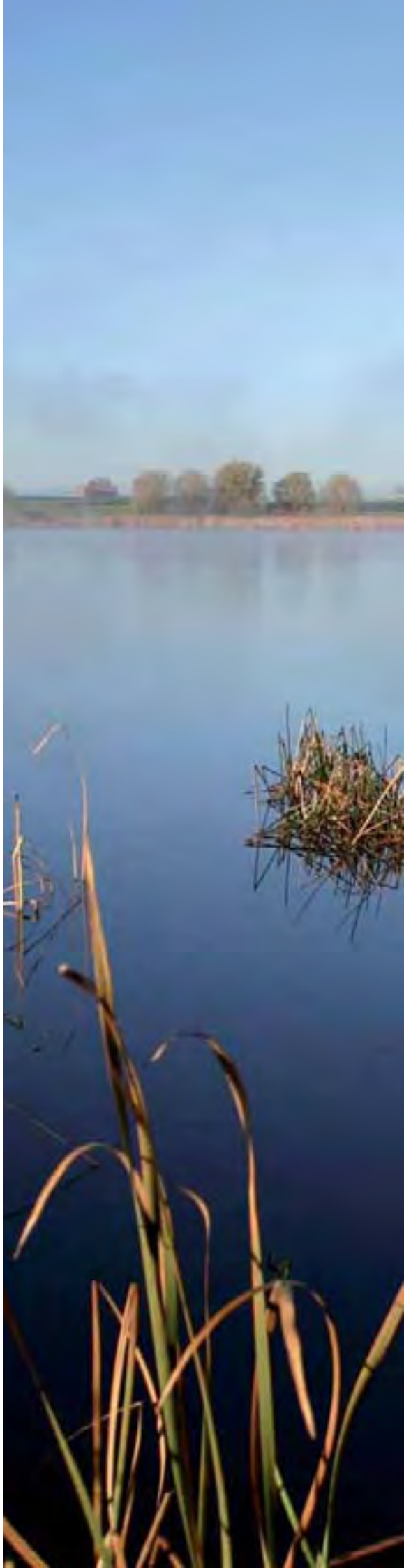
Guidelines for landowners in peat lake catchments

Current best management practices for farming sustainably to protect the peat lakes



Lake Rotomanuka

Contents

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- Tony Roxburgh, Waipa District Council.
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1 Introduction

The aim of the Guidelines is to provide landowners farming in peat lake catchments with a range of current 'Best Management Practices' (BMPs) to reduce environmental impacts on the region's peat lakes. The BMPs centre on sustainable land managment and protecting important natural resources. To provide a context for the BMPs, information on peat lake values with an emphasis on the benefits of the lakes to farms are also included.

The BMPs highlight how to:

- manage the flow of nutrients and sediments from farmed land to the lakes and surrounding wetlands
- minimise further peat shrinkage around the lakes.

Rules drawn from the Regional and District Council Plans which relate to the BMPs are also included[1].

1.1 What are peat lakes?

Peat lakes are water bodies that are either entirely surrounded by peat or sandwiched between the edge of a peat bog and low hills or ridges. Their unique character is due to a combination of the low fertility peat surrounding them and the fact that they traditionally had few, if any, surface water inflows. Most water flowing into these lakes passed through the surrounding peat, being stripped of nutrients and becoming mildly acidic and tea or peat coloured as a result. The loss of peat around these lakes and the change to surface water inflows are the two biggest factors in their decline.

Lake Maratoto is a privately owned peat lake with parts of its margins covenanted to protect remnant wetland vegetation.

1.1.1 Peat lake formation

The lakes were formed when the Waikato River abandoned its easterly course through the Hinuera Valley to the Firth of Thames and entered the Hamilton basin some 19,000 years ago. Over time, sediment carried by the river blocked valley mouths, capturing water behind these blockages and forming lakes. Forests eventually established on these alluvial plains but as the climate became wetter and warmer (around 10,000 years ago), peat forming plants began to grow where drainage was poor. The slow build-up of peat raised ground water levels in the process destroying and eventually burying the forests which had established near the lakes. The stumps which emerge today as the peat shrinks during drainage operations are remnants of these ancient forests. Over the next 3,000 years peat continued to form creating the Rukuhia (6,400ha) and Moanatuatua (8,500ha) peat domes. These domes have since been cleared of indigenous vegetation and are now in pasture. Only the 114ha Moanatuatua Scientific Reserve survives as a small remnant reminding us what the local landscape once looked like.

1.1.2 Peat facts

- Peat is made up of the remains of wetland plants in wet environments. The high water table and acidic conditions prevents the rapid break-down of the dead plants by fungi and bacteria, causing the peat to 'grow' upwards, in some cases forming broad domes.
- Peat grows very slowly – on average around 1mm per year.
- The term 'peat' generally applies when the organic content is 50 per cent or more.
- 'Peat land' applies to all land having a peat substrate, regardless of degree of drainage.

[1] See Environment Waikato Farmer's Guide to Permitted Activities (1 and 2) www.ew.govt.nz

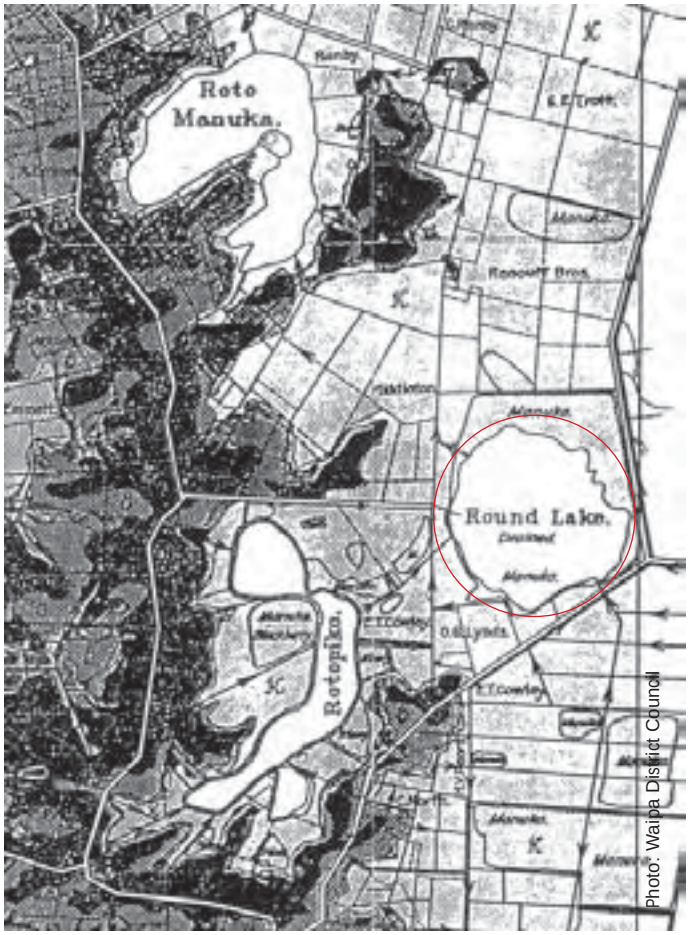


Photo: Waipa District Council

The drainage and development of land for pasture has reduced the size and depth of all of the region's peat lakes. This map dates from the early 20th century.

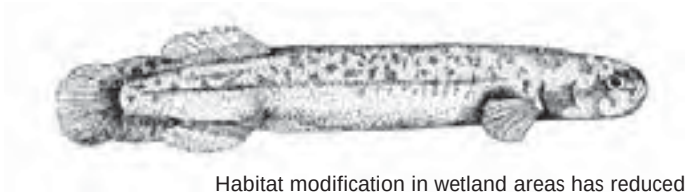
Photo: Terralink International LTD and Environment Waikato.

In some cases, entire lakes have disappeared from the Waikato landscape – compare this recent photo with the map opposite.

1.2 Why are the Waikato peat lakes so important?

There are 34 peat lakes in the Waikato and Waipa Districts and Hamilton city. Globally, peat lakes are a rare phenomenon. Some of the peat lakes in the Waikato Region still support remnants of the original plant, animal and insect communities. The species present in these communities have adapted to the physical and chemical conditions resulting from peat substrates. Some native species such as the black mudfish (kowaro) are very unusual. This fish can survive without water for two months, needing only vegetative cover to keep in moisture. Remaining populations are found mostly on private land in farm drains with plant cover and wetlands.

Native aquatic plants have almost entirely disappeared from the peat lakes due to pest fish introductions, competition from exotic weeds and changes in water quality due to catchment development. Lake Serpentine is one of the few peat lakes left which still has sufficiently high water quality to support the growth of these plants.



Habitat modification in wetland areas has reduced populations of the unusual native black mudfish. Drawing: Sonia Frimmel

Photo: Rohan Wells, NIWA

The condition and cover of native aquatic plants can provide a lot of information about overall lake health. Native plants in Lake Serpentine East are shown in the photo above.

Habitat modification and loss has significantly impacted on native bird species. The Australasian bittern (matuku), North Island fernbird (matata), marsh crake (koitareke), spotless crake (puweto) and banded rail (moho-pereru) have all become extremely rare.

Many of the lakes provided Maori with a range of animal and plant foods, medicines, fibre for clothing and wood for construction. Pa and kainga (villages) were built on lake margins to provide security from invasion.

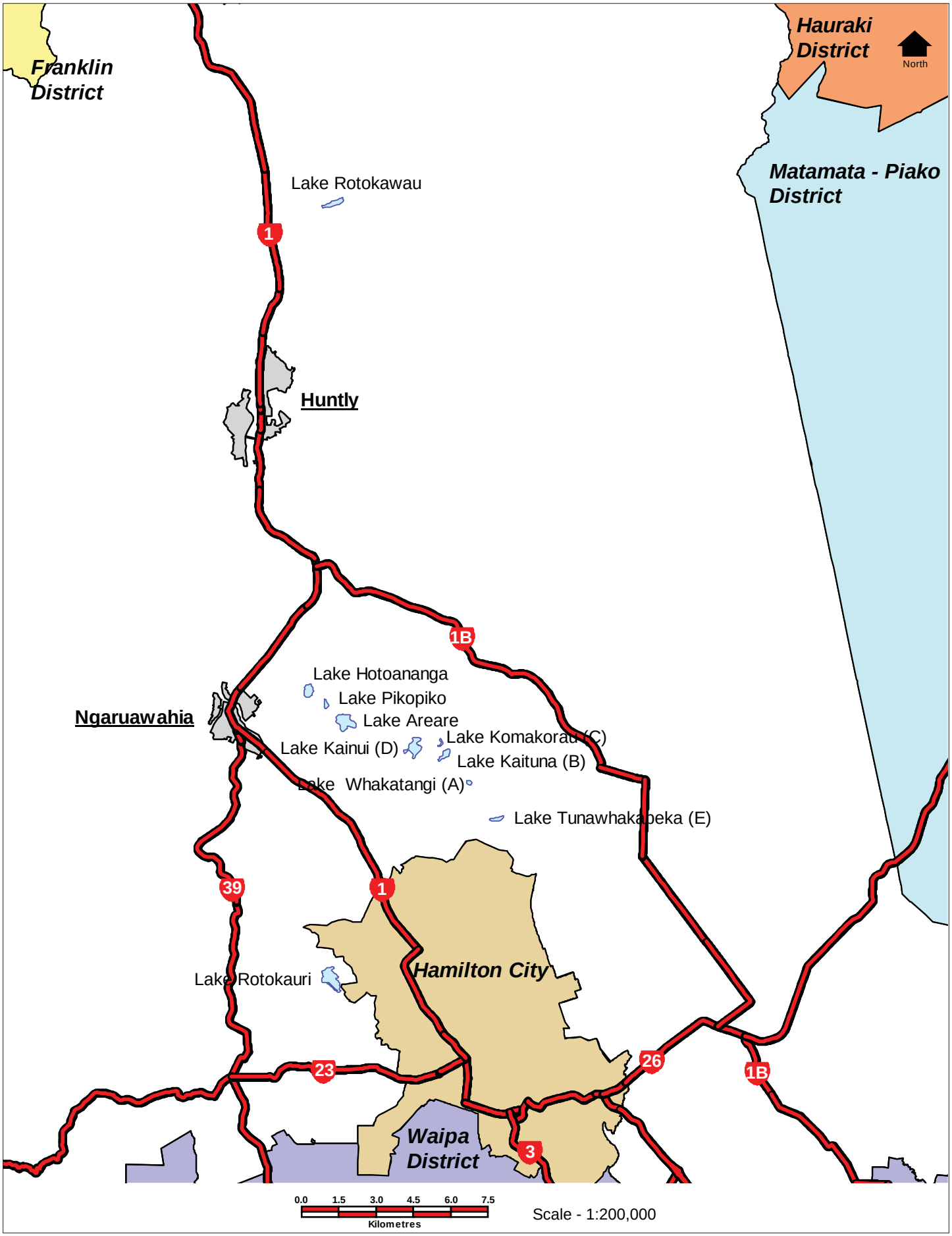
Larger peat lakes such as Ngaroto and Kainui are important recreational assets and are used for sailing, rowing, kayaking, fishing and game bird hunting. Several lakes including Ngaroto, Kainui, Kaituna, Cameron (Kareaotahi) and Koromatua now have walkways around their perimeters and some have areas set aside for picnicking. In recent years, the margins of these and several other peat lakes in the region have undergone extensive restoration. Native species planted out by community volunteers are gradually taking the place of invasive introduced species which once dominated the lake margins. The restoration projects not only improve lake margin health but also provide important environmental education opportunities for school children and the wider community.

This aerial image shows the remains of a pa site at Lake Mangakaware, one of several pa recorded in the Waipa District.

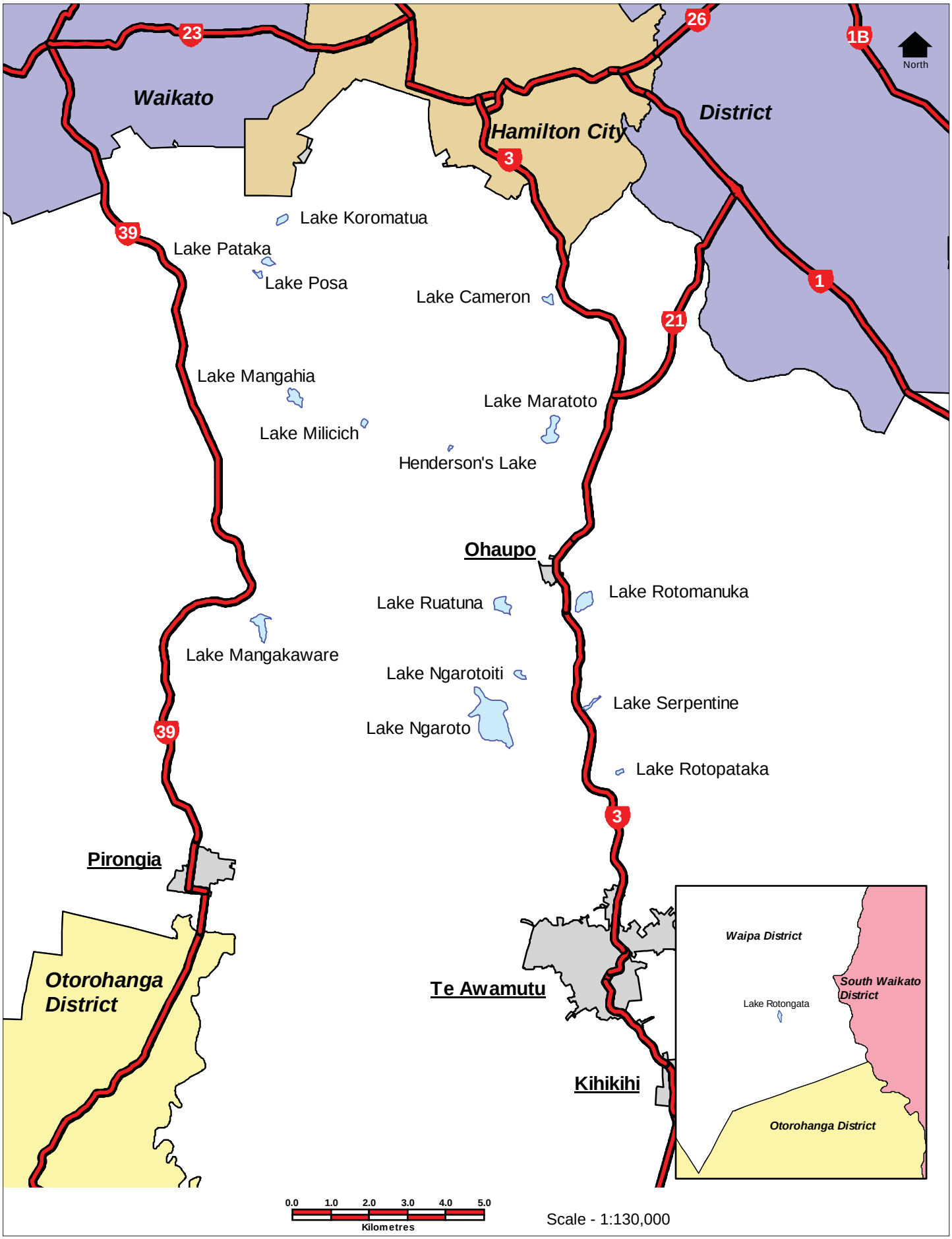
Most of the peat lakes have mai mai tucked into their margins.

Lake Ngaroto has a perimeter walkway with signage highlighting local history and ecology. The lake is used extensively for recreation.

1.2.1 Waikato District peat lakes



1.2.2 Waipa District peat lakes



1.3 Wetlands and farming

The peat lakes and their associated wetland margins provide pockets of habitat for native and game birds, insects and fish. The lakes add ecological diversity interest and aesthetic appeal to what has become a predominantly agricultural landscape. However, a less known fact is that wetlands provide the farmer with many valuable services – all of which are free.

On good quality lake margins, the damp soils and dense swards of native rushes and sedges are very effective in:

- converting nitrogen from surface runoff and leaching and returning the resulting nitrate gas to the atmosphere (denitrification)
- trapping sediments from overland flow, preventing the effects of infilling and smothering
- filtering and trapping effluent particles and storing the resulting carbon
- trapping harmful micro-organisms such as bacteria which are either retained by the soil, or killed by exposure to sunlight
- retaining ground water tables and soil moisture levels
- protecting down stream land from flood damage by absorbing and slowly releasing runoff.

Raupo establishes quickly and is a useful plant for capturing nutrients and trapping sediments from farm runoff.

After removing all willow at Lake Kaituna, native plants have rapidly re-colonised the lake's margins creating a buffer between the lake and adjacent farmland.

Silt traps have been constructed on all drains entering Lake Kainui. Once the native plants have established, the trap will have similar functions – and benefits – to a wetland.

2 Peat lake management

While all peat lakes are regarded as significant, many are also public reserves gazetted under the Reserves Act 1977. The Reserves Act requires those agencies responsible for their protection and management, namely the Department of Conservation, Hamilton City Council, Waipa District Council and Waikato District Council, to ensure the primary purposes for which the reserve was established and classified, are met.

Those lakes classified as Government Purpose Reserves (Wildlife Management) require the Department of Conservation to:

- protect and manage wildlife populations and wildlife habitats
- protect and manage scenic, historic, archaeological, biological, geological features
- provide for public access.

Those lakes classified as Recreation Reserves require councils to:

- provide for public recreation and physical welfare and enjoyment
- protect the natural environment and landscapes
- protect and manage scenic, historic, archaeological, biological, geological features and indigenous flora and fauna or wildlife.
- ensure public access.

While regional, district and city councils are responsible for peat lake reserves, landowners both adjacent to the reserves and within the lakes' catchments are also responsible for ensuring that day to day farming operations are not detrimental to the lakes. Achieving a vision of lakes which are ecologically healthy and are valued by the wider community is possible.

This vision means:

- lakes free from algal blooms
- environmentally sustainable farming
- diverse native plants and wildlife
- enhanced recreational opportunities on lake reserves
- protected heritage sites.

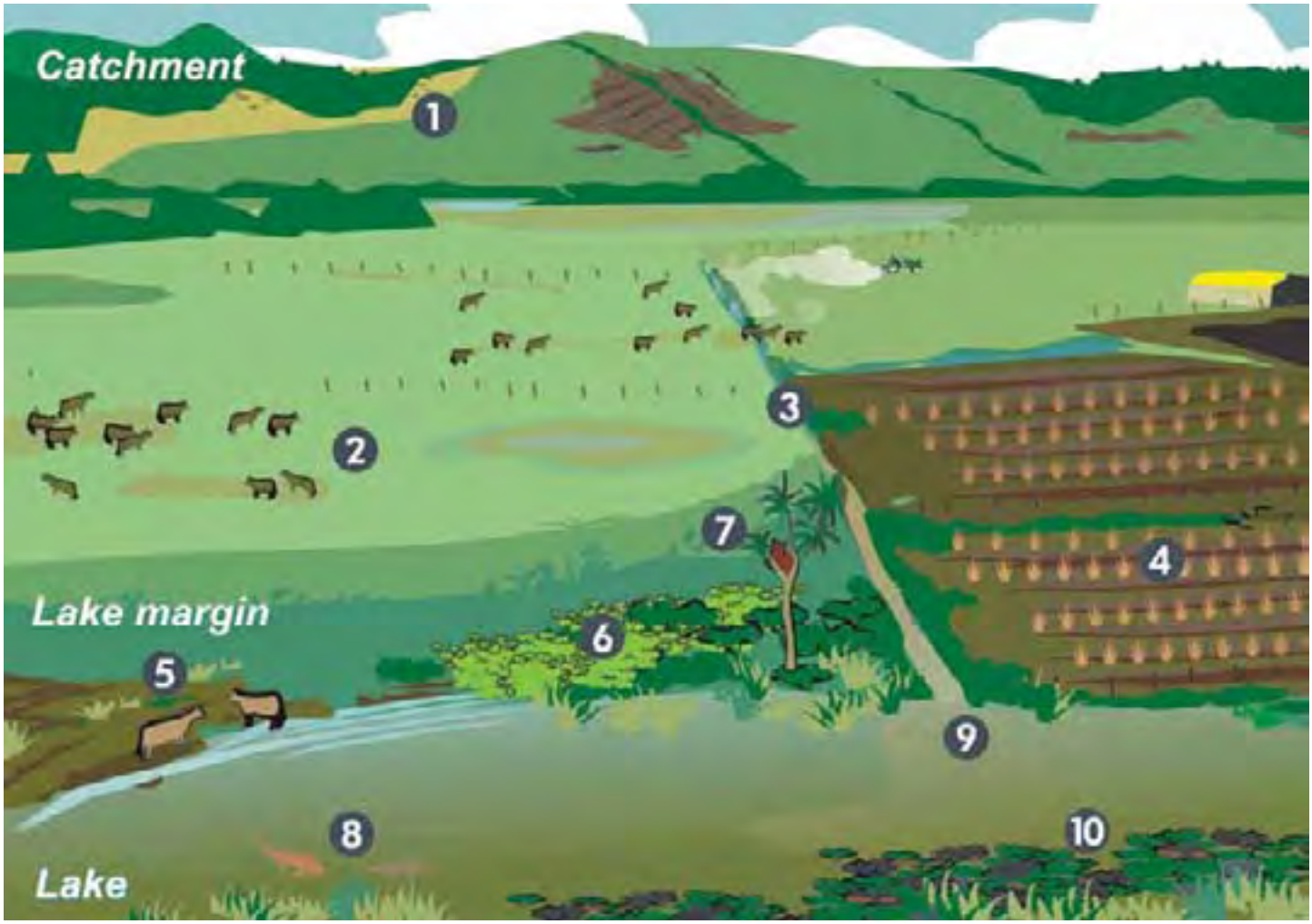
However achieving this vision relies strongly on the combined input from many different people. For example, landowners working in partnership with other farmers in the same catchment, councils, community groups and non-government organisations (such as NZ Landcare Trust, and Fish and Game).

The wetland margins of Lake Komakorau are being extensively restored: all willow (circled) has been removed, silt traps constructed and a planting programme using natives developed.

Many of the larger planting programmes around the peat lakes rely heavily on volunteer input.

3 The changing landscape

The health of the Waikato peat lakes has steadily declined. The scene below demonstrates some of the pressures on the region's peat lakes. These combined pressures have caused a significant loss of the lake's ecological, recreational, cultural and aesthetic values.



1. Large scale clearing of native vegetation to create pasture contributes to soil loss through erosion, reducing the ability of the upper catchment to retain water.
2. Stock contribute nutrients, bacteria and pathogens to the lakes through faecal matter and urine. Soil compaction through pugging increases the rates of nutrient rich runoff entering the lakes.
3. Drainage reduces the lakes' ability to manage nutrients and survive long dry periods.
4. Cultivation causes peat to shrink twice as fast as it does under pasture.
5. On the lake margins, stock browsing and trampling the marginal 'peat forming' plant communities, destroys wildlife habitat and the ability of these areas to strip and filter farm nutrients.
6. Introduced weeds, such as willow and blackberry are more resilient to stock browse and displace native plants as lake margins become drier.
7. Pest animals, such as mice, rats, hedgehogs, rabbits, ferrets and possums compete with native birds for food, prey on nests and young, damage native plants and act as disease vectors for stock.
8. Introduced fish, such as mosquito fish predate and compete with native fish for food. Koi carp and catfish feed by grubbing up lake sediments and cloud the water.
9. Farm run-off elevates the nutrient levels of the lakes so that algal 'blooms' are now a frequent occurrence.
10. The accidental and intentional spread of aquatic weeds displace native aquatic plants, changing the structure of submerged plant communities and habitats used by fish and diving water birds.

4 Farming in peat lake catchments

For long term improvements to peat lake health, a catchment level approach is necessary. This means that all landowners in lake catchments can, and should, play a major role in improving the health of their local peat lake. The focus in this section is on nutrients, sediments and peat shrinkage as all have a pronounced negative effect on overall lake and catchment health. Tables highlighting practical on farm solutions to these issues in the form of current best management practices (BMPs) are also included. The BMPs can be adapted to suit individual farm management regimes.

As multiple use landscapes, reconciling economic, cultural, social, historical and ecological values in peat lake catchments is challenging. This photo shows Lake Rotomanuka.

4.1 The effects of farm nutrients on peat lake health

Although nitrogen (N) and phosphorus (P) are critical for farm production, excess quantities entering the lakes (through surface runoff, subsurface flows and via drains and streams) can be extremely damaging. Even small increases in N and P can cause weeds or undesirable species to proliferate producing algal blooms. Some algal blooms can have very serious consequences for recreational use, livestock and native animals if the resulting toxins are ingested.

4.1.1 Nitrogen (N)

- N is supplied to the soil from fertiliser, stock urine, manure, effluent irrigated to land and nitrogen fixing bacteria living in the root nodules of clover.
- N is relatively mobile and easily lost from pasture once it has converted to the nitrate form.
- N requires careful management to ensure the right quantities are maintained in the soil, without excessive amounts being lost from the productive farming system.
- up to 30 per cent of N entering soils on intensive farms may end up leaching into ground water, eventually flowing into drains, waterways and lakes.

At Lake Kaituna, all drains are fenced and have a buffer of either long grass or native vegetation.

4.1.2 Phosphorus (P)

- P is supplied to the soil from fertiliser, animal effluent, manure and natural weathering of rock and soil.
- P will not generally move far from the soil surface and is not easily leached except in peat and coarse textured soil with low P retention properties.
- serious losses of P occur through soil erosion.
- P enrichment of waterways occurs through poor fertiliser placement and the release of P from eroded soil particles. Soil particles/sediment may enter the lakes through drain clearing in the catchment, poorly designed raceways and unvegetated steep areas.

4.2 Farm nutrient and sediment hot spots

High animal traffic zones such as:

- the dairy shed and all raceways entering it
- stand off/feed pad operation
- raceway runoff into drains and waterways, especially those close to the shed.

Other parts of the farm and farming operations:

- compaction with increased runoff due to overgrazing
- drain/waterway/lake margin erosion due to poor management
- stock access to drains/waterways/lakes
- fertiliser too close to drains/waterways/lakes
- effluent disposal area
- drainage clearing
- silage pits
- offal holes and farm dumps
- overuse of fertiliser.

Scum and algae build-up in Lake Kainui, October 2007 .

The dense swards of sedges at Lake Kaituna help trap sediments and nutrients from the surrounding farms.

4.2.1 Current BMPs for minimising excess nutrient and sediment loss

Farm activity	Potential environmental and production consequences	Management objectives	Current best management practices	Regional and district council rules
Grazing	**Compaction and increased runoff** = topsoil and nutrient loss (especially P) in run-off. **Compaction and reduced grass growth** = long term loss of farm productivity.	• Manage stock to avoid compaction. • Maintain pasture cover to promote rapid recovery as well as topsoil and nutrient retention.	• Move stock from pasture before pugging of high risk areas or humped/hollowed areas. • Maintain pasture cover of 25mm+ over more than 80 per cent on high risk areas or humped/hollowed areas.	
	Erosion of drain, waterway, lake margins and naturally boggy areas = water quality decline through excess nutrient and bacteria inputs.	• Exclude stock from all drains, waterways, lake margins and naturally boggy areas. • Ensure stock have no pressure to enter drains, waterways, lake margins and naturally boggy areas.	• Fence drains, waterways and lake margins. • Avoid forage pressure in areas outside pasture (such as riparian zones) through stocking rate and management. • Supply reticulated stock water. • Supply shade and shelter away from water.	Waikato Regional Plan Rules 4.3.5.3, 4.3.5.4, 4.3.5.5 and 4.3.5.6.
On farm stock movement	**Compaction and erosion of drains waterways, lake margins and naturally boggy areas through stock access** = water quality decline through excess nutrient and bacteria inputs.	• Avoid stock losses and promote easier stock flow.	• Culvert or bridge all stock crossings. • Divert runoff from culverts/ bridges to pasture. *See Environment Waikato Best Practice Guidelines for Waterway Crossings at www.ew.govt.nz.*	Waikato Regional Plan Rules 4.3.5.3, 4.3.5.4, 4.3.5.5 and 4.3.5.6.
Stand off/feed pad operation	**Entry of runoff into drains, waterways and lakes** = water quality decline through excess nutrient, bacteria and concentrated effluent inputs.	• Minimise risk of drain, waterway and lake contamination.	• Confine stock to stand-offs/feed pad areas of adequate size, sited and constructed to avoid or pose least possible risk of drain, waterway and lake contamination. • Construct effluent capture/ storage facilities. • Ensure regular cleaning of standoff areas and appropriate disposal of material.	Waikato Regional Plan Rules 3.5.5.1, 3.5.5.2 and 6.1.8.
Raceway design	**Runoff from raceway into drains, waterways and lake** = water quality decline through excess nutrient and bacteria inputs, and sediment buildup through erosion.	• Minimise risk of drain, waterway and lake contamination.	• Locate raceway away from drains, waterways and lakes. • Buffer raceways crossing drains/ waterways with vegetation and/ or channel designed to filter runoff before reaching drains/ waterways. • Remove build up along the sides of tracks and raceways to allow runoff to flow into neighbouring paddocks for filtration by pasture. *See Environment Waikato Best Practice Guidelines for Tracking and Raceways at www.ew.govt.nz.*	

Farm activity.	Potential environmental and production consequences	Management objectives	Current best management practices	Regional and district council rules
Fertiliser use	**Runoff and leaching into drains, waterways and lake** = water quality decline through excess nutrient inputs.	• Manage fertiliser to avoid excess application and limit losses by leaching/runoff to drains, waterways and lakes.	• Maintain and revise nutrient budget based on soil test results, changes in farm practices and stocking rates/production. • Check and correct spreader calibrations for planned application rate. • Maintain adequate buffer strips with dense grass sward along drains and waterways (see Drainage management). • Don't apply fertiliser on buffer strips – advise contractors accordingly. • Postpone application if heavy rain is forecast. • Use fenced wetlands and grassed/vegetated open drains as nutrient traps. • Develop silt traps where drains enter into the lakes.	Waikato Regional Plan Rule 3.9.4.11.
	Water quality decline through N inputs.	• Manage N fertiliser to avoid application of excess and limit losses by leaching/runoff to drains, waterways and lakes.	• Split applications of more than 40kg N/ha. • Apply N fertiliser in spring only when soil temperature is more than 6ºC and increasing. • Apply N fertiliser when pasture cover is at least 50+mm high or c. 1700kg DM/ha for best response and retention. • Limit total N fertiliser input (incl. effluent if applicable) to no more than 150kg/ha/yr. • Use DCDs (nitrification inhibitors) if feasible to counter N leaching losses from paddock urine and manure.	Regional Plan Rule 3.9.4.11.
	Water quality decline through P inputs.	• Manage P fertiliser use to avoid application of excess and limit losses through runoff.	• Conduct regular soil testing – minimum every 2 years. • Don't exceed optimum P levels for your soil type. • Use slow release P fertiliser where possible. • Split applications of more than 50kg P/ha. • Manage pasture to avoid pugging and topsoil/sediment loss via runoff (see grazing).	Waikato Regional Plan Rule 3.9.4.11.

Farm activity.	Potential environmental and production consequence	Management objectives	Current best management practices	Regional and district council rules
Effluent disposal	**Entry of runoff and leaching into drains, waterways and lake** = water quality decline through N and bacteria inputs.	• Limit nutrient and bacteria entry to drains, waterways and lakes. • Limit runoff. • Limit leaching, such as into sub-surface drains.	• Contain stand off/feed pad effluent in suitable capture systems to avoid runoff and divert to treatment system. • Apply stand off/feed pad effluent to land at a rate not resulting in more than 150kg/ha/yr being applied from all effluent sources. • Contain shed effluent in storage ponds of adequate capacity to match cow numbers. • Maintain shed effluent storage pond efficiency and capacity through regular removal of contents as required. • Capture shed/yard effluent in storage ponds. • Direct clean shed/yard stormwater away from effluent pond via a controlled system. • Apply effluent to land via spreading from slurry tanker when ground conditions are suitable. • Apply sludge/effluent from pond to paddocks at depths not exceeding 25mm in any area/yr. Application cannot result in more than 150kg N/ha/yr from this source. • Sample effluent for nutrient content and spread at rates which can be utilised by grass. • Irrigate effluent 50m (minimum) away from water supplies. • Leave a 20m wide strip (minimum) of non-irrigated land next to all drains, waterways and lakes. • Check irrigator performance and set to lowest possible application rates. • Ensure spray drift does not reach drains, waterways and lakes. *See A Guide to Managing Farm Dairy Effluent at www.ew.govt.nz and www.dairynz.co.nz.*	Regional Plan Rules 3.5.5.1, 3.5.5.2 and 6.1.8.

Farm activity.	Potential environmental and production consequences	Management objectives	Current best management practices	Regional and district council rules
Drainage management	**Channelling of N, P, sediments and bacteria into drains, waterways and lakes** = water quality decline through excess nutrients, sediments and bacteria inputs.	• Minimise risk of contamination to drains, waterways and lakes. • Minimise risk of drains, waterways and lakes infilling with sediment.	• Fence and retire pasture to create filter strip to trap sediments. A minimum of 3m is recommended and 5m for erosion prone soils. • Develop sediment traps or constructed wetlands (or even simple, unmanaged drain areas) along straight channels where drainage gradient flattens. • Construct shallow, grassed 'v' shaped drains to minimise erosion and shrinkage. • If spraying, direct herbicide to the centre of the drain to avoid potential for eroding drain sides. • Don't deepen drains within 200m of a listed wetland without a resource consent (see Appendices for listed wetlands). • Where possible run drains at right angles to the lakes. • Never run main drains along conservation land margins. *See Environment Waikato's Best Practice Guidelines for Land Drainage at www.ew.govt.nz.*	Waipa District Plan rule 2.4.3. Waikato Regional Plan Rules 3.6.4.8, 4.2.18.1 and 4.2.21. Waikato Regional Plan Rules 3.2.4.6, 5.2.5.7 and 6.1.8.
Silage pits	**Discharge of leachate into drains, waterways and lakes** = water quality decline through excess nutrient inputs.	• Minimise risk of contamination to drains, waterways and lakes.	• Prewilt to minimise leachate. • Contain all leachate and direct to effluent system for treatment. • Site pits away from drains, waterways and lakes.	
Cropping	**N release and sediment runoff into drains, waterways and lakes** = water quality decline through excess nutrients and sediments.	• Minimise risk of drains, waterways and lakes infilling with sediment.	• Leave wide buffer zones to drains, waterways and lakes. • Use no-till technology. • Reduce cropping to absolute minimum.	

4.2.2 Other relevant rules

Earthworks and vegetation clearance see Waikato Regional Plan Rules 5.1.4.11, 5.1.4.12, and 5.1.5.

The Waikato District Plan (2007) contains a Rule (25.43 and 25.43A) to be finalised in 2008/09 which controls the clearance of indigenous vegetation. The Waipa District Plan (1997) contains a Rule (2.4.3) which prevents modification of the natural vegetation composition within 50m of the edge of any peat lake measured at its maximum annual water level.

4.3 Peat shrinkage

Peat drainage, although necessary to dry the peat sufficiently to grow pasture and crops, also triggers an irreversible process that leads to peat loss. Once the water table is lowered through drainage, the surface of the land then begins to sink as the organic matter in the peat shrinks and decomposes with exposure to air (oxidation). Shrinkage continues until the land surface again approaches the ground water table and water logging prevents further oxidation. Very low water tables will therefore shorten the life of the peat resource. Shrinkage rates are exacerbated by stock pugging, cultivation, and the addition of lime and fertilisers. Ongoing peat shrinkage also results in the release of carbon to the environment and the loss of a potentially valuable carbon sink.

Peat deposits around Lake Serpentine are up to 6m deep. The pale layer is a band of pumice from an eruption (possibly Taupo) which shows the time scale necessary for peat deposition.

Poor land management practices have markedly accelerated peat shrinkage. Deepening drains and excavating lake outlets to maintain gravity drainage has lowered the water levels in all peat lakes, in some cases by several metres. Ground water levels adjacent to these lakes are largely governed by the lake level, and the area of influence can be as much as 350m from the lake edge. There are already examples of peatland adjoining the lakes flooding more frequently and no longer able to grow desired pasture grasses. Today, minimum lake levels have been established or are being established for many peat lakes and rules are in place which prohibit the deepening of drains within 200m of a listed wetland without a resource consent (see appendices for listed wetlands). Additionally, a resource consent is also required to deepen the outlet of any peat lake in the region.

Minimum water levels help protect the lakes by reducing the impacts of drainage immediately downstream. This weir is installed at Lake Koromatua.

4.3.1 How fast does peat shrink?

In the Waikato region, 40 years of agriculture has resulted in a 1370 mm decrease in peat depth[2].

- Initial settling rates of peat newly converted to pasture or after recultivation can exceed can exceed 200 mm per year before settling to around 20 mm per year.
- Average annual shrinkage rates are 33 mm per year at Moanatuatua, and 25 mm per year at Rukuhia.
- Cultivation causes peat to shrink twice as fast as it does under pasture, therefore cultivating less will help protect your peat soils.
- Deep drains can have a pronounced effect on peat shrinkage. A drain 2-2.5 m deep can influence shrinkage rates up to 200 m away, whereas the influence of a 1m deep drain will stop approximately 25 m away[3].

[2] Schipper, L. A. and McLeod, M. 2002. Subsidence Rates and Carbon Loss in Peat Soils Following Conversion to Pasture in the Waikato Region, New Zealand. Soil Use and Management 18:2

[3] Fitzgerald, N., Basheer, S. and McLeod, M. 2005. Peat Subsidence Near Drains in the Waikato Region. Environment Waikato Technical Report 2005/40.

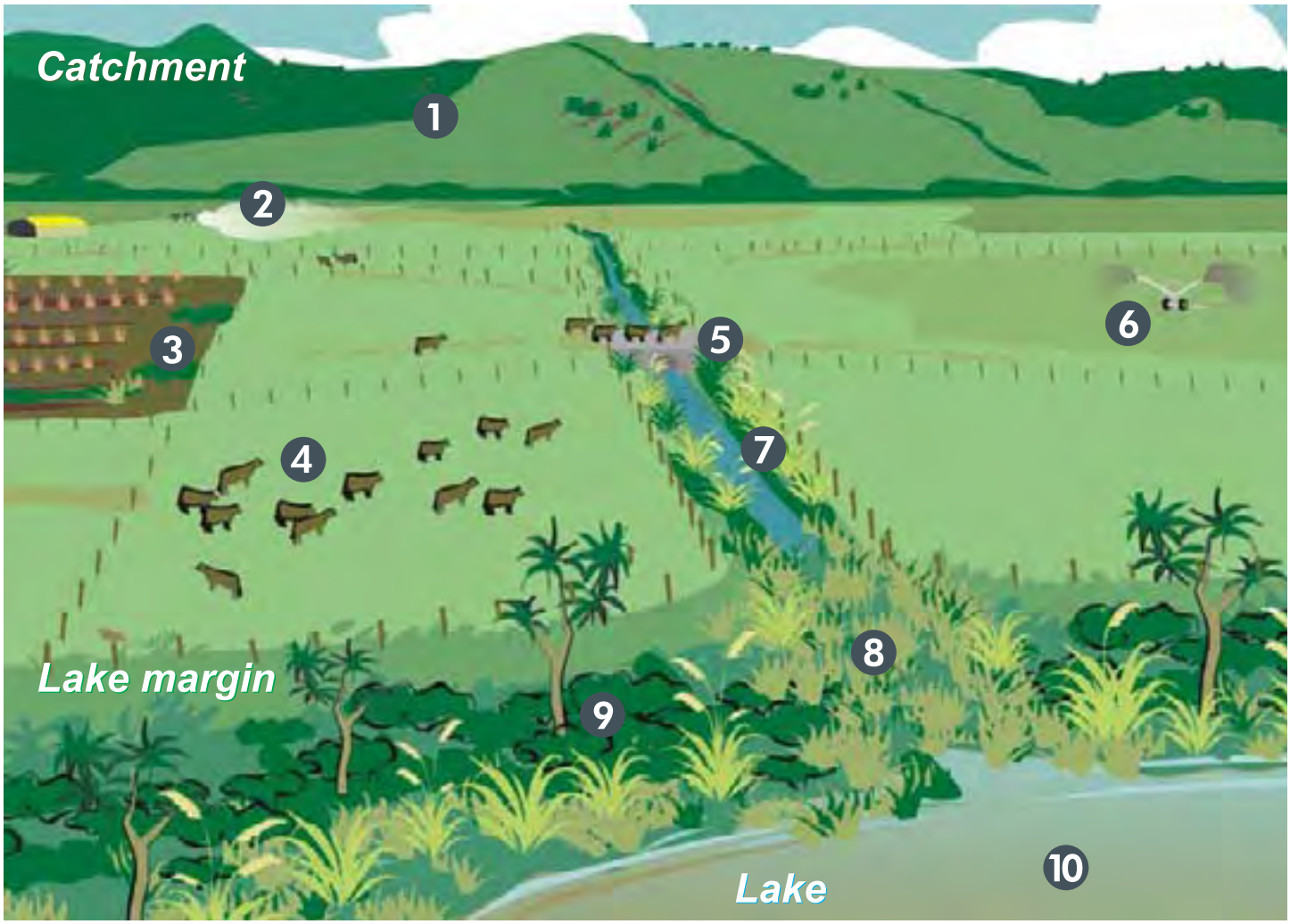
4.3.2 Current BMPs for slowing peat shrinkage

Farm activity	Potential environmental and production consequence	Management objectives	Current best management practices	Regional and district council rules
Stocking rates and grazing	**Overgrazing** = bare patches and pugging and compaction in wet months.	• Limit peat shrinkage and sediment losses.	• Match stocking rate to carrying capacity of land. Stock at lower rates within 200m of lake margins. • Maintain dense pasture sward. • Avoid overgrazing – uneven surfaces result from greater shrinkage of bare patches. • Avoid pugging and compaction during the wet winter months – graze animals on 'safe' land. • Have properly designed stand-off option.	
Drainage management	**Lowering of water table** = peat dries out and oxidises.	• Limit peat shrinkage and maintain water table.	• Construct shallow, grassed 'v' shaped drains in pasture. Drains are better wide and shallow than narrow and deep. • Maintain drain water levels at an average of 450mm below the surface. A sandbag or weirs with wooden planks can be used on private secondary drains*. • To avoid over drainage, don't deepen drains while cleaning. • Don't deepen drains within 200m of a listed wetland without a resource consent (see Appendices for listed wetlands). • Don't deepen the outlets of peat lakes without a resource consent. *See Environment Waikato's Best Practice Guidelines for Land Drainage at www.ew.govt.nz.*	Waipa District Plan rule 2.4.3 Waikato Regional Plan Rules 3.6.4.8, 4.2.18.1 and 4.2.21. Waikato Regional Plan Rules 3.2.4.6, 5.2.5.7 and 6.1.8.
Cropping and pasture renewal	**Loss of peat during cropping events** = destruction of peat structure, sedimentation and loss of nutrients.	• Limit peat shrinkage and sediment losses.	• Reduce aeration/cultivation where possible. • Avoid chopping peat too finely as this will destroy the fibrous peat structure. • Use no-till methods, such as direct drilling used for pasture renewal. • Don't crop close to the lake.	

* Landowners are not permitted to use sandbags or weirs to maintain water levels on board drains running through multiple properties or for example on the outlet of a lake.

5 The future of the peat lakes

What could the Waikato peat lakes and their catchments look like? What are the advantages to farmers of implementing the current best management practices highlighted in these guidelines? The scene below could represent the future of the many of the region's peat lakes both in public and private ownership.



1. Soils in steeper areas are stabilised by trees and shrubs.
2. Nutrients are only used where they can be of greatest benefit to farming operations, minimising runoff and leaching.
3. No-till cropping is carried out to protect peat structure and away from lake margins to limit nutrient leaching.
4. Paddocks are grazed at rates which match the carrying capacity of the land, avoiding compaction and excess runoff. Pasture recovers quickly, binds the topsoil and retains the nutrients in the soil. Sound fencing protects drains, waterways, lake margins and naturally boggy areas.
5. Stock use culverts and bridges. Stock losses are avoided and stock flow enhanced.
6. Effluent is applied away from drains, waterways, naturally boggy areas and the lake. Ponding is avoided to minimise leaching and runoff.
7. Drains are fenced and either left in grass or planted with suitable natives. Drains are not deepened thus avoiding the peat drying out and shrinking.
8. Silt traps are constructed on all drains to prevent excess silt and nutrients from entering the lakes.
9. Wetland areas on lake margins are fenced, preventing stock from damaging plants, pugging the wet soils and fouling the water. Introduced weeds are removed and plants are planted/allowed to regenerate. Pest animals are controlled to protect native/gamebird and plants.
10. Algal blooms are less frequent as fertiliser is applied in targeted amounts to farmland and any runoff/leaching is captured by plants edging drains, waterways and lakes. Introduced fish populations are reduced and aquatic weeds are no longer introduced accidentally or intentionally to the lakes.

6 Appendices

6.1 Peat lakes of the Waikato District

Lake	Ownership/ administered by	Environment Waikato listed wetland Regional plan section 3.7.7	Catchment size (ha)	Lake size (ha)	Ecological values
Areare	Wildlife Management Reserve, DOC	✓	123	33	Wetland Community. Breeding and habitat for common waterfowl, waders and the threatened NZ dabchick.
Hotoananga	Wildlife Management Reserve, DOC and privately owned areas	✓	71	19	Wetland Community. Breeding and habitat for ommon waterfowl, waders and the threatened NZ dabchick.
Kainui/D	Recreational Reserve, Waikato District Council		132	24.9	Restoration of the lake margins is being carried out and all drains are now diverted through silt traps. Algal blooms however still occur.
Kaituna/B	Wildlife Management Reserve, DOC	✓	580	15	All willow has been removed and a major long term restoration project is underway. Fauna include the reintroduced threatened black mudfish, large numbers of waterfowl and waders, eels, spotless crake and banded rail. There are silt traps on all drains entering the lake.
Komakorau/C	Wildlife Management Reserve, DOC		619	2.6	All willow has been removed and a long term restoration project is underway with native plantings and silt traps on all drains.
Pikopiko	Wildlife Management Reserve, DOC	✓	94	6.14	Wetland Community. Breeding and habitat for common waterfowl and waders.
Rotokauri	Local Purpose Reserve (Ecological Management) Waikato District Council		933	41.7	The lake has been fenced and a sediment trap built on the main inflow to reduce the amount of sediment entering the lake. Wetland areas adjoining the lake are being restored. The catchment is habitat for the giant kokupu.
Rotokawau/ Black Lake	Crown land under DOC control, Stewardship Land	✓	1804	22	Peat lake draining into Lake Waikare with large area of peat bog and semi-mineralised wetland. Fauna includes Australasian bittern, North Island fernbird, spotless crake and black mudfish. Moderate to high botanical values.
Tunawhakapeka/ E	Wildlife Management Reserve, DOC and privately owned areas	✓	100	6.7	The lake is small and shallow, and has been heavily modified by drainage and land clearance. The threatened NZ dabchick has been recorded here.
Whakatangi/A	Privately owned		170	2.7	This small peat stained lake is ringed with willow. The threatened NZ dabchick has been recorded here.

6.2 Peat lakes of the Waipa district

Lake	Ownership/ administered by	Environment Waikato listed wetland Regional plan section 3.7.7	Catchment size (ha)	Lake size (ha)	Ecological values
Hendersons	Privately owned		31	1.05	Associated with extremely deep acid peats. The lake has remnant manuka forest and is a waterfowl refuge.
Koromatua	Wildlife Management Reserve, DOC		67	6.5	The lake margins are being restored and public access enhanced for the community. Black mudfish are present.
Lake Cameron Reserve (Kareaotahi)	Recreational Reserve, Waipa District Council	✓	31	3.38	A small ecologically significant lake, surrounded on two sides by residential subdivision. It has deep peat on the west and south and is home to waterfowl and waders.
Mangahia	Privately owned and partially covenanted	✓	354	9.38	The lake's wetland have the highest ecological values of all Waipa District lakes. Part of the fringe is covenanted though the lake is severely threatened by adjacent land development. It has a high waterfowl population.
Mangakaware	Recreational Reserve, Waipa District Council	✓	238	12.89	This lake has a large buffer of land in public ownership around the lake. Although highly modified it has good ecological restoration potential. The lake provides habitat for waterfowl and native aquatic plants.
Maratoto	Privately owned and partially covenanted	✓	168	17.71	A large portion of the lake margin is covered with dense native peat/wetland vegetation. It is considered relatively pristine and has high waterfowl numbers.
Milicich	Privately owned		54	2.22	This lake has better water clarity than most of the other peat lakes in the Waikato. There is a remnant sphagnum and sedge community on the lake margins.
Ngaroto	Recreational Reserve, Waipa District Council	✓	1846	108	The lake is currently undergoing intensive and long term restoration. The lake has high recreational values as well as a high wildlife population.
Ngarotoiti	Wildlife Management Reserve, DOC	✓	504	3.42	The lake provides habitat for waterfowl species.
Pataka	Privately owned		55	4.6	Surrounded by deep acid peats. Some native aquatic plants remain. Part of the lake margin has recently been planted with natives.
Posa	Privately owned		95	2.05	Surrounded by deep acid peats. Part of the lake margin has recently been fenced and planted with natives.
Rotomanuka (North and South)	Wildlife Management Reserve, DOC	✓	479	25.5	Relatively deep and eutrophic lake divided by a raupo swamp into two lakes. High quality wetland habitat with a large number of waterfowl and waders. Fauna includes the threatened NZ Dabchick, Australasian bittern, whirligig beetle and threatened black mudfish.
Rotongata	Privately owned with covenanted areas		144	5.26	The provides habitat for waterfowl. The threatened NZ dabchick has been recorded here.
Rotopataka	Wildlife Management Reserve, DOC		76	1.37	The lake is embedded in deep peat and provides habitat for common waterfowl.
Lake Serpentine East, South and North (Rotopiko)	Wildlife Management Reserve, DOC, Recreational Reserve, Waipa District Council	✓	163	15.2	This complex of 3 linked lakes has important wildlife habitat values. Fauna includes the threatened NZ dabchick, scaup, Australasian bittern, spotless crake, white heron, banded rail. Historic values include a pa site.
Ruatuna	Wildlife Management Reserve, DOC, Recreational Reserve, Waipa District Council	✓	190	13.03	The lake is utilised by waterfowl and protected bird species including the threatened NZ dabchick, scaup and spotless crake.

6.3 Getting good advice

While there are many sources of advice in the Waikato region, below are a range of organisations which can help you find the answers to your questions. Other avenues include industry, science providers, Waikato University, community groups and non-government organisations.

Activities/advice on	Environment Waikato	Waipa District Council	Waikato District Council	Dairy NZ	DOC	NZ Landcare Trust	Biodiversity Advice Waikato
On site visits	✓	✓	✓	✓	✓	✓	✓
Advice on Plans and Rules	✓	✓	✓	✓			
Resource consents	✓	✓	✓	✓			
Nutrient management planning and nutrient budgeting	✓			✓			
Effluent management	✓			✓			
Track and raceway design	✓*			✓			
Fencing	✓**	✓	✓	✓	✓		✓
Pugging and compaction	✓			✓			
Bridge and culvert construction	✓*			✓	✓		
Silt/sediment trap design	✓				✓		
Wetland management	✓	✓	✓		✓	✓	
Native tree and shrub planting	✓				✓	✓	✓
Weed identification/management	✓	✓	✓		✓	✓	✓
Animal pest management	✓	✓	✓		✓	✓	✓
Native birds, fish and insects	✓	✓			✓	✓	✓

Contact details

Environment Waikato
Hamilton office: 0800 800 401
8:00am – 5:00pm Monday to Friday
www.ew.govt.nz

Waipa District Council
Te Awamutu office: 0800 WAIPADC/0800 924 723
8:00am – 5:00pm Monday to Friday
www.waipadc.govt.nz

Waikato District Council
Ngaruawahia office: 0800 492 452
8:00am – 5:00pm Monday to Friday
www.waikatodistrict.govt.nz

DairyNZ
Newstead office: 07 858 3750
8:00am – 5:00pm Monday to Friday
www.dairynz.co.nz

Department of Conservation
Hamilton office: 07 858 1000
8:00am – 4:30pm Monday to Friday
www.doc.govt.nz

NZ Landcare Trust
Hamilton office: 07 859 3725
8:30am – 5:00pm Monday to Friday
www.landcare.org.nz

Biodiversity Advice Waikato
0800 BIODIV/0800 246 348
9:00am to 5:00pm Monday to Friday
www.waikatobiodiversity.org.nz

*see best practice guidelines
**especially for subsidies

A vision for the Waikato peat lake catchments:

- lakes free from algal blooms
- environmentally sustainable farming
- diverse native plants and wildlife
- enhanced recreational opportunities on lake reserves
- protected heritage sites.

Environment Waikato REGIONAL COUNCIL

NZ Landcare Trust landcare action on the ground

Waikato DISTRICT COUNCIL

Waipa DISTRICT COUNCIL

December 2008