The Rarangi Wetland Complex

Conservation values, hydrology, impacts of groundwater extraction

Executive Summary

This report was commissioned by the Marlborough District Council to:

- establish the conservation values of the Rarangi Wetlands Complex
- assist in explaining the hydrology of the wetlands (especially in establishing links to the RSA)
- identify impacts of the proposed extraction on the ecology of the wetlands

Major findings of the investigation are:

1. (a) Previous reports have assigned high conservation values and recommended protection for the Rarangi Wetland Complex. The DOC PNA report considers it to be "..the most valuable unprotected area in the Wairau Ecological Region" and "of the highest possible value".
   (b) Ecological assessment ranks the complex as Nationally Significant.
2. (a) Water level and survey data shows the RSA and wetlands to be a single, interconnected water body, with the wetlands being located in swales intersecting the RSA.
   (b) The Hinepango Wetland is also shown to be directly linked to the RSA.
   (c) Dominant water source for the wetlands (especially at the southern end) is shown to be surface water flowing along the wetlands, with base levels provided by the RSA.
   (d) Extraction of groundwater for irrigation in summer and autumn is in direct competition with use of water for sustaining wetlands at these times.
   (e) Hydrology is the primary driver of wetland structure and function; changes to wetland hydrology have direct effects on wetlands.
3. (a) Information used to assess impacts of extraction on wetland hydrology is largely taken from MDC investigations and modelling.
   (b) Key findings of this study include:
      (i) "…wetlands are being affected under the current water permit regime".
      (ii) Normal drought frequency is predicted to change from 28% of years prior to extraction, to 93% of years under a 3,270m^3/day extraction regime.
      (iii) Significant drought (equivalent to 2000/01 summer) frequency is predicted to change from 13% of years prior to extraction to 60% of years under a 3,270m^3/day extraction regime.
      (iv) Duration of drought is predicted to increase significantly (about 50% for a level of 1.2m in well 4331.
   (c) Changes in levels under the proposed extraction regime are likely to alter the classification of the wetlands from swamp to fen, and cause changes in ecological function.
4. (a) Lowered water levels and increased drought frequencies will result in a reduction in the area of wetland, and a down-slope shift in distribution of species.
   (b) Terrestrial plants will spread further into the wetland from the edges, and weeds such as gorse and blackberry will become significant competitors to wetland edge species.
   (c) The impact on threatened species is difficult to predict, but the amount of potential habitat available to them is likely to be reduced.
   (d) The Rarangi Wetland Complex has already been extensively modified by draining, logging, grazing, flood control works, weed invasion and water abstraction.
5. It is concluded that the proposed extraction of 3,270m3/day is not sustainable for the Rarangi Wetland Complex.

Contents

1. Introduction

The purpose of this report is to provide information to the Marlborough District Council about the Rarangi Wetlands in order to assist with the assessment of the application by Wither Hills Ltd to extract water from the Rarangi Shallow Aquifer (RSA) adjacent to the upper reaches of these wetlands. In particular, the report focuses on the conservation significance of the wetlands, understanding their hydrology (especially any link between the wetlands and the RSA), identifying how extraction from the RSA may impact on wetland hydrology and, in turn, how hydrological changes may affect other aspects of the ecology of the wetlands.

1.1 Geographic terms

A number of terms are used to describe various areas throughout this report and other reports. To ensure consistency between reports these terms are discussed below. The wider area is referred to as the Lower Wairau/Pukaka/Rarangi area, and includes the hills above Rarangi, the Pukaka, lower Tuamarina, Lower Wairau Plains, and the Rarangi Beach Ridge complex, and it is this area which provides the context and links to other areas of ecological interest. The Rarangi Beach-Ridge complex refers to the ecosystems which occupy the beach ridges and swales deposited by marine action. These areas are shown in Figure 1 below. The Hinepango Wetland is shown below in Figure 2, this is called the Pipitea Wetland in the MDC Technical Supporting Document 2003. The MDC report and this report both refer to the Northern Wetlands as being all wetlands north of Rarangi Road, while the Simpson (2003) report numbers these wetlands as shown in Figure 2.


Figure 1 - Wider area


Figure 2 - Wetland names

1.2 Ecological Context

The study area lies within the Blenheim Ecological District, with the edge of the hills to the north of Rarangi marking the boundary with Para Ecological District. The Blenheim Ecological District is characterised by flat, low lying topography caused by the formation of large alluvial river flats by the Wairau River, and is one of the most developed parts of Marlborough. The coastal edge of the district is formed from marine gravels, including the Rarangi Wetlands Complex. Land use within the catchment of the wetland includes horticulture (grapes and olives), pastoral farming, lifestyle subdivisions, a golf course and a small settlement at Rarangi. The catchment of the streams which flow into the northern end of some of the wetlands is in regenerating coastal forest within the Conservation estate. While much of the flat land is privately owned and developed, there are areas of land administered for conservation in the vicinity. The coastal forest to the north is reserve, while to the east there is a narrow strip of coastal reserves, and a few kilometres to the south are the Wairau Lagoons. To the west most of the Para Swamp is protected, and an arm of Mt Richmond Conservation Area extends close to the Para Swamp. The climate generally is warm and dry in a New Zealand context. Rainfall within the Reserve is estimated at about 900mm (Rae, 1987), but the head of the catchment may receive over 1200mm, as there is a very strong rainfall gradient. Periods of drought are common. Sunshine hours in Blenheim are the highest in the country. Sea breezes are a regular summer feature to which this site is exposed. Evapotranspiration rates in the eastern parts of central Marlborough are the highest in New Zealand, and for Wairau Lagoons there are 243 days of moisture deficit per year (Rae, 1987).

1.3 Wetland Definition

The term wetlands is often misunderstood so it is useful to consider various definitions which have been applied to them. The Resource Management Act 1991 interpretation is: "Wetland" includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions. This is a functional legal description, but overlooks a key element of wetlands, namely that of soils. Keddy (2000) provides an example of a definition which better promotes ecological understanding of wetlands: "A wetland is an ecosystem that arises when inundation by water produces soils dominated by anaerobic processes and forces the biota, particularly rooted plants, to exhibit adaptations to tolerate flooding". This clearly separates terrestrial and wetland ecosystems on the basis of hydrology, soil chemistry, and adaptations by biota to cope with flooding. Typically soil chemistry in terrestrial systems is dominated by aerobic processes and oxidation chemistry (using oxygen as an electron acceptor in respiration), while wetland soils are typically anaerobic and dominated by reduction chemistry (using other ions such as NO_3^-, Fe^{3+}, $SO4^{2-}$). It is a common misconception that wetlands require open water before they can be called wetlands - many wetlands have neither open water nor surface water.

1.4 The application

The application referred to in this report is that of Wither Hills Marlborough Vineyards Ltd (WHMVL) to take water from the Rarangi Shallow Aquifer at the rate of 3,270m^3/day; application number UO61185.

2. Conservation Values & Significance

In assessing the significance of the wetlands the values of the whole Rarangi Beach Ridge complex need to be considered. They are effectively part of the same system. A range of studies have assessed the values and significance of this area; these are outlined below.

2.1 Previous reports

The National Geopreservation Inventory (Hayward et al, 1999) considered the Rarangi beach ridge landform to be of regional scientific and educational value. A vegetation survey of the Wairau Catchment (Simpson, 1990) included amongst it's objectives to identify key sites which required protection. The swamp and gravel ridges of Rarangi were regarded as the key site for protection in the Blenheim Ecological District. A draft unpublished PNA survey of the Wairau Ecological Region (Clare & Chapman-Cohen, 1990) identified this area as an important site. An entomological survey (Dugdale, 2001) recommended that at least one vigorous shingle ridge community associated with a wetland should be preserved. A report discussing wetlands in New Zealand (Stephenson, 1983) notes that this type of wetland is almost extinct in New Zealand. The Lands & Survey Coastal Reserves Investigation (Lands & Survey, 1976) made a number of recommendations for protection of areas within Cloudy Bay. These included the Wairau Lagoons (which has been implemented) and nine other areas, amongst them the entire Hinepango Wetland, and all the area between it and the sea. The Wildlife Service recommended three areas for reserve status, the Wairau Lagoons, the Wairau Bar, and the Rarangi Wetlands (most of the existing wetlands were included). DSIR recommended four areas for reserve status, including the wetlands inland from the Rarangi Settlement, the wetlands to the south of the Diversion, and coastal areas and part of the wetlands between Rarangi Road and the Diversion. The whole wetland area appears on the WERI (Wetlands of Ecological and Representative Importance) database, with grazing and drainage being listed as threats, and significance being listed as excellent.

The DSIR Report (Walls & Park, 1977) notes that the area "includes a mosaic of coastal communities that are not represented elsewhere in New Zealand in our system of reserves".

Simpson (2003) concludes that the Rarangi Wetland Complex has high ecological value and is worthy of protection, as did Preece (2003).

The most recent report to recommend protection for the Rarangi Beach Ridge complex is that of North (2004), in the Protected Natural Areas Survey of the Wairau Ecological Region. A number of selection criteria were used but the following quotes summarises the conservation context:

"The dry gravel ridge sand associated wetland hollows constitute a vegetation and landform combination unique in New Zealand. Gravel ridges and hollows associated with retreated shorelines supporting semi-natural vegetation are extremely rare nationally. They are unusual on a world scale (Stephenson, 1983). The site is ***the most valuable unprotected area*** in the Wairau Ecological Region because of its uniqueness".

"This wetland area is the largest of the remaining freshwater wetlands in the Ecological Region. These areas the last vestiges of the once vast swamps that covered most of the lower Wairau river plain, and as such are of ***the highest possible value***".

The above eleven reports attest to the very high conservation significance of the whole complex. Few sites can have been recommended for protection so many times with such little effect (only the Hinepango Wetland is partially protected). Recent developments have destroyed significant areas of the dry ridges despite clear evidence of their significance.

2.2 Significance assessment

Assessment of significance is usually carried out with a set of commonly used criteria, including Representativeness, Species Rarity & Distribution, Diversity & Pattern, and Ecological Context.

2.2.1 Representativeness

At a National scale, New Zealand has lost about 90% of its wetlands. Regionally, the figure is approximately the same for Marlborough, and locally it is likely to be in the high 90% range for the Blenheim Ecological District (Preece, 2001). It is the largest remaining freshwater wetland in the Ecological District. The Rarangi Beach Ridge complex comprises by far the majority of the remaining wetlands. The complex with its adjacent swales and ridges is considered to be unique in New Zealand. The stony beach ridges have been recognised as a rare ecosystem in Williams (2006). The complex is clearly of National Significance for the representativeness criterion.

2.2.2 Species Rarity and Distribution

The complex contains five species which appear on the NZ Threat Classification System lists (Hitchmough 2002), one species which is at a distributional limit, and two which are now rare on the Wairau Plains. These are listed below.

- *Ranunculus macropus* - serious decline
- *Mazus novaezelandiae* - serious decline
- *Urtica linearifolia* - gradual decline
- *Muehlenbeckia ephedrioides* - sparse
- *Syzgium maire* - southernmost NZ population
- *Lepidurus apis viridis* - sparse, only population in Nelson/Marlborough Conservancy
- *Dacrydium dacrydioides* - most of the remaining kahikatea of the Wairau Plains occur here
- *Hoheria angustifolia* - common in many areas, rare on the Wairau Plains

The presence of the two species in the "serious decline" category elevates the Rarangi Wetland complex to National significance.

2.2.3 Diversity and Pattern

A number of communities are present which are almost continuous, starting with the broadleaf forest on the hills to the north, including the wetlands, their associated shrublands and woodland edges, and the grey scrub communities of the beach ridges. Close by on the seaward beach are grasslands, and the wetlands continue all the way to the Wairau Lagoons and Wairau River. Collectively this is a very diverse sequence linked by the wetlands and ridges, and confers Regional Significance for this attribute.

2.2.4 Ecological Context

The Rarangi Beach Ridge complex provides the link between the hills, plains, lagoon, and Wairau River. The upper reaches provide the water to sustain the lower reaches of the system. It is the only place in Marlborough and Nelson where the tadpole shrimp is present, with the presence of some ephemeral habitat being critical to the completion of its life cycle. For its connectivity and provision of resources to the tadpole shrimp the complex is probably of Regional Significance.

2.2.5 Summary

The Rarangi Beach Ridge complex is of National Significance, and the concurrence of a wide range of reports on the high conservation values provides verification for this assessment.

3. Wetland Hydrology

The key aspect of understanding/predicting the potential impacts of extraction on the wetlands is to understand their hydrology. Despite this, no efforts were made to gain a better understanding of wetland hydrology until the council commissioned a survey of levels within the wetlands and installed paired water level recorders (one in a RSA well, one nearby in a wetland) in selected locations throughout the complex. In addition to this network, WetlandsNZ installed a water level recorder and rain gauge in the Hinepango Wetland.

A wetland's hydrological regime is determined by:

- the timing of the presence of surface water
- how often it floods and dries ('frequency')
- the length of wet and dry periods ('duration')
- how far the water spreads ('extent')
- the depth of surface water
- how far the water is below ground
- the water's source (e.g. rainfall, groundwater)
- the variability of water levels (including depth and extent seasonally and from year to year).

3.1 Recorder network

There are no long term records available for the wetlands, but records at the time of writing were available from September 2006 to February 2007. Recorder locations are shown in Figure 3 to the left. While recorders were placed in four locations, two of these were effectively drains. The recorders in the Eastern Wetland (8001, with associated well recorder 4074) and the Hinepango Wetland were placed in wetlands with beds which did not appear to have been disturbed, and therefore could be assumed to have a more typical wetland response than drains. Drains are deeper but narrower (Figure 4 below, 15m from Pipitea), and it is therefore likely that there is greater variation in water levels than the more natural wide, shallow wetlands.

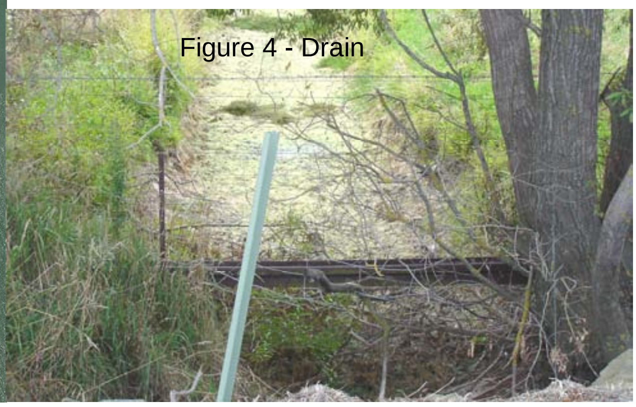
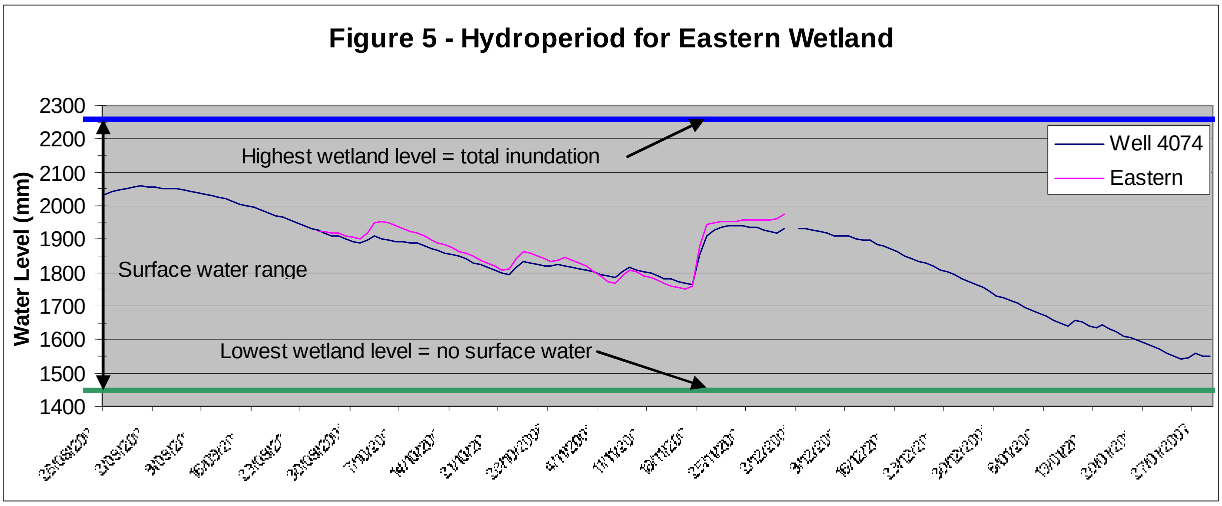


Figure 4 - Drain

3.2 Wetlands - RSA relationship

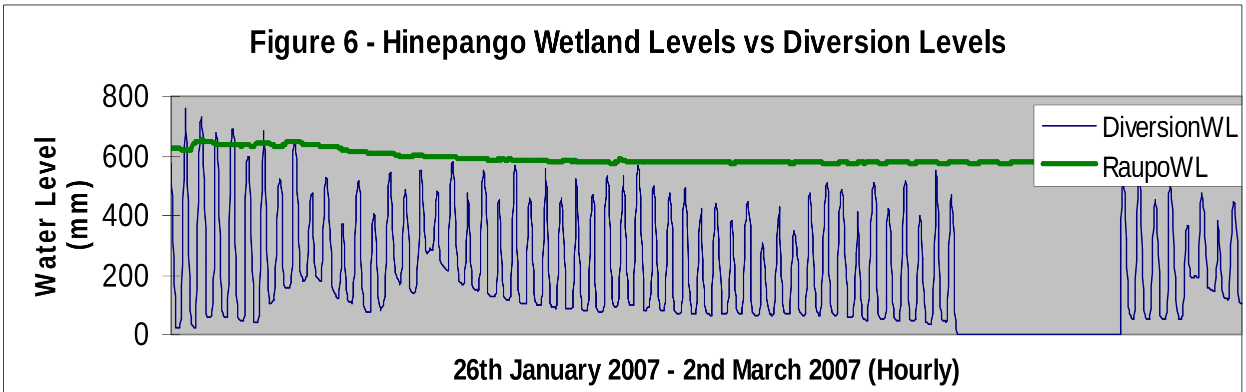
Figure 5 below shows the relationship between well 4074 situated in the RSA, and recorder 8001 situated in the Eastern Wetland. Clearly the two are very closely related, and this relationship is repeated with minor variations with the other paired recorders. The MDC Technical Supporting Document (MDC, February 2007) concludes that the similarity in levels between the RSA and Northern Wetlands suggest a single, interconnected water body. In effect this means that the swales in which the wetlands are located intersect the RSA, creating hydrological conditions suitable for wetlands.



3.3 Hinepango Wetland - Aquifer relationship

It is suggested in the MDC Technical Supporting Document that the Hinepango Wetland is "more dependent on relative level in Wairau Diversion Channel and status of control gate than Rarangi Shallow Aquifer". However, additional data has now been made available from a water level recorder placed in the Hinepango Wetland by WetlandsNZ. The relationship between the hydrology of this wetland and the Wairau Diversion, the Wairau Aquifer, the control gate, and the RSA is explored below.

If the water levels of the Hinepango Wetland were dependent on levels in the Wairau Diversion, we would expect to see a relationship between these levels. Figure 6 below shows no observable relationship between the two, therefore it is unlikely that Diversion levels exert control over wetland levels. The Hinepango levels were taken from location "Raupo", while Diversion levels are taken approximately 1.8km upstream. Wairau Diversion levels clearly show tidal influence.



If the position of the flood gate was the control for water levels in the Hinepango Wetland we might expect water to back up from the flood gate upstream. Observation showed that water was flowing downstream over the track only about 110m above the culvert beneath the stop bank until levels reached about 950mm in the wetland. Therefore, during periods when levels are reasonably high, for levels over the majority of the 2km length of the Hinepango Wetland, water levels are not controlled by backup from the culvert. Observation showed that there was no extensive backup from the culvert at any stage. Flood gate position did not change.

Figure 7 below shows the relationship between the levels in the Hinepango Wetland compared with the nearest Wairau Aquifer well, well 3667, located within 2km. There is no relationship apparent between the two. It is clear that levels in this well are tidally controlled, and equally clear that tidal levels have no influence on levels in the Hinepango Wetland.

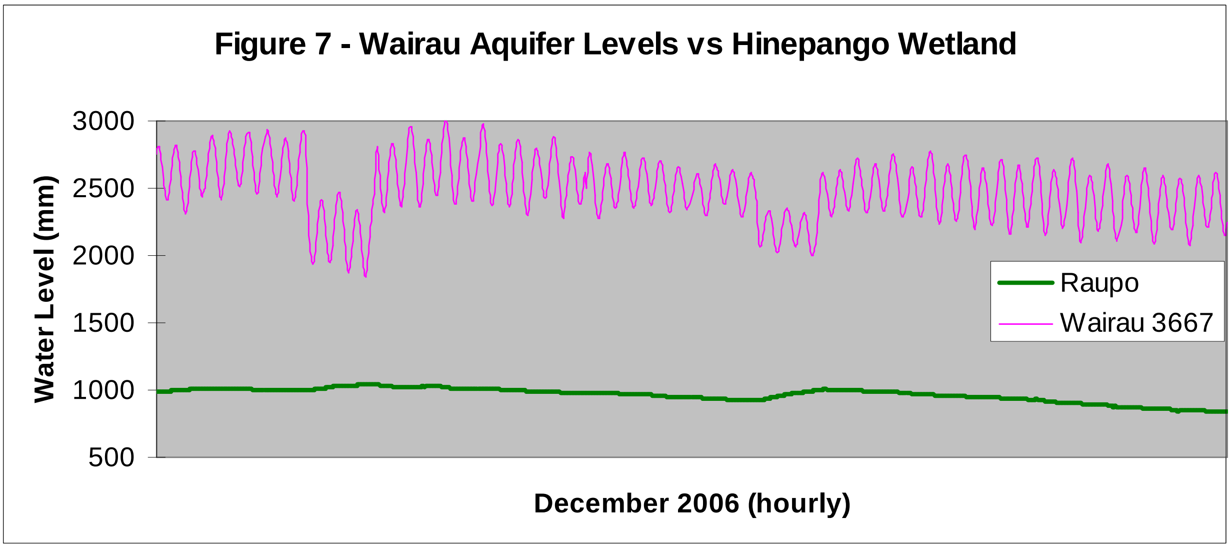
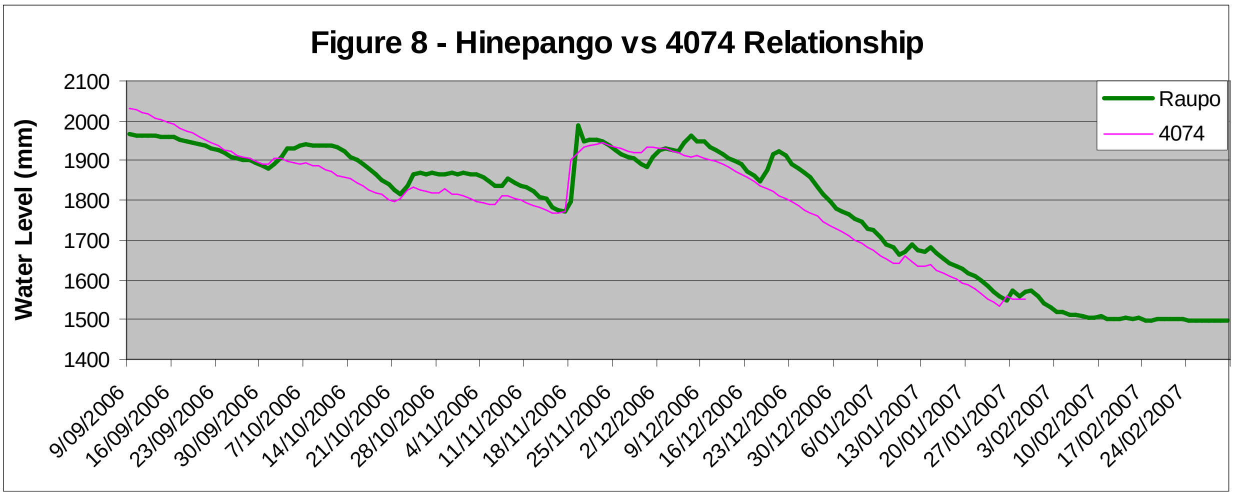


Figure 8 below shows the relationship between levels at Hinepango Wetland and the RSA well 4074, at the lower end of the golf course. This shows a clear relationship over this time period, indicating that the Hinepango Wetland is also part of the RSA. The relevance of this is that any impacts of extraction on the RSA potentially affect areas outside the WHMVL property boundary. The levels have again been adjusted for ease of comparison.



3.4 Dominant water source

The preceding discussion shows that the wetlands are effectively part of the RSA, and therefore are at least partially groundwater fed. Wetlands which have a predominant groundwater source are classified as fens. However, the nature of vegetation in these wetlands is very much that of a swamp. Characteristic fen vegetation includes sedges, fens, tussocks and shrubs. Swamp vegetation typically consists of plants which prefer higher fertility such as flax, raupo, and forest species. Initial assessment of the classification of the wetlands was that they were fens, based on the clear presence of groundwater and the assumption that it provided the dominant water source. However, closer consideration of the vegetation composition shows that, for the current vegetation pattern to develop, the dominant water source must have been surface water. It may not have been dominant in terms of the amount of time surface water was present, but it clearly was the water source which has had the greatest impact in shaping native vegetation distribution and abundance. Therefore the wetlands are swamps.


Figure 9 - Vegetation patterns

Figure 9 above shows the northern end of the wetland nearest the golf course, with typical swamp vegetation of flax and raupo occupying the majority of the wetland. On the upper right edge of the wetland shrubland vegetation of manuka, cabbage tree, *Carex virgata* and *Coprosma propinqua* is extending into the main body of the wetland. This shrubland association is the type of vegetation often found in fens. So the wetter central part of the wetlands have typical swamp vegetation, while the drier edges have vegetation elements which are more typical of fens.

To show that surface water is having a major influence on the hydrology of the wetlands, evidence of flow down the wetlands is required. This is shown clearly in Figure 10, taken at the ford across the wetland approximately 115 metres above the culvert at the Wairau Diversion. This photo was taken on 2/11/2006, and shows a strong flow of water across the ford at that time. Evidence that flows had been maintained for a considerable period at this level (or higher) is provided by Figure 11, showing an assemblage of algae which require permanent water to develop to this extent. It is estimated that water stops flowing over the ford at a water level for the Raupo Water level recorder of about 950mm. When the flow stops, the wetland below this point effectively becomes reliant on groundwater, and the hydrology changes from that of swamp to that of fen. The implications of this are discussed later.


Figure 10 - Water flow

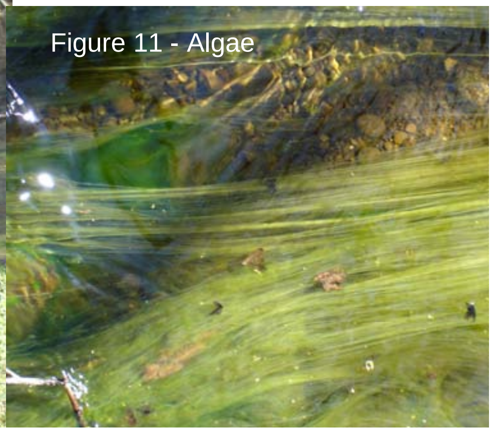
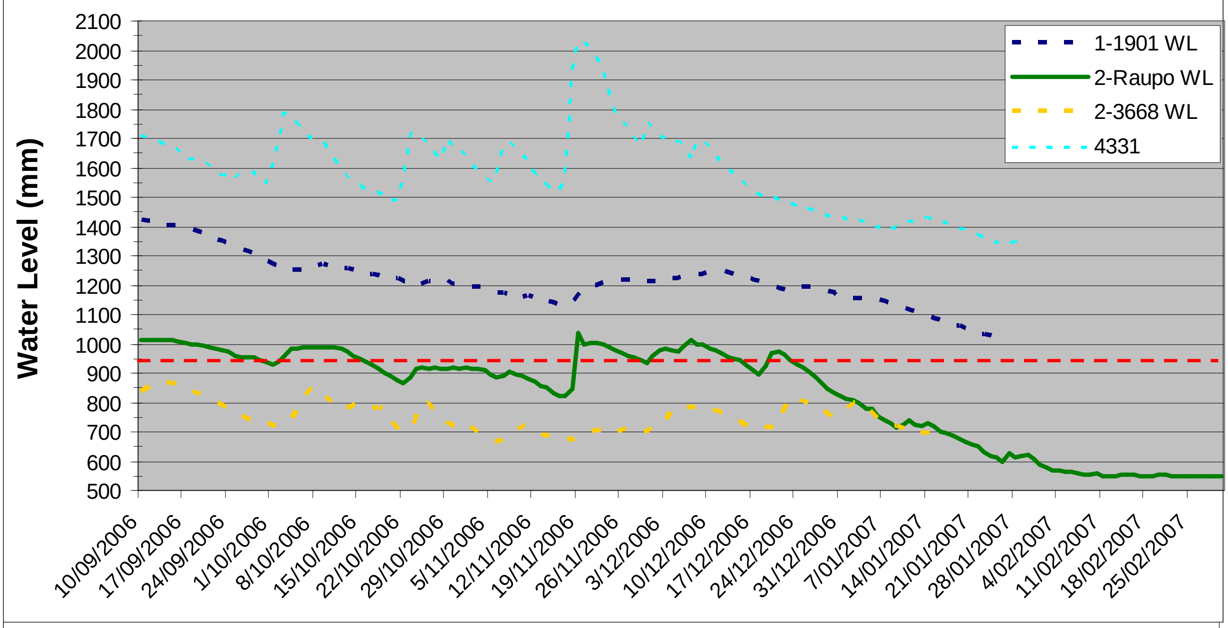


Figure 11 - Algae

3.4.1 RSA - Well Relationships

Each part of the wetland, and each level in the wetland will have a series of hydrological parameters which determine their structure and function. As outlined previously, these include the frequency, duration, timing, and extent of flood and drought periods, the depth of water, the distance to groundwater, the source of water, whether water is flowing or not, and the variability of water levels. Most aspects of wetland hydrology can be determined by level survey and water level recording over time, preferably enough to cover years in which moderate and severe droughts occur. This data is unfortunately not available, and the time for which data is available was wetter than average, making it difficult to draw direct conclusions as to the behaviour of the RSA and wetlands during drought conditions. The RSA wells for which long term data is available includes well 4331, located at Rarangi Road, well 1901 at the Golf Course, and well 3668, north-east of Flaxmill Drive. A comparison of water levels between these three wells and the Hinepango Wetland is shown in Figure 11 on the next page. It shows that the wells and wetland levels are broadly similar in pattern, with the two most responsive to rainfall events being 4331 and the Wetland at Hinepango. This is not surprising, since Hinepango represents the lower reaches of the wetlands and 4331 is located effectively almost in the wetland, while the other two wells are located much further (150 and 500 metres) from the wetland. The greater amplitude in fluctuations shown by well 4331 is interpreted as being a result of being adjacent to a drain with a restricted cross section promoting greater height variations.

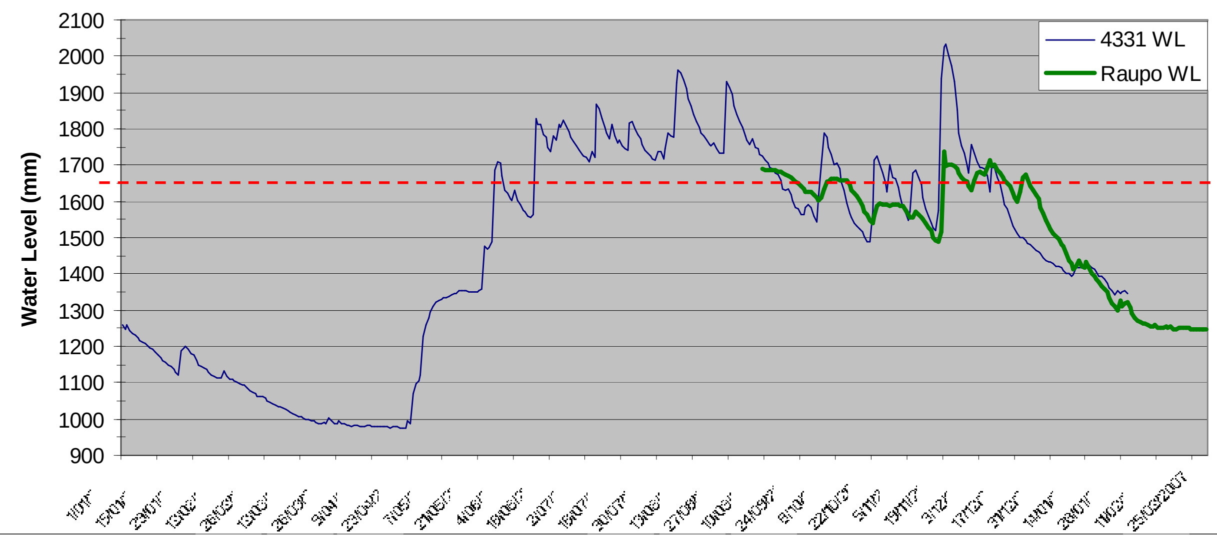
Figure 11 - Comparison of RSA Wells and Hinepango Wetland levels



3.4.2 Flowing water in Hinepango Wetland

The red line in Figure 11 above represents a level of 950mm, the approximate level at which flow to the lower Hinepango wetland was observed to cease. Because long term data is not available for the Hinepango Wetland it is difficult to estimate how long flowing conditions would be present. An attempt to correlate levels between the Hinepango Wetland and well 4331 is shown in Figure 12. By scaling the levels of the Hinepango wetland up to approximately the same level as well 4331, it is possible to derive a value of 1650mm being the equivalent level in well 4331 of 950mm in Hinepango wetland. Of the 395 days for which data is shown for well 4331, 198 days exceed 1650mm in water level. Extrapolating to Hinepango Wetland, this means that, for this time period, the wetland was subject to flowing water 50% of the time. So for half the time it was functionally a swamp, while for the other half it was functionally a fen.

Figure 12 - Well 4331 comparison with Hinepango Wetland levels



With sufficient data and resources it is possible to develop models or approximations for all of the various key parameters such as flood frequency, duration, extent etc. Time restraints and data limitations have limited closer examination of these parameters to establishing water source, looking at the flowing frequency in the Hinepango Wetland, and establishing relationships between plant and water levels in the wetlands (covered in a later section).

3.5 Wetland Misconceptions

While considering aspects of wetland hydrology, it is appropriate to discuss some commonly held perceptions about wetlands and their hydrology.

3.5.1 Wetlands and open water

It is a common misconception that wetlands require open water before they can be called wetlands - many wetlands have neither open water nor surface water. Looking at the definitions discussed previously we see that this is clearly not a requirement, and it is also possible for wetlands to be ephemeral in nature - part of the year they may function as terrestrial ecosystems.

3.5.2 Seasonal water requirements

Barker (2003) stated that "Fortunately, the seasonal demand for water extraction is synchronized with the natural water cycle of this wetland" (i.e. the wetland needs its water least in summer/ autumn, and most in winter/spring). While it is true that some species of waterfowl, for example, depend on high spring water levels for successful nesting, waterfowl are only a minor element in the biota of this wetland. By far the major element is the wetland vegetation. This vegetation is present because it has adaptations to cope with flooding and anaerobic soils. The distribution of many wetland plants is related to water levels and frequency and duration of drought, and as a group is more limited by drought than flooding. Droughts typically occur in summer and autumn. It is clear that extraction of groundwater for irrigation in summer and autumn is in direct competition with use of the water for sustaining wetlands at these times.

3.5.3 Vegetation, hydrology, and wetlands

In considering the potential impact of an activity on wetlands, there is often a focus on how vegetation is affected. While vegetation is the most readily observed component of natural character of wetlands, it must be remembered that there are three components of wetlands - hydrology, biota, and soils. Of these, hydrology is the key driver, and changes to wetland hydrology must be viewed as changes to the wetland itself. It may take many years before changes to hydrology manifest themselves as changes to vegetation or other biota.

3.6 Specific effects of hydrology on wetlands

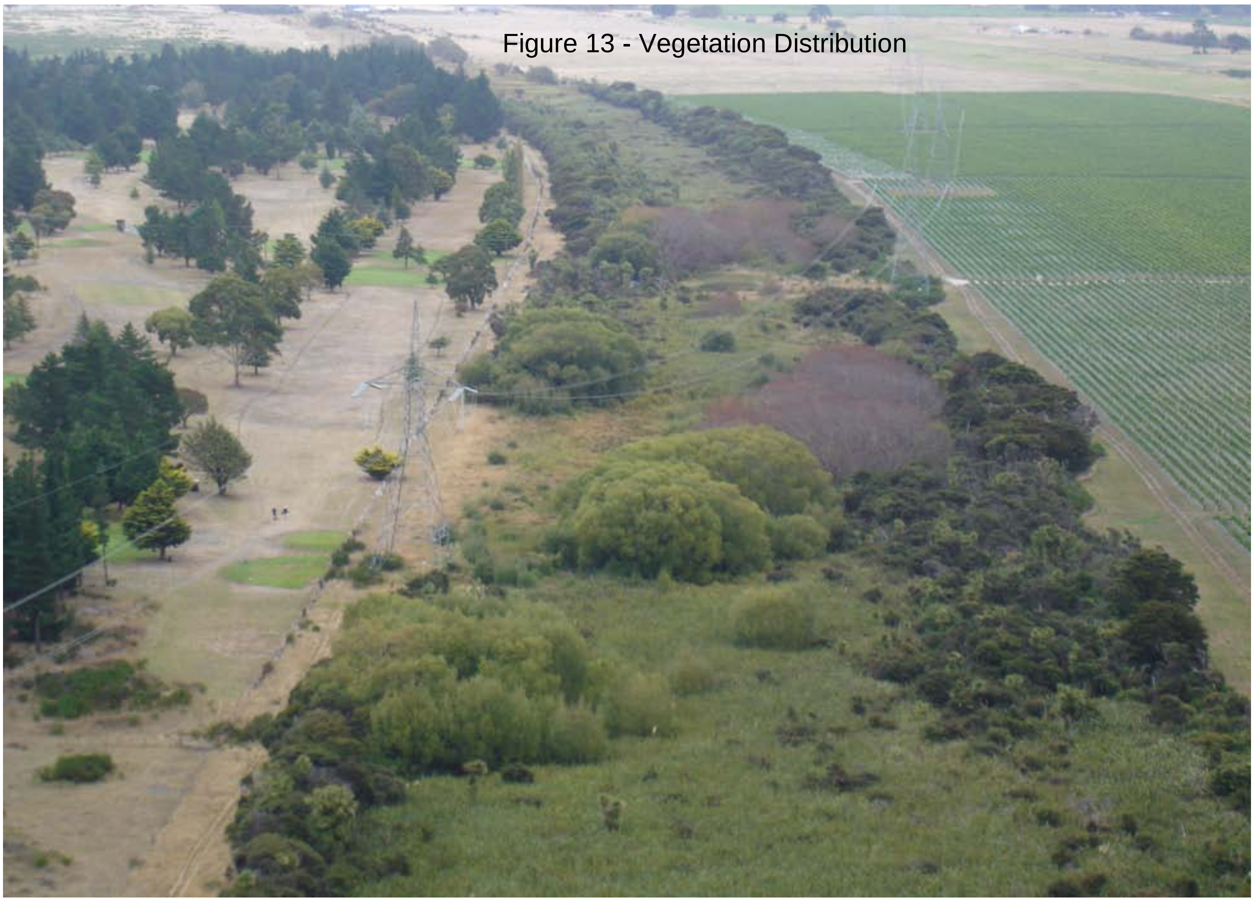
Hydrology is the primary driver of wetland structure and function. Several principles have been used (Mitsch & Gosselink, 2000) to illustrate this. These principles are briefly outlined below.

3.6.1 Species composition and richness

Hydrology controls distribution of wetland communities, and therefore species. Water levels are a key determinant of wetland plant distribution. Suitable habitat for a species along a moisture gradient is determined by its adaptations to flooding. Typically the major wetland species can be arranged along a moisture gradient. In this case gradients are clearly seen at right angles to the axis of the wetlands, so any given cross section (bearing in mind the wetlands are situated in a series of swales between beach ridges) will have a typical plant distribution. There could also be a moisture gradient along the length of the wetlands, with the upper reaches tending to be drier than those lower down. Species richness tends to increase as flow through increases.

Common species found in a cross section of the wetland show an approximate distribution along a moisture gradient (wet to dry) of: raupo, flax, *Carex secta*, *Coprosma propinqua*, cabbage tree, *Carex virgata*, toetoe, manuka, kahikatea, kanuka. This distribution can be seen in Figure 13 below.

Figure 13 - Vegetation Distribution



3.6.2 Primary Productivity

Primary productivity and other ecosystem functions in wetlands are often enhanced by flowing conditions and a pulsing hydroperiod and are often depressed by stagnant conditions. Faster flow rates can increase productivity because of increased exchange rates of gases and solutes as faster flows decreased the boundary layers around plants.

3.6.3 Organic Accumulation and Export

Accumulation of organic material in wetlands is controlled by hydrology through its influence on primary productivity, decomposition, and export of particulate organic matter. Higher rates of particulate matter export can be expected with greater flow rates.

3.6.4 Nutrient Cycling

Nutrient cycling and nutrient availability are both significantly influenced by hydrologic conditions. Higher productivity leads to faster rates of nutrient cycling.

4. Potential Impacts on Wetland Natural Character

Extraction of groundwater from the RSA could potentially impact on all three main elements of wetland natural character; their hydrology, biota, and soils. No data is available for soils, so discussion is limited to hydrology and biota. It should be noted that the ability to quantify hydrological impacts is hampered by the lack of data specific to wetlands. This has necessitated some extrapolation based on well 4331 data and predictions by MDC.

4.1 Wetland Hydrology

4.1.1 Results of MDC Hydrological investigations

The potential impacts of extraction are documented in the Technical Supporting Document (MDC - February 2007). This is the source of information regarding predictions of the impacts of extraction of the proposed 3,270m^3/day on the RSA and hydrology of the wetlands. Key extracts from this document are listed below:

2.b.

iv. Wetland recession is a natural, seasonal, summer phenomenon however extraction from RSA will accelerate process

v. Wetlands are groundwater dependent ecosystems and management of the RSA can directly affect their areal extent

vi. Frequency of wetland recession south of Rarangi Road prior to operation of WHMVL consent is uncertain, but was unlikely to be an annual occurrence based on historical records

vii. Northern Wetlands are predicted to dry up almost every summer if application is granted for an increased rate of 3,270m^3/day, and be dry on average for 125 days.

viii. Areal extent of Northern Wetland influences rate of recharge from the Pukaka Ranges which receives the highest rainfall. When Northern Wetland is fully extended to Pukaka Ranges, it is highly responsive to recharge and generates runoff that moves quickly through wetland system to Wairau Diversion.

2.c.

i. Wetlands reach full extent when Rarangi Shallow Aquifer elevations at Rarangi Road (well 4331) equal about 1.7 metres above mean sea-level.

ii. When Rarangi Shallow Aquifer elevation at Rarangi Road (well 4331) equals 1.6metres above mean sea-level, wetlands recede to southern boundary of WHMVL property, but still act dynamically to redistribute discharge through wetlands to Rarangi Shallow aquifer of Wairau Diversion channel.

iii. When Rarangi Shallow Aquifer elevation at Rarangi Road (well 4331) falls below 1.2 metres above mean sea-level, Northern Wetland system ceases to exist. Due to disconnection, Rarangi Shallow Aquifer doesn't respond dynamically to northern rainfall or runoff.

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> "It is possible that a drawdown of this magnitude (i.e. 150mm) occurs under the present consented take of 1,100m^3/day, and that a larger drawdown would occur in a dry season at the proposed pumping rate. In other words, that ***the wetlands are being affected under the current water permit regime***".
>
> "The predicted levels in the RSA at well 4331 prior to the advent of significant pumping by WHMVL during the 2005/06 summer season, would have fallen to less than 1.2m on four occasions over 15 years, or every 3.5 years on average. Aquifer levels would have been below 1.2m for between 40 and 150 days".

"Under the proposed pumping rate of 3,270 m^3/day levels are predicted to fall below the 1.2metre threshold on 14 out of the 15 years, with an average duration of 125 days. This would mean the wetlands upstream of Rarangi Road would be dry virtually every season, instead of on summer in around 3. Of the 2 regionally significant droughts experienced since 1989, the 1997/98 event caused the lowest predicted levels but the 2000/01 drought lasted longer with 150 days when well 4331 levels were less than 1.2metres elevation".

"The spreadsheet model predicts the equivalent of a 1997/98 or 2000/01 drought event in terms of lower RSA levels, will occur in 9 out of 15 years under a higher pumping regime".

4.1.2 Specific hydrological effects

These findings represent major changes to the hydrology of the wetlands, and are discussed in more detail below. As discussed previously, a wetland's hydrological regime is determined by:

- the timing of the presence of surface water (timing)
- how often it floods and dries (frequency)
- the length of wet and dry periods (duration)
- how far the water spreads (extent)
- the depth of surface water
- how far the water is below ground
- the water's source (e.g. rainfall, groundwater)
- the variability of water levels (including depth and extent seasonally and from year to year).

4.1.2.1 Timing

The peak levels of surface water will probably be present at a similar time, but will arrive slightly later and recede slightly earlier under a pumping regime.

4.1.2.2 Frequency

Frequency of drought on a long term basis will change dramatically, effectively creating a regime where drought is the normal situation, and regionally significant drought can be expected more often than not. Table 1 below summarises these changes in drought frequency. Drought and flooding in the wetland hydrology sense mean periods when surface water is absent or present. Wetland drought frequency will increase by an amount depending on the bed levels in the wetland under consideration.

Table 1 - Drought Frequency

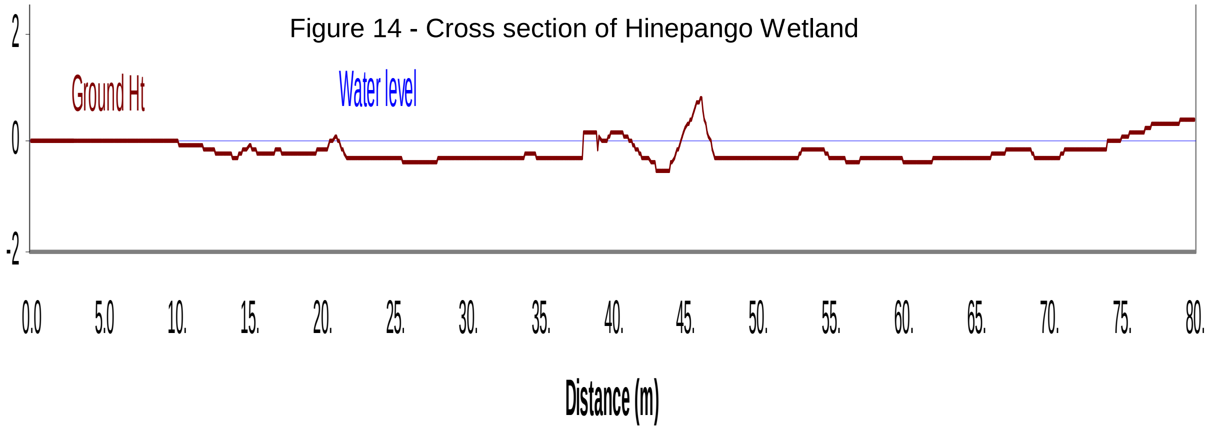
	Prior to 2005/06 regime Drought Frequency	Predicted under 3270m^3/day regime
Drought (<1.2m @ 4331)	28%	93%
Significant droughts (equivalent to 2000/01)	13%	60%
Days <1.2m @ well 4331 (2002-03)	112	170

4.1.2.3 Duration

Drought duration will increase markedly - as shown in Table 1 above. The number of days below 1.2m at well 4331 will increase from 112 to 170, a very significant increase for species which are drought limited. Flooding duration will decline significantly, for a November 2001 flood at a level of 1700mm it changes the duration of flooding from weeks to days.

4.1.2.4 Extent

The wetlands are located within swales, which appear to have relatively steep sides with little change in gradient over the majority of the width of the wetland. This is borne out by observation, by the ground levels taken during survey, and by the Cawthron survey (Young, 2002) from which the cross section below (Figure 14) is taken (from about 50m north of Flaxmill Drive). The effect of this is that, once levels start to recede, there is a rapid loss of extent of flooded areas. The extent of surface flooding will reduce, depending on the contour of the area, and the nature of the flood event. If we take a flood event in November 2001, the difference in flooded extent at peak levels between the synthesised MDC 4331 plot and predicted under the proposed 3,270m3 regime is about 140mm. This means a flooding extent to levels of about 1770mm compared with 1910mm without extraction. This may be half the width of the wetland in some areas.



4.1.2.5 Depth of surface water

MDC figures indicate a decrease in depth of approximately 150mm for well 4331 a significant amount within typical fluctuations of about 1000mm.

4.1.2.6 Distance to groundwater

Similar reduction in levels will occur for groundwater, so when surface water has gone distance to groundwater will increase.

4.1.2.7 Water source

For the Hinepango wetland below Flaxmill Drive, an estimate was made that levels of above 1650mm in well 4331 meant that water was flowing through the wetland, meaning it was functionally a swamp, and from level information it was estimated that water flowed about 50% of the time during 2006. Under the proposed 3,270m^3/day pumping regime it is estimated (using a 150mm drop in water level) that water would flow through this part of the wetland only about 20% of the time, and there would be no flow about 80% of the time. It is probable that this wetland would functionally become a fen. Even allowing for the difficulty of estimating drops in water level in the wetlands under the proposed regime, these figures illustrate the significant changes in wetland function which can result from small level changes.

4.1.2.8 Water level variability

Fluctuations in water level will show a generally similar pattern, with reduced flooding levels and frequencies, and increased drought frequencies.

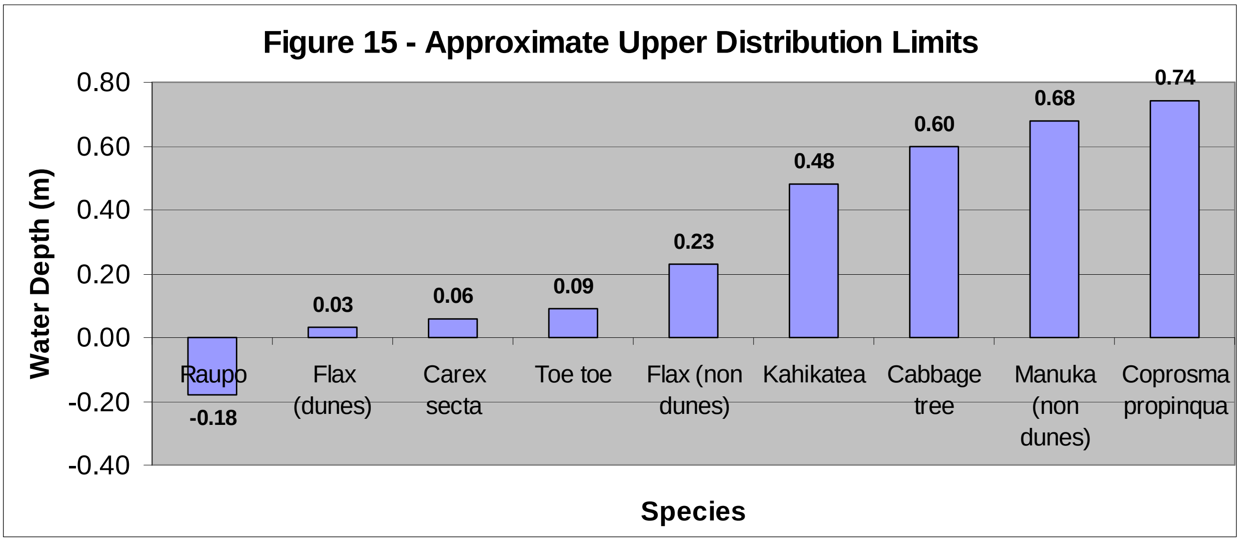
4.2 Wetland Biota

As discussed previously, hydrology controls distribution of wetland communities. The major changes to hydrology for any given wetland or level include:

- A general drying out with reduced water levels, longer drought periods, and less time flooded
- A shift in the type of wetland from swamp towards fen

4.2.1 Reduced water level impacts

Wetland plants are typically limited by water level and drought. During the survey undertaken for MDC levels of wetland plants were taken. The surveyors were asked to choose examples of common wetland species which were at or near their upper limits. Some records were discarded because aerial photography and first hand knowledge of the site showed that they were sites which were not near the upper limits of distribution. The water depth for each site was calculated, and the records averaged for each species. The results are shown in Figure 15 below.



These results are specific to the date of survey only; from 4th to 6th September 2006, when levels were high (about 1750 - 1770 for well 4331). However the relativity between species is likely to remain the same. Raupo is the only species that has an upper limit which was underwater at the time of survey. The upper limit is interpreted as being the highest level the species will typically occupy within these wetlands. It is not known whether these species are limited by water level or drought. A base line for comparison is the mean water level, especially the mean water level during the growing season. That would provide a more meaningful zero point, but the relativity between species would remain the same. The order of species and their relative level from the zero point used in the graph above correspond well with observations made in other wetlands. If we can expect a decrease in water level in the order of 150mm, it is likely that these species will eventually move down the slope by about this amount. For raupo, in the Hinepango Wetland at the Raupo recorder, it could mean a change in distribution of 10 - 15m on both edges. At the wetland adjacent to well 4074 it is will mean that water levels are outside those previously tolerated by raupo, which could lead to local extinction.

It was noted that flax in wetland 4 was unable to exist at levels as high as outside this wetland. Kanuka was able to survive much closer to the water table in wetland 4. These effects are attributed to the very free draining sandy substrate present in and around this wetland.

4.2.2 Increased drought impacts

4.2.2.1 Plant death and die back

It is considered that the 2000/01 drought was responsible for death or die back of some wetland and terrestrial vegetation in wetlands adjacent to the golf course and to the west (Simpson, 2003). It should be noted that there was also a drought in the 2002/03 summer during which levels in the well 1901 at the Golf Course dropped to very similar levels to those of 2000/01, but did not remain at these levels for as long. It is possible that the drought damage was in fact from the 2002/03 event. It is interesting to consider the levels which were reached during the 2000/01 drought and try to relate those to duration of drought in the areas affected. The data is not available to determine this directly, but it is possible to make some informed estimates based on available data. Figure 16 below shows water levels for wells 4074, 1901, and for the Eastern wetland adjacent to 4074. The purpose of the graph is to see if it is valid to extrapolate data from the long term record for well 1901 and relate it to levels in the eastern wetland. It is clear there is a strong relationship between wells 4074 and 1901. The relativity of the levels in these wells is shown by the dotted blue line, which represents the difference between the levels. It shows that, during the latter stages of recession events, there is a relatively constant difference between the two levels. Because 4074 is more responsive to rainfall, the difference between the two levels increases during rainfall events. For the most recent recession, the difference between the two levels is about 540mm. There appears to be a very close relationship between RSA levels as shown by well 4074 and wetland levels as shown by the Eastern wetland recorder. It would seem a reasonable approximation, therefore, to add 540mm to the levels recorded for well 1901 at the time of drought, and consider those to be the water levels at the Eastern Wetland. It is then possible to consider what the impact of extraction might be.

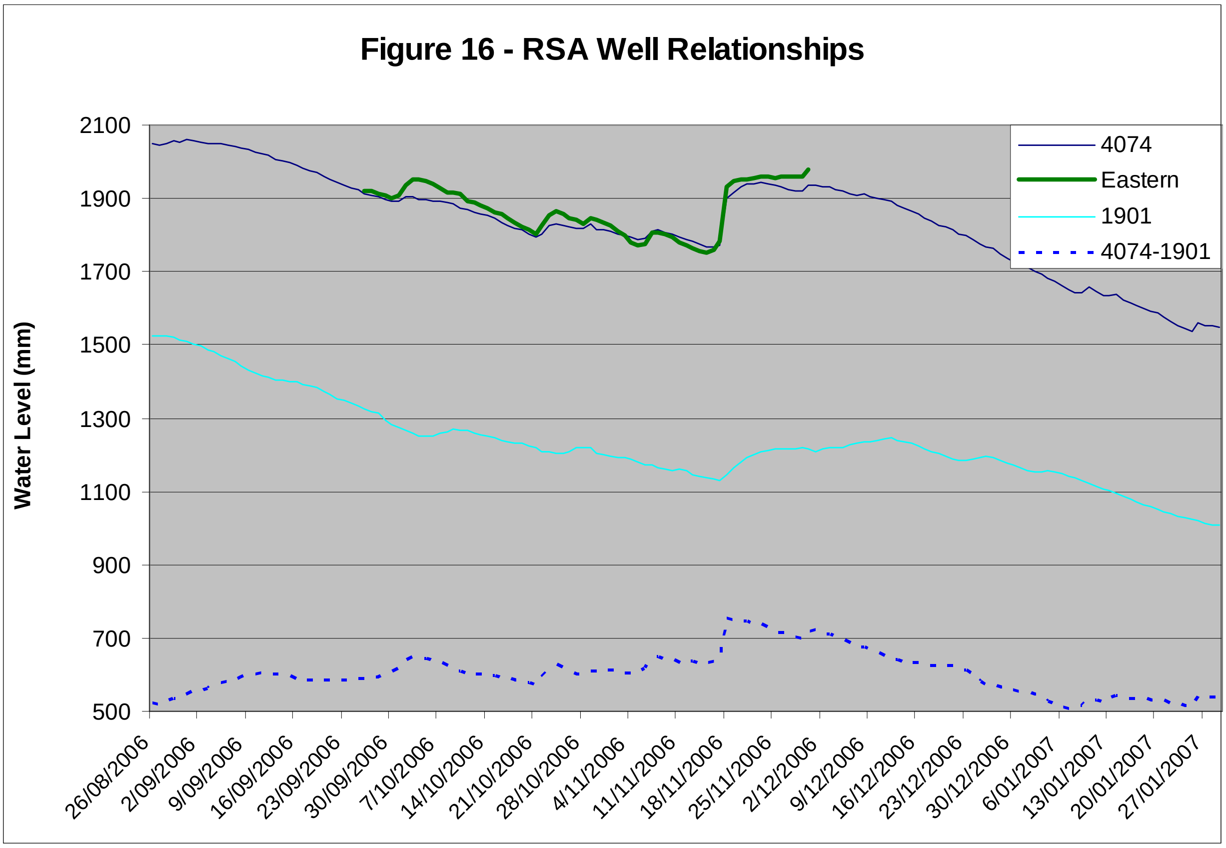


Table 2 shows the distance to water for the species listed. The first reading in Spring 2006 was taken at the time of survey. At that stage raupo and flax were both submerged. The remaining readings are extrapolated from well 1901, with summer 07 being represented by end of January. None of these species are submerged at this stage. Minimum records for the 2000/01 drought, and predicted minimums for the same level of drought under a pumping regime are also shown. The effect of this is to increase the number of drought days experienced in a 2000/01 drought event by about 40 - 60 days for the species above. The 2000/01 drought appears to have caused vegetation death and die back. Increases in the number of drought days of this order will certainly have greater effects, with death and die back taking place over a wider area. Increasing the frequency of such droughts to approximately 60% of years (as predicted by MDC) through extraction at 3,270m^3/day levels will provide less opportunity for species to recover between droughts.

Table 2 - Distance to water

Species	Spring 06	Summer 07	2000/01 Drought	Drought + extraction
Raupo	-350	130	400	550
Flax	-170	310	580	730
Carex secta	80	560	830	980
Cabbage tree	130	610	880	1030

4.2.2.2 Threatened species impacts

The three threatened plant species most characteristic of wetlands are *Ranunculus macropus*, *Mazus novaezelandiae*, and *Urtica linearifolia*. The exact hydrological requirements of these species is unknown, but they are typically edge species rather than aquatics. There is certainly a risk that weed invasion may reduce the available habitat of these species, in particular *Mazus novaezelandiae*. Light and space competition on the edge of the wetland is likely to increase significantly through weed invasion. The tadpole shrimp is a species which favours ephemeral habitats. It was suggested (Taylor, 2003) that they “may therefore be tolerant to seasonal surface water loss due to groundwater extraction”. They do have the ability to reach sexual maturity in a very short time (2 - 4 weeks), but, if levels drop to the extent predicted, the amount of habitat available to them which fulfils this flooding requirement will certainly be reduced.

4.2.2.3 Weed invasion

The progressive drying out of the wetlands which is predicted to take place will favour invasion of the wetland by terrestrial weed species. Broom, gorse, barberry, blackberry, Cotoneaster, boxthorn and briar are all species which are present on the edge of the wetlands which are ideally placed to expand into the wetland as drier conditions become normal. Species such as gorse can invade wetlands such as these when levels are low, and germination can take place. Once established, gorse can then survive periodic flooding provided it is not sustained. Willows have a wide tolerance range along a moisture gradient and are likely to increase their range in the wetlands. Blackberry will find conditions much more to its liking and is likely to become established on damp margins and spread runners from there, become a light competitor for those species on the edge of the wetland. Gorse and blackberry are typically the species which invade wetlands which are drying out.

4.2.2.4 Terrestrial plant invasion

Species such as kanuka, kohuhu, and mahoe are all present and can easily spread to lower levels with progressive drying out of the wetlands. The likely scenario, with a 150mm decrease in water levels, is that terrestrial plants (and weeds as discussed above) will move down slope by at least this amount, which could be in the order of 10 - 15m on each side.

4.2.2.5 Swamp to fen

From the section on hydrology the time when water flows through the lower Hinepango Wetland was reduced from about 50% of days currently to about 20% under the proposed regime. This wetland is at the lower end of the wetlands north of the Diversion, and therefore inundated more often than those nearer the hills, which will have even less time with flowing water present. Overall the wetlands will become functionally a fen, with consequent reduction in primary productivity and change in vegetation structure. Decreased primary productivity may leave plants more vulnerable to drought effects.

4.3 Historical impacts on natural character of Rarangi Wetland Complex

In considering the impacts on the Rarangi Wetland Complex of the proposed extraction, it is also necessary to look at the extent to which this complex has already been modified, so that cumulative impacts can also be considered. Wetlands are especially vulnerable to "death by a thousand cuts", where the cumulative impacts of grazing, lowered water tables, fire, weeds, minor drainage etc virtually extinguish natural vegetation and this absence of apparent natural values is used as justification to complete the process through drainage.

The modification of the wetlands probably began with the channelisation of the Pukaka, about 1900. At this time the Pukaka did not have an outlet to the Wairau, and discharged into wetlands which are very likely to have recharged the RSA. Removal of this water from the RSA may have been one of the largest hydrological impacts on the RSA. Flow rates for the Pukaka are about 150l/s (Rae, 1987), or about 13,000m^3/day. It is possible that the Pukaka flowed along the base of the hills - the remnants of an old channel can still be seen on current aerial photos. The 1942 topographical map shows four drains north of Rarangi Road, and it is likely that these, too, were early developments. Flood control by way of stop banks and culverts, and pumping stations to remove water from low lying areas all impact on the natural hydrology. Vegetation was removed by burning, and logging has left only a handful of kahikatea on the whole of the Wairau Plains (most of them on this site). Flax mills operated in this area, with nine being present between here and Patriarch. A very large wetland was still present between the Pukaka Drain, the base of the hill and Whites Bay Road. The lower Wairau Plains was once the centre of wetlands for Marlborough, and has experienced a very high rate of wetland loss. In more recent times the creation of the Wairau Diversion and extraction of water from the RSA for domestic, recreational, and horticultural use have impacts on the hydrology. Willows have spread over some of the wetlands, especially Hinepango Wetland, and have become the dominant vegetation in places, and also decrease water quantity and quality. Within the last decade there have been significant changes in land use, with large areas of land being developed for horticulture or residential development. This has resulted in a significant reduction in the area of dry ridges, despite evidence of their significance.

Collectively it can be seen that the natural character of the area has already been extensively modified, and it is against this background that additional impacts need to be assessed.

5. Conclusions

In assessing potential impacts of extraction on the Rarangi Wetland Complex, it is useful to go back to first principles and consider the Resource Management Act context under which this assessment is made. The purpose of the Act is "to promote the sustainable management of natural and physical resources". Section 6 lists a number of matters of national importance:

(a) The preservation of the natural character of wetlands, and the protection of them from inappropriate subdivision, use, and development:

(b) The protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development:

(c) The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna:

All three of these matters are relevant in this case. An assemblage of wetlands is present, the whole complex is considered an outstanding feature and landscape, and the complex is assessed as being of national significance. It is against this background that potential impacts are assessed.

The key issue is that the proposal for extraction is from the RSA, which has been shown to be a single interconnected water body with the wetlands. Extraction from the RSA therefore directly impacts on the hydrology of the wetlands. Wetland hydrology, although a less visible entity than the vegetation of a wetland, is the primary driver of wetland structure and function, and a very significant component of wetland natural character. The hydrological changes predicted by MDC, as a result of the proposed extraction, can be described as large scale. The increased frequency of droughts from 28% of years to 93% of years, and regionally significant droughts from 13% of years to 60% of years is an illustration of the magnitude of change. Effectively drought will become the normal situation. When these changes are overlain on an already water stressed system (with extensive drainage, low rainfall, high sunshine and high evapo-transpiration) the impacts on hydrology is considered to be significant. While it is not straightforward to quantify effects on wetland biota (because insufficient data is available), the scale of change to hydrology clearly indicates significant change to biota, though this may take some time to manifest itself.

Therefore it is considered that the taking of 3,270m^3/day of water from the RSA is not sustainable for the Rarangi Wetland Complex because:

- the degree of hydrological change will change rather than preserve the natural character of the wetlands
- the areas of nationally significant vegetation and habitats of fauna will be reduced

and that the scale of these changes will be significant.

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