# APPENDICES

## APPENDIX 1

## VEGETATION AT SALTMARSH BROOKLANDS LAGOON/TE RIU O TE AIKA KAWA

The following information is taken and adjusted from the publication by Worner G. and Partridge, T. (2008). Saltmarsh vegetation at Brooklands Lagoon. CCCECO Report 08/14.

The vegetation of the saltmarshes of Brooklands Lagoon/Te Riu o Te Aika Kawa, including those at the mouth of Styx River/Puharakekenui, were surveyed and twenty four vegetation types or communities identified (making up these are twenty four common saltmarsh species, with nineteen of these being native and five exotic – see the list of these on page 124 and a species list on pages 125 to 126. In addition, analysis indicated these are grouped into three distinct saltmarsh ecosystems, comprising the southern end of Brooklands Lagoon/Te Riu o Te Aika Kawa, the northern end of Brooklands Lagoon/Te Riu o Te Aika Kawa, and the areas around the mouth of the Styx River/Puharakekenui:

### (A) Southern ecosystem

- Very fine, water-logged sediments.
- Reduced salinity.
- Vegetation dominated by three-square and oioi, with other species indicative of brackish water conditions.

These southernmost saltmarshes, in the vicinity of Spencerville, contain fine, muddy sediment colonised by a rapidly expanding three-square marsh. The rapid buildup of fine sediment, possibly exacerbated by the vegetation, has led, at the southern extremity, to some freshwater ponded areas, populated by vegetation types found exclusively in this part of the estuary. Comparison of recent and earlier aerial photographs indicates that this colonisation by three-square is recent and still taking place. Therefore, much of the vegetation there is young.

### (B) Central/northern ecosystem

- Coarser, sandy, free-draining sediments.
- Greater range of salinities over the four seasons.
- Vegetation dominated by sea rush and herbaceous species indicative of salt water.

The saltmarshes of the northern half of Brooklands Lagoon/Te Riu o Te Aika Kawa extend from a natural division in the mid-channel island northwards to the Styx River/Puharakekenui mouth, although the transition from three-square dominated vegetation to other communities occurs further north on the eastern (Brooklands Spit/Kairaki) side of the estuary than on the western side. This area has a much coarser sediment, probably due to a combination of wind blown sand prior to the stabilisation of the spit, and the greater tidal flow that prevents the fine sediment being deposited. This system shows the more typical zonation pattern of an estuarine saltmarsh. It shows a gradual gradation from lower to upper marsh, with diverse pockets of middle marsh, and drier and potentially more saline habitats.

### (C) Styx/Waimakariri ecosystem

- Stable, not affected by human activity, but now moribund[83] and impounded by stopbanks.
- Reduced salinity.
- Vegetation represents a final stage of successional change, dominated by oioi, and with marsh ribbonwood present.

The Styx River/Puharakekenui saltmarsh system has been impounded by the construction of stopbanks. It lacks a lower marsh, having stabilised with a vegetation characteristic of middle to upper marsh, and upper marsh fringe vegetation types of the main part of Brooklands Lagoon/Te Riu o Te Aika Kawa. The Styx River/Puharakekenui has tidal floodgates to prevent salt water flowing upstream with the tide. As the tide comes up the short tidal length of the Styx River/Puharakekenui, it doesn't mix with freshwater from the river, resulting in the inundation of the marshes being of water that is more saline than would be expected.

Therefore, there appears to be a distinct age/sediment relationship between the three parts of Brooklands Lagoon/Te Riu o Te Aika Kawa. The southern part (Ecosystem A) is young, expanding and characterised by fine sediment. The central and northern Brooklands Lagoon/Te Riu o Te Aika Kawa marshes (Ecosystem B)

[83] Being in a state of inactivity or obsolescence (Definition from Merriam-Webster Online Dictionary (2009) ‹http://www.merriam-webster.com/dictionary/moribund›).

are stable and mostly mature, with little signs of expansion, and are characterised by coarser sediment. The Styx River/Puharakekenui marshes (Ecosystem C) are mature and moribund, have nowhere to expand and have little sign of sediment being deposited – instead, there is evidence that these marshes are cutting down through the formation of new channels.

Despite the apparent cyclic nature of recent events, over a longer timescale there is evidence that the southern end of Brooklands Lagoon/Te Riu o Te Aika Kawa is infilling, as shown on older aerial photographs. There does not appear to be anything like the same level of infilling at the Brooklands end near the estuary mouth, as the vegetation there is remarkably stable. This suggests that Brooklands Lagoon/Te Riu o Te Aika Kawa is a typical tidal estuary, with a stable saltmarsh system at the northern/middle end, and a rapidly sedimenting, slightly impounded southern end. The southern end of Brooklands Lagoon/Te Riu o Te Aika Kawa even has some freshwater communities, such as stands of raupo, and the presence of freshwater plants, such as *Eleocharis acuta*. The brackish water species, New Zealand musk, on the channel margins, is strongly suggestive of a brackish water system, rather than a true saltmarsh.

Although Owen (1992) reports that the southern end of the estuary was silting up even in the 1930s, it appears to have filled substantially since the 1940s, both with silt and sand from the Waimakiriri River and sand blown and washed from the open coast (Hicks and Duncan, 1993).

The stabilisation of the four kilometre long sand spit with plantings of marram grass and pine trees, and the subsequent spread of these, along with the construction of fences along the dunes to trap sand, has reduced the impact of wind blown sand. Upstream developments, though, both urban and rural, have increased the sediment load of the Waimakiriri River (Owen 1992, Bolton-Ritchie, 2007). The finest of this sediment has been deposited at the southern end. Hicks and Duncan (1993) reported that despite the significant amount of sediment accumulation since the shift in the Waimakariri River mouth, the rate of infilling of the estuary is reducing, with the present and future rates liable to be no more than a few milimetres per year. They suggested that the main net deposition would build north as the shallow flats at the Spencerville end are gradually transformed from mudflat to marsh.

Cross-section profiles of Brooklands Lagoon/Te Riu o Te Aika Kawa have been created with surveys along thirteen transect lines intermittently carried out between 1932 and 2007. Bolton-Ritchie (2007), in a detailed survey of five of these cross sections, concluded that, from 1977 to 2005, the percentage of sand sediment has decreased, while the percentage of finer mud has increased, and that there is a significant gradation of sediment from coarser grained sandy sediment to silty mud with distance from the estuary mouth.

In March 2008 further data was collected by one of the teacher fellows from sediment sampling along the transect lines. Together with recent data collected by the Geography Department of the University of Canterbury surveying the estuary depth, and surveys carried out between 1930 and 1988, it was intended to chart the sediment build up in the estuary and relate that to the increase in three-square vegetation.

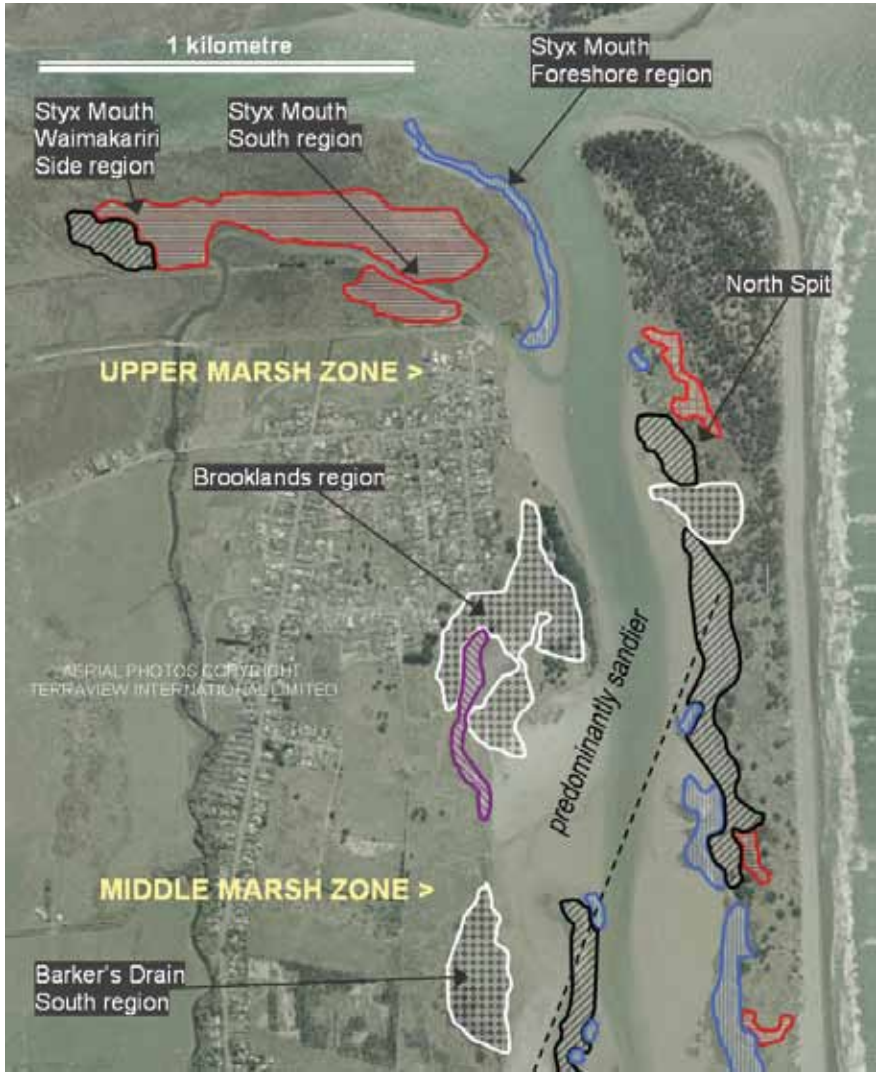
Analysis indicates that the pattern of fine sediment deposition in Brooklands Lagoon/Te Riu o Te Aika Kawa closely matches the distribution of the three-square vegetation type (Type 3a). In the southern part of the estuary, where three-square dominates, there are low levels of sand (less than five percent) and high levels of fine silt. The proportion of sand jumps abruptly to greater than fifty five percent just north of a line angling SSW-NNE across the central part of the estuary (see the photo plans on pages 122 and 123). At the same point, the dominance of three-square vegetation ceases, and sea rush and sea primrose dominate. In the northern reaches of the estuary, the only area containing less than five percent of sand supports a small area of three-square.

A

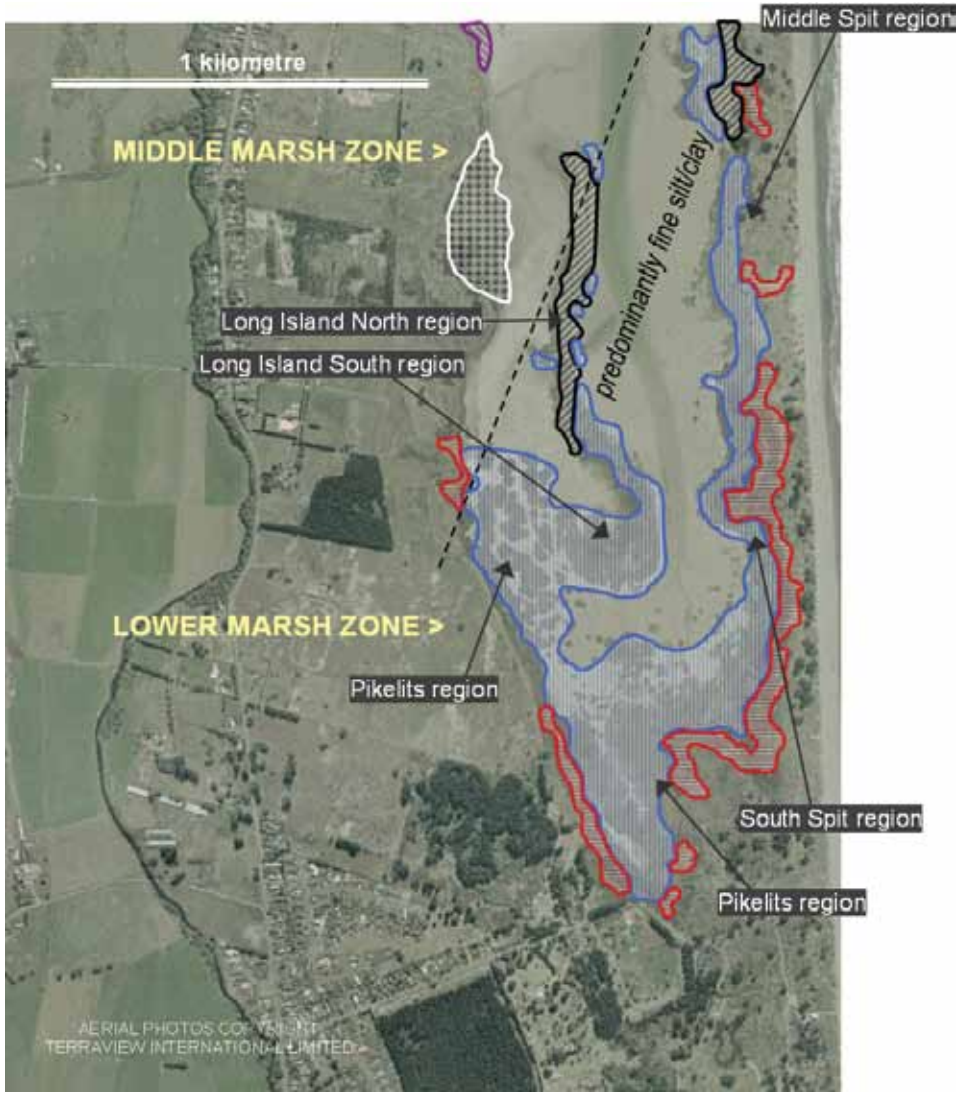

B

Photos flow as shown above

A



B




| PREDOMINANT VEGETATION TYPES | FOUND MAINLY IN THE: |
|---|---|
| 3a (*Schoenoplectus* reedland)<br>9 (*Juncus/Schoenoplectus* rushland) | Lower marsh zone |
| 10 (*Juncus* rushland) | Lower marsh zone |
| 14 (*Juncus/Selliera* rushland)<br>15 (*Juncus/Selliera-Samolus* rushland) | Middle marsh zone |
| 19 (*Juncus/Selliera-Plantago -Sarcocornia* rushland)<br>18 (*Juncus/Selliera-Plantago* rushland) | Middle marsh zone |
| 2 (*Apodasmia* restiad rushland)<br>7 (*Apodasmia/Schedonorus* restiad rushland)<br>1 (*Plagianthus/Apodasmia* shrubland) | Upper marsh zone |
| 17 (*Juncus/Selliera-Schoenus* rushland)<br>3d (*Selliera-Schoenus-Samolus* herbfield) | Salt meadows in the middle to upper marsh zone |

## Vegetation types

The vegetation types associated with specific zones in the Brooklands Lagoon/Te Riu o Te Aika Kawa area (see pages 122 and 123) are:

### (a) Lower marsh zone

- Type 3a *Schoenoplectus* reedland
- Type 9 *Juncus/Schoenoplectus* rushland
- Type 10 *Juncus* rushland
- Type 11 Mudflats
- Type 13 *Juncus/Samolus* rushland
- Type 16 *Samolus* herbfield

### (b) Middle marsh zone

- Type 12 *Apodasmia/Juncus* restiad rushland
- Type 14 *Juncus/Selliera* rushland
- Type 15 *Juncus/Selliera-Samolus* rushland
- Type 18 *Juncus/Selliera-Plantago* rushland
- Type 19 *Juncus/Selliera-Plantago-Sarcocornia* rushland

### (c) Upper marsh zone

- Type 1 *Plagianthus/Apodasmia* shrubland
- Type 2 *Apodasmia* restiad rushland
- Type 7 *Apodasmia/Schedonorus* restiad rushland
- Type 20 *Plagianthus/Schedonorus-Juncus* shrubland

### (d) Salt meadows in the middle to upper marsh zone

- Type 3d *Selliera-Schoenus-Samolus* herbfield
- Type 3e *Sarcocornia-Selliera-Plantago* herbfield
- Type 17 *Juncus/Selliera-Schoenus* rushland

### (e) Upper marsh fringe zone

- Type 3c *Schedonorus* grassland and mixed herbfield
- Type 6 *Schedonorus* grassland

### (c) Brackish water hollows or ponded areas

- Type 3b *Typha* reedland
- Type 4 *Mimulus* herbfield
- Type 5 *Schoenoplectus/Mimulus* herbfield
- Type 8 *Schoenoplectus/Carex* reedland

## Species list – Brooklands Lagoon/Te Riu o Te Aika Kawa area

| Species | Family | Common name |
|---|---|---|
| INDIGENOUS PLANTS | | |
| Woody plants | | |
| *Leptospermum scoparium* | Myrtaceae | manuka |
| *Plagianthus divaricatus* | Malvaceae | saltmarsh ribbonwood |
| Herbaceous plants | | |
| *Apodasmia similis* | Restionaceae | oioi |
| *Bolboschoenus caldwellii* | Cyperaceae | grassy club sedge |
| *Carex litorosa* | Cyperaceae | shore sedge |
| *Eleocharis acuta* | Cyperaceae | spike sedge |
| *Juncus caespiticius* | Juncaceae | grass-leaved rush |
| *Juncus kraussii var. australiensis* | Juncaceae | sea rush |
| *Juncus pallidus* | Juncaceae | giant rush |
| *Phormium tenax* | Phormiaceae | harakeke, swamp flax |
| *Puccinellia stricta* | Poaceae | salt grass |
| *Schoenoplectus pungens* | Cyperaceae | three-square |
| *Schoenus concinnus* | Cyperaceae | dwarf cushion sedge |
| *Triglochin striatum* | Jungcaginaceae | arrow grass |
| *Typha orientalis* | Typhaceae | raupo |
| *Zostera capricorni* | Zosteraceae | eel grass |
| *Apium prostratum* | Apiaceae | New Zealand celery |
| *Chenopodium glaucum* | Chenopodiaceae | glaucous goosefoot |
| *Cotula coronopifolia* | Asteraceae | bachelor's button |
| *Leptinella dioica* | Asteraceae | turf daisy |
| *Mimulus repens* | Scrophulariaceae | native musk |
| *Samolus repens* | Primulaceae | sea primrose |
| *Sarcocornia quinqueflora* | Chenopodiaceae | glasswort |
| *Selliera radicans* | Goodeniaceae | remuremu |

### Explanation of terms defining the origin of plant species in the Brooklands Lagoon/Te Riu o Te Aika Kawa area

**Endemic:** Covering species naturally occurring in New Zealand and only in New Zealand. Species which are endemic to New Zealand will not necessarily be endemic to this or any other area. This term is not used in this master plan for plants but is used for birds, referring to species found only in the New Zealand geographical area (see Appendix 3).

**Indigenous (Native):** Naturally occurring in New Zealand and elsewhere in the world. Indigenous species have either originated in New Zealand and spread, including overseas, or have originated outside New Zealand and dispersed in New Zealand.

**Exotic:** Not naturally occurring in New Zealand. Exotic species have arrived as the direct result of human introduction, be that deliberate or accidental.

**Native-Exotic:** For New Zealand native species that have arrived in the Brooklands Lagoon/Te Riu o Te Aika Kawa area from elsewhere in New Zealand.

| Species | Family | Common name |
|---|---|---|
| *Senecio glomeratus* | Asteraceae | fireweed |
| *Spergularia media* | Caryophyllaceae | sea spurrey |
| *Suaeda novaezelandiae* | Chenopodiaceae | sea blite |
| EXOTIC PLANTS | | |
| Woody plants | | |
| *Ulex europeus* | Fabaceae | gorse |
| *Pinus radiata* | Pinaceae | radiata pine |
| Herbaceous plants | | |
| *Agrostis capillaris* | Poaceae | browntop |
| *Agrostis stolonifera* | Poaceae | creeping bent |
| *Ammophila arenaria* | Poaceae | marram grass |
| *Elymus repens* | Poaceae | couch grass |
| *Holcus lanatus* | Poaceae | Yorkshire fog |
| *Parapholis incurva* | Poaceae | sickle grass |
| *Schedonorus arundinaceus* | Poaceae | tall fescue |
| *Spartina anglica* | Poaceae | cord grass |
| *Thinopyrum juneiforme* | Poaceae | sand couch |
| *Atriplex prostrata* | Chenopodiaceae | orache |
| *Crepis capillaris* | Asteraceae | smooth hawksbeard |
| *Lotus tenuis* | Fabaceae | yellow lotus |
| *Plantago coronopus* | Plantaginaceae | buck's horn plantain |
| *Vicia sativa* | Fabaceae | vetch |

Raupo (*Typha orientalis*) or bullrush - a significant coloniser of freshwater ponded areas at the southern end of Brooklands Lagoon/ Te Riu o Te Aika Kawa. It is also found on the edge of freshwater ponds close to the stopbanks of the Waimakariri River.

## Implications for management

There have been calls for actions by groups concerned for the future of Brooklands Lagoon/Te Riu o Te Aika Kawa, especially in relation to changes that have occurred in sedimentation. These changes, and the response of saltmarsh vegetation to them, are, in many cases, the consequence of changing channels and the shifting of the mouth of the estuary northwards. Botanically, there is very little wrong with Brooklands Lagoon/Te Riu o Te Aika Kawa, other than the moribund nature of the marshes at the Styx River/Puharakekenui mouth. Therefore, any proposals for action would need to carefully consider the considerable values of these marshes and take into account the risks of undesirable outcomes. The saltmarshes of Brooklands Lagoon/Te Riu o Te Aika Kawa are a valuable ecological asset, and the system needs to be managed in such a way that these values are not compromised.

Options for the future management of Brooklands Lagoon/Te Riu o Te Aika Kawa, considering each of the three defined saltmarsh ecosystems separately, are (refer to the photo plans on pages 122 and 123 for location of described regions of the estuary):

Note: These options are raised only in the context of the teacher survey report, and any one or more of these are not necessarily a direction for management the Council advocates. They are included here for information, consideration and debate.

## Option 1. Leave the saltmarshes of Brooklands Lagoon/Te Riu o Te Aika Kawa to expand, change in composition or decline as the natural controlling factors in the environment dictate.

### (A) Southern ecosystem

In the future, fine sediment would be expected to continue to accumulate and the three-square (*Schoenoplectus pungens*) pikelets saltmarsh region (extending for one kilometre along the western margin of the estuary channel towards the southern end of the estuary - contains twenty to thirty islets of thriving three-square) would continue to expand. This would gradually link with the western and southern margins of Long Island South (the southern part of the one and a quarter kilometre island that has formed in the middle of the main estuary channel. A sizeable channel subdivides the island neatly into the southern part dominated by three-square, and the northern part (referred to as Long Island North), which is dominated by sea rush (*Juncus kraussii var. australiensis*)). This may reduce the tidal flow into the southern tip of the estuary, which would progressively become less brackish and more of a typical raupo/swamp flax wetland. Exotic grasses and weeds, normally controlled by the salt water inundation, may invade and dominate the open areas. The areas of higher ground may be invaded by neighbouring gorse and grey willow.

The saltmarsh associated with South Spit (this extends for 1.2 kilometres along the western margin of Brooklands Spit/Kairaki at the southern end of the Spit, and contains a large number of existing or partially eroded three-square pikelet islands, and an eroded margin of three square) is in a dynamic state at present, with extensive pikelet areas and lower marsh zones of three-square eroding. This situation may continue or abate and the infilling of that part of the estuary may continue again. The demise of the pikelets and the eroding of the channels in this area warrant further study. Birdlife may be implicated. These expansion and erosion phases may be cyclic.

### (B) Central/northern ecosystem

The change in the future here would depend on how effective the outgoing tidal flow is at removing any sediment brought into the estuary. This part of the estuary may be quite static, with the saltmarsh reflecting any change in the composition or elevation of the substrate.

### (C) Styx/Waimakariri ecosystem

Providing the status quo management continues as far up as the tidal flood control gates on the Styx River/Puharakekenui and the regular dredging programme continues (Hicks & Duncan, 1993), the undisturbed saltmarsh between the two stopbanks and on either side of the Styx River/Puharakekenui (up to the tidal flood gates) should remain relatively unchanged for a long time. A gradual succession from sea rush to oioi to marsh ribbonwood will occur, but slowly. Spread of the rampant gorse and broom from the tops of the stopbanks down into the saltmarsh should be carefully monitored, as it will signal that the saltmarsh is beginning to lose its controlling factor, the tidal influence. This area is large and a valuable wildlife refuge.

## Option 2. Carefully manage Brooklands Lagoon/Te Riu o Te Aika Kawa to preserve the existing saltmarsh vegetation.

### (A) Southern ecosystem

This option assumes that this transitional part of the estuary contains significant vegetation types and individual species that are possibly under threat if there is no management. The two plants listed as threatened species (shore sedge and native musk) are abundant in this part of the estuary and occupy distinctive zones visible from the viewing platforms around the upper marsh fringe. Shore sedge is found in two main zones. It occupies the tops of the main channel levees, and in amongst the broad expanse of native musk that has formed at the end of this channel as is flattens out to form a small mudflat. Native musk has relatively low salt tolerance, so any tinkering with the depth of channels and tidal flow would have to be carried out carefully. On the other hand, continued sediment buildup could increase the freshwater ponding and leave the area vulnerable to invasion by raupo and other freshwater species. Monitoring sites should indicate when significant change in sediment level and salinity is occurring, but care would be required to manage the area.

Native musk and shore sedge are also found in the Pikelets region. Again, monitoring should reveal whether the native musk is under threat by three-square, and if the abundance of shore sedge will increase on the pikelets of three-square.

Shore sedge also occupies a relatively bare middle marsh zone in the South Spit and Middle Spit (the middle one kilometre of saltmarsh along Brooklands Spit/Kairaki, also with an eroded margin of three-square) regions, between isolated clumps of three-square, sea rush, oioi and marsh ribbonwood. It is uncertain what factors control its distribution, and more information from monitoring sites in this area would be required in order to find out if it is increasing or stable, and so manage this species in these locations. It does not appear under threat in the near future.

### (B) Central/northern ecosystem

The eastern (Brooklands Spit/Kairaki) margin to the estuary, as well as the western margin, contain typical well zoned saltmarsh, with some regionally distinct vegetation types that could be under threat in four ways:

i. The same erosion of three-square zones that is occurring at South Spit, also occurs at Middle Spit and, to a lesser extent, at North Spit. The final 1.2 kilometres of saltmarsh along Brooklands Spit/Kairaki, ending at the extensive wilding pine ‘plantations’, and directly opposite the Styx River/Puharakekenui mouth, has a significant number of four wheel drive tracks running through it. It would be valuable to determine the cause.

ii. The gorse, tree lupin and broom present on secondary sand dunes adjacent to the upper marsh fringe have the potential to invade the saltmarsh, as organic matter accumulates and wind blown sand is trapped by marsh ribbonwood. Swamp flax bushes have started to appear in this upper marsh fringe, but these remain relatively small in size, probably due to the salt content of the soils.

iii. The expanses of salt turf or salt meadow, which are relatively uncommon, both regionally and nationally, have been, and probably still are, accessible to motor vehicles. Significant, possibly irreparable, damage has already been done. Such activity needs to cease.

iv. The pines from the estuary mouth end of Brooklands Spit/Kairaki are already invading the salt meadow areas of North Spit. Control of the largest of these has already occurred, but, at present there are a huge number of small wilding pines that should be removed.

It is recognised that the tall stand of pines at the northern tip of the spit are valuable as a bird refuge, and that protecting the open expanses of salt meadow would also maintain existing bird habitat.

The management required to meet, firstly, the aim of removing wilding pines and, secondly, protecting bird habitat is different. A level and type of management that is compatible with both aims may be impossible to achieve. What is achievable in the short term:

- Limiting unauthorised vehicle access to any part of the saltmarsh. This would require barriers, fences and locked gates.

- Retaining the pines at the northern tip of the spit, but progressively removing all pines from where the saltmarsh margin begins, all the way to the end of the South Spit region. The pines are not needed for shelter by walkers, as the height of the dunes provide this, but do prevent excess sand from blowing into the saltmarsh.
- Removing as much gorse as possible from near the edge of the saltmarsh on both sides of the estuary.

### (C) Styx/Waimakariri ecosystem

Providing the tidal influence on the two large saltmarsh regions that comprise this ecosystem is monitored regularly and maintained and so little action is required. The two saltmarsh regions are:

- **Styx Mouth South** – this covers both sides of the Styx River/Puharakekenui near its mouth between the stopbanks on each side. The natural western boundary is a gorse area and the eastern boundary comprises extensive gorse (*Ulex europaeus*) covered sand dunes.

- **Styx Mouth Waimakariri Side** - another 'between the stopbanks' area extending from the eastern gorse covered dune system for 1.4 kilometres westwards to again end in gorse. Despite the stopbanks, this large area of oioi (*Apodasmia similis*) and marsh ribbonwood (*Plagianthus divaricatus*) dominated saltmarsh vegetation is well supplied by deep dendritic channels extending throughout and some ponded areas contain raupo and swamp flax.

Control of the gorse on the stopbanks would help preserve this area, should a reduction in the tidal influence occur.

## Option 3. Restore Brooklands Lagoon/Te Riu o Te Aika Kawa to be a well flushed estuarine system.

### (A, B) Southern and Central/northern ecosystems

These areas could be considered together, as a shift in the flow of the Waimakiriri River will impact on the whole estuary. Should the Waimaikiriri River ever be re-directed through the estuary again it would probably:

- Destabilise Brooklands Spit/Kairaki at the northern end, and around the position of the new outlet to the sea. This would change the sediment on surrounding mudflats to a sandier grade.
- Scour out a deep central channel and create unpredictable effects on the existing saltmarsh in the Brooklands region. Bordering the residential area of Brooklands, this 19.4 hectare area is unusual in having a wilding pine tree stand (*Pinus radiata*) along half of its estuary margin, a constructed ridge with planted conifers bisecting it, an odd array of tidal channels, and several well-used vehicle and walking tracks.
- Erode the mid-channel Long Island.
- Flood the southern part of the estuary at high tide and change the vegetation type.
- Remove the native musk, and a lot of the three-square, replacing it with sea rush and sea primrose.

Such a shift of the Waimakariri River may unify the saltmarsh vegetation of the estuary, but in doing so, reduce the biodiversity.

### (C) Styx/Waimakariri ecosystem

Changing the course of the Waimakiriri River would have implications for the position of the mouth of the Styx River/Puharakekenui, but may not substantially affect the existing saltmarsh vegetation. It may reduce the salinity of the tidal inundation.

An earlier study[84] indicated that once the appropriate conditions are present, saltmarsh communities frequently establish well by themselves and thus several areas surrounding the Brooklands Lagoon/Te Riu o Te Aika Kawa estuary lend themselves to restoration. This has successfully taken place at Bexley Wetland, Charlesworth Wetland and elsewhere.

Such restoration may also apply to the re-establishment of saline connections with the stranded areas of weedy saltmarsh in the landward zone near the Brooklands settlement, thereby enabling the extension of bird habitat[85].

[84] McCombs and Partridge (1992).
[85] Supported by Crossland A. C. (2008).

## Other saltmarsh regions

Other saltmarsh regions in the Brooklands Lagoon/Te Riu o Te Aika Kawa estuary area described by Worner and Partridge (2008) are:

- **Spencerville region** - the heart-shaped southern tip of the estuary, close to Spencer Park, with two large channels that carry tidal flow to inundate the saltmarsh vegetation. It is partially impounded and colonised by raupo (*Typha orientalis*) and swamp flax (*Phormium tenax*) at the southern end.
- **Barker's Drain South** - a small (seven and a half hectare) area of saltmarsh vegetation surrounded on the western side by a series of parabolic sand dune mounds and narrowing towards Barkers Drain.
- **Styx Mouth Foreshore** - a very dynamic area containing an unusual diverse mix of plant communities covering the thin sliver of mudflats from the Styx River/ Puharakekenui mouth north to the true right bank of the Waimakariri River at the entrance to the estuary.

Photo
Saltmarsh in the estuary viewed from Mid Seafield Park.

# APPENDIX 2

## CLUBHOUSE/PATROL FACILITIES – SPENCER PARK SURF LIFE SAVING CLUB

The Spencer Park Surf Life Saving Club Incorporated has raised a number of issues regarding the surf patrol building it maintains and operates but which the Council owns. The Club has requested that the Council upgrade the building in order to adequately meet existing and future needs.


Photo
Spencer Park Surf Life Saving Club site, Spencer Park Beach.

## Land/asset status

The Club has a licence issued by the Waimairi District Council for 21 years from 1 October 1987 to occupy the building for its surf lifesaving activities. This does not cover the adjacent public toilet/changing facilities. The licence requires the Club to maintain the interior and exterior of the building, with the prior written consent of the Council before any work is done. The Council supplies materials required for the maintenance of the building exterior and public area. The licence expired at the end of September 2008 but is being carried over until such time a new licence document is prepared. The Club has the right of renewal for a further term of 21 years, if the Council is satisfied the terms and conditions have been complied with, there is sufficient need for a surf life saving club, and no other recreational use of the site has priority in the public interest.

The building and toilet/change facilities were previously sited on Crown land administered by the Department of Conservation, although on 12 June 2008 the Council resolved to accept an offer from the Department to vest in the Council this land as recreation reserve under the Reserves Act 1977. The land was classified as such, through gazette notice, on 28 November 2008 (with a correction made on 15 December).

## Club provided information

The Spencer Park Surf Life Saving Club has approached the Council, with respect to its facility. The following account is derived from information the Club has provided.

### Background

Lifeguard patrols were established at Spencer Park Beach in 1969, providing for the safety of the general public. This volunteer service has remained year by year under the administration of the Spencer Park Surf Life Saving Club and, today, is as strong as ever with an enthusiastic group of lifeguards, many of whom live in the local community.

During the initial patrolling years, a temporary shed type arrangement was used on the beach to give the lifeguards shelter from the elements. The building that exists today was never purposely built for the role it serves, but evolved over time, with periodic additions.

The building originally started as a single level structure, consisting of two identical buildings, built parallel and approximately three metres apart, designed as separate public male and female changing and toilet facilities. These were unroofed and open to the weather.

The space between these buildings was subsequently covered and made secure. This was used by the lifeguards to store equipment for beach patrols. Alterations were later made by constructing a first floor watch tower, with an internal access ladder (still existing today) and enclosed with a roof, walls and windows.

Many more changes to the building were to follow over the years. The first floor centre room, that included a small kitchen bench, was built. With the covering of the roofless changing areas, this created a west-facing first floor balcony area. Two thirds of the change areas were also roofed to make secure areas for the storage of increasing amounts of patrolling equipment. Further changes saw a small balcony formed on the north-east corner to allow an outside view from the first floor, and a first aid room was established on the south-east corner of the first floor.

Some years later, an extension was made to the south end of the building in order to house inflatable rescue boats (IRBs) and associated equipment.

All these changes to the building at different times, although making small improvements, were done without a logical plan and vision for the future.

## The present day situation

The Club advises that today (in 2008) the demands of the service it provides are far different to those when the building was merely a public toilet and changing sheds.

Over the years there has been an increase in the public use of Spencer Park Beach and the Club says that this has placed more pressure on the volunteer patrol services that it provides. Its membership has similarly grown (now in excess of 110 members), which has enabled it to manage the increased needs for beach patrols. However, the Club says the building does not now meet its requirements. It is concerned that the limitations of the building means that it is constrained in carrying out an effective service for the benefit of the public.

## The service the Club provides

There has been a considerable growth in the Club's junior membership (that is, of those under 14 years of age), which the Club believes is very promising in terms of providing for future lifeguards.

The Club became a registered incorporated society in 1970. Its operating practices gained it Silver Club Mark status in 2006, a status only one other surf club in Canterbury has. The Club made application for, and has been awarded, Charitable Entity Status with the Charities Commission in June 2008. The Club is currently developing a long term strategic plan, which has identified the upgrade of the clubhouse as a priority to facilitate the future needs of the Club.

## Facility issues

The Club indicates that it currently has the following issues with its facilities:

- The first aid room is located upstairs, only accessible by either a nearly vertical internal stairway, or a steep external stairway at the rear of the building. This is totally impractical, particularly in the event of a patient requiring serious medical assistance.
- The actual clubhouse area is very small. It is not suitable to hold club gatherings and functions and the Club is forced to hire larger facilities for events, such as end of season prize giving.
- Space to store patrol and surf equipment is limited, necessitating the use now of a shipping container (put in place in September 2008) to make the downstairs gear areas more useable.
- The elevated 'patrol lookout' on the first floor is not ideal. Field of view to the beach is limited and this post is not in a very comfortable environment for lifeguards, as a cramped small wooden bench provides the only means of seating for observing the beach from.
- The entire upstairs area is dark and cold as there are no windows on the north face of the building.
- The small kitchen facilities are less than ideal when lifeguards are patrolling for an entire day and need to prepare food and refreshments.
- The internal stairs are narrow, and almost vertical, making them hazardous. Children are not allowed to use them but it remains the quickest access to the beach from the patrol lookout.
- The only warm water showers fitted are located within the gear bay, which, being hindered by board racks, has them in an impractical location and taking up much needed space. In addition, there are only two shower heads and the communal location in the gear bay does not provide the privacy many children need.

- Due to the adhoc construction over the years, the building is subject to leaks, which has degraded the building materials.
- The long term stability of the structure is questionable, and it is now far from meeting any current regulations for both building standards and health and safety.
- Power supply to the building is insufficient.
- Doors are locked with padlocks, which are often difficult to use and hard to maintain.

## Club proposal

The Spencer Park Surf Life Saving Club proposes that the existing building be rebuilt to address the issues identified and to future proof the service that it provides to the public for many years to come.

The Club believes, following its assessment of the current layout of its facilities, that an increase in the overall ground footprint will be the only way to achieve a practical and useable amount of storage and workspace necessary to undertake its activities. The Club considers that potentially this could be achieved by adding to the existing structure along the southern boundary but this would be dependant on the current structure being sound and feasible to accommodate an altered layout. Its preference would be to start afresh to enable an entirely purpose-built facility to be constructed.

One of the aims is to relocate the first aid room on the ground floor to facilitate easier access by lifeguards and any emergency services. The first floor area required would need to significantly larger than it is at present to allow sufficient space to configure a main lounge/ clubhouse area, separate kitchen and toilet. A further elevated and separate patrol observation station would be required, and outside decking areas facing the beach to supplement patrols.

The Club has provided an initial draft concept plan to illustrate some proposed changes to the existing building. The Club advises that this does not constitute a final design but demonstrates what it believes is a starting point for discussion with the Council. Following initial consultation with the Council, the Club would commit resources into having more accurate designs and details presented.

## Linkage with Spencer Park circulation

The Spencer Park Surf Life Saving Club sees that their proposed redevelopment of the Surf Life Guard building now is timely to ensure that this is integrated with the consideration of potential improvements of road and path circulation in the Spencer Park area as part of the wider planning for open space in the Brooklands Lagoon/Te Riu o Te Aika Kawa area. Any facility redevelopment will need to be assessed in conjunction with addressing issues over the accessways around Spencer Park and with swimmers using unpatrolled areas of the beach.

## Future occupation agreement

Any future occupation agreement between the Club and the Council for the Club's continued use of the facility, and particularly so if changes are made to the facility, is likely to need to be in the form of a lease prepared under the Reserves Act 1977.

The proposal will be considered as part of the process for preparation of a new occupation agreement. There is no funding in the LTCCP 2009-19 for any developments of the site.

Vegetated coastal sand dunes in Spencer Park Beach.

# APPENDIX 3

# CHECKLIST TO THE BIRDS OF BROOKLANDS LAGOON/TE RIU O TE AIKA KAWA AND ENVIRONS[86]

Including: Brooklands Lagoon/Te Riu o Te Aika Kawa, Brooklands Spit/Kairaki, Lower Styx Ponding Area, Styx River/Puharakekenui mouth, Kainga Road Salt meadow, Waimakariri River mouth, Kairaki Paddocks and Kaiapoi Oxidation Ponds.

(Tenth update to July 2008)

Compiled by Andrew Crossland, Park Ranger Services, Transport and Greenspace Unit, City Environment Group, Christchurch City Council

## Key

### Origin:

| | |
|---|---|
| o | = oceanic species |
| w | = wetland/coastal species |
| t | = terrestrial/non wetland species |
| **bold** | = native or endemic sp. or sub.sp. |
| *italics* | = Australian visitor |
| std font | = human-introduced (exotic) |
| underlined | = northern hemisphere migrant |

### Maximum numbers:

| | |
|---|---|
| ***** | over 2000 (abundant) |
| **** | over 500 (abundant) |
| *** | over 200 (very common) |
| ** | over 50 (common) |
| * | 10 - 50 (less common) |
| # | < 10 (uncommon) |

### Status:

| | |
|---|---|
| R | = resident all year round |
| Rb | = resident and breeding |
| RS | = resident with seasonal population influxes |
| V | = vagrant or irregular visitor |
| S | = seasonal or regular visitor |
| Ex | = extinct |

[86] Source: Appendix 2 in Crossland A. C. (2008).

## SPECIES RECORDED 1850 to 2004

### Grebes:

1. **Australasian Crested Grebe** (Podiceps cristatus) w V #
2. **New Zealand Dabchick** (Poliocephalus rufopectus) w Ex

### Petrels and allies:

3. **Northern Giant Petrel** (Macronectes halli) o V #
4. **Sooty Shearwater** (Puffinus griseus) o V #
5. **Broad-billed Prion** (Pachyptila vittata) o V #
6. **Fairy Prion** (Pachyptila turtur) o V #

### Penguins:

7. **Yellow-eyed Penguin** (Megadyptes antipodes) w V #
8. **White-flippered Penguin** (Eudyptula minor albosignata) w S #
9. **Little Blue Penguin** (Eudyptula minor) w V #

### Gannets:

10. **Australasian Gannet** (Morus serrator) w S #

### Cormorants and Shags:

11. **Black Cormorant** (Phalacrocorax carbo) w RS *
12. **Pied Cormorant** (Phalacrocorax varius) w RS **
13. **Little Cormorant** (Phalacrocorax melanoleucos) w RS *
14. **Little Black Cormorant** (Phalacrocorax sulcirostris) w S #
15. **Spotted Shag** (Stictocarbo punctatus) w RS

****

### Herons and Allies:

16. **White-faced Heron** (Ardea novahollandiae) w RbS *
17. **White Heron** (Egretta alba) w S #
18. **Reef Heron** (Egretta sacra) w Ex
19. *Cattle Egret* (Bubulcus ibis) w V #
20. **Australasian Bittern** (Botarus poiciloptilus) w RbS # ?
21. **Royal Spoonbill** (Platalea regia) w S #
22. *Australian White Ibis* (Threkiornis molucca) w V #

### Waterfowl:

23. Mute Swan (Cygnus olor) w V #
24. **Black Swan** (Cygnus atratus) w RbS **
25. Canada Goose (Branta canadensis) w RbS ****
26. Greylag (feral) Goose (Anser anser) w Rb *
27. Cape Barren Goose (Cereopsis novaehollandiae) w V #
28. **Paradise Shelduck** (Tadorna variegata) w RbS ****
29. *Chestnut-breasted Shelduck* (Tadorna tadornoides) w V #
30. Mallard (Anas platyrhynchos) w RbS ****
31. **Grey Duck** (Anas superciliosa) w RbS **
32. **Grey Teal** (Anas gracilis) w RbS *****
33. **New Zealand Shoveler** (Anas rhynchotis) w RbS *****
34. **New Zealand Scaup** (Aythya novaseelandiae) w RbS ***

### Raptors (Birds of Prey):

35. **Australasian Harrier** (Circus approximans) w RbS *

## Gamebirds:

| | | | | |
|---|---|---|---|---|
| 36. | California Quail (Callipepla californica) | t | Rb | *** |
| 37. | Pheasant (Phasianus colchicus) | t | Rb | * |

## Rails/Gallinules:

| | | | | |
|---|---|---|---|---|
| 38. | **Buff Weka** (Gallirallus australis hectori) | w | Ex | |
| 39. | **Banded Rail** (Rallus philippensis) | w | Ex | |
| 40. | **Marsh Crake** (Porzana pusilla) | w | RbS | * ? |
| 41. | **Pukeko** (Porphyrio porphyrio) | w | Rb | * |
| 42. | **Australasian Coot** (Fulica atra australis) | w | S | # |

## Waders:

| | | | | |
|---|---|---|---|---|
| 43. | **South Island Pied Oystercatcher** (Haematopus ostralegus) | w | S | *** |
| 44. | **Variable Oystercatcher** (Haematopus unicolor) | w | V | # |
| 45. | **Pied Stilt** (Himantopus himantopus) | w | RbS | *** |
| 46. | **Black Stilt** (Himantopus novaezelandiae) | w | V | # |
| 47. | **Red-necked Avocet** (Recurvirostra novaehollandiae) | w | Ex | |
| 48. | **Spur-winged Plover** (Vanellus miles) | w | RbS | *** |
| 49. | **New Zealand Dotterel** (Charadrius obscurus) | w | Ex | |
| 50. | **Banded Dotterel** (Charadrius bicinctus) | w | RbS | ** |
| 51. | **Wrybill** (Anarhynchus frontalis) | w | S | * |
| 52. | Pacific Golden Plover (Pluvialis fulva) | w | V | # |
| 53. | Turnstone (Arenaria interpres) | w | V | # |
| 54. | Ruff (Philomachus pugnax) | w | V | # |
| 55. | Red Knot (Calidris canutus canutus) | w | S | # |
| 56. | Sanderling (Calidris alba) | w | V | # |
| 57. | Sharp-tailed Sandpiper (Calidris acuminata) | w | V | # |
| 58. | Eastern Curlew (Numenius madagascariensis) | w | V | # |
| 59. | Asiatic Whimbrel (Numenius phaeopus variegatus) | w | S | # |
| 60. | American Whimbrel (Numenius phaeopus hudsonicus) | w | V | # |
| 61. | Eastern Bar-tailed Godwit (Limosa lapponica baueri) | w | S | ** |
| 62. | Hudsonian Godwit (Limosa haemastica) | w | V | # |
| 63 | Terek Sandpiper (Tringa terek) | w | V | # |
| 64. | Alaskan Tattler (Tringa incana) | w | V | # |

## Skuas, Gulls and Terns:

| | | | | |
|---|---|---|---|---|
| 65. | Arctic Skua (Stercorarius parasiticus) | w | S | # |
| 66. | Pomarine Skua (Stercorarius pomarinus) | w | S | # |
| 67. | **Black-backed Gull** (Larus dominicanus) | w | RS | **** |
| 68. | **Red-billed Gull** (Larus novahollandiae) | w | R | *** |
| 69. | **Black-billed Gull** (Larus bulleri) | w | S | *** |
| 70 | **Black-fronted Tern** (Sterna albostriata) | w | S | ** |
| 71. | **Caspian Tern** (Sterna caspia) | w | S | * |
| 72. | **White-fronted Tern** (Sterna striata) | w | S | **** |
| 73. | Eastern Little Tern (Sterna albifrons sinensis) | w | V | # |

## Pigeons and Doves:

| | | | | |
|---|---|---|---|---|
| 74. | Rock Pigeon (Columba livia) | t | S | ** |
| 75. | **New Zealand Pigeon** (Hemiphaga novaeseelandiae) | t | S | # |
| 76. | Barbary Dove (Streptopelia chinensis) | t | R | # |

## Cuckoos:

| | | | | |
|---|---|---|---|---|
| 77. | **Shining Cuckoo** (Chrysococcyx lucidus) | t | Sb | * |
| 78. | **Long-tailed Cuckoo** (Eudynamys taitensis) | t | V | * |

## Owls:

| | | | | |
|---|---|---|---|---|
| 79. | Little Owl (Athene noctua) | t | Rb | * |

## Kingfishers:

| | | | | |
|---|---|---|---|---|
| 80. | **New Zealand Kingfisher** (Halcyon sancta) | w | RbS | ** |

## Swallows

| | | | | |
|---|---|---|---|---|
| 81. | **Welcome Swallow** (Hirundo tahitica) | w | RbS | **** |

## Passerines:

| | | | | |
|---|---|---|---|---|
| 82. | Skylark (Alaudu arvensis) | t | RbS | *** |
| 83. | **New Zealand Pipit** (Anthus novaseelandiae) | t | S | * |
| 84. | Dunnock (Prunella modularis) | t | RbS | |
| 85. | Blackbird (Turdus merula) | t | RbS | |
| 86. | Song Thrush (Turdus philomelos) | t | RbS | |
| 87. | **South Island Fernbird** (Bowdleria punctata punctata) | t | Ex | |
| 88. | **Grey Warbler** (Gerygone igata) | t | RbS | ** |
| 89. | **South Island Fantail** (Rhipidura fuliginosa) | t | RbS | ** |
| 90. | **Silvereye** (Zosterops lateralis) | t | RbS | ***** |
| 91. | **Bellbird** (Anthornis melanura) | t | S | # |
| 92. | Yellowhammer (Emberiza citrinella) | t | RbS | |
| 93. | Cirl Bunting (Emberiza cirlus) | t | S | |
| 94. | Chaffinch (Fringilla coelebs) | t | RbS | |
| 95. | Greenfinch (Carduelis chloris) | t | RbS | |
| 96. | Goldfinch (Carduelis carduelis) | t | RbS | |
| 97. | Redpoll (Carduelis flammea) | t | RbS | ***** |
| 98. | House Sparrow (Passer domesticus) | t | RbS | |
| 99. | Starling (Sturnus vulgaris) | t | RbS | |
| 100. | White-backed Magpie (Gymnorphina tibicen) | t | RbS | ** |

100 species were recorded 1850 – 2008, including 43 resident species, 23 seasonal visitors, 26 vagrants and 8 species now locally extinct.

# APPENDIX 4

## LINKED PLANNING AND REGULATORY DOCUMENTS

The following table presents, not in any particular order, some key documents that have particular relevance to the planning for public parks and open space in the Brooklands Lagoon/Te Riu o Te Aika Kawa area and/or were referred to in this master plan. It does not necessarily include all published planning and regulatory documents that apply to this general area.

| TITLE | DATE ADOPTED (DATE OPERATIVE) | PREPARED BY | APPLICABLE LEGISLATION | INTERNET LINK |
|---|---|---|---|---|
| Environment Canterbury Navigation Safety Bylaws 2005 | (1 December 2005) | Environment Canterbury | Local Government Act 2002 | http://ecan.govt.nz/services/environmental-planning/pages/boating-navigation-safety.aspx |
| Christchurch City Council Bylaws | Various | Christchurch City Council | Local Government Act 2002, Reserves Act 1977, Dog Control Act 1996 | http://www.ccc.govt.nz/thecouncil/policiesreportsstrategies/bylaws/index.aspx |
| Regional Coastal Environment Plan for the Canterbury Region 2005<br><br>(Proposed Plan Changes 1 and 2 notified on 31 May 2007) | 24 June 2004 (30 November 2005) | Environment Canterbury | Resource Management Act 1991 | http://ecan.govt.nz/publications/pages/regional-coastal-environment-plan.aspx |
| New Zealand Coastal Policy Statement 1994 | 5 May 1994 (by Gazette notice) | Department of Conservation | As above | http://www.doc.govt.nz/publications/conservation/marine-and-coastal/new-zealand-coastal-policy-statement/ |

| TITLE | DATE ADOPTED (DATE OPERATIVE) | PREPARED BY | APPLICABLE LEGISLATION | INTERNET LINK |
|---|---|---|---|---|
| Proposed New Zealand Coastal Policy Statement 2008 | | Department of Conservation | Resource Management Act 1991 | http://www.doc.govt.nz/templates/summary.aspx?id=56250 |
| Canterbury Conservation Management Strategy | 14 June 2000 | As above | Conservation Act 1987 | http://www.doc.govt.nz/templates/MultipageDocumentTOC.aspx?id=41496 |
| Canterbury Conservation Management Strategy review | | As above | As above | http://www.doc.govt.nz/templates/page.aspx?id=46394 |
| Waimakariri River Regional Park | | Environment Canterbury | | http://ecan.govt.nz/advice/recreation-and-parks/waimakariri-park/pages/Default.aspx |
| Waimakariri River Regional Plan (Proposed Plan Change 1 notified 8 August 2009) | (23 October 2004) | As above | Resource Management Act 1991 | http://ecan.govt.nz/our-responsibilities/regional-plans/pages/waimakariri-river-regional-plan.aspx |
| Christchurch City Plan | Proposed plan approved on 22 March 2005 (All operative on 21 November 2005) | Christchurch City Council | As above | http://www.ccc.govt.nz/thecouncil/policiesreportsstrategies/districtplanning/cityplan/index.aspx |
| Christchurch City Council Biodiversity Strategy 2008-2035 | 24 July 2008 | As above | Resource Management Act 1991, Local Government Act 2002 | http://www.ccc.govt.nz/thecouncil/policiesreportsstrategies/strategies/healthyenvironmentstrategies/biodiversity.aspx |

| TITLE | DATE ADOPTED (DATE OPERATIVE) | PREPARED BY | APPLICABLE LEGISLATION | INTERNET LINK |
|---|---|---|---|---|
| A Biodiversity Strategy for the Canterbury Region | February 2008 | Biodiversity Strategy Advisory Group | Resource Management Act 1991 | http://www.canterburybiodiversity.org.nz/canterbury-region-biodiversity-strategy.html |
| Styx Vision 2000-2040 | 26 July 2001 | Christchurch City Council | Resource Management Act 1991, Local Government Act 2002 | http://www.thestyx.co.nz/new-zealand/main/ |
| Coastal Parks Strategy 2000-2010 | | As above | As above | http://www.ccc.govt.nz/cityleisure/parkswalkways/popularparks/christchurchbeaches/index.aspx |
| Christchurch Beaches and Coastal Parks Management Plan 1995 | December 1995 | As above | As above | |
| Christchurch City Council Surface Water Strategy 2009-2039 | 26 November 2009 | As above | Resource Management Act 1991, Local Government Act 2002 | http://www.ccc.govt.nz/thecouncil/policiesreportsstrategies/strategies/healthyenvironmentstrategies/surfacewaterstrategy.aspx |
| Spencer Park Management Plan 2010 | 12 August 2010 | As above | Reserves Act 1977 | http://www.ccc.govt.nz/cityleisure/parkswalkways/index.aspx |
| Seafield Park Management Plan 2010 | As above | As above | As above | As above |
| Public Open Space Strategy 2010-2040 | As above | As above | Local Government Act 2002, Resource Management Act 1991 | http://www.ccc.govt.nz/thecouncil/policiesreportsstrategies/strategies/healthyenvironmentstrategies/openspacestrategy.aspx |

# APPENDIX 5 - REPORTS

## Reports used or referred to directly in this master plan

Hicks, D. M. and Duncan, M. J. (1993). *Sedimentation in the Styx River Catchment and Brooklands Lagoon.* Report to the Christchurch City Council and Environment Canterbury. Miscellaneous Report No. 128. Freshwater Division, NIWA, Christchurch.

McCoombs, K. (1999). *Weeds at Brooklands Lagoon.* Report: CCCECO 99/09. Greenspace Unit, Christchurch City Council.

Rob Greenaway & Associates (2005). *Spencer Park / Brooklands Lagoon area Recreation Survey 2004*. Report to the Christchurch City Council. Rob Greenaway and Associates. 22 February 2005.

Taylor, M. J. and Bradshaw, D. (2005). *Inanga spawning on the lower Styx River.* Aquatic Ecology Limited, Christchurch. AEL Report No. 28. 14 p.

Worner, G. and Partridge, T. (2008). *Saltmarsh vegetation at Brooklands Lagoon.* Report: CCCECO 08/14. Asset and Network Planning Unit, Christchurch City Council.

## Other documents and publications used or referred to directly in this master plan

Christchurch City Council (2000). Resource Information for the Christchurch Coastal Zone. Produced and published by Coast Care, Parks Unit, Christchurch City Council. June 2000.

Crossland, A. C. (2008). *Brooklands Lagoon Wetland Complex: An overview of the site's importance to birdlife with habitat management recommendations*. Unpublished report for the Transport and Greenspace Unit, City Environment Group, Christchurch City Council. August 2008.

Crossland, A. C. (1992). Birds of the Estuary. In: Owen, S-J. (ed.), *The Estuary: Where Our Rivers Meet The Sea: Christchurch's Avon-Heathcote Estuary and Brooklands Lagoon.* Christchurch.

Owen, S. J. (ed.) (1992). *The Estuary: Where Our Rivers Meet The Sea: Christchurch's Avon-Heathcote Estuary and Brooklands Lagoon.* Parks Unit, Christchurch City Council.

## Other reports and publications

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

Bolton-Ritchie, L. (2007). *Sediments and benthic macrobiota of Brooklands Lagoon.* Report No. U07/52. Environment Canterbury. ISBN: 978-1-86937-680-2.

Christchurch City Council (1995). *Christchurch Beaches and Coastal Parks Management Plan – Policy document.* Parks Unit, Christchurch City Council. December 1995.