MONITORING CHANGES IN WETLAND EXTENT: AN ENVIRONMENTAL PERFORMANCE INDICATOR FOR WETLANDS

Coordinated Monitoring of New Zealand Wetlands
A Ministry for the Environment SMF Funded Project

Final Report – Project Phase One

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EXECUTIVE SUMMARY

This report documents Phase One of the Coordinated Monitoring of New Zealand Wetlands (SMF) project, which is aimed at developing a nationally consistent methodology for mapping and monitoring New Zealand's wetlands.

Phase One of this Wetlands Project has successfully developed and evaluated a classification system as a framework for analysis of the spatial extent (indicator) of wetland types. Included within the outputs of this phase are practical tools and guidelines for wetland managers in New Zealand. These tools and guidelines are the basis for effective and coordinated wetlands inventory, monitoring and management, using spatial extent as an indicator of the state of New Zealand's wetlands.

During initiation of any wetlands monitoring project, we recommend building collaborative partnerships with local government authorities, Department of Conservation (DoC) staff, scientists, Mâori organisations and individuals, and landowners if appropriate. Potential points of contact are listed in Appendix 2.

Information about the wetland of interest may be collected from a number of sources and these are listed in this report. Advice is given on the application of remote sensing and ground survey techniques. Also outlined are processes for partnership and two-way information sharing with Mâori organisations. We see this as a key component of coordinated wetlands monitoring and management in the future.

Phase One of this project focused on a working classification for Palustrine and Estuarine wetlands. However, wetland systems are often linked ecologically (e.g, Estuarine and Marine, and Palustrine and Lacustrine) and the demarcation between them is not always clear. Therefore, an overall wetlands classification framework is presented in tabular of major wetland systems: Palustrine and Estuarine (Table 2), Geothermal and Plutonic (Table 3), and Marine, Lacustrine and Riverine (Table 4).

Application of the classification system is outlined and a Glossary of Wetland Terms and Definitions is given to assist in differentiating wetland types and defining wetland boundaries. Guidelines on the most appropriate scale and recommended mapping protocols are also given.

1

2 ORIGINS OF THE WETLANDS SMF PROJECT

During the development of environmental indicators for freshwater by the Ministry for the Environment (MfE), as part of the national Environmental Performance Indicators Programme (EPIP), it was realised that very little information existed on appropriate indicators for monitoring wetlands. A workshop was convened at Lincoln Environmental, Lincoln University in September 1996 with seven wetland scientists to help MfE to develop these indicators.

Two categories of indicators were identified:

- region specific indicators including spatial extent of wetlands and their number measured using aerial photographs and maps
- site specific indicators built around the ecological elements of natural character and wetland condition[1].

The need for a wetland classification became apparent because indicators may vary according to wetland type. Several classifications had already been attempted in New Zealand as well as overseas, but none were considered adequately developed or sufficiently relevant to the New Zealand context post-Resource Management Act (1991).

Since no wetland indicators were available as Stage 1 "ready to use" for the EPIP, this project aimed to develop indicators of spatial extent in Phase One and indicators of wetland condition in Phase Two.

This report documents Phase One of the Coordinated Monitoring of New Zealand Wetlands (SMF) project (Wetlands Project), which aimed to develop a nationally consistent methodology for mapping and monitoring NZ wetlands.

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[1] Ward and Pyle, 1997.

4 PROJECT OVERVIEW AND DESIGN

The main objective of Phase One of the Wetland Project was to develop practical tools and procedures necessary to enable a consistent approach to assessing wetland spatial extent and subsequent monitoring. This involved:

1. developing a draft classification of New Zealand wetlands, trialing it in the field, and re-assessing it so that it is consistent for wetland managers to use throughout the country;

2. developing tools so that wetland managers can use the classification and available maps, aerial photographs and satellite imagery to determine the spatial extent of different wetland types in their region;

3. consulting and discussing the development of tools for wetland monitoring with tangata whenua with a view to incorporating their values and uses of wetlands in Phase Two of the Wetlands Project.

5 SUMMARY OF PHASE ONE GOALS

To manage Phase One effectively four goals were used to address the activities above. This section outlines the achievements of each goal.

5.1 Goal 1: Develop standardised hierarchical classification of NZ wetland types

To achieve Goal 1, Workshop 1 was held in March 1998 to develop a standardised hierarchical classification system for application to monitoring NZ wetlands that would be practical to managers of wetland environments. During the workshop, a tentative classification system was developed for palustrine and estuarine wetlands[2]. These classifications were subsequently tested in field trials.

5.2 Goal 2: Trial the practical application of the classification to determine spatial extent (the indicator) of wetland types

Goal 2 (commenced in April 1998) trialed the classification from Workshop 1 on sites selected in Auckland, Waikato, Canterbury, West Coast, and Southland. Trial wetlands were selected from each region on the basis of representativeness, existing information, significance, size, logistics, land use pressure and threats, and tenure[3]. The results of the trials were reported and the efficacy of the palustrine and estuarine classification systems evaluated[4].

A second workshop was held in March 1999, where the wetland classification systems developed at Workshop 1 (Goal 1) were critically evaluated in light of the results of the field trials (Goal 2). Discussion of Goals 1 and 2 focused on the anomalies in the classification systems and issues raised as a result of the trials[5].

[2] Ward and Lambie, 1998.
[3] Smith, 1998.
[4] Clarkson, 1998; Clarkson, 1999a; Clarkson, 1999b; Partridge et. al, 1999; Gerbeaux and Partridge, 1999.
[5] Ward and Lambie, 1999.

Technical issues raised at Workshop 2 were discussed and resolved by a group of wetland scientists (the Technical Group)[6] in April 1999 and a classification system for estuarine and palustrine wetland types was finalised.

5.3 Goal 3: Evaluation of remote sensing techniques for wetland identification and classification in NZ

Goal 3 (commenced July 1998) compared and evaluated colour aerial photography and SPOT satellite imagery as remote sensing techniques to identify wetland types[7]. Results of the Whangamarino pilot study suggest that both SPOT and colour aerial photograph imagery can be used to produce broad scale representations of the vegetation patterns within the wetland. SPOT imagery was useful for locating wetlands on a regional scale while colour aerial photographs proved more useful for mapping vegetation within the wetland. Supervised spectral classifications of images generated better results than unsupervised classifications. Spectral classifications also have some potential to be improved upon with better ground truth data although there is a limit to how well spectral classifiers work, because only image 'colour' is used to discriminate between vegetation classes.

5.4 Goal 4: Build a framework for partnerships with iwi for two pilot regions, with a view to developing appropriate methods to incorporate iwi values and uses of wetlands in spatial databases and decision support systems

Goal 4 (commenced July 1998) established constructive relationships between wetland researchers and tangata whenua. Consultations and discussions were held with iwi, hapû, or rûnanga representatives from Tainui, Ngâti Te Ata, Ngâti Naho, and Hauraki (North Island) and Te Rûnanga O Ngai Tahu and Papatipu Rûnanga (South Island)[8]. The relationships developed provide the basis for future partnerships with these Mâori groups. Dialogue has opened the way for understanding the requirements and approaches for Mâori environmental monitoring, and the identification of environmental indicators that incorporate Mâori values and uses of wetland ecosystems and environments.

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[6] The Technical Group is listed in Appendix 3
[7] Smith, 1999.
[8] Harmsworth, 1999.

7 TOOLS AND GUIDELINES FOR WETLAND MANAGERS

Phase One of the Wetlands Project has successfully developed and evaluated a classification system as a framework for analysis of the spatial extent (indicator) of wetland types. The outputs of this phase provide practical tools and guidelines for wetland managers in New Zealand. This section details these tools and guidelines, as the basis for effective and coordinated wetlands inventory, monitoring and management. The summary flow chart below (Table 1) of major procedural steps is provided to guide the manager through this section.

Table 1: Summary flow chart of major procedural steps

Phase 1: ***Project initiation*** (these steps are simultaneous)	Determine area or wetlands of interest.
	Develop collaborative partnership with relevant local DoC and council staff, scientists, and Mâori (Sections 4.1 and 4.2.2).
	Determine information needs (based on policy) and scale at which information is to be presented (Section 4.4.1).

Phase 2: ***Analysis of existing information*** (these steps are simultaneous)	Compile existing data on the wetland of interest (Section 4.2). Check that data sets are approximately same age, split data sets into age groups, or account for discrepancies based on time lags between data sets.
	Apply the Wetlands Classification System to existing data on the wetland of interest (Section 4.3) and map extent of wetland types based on existing data (Section 4.4).
	Determine future information needs (based on missing data needed to fulfil policy requirements and/or classification).

Phase 3: ***Determining and reporting change in extent*** (these steps are sequential)	Collect new information by fieldwork or remote sensing (Section 4.2).
	Apply classification to new information and map extent of wetland types (Sections 4.3 and 4.4).
	Determine change in extent of wetland types over time by comparing past and present maps.
	Inform project partners and relevant local people of results (ie. Sections 4.1 and 4.2.2).

7.1

7.2 Process of collaboration and partnership

One of the strengths of the Wetlands Project has been the composition and diversity of the project partners. In successfully completing Phase One, the team has developed and demonstrated an effective process of collaboration and partnership among Crown Research Institutes, Department of Conservation, local government authorities, tangata whenua and Universities.

When the project was conceived, much work went into identifying who the project partners should be. During this process, it was identified that partnerships with Mâori institutions needed strengthening. Although not a partnership, a constructive relationship has developed between wetland researchers and representatives from Tainui, Ngâti Ata, Ngâti Naho, Hauraki, Te Rûnanga O Ngai Tahu and Papatipu Rûnanga (see Section 4.2.3; iwi involvement and input). Effective mechanisms for partnership begin by developing the relationship between key contacts with local government authorities[9], DoC staff[10], scientists[11] and Mâori organisations and individuals[12].

7.3 Information collection

Existing data sources include reports on the wetland of interest, biological assessments under the Protected Natural Areas Programme (PNAP), the Wetlands of Ecological Representativeness and Importance (WERI) database, Land Resources Inventory (LRI), topography maps, mapping of wetlands extent carried out by the NZ Soil Bureau (1954, 1968) and Water and Soil Division (1979), aerial photographs, and satellite imagery. Check with regional or district councils, DoC, Fish and Game Council, National Institute of Water and Atmospheric Research (NIWA), Landcare Research, tangata whenua and universities, to determine what information these organisations already have on the wetland of interest.

7.3.1 Remote sensing

The types of remotely sensed image data that can be used to identify and map wetland environments include visible and infrared imagery from aerial photography and satellite sensors, and microwave radar imagery. To improve discrimination between non-wetland vegetation (or drained wetland with pasture) and wetlands, the imagery should be acquired in late summer or autumn when vegetative differences due to soil moisture are greatest. Ideally, the ground survey information should be gathered at the same time so that the imagery accurately represents what the ground observers see during the course of their fieldwork. Interpretation of all remotely sensed imagery requires extensive experience and competence in accurate identification of wetland vegetation classes.

Large scale monochrome, colour, and colour-infrared photography are presently used to identify and map vegetation class and surface hydrology in New Zealand wetlands using the colour, tonal variation and texture of the images[13]. Colour-infrared photography has emerged as the preferred photographic technique because it provides excellent contrast between non-wetland (dry land) and wetland vegetation. Colour-infrared is good at distinguishing "wet" areas but in not as good as colour photography for discriminating vegetation types. Results of the Whangamarino pilot

[9] Refer to Appendix 2a. These council/regulatory authority contacts may be able to assist in establishing rapport with local government authorities familiar with local wetlands.

[10] Refer to Appendix 2c. These DoC contacts may be able to assist in establishing rapport with local DoC staff familiar with local wetlands.

[11] Refer to Appendix 2d. These science contacts may be able to assist in establishing rapport with scientists familiar with local wetlands.

[12] Refer to Appendix 2b for points of contact with iwi. These individuals may be able to assist in establishing rapport with tangata whenua with local wetland interests.

[13] Wilde, 1999.

study suggest colour photographs can be applied to wetland vegetation mapping within wetlands if the appropriate visual interpretation and digital processing techniques are used, and photos are accurately georeferenced.

Limitations: *Mapping and classification of vegetation using aerial photography is labour intensive. Digital processing requires images to be scanned. Degradation of images by scanning and digitising can result in a loss of data, and the scanning, digitising, and rectification increases processing costs. Any imperfections in photographic images (for example uneven developing, or poor print quality in individual photographs) interfere with image analysis. Aerial photography is also subject to cloud contamination.*

High-resolution multispectral digital data sources include SPOT and Landsat TM imagery. Landsat TM imagery is currently not acquired for New Zealand, but archived imagery is available from Landcare Research. SPOT 4 imagery has recently become available. Results from the Whangamarino pilot study suggest SPOT satellite imagery is useful for locating wetlands on a regional scale. One of the advantages of digital multispectral imagery is that data in the infrared parts of the electromagnetic spectrum can be used to better discriminate vegetation classes than visible wavelengths (monochrome and true colour photographs) alone. Costs per hectare of satellite imagery are low when compared with the acquisition costs of aerial photos[14].

Limitations: *The spatial resolution of most images is too coarse to discriminate successfully between a range of individual vegetation species. Images from SPOT and Landsat TM are also subject to cloud contamination.*

An archive of **Synthetic Aperture Radar** (SAR) imagery of New Zealand is presently being developed by Landcare Research. Radar imagery has been used overseas to detect surface soil moisture differences. The ability for radar to detect the polarisation of the returning signal provides information about the structure (morphology and orientation) of the scattering medium (i.e. trees, rushes, pine trees vs broadleaf species, ground surface etc), so could be effective for wetland vegetation mapping. SAR is not subject to cloud contamination.

Limitation: *More research is needed to evaluate SAR imagery as a remote sensing tool for wetlands monitoring in New Zealand.*

7.3.2 Ground survey

Ground data ("ground truthing") is essential to calibrate and enable extrapolation of boundaries for wetland structure class and dominant canopy class, particularly where little field data on these is available. Techniques for ground survey will vary with wetland type and with data objectives, so are not prescribed here. Refer to Appendix I on the application of the Atkinson system to record vegetation information when doing ground surveys.

7.3.3 Iwi involvement and input

The collection of Mâori wetland information (e.g. mâtauranga Mâori) and the way it is managed in an information system, will require a high level of Mâori input to develop databases which are culturally acceptable, take account of intellectual property rights, and can handle and store

[14] Photographs need to be individually rectified before joining together to form a larger composition (mosaic). Satellite images cover more area, resulting in fewer rectifications.

sensitive information[15]. As coordinated strategies are developed for wetland monitoring and management, there will be increasing demands from Mâori organisations, government, and private agencies to access and interpret Mâori sourced information. There will also be also be an increasing desire from Mâori organisations to have access to national and regional wetland scientific and technical databases and meta-databases.

Process for partnership. The following methods were used to extend the relationship between tangata whenua and scientists in Phase One of the Wetlands Project. These are provided as guidelines for building relationships with Mâori organisations for coordinated wetland inventory, monitoring and management purposes.

- Hold participatory hui with key iwi/hapû/rûnanga representatives in a place agreed to by all parties.
- Establish working groups with Mâori representatives.
- Invite members of working groups to assist in fieldwork.
- Invite feedback from tangata whenua regarding the process of partnership and ways to strengthen relationships further.
- Share the results of research and monitoring work with Mâori representatives.

As part of a formal process, the project established that all communication should first be forwarded to a coordinator within each Mâori working group, through which project information can be disseminated to appropriate Mâori interests. The venue and participants for each hui should also be arranged between project researchers and the Mâori working group coordinator.

Process for Information sharing. In the context of information sharing, the following needs for future projects were identified by Mâori representatives in Phase One:

- There should be much greater tangata whenua involvement across all project areas if a true partnership for monitoring and managing wetlands is to be achieved;
- Recognition should be given to the role and legitimacy of mâtauranga Mâori (traditional and contemporary Mâori knowledge) in all aspects of environmental monitoring and management of wetlands;
- Culturally significant wetlands should be included, so that Mâori environmental monitoring approaches and indicators can be developed, trialed, and evaluated at these sites.

The sharing of information will be a key component for successfully managing and monitoring wetlands in future. Addressing the above requirements includes tangata whenua involvement in wetland monitoring or inventory fieldwork, wetland policy formulation, and access to wetland databases. Mâori involvement and collaboration should be supported by the development of culturally appropriate information systems, including spatial databases, by Mâori organisations such as iwi, hapû and rûnanga. It will also be essential to establish linkages between the information systems of Mâori organisations, and wetland databases held and managed by agencies such as government departments (e.g. MfE, DOC), local government authorities, Crown Research Institutes (CRIs), and universities.

7.4

[15] Harmsworth 1999.

7.5 Classification

7.5.1 Classification framework

A working classification system for New Zealand palustrine and estuarine wetland systems was the focus of Phase One[16]. This classification is presented in Table 2 (overleaf).

The classification comprises descriptors to be used at increasing levels of detail. Reading from left to right, the classification deals with coarse to fine scales of distinctive difference for wetland types. With some understanding of the wetland functions that drive or are driven by particular biotic (especially vegetation) and landscape characteristics, the classification may be used from left to right (higher to lower levels), or from right to left (lower to higher levels).

The highest (least detailed) levels consist of Level I: Hydrosystems, Level IA: Sub-systems and Level II: Wetland Class. Within these levels there is a picklist of wetland types to choose from based on salinity and broad hydrological setting (Level I), flooding regime (Level IA) and substrate, pH, and/or chemistry (Level II). Refer to Section 8: Glossary for definitions of wetland types under each level.

Level IIA: Wetland Form describes the landform in which a wetland is placed. Including this category in the classification offers the advantage that wetlands may be classified using geomorphic descriptors when other aspects such as salinity and flow regime are unknown.

Level III: Structural Class and Level IV: Dominant Cover (the most detailed level) describe the biota in the wetland. Level III describes the growth form of the vegetation or, in the case of open communities, the leading type of ground surface. Level IV is the species composition of the dominant cover. Only the dominant species are used for classification purposes to avoid the proliferation of terms.

Usually Level I would always be used to classify a wetland. The used of the other levels or combinations thereof can vary according to different data needs.

Tentative classifications for plutonic (underground) and geothermal systems are posed in Table 3, and lacustrine (lake-based), riverine (river-based), and marine systems in Table 4. The reason the classification system has been extended to include these other wetlands is that they are often integral with estuarine or palustrine systems. Therefore, an overarching framework for defining types and drawing boundaries that is compatible with the classification devised for palustrine and estuarine wetlands is needed. However, the classification of these other wetland systems, in this manner is yet, to be verified through other research initiatives. Definitions for the wetland terms embodied in these classifications can also be found in the glossary.

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[16] Partridge et al. 1999.

Table 2: SMF Coordinated Monitoring of New Zealand Wetlands classification framework for Palustrine and Estuarine wetlands.

Level I **Hydrosystem**	**Level IA** **Sub-System**	**Level II** **Wetland Class**	**Level IIA** **Wetland Form**	**Level III** **Structural Class** [examples]	**Level IV** **Dominant Cover** [examples]
Estuarine ***(Alternating saline and freshwater)***	Intertidal Subtidal	Saltmarsh Seagrass meadows	Estuary Lagoon	[e.g. herbfield] [e.g. (wire)rushland]	[e.g. Zostera] [e.g. Leptocarpus/Juncus]
	Non-tidal Inter-dunal	Algalflat Mudflat Cobbleflat Rocky reef Sandflat	Dune slack	[e.g. forest] [e.g. wormfield] [e.g. cocklebed] [e.g. gravelfield] [e.g. musselreef] [e.g. shrubland]	[e.g. Avicennia] [e.g. Polychaete] [e.g. Austrovenus] [e.g. Diatomfelt] [e.g. Perna] [e.g. Muehlenbeckia]
Palustrine *(Vegetation emergent over freshwater, not incl. floating plants)*	Permanent Ephemeral	Marsh Swamp Fen Bog Flush	Shore Artificial Slope Channel Flat	[e.g. reedland] [e.g. algalbed] [e.g. macrophyte bed] [e.g. sedgeland] [e.g. cushionfield]	[e.g. Typha] [e.g. Enteromorpha] [e.g. Ruppia] [e.g. Carex] [e.g. Leptospermum /Cordyline]
		Seep	Basin Pool	[e.g. rushland] [e.g. rockfield]	[e.g. Donatia] [e.g. Schoenus] [e.g. Nostoc] [e.g. Spirogyra]
Basis of discrimination: Hydrological setting, Salinity	Flow Regime	Substrate, pH, Chemistry	Land Form	Biotic Structure	Dominant species

Table 3: Draft structure for classification of Geothermal and Plutonic systems – yet to be determined if these systems should be classified to Hydrosystem level.

Level I **Hydrosystem**	**Level IA** **Sub-System**	**Level II** **Wetland Class**	**Level IIA** **Wetland Form**	**Level III** **Structural Class**	**Level IV** **Dominant Cover**
Geothermal ***(>30 degrees C or influenced by waters with geothermal chemistry)***	Permanent PermaFlow Seep SplashZone SteamZone Reservoir	Marsh Swamp Fen Pool Lake Spring Stream Flush	 Channel Terrace Slope Geoterrace Fumerole Basin Confined aquifer	 (examples pending trials)	
Plutonic ***(underground water, no photosynthesis)***	Permanent Intermittent	Aquifer Pool Stream “watertable”??	(un)confined Karst cavern Tephra tube Lava tunnel “wet-land”??		

Table 4: Draft structure for classification of Marine, Lacustrine and Riverine systems – yet to be determined if aquatic based systems can be classified in SMF Coordinated Monitoring of Wetlands Classification framework.

Level I **Hydrosystem**	**Level IA** **Sub-System**	**Level II** **Wetland Class**	**Level IIA** **Wetland Form**	**Level III** **Structural Class**	**Level IV** **Dominant Cover**
Marine	Supratidal	[e.g. splashzone]	[e.g. exposed coast]	[e.g. barnacle field]	[e.g. Elmius]
(saline open water)	Intertidal	[e.g. sandy megaripple]	[e.g. embayment]	[e.g. surfclam bed]	[e.g. Spisula]
	Subtidal	[e.g. boulder reef]	[e.g. tidal bore]	[e.g. kelpforest/urchin barren]	[e.g. Ecklonia/Evechinus]
		[e.g. coral reef]	[e.g. bombie]	[e.g. staghorn coralgarden]	[e.g. Acropora]
Lacustrine	Permanent	Oligotrophic monomictic	{Marginal}	{Low mixed community}	[e.g. Isoetes]
(standing open freshwater		Oligotrophic amictic	{Littoral}	{Mound community}	[e.g. Glossostigma]
incl. lake, pond, pool)		Mesotrophic monomictic	{Sublittoral}	{Tall mixed community}	[e.g. Myriophyllum]
		Mesotrophic amictic	{Profundal}	{Characean meadow}	[e.g. Nitella]
		Eutrophic monomictic	{Pelagic}	{Byrophyte bed}	[e.g. Drepanocladus]
		Eutrophic amictic		{Algal bed}	[e.g. Zygnemopsis]
		Eutrophic polymictic		{Tall adventive community}	[e.g. Lagarosiphon]
		Dystrophic monomictic		{Floating fern/lily community}	[e.g. Azolla]
		Dystrophic amictic			
		Dystrophic polymictic			
	Seasonal	Mesotrophic amictic			
		Eutrophic amictic			
	Ephemeral	Mesotrophic amictic			
		Eutrophic amictic			
Riverine	Perennial	Stable steepland	{entrenched channel}	{Fall/cascade}	{Bedrock}
(flowing open freshwater		Variable steepland	{meander channel}	{Rapid}	{Rubble/boulder}
incl.river,stream, canal)		Flashy steepland	{braided channel}	{Riffle}	{Cobble/gravel}
		Stable midland	{anastomosing ch.}	{Run/glide}	{sand}
		Variable midland	{unincised shelf}	{Pool}	{silt/clay}
		Flashy midland		{Spring}	{vegetated}
		Stable lowland			
		Variable lowland			
		Flashy lowland			
	Tidal	Variable		{Saltwedge}	
		Flashy		{Bore}	
		Headwater steepland		{intermittent channel}	
		Floodplain lowland		{flood ponding}	

7.5.2

7.5.3 Application of classification to defining wetland boundaries[17]

Before any fieldwork or remote sensing is performed, existing information should be used to attempt to classify the wetland (refer to Section 4.2; Information collection for existing information sources). For wetland inventory using the classification, this step may negate the need for fieldwork. For monitoring, applying the classification to existing data provides a system for standardising data so that temporal changes in extent of particular wetland types can be tracked.

Data required to successfully classify wetland types follow logically from the elements used to define each level of the classification system. The process described below works from coarse to fine scales of distinctive difference. However in reality, approaching the classification requires thinking about what data at one level is indicating about the nature of levels above AND below it on the classification.

Hydrosystems (Level I) describe the **basic type of wetland ecosystem function**. For the purpose of this classification, this is predominantly based on **salinity gradient** as the distinctive determinant between palustrine, estuarine, and marine systems. The classification also uses presence of emergent vegetation (in the case of distinguishing palustrine from other fresh water systems), temperature (in the case of geothermal), flow (riverine vs lacustrine), and under ground (plutonic) as elements of classification at this level.

Data on chemical status will primarily determine the hydrosystem to which the wetland belongs, but this can require extensive time in the field. Level IV: Dominant Cover (salt tolerant versus salt intolerant species) may be used to indicate the dominant hydrosystem. Where wetlands comprise biota that is indicative of a mixture of hydrological and salinity regimes, the system should (with reference to scale) be allocated a dominant hydrosystem type based on the dominant vegetation type. Data from Level IA: Sub-system categories or the descriptors in Level IIA: Wetland Form also provide assistance in wetland identification at hydrosystem level.

Sub-system (Level IA) units are primarily defined by **flooding regime**. Water level regime dominates biotic composition to such an extent that it can be used to define subdivisions within the major types of hydrosystems. Data on flooding regime can be gathered in the field where the periodicity in flow is short (e.g. tidal wetlands), or generated from time series aerial photos where the periodicity is longer (e.g. ephemeral wetlands). The dominant biotic composition (Level IV) and Wetland Form (Level IIA) will allude to the flooding regime.

Wetland Class (Level II) comprises wetlands with characteristic vegetation patterns caused by distinct **functional features**, including substrate, pH, and chemistry. Chemistry (and source of water as it relates to nutrient input) are important for defining different types of palustrine wetland classes, while substrate types define estuarine classes. Data for level II may be collected by remote sensing, particularly for estuarine wetlands. Field data may be needed in palustrine situations if the origin of water (and thus associated chemistry) is not known. Due to the effect these factors have on vegetation, Wetland Class may be deduced from Level IV if the user is aware of the functional relationship between vegetation, chemistry and substrate. Level IIA will also allude to substrate categories.

[17] Adapted from Partridge et al. 1999.

Wetland Form (Level IIA) is defined by geomorphic setting. The **landform** in which a particular wetland is placed has important consequences for determining both higher and lower descriptive levels and provides further definitive characteristics to assist in wetland identification by highlighting physiographic features that impact upon the wetland in terms of inputs and outputs. For example, it is improbable that the user will find a bog (which is rain fed) in a lagoonal setting (which is often river fed with periodic saline inundation).

Structural Class (Level III) is defined by the structure of wetland biota (especially vegetation), using the **physiognomy or growth form of the dominant canopy species** (described in Atkinson 1985). Terms include forest, shrubland, grassland, sedgeland, and tussockland. The Atkinson system applies equally well to faunal communities and should be used when communities consist predominantly (by sight rather than biomass) of animals (e.g. *Amphibola* on estuary mud flats) and terms such as snailfield, musselfield, or cocklebed should be used. In open communities where the area covered by the leading type of ground surface exceeds that covered by biota, then ground surface names are used such as rockland and sandfield. Some flexibility is provided for describing structural class in the classification. Structural class components reflect functional features of the system to the extent that these can often be used to determine wetland type without collecting salinity regime data, which is useful if relying on remotely sensed data.

Dominant Cover (Level IV) is defined by the **dominant species** in the canopy vegetation (see Appendix 1). This comprises the dominant species (to a maximum of five) with separators to indicate co-dominance in the form of a dash (-), and successive canopy layers as a slash (/), starting from the top layer. For consistency and correctness, Latin names should be used (see Appendix 1 for details of how to use the Atkinson system).

The degree of detail used in the vegetation description is scale dependant. For instance at 1:50 000 only the main canopy species and structural class would be used. At 1:5 000, associated subdominant or lower canopy layers can be used to subdivide the 1:50 000 vegetation description into vegetation subtypes. Likewise from detailed descriptions at 1:5000, minor components can be subsumed under the more dominant vegetation when mapped at 1:50 000 scale. See Section 4.4.3: Mapping Protocols for suggestions on managing additional cover information and minor variants.

Definitions for the wetland descriptors under each level of the classification can be found in Section 8: Glossary. For mapping wetland boundaries, these definitions provide the guidance needed to slot a particular wetland into one category or another.

Limitations: *If aerial photography or satellite imagery are the only data source used, the wetland of interest might only be classified at Level I Hydrosystem. Aerial photos will allow classification of vegetation class and possibly species, if good ground truth data is obtained. From vegetation, and landform (obtained from topography maps), some inference may be drawn for Levels IA, II, IIA and III but will require a good knowledge of wetland ecosystem function.*

7.6

7.7 Mapping

7.7.1 Appropriate Scale

Wetlands can be mapped at a range of scales depending on their size and distribution. The detail of the information to be portrayed will influence the mapping scale chosen. The following guidelines will assist in the choice of appropriate scale.

A scale of 1:250 000 can be used to map all large wetlands within a region. As a guide, a wetland of dimensions 250 metres by 250 metres (6.25 ha) will appear $1mm^2$ on a map at this scale. By aggregating information, classification levels I, IA, II, IIA and III may be mapped at this scale.

Limitation: *The broad classification at this level lacks detailed information that may be required for specific management purposes. For example, this scale will not provide information to detect the presence of small pockets of grey willow trees in large wetlands with otherwise homogenous vegetation structures. If satellite remote sensing data is the only data used at this scale, wetlands might only be mapped at Level I Hydrosystems.*

A scale of 1:50 000 is generally sufficient to provide accurate delineation of wetland vegetation classes, and can be used to map wetlands at the wetland class level (Level II) and vegetation structure level (Level III). As a guide a wetland of dimensions 50 metres by 50 metres (0.25 ha) will appear $1mm^2$ on a map at this scale. 1:50 000 provides information useful for management at regional level and can be applied to region-wide, or nation-wide wetland inventory.

Limitation: *The broad classification at the level of Wetland Class lacks detailed information that may be required for specific management purposes. For example, this scale will not provide information to detect the presence of individual grey willow trees.*

At 1: 10 000 mapping scales, minor wetland components such as fen within swamp systems, or vegetation components such as exotic species may be observed and this scale can be used to display wetland vegetation types. As a guide, a homogenous vegetation type occupying the dimension 10 metres by 10 metres will be $4mm^2$ on a map at 1: 5000 and $1mm^2$ on a map at 1: 10 000 scale. Mapping at this level provides specific information useful for implementing wetland protection strategies and responsibilities for management under the Resource Management Act.

Limitation: *Field verification is essential when classifying wetlands to vegetation type level and to produce accurate vegetation maps.*

7.7.2 Mapping of wetland extent using remote sensing:

A cost effective method for mapping changes the aerial extent of wetlands in New Zealand at scales 1:50 000 or smaller is to use the soil mapping (which identifies the extent of wetland soils) carried out by the NZ Soil Bureau (1954, 1968) and Water and Soil Division (1979), and modify and improve the mapped boundaries using manual interpretation of remotely sensed imagery[18].

For predominantly open-water wetlands, the identification of land/water boundaries is readily obtained from aerial photos and multispectral imagery, depending on scale. In most palustrine

[18] Wilde, 1999.

wetlands, pixel differences between wetland and non-wetland vegetation will obscure boundaries and can make classification using image processing software difficult. However, textural differences in the vegetation may assist in defining the actual wetland. This is relatively easily done manually on aerial photos, as long as the textural and tonal differences between wetland vegetation and farmland can be mapped by eye.

To aid digital processing of images, the visual recognition of a boundary can be used to draw an area of interest around the wetland, creating a wetland subset. The wetland itself can then be separated out from the original image. The remaining wetland pixel values may then be spread further, making any spectral and spatial patterns within the image more visible. Supervised classifications on the image can then be performed to map structural classes and dominant canopy class[19].

Using digital processing methods, we found SPOT imagery was useful for locating wetlands on a regional scale (1:250 000) while colour aerial photographs proved more useful for mapping vegetation within the wetland (1: 50 000). Supervised classifications generated better classifications than unsupervised classifications[20]. Fieldwork will be required to calibrate imagery using reference sites of known vegetation composition to assign spectral signatures. This would improve the potential of supervised classifications.

7.7.3 Mapping Protocols

When mapping wetlands, particularly at vegetation type level, the following protocols should be observed:

Scale. If an aspect of wetland classification at any level can be portrayed accurately at a particular scale, then it should be mapped. For instance, if a wetland vegetation type is homogenous over an area greater than 6.5 ha, then it may be mapped at the 1:50 000 scale, and possibly the 1:250 000 scale. On the other hand, where a wetland is small, important information may be lost when aggregating details or scaling down. Given the coarse pixel resolution of satellite imagery (20 m for SPOT and 30 m For Landsat TM), we recommend SPOT imagery be restricted to mapping at scales of 1:50 000 or smaller, and Landsat TM imagery be restricted to 1:100 000 or smaller.

Standard colours on maps. Presently there is no protocol for colouring wetland vegetation types on maps. The recommendation is given to standardise the use of colours used for depicting mapping units within an organisation. Collaboration with relevant agencies to standardise wetland mapping colours within a region or conservancy is also suggested.

What to do with minor variants? Some vegetation types observed at local level (1:5 000 or 1:10 000) will be too small to map at regional levels (ie. 1:50 000 or 1:250 000 scales). Clarity is improved when similar types are aggregated up under the dominant vegetation type overall.

The focus on the classification is to keep vegetation descriptions as succinct as possible (ie. the use of dominant species). Aggregation of data to regional or national level results in the loss of some

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[19] Refer to Smith 1999 for an extensive review of the methodology used.
[20] Supervised classification involves assigning pixel values to known vegetation types from ground truth data. Polygons drawn by a supervised classification represent groups of vegetation of similar spectral signature. Unsupervised classification involves grouping pixels which are most similar, so polygons drawn by an unsupervised classification represent pixels of similar spectral value.

important aspects related to wetland management, particularly minor vegetation components such as rare species. Relying on data for classification alone may not provide the data needed for specific management purposes.

The Atkinson system (Appendix 1) allows for the inclusion of as many aspects of the biota as needed to assist in formulating wetland management strategies. We advocate the use of an extended Atkinson system for recording field data. In terms of storing and presenting the additional information, small significant features could be marked as reference points on a map or as entered as another level in a GIS overlay. This would also be the format for keeping records of percentage composition in telescoped or mosaic vegetation.

Patch and telescoped[21] zonation vegetation patterns provide difficulties in mapping. When patchiness or telescoping occurs, percentage contributions should be assigned to composite communities as whole mapping units, to map the spatial extent of composite vegetation types.

8

[21] An extreme situation where vegetation community sequences/ecotypes are compressed into short distances (often centimetres).

9 EVALUATION OF WETLAND EXTENT AGAINST MFE INDICATOR CRITERIA

The classification developed provides a systematic framework for monitoring change in wetland extent. In evaluating wetland extent as an effective indicator, it is useful to critically evaluate both the indicator and the classification in relation to the criteria MfE (1996) have developed for the national Environmental Performance Indicators Programme.

Is the indicator, using the classification, easy to interpret and understand?

Yes. For reporting wetland extent nationally and regionally, the classification framework provides an accurate depiction of extent of wetland classes. At local levels, the classification allows for the monitoring of change in the extent of wetland vegetation composition.

Can the indicator be measured and at reasonable cost?

Yes. Inventory of wetlands at regional level may be done using existing information for all but the least known wetlands, so avoiding the cost of further fieldwork. Monitoring extent using the classification can be done at a range of cost options depending on what level (national, regional, or local) of information is needed. The classification system devised does not place an additional cost on the manager as it uses data reasonably expected to be collected by managers when monitoring wetland extent.

Is the indicator measurable with available technology?

Yes. Monitoring extent at regional and national level can be done using current aerial photography techniques, and present satellite imagery. Monitoring at local level uses traditional fieldwork approaches.

Is the indicator scientifically defensible?

Yes. The classification system, and the methodology and protocol developed as part of the project have gone thorough a rigorous system of scientific review. As the classification and the monitoring protocols developed are the foundation of identifying the extent of wetland types, it follows that information from measuring the indicator is also scientifically defensible.

Is the indicator policy relevant?

Yes. Monitoring extent of wetland types is useful for wetlands inventory at the regional and national level. Monitoring at this level can be used to test the effectiveness of policies aimed at reducing wetland loss, achieving no net loss, or increasing the area and number of wetlands. The information can also be used to determine if wetland loss is an issue via State of the Environment Reporting. At the local level information can assist in management and policy making to address RMA responsibilities.

10

11 WHAT IS MISSING AND PLANNED FOR PHASE TWO

It is anticipated that Phase Two of the Wetlands Project will focus on providing indicators and tools for monitoring wetland condition. Science-based indicators for wetland condition will be identified and developed by a team of wetland experts, in partnership with wetland managers and iwi. These indicators will be trialed in the field for verification and calibration by scientists to test the scientific validity of the indicators, and by managers to test the utility of the indicators.

Building on the relationship with iwi, a generic set of Mâori-based indicators will be developed by iwi and the project team. These will also be verified and calibrated by field testing. An assessment will be made of the need for a formal Mâori-based wetland classification system. Protocols will be established to assist in the sharing of information between Mâori-based wetland monitoring data-bases and the data-bases of local and central government agencies.

The utility of Phase Two will be enhanced by the production of an illustrated classification and key of New Zealand Wetlands. In addition, a handbook for managers will provide case studies for monitoring wetland extent and condition, drawing from the results of Phase One and Phase Two. A complete package for wetland managers will be provided through a World Wide Web wetland resource that can be used to source information and access to other data-bases. As part of the web resource, a knowledge-based GIS or some other information management system will be devised to allow information from science and Mâori-based wetlands monitoring to be incorporated as an information layer into existing systems used by wetland managers.

GLOSSARY OF WETLAND TERMS AND DEFINITIONS

- ***Amictic*** waters have no periods of thermal stratification or mixing each year.

- ***Bog***. A wetland deriving its water supply entirely from rainfall, and therefore generally nutrient poor (oligotrophic) (cf ***Fen***). All bogs have peat (an accumulation of partially decomposed organic matter), and so are usually markedly acidic.

- ***Dominant Cover*** is used for Level IV of the classification system. Dominant cover is primarily defined by the **dominant plant species** in the vegetation.

- ***Dune Slack***. A wet area between sand dune ridges in which wetland plants occur and where the water table is close to or above the sand surface.

- ***Dystrophic*** waters have significant peat staining which inhibits or masks nutrient status.

- ***Ephemeral*** describes wetlands where the open water surface is present only temporarily (lacustrine) or seasonally or where the defining emergent wetland vegetation is only seasonally present or temporarily induced by water level change (palustrine). Ephemeral wetlands are saturated or submerged for some periods and effectively non-wetland habitat for alternate substantial periods. During dry periods species otherwise indicative of dry-land situations invade. Wetland species may be annuals that re-establish with wet periods, or may die back to under ground storage organs.

- ***Estuarine***. A wetland hydrosystem which is permanently or periodically inundated by **estuarine waters**, where **occasionally or periodically saline waters are diluted** to > 0.5% by freshwater, **or freshwater is occasionally or periodically made saline**. The dominant function affecting biota is that of saline water (>0.5% salinity). A **coastal wetland semi-enclosed by land** (open, or partly obstructed, or has sporadic access to sea), is the geomorphological setting indicative of an estuarine hydrosystem. Estuarine wetlands include supra-tidal zones in which biota is strongly influenced by irregular saline/freshwater inundation, lagoonal areas where tidal influences are restricted to periodic incursion of saline water, and dune swale areas where ground water sources are periodically supplemented be saline contributions from storm-spray, storm-surge, and estuarine flood-flows.

- ***Estuary***. A partially embayed coastal system which receives both sea waters and freshwaters in a zone of mixing in a tidal regime. The tidal regime is frequently modified by river flows or bars restricting sea water inputs or outputs, but there is always continuity of connection to the sea. Distinguished from the open coast by its protection.

- ***Eutrophic*** waters and wetlands have high nutrient status.

- ***Fen***. A wetland receiving water from rain with some ground water seepage or surface run-off carrying dissolved nutrient and organic matter (cf ***Bog***). The nutrient status of fens therefore is poor to medium (oligotrophic to mesotrophic). Fens also have peat.

- ***Flashy*** describes riverine flows which allow development of little more than microalgal felts.

- ***Flush.*** A wetland on a slope which carries moving surface water from a higher level, either continuously or occasionally (cf ***Seep***).

- ***Geothermal***. A wetland hydrosystem where the dominant function is **geothermally heated water**. The RMA specifies geothermal waters as those heated by natural phenomena to 30 degrees C or above. Geothermal wetlands may have water temperatures below this but must be considered geothermal due to the chemical composition of the water. Geothermal wetlands are permanently or intermittently wet areas, shallow water, or land water margins that support a natural ecosystem of plants that have compositional, structural, and/or growth rate characteristics determined by current or former inputs of geothermally-derived water .

- ***Hydrosystems*** (classification Level I) are wetland ecosystems differentiated by their broad hydrological setting, and by water salinity and temperature. In systems where wetlands comprise biota that is indicative of a mixture of hydrological and salinity regimes, the system is allocated by its dominant hydrosystem type.

- ***Intermittent*** wetlands have irregular fluctuations in water level or water table.

- ***Intertidal.*** This comprises the foreshore area exposed to air between the high and low tides, and includes the overlying waters. It includes vegetated and non-vegetated wetland classes.

- ***Lacustrine***. A wetland hydrosystem including permanent or intermittent **standing open water** in topographic depression or dammed river channel and the beds of lakes, ponds, and pools so formed. The dominant function is that of **freshwater**, with low salinity (<0.5%) if tidal. Lacustrine wetlands exclude significant (mappable) areas of water with emergent vegetation (cf ***Palustrine***) or areas where water moves at speed (cf ***Riverine***). Present definitions do not define minimum depth. The boundary between ***Palustrine*** and ***Lacustrine*** systems by definition is where vegetation is not emergent over water.

- ***Lagoon.*** A completely enclosed saline body of water that may have occasional connections to the sea. Water level fluctuations occur, but are not tidal. Sea water inputs are irregular and fluctuations in level tend to be long period, and often seasonal. Evaporation often plays an important role in modifying salinity patterns.

- ***Lowland*** wetlands have a low gradient with slow runs and pools, and are close to the sea.

- ***Marine***. A Wetland hydrosystem including **saline open waters, seabed, and foreshore**. The dominant function is that of saline (>0.5% salinity) water. Marine wetlands are bounded by the landward limit of tidal inundation and splash, or seaward limit of other hydrosystems (particularly ***Estuarine***). Marine includes shallow coastal waters to 6 metres depth and coral reef systems to any depth. For the purposes of this classification marine wetlands include the littoral zone (photic zone to depth limit of rooted plants), intertidal, and supra-tidal zones.

- ***Marsh***. A mineral wetland that may have a peat component, that is periodically inundated by standing water or slowly moving water. Water levels may fluctuate markedly (cf ***Swamp***). Marshes are usually moderate to highly nutrient rich (mesotrophic to eutrophic).

- ***Mesotrophic*** waters and wetlands have moderate nutrient status.

- ***Midland*** systems have overall flows that have a moderate gradient, and are dominated by runs/riffles.

- ***Monomictic*** lacustrine waters have single periods of thermal stratification and mixing each year.

- ***Nontidal.*** This comprises coastal areas which contain open water of variable salinity in which the water level usually changes not with diurnal tidal fluctuations but in response to irregular climatically induced events such as barrier breaches and floods. It includes lagoons and dune swale impoundments.

- ***Oligotrophic*** waters and wetlands have low nutrient status.

- ***Palustrine***. A wetland hydrosystem including lands bound by dry land or by any other hydrosystem, where attached/rooted **vegetation is emergent** (cf ***Riverine*** or ***Lacustrine***) permanently or seasonally above **freshwater** (<0.5% salinity), non-tidal surface water or groundwater. Palustrine wetlands include marsh, bog, swamps, fens, bog, marshes, seeps and flushes. Palustrine wetlands exclude wetlands influenced by saline water such as saltmarsh.

- ***Perennial*** riverine systems include permanently flowing waters in channels, even where parts of a flow are below a porous channel surface.

- ***Permanent*** wetlands have a water level or watertable that is constantly high, and the defining vegetation persists throughout the year. In extreme dry periods, plant community composition may change, but species are identifiable to wetlands (cf ***seasonal***, ***ephemeral*** and ***intermittent***).

- ***Plutonic.*** A wetland hydrosystem that includes all underground water-bodies where light level are too low to permit photosynthetic activity, and hence plant production. Biotic communities include fungi, microbes, meiofauna, insect larvae, and/or some fish species. Plutonic wetlands include underground pools and streams from karst and volcanic strata, and aquifers.

- ***Polymictic*** waters have several periods of thermal stratification and mixing each year.

- ***Riverine***. A wetland hydrosystem where the dominant function is **continually or intermittently flowing open fresh water**. Includes natural and modified streams and rivers, creeks, canals and channels and the beds so formed. Riverine wetlands exclude significant (mappable) areas of emergent vegetation (cf ***Palustrine***), even where these are emergent over running water. Riverine wetlands are bounded by their downstream limit by ***Estuarine*** hydrosystems which contain a saline influence.

- ***Saltmarsh*** consists of vegetation of land-based physiology which are tolerant of salt, and the absence of species which are not salt tolerant.

- ***Seagrass meadows*** are within the tidal zone and are dominated by *Zostera*, a marine (aquatic physiology) flowering plant intolerant of long exposure.

- ***Seasonal.*** Water level, water input, and / or waterlogging vary with seasonal events such as spring snow melt or autumn drought (cf ***permanent***, ***ephemeral*** and ***intermittent***).

- ***Seep*** describes a wetland where water percolates to the soil surface (cf ***Flush***), with a flow being less than that which would be considered as a ***Spring***.

- ***Stable*** flow is one that allows attached macrophytes and mosses to persist from year to year.

- ***Spring***. A stream emerging to the surface from underground. Usually of considerable flow, without emergent vegetation where the spring emerges from the ground (cf ***Flush*** and ***Seep***).

- ***Steepland*** has overall flows which are high gradient, well aerated with broken surfaces.

- ***Structural class*** is primarily defined by the **structure/physiognomy** of the dominant canopy vegetation (classification Level III). These terms have been described in Atkinson (1985) and include such common terms as forest, shrubland, grassland, sedgeland, tussockland etc. In response to the issue of identification of certain of these in the wetland situation, flexibility is allowed, with the compositional descriptors providing the appropriate comparisons where there is confusion.

- ***Sub-systems*** are primarily defined by **flooding regime** (hydro-periodicity) and are used to describe wetlands at Level IA in the classification.

- ***Subtidal.*** This comprises areas that are permanently inundated with marine or estuarine waters. It includes vegetated and unvegetated wetlands. Within the estuarine hydrosystem the intertidal is defined here to include the supratidal because of the difficulties of delineating the actual boundary on the ground.

- ***Supratidal.*** This comprises areas above the high water mark which are strongly influenced by periodic incursions of saline water or spray. It includes the splash zone and areas inundated by storm surges.

- ***Swamp.*** A wetland where water supply is augmented by ground-water seepage or surface run-off that has been in contact with mineral materials in adjacent land, and carries inputs of dissolved nutrients and often also suspended inorganic sediment. Swamps usually have a combination of mineral and peat substrates. Leads of standing water or surface channels with gentle permanent or periodic internal flow may be present (cf ***Marsh***). Swamps are relatively rich in nutrients (mesotrophic to eutrophic) and the watertable is usually permanently above some of the ground surface, or periodically above much of it.

- ***Tidal.*** Wetlands where the water level regime is determined by the diurnal rise and fall of tidal saline waters. Tides can have upstream effects above saline inputs, but where the salinity falls below 0.5%, or where the vegetation is characteristic of freshwater conditions, the boundary with the palustrine system occurs. The extent of the wetland may be above the full tidal range (Mean High and Low Water Spring are often used as definitions), but seldom below.

- ***Variable*** flow is one which allows development and scouring of macroalgae.

- ***Watertable*** defines the water level relative to the ground surface, i.e. the level below which is fully saturated. Also commonly applied to road ditches in New Zealand.

- ***Wetland***. The RM Act (1991) defines wetlands as "permanently or intermittently wet areas, shallow water or land/water margins that support a natural ecosystem of plants and animals that are adapted to living in wet conditions". They may be saline, freshwater, or brackish. Wetlands have internal interactions between water regime, chemistry, soils, vegetation and fauna that define them, and have a boundary beyond which external interactions that are either inputs or outputs.

- ***Wetland Class*** is used in the classification system (Level II) comprises distinct kinds of vegetation in which characteristic **functional** features other than those of hydrology dominate to such an extent that they cause major vegetation patterns. These include substrate, acidity and chemistry. For instance acidity and chemistry are important at defining different types of palustrine system, while chemistry, especially in relation to salinity help define estuarine wetland classes.

- ***Wetland Form*** is primarily defined by **landform** (hydrogeomorphic setting) and is used to classify wetlands at level IIA.

REFERENCES CITED AND BIBLIOGRAPHY OF PROJECT REPORTS

Atkinson, I.A.E. 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.

Clarkson, B. R. 1998: Orums Road Wetland. *Landcare Research Contract Report* LC9899/019.

Clarkson, B. R. 1999a: Puhinui Wetland. *Landcare Research Contract Report* LCG899/089.

Clarkson, B. R. 1999b: Te Henga (Waitakere) Wetland. *Landcare Research Contract Report* LC9899/108.

Gerbeaux, P.; Partridge, T. 1999: Okarito Lagoon Wetland: A trial site to test the applicability of a classification system for New Zealand wetlands. West Coast Technical Support Series Number 3. *Department of Conservation.*

Harmsworth, G. 1999: Coordinated Monitoring of New Zealand Wetlands: A Ministry for the Environment SMF Funded Project; Phase 1— Goal 4: Building Iwi Partnerships. *Landcare Research Contract Report* LC9899/085.

Johnson, P.N.; Jackson, R.J. 1999: Glenmore, Lake Tekapo: wetland classification. *Landcare Research Contract Report* LC9900/016

Johnson, P.N.; Partridge, T.R. 1999: Waituna Lagoon Wetland. *Landcare Research Contract Report* LC9900/018

Ministry for the Environment. 1996: National Environmental Indicators: Building a Framework for a Core Set. Ministry for the Environment. Wellington.

Partridge, T.; Clarkson, B.D.; Ward, J.; Gerbeaux, P.; Sorrell, B.; Richmond, C.; Clarkson, B.R.; Johnson, P.; Lambie, J.; Denyer, K.; Meurk, C. 1999: An Evaluation of the Workshop 1 Wetland Classification Using an Issues Approach, and the Consequent Development of a Modified Classification. *Landcare Research Contract Report* LC9899/017

Partridge, T.R.; Ward, J.C.; Meurk, C.D. 1999. Te Waihora (Lake Ellesmere) Wetland. *Landcare Research Contract Report* LC9900/019

Partridge, T.R.; Sorrell, B.K. 1999: Kongahu Wetland. *Landcare Research Contract Report* LC9900/020

Smith, S.M. 1998: Coordinated Monitoring of New Zealand wetlands: A Ministry for the Environment SMF funded project; Project Control and Co-ordination Plan. UNEP/GRID. Christchurch.

Smith, S.M. 1999: Comparison of Colour Aerial Photography and SPOT Satellite Imagery as Aids in Identifying and Mapping Wetlands. In P Bealing (Producer). 1999: Comparison of

Colour Aerial Photography and SPOT Satellite Imagery as Aids in Identifying and Mapping Wetlands. UNEP/GRID. Christchurch

Ward, J.C.; Lambie, J.S. 1998: Coordinated Monitoring of New Zealand wetlands: A Ministry for the Environment SMF funded project; Classification of Wetlands Report from Workshop One. UNEP/GRID. Christchurch.

Ward, J.C.; Lambie, J. S. 1999: Coordinated Monitoring of New Zealand wetlands: A Ministry for the Environment SMF funded project; Report on Workshop Two. UNEP/GRID. Christchurch.

Ward, J.C.; Pyle, E. 1997: Environmental indicators for the sustainable management of fresh water. Unpublished Report No 2416/2 for the Ministry for the Environment. Lincoln Environmental, Lincoln University.

Wilde, R.H. 1999: Remote Sensing for Wetlands Mapping in New Zealand. In P. Bealing (Producer). 1999: Comparison of Colour Aerial Photography and SPOT Satellite Imagery as Aids in Identifying and Mapping Wetlands. UNEP/GRID. Christchurch.

APPENDIX 1: The Atkinson System.

Guide to the use of the Atkinson System for the description of vegetation.
Trevor Partridge, Landcare Research

Describing vegetation

A vast array of techniques have been developed for the purpose of describing vegetation. They range in detail from the very simple, in which only the most basic of features are determined, to those that are complex and which involve detailed measurements of all components. The choice of technique is dependent upon the type of information desired and its use, and often involves a trade-off between time to carry out a description, and the number of descriptions desired. Increasing level of detail is time consuming, and is only necessary where the output requires such levels of information. Faster methods tend to lack information detail and precision.

Choosing the technique

For the description and mapping of wetland vegetation in New Zealand, the priorities are for speed and consistency, with little detail, especially of minor species. A common technique that is rapid involves estimation of cover of species, but this has problems of user consistency. The Atkinson system described here is sufficiently simple and well defined to be used relatively consistently by a large number of users of varying expertise. It is also flexible enough to be readily generated from existing descriptions of most techniques with only a little interpolation.

The Atkinson descriptors

The technique comprises two features of vegetation: **structure** and **composition**. Structure involves describing the vegetation by its appearance using terms that are relatively well understood by most end users. Terms such as forest, shrubland, and herbfield require little explanation, but for those concerned with detail or accuracy, descriptions of these terms are available in the paper Atkinson used to originally describe the technique (Atkinson 1985). For the user who needs to ascribe a structural term to the type of vegetation they are observing, this list of descriptors is a valuable tool. What is needed is for the observer to view the vegetation and choose an appropriate term to describe its appearance.

Canopy layer structure

Describing composition is a little more complicated, but also utilises a feature of the appearance of the vegetation, that is its vertical layer characteristics in what are referred to as **canopy layers**. As a result of growth form and light tolerance, different species tend to dominate in various canopy layers from the tallest species of the highest light exposure in the uppermost layer to the shortest growing shade tolerant species of the lowest layers. The degree of complexity depends upon the species involved and their heights. For instance, multi-layering may occur in the podocarp forests of New Zealand where there are readily identifiable layers of tree canopy (tall trees forming continuous cover), subcanopy (shorter trees below the tallest), shrub layer (smaller woody species of about 2m height), forest floor (large herbs) and ground layer (small, often creeping herbs). Added to this are the emergents (individual tall trees that reach above the canopy), lianes (climbing species) and epiphytes (perching plants); the degree of complexity is considerable. In grassland situations, the layers are fewer and more height compressed, while in some situations, especially in some wetland vegetation, there may only be one layer as in a raupo stand or a glasswort saltmarsh.

Canopy layer composition

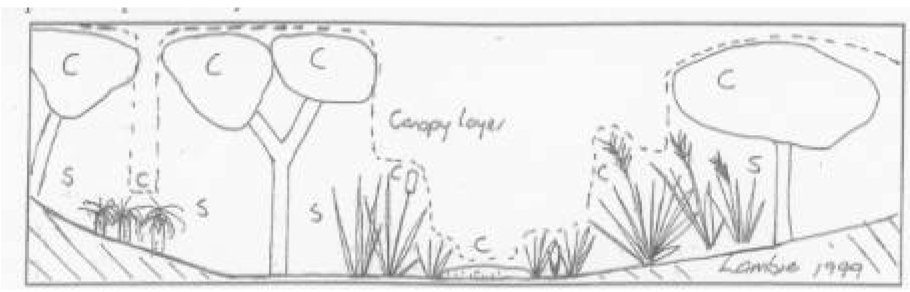
The Atkinson system uses these canopy layers as the structure to the vegetation description, coupled with the names of the **canopy layer dominants**. For a full description, all vertical layers should be described, but for the purposes of describing vegetation for a project such as this, only the uppermost layers are usually used. Remote sensing of course may detect only the uppermost canopy layers, so descriptions based on that technique will often only comprise one or two layers. Within each layer the dominant species are listed, usually one or two, seldom more than three. The description of the vegetation is now recorded using two separators; a solidus (/) for separating the layers, a dash (-) for separating co-dominants. So the description *Salix fragilis* / *Salix cinerea* - *Cordyline australis*, indicates two layers, the uppermost which has *Salix fragilis* (crack willow) as the sole dominant, and an understorey layer comprising *Salix cinerea* (grey willow) and *Cordyline australis* (cabbage tree). Add to this the structural term "forest" and the description is complete.

Identification of dominants

For many, the biggest difficulty will be identifying the species and assigning the Latin names in the description. It is however essential for accuracy, especially as common names can be misused so easily. Wetlands are not particularly diverse in canopy species, and only the dominants need to be known. With only a little training, especially where it is regionally based, most descriptions should be able to be drawn up by non-experts. The greatest difficulties will be in the identification of rushes (*Juncus*), sedges (*Carex*) and other grass-like species that dominate many wetlands. Peter Johnson's (1998) *Wetland Plants in New Zealand* is a useful starting point for wetland plant identification for the non-expert. There are unfortunately many species of these, so it is important that experts are used to verify specimens collected from the field. These specimens need to comprise both leaf and flowering or fruiting shoot material that are well looked after. The taxonomists often require long periods trying to determine poorly collected and poorly stored specimens, to frequently give only a number of possibilities. The Atkinson system is based on dominant species however, so at least the determination of different vegetation types by changing dominance should not be as difficult as the actual identification of the species.

To summarise, the Atkinson system of vegetation description is ideally suited for this kind of exercise. It is consistent yet flexible enough to allow most users to be able to describe most vegetation accurately. It is however not so simple that it can be adopted by all users without some training and practice. Such a technique does not exist. With a little effort and training, it can be readily learned by the users for which it is intended.

Figure 1. Difference between canopy (C) and sub-canopy (S) vegetation as determined by exposure of plants to sky.



Derivation of vegetation mapping units for an ecological survey of Tongariro National Park North Island, New Zealand.
I.A.E. Atkinson, 1985.
Published in: New Zealand Journal of Botany, 23: 361-378.

Table 9 Diagnostic criteria for terrestrial vegetation structural classes (modified and extended from Atkinson 1962).

Structural class	Diagnostic criteria for structural classes and definitions of growth forms
1. FOREST	Woody vegetation in which the cover of trees and shrubs in the canopy is > 80% and in which tree cover exceeds that of shrubs. Trees are woody plants ≥ 10 cm dbh. Tree ferns ≥ 10 cm dbh are treated as trees.
2. TREELAND	Vegetation in which the cover of trees in the canopy is 20-80%, with tree cover exceeding that of any other growth form, and in which the trees form a discontinuous upper canopy above either a lower canopy of predominantly non-woody vegetation or bare ground e.g., mahoe/bracken treeland. (Note: Vegetation consisting of trees above shrubs is classified as either forest or scrub depending on the proportion of trees and shrubs in the canopy).
3. VINELAND	Vegetation in which the cover of *unsupported* (or artificially supported) woody vines in the canopy is 20-100% and in which the cover of these vines exceeds that of any other growth form or bare ground. Vegetation containing woody vines that are supported by trees or shrubs is classified as forest, scrub or shrubland. Examples of woody vines occur in the genera *Actinidia, Clematis, Lonicera, Metrosideros, Muehlenbeckia, Ripogonum, Vitis* and others.
4. SCRUB	Woody vegetation in which the cover of shrubs and trees in the canopy is > 80% and in which shrub cover exceeds that of trees (cf. FOREST). Shrubs are woody plants < 10 cm dbh.
5. SHRUBLAND	Vegetation in which the cover of shrubs in the canopy is 20-80% and in which the shrub cover exceeds that of any other growth form or bare ground. It is sometimes useful to separate tussock-shrublands as a sub-class for areas where tussocks are > 20% but less than shrubs. (Note: The term scrubland is not used in this classification).
6.TUSSOCKLAND	Vegetation in which the cover of tussocks in the canopy is 20-100% and in which the tussock cover exceeds that of any other growth form or bare ground. Tussocks include all grasses, sedges, rushes, and other herbaceous plants with linear leaves (or linear non-woody stems) that are densely clumped and > 1 0 cm height. Examples of the growth form occur in all species of *Cortaderia, Gahnia,* and *Phormium,* and in some species of *Chionochloa, Poa, Festuca, Rytidosperma, Cyperus, Carex, Uncinia, Juncus, Astelia, Aciphylla,* and *Celmisia.* It is sometimes useful to separate *flaxland** as a subclass for areas where species of *Phormium* are dominant.
7. FERNLAND	Vegetation in which the cover of ferns in the canopy is 20-100% and in which the fern cover exceeds that of any other growth form or bare ground. Tree ferns ≥10 cm dbh are excluded as trees (cf. FOREST).
8. GRASSLAND	Vegetation in which the cover of grass in the canopy is 20-100% and in which the grass cover exceeds that of any other growth form or bare ground. Tussock-grasses are excluded from the grass growth-form.
9. SEDGELAND	Vegetation in which the cover of sedges in the canopy is 20-100% and in which the sedge cover exceeds that of any other growth form or bare ground. Included in the

	sedge growth form are many species of *Carex, Uncinia,* and *Scirpus.* Tussock-sedges and reed-forming sedges (cf. REEDLAND) are excluded.
10. RUSHLAND	Vegetation in which the cover of rushes in the canopy is 20-100% and in which the rush cover exceeds that of any other growth form or bare ground. Included in the rush growth form are some species of *Juncus* and all species of *Sporadanthus, Leptocarpus,* and *Empodisma.* Tussock-rushes are excluded.

*The term "flaxland" could not be used outside New Zealand because elsewhere the name flax is widely applied to species of *Linum.*

Table 9 *cont.*

Structural class	Diagnostic criteria for structural classes and definitions of growth forms
11. REEDLAND	Vegetation in which the cover of reeds in the canopy is 20-100% and in which the reed cover exceeds that of any other growth form or open water. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either hollow or have a very spongy pith. Example include *Typha, Bolboschoenus, Scirpus lacutris,, Eleocharis sphacelata,* and *Baumea articulata.*
12. CUSHIONFIELD	Vegetation in which the cover of cushion plants in the canopy is 20-100% and in which the cushion-plant cover exceeds that of any other growth form or bare ground. Cushion plants include herbaceous, semi-woody and woody plants with short densely packed branches and closely spaced leaves that together form dense hemispherical cushions. The growth form occurs in all species of *Donatia, Gaimardia, Hectorella, Oreobolus,* and *Phyllachne* as well as in some species of *Aciphylla, Celmisia, Centrolepis, Chionohebe, Colobanthus, Dracophyllum, Drapetes, Haastia, Leucogenes, Luzula, Myosotis, Poa, Raoulia,* and *Scleranthus.*
13. HERBFIELD	Vegetation in which the cover of herbs in the canopy is 20-100% and in~which the herb cover exceeds that of any other growth form or bare ground. Herbs include all herbaceous and low-growing semi-woody plants that are not separated as ferns, tussocks, grasses, sedges, rushes, reeds, cushion plants, mosses or lichens.
14. MOSSFIELD	Vegetation in which the cover of mosses in the canopy is 20-100% and in which the moss cover exceeds that of any other growth form or bare ground.
15. LICHENFIELD	Vegetation in which the cover of lichens in the canopy is 20-100% and in which the lichen cover exceeds that of any other growth form or bare ground.
16. ROCKLAND	Land in which the area of residual bare rock exceeds the area covered by any one class of plant growth-form. Cliff vegetation often includes rocklands. They are named from the leading plant species when plant cover ≥1% e.g., [koromiko] rockland.
17. BOULDERFIELD	Land in which the area of unconsolidated bare boulders (>200 mm diam.) exceeds the area covered by any one class of plant growth-form. Boulderfields are named from the leading plant species when plant cover ≥ 1%.
18. STONEFIELD/ GRAVELFIELD	Land in which the area of unconsolidated bare stones (20-200 mm diam.) and/or gravel (2-20 mm diam.) exceeds the area covered by any one class of plant growth-form. The appropriate name is given depending on whether stones or gravel form the greater area of ground surface. Stonefields and gravelfields are named from the leading plant species when plant cover ≥ 1%.
19. SANDFIELD	Land in which the area of bare sand (0.02-2 mm diam.) exceeds the area covered by any one class of plant growth-form. Dune vegetation often includes sandfields which are named from the leading plant species when plant cover ≥ 1%.
20. LOAMFIELD/ PEATFIELD	Land in which the area of loam and/or peat exceeds the area covered by any one class of plant growth-form. The appropriate name is given depending on whether loam or peat forms the greater area of ground surface. Loamfields and peatfields are named from the leading plant species when plant cover ≥ 1%.

APPENDIX 2: Sources of information and advice

Appendix 2a. Council/Regulatory authority contacts.

Surname	First Name	Organisation	Address	City/ Town	Telephone	Facsimile	E-mail
Auton	Leigh	Manukau City Council	Private Bag 76 917	Manukau City	09 262 8900	09 262 5166	lauton@manukau.govt.nz
Cuff	Jeromy	Canterbury Regional Council	PO Box 550	Timaru	03 365 3828	03 365 3194	Jerryc@crc.govt.nz
Denyer	Karen	Environment Waikato	PO Box 4010	Hamilton East	07 856 7184	07 856 0551	karend@wairc.govt.nz
Fenmore	Andrew	Taranaki District Council					andrw@tdc.govt.nz
Halligan	Bruce	Southland District Council	PO Box 903	Invercargill	03 208 7259	03218 9460	
Hamill	Keith	Southland Regional Council	Private Bag 90 116	Invercargill	03 215 6197	03 215 8081	kdh@src.govt.nz
Harrison	Wayne	West Coast Regional Council	PO Box 66	Greymouth	03 768 0466	03 768 7133	WH@WCRC.govt.nz
Hopkins	Bob	Christchurch City Council	PO Box 237	Christchurch	03 371 1487		bob.hopkins@ccc.govt.nz
Huser	Beat	Environment Waikato	PO Box 4010	Hamilton East	07 856 7184	07 856 0551	beath@wairc.govt.nz
Johnson	Bryce	Fish & Game Council	PO Box 13 141	Wellington	04 499 4767	04 499 4768	bjohnson@fishandgame.org.nz
Keys	Richard	Otago Regional Council	Private Bag 1954	Dunedin	03 474 0827	03 479 0015	richardk@orc.govt.nz
Main	Malcolm	Canterbury Regional Council	P. O. Box 345	Christchurch	03 365 3828		Malcolm@crc.govt.nz
Myers	Shona	Auckland Regional Council	Private Bag 92 012	Auckland	09 366 2000	09	smyers@arc.govt.nz
Preece	John	Fish and Game Council	P.O.Box 7173	Nelson.			
Reeves	Paula	Waitakere City Council	Private Bag 93 019	Henderson	09 836 8080	09 836 8057	reevesp@waitakere.govt.nz
Sullivan	Frances	Canterbury Regional Council	PO Box 345	Christchurch	03 365 3828	03 365 3194	francess@crc.govt.nz
Teal	Phil	Fish & Game Council	RD 9	Hamilton	07 849 9164	07 849 1648	
Turner	Allan	Waikato District Council	Privte Bag 544	Ngaruawahia	824 8633	824 8091	allan.turner@waidc.govt.nz
Wilding	Thomas	Environment Bay of Plenty	P. O. Box 364	Whakatane.	07 307 2545		Thomas@boprc.govt.nz

2b. Mâori organisation contacts

Surname	First Name	Organisation	Address	City/ Town	Telephone	Facsimile	E-mail
Constable	Linda	Te Rûnanga O Ngai Tahu	PO Box 13 046	Christchurch	03 366 4344	03 365 4424	Lindac@ngaitahu.iwi.nz

Harmsworth	Garth	Landcare Research NZ Ltd	Private Bag 11 052	Palmerston North	06 356 7154	06 355 9230	harmsworthg@landcare.cri.nz
Kirikiri	Rau	Landcare Research NZ Ltd	PO Box 40	Christchurch	03 325 6700	03 325 2127	Kirikirir@landcare.cri.nz
Manukau	Nicholas	Environment Waikato	PO Box 4010	Hamilton East	07 856 7184	07 856 0551	nicholasm@wairc.govt.nz

Appendix 2c. Department of Conservation contacts.

Surname	First Name	Organisation	Address	City/ Town	Telephone	Facsimile	E-mail
Barnes	Grant	DoC Waikato	P.O. Box 20025	Te Rapa			Gbarnes@doc.govt.nz
Comrie	Joy	DoC Christchurch			03 3799758		JComrie@doc.govt.nz
Gerbeaux	Philippe	DoC West Coast	Private Bag 701	Hokitika	03 755 8301	03 755 8380	pgerbeaux@doc.govt.nz
Grainger	Natasha	DoC West Coast		Westport	03 788 8008	03	bullerAO@doc.govt.nz
Head	Nick	DoC Christchurch			03 3799758		NHead@doc.govt.nz
McColl	Rob	DoC Head Office	PO Box 10 420	Wellington	04 471 0726	04 471 1082	
Miller	Rosemary	DoC Wanganui			06 345 2402		rosemary@xtra.co.nz
Morgan	Kate	DoC Christchurch			03 3799758		KMorgan@doc.govt.nz
Rance	Brian	DoC Southland	PO Box 743	Invercargill	03 214 4589	03 214 4486	
Rance	Chris	DoC Southland	PO Box 743	Invercargill	03 214 4589	03 214 4486	
Richmond	Chris	DoC Head Office	PO Box 10 420	Wellington	04 471 0726	04 471 1082	CRichmond@doc.govt.nz
Roxburgh	Tony	DoC Waikato	Private Bag 3072	Hamilton	07 838 3363	07 838 1004	TRoxburgh@doc.govt.nz
West	Carol	DoC Southland	PO Box 743	Invercargill	03 214 4589	03 214 4486	carol.west@doc.govt.nz
Woolmore	Chris	DoC Christchurch			03 3799758		CWoolmore@doc.govt.nz

Appendix 2d. Science contacts.

Surname	First Name	Organisation	Address	City/ Town	Telephone	Facsimile	E-mail
Champion	Paul	NIWA	PO Box 11 115	Hamilton	07 856 7026	07 856 0151	p.champion@niwa.cri.nz
Clarkson	Bev	Landcare Research NZ Ltd	Private Bag 3127	Hamilton	07 838 4542	07 838 4442	bev@landcare.cri.nz
Clarkson	Bruce	University of Waikato	Private Bag 3105	Hamilton	07 8355 9534	07 838 4324	clarksonb@extra.co.nz
Gerbeaux	Philippe	DoC West Coast	Private Bag 701	Hokitika	03 755 8301	03 755 8380	pgerbeaux@doc.govt.nz
Harmsworth	Garth	Landcare Research NZ Ltd	Private Bag 11 052	Palmerston North	06 356 7154	06 355 9230	harmsworthg@landcare.cri.nz
Jackson	Rick	Landcare Research NZ Ltd	P. O. Box 69	Lincoln.	03 325 6700		Jacksonr@landcare.cri.nz
Johnson	Peter	Landcare Research NZ Ltd	Private Bag 1930	Dunedin	03 479 9674	03 477 5232	JohnsonP@landcare.cri.nz
Partridge	Trevor	Landcare Research NZ Ltd	PO Box 40	Lincoln	03 325 6700	03 325 2127	Partridget@landcare.cri.nz
Richmond	Chris	DoC Head Office	PO Box 10 420	Wellington	04 471 0726	04 471 1082	CRichmond@doc.govt.nz
Smith	Steve	GRID – Christchurch	P. O. Box 14-199,	Christchurch	03 358 6990	03 358-6999	s.smith@alchemy.co.nz
Sorrell	Brian	NIWA	PO Box 8602	Christchurch	03 348 8987		b.sorrel@NIWA.cri.nz
Stephens	Theo	Landcare Research NZ Ltd	Private Bag 3127	Hamilton	07 838 4441	07 838 4442	stephenst@landcare.cri.nz
Thompson	Keith	University of Waikato	Private Bag 3105	Hamilton	07 838 4703	07 838 4324	keithomp@waikato.ac.nz
Ward	Jonet	Lincoln Environmental	PO Box 84	Lincoln University	03 325 2021	03 325 3725	wardj@lincoln.ac.nz

APPENDIX 3: Lists of wetlands project participants

Wetlands Project Steering Group

Surname	First Name	Organisation
Berry	Ruth	Ministry for the Environment
Clarkson	Bruce	University of Waikato (previously Landcare Research)
Denyer	Karen	Environment Waikato
Richmond	Chris	Department of Conservation, Wellington
Smith	Steve	Alchemy Group Ltd (previously UNEP/GRID Christchurch)
Thompson	Keith	University of Waikato
Ward	Jonet	Lincoln Environmental, Lincoln University

Workshop 1

Held 12 –13 March 1998. The objectives of a standardised wetlands classification system were discussed, and principles of wetland classification were reviewed. Working definitions for different wetland types were posed. A tentative standardised hierarchical wetland classification system was then devised after two group sessions.

Workshop 1 participants:

Surname	First Name	Organisation
Arbuckle	Chris	Department of Zoology, University of Otago
Berry	Ruth	Ministry for the Environment
Champion	Paul	NIWA, Hamilton
Clarkson	Bev	Landcare Research NZ Ltd, Hamilton
Clarkson	Bruce	Landcare Research NZ Ltd, Hamilton
Cuff	Jeromy	Canterbury Regional Council
Davis	Mark	Consultant, Christchurch
Denyer	Karen	Environment Waikato
Gerbeaux	Philippe	Department of Conservation, West Coast
Hamill	Keith	Southland Regional Council
Harris	Colin	GRID Christchurch
Jackson	Rick	Landcare Research NZ Ltd, Lincoln
Johnson	Peter	Landcare Research NZ Ltd, Dunedin
Lambie	James	Lincoln Environmental, Lincoln University
Lythe	Matt	GRID Christchurch
Main	Malcolm	Canterbury Regional Council
Myers	Shona	Auckland Regional Council
Partridge	Trevor	Landcare Research NZ Ltd, Lincoln
Preece	John	Fish and Game Council, Nelson-Marlborough
Rance	Brian	Department of Conservation, Southland
Reeves	Paula	Waitakere City Council
Richmond	Chris	Department of Conservation, Wellington
Smith	Steve	GRID Christchurch
Sorrell	Brian	NIWA, Christchurch
Stephens	Theo	Landcare Research NZ Ltd, Hamilton
Thompson	Keith	University of Waikato
Ward	Jonet	Lincoln Environmental, Lincoln University
Wilding	Thomas	Environment Bay of Plenty

Orums Road Field Trip

Held 27 April 1998, to evaluate the practical application of the tentative classification posed in Workshop 1, with wetland managers.

Field Trip Participants

Surname	First Name	Organisation
Bev	Clarkson	Landcare Research NZ Ltd, Hamilton
Jamieson	Alastair	Auckland Regional Council
Myers	Shona	Auckland Regional Council
Ranacou	Emi	Manukau City Council

Te Waihora Field Trip

Held 22 June 1998, to evaluate the practical application of the tentative classification posed in Workshop 1, with wetland managers.

Field Trip Participants

Surname	First Name	Organisation
Woolmore	Chris	Department of Conservation, Christchurch
Lambie	James	Lincoln Environmental, Lincoln University
Partridge	Trevor	Landcare Research NZ Ltd, Lincoln
Sullivan	Francis	Canterbury Regional Council
Ward	Jonet	Lincoln Environmental, Lincoln University

Hui # 1

Held 30 September 1998, to build a framework of partnership with Waikato iwi and hapû representatives with a view to developing appropriate methods to incorporate iwi values and uses of wetlands into spatial databases and decision support systems.

Hui Participants

Surname	First Name	Organisation
Anderson	Alice	Hauraki Mâori Trust Board
Anderson	Barney	Department of Conservation, Hamilton
Clarkson	Bruce	Landcare Research NZ Ltd, Hamilton
Flavell	Karl	Ngati Te Ata
Harmsworth	Garth	Landcare Research NZ Ltd, Palmerston North
Herbert	Rima	Wetlands Researcher, Mercer
Kirikiri	Rau	Landcare Research NZ Ltd, Lincoln
Lambie	James	Lincoln Environmental, Lincoln University
Manukau	Nicholas	Environment Waikato
Manukau	Tim	Tainui Mâori Trust Board
Wara	Sonny	Chairman, Ngati Naho Hapû
Wara	Malcolm	General Manager, Ngati Naho Hapû Trust Board
Ward	Jonet	Lincoln Environmental, Lincoln University
Watene	Erina	Tainui Mâori Trust Board

Hui # 2

Held 15 October 1998, to build a framework of partnership with Te Rûnanga O Ngai Tahu with a view to developing appropriate methods to incorporate iwi values and uses of wetlands into spatial databases and decision support systems.

Hui Participants

Surname	First Name	Organisation
Brown	Don	Te Taumutu Rûnanga
Constable	Linda	Te Rûnanga O Ngai Tahu
Cook	Sandra	Te Rûnanga O Ngai Tahu
Harmsworth	Garth	Landcare Research NZ Ltd, Palmerston North
Inns	Justine	Te Rûnanga O Ngai Tahu
Kirikiri	Rau	Landcare Research NZ Ltd, Lincoln
Lambie	James	Lincoln Environmental, Lincoln University
O’Connell	David	Te Taumutu Rûnanga
Penter	Bob	Te Rûnanga O Ngai Tahu
Smith	Steve	UNEP/GRID, Christchurch
Ward	Jonet	Lincoln Environmental, Lincoln University

Puhihui Field Trip

Held 7 December 1998, to evaluate the practical application of the tentative classification posed in Workshop 1, with wetland managers.

Filed Trip Participants

Surname	First Name	Organisation
Clarkson	Bev	Landcare Research NZ Ltd, Hamilton
Flavell	Karl	Ngâti Te Ata
Manukau	Nicholas	Environment Waikato
Manukau	Tim	Tainui Mâori Trust Board
Ranacou	Emi	Manukau City Council
Reeves	Paula	Waitakere City Council

Glenmore Tarns Field Trip

Held 9 December 1998, to evaluate the practical application of the tentative classification posed in Workshop 1, with wetland managers.

Field Trip Participants

Surname	First Name	Organisation
Ackleton	Simon	Department of Conservation, Twizel
Cuff	Jeromy	Canterbury Regional Council
Mark	Davis	Consultant, Christchurch
Jackson	Rick	Landcare Research NZ Ltd, Lincoln
Jardine	George	Arowhenua
Johnson	Peter	Landcare research NZ Ltd, Dunedin
Lambie	James	Lincoln Environmental, Lincoln University
Reihana	Ben	Arowhenua
Wilson	Gareth	University of Waikato

Okarito Lagoon Field Trip

Held 1-3 February 1999, to evaluate the practical application of the tentative classification posed in Workshop 1, with wetland managers.

Field Trip Participants

Surname	First Name	Organisation
Crofton	Jo	Department of Conservation, Franz Joseph Area Office
Gerbeaux	Philippe	Department of Conservation, West Coast Conservancy
Grainger	Natasha	Department of Conservation, Buller Area Office
Knightbridge	Phil	Department of Conservation, West Coast Conservancy
Tish	Phil	Department of Conservation, Franz Joseph Area Office

Te Henga Field Trip

Held 1 March 1999, to evaluate the practical application of the tentative classification posed in Workshop 1, with wetland managers.

Field Trip Participants

Surname	First Name	Organisation
Clarkson	Bev	Landcare Research NZ Ltd, Hamilton
Jamieson	Alastair	Auckland Regional Council
Knox	Wayne	Kawerau A Maki Tribal Trust
Myers	Shona	Auckland Regional Council
Reeves	Paula	Waitakere Regional Council

Hui # 3

Held 22 March 1999 with the **Northern Mâori Wetland Group**, to update progress, and discuss and evaluate the Wetlands Project with respect to iwi and hapû, and decide on future directions for this work.

Hui Participants

Surname	First Name	Organisation
Anderson	Alice	Hauraki Mâori Trust Board
Clarkson	Bev	Landcare Research NZ Ltd, Hamilton
Clarkson	Bruce	Landcare Research NZ Ltd, Hamilton
Flavell	Karl	Ngati Te Ata
Harmsworth	Garth	Landcare Research NZ Ltd, Palmerston North
Hill	Norman	Waikato Rapatu Lands Trust - Tainui
Kirikiri	Rau	Landcare Research NZ Ltd, Lincoln
Lawton	Margaret	Landcare Research NZ Ltd, Hamilton
Manukau	Nicholas	Environment Waikato
Manukau	Tim	Waikato Rapatu Lands Trust - Tainui
Roa	Sheryl	Waikato Rapatu Lands Trust - Tainui
Wara	Malcolm	General Manager, Ngati Naho Hapû Trust Board
Wara	Sonny	Chairman, Ngati Naho Hapû

Hui # 4

Held 24 March 1999 with the **Southern Mâori Wetland Group**, to update progress, and discuss and evaluate the Wetlands Project with respect to iwi and hapû, and decide on future directions for this work.

Hui Participants

Surname	First Name	Organisation
Clayton	Rebecca	Takahanga/Kaikoura
Constable	Linda	Te Rûnanga O Ngai Tahu
Harmsworth	Garth	Landcare Research NZ Ltd, Palmerston North
Harris	Nigel	Ngai Tuahuriri
Hill	Wade	Te Rûnanga O Ngai Tahu
Jardine-Bates	Teoti	Arowhenua Rûnanga
Leith	Aaron	Te Rûnanga O Ngai Tahu
Manttan	Mereaina Repika	Te Rûnanga O Ngai Tahu
O'Connell	David	Te Taumutu Rûnanga
Penter	Bob	Te Rûnanga O Ngai Tahu
Reihana	Ben	Arowhenua Rûnanga
Ryan	George	Awarua
Smart	Viv	Ngai Tuahuriri
Solomon	Darcia	Takahanga/Kaikoura
Te Maiharoa	Margaret	Te Waihoa Rûnanga
Te Maiharoa-Dodds	Anne	Te Rûnanga O Waihao, Morven
Unahi	M.A.	Takahanga/Kaikoura
Waaka	Paul	Arowhenua/Waihao, Canterbury Regional Council

Workshop 2
Held 25-26 March 1999. The progress on each of the Wetland Project goals was reviewed. The tentative classification posed at Workshop 1 was critically appraised in light of the field trials. Issues outstanding from Workshop 1 were also discussed.

Workshop 2 participants:

Surname	First Name	Organisation
Barnes	Grant	Department of Conservation, Waikato
Berry	Ruth	Ministry for the Environment
Clarkson	Bev	Landcare Research NZ Ltd, Hamilton
Clarkson	Bruce	Landcare Research NZ Ltd, Hamilton
Cuff	Jeromy	Canterbury Regional Council
Denyer	Karen	Environment Waikato
Gerbeaux	Philippe	Department of Conservation, West Coast
Harmsworth	Garth	Landcare Research NZ Ltd, Palmerston North
Jackson	Rick	Landcare Research NZ Ltd, Lincoln
Lambie	James	Lincoln Environmental, Lincoln University
Leith	Aaron	Te Rûnanga O Ngai Tahu
Myers	Shona	Auckland Regional Council
Partridge	Trevor	Landcare Research NZ Ltd, Lincoln
Richmond	Chris	Department of Conservation, Wellington
Roxburgh	Tony	Department of Conservation, Waikato
Shaw	Willie	Wildlands Consultants
Smith	Steve	GRID Christchurch
Teal	Phil	Fish and Game Council, Waikato
Turner	Allan	Waikato District Council
Wara	Malcolm	Ngâti Naho Hapû Trust Board
Ward	Jonet	Lincoln Environmental, Lincoln University
Wilding	Thomas	Environment Bay of Plenty
Wilson	Gareth	University of Waikato

Technical Group Meeting
Held 23 April 1999 to discuss technical issues outstanding from Workshop 2.

Technical Group Participants

Surname	First Name	Organisation
Clarkson	Bruce	Landcare Research NZ Ltd, Hamilton (chair)
Gerbeaux	Philippe	Department of Conservation, West Coast
Johnson	Peter	Landcare Research NZ Ltd, Dunedin
Partridge	Trevor	Landcare Research NZ Ltd, Lincoln
Richmond	Chris	Department or Conservation, Wellington
Sorrell	Brian	NIWA, Christchurch
Ward	Jonet	Lincoln Environmental, Lincoln University

Whangamarino Field Trip
Held 31 May 1999, to evaluate the practical application of the tentative classification posed in Workshop 1, with wetland managers.

Field Trip Participants

Surname	First Name	Organisation
Bev	Clarkson	Landcare Research NZ Ltd, Hamilton
Denyer	Karen	Environment Waikato
Henzell	Ron	HortResearch, Hamilton
Kelleher	Rachel	Department of Conservation, Hamilton

Miller	Shirley	HortResearch, Hamilton
Wara	Sonny	Ngâti Naho Hapû Trust Board
Ward	Brian	HortResearch, Hamilton
Yang	Suann	Environment Waikato