HAWKE'S BAY
REGIONAL COUNCIL

Tukituki Catchment

State of the Environment monitoring of Hawke's Bay wetlands

January 2017
HBRC Report No. RM 17-06 HBRC Publication No. 4928

Telarc. Registered
Quality ISO 9001

Resource Management Group

ISSN 2324-4127 (PRINT)
ISSN 2324-4135 (ONLINE)

State of the Environment monitoring of Hawke's Bay wetlands: Tukituki Catchment

Beverley R Clarkson, Scott Bartlam

Landcare Research

Prepared for:

Hawke's Bay Regional Council

159 Dalton Street
Napier 4110

January 2017

Landcare Research, Gate 10 Silverdale Road, University of Waikato Campus, Private Bag 3127, Hamilton 3240, New Zealand, Ph +64 7 859 3700, Fax +64 7 859 3701, www.landcareresearch.co.nz

Reviewed by:	*Approved for release by:*
Neil Fitzgerald Research Technician Landcare Research	Gary Houliston Interim Portfolio Leader – Enhancing Biodiversity Landcare Research

Landcare Research Contract Report:	LC2713

Contents

Summary

Project and client

- Hawke's Bay Regional Council contracted Landcare Research to develop a system for state of the environment monitoring of wetlands in Hawke's Bay, commencing with a pilot project in the Tukituki Catchment.

Objectives

- To develop a framework for assessing priority sites for monitoring the range of wetlands present in the Tukituki Catchment.
- To develop and implement a system for monitoring wetlands in the Tukituki Catchment that could be applied to the wider Hawke's Bay region.
- To provide guidelines and training for establishing vegetation plots, replication, plot size and overall wetland condition assessment.
- To provide guidance on interpreting field data.

Methods

- Wetland priorities in the Tukituki Catchment were assessed according to criteria such as rarity, wetland type, geographical distribution and ecological condition to yield a representative set of wetlands for monitoring.
- Current wetland monitoring systems were refined and implemented, together with Regional Council staff, as a field training exercise in the representative set of Tukituki Catchment wetlands.
- The refined approach and results of the pilot survey were summarised.

Results

- A framework for assessing wetland priorities was developed and used to provide a set of representative wetlands in the Tukituki Catchment. Wetland types present were marsh, swamp and fen.
- Monitoring baselines were established in ten priority wetlands, which were selected as being representative of wetlands in the Tukituki Catchment.
- Wetland monitoring system guidelines and training were provided for establishing vegetation plots, plot replication, location and size, sampling techniques, and overall condition assessment.
- The Wetland Condition Index of the Tukituki Catchment wetlands ranged from 8.41 to 20.25 out of a possible 25. This is relatively low by national standards, but typical of wetlands in productive landscapes.

- Soil nutrient levels were relatively high but mostly within the 80% ranges for marsh, swamp and fen wetlands sampled throughout New Zealand. Foliage nutrient concentrations in most wetlands were also relatively high.

Conclusions and recommendations

- Analysis of data from the pilot survey indicates that the system is suitable for Hawke's Bay Regional Council reporting requirements for the Tukituki Catchment wetlands, and should also be appropriate for state of the environment monitoring of wetlands in the wider Hawke's Bay region.

1 Introduction

The extent and condition of wetlands in New Zealand have declined significantly since the arrival of humans. More than 90% of wetland area has been destroyed and many wetland sites continue to degrade because of drainage, nutrient enrichment and impacts from invasive species (Ministry for the Environment & Statistics New Zealand 2015). Monitoring is important for detecting negative changes in biodiversity and ecosystem condition so that early and effective remedial action can be taken.

Regional councils have responsibilities to maintain indigenous biodiversity under the Resource Management Act 1991, to protect the significant values of wetlands under the National Policy Statement for Freshwater Management (NPS-FM 2014), and to monitor the state of the environment, which includes monitoring the state of wetlands. This project aims to assist Hawke's Bay Regional Council (HBRC) with meeting these requirements for wetlands.

2 Background

HBRC has developed provisions to protect the values of wetlands, such as the operative Regional Resource Management Plan and the Land and Water Management Strategy. More recently, the Tukituki River Catchment Plan Change 6 (PC6) is intended to establish improved and additional provisions for protecting wetland values. PC6 has given urgency to developing a monitoring framework for selecting representative wetland sites and a sampling methodology that are robust enough to measure the effects of PC6 on wetlands. It is intended that the pilot project in the Tukituki Catchment will lead to a full-scale state of the environment (SOE) monitoring programme to assess the state and trend of wetlands across the Hawke's Bay region.

HBRC contracted Landcare Research to establish a monitoring system to measure the state and trend of wetland condition in the Tukituki Catchment as a pilot for rolling out the monitoring system for SOE reporting across the region. The project comprises:

1. a Hawke's Bay wetland inventory review – a review of Tukituki Catchment wetland inventory data, in particular the classification system
2. development of a framework for identifying priority wetlands for PC6 and SOE monitoring, including:
    - criteria based on wetland characteristics and other hydrological factors
    - the ability to detect change in wetland condition measures
    - necessary sampling size
3. development of site assessment methods – the assessment method will follow monitoring approaches developed for other regional councils, specifically Southland (Clarkson et al. 2011) and Bay of Plenty (Fitzgerald et al. 2013, Clarkson et al. 2014), but further guidance is required with regard to:
    - additional measures for PC6: the impact of water takes, livestock access/fencing

- the number and size of plots at each wetland
- general guidance on where to locate water-level-monitoring apparatus

4. site selection using inventory information – select sites using criteria established in point 2 above
5. site set-up – at selected wetlands provide advice to HBRC staff for site set-up, particularly with regard to plot locations, vantage point (for vegetation mapping) and water-level-monitoring apparatus locations
6. staff training and assistance for a baseline survey
7. guidance on how data should be analysed, interpreted and presented.

This report focuses on items 2, 3, 4 (in the form of GIS feature class) and 7 above.

3 Objectives

- To review the Tukituki Catchment wetland inventory data with respect to area, wetland class, vegetation type (vegetation structure and dominant species), ecological values and historical extent.
- To develop a framework for assessing wetland priorities for monitoring that represents the full range of freshwater wetlands in the Tukituki Catchment.
- To provide a working set of priority wetlands in the Tukituki catchment for monitoring.
- To develop a sampling approach and monitoring system applicable to wetlands in the Tukituki Catchment that could be applied to the wider Hawke's Bay region.
- To implement the monitoring system in a finalised set of Tukituki priority wetlands.
- To provide detailed guidelines and training for establishing vegetation plots, replication, plot size, and overall wetland condition assessment.

4 Framework for selecting the priority wetlands for monitoring

4.1 Criteria for selection

The wetland inventory data for the Tukituki Catchment were checked, refined and supplemented using current and historical wetland data (Ausseil et al. 2008), vegetation maps, photos of individual wetlands taken from a helicopter, Google Earth images, and existing information, including sites of special wildlife interest, recommended areas for protection, and ecological survey reports. This exercise was undertaken by Keiko Hashiba (HBRC) and Bev Clarkson (Landcare Research) at a workshop on 21/22 April 2016 at Landcare Research, Hamilton.

Each extant wetland was assessed and ranked using the following criteria.

- *Rarity:* This is based on the magnitude of the loss of a particular wetland class compared with historical extent, relative to other wetland classes, and undertaken at both the territorial local authority scale (HBRC) and ecological district scale. Other frameworks, such as biogeographic region (Ausseil et al. 2008) or NZ Land Environments (Cieraad et al. 2015), could also be used.
- *Current extent:* In the Tukituki Catchment, the focus was on wetlands larger than 2 ha, but smaller sites known to be ecologically significant were also included.
- *Geographical distribution:* Ecological districts with the largest extent of wetlands remaining and/or with the greatest wetland losses are high priorities for monitoring.
- *Ecological significance:* Wetlands of high ecological significance (e.g. nationally and regionally significant) are higher priority for monitoring than wetlands of lower ecological significance (e.g. locally significant).
- *Vegetation type:* Aim to incorporate a full range of vegetation types present in the catchment.

The ranking exercise yielded a working set of priority wetlands, ranked in approximate order of importance for monitoring. At this stage 15 wetlands were listed and ranked. This draft set was subsequently refined to a final set of 10 wetlands. Wetlands were rejected, added or substituted using the following principles.

- *Addition:* A wetland considered to be of high priority was added as more information became available on conservation values and/or it contained a poorly represented wetland class or vegetation type.
- *Rejection:*
    - A wetland was rejected if it was considered unsuitable during field inspection (e.g. a recently dammed valley) or a very poor quality example of wetland/vegetation types better represented elsewhere (e.g. overwhelming domination by exotics).
    - Areas of open or deep water dominated by aquatic processes (usually water deeper than 1–2 m) and devoid of substrate-rooted emergent vegetation were rejected.
    - Wetlands were rejected where landowner permission was not granted. Where possible, a wetland site with similar attributes (e.g. geographic location, altitude, wetland class, vegetation type, significance) should be substituted.

4.2 Results of criteria application: wetland statistics

Compared to their historical extent, only 1.9% of wetlands remain in the Hawke's Bay Territorial Local Authority region (Ausseil et al. 2008) – the greatest loss of any territorial local authority in New Zealand. The most abundant historical wetland class was swamp, followed by marsh, then fen, and other minor classes.

Data on wetland class, area, ecological district, and vegetation for wetlands in the Tukituki Catchment are summarised in Appendix 1. Current wetlands (excluding lakes, artificial

bunds and other non-wetlands) totalled 311.65 ha, with 206.62 ha of swamp, 17.63 ha of marsh, and 87.40 ha of shallow water. Shallow water was not classified in the historical data of Ausseil et al. 2008, and was probably included within other wetland classes.

The Tukituki Catchment encompasses parts of four ecological districts:

- Heretaunga (56% of the Tukituki Catchment area)
- Eastern Hawke's Bay (30%)
- Ruahine (13%)
- Puketoi (2%).

The wetlands are located in the three largest ecological districts within the region: Heretaunga (275.9 ha of wetlands), Eastern Hawke's Bay (29.08 ha) and Ruahine (6.67 ha).

The main vegetation types are crack willow (*Salix fragilis*) forest, exotic grassland, and raupō (*Typha orientalis*) reedland, with minor amounts of native-dominated sedgeland, shrubland and treeland. In some cases information was insufficient to identify vegetation types accurately; these were indicated as requiring field verification.

4.3 Priority wetlands for monitoring

A final set of 10 wetlands (Table 1) was determined, based on the priority rankings in the HBRC Tukituki Catchment database (see Site selection_20160504.xlsx Microsoft Excel spreadsheet: 'Prioritised' sheet, K Hashiba HBRC), and subsequently refined following field checking and applying the principles outlined in the Methods section above. The wetlands were considered to cover the range of wetland class, vegetation type, condition and geographical spread, and to be representative of the range of wetlands remaining in the Tukituki Catchment. They should therefore be suitable for monitoring for SOE purposes and for assessing the efficiency and effectiveness of PC6 with regard to wetlands.

Table 1 Wetlands selected for monitoring in the Tukituki Catchment. Brackets indicate additional, minor wetland classes

Wetland name	ID	Easting	Northing	No. plots	Wetland class	Wetland form
Atua Road Wetland	2182	1925779	5570283	2	Marsh	Basin
Duff's Flat Wetland	4435	1881529	5598997	3	Fen (swamp)	Flat
Fleming Road Wetland	2103	1913999	5564464	2	Fen	Basin
Mangatewai Wetland	2167	1876575	5569306	2	Swamp	Oxbow
Omakere Wetland	4434	1921204	5559360	1	Marsh	Flat, floodplain
Orea Swamp	2209	1926279	5573655	1	Swamp	Basin
Otane Willow Swamp	3428	1912638	5581567	3	Marsh	Flat
Wakarara	2326	1882155	5587038	2	Swamp (fen)	Oxbow
Whatuma	2096	1901397	5564236	4	Swamp	Basin
Willow Pond Nicholls Road	2058	1898495	5558698	1	Swamp	Basin

5 Establishment of plots at the selected priority wetlands

5.1 Ground-truthing and baseline survey

The wetlands were visited between 27 June and 17 August 2016, assessed for condition (Wetland Condition Index: WCI/25), and 21 plots in total were sampled (Tables 1–2). As outlined in the wetland monitoring protocols in Section 6.2.2, at least 1 plot per vegetation type is recommended. Data and nutrient analysis results have been entered into the Landcare Research National Wetland Database. These have been provided as Microsoft Excel spreadsheets to K. Hashiba, HBRC. Copies of the filled-in field sheets for one wetland and one plot, Mangatewai Wetland, plot 1, are given in Appendices 2–5. These provide examples and guidance on filling in the data sheets. All the filled-in field sheets have been supplied to K. Hashiba, HBRC.

Table 2 Summary of plots sampled in Tukituki Catchment wetlands

Wetland name	ID	Plot	Easting	Northing	Plot size m^2	Structure	Composition
Atua Road	2182	1	1925779	5570283	5 × 5	Rushland	JUNedg
Atua Road	2182	2	1925974	5570223	5 × 5	Sedgeland	ELEacu/AGRsto
Duff's Flat	4435	1	1881529	5598997	5 × 5	Sedgeland	*Machaerina*
Duff's Flat	4435	2	1881616	5598978	5 × 5	Sedgeland	MACrub
Duff's Flat	4435	3	1881546	5598901	5 × 5	Shrubland	LEPsco/MACrub
Fleming Road	2103	1	1913999	5564465	5 × 5	Shrubland	LEPsco/bracken
Fleming Road	2103	2	1913932	5564340	5 × 5	Shrubland	LEPsco
Mangatewai Wetland	2167	1	1876575	5569306	5 × 5	Reedland	TYPori/BLEnov
Mangatewai Wetland	2167	2	1876407	5569274	5 × 5	Fernland	BLEnov
Omakere	4434	1	1921204	5559360	10 × 10	Treeland	DACdac/AGRsto
Orea Swamp	2209	1	1926279	5573655	10 × 10	Treeland	DACdac/AGRsto
Otane Willow Swamp	3428	1	1912638	5581567	10 × 10	Forest	SALfra
Otane Willow Swamp	3428	2	1912352	5581483	10 × 10	Treeland	SALfra
Otane Willow Swamp	3428	3	1912526	5581830	10 × 10	Forest	SALfra
Wakarara Road Oxbow	2326	1	1882155	5587038	5 × 5	Sedgeland	LEPsco/MACarth
Wakarara Road Oxbow	2326	2	1881926	5587081	5 × 5	Sedgeland	*Carex*
Whatuma	2096	1	1901397	5564236	5 × 5	Reedland	TYPori
Whatuma	2096	2	1901436	5564435	5 × 5	Sedgeland	SCHtab/LUDpal
Whatuma	2096	3	1900512	5564309	10 × 10	Forest	SALfra
Whatuma	2096	4	1900267	556404	5 × 5	Grassland	AGRsto
Willow Pond Nicholls Road	2058	1	1898495	5558678	5 × 5	Reedland	TYPori

At each wetland, with the exception of Omakere, one HOBO data logger was installed by the Land Science Team, HBRC, to record total pressure (water and atmospheric pressures) every 30 minutes, which was then converted to a water depth. Where possible, the logger was installed beside a plot representative of the main vegetation type in the wetland. These data, together with on-going assessments of ecological state based on the permanent plots, particularly the prevalence index(PI), will allow HBRC to monitor changes over time and to assess the efficacy of PC6 on wetlands. The loggers were located at one corner of the designated plot, except at Whatuma, where the HOBO logger was installed at the existing HBRC staff gauge. For calibration purposes, one additional HOBO logger was positioned above the ground surface at Orea Swamp (Table 3).

Table 3 Location of HOBO loggers, Tukituki Catchment wetlands

Wetland name	Wetland ID	Closest plot	Easting	Northing
Atua Road	2182	Plot 2	1925971	5570221
Duff's Flat	4435	Plot 1	1881537	5598994
Fleming Road	2103	Plot 2	1913930	5564339
Mangatewai Wetland	2167	Plot 1	1876585	5569308
Omakere	4434	N/A		
Orea Swamp	2209	Plot 1	1926291	5573667
Orea Swamp – calibration	2209	Plot 1	1926291	5573667
Otane Willow Swamp	3428	Plot 1	1912649	5581573
Wakarara Road Oxbow	2326	Plot 2	1901400	5564286
Whatuma	2096	Plot 1	1901400	5564286
Willow Pond Nicholls Road	2058	Plot 1	1898499	5558674

5.2 Overall approach

The methods were based on the *Handbook for Monitoring Wetland Condition* (Clarkson et al. 2004),[1] with refinements as outlined in the wetland monitoring system developed for Bay of Plenty wetlands (Fitzgerald et al. 2013; Clarkson et al. 2014). The points of difference between the current approach and the *Handbook* method and/or background information are summarised in sections 5.2.1 to 5.2.3 below, with revised guidelines for scoring wetland condition in Appendix 6.

[1] http://www.landcareresearch.co.nz/publications/researchpubs/handbook_wetland_condition.pdf

5.2.1 Wetland sheet

Removal of indicator component fire damage: any nutrient enrichment caused by recent fires is now incorporated in the indicator component 'Nutrient levels', and any vegetation/biota damage can be captured in the new indicator component 'Recent vegetation damage/clearance'. This follows the WETMAK approach (Denyer & Peters 2012). The new indicator component is assessed for degree of modification and scored in the same manner to that outlined in Table 5 of the Clarkson et al. (2014) *Handbook* (i.e. 0 = extreme, 1 = very high, 2 = high, 3 = medium, 4 = low, 5 = very low/none).

New indicator components: 'native animal species occupancy decline' and 'native plant species occupancy decline' have been added to measure the extent of divergence from the expected or typical species composition and/or structure expected for that particular wetland type. This follows the recommended monitoring framework for councils by Lee and Allen (2011). The indicator components are scored in the same manner as in Table 5 of the Clarkson et al. (2014) *Handbook* (i.e. 0 = extreme, 1 = very high, 2 = high, 3 = medium, 4 = low, 5 = very low/none). For species or groups that are difficult to measure, a corollary of an increase in exotic animal occupancy (e.g. abundance of invasive earthworms) may be used to inform the assessment.

5.2.2 Wetland plot sheet

This differs from the *Handbook* approach for the vegetation sampling component. In addition, there are extra sections, such as the prevalence index (section 5.2.3 below). For more information and guidance, see 'Wetland monitoring protocols' (section 6 below).

5.2.3 Prevalence index

This is a method for assessing the 'wetness' or, more correctly, 'dryness' of a plot based on plant species composition and cover. It was developed for the US wetland delineation system (Environmental Laboratory 1987) using individual wetland species indicator status based on typical wetland habitat (OBL: obligate wetland, FACW: facultative wetland, FAC: facultative, FACU: facultative upland [dryland], UPL: upland) to calculate a prevalence index (PI). The PI is a weighted average method that gives a value between 1 and 5. If the PI is ≤ 3, the vegetation is considered hydrophytic and satisfies the vegetation criterion for delineating wetlands (the other criteria are soils and hydrology). Epiphytes are not included in the assessment because they are not rooted in wetland soils.

In New Zealand, the PI is used to monitor changes in hydrological regime in permanent plots (Clarkson 2014). The list of indicator status ratings for New Zealand wetland plants is updated periodically and is available online at http://www.landcareresearch.co.nz/__data/assets/pdf_file/0014/64400/wetland_rating_species_December_2013.pdf. As plants integrate and reflect the environmental conditions at a site, significant changes in the hydrological regime will be apparent in changes in species composition and cover. For example, influxes of FACU and UPL pasture species may be promoted by the lowering of the water table following drain construction, and will result in increases in PI values.

The PI for plots sampled in the Tukituki Catchment (Table 4) ranged from 1.000 to 3.105, reflecting very wet through to relatively dry hydrological regimes. Following the US wetland delineation system, Fleming Road Wetland Plot 1 does not satisfy the wetland vegetation criterion (i.e. PI has to be ≤ 3). However, as the PI is only marginally greater than 3.0, and *Sphagnum* (an obligate wetland species) is common in the plot, this plot may still qualify as a wetland by having wetland (hydric) soils and hydrology. A wetland soil tool for field identification of hydric soils is currently under development by Landcare Research and will assist in delineating wetlands. Monitoring the permanent plots and assessing the PI in the future will indicate whether the sites are drying out or not.

Table 4 Prevalence index for wetland plots sampled in the Tukituki Catchment

Wetland name	Database no.	Plot no.	Prevalence index	Wetland vegetation
Atua Road Wetland	2182	1	2.038	Yes
Atua Road Wetland	2182	2	1.510	Yes
Duff's Flat Wetland	4435	1	2.076	Yes
Duff's Flat Wetland	4435	2	1.463	Yes
Duff's Flat Wetland	4435	3	1.992	Yes
Fleming Road Wetland	2103	1	3.105	No
Fleming Road Wetland	2103	2	1.783	Yes
Mangatewai Wetland	2167	1	2.023	Yes
Mangatewai Wetland	2167	2	2.892	Yes
Omakere Wetland	4434	1	2.618	Yes
Orea Swamp	2209	1	2.109	Yes
Otane Willow Swamp	3428	1	1.979	Yes
Otane Willow Swamp	3428	2	1.999	Yes
Otane Willow Swamp	3428	3	1.984	Yes
Wakarara	2326	1	1.627	Yes
Wakarara	2326	2	2.933	Yes
Whatuma	2096	1	1.277	Yes
Whatuma	2096	2	1.008	Yes
Whatuma	2096	3	2.005	Yes
Whatuma	2096	4	2.124	Yes
Willow Pond Nicholls Road	2058	1	1.000	Yes

6 Wetland monitoring protocols

6.1 Overview

Based on testing and refining the protocols for monitoring wetlands in the Tukituki Catchment wetlands, the guidelines and methodology are summarised below. In addition, repeat measurements (inter-annual) should be undertaken at the same time of year, to avoid seasonal differences, and under 'normal' conditions, to avoid short-term fluctuations caused by abnormal climatic conditions, disturbance or other atypical situations. This should preferably be summer to early autumn, when summer-green plants (such as orchids) and flowers/seeds (to aid species identification) are most likely to be present, and when water levels (for easier access) are lower.

6.2 Pre-field preparation

6.2.1 Background references and equipment required

Essential references and equipment include:

- a list of priority HBRC / Tukituki Catchment wetlands for monitoring (Contact: K Hashiba, HBRC; the working list from the April 2016 workshop is in Appendix 1)
- this report (Clarkson and Bartlam 2017) for monitoring methodology
- the *Handbook for Monitoring Wetland Condition* (Clarkson et al. 2004) for assessing wetland condition in a wetland record sheet, soil and foliage sampling protocols, and the von Post scoring scale
- aerial photos, reports, wetland vegetation maps, and other relevant information on the wetland sites
- GPS points, both primary and at least one or two back-up points per major vegetation type (see section 6.3)
- GPS receiver and spare batteries
- field sheets (Appendix 7): Wetland Record Sheets, Wetland Plot Sheets, prevalence index sheets
- aluminium poles (four per plot) about 2 m tall for permanent plot corners, four per plot
- small Permolat squares (four per plot) or similar for marking plot numbers (use a nail or something similar to scratch the label on – not a marker pen as this fades) and compass to orient the corners (e.g. SW, etc.); beforehand, drill holes in the top and bottom of the square so that it slides snugly over the aluminium pole
- tape measures – two 30 m tapes for marking out plots
- a builder's retractable steel tape-measure for species heights
- a steel liner for taking substrate/soil cores (e.g. 10 cm diameter by 7 cm height)

- a knife for cutting out the cores – one with a serrated edge is recommended
- sealable plastic bags for the cores (two per plot)
- small paper bags (e.g. 15 × 15 cm) or envelopes for foliage samples (not plastic bags as these tend to sweat and the samples may become mouldy), usually one or two per plot; however, we recommend that mānuka also be collected if present as this is a standard species for nutrient content
- field pH and electrical conductivity meter – we use a TPS-WP81 waterproof hand-held meter
- the von Post scoring scale (Appendix VI in *Handbook for Monitoring Wetland Condition*)
- a chilly bin with ice packs for storing substrate/soil samples in the field – store in a fridge as soon as possible on return from the field
- courier samples for analysis at an ISO-accredited laboratory, such as the Landcare Research environmental chemistry laboratory at Palmerston North.[2]

6.2.2 Plot selection

- Delineate in a GIS system the main vegetation types at each wetland, based on published and unpublished reports, local knowledge, interpretation of recent aerial photos and other relevant information. The GIS information will be used to choose sample locations (see below) and forms an important part of the metadata associated with the sample. It should be documented, and the version used should be stored for later analysis and reporting.
- Determine the desired number of sample locations per vegetation type. We recommend at least one plot per vegetation type. Vegetation types covering larger areas should have more plots to cater for site variations.
- Using a probability sampling method, choose the desired number of plot locations in each vegetation type. We recommend that the SPAS (SPAtial Sampling) sampling extension developed for ArcView 3.2 by Landcare Research be used to choose spatially balanced samples (contact Landcare Research for more information). This program operates as an extension of ArcView 3.2 or 3.3. SPAS does not require that ArcView be running, but does require the ArcView libraries. If ArcView is not available, then the simple random sampling options available in ArcGIS are suitable. In all cases the area of each vegetation type and the number of samples in that type should be recorded and maintained with the data to provide information on sampling intensity (inclusion probabilities) required for analysis. The SPAS program will calculate inclusion probabilities and include them in the output file containing plot locations.
- It is recommended that at least an equal number of alternative back-up locations be generated for each vegetation type in case plots are rejected on the basis of misclassification or recent development/destruction. This can be achieved simply by

[2] http://www.landcareresearch.co.nz/resources/laboratories/environmental-chemistry-laboratory.

repeating the above procedure for each vegetation type using a different random 'seed'.

If ground-truthing of the aerial photographs and/or vegetation maps reveals that a vegetation type has been missed during the sampling process, additional plot(s) may be sampled. To do this, delineate the vegetation type in the field and use random numbers (e.g. x metres towards the centre of the vegetation type) to select the plot origin, ensuring the plot is representative of the target vegetation type. Indicate that this plot is 'additional' to the randomly generated plots.

Note: this is the approach (stratifying vegetation types in the field) we took for all the Tukituki Catchment wetlands because the vegetation maps were of insufficient detail and accuracy to predetermine random sampling points. While probability sampling is a more statistically robust method, it requires comprehensive spatial data on vegetation type, which may not be available.

- If water level monitoring equipment is used (e.g. HOBO logger), these should be installed near a plot considered to be most representative of the wetland vegetation.

6.3 Field survey

6.3.1 Plot establishment and sampling

- Using the GPS random point coordinates as the origin and south-west corner, set up a plot due north, east, etc. from that point using tape-measures and poles. Use a plot size of 5 × 5 m for a maximum vegetation height < 5 m, and a plot size of 10 × 10 m for vegetation > 5 m (e.g. willow forest).
- Take two photos at the south-west corner, the first looking north and the second looking east, with the poles and tape delineating the plot along the edge of the photo if possible. Record the photo number and the time it was taken.
- Fill in page 1 of the Wetland Plot Sheet in the field. Page 2 of the Wetland Plot Sheet can be left until later, when soil/foliage analyses are completed.
- Species cover (the Cover % column) is not measured in fixed height (RECCE; see Hurst & Allen 2007) or Atkinson variable height (Atkinson 1985) tiers. It is the vertical projection (spread) of the above-ground live biomass for each species, measured as percentage cover of the total area of the plot, irrespective of height or tier, or the position of other vegetation. Imagine each species is the only species in the plot and estimate its cover. Individual species cover cannot be more than 100%, but total vegetation cover usually will be > 100%. This applies to all vascular species and *Sphagnum* moss. Bryophytes and lichens may also be recorded to species level if known, but must also be recorded collectively as bryophytes or lichens. Use a minimum cover of 0.5% for species with very low percentage cover. Note that 1% cover is equivalent to a 50 × 50 cm square in a 5 × 5 m plot, and a 1 × 1 m square in a 10 × 10 m plot.

- Cover class estimates for each species in the different height tiers is the cover class estimate based on the percentage cover of that species within the appropriate height tier compared with the total area of the plot.
- Fill in the plot vegetation data table on page 2 of the Wetland Plot Sheet.

6.3.2 Wetland Record Sheet

Fill in the Wetland Record Sheet to calculate a Wetland Condition Index for each wetland, based on the *Handbook for Monitoring Wetland Condition* Table 5 (Clarkson et al. 2004) and the information contained therein. For the new indicator components of 'Native animal species occupancy decline' and 'Native plant species occupancy decline', assess the extent of divergence from the expected or typical species composition and/or structure for that particular wetland type (1,840 baselines or reference sites based on ecological knowledge). Use similar scoring categories as used for the other indicator components (i.e. 5: none/very low; 4: low; 3: moderate; 2: high; 1: very high; 0: extreme).

As outlined in the *Handbook* (Clarkson et al. 2004, pp. 36–37), changes between monitoring periods may be analysed at several scales, such as the wetland condition total score, the indicator score, and the indicator component score. For example, changes in the indicator component 'B1: Damage by domestic or feral animals' can be used to assess the effectiveness of a fencing/stock exclusion programme.

6.3.3 Prevalence index

Calculate the PI by filling in the PI table using plot percent cover and species indicator group data from the New Zealand wetland species indicator status ratings available on the web (Clarkson et al. 2013).[3]

The PI can be calculated by populating the Prevalence Summary Worksheet on page 2 of the Wetland Plot Sheet. This provides a step by step longhand method. However, it is probably more easily calculated using a spreadsheet (e.g. MS Excel).

6.3.4 Soil and foliage sampling for nutrient and bulk density analyses

Instructions for collecting foliage and substrate samples are outlined in the *Handbook* (Clarkson et al. 2004). Living vegetation and leaf litter are removed to expose the substrate for coring using a steel-liner corer, typically 10 cm in diameter and 7.5 cm deep. In *Sphagnum* peatlands, remove the green/living plant material with a serrated knife (e.g. a breadknife) to access the non-living peat substrate. This boundary can be quite deep in tall *Sphagnum* hummocks but should be marked by a slight change in colour to yellow/brown.

---

3 http://www.landcareresearch.co.nz/__data/assets/pdf_file/0014/64400/wetland_rating_species_December_2013.pdf).

The height of the *Sphagnum* moss vegetation is based on the height of the *Sphagnum* canopy above this living/non-living boundary.

Soil cores and field water measurements are taken in the south-west corner, just within the plot. When substrate and foliage nutrient analyses have been received from the analytical laboratory, fill in the tables on page 2 of the Wetland Plot Sheet.

7 Guidance on data interpretation and presentation

7.1 Baseline data

The Wetland Condition Index of the Tukituki Catchment wetlands ranged from 8.41 to 20.25 out of a possible 25 (Table 5). Overall this is low by national standards, but is generally typical of wetlands in productive landscapes. Preliminary work on wetland limits (Clarkson et al. 2015) in the development of the National Objective Framework under the National Policy Statement for Freshwater Management (NPS-FM) used preliminary working wetland condition states (bands) of:

- A: >20 to 25; excellent
- B: >15 to 20; good
- C: >10 to 15; moderate
- D: ≤10; poor, degraded.

Under this system, only Duff's Flat Wetland reaches the A state, five wetlands are B state (Wakarara, Mangatewai, Whatuma, Orea Swamp and Fleming Road), three wetlands are C state (Atua Road, Willow Pond and Otane Willow Swamp), and Omakere is D state (i.e. below the bottom line).

Table 5 Wetland Condition Index (WCI), condition states and soil nutrient data for Tukituki wetlands

Wetland name	Type	ID	WCI /25	State /Band	Plot No.	BD T/m^3	pH	TC %	TN %	TK %	TP %
Duff's Flat	fen	4435	20.25	A	1	0.081	5.28	22.5	1.19	0.035	0.079
					2	0.069	5.55	30.03	1.50	0.147	0.171
					3	0.166	5.58	22.51	1.35	0.098	0.098
Fleming Road	fen	2103	15.12	B	1	0.064	4.23	51.5	1.73	0.067	0.083
					2	0.022	4.20	50.5	0.78	0.029	0.029
Wakarara	swamp	2326	19.51	B	1	0.059	5.65	43.8	2.13	0.094	0.092
					2	0.055	5.75	39.77	2.42	0.166	0.129
Mangatewai	swamp	2167	19.12	B	1	0.048	5.89	42.4	2.18	0.150	0.198
					2	0.056	5.78	43.9	1.85	0.802	0.273
Whatuma	swamp	2096	15.91	B	1	0.802	7.11	1.32	0.13	0.220	0.017
					2	0.431	7.29	4.16	0.44	0.512	0.060
					3	0.418	6.87	19.38	1.53	0.609	0.120
					4	0.404	5.68	25.61	1.95	0.470	0.139
Orea Swamp	swamp	2209	15.8	B	1	0.626	6.36	8.87	0.60	1.801	0.085
Atua Road	marsh	2182	14.96	C	1	0.721	5.21	10.6	0.95	0.922	0.161
					2	0.500	4.52	12.2	1.14	0.720	0.111
Willow Pond	swamp	2058	14.49	C	1	0.072	5.51	23.6	1.59	0.456	0.106
Otane Willow	marsh	3428	12.37	C	1	0.305	7.31	21.2	1.70	0.582	0.121
					2	0.453	5.57	13.77	1.02	0.838	0.096
					3	0.285	6.62	18.46	1.44	0.625	0.096
Omakere	marsh	4434	8.41	D	1	1.032	8.12	4.21	0.29	1.307	0.071

Soil nutrient levels in the Tukituki Catchment wetlands (Table 5) can be compared with those recorded in similar wetland types elsewhere in New Zealand using Clarkson et al. 2015. These have been separated out according to wetland type. Only fens, swamps and marshes are represented in the Tukituki wetland monitoring set. Because of the current lack of data for marshes throughout New Zealand, these can be treated under the swamp type category at this stage.

Soil variable data (means, 10th percentile, 90th percentile) from Clarkson et al. 2015 are presented as Appendix 8 for comparison. This shows that most soil nutrient levels are relatively high but within the 80% range (between the 10th and 90th percentile) for similar wetland types in New Zealand according to the relevant wetland condition bands. The soil nutrient levels measured in the present survey (2016) also provide baselines for measuring any future changes.

Foliage nutrients were also measured (Table 6). Samples were collected from the dominant species in each plot, and from indicator species such as mānuka (*Leptospermum scoparium*),

which has a wide national distributional range and has foliage nutrient levels that reflect soil nutrient levels.

Table 6 Foliage nutrient concentrations for Tukituki wetlands. IS indicates insufficient sample

Wetland Name	Type	Plot	Species	Carbon %	Nitrogen %	Phosphorus %	Potassium %	N:P Ratio
Atua Road	marsh	1	JUNedg	47.5	2.02	0.153	1.42	13.23
Atua Road	marsh	2	AGRsto	IS	IS	0.528	3.28	
Atua Road	marsh	2	ELEacu	45.5	1.75	0.141	1.37	12.44
Omakere	marsh	1	AGRsto	IS	IS	0.346	2.02	
Omakere	marsh	1	DACdac	48.3	1.16	0.134	0.44	8.67
Otane Willow	marsh	1	URTlin	IS	IS	0.486	2.75	
Otane Willow	marsh	2	CARgem?	47.8	3.03	0.308	1.99	9.84
Otane Willow	marsh	2	URTlin	39.4	5.60	0.472	3.49	11.86
Mangatewai	swamp	1	BLEnov	42.4	1.17	0.155	1.26	7.56
Mangatewai	swamp	1	LEPsco	54.9	1.13	0.110	0.44	10.27
Mangatewai	swamp	2	BLEnov	43.8	1.24	0.121	1.19	10.19
Mangatewai	swamp	2	CARsec	44.3	1.51	0.156	1.49	9.69
Mangatewai	swamp	2	LEPsco	55.4	1.12	0.130	0.47	8.64
Orea	swamp	1	AGRsto	45.6	4.36	0.423	2.68	10.31
Orea	swamp	1	DACdac	49.8	1.36	0.194	0.88	6.99
Wakarara	swamp	1	MACarth	46.9	1.15	0.048	0.88	23.72
Wakarara	swamp	2	AGRsto	44.8	3.85	0.209	3.35	18.42
Wakarara	swamp	2	CAREX sp	46.7	2.54	0.305	1.94	8.33
Wakarara	swamp	1	LEPsco	55.0	1.00	0.049	0.47	20.20
Whatuma	swamp	1	RANmac	41.6	5.90	0.960	5.51	6.15
Whatuma	swamp	2	SCHtab	43.8	2.07	0.166	1.59	12.42
Whatuma	swamp	2	VERana	39.8	4.08	0.745	3.61	5.48
Whatuma	swamp	3	AGRsto	IS	IS	0.483	3.03	
Whatuma	swamp	3	URTlin	42.0	4.68	0.524	2.12	8.94
Whatuma	swamp	4	AGRsto	46.3	3.77	0.335	1.66	11.28
Whatuma	swamp	4	CAREX sp	46.3	2.30	0.173	1.23	13.31
Willow Pond	swamp	1	TYPori	43.5	3.71	0.402	3.64	9.22
Duff's Flat	fen	1	ELEacu?	47.1	0.93	0.039	0.64	23.83
Duff's Flat	fen	1	LEPsco	IS	IS	0.051	0.45	
Duff's Flat	fen	2	MACrub?	47.1	1.63	0.066	0.85	24.72
Duff's Flat	fen	3	LEPsco	56.5	1.25	0.050	0.39	24.78
Duff's Flat	fen	3	MACrub?	47.4	1.49	0.053	0.55	28.15
Fleming Road	fen	1	LEPsco	54.6	0.84	0.095	0.44	8.85
Fleming Road	fen	1	PSEcra	48.3	0.78	0.121	1.05	6.49
Fleming Road	fen	2	LEPsco	55.0	1.13	0.151	0.61	7.49
Fleming Road	fen	2	JUNCUS sp	47.4	1.30	0.305	1.15	4.26

Nitrogen (N) and phosphorus (P) are the two nutrients most likely to limit plant growth in wetlands. The N:P ratio can be used to determine the nature of the nutrient limitation of a wetland plant community, particularly in oligotrophic systems (Verhoeven et al. 1996). Foliage tissue ratios of N:P < 14 indicate nitrogen limitation, and ratios of N:P > 16 indicate phosphorus limitation. Although N:P ratios may vary according to species, wetland plant communities with N:P < 14 are more likely to respond and change with inputs of N, and likewise, those with N:P > 16 are more susceptible to P inputs. However, in more eutrophic sites the tissue nutrient concentrations may exceed growth-limiting thresholds. In the Tukituki Catchment, Duff's Flat (fen) has relatively low nutrient concentrations and high N:P ratios, and Otane Willow (marsh) and Willow Pond (swamp) have high nutrient levels and low N:P ratios. For the majority of wetland sites, the nutrient levels are high compared with national trends (See Appendix II in Clarkson et al. 2004).

Wetland catchment pressures are scored on a scale of 0–5 and summed to produce a Wetland Pressure Index (WPI) out of a maximum of 30 (Clarkson et al. 2004). A high value (e.g. WPI ≥ 20, or individual pressures ≥ 4), indicates high pressures and stresses on the wetland environment, which can potentially cause changes in condition (state). The pressure scores and WCI are used as a tool to signal where resources and effort should be targeted within the wider monitoring programme. Wetlands with high pressure and condition are priorities for management. In the Tukituki Catchment, Fleming Wetland had the highest WPI (22), and several wetlands scored ≥ 4 for individual pressures (Table 7).

Table 7 Wetland Pressure Index (WPI) and individual pressure scores for Tukituki wetlands

Wetland name	ID	Hydrology	Water quality	Animal access	Undesirable species	Introd veg	Other	WPI /30
Atua Road Wetland	2182	3	4	3	1	5		16.0
Duff's Flat Wetland	4435	2.5	2.5	3	2	5		18.0
Fleming Road Wetland	2103	4	4	5	2	4.5	2.5	22.0
Mangatewai Wetland	2167	2	2	3	2	2		11.0
Omakere Wetland	4434	4	4	3	1	5		17.0
Orea Swamp	2209	3	3	3	3	4		16.0
Otane Willow Swamp	3428	4	3	4	3	4.5		18.5
Wakarara	2326	3	3	4	3	5		18.0
Whatuma	2096	2.5	3	1	3	5		14.5
Willow Pond Nicholls Road	2058	2.5	2.5	3	2	5		15.0

7.2 Changes over time

Analysis and interpretation of change over time are covered in the *Handbook* (Clarkson et al. 2004) and are appended here as Appendix 9. In summary, changes may be analysed at different scales and within different layers, such as council administration boundary, catchment, wetland class, vegetation type, or any other similar ecological grouping.

Wetland indicators may also be analysed at different levels or any combination of levels, depending on the aim of the monitoring project (e.g. total score index, individual indicator sub-index, or separate component indicator score). They can also be used to assess the effectiveness of rules, regulations or education programmes designed to protect wetlands and their values. Similar levels may be used for analysing indicators and data at the plot scale. A simple pie chart is an effective way to show the overall trends of wetland condition between two periods of time on a region/catchment basis using the categories of 'deteriorating', 'steady' and 'improving'.

8 Conclusions

The field protocols outlined above were relatively quick and easy to follow. They provided both quantitative and semi-quantitative data for inter-annual monitoring, and were suitable for the range of wetland types encountered during the pilot survey. Recent work in Southland and Bay of Plenty wetlands (and elsewhere) indicates the protocols are also suitable for other wetland types present in Hawke's Bay but not included in this pilot (e.g. bogs). We conclude that the protocols and data should assist HBRC in monitoring the state of their wetlands.

9 Recommendations

We recommend keeping protocols as consistent as possible within the region (and nationally) by ensuring the field team is familiar with the standard wetland monitoring approach and/or undertakes training at the start of the project to ensure consistency. This is particularly important for new team members or those unfamiliar with the wetland monitoring technique.

Also, field sampling should be undertaken under 'normal' conditions, and re-measurements over different time periods should be at similar times of the year (preferably summer to early autumn).

10 Acknowledgements

We thank Keiko Hashiba, Hawke's Bay Regional Council, for organising the project, assistance in the field, and providing ongoing feedback. Tim Morris, Hawke's Bay Regional Council, also provided assistance in the field. We thank Keiko Hashiba and Neil Fitzgerald for reviewing the report.

11 References

Atkinson IAE 1985. Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand. New Zealand Journal of Botany 23: 361–378.

Ausseil A-G, Gerbeaux P, Chadderton W, Stephens T, Brown D, Leathwick J 2008. Wetland ecosystems of national importance for biodiversity. Landcare Research Contract Report LC0708/158 for Chief Scientist, Department of Conservation. 162 p.

Cieraad E, Walker S, Price R, Barringer J 2015. An updated assessment of indigenous cover remaining and legal protection in New Zealand's land environments. New Zealand Journal of Ecology 39: 309–315.

Clarkson BR 2014. A vegetation tool for wetland delineation in New Zealand. Landcare Research Contract Report LC1793 for Meridian Energy. 62 p. http://www.landcareresearch.co.nz/__data/assets/pdf_file/0003/71949/vegetation_tool_wetland_delineation.pdf.

Clarkson BR, Champion PD, Rance BD, Johnson PN, Bodmin KA, Forester L, Gerbeaux P, Reeves PN 2013. New Zealand wetland indicator status ratings. Landcare Research, Hamilton. Revised December 2013. http://www.landcareresearch.co.nz/__data/assets/pdf_file/0014/64400/wetland_rating_species_December_2013.pdf

Clarkson BR, Fitzgerald NB, Overton JM 2014. A methodology for monitoring Bay of Plenty wetlands. Landcare Research Contract Report LC1779 for Bay of Plenty Regional Council. 56 p.

Clarkson BR, Overton J, Robertson H, Ausseil A-GE 2015. Towards quantitative limits to maintain the ecological integrity of freshwater wetlands: interim report 2015. Landcare Research Contract Report LC1933 for the Department of Conservation. 29 p.

Clarkson BR, Rance B, Briggs C, Ogilvie H, Fitzgerald N 2011. Current and historic wetlands of Southland Region: Stage 2. Landcare Research Contract Report LC312 for Environment Southland. 53 p.

Clarkson BR, Sorrell BK, Reeves PN, Champion PD, Partridge TR, Clarkson BD 2004. Handbook for monitoring wetland condition. Coordinated Monitoring of New Zealand Wetlands: a Ministry for the Environment Sustainable Management Fund Project. 74 p. http://www.landcareresearch.co.nz/publications/researchpubs/handbook_wetland_condition.pdf

Denyer K, Peters M 2012. WETMAK: Wetland Monitoring and Assessment Kit. New Zealand Landcare Trust. http://www.landcare.org.nz/wetmak

Environmental Laboratory 1987. Corps of Engineers wetland delineation manual. Technical Report Y-87-1. Vicksburg, MS, US Army Engineer Waterways Experiment Station.

Fitzgerald N, Clarkson BR, Price R 2013. Bay of Plenty wetland sampling priority framework. Landcare Research Contract Report LC1213 for Bay of Plenty Regional Council. 74 p.

Hurst JM, Allen RB 2007. The RECCE method for describing New Zealand vegetation: field protocols. Lincoln, Landcare Research. 29 p.

Lee WG, Allen RB 2011. Recommended monitoring framework for regional councils assessing biodiversity outcomes in terrestrial ecosystems. Landcare Research Contract Report LC144 for the New Zealand Regional Council Biodiversity Forum. 29 p.

Ministry for the Environment, Statistics New Zealand 2015. New Zealand's environmental reporting series: Environment Aotearoa 2015. Ministry for the Environment and Statistics New Zealand, Wellington.

Verhoeven JTA, Koerselmann W, Meuleman AF 1996. Nitrogen- or phosphorus-limited growth in herbaceous, wet vegetation: relations with atmospheric inputs and management regimes. Trends in Ecology and Evolution 11: 494–497.

Appendix 1 – Working list of priority wetlands

Note: for the full MS Excel spreadsheet, contact Keiko Hashiba, HBRC. This preliminary list was refined post-workshop for the final 10-wetland selection

Wetland_ID	Workshop	WetlandNam	Hydrosyste	WetlandCla	WetlandFor	Structure	Species	Percentage	Comment	Area_ha	Revised tota	EcoDist	Priority
2096	Assessed	Lake Hatuma	NA	NA	NA		NA	33%	Lake	81.00	247.27354	Heretaunga	1
2096	Assessed	Lake Hatuma	Palustrine	shallow wat	depression	Open water		27%		66.76	247.27354	Heretaunga	1
2096	Assessed	Lake Hatuma	Palustrine	swamp		Exotic forest	SALfra-SALcin	20%		49.45	247.27354	Heretaunga	1
2096	Assessed	Lake Hatuma	Palustrine	swamp		Exotic treeland	SALcin - (SALfra)	5%		12.36	247.27354	Heretaunga	1
2096	Assessed	Lake Hatuma	Palustrine	swamp		Reedland	TYPori	5%		12.36	247.27354	Heretaunga	1
2096	Assessed	Lake Hatuma	Palustrine	swamp		Exotic grassland	AGRsto - others	9%		22.25	247.27354	Heretaunga	1
2096	Assessed	Lake Hatuma	Palustrine	swamp		Exotic rushland	Juncus	1%		2.47	247.27354	Heretaunga	1
3428	Assessed	Willow Swamp	Palustrine	swamp	basin	Exotic forest	SALfra	100%	2-3 plots. Some private	76	76	Heretaunga	2
2196	Assessed	Wainui created wetla	NA	NA	NA		NA	60%	Lake	9.02		Heretaunga	3
2196	Assessed	Wainui created wetla	Palustrine	shallow wat	depression	Open water		10%		1.50		Heretaunga	3
2196	Assessed	Wainui created wetla	Palustrine	swamp	depression	Reedland	TYPori	15%	Area TBC - all brown are	2.25		Heretaunga	3
2196	Assessed	Wainui created wetla	Palustrine	swamp	depression	Exotic herbfield	Mix	15%	TBC	2.25		Heretaunga	3
2058	Assessed	Rotorunga Wetlands	NA	NA	NA		NA	60%	Lake	6.4		Heretaunga	
2058	Assessed	Rotorunga Wetlands	NA	NA	NA		NA	5%	Artificial bund	0.5		Heretaunga	
2058	Assessed	Rotorunga Wetlands	Palustrine	swamp	depression	Exotic treeland	Salix	15%	TBC	1.6		Heretaunga	4
2058	Assessed	Rotorunga Wetlands	Palustrine	swamp	depression	Reedland	TYPori	10%	TBC	1.1		Heretaunga	4
2058	Assessed	Rotorunga Wetlands	Palustrine	swamp	depression	Exotic herbfield	Mix	10%	TBC	1.1		Heretaunga	4
2182	Assessed	Atua Rd wetland	Palustrine	shallow wat	depression	Open water		40%		3	7.5	Eastern HB	5
2182	Assessed	Atua Rd wetland	Palustrine	marsh	depression	Rushland	JUNedg-JUNart-(AGRsto)	25%	Rushland and sedgelar	1.875	7.5	Eastern HB	5
2182	Assessed	Atua Rd wetland	Palustrine	swamp	depression	Sedgeland	CARvir-ELEacu-(AGRsto)	25%	Rushland and sedgelar	1.875	7.5	Eastern HB	5
2182	Assessed	Atua Rd wetland	Palustrine	marsh	depression	Exotic herbfield	Mix	10%	Being cultivated	0.75	7.5	Eastern HB	5
2103	Assessed	2103	Palustrine	shallow wat	basin	Open water		40%		2.97		Eastern HB	6
2103	Assessed	2103	Palustrine	swamp	basin	Exotic forest	Salix	45%		3.34		Eastern HB	6
2103	Assessed	2103	Palustrine	swamp	basin	Reedland	TYPori (?)	15%	Includes mysterial patc	1.05		Eastern HB	6
2209	Assessed	2209	Palustrine	shallow wat	basin	Open water		20%		1.35		Eastern HB	7
2209	Assessed	2209	Palustrine	swamp	basin	Exotic forest	SALfra-mixed spp	20%	Mixed species TBC	1.35		Eastern HB	7
2209	Assessed	2209	Palustrine	swamp	basin	Exotic forest	SALcin-(SALfra)	60%		4.05		Eastern HB	7
2386	Assessed	2386	Riverine	marsh	riparian	Forest	Podocarp mix	60%	Polygon re-drawn. Checl	0.84		Ruahine	8
2386	Assessed	2386	Riverine	marsh	riparian	Exotic forest	SALfra-(SALele)	40%		0.56		Ruahine	8
2326	Assessed	2326	Palustrine	marsh	oxbow	Shrubland	LEPsco?	50%	Needs checking. Also R'	3.12		Heretaunga	9
2326	Assessed	2326	Palustrine	marsh	oxbow	Reedland	TYPori	15%		0.93		Heretaunga	9
2326	Assessed	2326	Palustrine	marsh	oxbow	Sedgeland	Carex sp	20%		1.25		Heretaunga	9
2326	Assessed	2326	Palustrine	shallow wat	oxbow	Open water		5%		0.31		Heretaunga	9
2326	Assessed	2326	Palustrine	marsh	oxbow	Exotic herbfield		10%		0.62		Heretaunga	9

Wetland_ID	Workshop	WetlandNam	Hydrosyste	WetlandCla	WetlandFor	Structure	Species	Percentage	Comment	Area_ha	Revised tota	EcoDist	Priority
2084	Assessed	2084	NA	NA	NA		NA	90%	Lake	5.30		Eastern HB	
2084	Assessed	2084	Palustrine	swamp	basin	Exotic treeland	SALcin	2%	Include 2081	0.12		Eastern HB	
2084	Assessed	2084	Palustrine	swamp	basin	Reedland	TYPori	5%		0.29		Eastern HB	
2084	Assessed	2084	Palustrine	swamp	basin	Exotic herbfield	Mix	1%		0.06		Eastern HB	
2084	Assessed	2084	Palustrine	swamp	basin	Sedgeland	ISOpro?	2%	The bright green patch	0.12		Eastern HB	
2362	Assessed	2362	Palustrine	marsh	valley	Exotic shrubland		50%	TBC - seems to be highl	1.97		Ruahine	
2362	Assessed	2362	Palustrine	marsh	valley	Exotic herbfield		50%	TBC - seems to be highl	1.97		Ruahine	
2334	Assessed	2334	Palustrine	shallow wat	valley	Open water		20%		0.70		Eastern HB	10
2334	Assessed	2334	Palustrine	shallow wat	valley	Reedland		5%		0.17		Eastern HB	10
2334	Assessed	2334	Palustrine	shallow wat	valley	Exotic forest	SALcin	60%	Centre of the willow pa	2.10		Eastern HB	10
2334	Assessed	2334	Palustrine	shallow wat	valley	Exotic forest	SALfra	10%	Fringe of the SALcin	0.35		Eastern HB	10
2334	Assessed	2334	Palustrine	shallow wat	valley	Sedgeland		1%	TBC	0.03		Eastern HB	10
2334	Assessed	2334	Palustrine	shallow wat	valley	Exotic forest	Pinus?	4%		0.14		Eastern HB	10
2303	Assessed	2303	NA	NA	NA			55%	Lake	2.57		Heretaunga	
2303	Assessed	2303	Palustrine	swamp	floodplain	Exotic treeland	Salix	5%	Polygon re-drawn, TBC,	0.23		Heretaunga	
2303	Assessed	2303	Palustrine	swamp	floodplain	Exotic grassland	Mix	20%		0.94		Heretaunga	
2303	Assessed	2303	Palustrine	swamp	floodplain	Exotic rushland		10%		0.47		Heretaunga	
2303	Assessed	2303	Palustrine	swamp	floodplain	Sedgeland		10%		0.50		Heretaunga	
2322	Assessed	2322	Palustrine	shallow wat	basin	Open water		75%		1.93		Heretaunga	
2322	Assessed	2322	Palustrine	shallow wat	basin	Sedgeland	SCHtab-others	10%		0.26		Heretaunga	
2322	Assessed	2322	Palustrine	shallow wat	basin	Exotic rushland		5%		0.13		Heretaunga	
2322	Assessed	2322	Palustrine	shallow wat	basin	Exotic herbfield		10%		0.26		Heretaunga	
2467	Assessed	2467	Palustrine	swamp	floodplain	Reedland	TYPori	10%	Created between 2004 a	0.24		Heretaunga	
2467	Assessed	2467	Palustrine	shallow wat	floodplain	Open water		80%		1.96		Heretaunga	
2467	Assessed	2467	Palustrine	swamp	floodplain	Exotic herbfield		10%		0.24		Heretaunga	
2107	Assessed	2107	Palustrine	shallow wat	basin	Open water		45%		1.07		Eastern HB	
2107	Assessed	2107	Palustrine	swamp	basin	Reedland	TYPori	10%		0.24		Eastern HB	
2107	Assessed	2107	Palustrine	swamp	basin	Exotic forest	Salix	30%		0.71		Eastern HB	
2107	Assessed	2107	Palustrine	swamp	basin	Exotic scrub	Mix	15%	Needs checking	0.30		Eastern HB	
2167	Assessed	2167	Palustrine	swamp	terrace	Treeland	DACdac	30%	INTERESTING, definetel	0.7		Heretaunga	11
2167	Assessed	2167	Palustrine	swamp	terrace	Reedland	TYPori?	70%	Brown patch	1.7		Heretaunga	11
2331	Assessed	2331	NA	NA	NA	Open water		55%	Artificial	1.65		Heretaunga	
2331	Assessed	2331	Palustrine	marsh	oxbow lake	Exotic shrubland	RUBfru - mix	5%	Less priority given large	0.15		Heretaunga	
2331	Assessed	2331	Palustrine	marsh	oxbow lake	Exotic herbfield	Mix	5%		0.15		Heretaunga	
2331	Assessed	2331	Palustrine	marsh	oxbow lake	Exotic rushland	Juncus	20%		0.60		Heretaunga	
2331	Assessed	2331	Palustrine	marsh	oxbow lake	Sedgeland	CARsec	5%		0.15		Heretaunga	
2331	Assessed	2331	Palustrine	marsh	oxbow lake	Exotic grassland		10%		0.30		Heretaunga	
2216	Assessed	2216	Palustrine	shallow wat	valley	Open water		5%	Fenced	0.2	3.0	Heretaunga	**12**
2216	Assessed	2216	Palustrine	swamp	valley	Exotic forest	Salix	75%		2.3	3.0	Heretaunga	**12**
2216	Assessed	2216	Palustrine	swamp	valley	Exotic grassland	Mix	10%		0.3	3.0	Heretaunga	**12**
2216	Assessed	2216	Palustrine	swamp	valley	Rushland	Mix	5%		0.2	3.0	Heretaunga	**12**
2216	Assessed	2216	Palustrine	swamp	valley	Sedgeland	Mix	5%		0.2	3.0	Heretaunga	**12**

Wetland_ID	Workshop	WetlandNam	Hydrosyste	WetlandCla	WetlandFor	Structure	Species	Percentage	Comment	Area_ha	Revised tota	EcoDist	Priority
2146	Assessed	2146	Palustrine	shallow wat	floodplain	Open water		75%	Originally formed with t	1.23		Heretaunga	
2146	Assessed	2146	Palustrine	swamp	floodplain	Exotic forest	Salix	20%		0.33		Heretaunga	
2146	Assessed	2146	Palustrine	swamp	floodplain	Exotic grassland	Mix	3%		0.05		Heretaunga	
2146	Assessed	2146	Palustrine	swamp	floodplain	Rushland		1%		0.02		Heretaunga	
2146	Assessed	2146	Palustrine	swamp	floodplain	Sedgeland		1%		0.02		Heretaunga	
2405	Assessed	2405	Palustrine	shallow wat	valley	Open water		75%	Photo in the inventory i	1.03		Heretaunga	
2405	Assessed	2405	Palustrine	swamp	valley	Exotic treeland	Salix	15%		0.21		Heretaunga	
2405	Assessed	2405	Palustrine	swamp	valley	Exotic herbfield		10%		0.14		Heretaunga	
2392	Assessed	2392	Riverine	marsh	terrace	Grassland	Austroderia	50%	Needs checking (with W	0.67		Ruahine	13
2392	Assessed	2392	Riverine	marsh	terrace	Shrubland	Mix	50%		0.67		Ruahine	13
3329	Assessed	DSC_1233.JPG	Palustrine	marsh	slope	Shrubland	CORaus - (DACdac)	33%	Originally kahikatea fo	0.35		Eastern HB	14
3329	Assessed	DSC_1233.JPG	Palustrine	marsh	slope	Sedgeland	Carex?	33%		0.35		Eastern HB	14
3329	Assessed	DSC_1233.JPG	Palustrine	marsh	slope	Exotic grassland		33%		0.35		Eastern HB	14
2343	Assessed	Mangataura Wetland	Palustrine	swamp	oxbow lake	Open water		30%		0.51	1.7	Heretaunga	15
2343	Assessed	Mangataura Wetland	Palustrine	swamp	oxbow lake	Shrubland	DACdac - mix	30%		0.51	1.7	Heretaunga	15
2343	Assessed	Mangataura Wetland	Palustrine	swamp	oxbow lake	Sedgeland	Carex	40%		0.68	1.7	Heretaunga	15

Appendix 2 – Wetland Record Sheet: Mangatewai Wetland 2167, field sheet

WETLAND RECORD SHEET

Wetland name: 2167 Mangatewhai Stream **Date:** 1/7/2016
Region: Hawkes Bay **GPS/Grid Ref.:** E1876575 N5569306
Altitude: 320m asl **No. of plots sampled:** 2

Classification: I System	IA Subsystem	II Wetland Class	IIA Wetland Form
Palustrine	Permanent	Swamp	Oxbow

Field team: Keiko Hashiba, Ben Clarkson, Scott Bartlam

Indicator	Indicator components	Specify and Comment	Score 0–5[1]	Mean score
Change in hydrological integrity	Impact of manmade structures	Farmtrack to S, minor ditches by stream	4	
	Water table depth	Regularly high	4.5	4.16
	Dryland plant invasion	low - Hyasteria, Spanish heath, bracken	4	
Change in physico-chemical parameters	Degree of sedimentation/erosion	Minor - from hillside + stream	4	
	Nutrient levels	Occasional grazing on margins Low mostly	4	4
	Von Post index	N/A		
Change in ecosystem intactness	Loss in area of original wetland	Mainly intact - some loss by stream,	4	
	Connectivity/fish barriers	Mainly intact - some loss by stream (Mytchett dam)	4	4
	Recent vegetation damage/clearance	Minor - mainly on margins old fire damage on beech spurs	4	
Change in browsing, predation & harvesting regimes	Damage by stock/feral browsers	Minor	4	
	Introduced predator impacts on wildlife	Some pest/possum control, but high rodent damage on passionfruit.	2	4.16
	Harvesting levels	Probably low	4	
	Native animal species occupancy decline	Fernbirds + wetland birds not recorded.	2.5	
Change in dominance of native plants	Introduced plant canopy cover	Minor - some Hm. honeysuckle, Spanish Heath, possible	4	
	Introduced plant understorey cover	Minor - pasture grasses + weeds	4	3.83
	Native plant species occupancy decline	Induced vegetation - former forest burnt but recovering	3.5	
Total wetland condition index /25				20.15

No fernbirds noted

[1] Assign **degree of modification** as follows: 5=v. low/ none, 4=low, 3=medium, 2=high, 1=v. high, 0=extreme

Main vegetation types: raupo reedland, mixed shrubland (COLE var, COPrig), kahikatea treeland (DACdac, ELEedw), minor pockets of MACrub or ELEacu sedgeland

Native fauna: Tui, grey warbler

Other comments: Good condition wetland

Pressure	Score[2]	Specify and Comment
Modifications to catchment hydrology	2	Immediate Catchment mostly in native forest
Water quality decline in catchment	2	Low - Mainly from upstream agricultural inputs
Animal access	3	Prob. high as no fences
Key undesirable species	2	Low - Hm honeysuckle, Spanish heath
% catchment in introduced vegetation	2	Mainly native in immediate catchment
Other landuse threats		
Total wetland pressure index /30	11	

[2] Assign pressure scores as follows: 5=very high, 4=high, 3=medium, 2=low, 1=very low, 0=none

Appendix 3 – Wetland Plot Sheet: Mangatewai Wetland 2167, Plot 1 field sheet

Glyceria - cross walls
This is not the right habitat

WETLAND PLOT SHEET

Toecoe - waxy white e. reeve no ear like e. flu. oracle.

Wetland name: 2167 (mangatewai stm wetland) **Date:** 1/7/2016 **Plot no:** 1
Plot size: 5m x 5m **Altitude:** **GPS:** E1876575 N5[illegible]
Recorder: BC, KH **Veg structure:** Reedland **Composition[1]:** TYP.ori / BLE nov.

Species (* for exotics)	Cover %[2]	Height m		Cover class 1<1%, 2 1-5%, 3 6-25% 4 26-50%, 5 51-75% 6 76-100%					Seed-ling #[3]	IS[4]	Notes
		Max	Avg	<0.3 m	0.3-1 m	1-2 m	2-5 m	>5 m			
OLE vir	0.5	1.80	1.60	—	1	1	—				
TYP ori	50	2.6	1.6	4	4	3	2	—			summer green
BLE nov.	50	1.2	0.85	4	4	2	—				branches off drooping
CAR sec	4	1.30	1.0	2	2	1	—				
Tall fescue SCH aru ?	0.5	0.65	0.55	1	1	—					Sheath (ie. carex is attached.)
ELE acu	0.5	0.80	0.65	1	1	—					ear-lobe (carex)
EPL Pal ?	0.5	0.70	0.55	1	1	—					
COR flu	2	1.9	1.5	1	2	1	—				
BOH ang	0.5	1.80	1.60	1	1	1	—				Hoh. angustifolia
Car wide leaf (W)	1	1.30	1.10	1	1	1	—				no flowers Winter die back.
CLE pan	0.5	0.9	0.7	1	1	—					
COP rig	0.5	1.15	0.90	1	1	1	—				

Litter (total %)	75	Bare Ground (total %)	0.5	Photo (SW corner) N:	✓
Bryophytes (total %)	—	Water (total %)	5	Photo (SW corner) E:	✓

[1]Atkinson bird's eye view method, ie /or – for different or same height; 50-100%, 20-49% (10-19%) [1-9%]
[2]Live shoot biomass for each species; total plot cover usually >100%. Note dead foliage if >20% cover
[3]Woody seedling number: actual count for low numbers, otherwise estimate; [4]Indicator Status e.g. OBL (page 2)

DO 2.63

Field measurements:

Water table cm	+7cm	Water conductivity uS	67.1
Water pH (if present)	@ 6.98	Von Post index (peatlands)	N/A
Water temperature	6.6	Species foliage (list)	BLE nov, CAR sec.
Soil cores collected (√)	✓ all litter needs to be removed. Soil sunfull under water, avoid		

Comments/additional species in vicinity in same vegetation type:

Spp. outside plot – COP luc, LEPsco
COP rob
COR aus
HEB Str
Dense understorey (hard for seedling count)

– Lots of litter understorey and ground

litter detached from stem, on ground & perched.

Appendix 4 – Wetland Plot Sheet Page 2, Mangatewai Wetland 2167, Plot 1

Wetland Plot Sheet: Page 2

Wetland Name: Mangatewai Wetland 2167 **Date:** 1-07-2016 **Plot No.:** 1

Plot vegetation (use plot data only: vascular species and *Sphagnum*)	%
A Native species cover: sum of % cover for all native species	110
B Total species cover: sum of % cover for all plants	110.5
A/B*100, i.e. % native vegetation cover	99.5%
C Native species richness: number of native species	11
D Total species richness: total number of species	12
C/D*100, i.e. % native species number	92%

Soil core laboratory analysis (two soil core subsamples):

Water content % dry weight	1656	Total (organic) C %	42.4
Bulk density T/m^3	0.048	Total N %	2.18
pH	6.29	Total P mg/kg	0.198
Conductivity µS (optional)	0.38	Total K % (optional)	0.150

Foliage laboratory analysis (leaf/culm sample of dominant canopy species and wetland target species):

Species	% N	% P	% C	% K optional
Blechnum novae-zelandiae	43.8	1.24	0.121	1.19
Leptospermum scoparium	55.4	1.12	0.130	0.47
Carex secta	44.3	1.51	0.156	1.49

Prevalence index summary worksheet

Total % cover of:		Multiply by:	
OBL species	55	× 1 =	55
FACW species	0	× 2 =	0
FAC species	54	× 3 =	162
FACU species	1	× 4 =	4
UPL species	0.5	× 5 =	2.5
Column totals:	(A) 110.5		(B) 223.5
Prevalence index[a] = B/A = 2.023			

[a] In the US, if PI ≤ 3, vegetation is hydrophytic (i.e. wetland veg). Changes in PI over time indicate hydrology changes.

Appendix 5 – Prevalence index data, Mangatewai Wetland 2167, Plot 1

Prevalence index – Mangatewai Wetland 2167, Plot 1

Indicator group	Species name	Percent cover, by species	Total cover, by group	Weighting factor	Product
OBL	*Carex secta* *Eleocharis acuta* *Epilobium pallidiflorum* *Typha orientalis*	4 0.5 0.5 50	55	1	55
FACW			0	2	0
FAC	*Austroderia fulvida* *Blechnum novae-zelandiae* *Carex* sp.* *Hoheria angustifolia* *Schedonorus arundinaceus*	2 50 1 0.5 0.5	54	3	162
FACU	*Coprosma rigida* *Olearia virgata*	0.5 0.5	1	4	4
UPL	*Clematis paniculata*	0.5	0.5	5	2.5
	Totals		(A) 110.5		(B) 223.5
Hydrophytic vegetation determination	Prevalence index = B/A = 2.023 _ Hydrophytic Vegetation by PI Indicator? ✓ Yes No				

Notes

If PI = 3.0 or less, the site is defined as having hydrophytic vegetation (i.e. it satisfies one criterion for delineating wetlands) (US Wetland delineation approach; Environmental Laboratory 1987).

The PI is more easily calculated using a spreadsheet (e.g. Excel). It is expanded here to show the working out.

* The indicator group for *Carex* sp. was conservatively estimated as FAC. Identification of the species, once flowers/fruit are available, will enable an accurate classification. However, its cover was very low, so a change in indicator status will not significantly affect the PI.

Appendix 6 – Guidelines for scoring indicator components for wetland condition

The following is modified from Table 5 of the *Handbook for Monitoring Wetland Condition* (Clarkson et al. 2004). Please note:

- The P1 indicator component of the Clarkson et al. (2004) *Handbook* has now been subsumed into P2: 'Nutrient levels', and E3: Recent vegetation clearance.
- New indicator components are: B4: 'Native animal species occupancy decline', and D3: 'Native plant species occupancy decline'

Indicator and components	Score and degree of modification					
	5 None/very low	4 Low	3 Moderate	2 High	1 Very high	0 Extreme
Δ Hydrological integrity						
H1: Impact of man-made structures	None or not impacting on wetland.	Affect less than 25% of the wetland.	Affect 25–49% of the wetland.	Affect 50–75% of the wetland.	Dominate wetland (> 75%)	Totally dominated or affected by man-made structures.
H2: Δ Water table depth	No detectable changes.	Abnormally lowered (or raised) only occasionally and temporarily	Noticeably lower for short periods during dry spells. Average water table shows small but definite decline over time.	Lowered for long periods during dry spells. Average water table in wetland has noticeably declined over time.	Very low for most of year; not recharged fully by high rainfall events. Average water table much lower than previously.	Unable to be easily measured throughout season. Now a 'dryland' or artificially totally flooded.
H3: Dryland plant invasion	No / virtually no dryland plants in wetland.	< 25% of wetland has dryland plant species present	25–49% of wetland has dryland plant species present.	50–75% of wetland has dryland plant species present.	> 75% of wetland has dryland plant species present.	All species (100%) in community are dryland species
Δ Physicochemical parameters						
P1: Degree of sedimentation/ erosion	None: high water clarity (< 40 NTU), no visible sediment, stable banks and soil.	Water clarity 41–80 NTU; or visible sediment deposits affect < 25% of wetland; or some minor spot erosion visible.	Water clarity 81–120 NTU; or visible sediment deposits affect 25–49% of wetland; or erosion spots linked and causing minor	Water clarity 121–160 NTU; or visible sediment deposits affect 50–75% of wetland; or widespread erosion or scouring over greater	Water clarity >160 NTU; or visible sediment deposits affect >75% of wetland; or widespread erosion causes severe damage	All wetland character lost due to prolonged extreme turbidity, almost total infilling by sediment, or unchecked erosion and scouring.

Indicator and components	Score and degree of modification					
	5 None/very low	4 Low	3 Moderate	2 High	1 Very high	0 Extreme
			structural damage.	than 50% of area.	throughout.	
P2: Nutrient levels	No evidence of eutrophication.	Localised (< 25%) or infrequent signs of algal blooms or changes in nutrient concentrations or vegetation composition.	25–49% of area shows algal blooms, increased nutrients (including from fire) or vegetation change to high-nutrient species.	50–75% of area shows algal blooms, increased nutrients or vegetation change to high-nutrient species.	Eutrophication has shifted > 75% of system to almost continuous algal blooms or monospecific stands of high-nutrient plants.	All wetland character lost due to eutrophication: now just a pond or dryland with no higher wetland plants present.
P3: von Post index Relevant to peat bogs only	1 undecomposed; plant structure unaltered, yields clear colourless water.	2–3; plant structure distinct, yields clear, yellow or brown water.	4–5; plant structure becoming indistinct. Yields turbid brown water, some peat may escape between fingers, residue mushy.	6–7; plant structure indistinct, about half the peat escapes between fingers, residue strongly mushy.	8–9; plant structure very indistinct, two-thirds to almost all peat escapes between fingers.	10 completely decomposed; plant structure unrecognisable, all peat escapes between fingers.
Δ Ecosystem intactness						
E1: Loss in area of original wetland	No loss: original wetland area essentially intact.	< 25% of original area lost.	25–49% of original area lost.	50–75% of original area lost.	> 75% of original area lost, remnants still retain some original character.	Wetland lost, or almost lost but remnants completely modified.
E2: Connectivity barriers	None: all natural upstream and downstream connections retained.	< 25% of upstream or downstream connection lost.	25–49% of upstream or downstream connection lost.	50–75% of upstream or downstream connection lost.	> 75% of connection lost with some minor links remaining.	Isolated: all former connections to other water bodies lost.
E3: Recent vegetation damage/ clearance	None / no evidence of recent vegetation removal	Recent vegetation removal in < 25% of wetland, e.g. < 2 yr fires or clearance	Recent vegetation removal in 25–49% of wetland; or veg. in 50–75% wetland still recovering	Recent veg. removal affected 50–75% of wetland; or veg. in >75% wetland still recovering from	Recent clearance (< 2 yr) affected > 75% of wetland; or fire sensitive/disturbance sensitive species now	All or most wetland vegetation cleared or destroyed (e.g. by bulldozer, fire, etc.)

Indicator and components	Score and degree of modification					
	5 None/very low	4 Low	3 Moderate	2 High	1 Very high	0 Extreme
			from older clearance or fires.	older clearance/ fires	extinct	
Δ Browsing, predation & harvesting regimes						
B1: Damage by domestic or feral animals	No domestic animal or feral animal browsing or trampling damage.	< 25% of wetland showing light–medium damage; or very light or localised browsing throughout wetland.	25–49% of wetland showing medium–heavy browsing and/or trampling damage.	50–75% of wetland medium–heavily browsed and/or trampled.	>75% of wetland heavily browsed and/or trampled.	All wetland character lost due to severity of browsing and trampling activity.
B2: Introduced predator impacts on wildlife	No virtually no predator access or impact; or wetland and catchment under long-term effective predator control.	Low levels of predators – susceptible wildlife spp. still present; or pulsed predator control. Low predator reinvasion from catchment.	Medium predator impact, decline in numbers of some wildlife species; or control very intermittent or of not all predators. Medium reinvasion from catchment.	High declines in populations and/or loss of 1 or 2 wildlife species; or no or ineffective predator control. High reinvasion from catchment.	Severe declines in wildlife population and species number; or no predator control. Very high reinvasion from catchment. Predators/signs visible.	Extreme: most native wildlife species extinct in wetland. Predators/signs highly visible.
B3: Harvesting levels	No harvesting (plants, birds, fish or other components) activity in wetland.	< 25% of wetland with medium–heavy harvesting damage; or light damage throughout wetland; or virtually recovered from earlier harvesting.	25–49% of wetland affected by active harvesting; or 50–75% of wetland recovering from earlier harvesting.	50–75% of wetland affected by active harvesting; or > 75% of wetland recovering from earlier harvesting.	Active harvesting affecting > 75% of wetland.	All wetland character lost due to harvesting activity.
B4: Native animal species occupancy decline	All expected or typical fauna species present for	Most expected fauna species present and/or	Moderate numbers of expected fauna species present. Loss of a few	High decline in expected fauna. Sensitive species absent	Only common/ cosmopolitan or visiting native species	Extreme: all or virtually all typical wetland fauna absent.

Indicator and components	Score and degree of modification					
	5 None/very low	4 Low	3 Moderate	2 High	1 Very high	0 Extreme
	relevant wetland type and in good numbers.	numbers starting to decline	sensitive species and/or numbers declining		present and numbers much reduced	
Δ Dominance of native plants						
D1: Introduced plant canopy cover	No introduced plants in canopy (i.e. all plants are native).	< 25% canopy cover of introduced plants.	25–49% canopy cover of introduced plants.	50–75% canopy cover of introduced plants.	> 75% canopy cover of introduced plants.	All canopy plants are introduced.
D2: Introduced plant understorey cover	No / virtually no (< 1%) plants in understorey are introduced.	< 25% cover of introduced plants in understorey.	25–49% cover of introduced plants in understorey.	50–75% cover of introduced plants in understorey.	> 75% cover of introduced plants in understorey.	All / virtually all (> 99%) plants in understorey are introduced.
D3: Native plant species occupancy decline	All expected or typical plant species composition, structure and habitat present for relevant wetland type	Most expected or typical species present and typical structure and habitats intact	Moderate numbers of expected plant species present. Loss of a few sensitive species and/or population numbers declining	High declines in expected plant composition, structure and habitat. Sensitive species absent.	Only common/ cosmopolitan native species present (e.g. mānuka). Wetland native species richness very low.	Extreme: all or virtually all typical native wetland plant species, structure and/or habitat absent

Appendix 7 – Field record sheet templates

These comprise:

- Wetland Record Sheet
- Wetland Plot Sheet (pages 1 and 2)
- Prevalence index worksheet

WETLAND RECORD SHEET

Wetland name: **Date:**

Region: **GPS/Grid Ref.:**

Altitude: **No. of plots sampled:**

Classification: I System	IA Subsystem	II Wetland Class	IIA Wetland Form

Field team:

Indicator	Indicator components	Specify and Comment	Score 0–51	Mean score
Change in hydrological integrity	Impact of man-made structures			
	Water table depth			
	Dryland plant invasion			
Change in physico-chemical parameters	Degree of sedimentation/erosion			
	Nutrient levels			
	Von Post index			
Change in ecosystem intactness	Loss in area of original wetland			
	Connectivity/fish barriers			
	Recent vegetation damage/clearance			
Change in browsing, predation & harvesting regimes	Damage by stock/feral browsers			
	Introduced predator impacts on wildlife			
	Harvesting levels			
	Native animal species occupancy decline			
Change in dominance of native plants	Introduced plant canopy cover			
	Introduced plant understorey cover			
	Native plant species occupancy decline			
Total wetland condition index /25				

Note: Assign degree of modification as follows: 5 = very low/none, 4 = low, 3 = medium, 2 = high, 1 = very high, 0 = extreme

Main vegetation types:

Native fauna:

Other comments:

Pressure	Score2	Specify and Comment
Modifications to catchment hydrology		
Water quality decline in catchment		
Animal access		
Key undesirable species		
% catchment in introduced vegetation		
Other land-use threats		
Total wetland pressure index /30		

Note: Assign pressure scores as follows: 5 = very high, 4 = high, 3 = medium, 2 = low, 1 = very low, 0 = none

WETLAND PLOT SHEET

Wetland name:	**Date:**	**Plot no:**
Plot size:	**Altitude:**	**GPS:**
Recorder:	**Veg. structure:**	**Composition[1]:**

Species (* for exotics)	**Cover %[2]**	**Height m**		**Cover class** **1** <1%, **2** 1–5%, **3** 6–25%, **4** 26–50%, **5** 51–75%, **6** 76–100%					**Seed -ling #[3]**	**Notes**
		Max	Avg	< 0.3 m	0.3–1 m	1–2 m	2–5 m	> 5 m		

Litter (total %)		**Bare Ground** (total %)		**Photo** (SW corner) N:	
Bryophytes (total %)		**Water** (total %)		**Photo** (SW corner) E:	

[1] Atkinson bird's eye view method (i.e. / or – for different or same height; 50–100%, 20–49% (10–19%) [1–9%]

[2] Live shoot biomass for each species; total plot cover usually > 100%. Note dead foliage if > 20% cover

[3] Woody seedling number: actual count for low numbers, otherwise estimate.

Field measurements:

Water table cm		Water conductivity µS	
Water pH (if present)		Von Post index (peatlands)	
Soil cores collected (✓)		Foliage collected (list species)	

Comments/additional species in vicinity in same vegetation type:

Wetland Plot Sheet: Page 2

Wetland Name: **Date:** **Plot No.:**

Plot vegetation (use plot data only: vascular species and *Sphagnum*)	**Total**
A Native species cover: sum of % cover for all native species	
B Total species cover: sum of % cover for all plants	
A/B*100, i.e. % native vegetation cover	
C Native species richness: number of native species	
D Total species richness: total number of species	
C/D*100, i.e. % native species number	

Soil core laboratory analysis (two soil core subsamples):

Water content % dry weight		Total (organic) C %	
Bulk density T/m^3		Total N %	
pH		Total P mg/kg	
Conductivity µS (optional)		Total K % (optional)	

Foliage laboratory analysis (leaf/culm sample of dominant canopy species and wetland target species):

Species	%N	%P	%C	%K optional

Prevalence index summary worksheet

Total % cover of:		Multiply by:	
OBL species		× 1 =	
FACW species		× 2 =	
FAC species		× 3 =	
FACU species		× 4 =	
UPL species		× 5 =	
Column totals:		(A)	(B)
Prevalence Index[a] = B/A =			

[a] In the US, if PI ≤ 3, vegetation is hydrophytic (i.e. wetland vegetation). Changes in PI over time indicate hydrology changes.

Table 1: Prevalence Index

Indicator Group	Species Name	Percent Cover by Species	Total Cover by Group	Weighting Factor	Product
OBL				**1**	
FACW				**2**	
FAC				**3**	
FACU				**4**	
UPL				**5**	
	Totals		**(A)**		**(B)**
Hydrophytic Vegetation Determination	Prevalence Index = B/A = _ Hydrophytic Vegetation by PI Indicator? ___ Yes ___ No				

Note: If PI = 3.0 or less, the site is defined as having hydrophytic vegetation(i.e. it satisfies one criterion for delineating wetlands)

(US Wetland delineation approach, Environmental Laboratory 1987.)

Appendix 8 – Variables for Wetland Condition Index states (bands), by wetland type

Source: Interim report on quantitative limits to maintain ecological integrity of wetlands (Clarkson et al. 2015).
***n* = number (*n* varies as individual wetlands may have multiple plots and, in earlier samplings, not all variables were analysed), perc10 = 10th percentile, perc90 = 90th percentile**

TotalCondition	Type	Number	TotalCondition	NutrientCondition	SoilpH				SoilvonPost				SoilTotalN				SoilTotalN.Vol			
State		*n*	mean	mean	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*
>20-25	Bog	16	22.711	4.671	3.948	5.008	4.494	39	1.5	4.8	2.9	23	0.697	2.136	1.282	39	0.266	1.949	0.921	35
>20-25	Fen	27	21.481	4.058	4.567	5.609	5.068	88	3.0	9.0	5.0	70	0.725	2.043	1.398	88	0.394	2.169	1.328	88
>20-25	Swamp	28	21.429	4.352	4.846	6.394	5.658	49	0.0	10.0	3.6	8	0.627	2.013	1.416	48	0.652	3.169	1.791	45
>15-20	Bog	9	16.070	3.892	3.645	4.527	4.128	22	3.0	7.0	4.2	51	1.257	2.050	1.690	22	0.866	2.026	1.390	22
>15-20	Fen	11	16.183	3.667	4.428	6.488	5.457	15	0.0	8.0	4.1	8	0.590	2.068	1.305	15	0.850	3.120	2.950	11
>15-20	Swamp	31	18.686	3.792	4.984	6.130	5.589	49	0.0	7.3	2.8	18	0.427	2.324	1.487	98	0.719	3.267	1.859	96

TotalCond	Type	SoilBD				SoilTotalP				SoilTotalP.Vol				SoilNtoP				SoilTotalC			
State		perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*
>20-25	Bog	0.036	0.092	0.063	35	102.40	1427.60	648.64	39	0.005	0.114	0.062	35	11.213	92.309	45.256	39	46.28	53.68	49.42	23
>20-25	Fen	0.049	0.153	0.105	88	295.10	1330.00	747.16	88	0.016	0.176	0.083	88	11.024	37.637	24.776	88	12.70	47.72	34.57	60
>20-25	Swamp	0.060	0.250	0.164	46	452.60	2235.20	1277.62	47	0.047	0.376	0.189	45	5.415	24.872	14.024	47	8.90	42.70	26.19	44
>15-20	Bog	0.060	0.120	0.082	22	338.60	957.20	616.64	22	0.023	0.088	0.053	22	19.105	42.275	33.210	22	45.79	51.20	49.45	22
>15-20	Fen	0.080	0.510	0.231	11	200.40	1219.60	804.40	15	0.031	0.319	0.130	11	7.102	40.180	42.378	15	10.44	40.60	28.34	12
>15-20	Swamp	0.061	0.629	0.212	96	724.90	1715.00	1240.67	98	0.055	0.751	0.247	96	4.431	19.940	12.839	98	11.10	43.15	29.09	49

TotalCond	Type	SoilTotalC.Vol				FENZ.EI				FENZ.EI.Nitrate				PropSppNative				PropAreaWetlandTypeRemain			
State		perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*	perc10	perc90	mean	*n*
>20-25	Bog	17.92	47.76	29.54	19	0.234	0.828	0.429	44	0.988	0.999	0.973	44	0.86	1.00	0.95	45	0.58	0.95	0.86	44
>20-25	Fen	19.44	42.21	29.59	60	0.226	0.795	0.343	161	0.978	0.995	0.981	161	0.79	1.00	0.93	159	0.54	0.84	0.59	161
>20-25	Swamp	15.07	52.02	29.81	42	0.225	0.928	0.515	51	0.935	0.993	0.902	51	0.43	1.00	0.81	50	0.18	0.92	0.57	51
>15-20	Bog	30.14	61.27	40.80	22	0.346	0.346	0.352	51	0.979	0.989	0.980	51	0.80	1.00	0.94	51	0.15	0.44	0.40	51
>15-20	Fen	33.57	108.89	66.81	8	0.304	0.889	0.749	57	0.902	0.980	0.903	57	0.20	1.00	0.49	56	0.17	0.46	0.23	57
>15-20	Swamp	13.72	45.40	29.73	49	0.257	0.795	0.458	113	0.946	0.986	0.967	113	0.33	1.00	0.63	109	0.10	0.73	0.59	113

Explanation of variables and units in above table.

Source: Tables 1 and 2 in Interim report on quantitative limits to maintain ecological integrity of wetlands (Clarkson et al. 2015).

Summary of predictor variables investigated for explaining the variation in wetland condition

Predictor Variables	Description	Code	Units
Physico-chemical	Soil pH	SoilpH	pH Unit
	Soil Bulk Density	SoilBD	g/cm^3
	Soil total nitrogen: gravimetric	SoilTotalN	%
	Soil total nitrogen: volumetric	SoilTotalN.Vol	mg/cm^3
	Soil total phosphorus: gravimetric	SoilTotalP	mg/kg
	Soil total phosphorus: volumetric	SoilTotalP.Vol	mg/cm^3
	Soil N:P ratio	SoilNtoP	ratio
	Soil total C: gravimetric	SoilTotalC	%
	Soil total C: volumetric	SoilTotalC.Vol	mg/cm^3
	Soil von Post (peat decomposition measure)	SoilvonPost	1–10
GIS-based	Proportion of wetland area remaining for the wetland type at an individual wetland scale	PropAreaWetland TypeRemaining	0–1
	Nitrate integrity, a surrogate measure of impact of land use intensity (nitrate leaching risk), in FENZ* (from Ausseil et al. 2008, Leathwick et al. 2010)	FENZ.EI.Nitrate	0–1
	Wetland ecological integrity index, in FENZ* (Ausseil et al. 2008, Leathwick et al. 2010)	FENZ.EI	0–1

* FENZ = Freshwater Ecosystems of New Zealand, a national geospatial database that maps the extent, condition and threats of wetland, lake and river ecosystems.

Summary of response variables investigated for explaining the variation in wetland condition

Response Variables	Description	Code	Units
Wetland ecological condition[1]	Wetland condition index (WCI of Clarkson et al. 2004)	TotalCondition	0–25
	Nutrient condition index ('P3: Nutrient levels' component of the WCI physico-chemical indicator)	NutrientCondition	0–5
	Wetland ecological integrity index of FENZ (Ausseil et al. 2008)	FENZ.EI	0–1
Biotic condition measures	Proportion (%) of plant species richness that is native	PropSppNative	0–1

Note that the FENZ wetland ecological integrity measure (FENZ.EI) was used as both a response variable and a predictor variable, but was not modelled against itself.

Appendix 9 – Analysing change

Source: *Handbook for Monitoring Wetland Condition* (Clarkson et al. 2004)

Change in condition may be analysed at different scales and within different layers of the classification system (as in Phase 1). The monitoring framework used may be Environmental Domain, Ecological District, council administration boundary, bioclimatic zone, wetland class, vegetation type, or any other similar ecological grouping. Wetland indicators may also be analysed at different levels or any combination of levels from the hierarchical classification depending on the aim of the monitoring project, e.g. total score index, individual indicator sub-index, or separate component indicator score. Similar levels may be used for analysis of indicators and data at the plot scale. Monitoring practitioners should develop their own techniques for interpretation of data and analysing change, designed to meet the needs of their specific monitoring projects. Some examples of different ways of analysing change in condition are as follows:

- If organisations wanted to assess the effectiveness of a fencing/stock exclusion education programme then the indicator component 'B1: Damage by domestic or feral animals' would be compared at time = 1 (pre-programme) and t = 2 (post-programme).
- Willow has newly arrived in a district and has started to invade wetlands. Swamps, being of relatively high fertility, are the most susceptible wetland class, so plot data for swamps throughout the district are analysed. Comparison of the plot indicator 'Canopy % cover introduced species' at t = 1 and t = 2 reveals the percent of swamps that have declined in condition (and the percent improved and percent unchanged or steady). The extent of the decline can be calculated from the raw quantitative data. These plot data, together with reconnaissance and other information (e.g. aerial photo comparisons at t = 1 and t = 2), provide the basis for assessing the wetland indicator component 'D1: Introduced plant canopy cover'.
- Changes in indicator sub-index (or indicator component scores) may be presented in several ways, e.g., as radar charts or bar graphs using simple graphing packages such as Microsoft Excel. Fig. 1 illustrates two ways of presenting the same data. These should also be accompanied by the raw data, e.g., indicator sub-indices or indicator component scores.
- At a district/region-wide scale, a summary of the trend in wetland condition may be required to show what proportion of the number of wetlands is deteriorating, improving or remaining steady. A pie chart based on the overall wetland index score at t = 1 and t = 2 effectively illustrates wetland condition (Fig. 2). This technique could also be applied to area data (using wetland extent information from Phase 1) to show the trends in condition for the total wetland area within the region. Other appropriate levels for illustrating and comparing changes include the wetland system (palustrine, estuarine), class (marsh, swamp, fen, bog), vegetation type, or other suitable grouping.

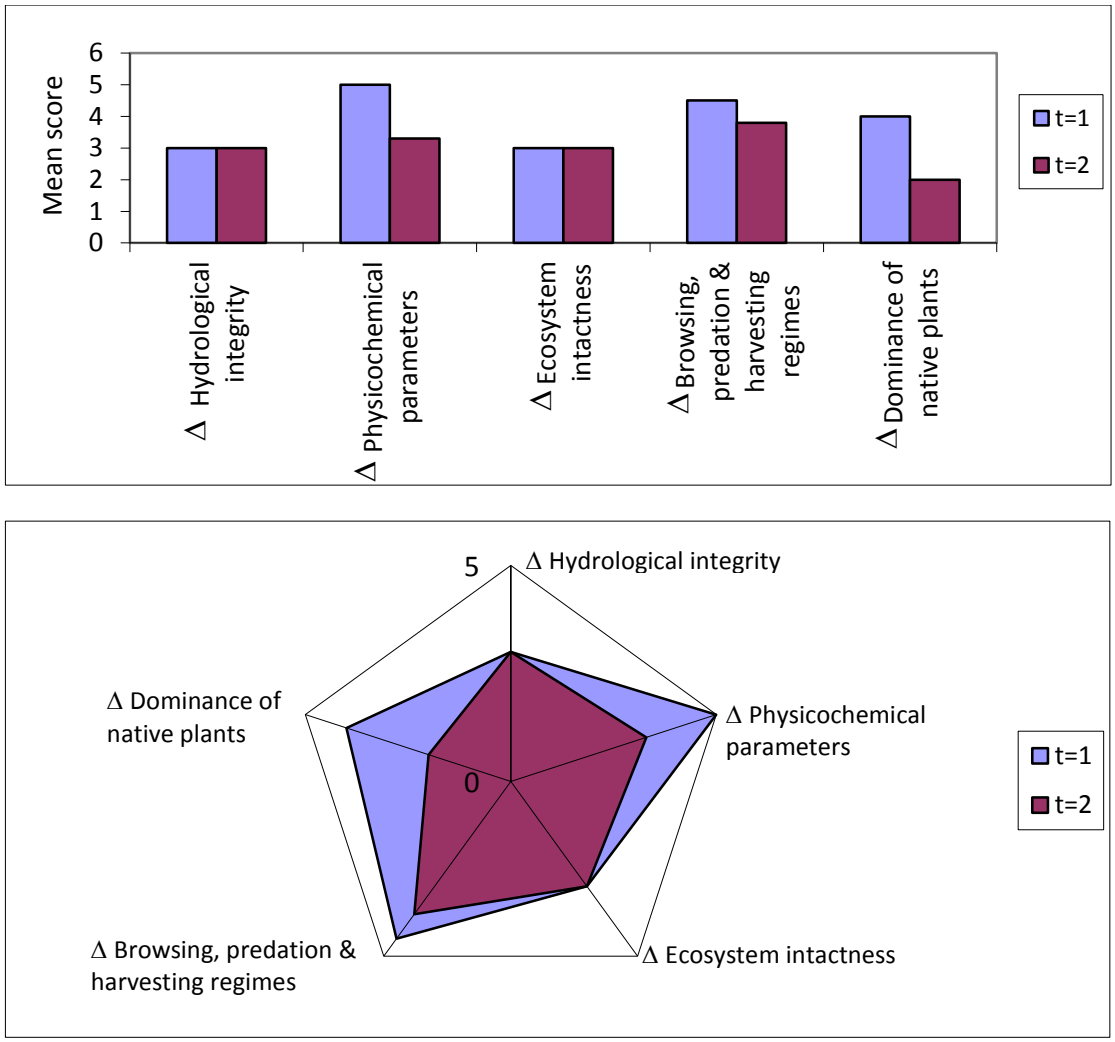

Figure 1 Representing change in condition over time using bar graphs (above) and radar charts (below: pentagon represents the unmodified condition). In both cases, t = 1 represents an initial sampling time and t = 2 a later sampling time. Deterioration in scores for changes in physicochemical parameters, browsing, predation & harvesting levels, and dominance of native plants, have lowered the overall condition index from 19.5 to 15.1.

- The condition and pressure indicators could be used together to determine priorities for wetland management. Wetlands that had a high condition index and a high pressure score would be obvious candidates for targeting resources or further monitoring.

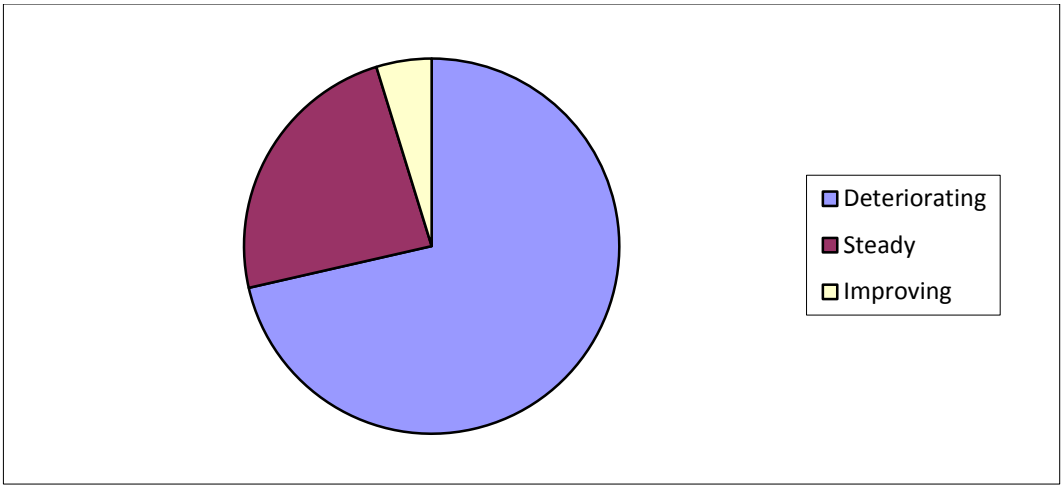

Figure 2 Pie chart showing use of the index to represent change in wetland condition at district or region-wide scales.