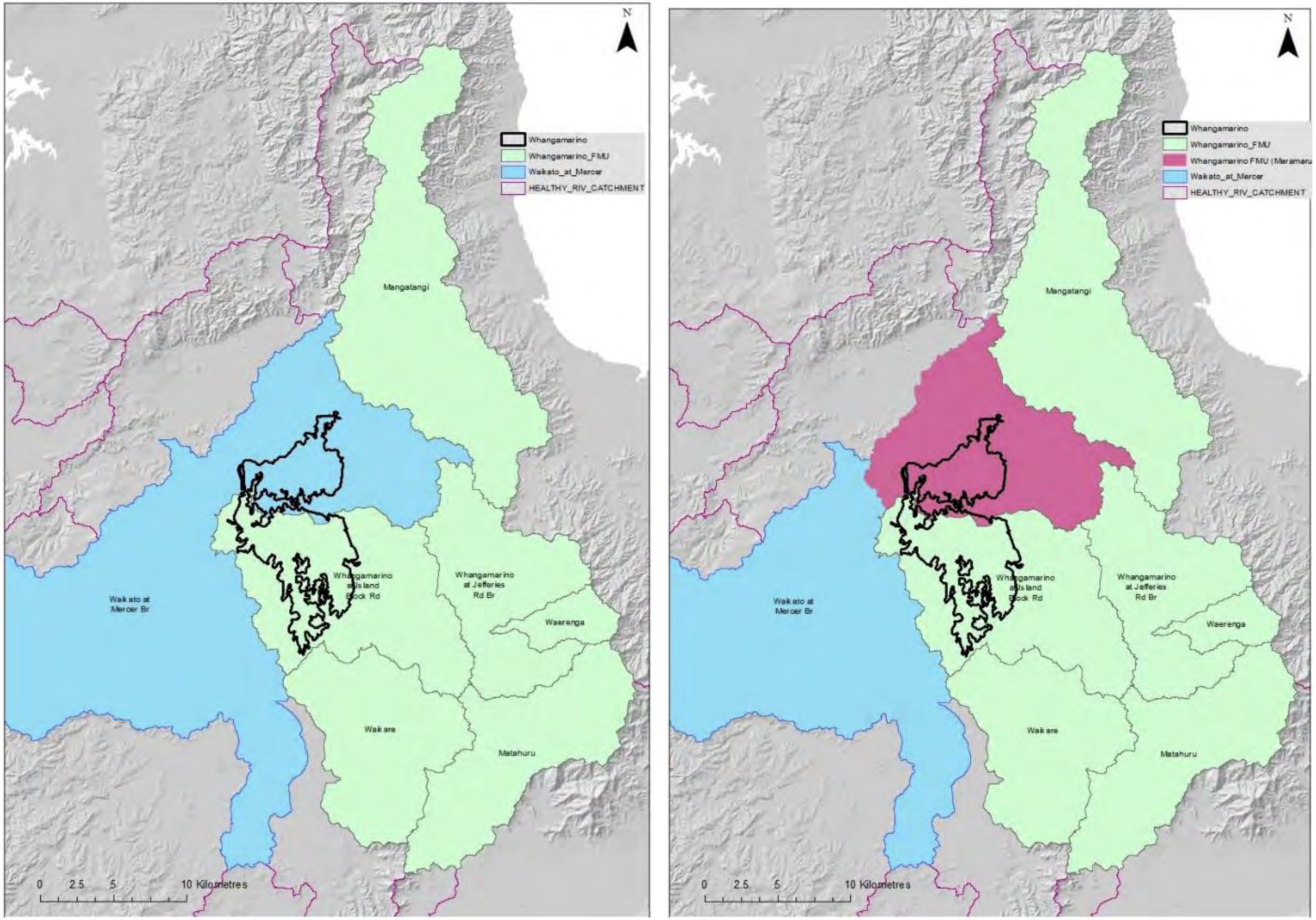


Figure 17. Geographical boundary of the sub-catchments that comprise the proposed Whangamarino Wetland FMU. Note it is proposed to split the Waikato at Mercer sub-catchment **(A)** so that the Maramarua sub-catchment can be included within the FMU **(as shown in B).**

Table 5. Summary of sub-catchments that comprise the proposed Whangamarino Wetland FMU.

Sub-catchments in proposed Whangamarino FMU	Number	Associated sites from Table 3.11-1	Notes
Mangatangi	2	Mangatangi River (Maramarua)	
Whangamarino at Jefferies Rd Br	8	Whangamarino at Jefferies Rd Br	
Whangamarino at Island Block Rd	10	Whangamarino at Island Block Rd	
Waerenga	12	Waerenga Stream	
Waikare	13	*Absent*	Additional Pungarehu Canal site required.
Matahuru	14	Matahuru Stream	
Maramarua (new – join with Whangamarino at Island Block Rd)	New (from 9)	Whangamarino at Island Block Rd	To be separated from Waikato at Mercer (9)

147. However, it is important to highlight that the Waikare sub-catchment does not have a river monitoring site associated with it. Given there is substantial flow of water from Lake Waikare into Whangamarino Wetland via Pungarehu Canal it is considered critical that a riverine (not lake) monitoring site is defined for the outflow of the Waikare sub-catchment. WRC have an established water monitoring programme at the Pungarehu Canal (for resource consent monitoring) so it is strongly recommended that this monitoring site is confirmed as the monitoring site for the Waikare sub-catchment (Table 3.11-1), and for the proposed Whangamarino FMU.

148. In summary, I recommend a separate FMU for Whangamarino Wetland is defined in PC1. To provide for appropriate water quality attributes and targets that will protect and restore ecosystem health, and to address the absence of targets for phosphorus, nitrogen and sediment relating to Whangamarino in Table 3.11-1.

Attributes for wetlands in PC1

149. At present PC1 lists attributes and associated targets for rivers and lakes, in Table 3.11-1. As outlined in previous sections of my evidence the absence of attributes and targets for wetlands is considered a critical gap.

150. The primary water quality attributes for all wetlands in PC1 should include

- Total phosphorus
- Total nitrogen
- Sediment
- Hydrological regime (where altered hydrology contributes to or exacerbates water quality pressures)

151. It is recommended for each attribute that a narrative target is established in PC1, as defined in Appendix 4. These narrative targets reflect that there has been insufficient monitoring of water quality impacts on wetlands in the Waikato[6] to determine numeric targets.

152. For nitrogen, phosphorus and sediment the proposed narrative target (from the D-G's submission) is that the '*[attribute] is within healthy range for the specific wetland type'*.

153. For hydrological regime the proposed narrative target is the '*Hydrological regime, if altered, does not exacerbate water quality impacts*'.

154. Even in narrative form these targets strengthen PC1 and will increase focus on the protection and restoration of wetlands. It is not technically sound to assume the targets set for river sub-catchments will protect wetlands from changes in water quality resulting from land use development. To date catchment modelling and scenario testing

[6] Except for Whangamarino Wetland

under PC1 has not examined the impacts of land use change on wetlands, and wetlands that lie at the bottom of hillslopes being used intensively for agriculture will be vulnerable to eutrophication and altered sediment dynamics.

155. The narrative targets will provide a link between the Objectives of PC1 and the subsequent policies and implementation methods. That is, the suitability of the proposed policies and implementation methods can be assessed relative to avoiding or reducing nitrogen, phosphorus and sediment contamination of wetlands.

156. Guidance on what is defined a 'healthy range' is achievable for wetlands in PC1. There is considerable national wetland data on wetland soil nutrient status and wetland condition (Clarkson et al. 2015). Table 6 provides data (held by Landcare Research) on mean TN, TP and N:P for bogs and swamp wetland types across New Zealand that are in good ecological condition.

Table 6: Nutrient soil concentrations from relatively intact (Condition score >20) New Zealand wetlands. Source: Clarkson et al. 2015

Wetland type	**n**	**Mean TN (mg/cm^3)**	**Mean TP (mg/cm^3)**	**Mean N:P**
Bog	35-39	0.92	0.06	45.3
Swamp	45-47	1.79	0.19	14.0

157. Benchmarking Waikato wetlands against this national data will provide information on wetland nutrient status. For example, monitoring at Whangamarino Wetland indicates the enriched nature of the wetland (Table 7) with elevated levels of TN and TP in wetland soils.

Table 7: Nutrient soil concentrations from Whangamarino Wetland. Source: DOC wetland monitoring

Wetland type	**n**	**Mean TN (mg/cm^3)**	**Max TN (mg/cm^3)**	**Mean TP (mg/cm^3)**	**Max TP (mg/cm^3)**
Bog	8	1.14	1.68	0.03	0.06
Swamp	12	2.98	4.90	0.23	0.43

158. In summary, I recommend that, in addition to a separate FMU for Whangamarino Wetland that specifies water quality attributes, PC1 should define specific water quality attributes for all other wetlands (nitrogen, phosphorus, sediment and hydrological change), and associated narrative targets. As presented in Appendix 4.

Attributes and numeric targets for Whangamarino Wetland in PC1

159. Table 3.11-1 lists 80-year numeric targets for sub-catchments in the Lower Waikato FMU. These attributes are relevant for protecting the ecological heath of Whangamarino Wetland (e.g. 'Clarity' and 'E.coli') and I support their retention in PC1.

160. I note however that the short-term targets for Clarity at Whangamarino Wetland (Whangamarino River at Island Block Road) is proposed at 0.3m in Table 3.11-1. This target does not adequately seek to achieve a water quality improvement in Whangamarino Wetland. The current (5-year median) clarity state at this site is 0.21m (LAWA website accessed 7 February 2019). I propose that to achieve an improvement in water clarity that a short-term target of 0.6m is defined in PC1 for the Whangamarino River at Island Block Road site.

161. Table 3.11-1 also did not include the Pungarehu Canal/Stream as a sub-catchment monitoring site (refer para 149). In my opinion it is important water clarity targets are defined for this site. A short-term target of 0.4-0.6m is proposed for this site.

162. Overall, however, the numeric targets listed in Table 3.11-1 omit water quality attributes that are fundamental to protecting the significant values of Whangamarino Wetland. The additional water quality attributes needed for Whangamarino Wetland are:

- TP Median Conc (mg/m^3)
- TN Median Conc (mg/m^3)
- TSS Annual Load (T/yr) [for Pungarehu Canal/Stream only]

163. To be effective, these targets need to be applied to the contributing sub-catchments to Whangamarino Wetland (Figure 18), ideally as part of the recommended FMU. The proposed water quality attributes relate to surface water quality (i.e. rivers/streams contributing to water quality issues in Whangamarino Wetland) and are therefore consistent with the approach that has been established in PC1 in Table 3-11.1.

164. The 80-year targets for these attributes are presented in Table 8. The 80-year targets set out long-term improvements in TN and TP for all sub-catchments, and TSS load for the Pungarehu Canal/Stream site.

165. The inclusion of TSS load recognises that sediment issues from the Lake Waikare sub-catchment are a function of both sediment concentration and the volume of water that is diverted to the wetland for flood control. It is important to set both a Clarity and TSS load target for this sub-catchment if the significant values of Whangamarino Wetland are to be protected.

Table 8. 80-year water quality targets for Whangamarino Wetland FMU. For further details see Appendix 5 and 6.

The additional primary attributes for the Whangamarino FMU are:	**80 Year Targets**[7]	**Reason**
TP Median Conc (mg/m3)	50 mg/m3[8]	The Whangamarino FMU is adversely affected by high phosphorus levels. The 80-year target of 50 mg/m3 aims to reduce TP overtime.
TN Median Conc (mg/m3)	750 mg/m3[9]	The Whangamarino FMU is adversely affected by high nitrogen levels. The 80-year

[7] In addition to the 80-year targets, short-term targets of 10% reduction over 10 years, and 20% reduction over 20 years are required

[8] If site is in a better water quality state, 80 year target is to maintain

[9] If site is in a better water quality state, 80 year target is to maintain

		target of 750 mg/m3 aims to reduce TN overtime.
TSS Annual Load (T/yr) [at Pungarehu Canal]	>30% reduction (10% reduction by 2030)	Water quality in the Pungarehu Canal is driven by the concentration of sediment, as well as the discharge volume regulated by a control gate. Achieving only the water clarity target for this site will not achieve an ecosystem health outcome.

166. The 80-year numeric targets for TP (50 mg/m^3), TN (750 mg/m^3) and TSS load (30% reduction) have been determined based on: (1) the current state of water quality (Appendix 6), (2) the need for a progressive reduction in water quality contaminants, (3) evidence that water quality is considerably 'over-allocated' for Whangamarino Wetland (para 104-125).

167. The 80-year targets, in my opinion, are reasonable and appropriate. While for some sites (e.g. Whangamarino River at Island Block Road) achieving the TP and TN target will be difficult, the long-time frame allows for the innovation gap to resolve implementation issues that has been characterised in the development of other aspects of PC1 (S42 officer's report, para 14).

168. In the absence of setting numeric targets for Whangamarino Wetland, there will be no required improvement in TN or TP concentrations. There will also be no long-term improvement in TSS load (the recently updated resource consent only requires a short-term improvement). Put simply, PC1 will not address the key water quality issues that are having an adverse effect on the significant values of Whangamarino Wetland.

169. In summary, I recommend that PC1 is amended to include:

- A new water quality table that defines numeric targets for TN, TP and TSS load for Whangamarino Wetland sub-catchments (Appendix 6).

- Inclusion of Pungarehu Canal/Stream as a sub-catchment site in Table 3.11-1.
- Short-term water clarity targets of 0.6m for the Whangamarino River (Island Block Rd) site and the proposed Pungarehu Canal/Stream site

Dr Hugh A. Roberston

15 February 2019

Literature cited

Ausseil, A.G; Gerbeaux, P; Chadderton, W.L; Stephens, T; Brown, D.J; Leathwick, J. (2008). Wetland ecosystems of national importance for biodiversity. Criteria, methods and candidate list of nationally important inland wetlands. Discussion Document. Landcare Research Contract Report LC0708/158.

Bassett I., Paynter Q., Hankin R., Beggs J.R. (2012). Characterising alligator weed (Alternanthera philoxeroides; Amaranthaceae) invasion at a northern New Zealand lake. New Zealand Journal of Ecology, 36(2), 216.

Blyth, J.M. 2011: Ecohydrological characterisation of Whangamarino Wetland. MSc thesis, University of Waikato, New Zealand.

Blyth J.M., Campbell D.I., Schipper L.A. (2013). Utilizing soil indicators to explain historical vegetation changes of a peatland subjected to flood inundation. Ecohydrology, 6(1), 104-116.

Boubée, J.A., Dean, T.L., West, D.W. and Barrier, R.F (1997). Avoidance of suspended sediment by the juvenile migratory stage of six New Zealand native fish species. New Zealand journal of marine and freshwater research, 31(1), pp.61-69.

Browne K, Campbell D, Brown E (2005). Ecohydrological characterisation of Opuatia wetland and recommendations for future management. Environment Waikato Technical Report 2005/17

Cavanagh, J.E., Kristy L Hogsden, K.L., Jon S Harding, J.S. (2014) Effects of suspended sediment on freshwater fish, Envirolink Advice Grant: 1445-WCRC129. Landcare Research, Christchurch

Clarkson, B.R., Thompson, K., Schipper, L.A. and McLeod, M. (1999). Moanatuatua Bog—proposed restoration of a New Zealand restiad peat bog ecosystem. In An international perspective on wetland rehabilitation (pp. 127-137). Springer, Dordrecht.

Clarkson, B.R., Schipper, L.A. and Lehmann, A., (2004). Vegetation and peat characteristics in the development of lowland restiad peat bogs, North Island, New Zealand. Wetlands, 24(1), pp.133-151.

Clarkson, B.R., Sorrell, B.K., Reeves, P.N., Champion, P.D., Partridge, T.R., & Clarkson, B.D. (2004). Handbook for monitoring wetland condition. Coordinated monitoring of New Zealand wetlands. Ministry for the Environment, Wellington.

Clarkson, B.; Overton, J.; Ausseil, A-G.; Robertson, H. (2015). Towards quantitative limits to maintain the ecological integrity of freshwater wetlands: Interim report. Contract report LC1933. Landcare Research, Hamilton

Cromarty P., Scott DA. (1996) A directory of wetlands in New Zealand. Department of Conservation, Wellington

Environment Waikato (2008) health of the Waikato River and catchment. Information for the Guardians Establishment Committee. March 2008

Denyer, K.; Robertson, H. (2016). National guidelines for the assessment of potential Ramsar wetlands in New Zealand. Department of Conservation, Wellington. 58 p.

DOC (2014) Waikato Conservation Management Strategy (CMS) 2014–2024. Department of Conservation, Hamilton.

Dunn, N.R.; Allibone, R.M.; Closs, G.P.; Crow, S.K.; David, B.O.; Goodman, J.M.; Griffiths, M.; Jack, D.C.; Ling, N.; Waters, J.M.; Rolfe, J.R. (2018): Conservation status of New Zealand freshwater fishes, 2017. New Zealand Threat Classification Series 24. Department of Conservation, Wellington. 11 p.

Environment Waikato (2008) health of the Waikato River and catchment. Information for the Guardians Establishment Committee. March 2008

Ewing, K. (1996). Tolerance of four wetland plant species to flooding and sediment deposition. Environmental and Experimental Botany, 36(2), pp.131-146.

Gibbs, M. (2009) Whangamarino Wetland pilot study: sediment sources. NIWA Report No. HAM2009-033 to the Department of Conservation. Project code DOC08205: 33.

Gibbs, M. (2016). Sediment source analysis using the CSSI technique – Whangamarino Wetland. Prepared for Department of Conservation. June 2016. NIWA Client Report: HAM2016-078.

Hicks B.J., Barrier R.F.G. (1996). Habitat requirements of black mudfish (Neochanna diversus) in the Waikato region, North Island, New Zealand. New Zealand journal of marine and freshwater research, 30(1), 135-150.

Johnson P, Gerbeaux P (2004). Wetland types in New Zealand. Wellington, Department of Conservation.

Jurik, T.W., Wang, S.C. and Van Der Valk, A.G. (1994). Effects of sediment load on seedling emergence from wetland seed banks. Wetlands, 14(3), pp.159-165.

Lake M.; Brijs J.; Hicks B.J. (2011). Fish survey of the Whangamarino Wetland 2007/2008. Department of Conservation and University of Waikato, Hamilton.

Leathwick J. (2016) Integrated biodiversity ranking and prioritisation for the Waikato region. Waikato Regional Council Technical Report 2016/12.

Lee, W.; McGlone, M.; Wright, E (2005). Biodiversity inventory monitoring: a review of national and international systems and a proposed framework for future biodiversity monitoring by the Department of Conservation. Department of Conservation, Wellington. 213 p.

Lockyer, C (2015a) Whangamarino Wetland Hydrology Study-Stage 3: Hydrological Modelling. Prepared for Department of Conservation. Jacobs NZ Ltd, Wellington

Lockyer, C (2015b) Whangamarino water quality modelling and mapping using SOURCE catchments. Prepared for Department of Conservation. Jacobs NZ Ltd, Wellington

Mahaney, W.M., Wardrop, D.H. and Brooks, R.P. (2005). Impacts of sedimentation and nitrogen enrichment on wetland plant community development. Plant Ecology, 175: 227-243.

Mitsch, W.J., Gosselink, J.G. (2007). Wetlands 4th ed. John Wiley & Sons Inc., New York, USA.

MfE (2016) A guide to identifying freshwater management units under the National Policy Statement for Freshwater Management 2014, Ministry for the Environment, Wellington.

MfE (2017a) National Policy Statement for Freshwater Management 2014. Ministry for the Environment, Wellington.

MfE (2017b) A guide to the National Policy Statement for Freshwater Management 2014 (as amended 2017). Ministry for the Environment, Wellington.

PDP (2018) Whangamarino wetland sediment monitoring report. Prepared for Waikato Regional Council.

Reeve, G., Gibbs, M., Swales, A. (2010) Recent Sedimentation in the Whangamarino Wetland. NIWA client report HAM2010-080 to Department of Conservation. Project code DOC10202. 40 pp.

Reeves, P. (2015) Statement of Evidence in Chief of Paula Nicole Reeves. Review of conditions of Resource Consent 101727. Council hearing, Te Kauwhata, May 2015.

Robertson, H.A.; Clarkson, B.R.; Campbell, D.I.; Tanner, C.C. 2016. Wetland biodiversity, ecosystem processes and management. In: Advances in New Zealand Freshwater Science. NZ Freshwater Sciences Society & NZ Hydrological Society.

Rowe, D.K. and Dean, T.L. (1998). Effects of turbidity on the feeding ability of the juvenile migrant stage of six New Zealand freshwater fish species. New Zealand Journal of Marine and Freshwater Research, 32: 21-29.

Schallenberg, M., Kelly, D., Clapcott, J., Death, R., MacNeil, C., Young, R., Sorrell, B. and Scarsbrook, M. (2011). Approaches to assessing ecological integrity of New Zealand freshwaters. Science for Conservation, 307, p.84.

Shearer, JC. (1997). Natural and anthropogenic influences on peat development in Waikato/Hauraki Plains restiad bogs. Journal of the Royal Society of New Zealand, 27(3), 295-313.

Taura Y, van Schravendijk-Goodman C, Clarkson B (Eds) (2017). Te reo o te repo = The voice of the wetland: connections, understandings and learnings for the restoration of our wetlands. Manaaki Whenua – Landcare Research and Waikato Raupatu River Trust, Hamilton

Van der Zwan W, Kessels G. (2017). Significant natural areas of the Waikato District: terrestrial and wetland ecosystems. Waikato Regional Council Technical Report 2017/36.

Verhoeven, J. T., Arheimer, B., Yin, C., & Hefting, M. M. (2006). Regional and global concerns over wetlands and water quality. Trends in ecology & evolution, 21(2), 96-103.

Appendix 1. Extract from the 1992 Ramsar Information Sheet for Whangamarino Wetland.

Note: the numbering convention for the Ramsar Convention has since been updated

Reasons for Inclusion: (state which Ramsar criteria - as adopted by Rec.C.4.15 of the Montreux Conference - arc applicable)

1(b) The Whangamarino Wetland is an outstanding example of a wetland characteristic of its region - it is the second largest bog and swamp complex in the North Island of New Zealand.

2(a) The Whangamarino Wetland supports appreciable numbers of threatened plants:

- *Corybas carsei* (status: endangered).
- *Lycopodium serpentinum* (status: vulnerable)
- *Utricularia laterifolia* (status: indeterminate)
- *Cyclosorus interruptus* (status: vulnerable)
- *Myriophyllum robustum* (status: vulnerable) the largest known North Island populations are found here
- *Utricularia australis* (status: indeterminate)
- *Utricularia novae-zealandiae* (status: indeterminate)
- *Prasophyllum aff. patens* (status: vulnerable)

Fauna in the rare, threatened or endangered categories include black mudfish (endemic, status: indeterminate).

2(b) The Whangamarino Wetland is more diverse botanically than any other large lowland peatland in the North Island, and its oligotrophic portions have a combination of very specialised plants which no longer occur elsewhere in the Waikato region or beyond. This diversity gives it an ability to support a wide range of regionally rare communities.

2(d) The following species are endemic to New Zealand and in each case the Whangamarino Wetland is one of the remaining strongholds for the species:

- *Corybas carsei*
- *Myriophyllum robustum*
- black mudfish *(Neochanna diversus)*

3(b) When linked with the Waikato lakes and the Waikato River, Whangamarino Wetland provides the most important freshwater wildlife habitat in New Zealand.

3(c) The Whangamarino Wetland regularly supports approximately:

- 20% of the New Zealand population of Australasian bittern
- 7% of the New Zealand population of black swan
- 5% of the New Zealand population of grey teal

The Whangamarino Wetland regularly supports approximately:

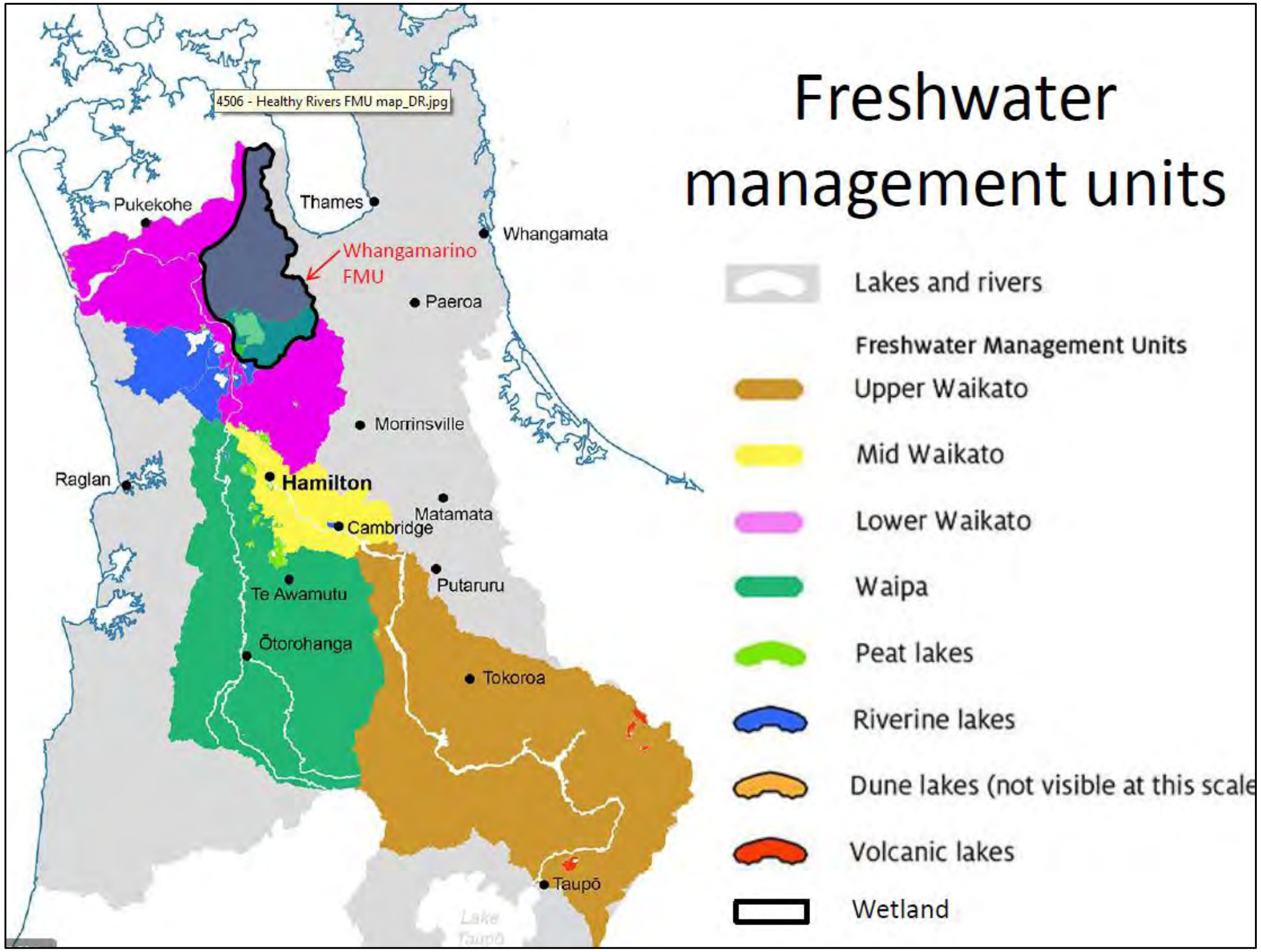
- 20% of the breeding pairs of Australasian bittern in New Zealand
- at least 1.7% of the breeding pairs of grey teal in New Zealand

N.B. These are 1988 figures. Number are likely to be somewhat reduced, as a lowering of water levels in the subsequent period, has resulted in reduced habitat for wildlife. Reinstatement of water levels is planned for 1993 (refer to section 17).

Appendix 2. Significance of Whangamarino Wetland in relation to the ecological value criteria from the Operative Waikato Regional Policy Statement.

Ecological Value Criteria	**Applies**	**Explanation**
3: It is vegetation or habitat that is currently habitat for indigenous species or associations of indigenous species that are threatened with extinction; or endemic to the Waikato Region	Yes	Whangamarino provides habitat for the Nationally Critical Swamp Helmet Orchid (*Corybas carsei*) and the Nationally Endangered Australasian Bittern
4: It is indigenous vegetation or habitat type that is under-represented (10% or less of its known or likely original extent remaining) in an Ecological District, or Ecological Region, or nationally.	Yes	There are less than 9% (by area) of wetlands remaining in the Waikato biogeographical region. It also supports wetland types that are under-represented in the Waikato biogeographical region, that is: swamp (6.9% remaining), fen (4.6% remaining) and fen (0.2% remaining)
5. It is indigenous vegetation or habitat that is, and prior to human settlement was, nationally uncommon such as geothermal, Chenier plain, or kaarst ecosystems.	No	Domed Bogs containing Sporadanthus are classified as naturally rare ecosystems in New Zealand (Williams et al. 2007). Natural succession of Whangamarino Wetland would need to continue for some time to allow for Sporadanthus to become dominant, i.e. as the peat soils build up into a raised dome.
6: It is wetland habitat for indigenous plant communities and/or indigenous fauna communities	Yes	Whangamarino supports extensive areas dominated by indigenous plants, such as the wirerush (*Empodisma robustum*) dominated bog habitat, and indigenous bird community (swamp wetland birds)
7: It is an area of indigenous vegetation or naturally occurring habitat that is large relative to other examples in the Waikato Region of similar habitat types, and which contains all or almost all indigenous species typical of that habitat type.	Yes	Whangamarino is the second largest wetland complex in the North Island (7290 ha)
8: It is aquatic habitat that is a portion of a stream, river, lake, wetland, intertidal mudflat or estuary, and their margins, that is critical to the self sustainability of an indigenous species within a catchment of the Waikato Region and which contains healthy, representative populations of that species.	Yes	Whangamarino supports a range of aquatic habitats that is important for indigenous species. This includes habitats for ‘Declining’ freshwater fish species such as Black Mudfish and Inanga. [incl mineralised wetland area]
9: It is an area of indigenous vegetation or habitat that is a healthy and representative example of its type because: its structure, composition, and ecological processes are largely intact; and if protected from the adverse effects of plant and animal pests and of adjacent landuse (e.g. stock, discharges, erosion), can maintain its ecological sustainability over time.	Yes	Whangamarino fulfils Criterion 1 of the Ramsar Convention as a representative example of its type (refer paragraph 4.8).
10: It is an area of indigenous vegetation or habitat that forms part of an ecological sequence, that is either not common in the Waikato Region or an ecological district, or is an exceptional, representative example of its type.	Yes	Whangamarino supports a distinctive wetland ecological sequence where low-lying swamp/marsh transitions to fen, and then to bog at higher elevations (e.g. Figure 5).This type of ecological is uncommon in the Waikato region.

Appendix 3 (D in submission): Whangamarino Wetland FMU extent



Appendix 4 (G in submission): Primary wetland attributes for ecosystem health (water quality)

Wetland type	Wetland type description	Attribute relating to water quality (narrative target)			
		TP	**TN**	**Sedimentation**	**Hydrological regime**
Bog	Bog wetlands are nutrient poor, poorly drained and aerated and usually acid. The water table is often close to or just above the ground surface, with rainwater the only source of water. These wetlands are dominated by indigenous vegetation that is representative of bogs in the Waikato, including peat forming plant species.	Nutrient status (TP) is within healthy range for the specific wetland type	Nutrient status (TN) is within healthy range for the specific wetland type	Inputs of external sediment are within healthy range for the specific wetland type	Hydrological regime, if altered, does not exacerbate water quality impacts
Fen	Fen wetlands are of low to moderate acidity and fertility and the water table is usually close to or just below the surface. These wetlands are dominated by indigenous vegetation that is representative of fens in the Waikato, including species adapted to low nutrient environments, such as sedges.				
Swamp	Swamp wetlands are generally of high fertility, receiving nutrients and sediment from surface run-off and ground water. These wetlands are dominated by indigenous vegetation that is representative of swamps in the Waikato, including vegetation cover that is often intermingled.				
Marsh	Marsh wetlands are mineral wetlands with good to moderate drainage that are mainly groundwater or surface water fed and characterised by fluctuation in the water table. Marsh wetlands can be differentiated from swamp wetlands by having better drainage, generally a lower water table and usually more mineral substrate and higher pH.				

Appendix 5 (based on Appendix E in submission): Whangamarino Wetland FMU Attributes

In addition to the primary attributes for all wetlands, the following attributes are sought for the Whangamarino FMU specifically:

- Total Phosphorus – Median TP Concentration – applied to all monitoring sites in FMU
- Total Nitrogen – Median TN Concentration – applied to all monitoring sites in FMU
- Sediment – Mean Annual TSS Load – applied to the Pungarehu Canal/Stream monitoring site

The existing attributes in Table 3-11.1 will also apply.

The 80 year targets for the additional primary attributes for the Whangamarino FMU are:

The additional primary attributes for the Whangamarino FMU are:	**80 Year Targets[10]**	**Rationale**
TP Median Conc (mg/m3)	50 mg/m3[11]	The Whangamarino FMU is adversely affected by high phosphorus levels. The 80-year target of 50 mg/m3 aims to reduce TP overtime.
TN Median Conc (mg/m3)	750 mg/m3[12]	The Whangamarino FMU is adversely affected by high nitrogen levels. The 80-year target of 750 mg/m3 aims to reduce TN overtime.
TSS Annual Load (T/yr)	>30% reduction (10% reduction by 2030)	Water quality in the Pungarehu Canal is driven by the concentration of sediment, as well as the discharge volume regulated by a control gate. Achieving only the water clarity target for this site will not achieve the ecosystem health outcome.

[10] In addition to the 80 year targets, short-term targets of 10% reduction over 10 years, and 20% reduction over 20 years are required
[11] If site is in a better water quality state, 80 year target is to maintain
[12] If site is in a better water quality state, 80 year target is to maintain

Appendix 6 (amended from Appendix F in submission): Whangamarino Wetland FMU numeric targets

Site	Current (data from LAWA, accessed 7 Feb 2019)			80 year[13] targets			Existing Table 3.11-1
	P Median Conc. (mg/m3)	**TNMedian Conc. (mg/m3)**	**TSS Annual Load (T/yr)**	**TP Median[14] Conc. (mg/m3)**	**TN Median[15] Conc. (mg/m3)**	**TSS Annual Load (T/yr)**	**Water clarity (m) – short-term**
Matahuru Stm Waiterimu Road Below Confluence	91	1430	na	50	750	na	No amendment
Waerenga Stm SH2 Maramarua (at Taniwha Rd)	42	1100	na	Maintain	750	na	No amendment
Whangamarino River Jefferies Rd Br	85	1150	na	50	750	na	No amendment
Mangatangi River SH2 Maramarua	62	530	na	50	Maintain	na	No amendment
Whangamarino River Island Block Rd	131	1960	na	50	750	na	Amend 0.6m
Pungarehu Canal at Waerenga Rd or Farm Bridge **This is a key additional site – not listed in Table 3-11.1**	138*	3000*	Mean TSS load for the period 1980-2012 was approx. 22,000 T/yr. Annual sediment load in 2017 was 27,000 T/yr.	50	750	>30% reduction (10% reduction by 2030)	Amend 0.6m

[13] In addition to the 80 year targets, short-term targets of 10% reduction over 10 years, and 20% reduction over 20 years are required
[14] If site is in a better water quality state, 80-year target is to maintain
[15] If site is in a better water quality state, 80-year target is to maintain