Appendix D

Wetlands Assessment (Hunter Wetlands Research)

HWR

07521

Wetlands Assessment for Riverside, Tea Gardens

Report to Crighton Properties

2009

HWR Pty Ltd t/as Hunter Wetlands Research (ABN 71094286147)

Versions of this Report

Version Date	Changes to Previous Version
30 Apr 07	na
4 Jul 07	Incorporate results of groundwater study; refinement of wetland vegetation map.
7 Nov 07	Incorporate latest groundwater and surface water modelling details.
8 May 08	Modify to match latest layout.
25 Jun 08	Incorporate channel widening.
29 Jul 08	Incorporate additional information on channel widening.
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Report Authorship

Personnel	Authorship Role	Research Role
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Wetlands Assessment for Riverside, Tea Gardens

Geoff Winning, 2009
Hunter Wetlands Research (*HWR Pty Ltd*)

Introduction

The proposed 'Riverside' development covers an area of 217ha, approximately 99ha of which would be developed as residential, commercial and tourism facilities. The remaining 118ha would be retained as open space parks, wildlife corridors and reserves. The reserved land includes approximately 45ha of wetlands which would be retained and protected in recognition of their local and State significance. More than half of the wetland reserve is covered by *State Environmental Planning Policy 14 - Coastal Wetlands* (SEPP 14), and virtually all of the wetland area supports ecological communities that are listed as endangered under the *Threatened Species Conservation Act 1995* (TSC Act). The proposal includes a new channel connecting the Myall Quays lake and a drain leading to the Myall River.

This report applies to the areas of land identified as the 'wetland precinct' and the 'habitat conservation precinct' in Great Lakes Council's *Development Control Plan No. 22 - Myall Quays Estate* (DCP 22). Even though DCP 22 no longer applies to the development proposal, these two precincts of DCP 22 effectively define and delineate the wetlands that are to be retained as part of the proposal. In Great Lakes Councils *Local Environmental Plan* (LEP) the wetland precinct is within 'Zone 7(a) - Wetlands and Littoral Rainforest' and the 'habitat conservation precinct' is mostly covered by 'Zone 7(b) - Conservation' (the southernmost part of the conservation buffer is within 'Zone 2(f) - Mixed Residential-Commercial').

The report complements the flora and fauna assessment prepared by Conacher Travers Pty Ltd, and focuses on wetland-specific matters. More general matters are deferred to the general flora and fauna assessment where appropriate.

Wetlands on the 'Riverside' Site

The wetlands on the site have been the subject of a specific wetlands study in 1988 (SWC, 1988), and were included in other flora and fauna studies of the whole Myall Quays site as part of the local environmental study prepared for the site (Gardner Brown Planning Consultants *et al.* 1991, Lembit 1992, Mount King Ecological Surveys 1992). In addition there have been detailed studies of parts of the wetlands (e.g. Winning 1997).

The wetlands lie on the floodplain of the lower Myall River. Those wetlands immediately adjacent to the river have strong estuarine tidal influences due to the close proximity to Port Stephens. The intertidal areas support characteristic estuarine wetland vegetation (mangroves and saltmarsh). The wetlands dominated by freshwater inputs occur on sands and their vegetation is dominated by plant species that are characteristic of sandplains of the lower north coast of New South Wales.

While the previous studies provide a good general description of the wetlands of the site, these studies are mostly quite dated now, and it was considered necessary to update these previous descriptions of the wetlands. This comprised re-mapping of the wetland vegetation through aerial photograph interpretation supported by ground-truthing undertaken during April 2007.

Wetland Vegetation Mapping Methods

Vegetation mapping is a iterative process of establishing a relationship between the spatial units and the vegetation they contain; the process of developing a map requires the mapper to link each land unit tract to the vegetation units (Thackway *et al.* 2008). Most vegetation mappers in Australia still proceed largely intuitively using qualitative techniques based on visual interpretation of aerial photography combined with substantial periods of fieldwork (Thackway *et al.* 2008).

This is the technique that was applied in this case. Visually evident spatial units on the aerial photography (identified as differences in colour and visual texture) were examined in the field to determine the vegetation present. Several examples of each type of visual pattern were examined to increase confidence in the interpretation of vegetation. Department of Lands 1996 and 2003 aerial photography and 1998 orthophotography were used. Intensive ground truthing was undertaken in April 2007. It is also important to note that the author has undertaken inspections of these wetlands on a number of occasions in the past 20 years.

The information collected on each vegetation unit is presented in Table 1, which includes a photograph of each vegetation unit to demonstrate its condition. The wetland vegetation map is presented in Figure 1.

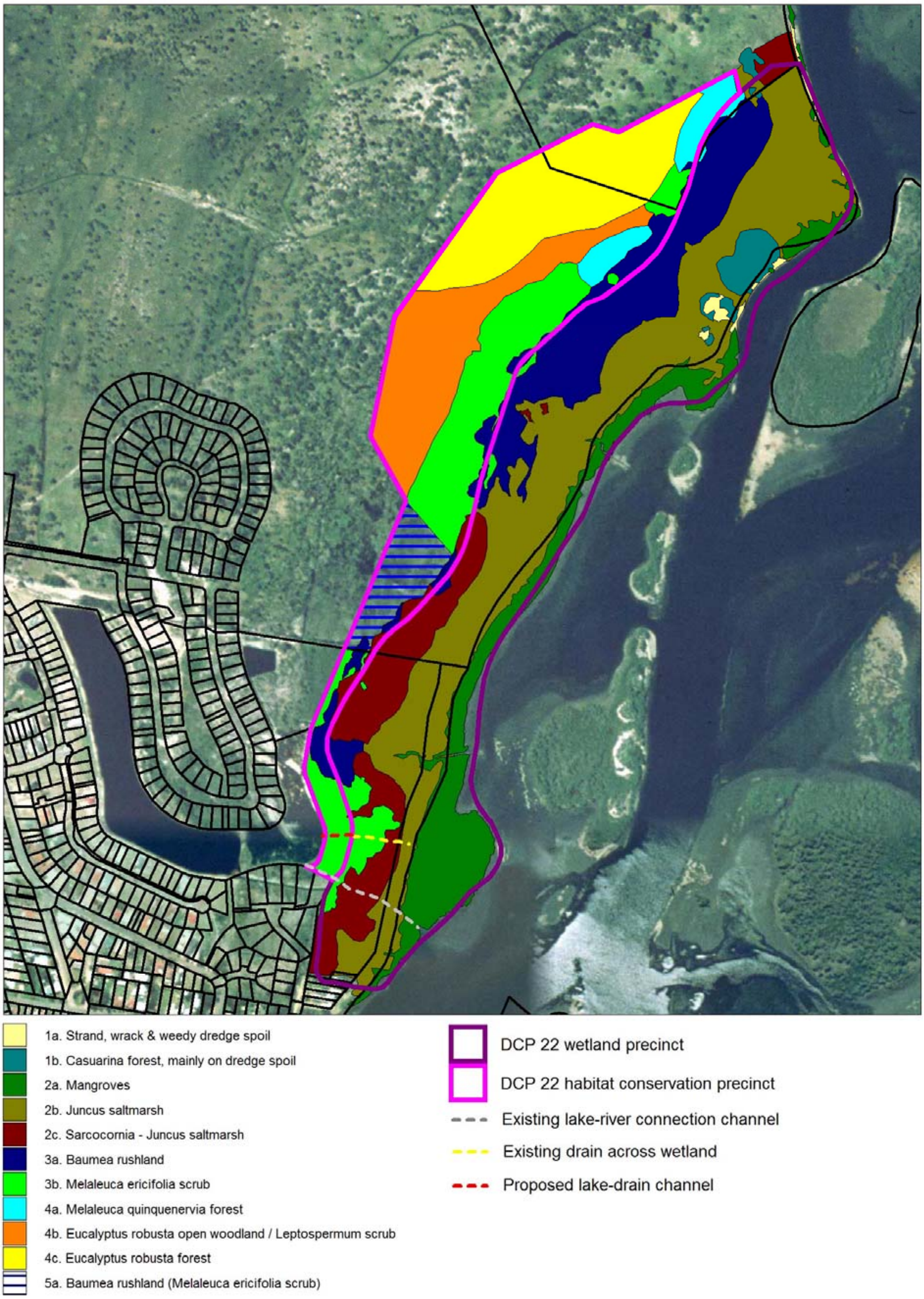

Figure 1. Wetland vegetation of the ‘Riverside’ site, shown in relation to DCP 22 boundaries.

Table 1. Vegetation map units defined for the 2007 wetland vegetation mapping.

1. Disturbed Estuarine Edge Communities		
1a. Strand, wrack & weedy dredge spoil		
Mapped Area:	0.32ha	
Structure:	variable - sparse grassland to open shrubland	
Characteristic Species:	*Chrysanthemoides monilifera*	
Other Main Species:	*Baumea juncea , Casuarina glauca*	
Notes:	This unit includes sandy beaches (strand), accumulated stream-borne organic litter (wrack) and areas of dredge spoil.	
1b. Casuarina forest		
Mapped Area:	1.08ha	
Structure:	low closed-forest	
Characteristic Species:	*Casuarina glauca*	
Other Main Species:	*Chrysanthemoides monilifera, Tetragonia tetragonoides, Baumea juncea, Sporobolus virginicus*	
Notes:	This unit comprises essentially monospecific stands of *Casuarina glauca,* mostly growing on dredge spoil along the river's edge.	
2. Intertidal Estuarine Communities		
2a. Mangroves		
Mapped Area:	6.28ha	
Structure:	low closed-forest to closed scrub	
Characteristic Species:	*Avicennia marina*	
Other Main Species:	*Aegiceras corniculatum, Myoporum acuminatum*	
Notes:	A variable width fringe of mangroves along the river frontage.	

2b. *Juncus* saltmarsh		
Mapped Area:	15.51ha	
Structure:	closed rushland	
Characteristic Species:	*Juncus kraussii*	
Other Main Species:	*Sporobolus virginicus, Baumea juncea, Samolus repens*	
Notes:	This is the main saltmarsh type on site, dominating most of the higher intertidal area.	
2c. *Sarcocornia - Juncus* saltmarsh		
Mapped Area:	5.53ha	
Structure:	open rushland, herbland	
Characteristic Species:	*Sarcocornia quinqueflora, Juncus kraussii*	
Other Main Species:	*Sporobolus virginicus, Samolus repens*	
Notes:	This map unit was defined to cover mosaic areas of several saltmarsh species which were too complex and interlocked to permit separate delineation.	
3. Brackish Communities		
3a. *Baumea* rushland		
Mapped Area:	8.04ha	
Structure:	closed rushland	
Characteristic Species:	*Baumea juncea*	
Other Main Species:	*Juncus kraussii, Sporobolus virginicus*	
Notes:	Although technically part of the saltmarsh, this community is more influenced by freshwater flows from the catchment than from tidal inundation (the latter does occur from time to time). This unit occurs in lower-lying depressions on the landward side of the saltmarsh.	
3b. *Melaleuca ericifolia* scrub		
Mapped Area:	7.04ha	
Structure:	closed scrub	
Characteristic Species:	*Melaleuca ericifolia*	
Other Main Species:	*Baumea juncea, Sporobolus virginicus*	
Notes:	This unit also occurs in lower-lying depressions on the landward side of the saltmarsh, but is further removed from tidal inundation than the previous unit, allowing the dominance of *Melaleuca ericifolia*.	

4. Freshwater Communities

4a. *Melaleuca quinquenervia* forest

Mapped Area:	1.46ha
Structure:	open forest to woodland
Characteristic Species:	*Melaleuca quinquenervia*
Other Main Species:	*Casuarina glauca, Eucalyptus robusta, Melaleuca ericifolia*
Notes:	Small patches of mixed forest dominated by *Melaleuca quinquenervia* occur in areas adjacent to the *Baumea* rushland where it is inferred that catchment surface flows lower the soil salinity sufficiently to give *Melaleuca quinquenervia* a competitive advantage over *Melaleuca ericifolia.*

4b. *Eucalyptus robusta* open woodland / *Leptospermum* scrub

Mapped Area:	5.34ha
Structure:	low open woodland to closed scrub
Characteristic Species:	*Eucalyptus robusta, Leptospermum juniperinum*
Other Main Species:	*Callistemon pachyphyllus, Viminaria juncea, Melaleuca nodosa, Melaleuca sieberi, Melaleuca quinquenervia, Acacia longifolia*
Notes:	This is a diverse community that is best described as a low open woodland of *Eucalyptus robusta* with a dense scrub understorey. *Eucalyptus robusta* is denser in the north and is very sparse towards the south.

4c. *Eucalyptus robusta* forest

Mapped Area:	6.34ha
Structure:	open forest
Characteristic Species:	*Eucalyptus robusta*
Other Main Species:	*Melaleuca quinquenervia, Pinus elliottii*
Notes:	This forest type occurs on areas that are inferred to support surface water for only short periods (typically no more than several weeks at a time), mainly during winter. The understorey is dominated by ferns, sedges and rainforest shrubs.

5. Modified Communities		
5a. Baumea rushland (*Melaleuca ericifolia* scrub)		
Mapped Area:	3.25ha	
Structure:	rushland	
Characteristic Species:	*Baumea juncea*	
Other Main Species:	*Melaleuca ericifolia*	
Notes:	This unit covers an area of *Melaleuca ericifolia* scrub (map unit 3b) which has been slashed. The frequency of slashing has been sufficiently frequent to permit dominance by *Baumea juncea.* If slashing was discontinued, this areas would readily re-establish as *Melaleuca ericifolia* scrub.	

Direct Impacts on Wetland Communities

The Great Lakes LEP provides for the protection of wetlands on the site. The SEPP 14 wetlands are covered by zone 7(a) which also coincides with the DCP 22 ‘wetland precinct’. The broad band of freshwater wetland vegetation are covered by the DCP 22 ‘habitat conservation precinct’, most of which is also covered by zone 7(b). The proposed ‘Riverside’ development is wholly outside of these areas other than for a proposed new channel between the Myall Quays lake and a drain leading to the Myall River which is within the DCP 22 ‘habitat conservation precinct’ although this area is mostly zoned 2(f) (Figure 1).

Details of the proposed construction method and erosion and sedimentation controls have been provided separately by Tattersall Surveyors. In summary, the proposal is to excavate the channel using a dredge pump floated to the site on a small barge. This would obviate the need for the construction of a temporary access track for plant that would be required for other construction methods. The selected construction method should also minimise the risk of collateral impacts outside of the drain footprint.

Construction of this drain would result in the direct loss of approximately 150m^2 (ca. 50m x 3m) of *Melaleuca ericifolia* scrub (3b) with small patches (unmapped) of *Juncus kraussii*. However, the resultant shallow water channel would provide alternative wetland habitat. The channel construction would be included in the wetland management plan (see below).

Potential Indirect Impacts on Wetland Communities

Developments adjacent to wetlands have the potential to indirectly affect the wetland communities in a number of ways:

- changes in quantity and quality of surface and groundwater flows into the wetlands;
- human pedestrian and vehicular intrusion;
- general 'edge effects', including:
  - predation of native fauna by domestic cats and dogs,
  - 'light spill' of street lights which can affect the behaviour of native animals,
  - dumping of rubbish and garden refuse,
  - 'weed creep' from lawn grasses, etc.,
  - mowing of wetland margins.

The general edge effects are applicable to all types of remnant habitats and have been addressed by the general flora and fauna assessment. The first two matters raise issues are specific to wetlands and are addressed below.

Surface and Groundwater Flows into the Wetlands

Quantity of Flows

Influences on Surface and Groundwater Quantity

Urban developments have more 'hard' impermeable surfaces than the natural communities that they replace and, as a result, there is typical a greater of quantity of stormwater flowing from developed areas. If these flows are directed into adjoining wetlands, the increased wetness can alter vegetation and habitats by giving a greater competitive advantage to plants that tolerate wetter conditions. Conversely, retaining the stormwater in some manner (e.g. in rainwater tanks) can lead to drier conditions in the adjoining wetland, again potentially altering the vegetation and habitats.

This issue is compounded on sites with highly permeable soils (e.g. sandy soils) such as the 'Riverside' site. On these soils, infiltration of rainwater into the soil forms a groundwater table, the height of which at any time is determined by the quantity of infiltrated rainwater. Thus, measures to manage surface water flows by, for example, detention ponds can affect the groundwater by influencing the quantity of infiltration.

There is, therefore, a complex link between surface water and groundwater quantity on the 'Riverside' site, and the modelling and management of both are integrally linked.

Potential Effects of Changes in Surface and Groundwater Quantity on Wetlands

Based on current scientific knowledge it is not possible to quantitatively model the potential effects of changes in groundwater quantity on the wetland communities. Rather, it is necessary to make qualitative judgements based on empirical knowledge.

The factors which determine the distribution of saltmarsh and the other wetland communities present on the ‘Riverside’ site are poorly understood, especially the influence of groundwater. It is generally accepted that soil salinity and water-logging are two major influences on estuarine vegetation but other factors, such as competition, also have an effect. Water-logging is also a major influence on the adjoining freshwater wetland types, and soil chemistry is another important influence, especially acidity and nutrient levels.

While chemistry (water quality) is more specifically addressed below, there is an inextricable link between water quantity and salinity in estuarine wetlands. As with most estuarine wetlands, the salinity of water and soil in the Myall River wetlands is influenced by tidal flows from the river, which have a varying salinity, and freshwater catchment flows, both surface and subsurface. Changes in the quantity of catchment flows can affect the salinity of water and soils in the estuarine wetlands. An increase in catchment flows can lead to lowering of salinity and a decrease in catchment flows can lead to an increase in salinity. Such changes in salinity can result in changes to the distribution of the various wetland communities.

In addition, changes in catchment flows, both surface and subsurface, can affect the hydroperiod of a wetland - the frequency and duration of inundation and/or the height and variability of the groundwater table. Changes in wetness can give different plant species a competitive advantage.

It is important to note that surface water flows and groundwater levels are both naturally highly variable, and it is the ‘average’ influence that must be considered. In this context, relatively minor changes in groundwater levels are likely to be inconsequential with respect to the overall variability. However, persistent changes, even minor ones, such as a permanent decrease in average groundwater level, can lead to changes in vegetation.

By way of example, a decrease in quantity of catchment flows into the wetlands would be likely to lead to a gradual increase in salinity in the estuarine wetlands, and a gradual expansion of these at the expense of adjoining communities, such as *Melaleuca ericifolia* scrub. There would also be a change in the distribution of the various estuarine communities, such as an increase in the area of *Sarcocornia* - *Juncus* saltmarsh, which is more competitive in drier conditions. Conversely an increase in catchment flows would lead to a reduction in salinity and an increase in wetness. Likely changes would be the expansion of *Melaleuca ericifolia* scrub into existing saltmarsh areas, and a reduction in the area of *Sarcocornia* - *Juncus* saltmarsh.

Modelled Impacts on Surface and Groundwater Quantity

Detailed modelling of the existing groundwater conditions has been undertaken by Coffey Geotechnics (2007), and this model has been used to predict the potential changes in groundwater levels that are likely to result from the proposed development. The predicted changes, as interpreted from the Coffey report, with respect to wetlands on the site are shown in Figure 2. As can be seen from Figure 2, the extension of the existing constructed lake would result in a substantial drawdown of average groundwater levels over much of the site, but the wetlands are essentially unaffected by this drawdown.

Detailed modelling of the existing surface water conditions has been undertaken by Cardno Willing (2008), and this model has been used to predict the potential changes in surface water flows that are likely to result from the proposed development.

Cardno Willing (2008, appendix D5) found that the past construction of east-west drains has diverted historical north to south surface water flows across the site in an easterly direction into the wetlands. This historical change was quantified as an increase to an annual average of approximately 704 ML/yr from an annual average of approximately 148 ML/yr. It is important to note that these are average values and that the actual runoff into the wetlands would vary from year to year, and would be sporadic during any year.

Under the proposed post-development conditions the average annual runoff into the wetlands would be approximately 480ML/yr. This represents a reduction from existing flows. However, this is unlikely to have a noticeable impact on the wetland vegetation, as this vegetation is predominantly determined by groundwater levels, which are predicted not to change substantially on all but a small part of the wetlands (Coffey Geotechnics 2007), as discussed above.

While urban developments have historically led to concentrated stormwater flows via pipes into adjoining wetlands or creeks the surface water flows for the proposed Riverside layout have been designed to mimic the existing surface flows, in part by providing for a diffuse input along the edge of the habitat conservation precinct (Cardno Willing 2008). This, combined with the various measures to manage the quantity of runoff, should ensure, as far as can be reasonably predicted, that surface water flows from the proposed development do not adversely affect the adjoining wetlands.

Quality of Flows

Influences on Surface and Groundwater Quality

Both the estuarine and freshwater wetlands on the site are subject to surface flooding (tidal and flood inundation from the river, and stormwater flows from the catchment). However, the dominant chemical influence on the wetlands is the quality of the groundwater, largely because any surface water flooding quickly infiltrates through the sandy soil, and the groundwater is always present. Indeed, it is fluctuations in the ground water level that largely determines whether surface water is present in the wetlands from time to time.

The groundwater chemistry at the 'Riverside' has been described by Coffey Geosciences (2004) and Coffey Geotechnics (2007). Key characteristics from these report are:

- salinity is related to proximity to the Myall River, with sites close to the river having a higher salinity;
- groundwater is slightly acidic - pH 5 to 6 (one site approximately 4);
- levels of macronutrients (nitrogen and phosphorus) are generally low.

These chemical characteristics are typical of this type of wetland system. The salinity is directly influenced by tidal water from the Myall River, which infiltrates into the groundwater. The acidic conditions probably derive from humic acids leached from surface and subsurface organic matter by infiltrating stormwater. The low levels of macronutrients are a result of the sandy soil on the site and in the catchment - sands do not generally have the surface electrical charges that bind phosphorus, and other chemicals as clay particles do.

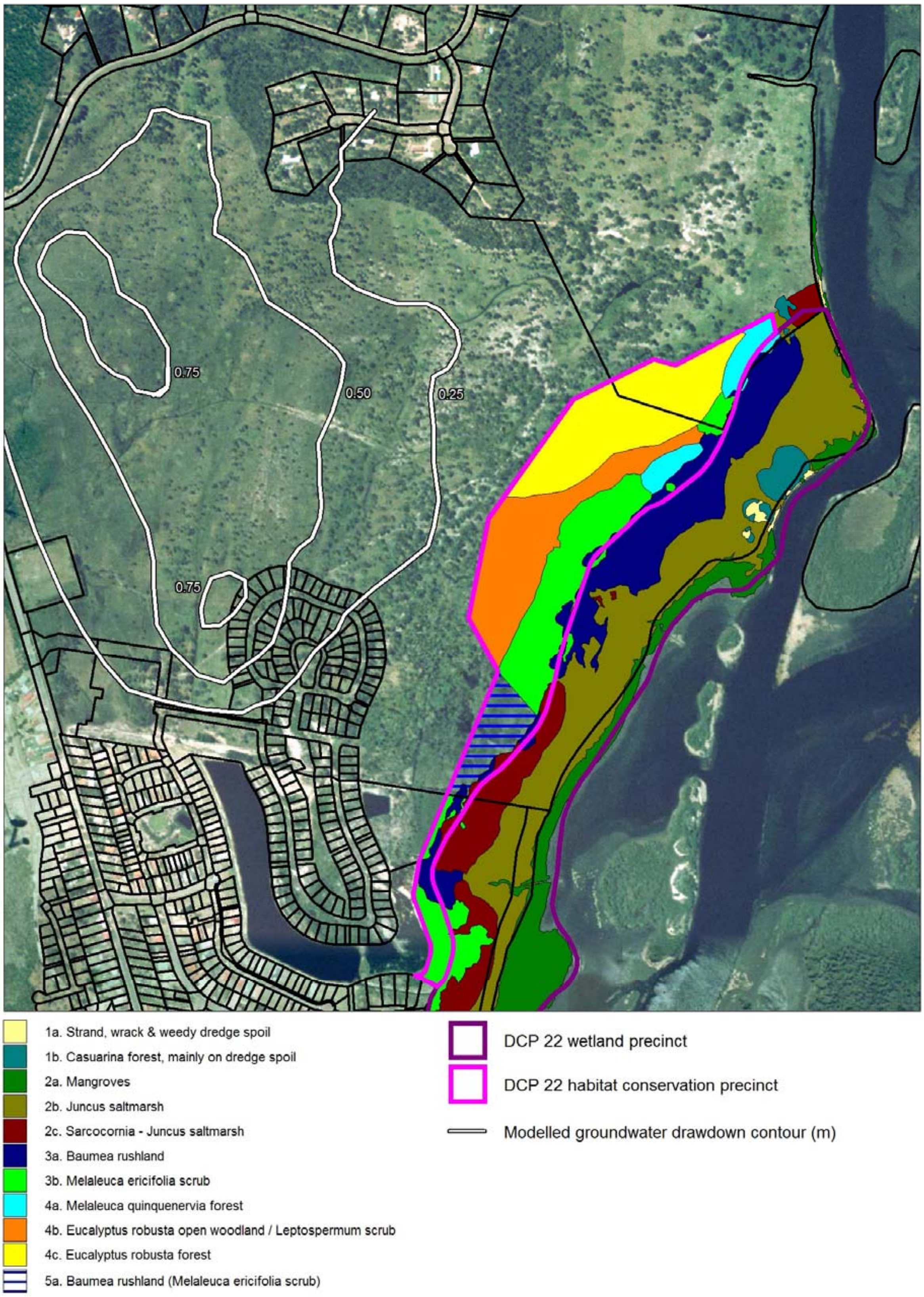

Figure 2. Modelled groundwater changes (Coffey 2007) relative to wetland vegetation.

The combination of this chemistry with the wetland's hydroperiod is probably the major determinant of the vegetation communities present and, to some extent, the site's fauna assemblage.

The main influence on chemistry of surface flows is as a source of substances that may end up in the groundwater through infiltration. Therefore, as with the quantity of water, there is an integral relationship between groundwater quality and surface water quality.

Potential Effects of Changes in Surface and Groundwater Quality on Wetlands

Development on the site could influence groundwater quality by changing the quality of surface water. Changes in quantity of water infiltrating can also influence chemistry, especially salinity, as discussed above.

The most likely potential changes in water quality resulting from urban development are a reduction in groundwater acidity (i.e. an increase in pH), and an increase in macronutrients. Urban stormwater runoff tends to be circum-neutral (ca. pH 7), and discharge of such water into a naturally acidic system can dilute the acids and lead to an increase in pH. If this dilution is sufficient to raise the pH of the groundwater to around neutral, these conditions would give a competitive edge to plant species (and some animal species) that are presently outcompeted by acidophilic plant species. This would result in changes to the wetland communities.

Levels of macronutrients in stormwater runoff from urban areas are characteristically high relative to undeveloped conditions. These elevated nutrient levels derive from a number of potential sources, including:

- fertilisers used on lawns and gardens;
- top soil and other introduced soils with a high clay or silt content;
- organic particulates, such as from leaf mulch;
- dumped organic matter, including lawn clippings, and bread and grain fed to waterbirds;
- faeces of domestic dogs and cats;
- detergents from car washing, etc.

As with changes in pH, an increase in macronutrients levels can give a competitive advantage to plant species that are presently not abundant or are absent. In extreme cases, very high levels of macronutrients can lead to eutrophication of surface waters - copious growth of algae and macrophytes, the decomposition of dead litter from which can lead to depleted oxygen levels and death of aquatic fauna.

Modelled Impacts on Surface and Groundwater Quality

Both the surface water modelling (Cardno Willing 2008) and the groundwater modelling (Coffey Geotechnics 2007) predict a reduction in pollutant loads (suspended solids, total nitrogen, total phosphorus) in water flowing into the wetlands. This is the result of the integrated water management scheme proposed by (Cardno Willing 2008) which includes measures to intercept and treat potentially polluted surface water runoff. Accordingly, there should be no impact on the wetlands resulting from the modelled pollutants.

The reduction of surface flows into the wetland, and the consequent increase in influence of lower pH groundwater flows, should obviate any potential reduction in acidity that may affect vegetation and 'wallum' fauna species.

Human Intrusion into Wetlands

Uncontrolled access into wetlands has the potential to impact the wetlands through trampling of vegetation, dumping of rubbish, etc. However, it is considered important to encourage controlled access into the wetlands to increase public appreciation of wetlands and their flora & fauna, as well as to discourage undesirable activities through increased public visibility of natural areas. Accordingly, the wetland management plan should include details of proposed access points, tracks, boardwalks, interpretation facilities, and measures to limit access into other areas.

Conclusions

The Riverside development has been planned and designed so as to avoid direct and indirect impacts on the wetlands. The only direct impact would be the required widening of the lake - river connection channel which would result in the loss of approximately 150m^2 of wetland vegetation (*Melaleuca ericifolia* scrub), although the resultant shallow water channel would provide alternative wetland habitat. The stormwater management design for the site should effectively prevent water borne impacts via both surface water and groundwater.

A wetland management plan would be prepared that would include:

- measures to mitigate the impacts that may arise from the construction of the connection channel;
- a description of measures to be adopted to rehabilitate any areas disturbed during construction such as for the new connection channel, including confirmation of levels, planting &/or propagule placement, etc.;
- measures to control human access into wetland areas;
- a monitoring program to confirm that the proposed development and associated works do not have adverse effects on the wetlands;
- an adaptive management framework that can permit response to any unanticipated impacts on the wetlands.

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APPENDIX 1 - Standard Report Interpretation

(i) Document Ownership & Property Rights

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This report has been prepared with the upmost care using information supplied by the client and other entities, as well as the results of original investigations. HWR does not warrant that the information in this report is free from errors or omissions. While the document satisfies the requirements of the brief, a need for additional investigations and reporting may be identified after consultations with relevant authorities.

The current knowledge of the ecology of most flora and fauna species is poor. As a consequence, there are often insufficient data to fully objectively assess potential consequences of a proposal for most species. Therefore, ecological assessments typically rely to some extent on professional opinion or judgements based on the personal knowledge of the ecological consultant, investigations undertaken specifically for the proposal, and/or data derived from previous studies (i.e. literature sources). In scientific jargon, such subjective judgements are hypotheses or ‘likely’ explanations based on the experience of the consultant. These hypotheses are often quite accurate (because of the extensive experience of the consultant) but they nevertheless remain subjective opinions unless tested scientifically. Where possible, HWR seeks to test hypotheses using scientifically sound methods. That is, HWR undertakes studies designed to replace subjective judgements with objective data. However, this is not feasible for many of the issues covered by most ecological assessments due to various constraints, and it is therefore necessary to rely on opinion in parts of the assessment. In keeping with our position that the authors of ecological assessments should be accountable for their opinions, the authors responsible for HWR’s reports are clearly stated.

(iii) Independence

Due to the reliance of ecological assessments on professional opinion, they unavoidably reflect the experiences and attitudes of the authors to some extent. Such personal ‘bias’ cannot be avoided where people are involved in any process. However, the advice provided should be independent. That is, the conclusions of a study should be the same regardless of who the client was. While others may disagree with opinions expressed in HWR’s reports, the opinions are independent and represent the best advice of the authors based on the available data.

It is common practice for a client to modify their proposal in response to information supplied by the ecological consultant in order to avoid excessive ecological impact. This typically results in an ecological assessment report that supports the final proposal, which is the considered opinion of the authors but it is in no way adversarial on behalf of the client.