

## 14. DRAFT HABITAT CREATION AND MANAGEMENT PLAN FOR THE WETLAND NATURE RESERVE

### 14.1 Study background and objectives

14.1.1 This draft Habitat Creation and Management Plan (HCMP) presents the details for the design and management of the on-site Wetland Nature Reserve (WNR) that was identified as appropriate mitigation and compensation for the construction of the residential development as detailed in Section 13. This is a draft document and key details presented here, including, for example, stocking densities and monitoring requirements are to be finalised subject to the endorsement of AFCD or other appropriate authority. If changes are required in light of the changing environment/baseline, such changes would need to be agreed with AFCD or the relevant authorities.

14.1.2 The proposed WNR has been designed to achieve sufficient functional enhancement to compensate for long-term operational phase disturbance. Section 3.5.6.4 xiv and xv of the Study Brief also specifically states that the Ecological Impact Assessment should:

- A. Identify any constraints associated with the finalized mitigation measures.
- B. Propose a management package for the proposed on-site WNR with particular attention to:
  - i. The habitat management plan and specification of resources requirement for its implementation.
  - ii. The long-term foundation management system with management guidelines.
  - iii. The financial arrangements to sustain the management of the wetland.
  - iv. The management agents and their responsibility.
  - v. A contingency plan for the management of the WNR before the establishment of the foundation management.
- C. Formulate an ecological monitoring and audit programme for the periods of construction and subsequent site operation, including the development and operation of the WNR.

14.1.3 Objectives A, Bi and C are covered within this management plan. The structure and financial arrangements of an independent management foundation to be established for the long-term management of the WNR (Bii – Bv) are outlined within a separate chapter of the EIA (Section 15).

#### **Description of development impacts and proposed mitigation**

14.1.4 The EIA carried out on the project found that there are potential ecological impacts on ecologically valuable habitats that require mitigation measures. These are:

- Habitat loss
- Habitat fragmentation
- Disturbance
- Pollution
- Soil compaction
- Hydrological disruption

14.1.5 The key strategy for mitigating permanent and temporary habitat loss arising from the construction of the Residential Development is the construction and appropriate management of a Wetland Nature Reserve (WNR) within that component of the site (approximately 76.1 hectares) not occupied by the proposed residential development. The aim of the WNR is to compensate permanent habitat loss and to mitigate disturbance effects through the creation of approximately 14.4 ha. of freshwater marsh habitat. In addition approximately 61.7 ha of remaining fishponds will be enhanced and managed to increase their carrying capacity for bird Species of Conservation Importance.

- 14.1.6 The strategy for constructing the WNR has been carefully considered and incorporates the following (strategic) elements:
- Advance construction. Construction works associated with the WNR will be completed in advance of the commencement of construction at the Residential Development – this minimises concurrent disturbance associated with construction works in these two areas.
  - Staged construction. The construction of the WNR will be staged to minimise the areas affected at any one time. This minimises disturbance effects and ensures that there is always sufficient habitat for birds, and other species, considered to be of Conservation Importance within Fung Lok Wai.
  - Interim management. To ensure that carrying capacity of areas unaffected by construction at any one time are sufficient to maintain populations of bird (and other) Species of Conservation Importance, interim management will be undertaken during WNR and Residential Development construction phases.
  - Long-term management. Once construction works are completed and the Residential Development enters its operational phase, long-term management within the WNR will commence.
- 14.1.7 Although Option 1A is relatively more superior than Option 1B in respect of ecological impacts due to less building blocks and wider building gaps, it is considered that for both options the impacts from disturbance, habitat loss and fragmentation, hydrological disruption and soil compaction can be fully mitigated for through the following habitat compensation measures:
- Structural and functional enhancement of existing aquaculture ponds (fishponds that are actively managed, those that are currently unmanaged, and the intervening bunds)
  - Design and creation of a naturalistic wetland
  - Establishment of disturbance buffers
  - Design and construction of a potential alternative egretty
  - Design and implementation of a management programme for long-term management of the wetland reserve
- 14.1.8 Standard avoidance and minimisation measures, as described within the mitigation measures section of the EcIA, are considered to be adequate to eliminate other residual impacts, such as pollution, from other potential impact sources.
- 14.1.9 The project proponent will be responsible for the creation, enhancement and management of the WNR during the construction phase and shall provide an undertaking to take sole responsibility for management until a designated successor such as an independent Foundation is identified to the satisfaction of EPD or its agents. Subject to the necessary agreements from relevant government authorities, an independent, non-profit Foundation will be established to take over the long-term management of the WNR. The proponent or its designated successor will implement the Habitat Creation and Management Plan (HCMP) submitted with the EIA report. Experienced ecologists will be employed as the Reserve Manager for the day-to-day management of the WNR and experienced fish farmers will be employed for the operation of the fish ponds under the supervision and guidance of the Reserve Manager.
- Purpose of the Habitat Creation and Management Plan**
- 14.1.10 This Habitat Creation and Management Plan (HCMP) aims to provide the detailed specifications for the habitat and other ecological mitigation measures to be provided within the Fung Lok Wai WNR. The content of this management plan aims to compliment the management goals of the Mai Po Inner Deep Bay Ramsar Site management plan in accordance with Ramsar Convention obligations. The recommendations and specifications given in this document and the accompanying appendices will be incorporated as appropriate into forthcoming contract documentation.
- 14.1.11 Thus the document includes:
- a summary of the current ecological importance and condition of the site, including physico-chemical conditions that may affect habitat restoration and enhancement measures;
  - definition of the target species requiring mitigation at the site and target habitats to be

restored, created or enhanced;

- a summary of specific habitat requirements and associated management measures required by target species;
- detailed design drawings and specifications for the habitats (e.g. vegetation composition and structure and water regimes) and associated structures (e.g. water courses for water supply and drainage and water control structures),
- management prescriptions and required actions to maintain the long-term ecological value and functions of the WNR;
- a detailed monitoring programme for habitat attributes and target species; and
- an outline programme for the implementation of the HCMP.

### **Description of the site**

#### **Site location and boundaries**

14.1.12 The proposed WNR is located to the south of Inner Deep Bay in the North West New Territories of the Special Administrative Region of Hong Kong. Figure 14-1 illustrates the proposed location of the WNR in the context of the Deep Bay environs.

14.1.13 To the west the site is bounded by mangroves along the tidal creeks of the Tai River outfall, beyond which are grasslands, reedbeds, a plantation and aquaculture ponds. Further to the west of Fung Lok Wai is Tin Shui Wai New Town. To the north-west there is an area of tidal lagoons (near Tsim Bei Tsui) created by the construction of a causeway for the road and border security fence. The site is surrounded to the north and east by wetland habitats. A continuous band of one or two fishponds bound the site to the immediate north, beyond which lies a belt of mangroves and then the tidal mudflats of Inner Deep Bay. Further to the north-east, beyond the Shan Pui River, there is a large area of aquaculture ponds (fishponds that are actively managed, those that are currently unmanaged, and the intervening bunds) and the Mai Po Nature Reserve, a complex of mangrove, gei wai, reedbed and aquaculture ponds. Aquaculture ponds also bound the site to the east, beyond which is the Main Drainage Channel for Yuen Long, Kam Tin and Ngau Tam Mei drainage from the Shan Pui River. This currently consists of a large area of open water. To the south east lies Yuen Long Sewage Treatment Works to the south of which lies Yuen Long Industrial Estate. The south of site is bounded by undeveloped low hills. These are predominantly covered in semi-natural scrub and woodland vegetation with some grassland and orchards.

#### **Topography and watercourses**

14.1.14 The site has an open, flat and low lying aspect. The major variation in site level is due to the excavation of the aquaculture ponds. The level on top of the bunds varies from approximately +3.1 m to +3.3 m PD, at the north and east of the site, to about +4.2 m PD at the south.

14.1.15 Water for the fishponds come from direct rainfall. In the normal course of aquaculture pond management ponds are periodically drawn-down and water pumped from one pond to another to conserve resources. After heavy summer rainfall, ponds may fill and drain into adjacent channels. Channels may also occasionally be used for transferring water, by pump, between fishponds.

14.1.16 No flow data are currently available for the drainage channels. However, a site inspection on 10th January 1998 revealed that all channels contained shallow water (c. 10 cm) and that there were low flows from those draining catchments the adjacent catchments to the south. These observations have been confirmed on subsequent site inspections.

14.1.17 The mangrove lined channel (Tai River outfall) at the north-western perimeter of the site is intertidal. The perimeter bunds are approximately +3.8 mPD and higher than the predicted mean high water in the channel (+2.4 m PD). Therefore in normal circumstances the interior of the site remains free of tidal influence. Overtopping of the perimeter might occur in an extreme combined high tide and storm event. However, this is likely to be extremely rare given the past extreme sea levels at nearby Tsim Bei Tsui which peaked at +3.85 mPD with a return period of 100 years for records between 1974 and 1990. The predicted tidal range for 2002 at Tsim Bei Tsui is 0-3 mPD with an average peak tide of +2.4 mPD.

**Soils**

- 14.1.18 The superficial geology of the site consists of estuarine deposits of marine and fluvial origin, predominantly silts and clays. No borehole information is available from Fung Lok Wai itself, but investigations elsewhere indicate that lenses of sands and gravels of alluvial origin may occur underneath the surface estuarine deposits (see Townland *et al.* 1992).
- 14.1.19 The soils of Fung Lok Wai are derived from mangrove soils and ultimately have their origin as marine sediment and riverine alluvium. Texturally the soils are dominated by silt and clay fractions, the relative proportions of which produce soils that vary from clay through silty clay to silty clay loam (USDA texture classes). Sand content is generally low. Very small amounts of gravel are present. The soils have been considerably reworked during reclamation and through management for fish-farming. The soils are poorly drained and frequently highly saline, rendering them of little agricultural value.

**Existing ecological interest****Habitat evaluation**

- 14.1.20 The ecological values of the current habitats are evaluated in the Fung Lok Wai EIA. The most valuable habitat components of the Assessment Area are wetland habitats. In particular the extensive block of Aquaculture Ponds (fishponds that are actively managed, those that are currently unmanaged, and the intervening bunds) that form a large contiguous area embedded within the broader Deep Bay Area that includes Mai Po. Adjacent to this central aquaculture pond area there is, in the southern part of the Assessment Area, a mosaic of other wetland habitats including wet agriculture, freshwater marsh and reedbeds. Whilst these areas are of less intrinsic ecological value, their close proximity and functional linkage with the main aquaculture pond area enhances their overall status.
- 14.1.21 The egretty in the small Fung Shui Woodland also in the southern part of the Assessment Area is also a feature of high ecological value due to the scarcity of active egrettries in the New Territories. Recent information indicates that this egretty has now been abandoned (see Anon 2005).
- 14.1.22 The key ecological value of the Assessment Area is, therefore, the habitat it provides for breeding and foraging birds, in particular wetland birds such as herons and egrets, ducks and waders. In addition the Assessment Area also supports reptile Species of Conservation Importance. Traditional aquaculture and agricultural management practices have, to a large extent, engendered the value of the site for birds. At the same time, however, these practices also limit the potential value of these habitats. Aquaculture ponds are for example small and steep sided which restricts bird access and pond bunds are cleared to maintain access to ponds. With more sympathetic management the value of the wetland habitats at Fung Lok Wai could be significantly higher.
- 14.1.23 The extensive area of inter-tidal habitat in the northern part of the Assessment Area is also of moderate to high ecological value due to the high biological diversity of mangal systems. There is no direct link between these habitats and the proposed Development Area, however, and the potential for impact is very low.
- 14.1.24 All other habitats within the Assessment Area are considered to have low ecological value due, primarily to previous and current levels of disturbance (Table 14-1).

Table 14-1 Ecological evaluation of habitats within the Fung Lok Wai Assessment Area

| Habitat                              | Overall evaluation |
|--------------------------------------|--------------------|
| Aquaculture ponds                    | High               |
| Fung-shui forest                     |                    |
| With egretty                         | High               |
| Without egretty                      | Low to moderate    |
| Intertidal forested wetlands         | Moderate to high   |
| Agricultural land                    |                    |
| Seasonally flooded agricultural land | Moderate           |

|                                      |                 |
|--------------------------------------|-----------------|
| Dry agricultural land                | Low to moderate |
| Inactive agricultural land           | Low to moderate |
| Permanent freshwater marsh and pools | Low to moderate |
| Secondary woodland                   | Low to moderate |
| Permanent rivers, streams and creeks | Low             |
| Reedbed                              | Low             |
| Ditches and drainage channels        | Low             |
| Wasteland                            |                 |
| Wasteland                            | Low             |
| Aquaculture ponds (infilled)         | Low             |
| Works in progress                    | Low             |
| Grassland                            | Low             |
| Grassland-shrubland mosaic           | Low             |
| Orchard                              | Low             |
| Plantation forest                    | Low             |
| Landscaped area                      | Low             |
| Developed areas                      |                 |
| Developed area                       | Low             |
| Wastewater treatment area            | Low             |
| Water storage area                   | Low             |

### **Species of Conservation Importance**

14.1.25 A list of Species of Conservation Importance that occur within the development site and 500m buffer zone are listed in Table 14-2 below.

Table 14-2 *Species of Conservation Importance that occur within the Fung Lok Wai Assessment Area*

| Common name                          | Scientific name              | Habitat preference in Hong Kong  |
|--------------------------------------|------------------------------|--|
| <b>Reptiles</b>                      |                              |  |
| Banded Krait*                        | <i>Bungarus fasciatus</i>    | Low lying areas near marshes, cultivated fields and shrub land   |
| Common Rat Snake                     | <i>Ptyas mucosus</i>         | Varied including agricultural areas, shrub land and around aquaculture ponds (fishponds that are managed, currently unmanaged, and the intervening bunds) and reservoirs |
| Indo-Chinese Rat Snake               | <i>Ptyas korros</i>          | Open habitats, including banks of streams and reservoirs, cultivated fields, aquaculture ponds and shrub land  |
| Many-banded Krait*                   | <i>Bungarus multicinctus</i> | Varied, including forest, agricultural areas and the edges of mangroves  |
| Mangrove Water Snake                 | <i>Enhydris bennettii</i>    | Muddy coastal habitats   |
| <b>Birds</b>                         |                              |  |
| <i>Global conservation concern</i>   |                              |  |
| Black-faced Spoonbill                | <i>Platalea minor</i>        | Mudflat, drained Gei Wai and aquaculture ponds   |
| Greater Spotted Eagle*               | <i>Aquila clanga</i>         | Brackish and freshwater marsh areas and aquaculture ponds  |
| Imperial Eagle*                      | <i>Aquila heliaca</i>        | Marshes, aquaculture ponds and adjacent hillsides in Deep Bay area. Also recorded in the NW, NE & central New Territories  |
| Red-billed Starling                  | <i>Sturnus sericeus</i>      | Aquaculture ponds, wet agricultural areas, perimeter of reedbeds; and natural and artificial drainage channels.  |
| <i>Regional conservation concern</i> |                              |  |
| Common Teal                          | <i>Anas crecca</i>           | Shallow wetlands including aquaculture ponds   |
| Eurasian Wigeon                      | <i>Anas penelope</i>         | Intertidal areas, marsh and aquaculture ponds  |

| Common name                                    | Scientific name               | Habitat preference in Hong Kong  |
|--|-------------------------------|--|
| Osprey*  | <i>Pandion haliaetus</i>      | Bays, coastal areas, gei wais, aquaculture ponds, reservoirs   |
| <i>Potential regional conservation concern</i> |                               |  |
| Black Kite                                     | <i>Milvus migrans</i>         | Sea, coast, intertidal mudflat, aquaculture ponds, grassy and shrubby hillsides and harbours.  |
| Chinese Pond Heron                             | <i>Ardeola bacchus</i>        | Freshwater marsh, aquaculture ponds, wet agriculture, rivers and drainage channels.  |
| Great Cormorant                                | <i>Phalacrocorax carbo</i>    | Coastal areas, aquaculture ponds   |
| Great Egret                                    | <i>Egretta alba</i>           | Wetlands, particularly shallow intertidal bays, aquaculture ponds and marshes.   |
| Grey Heron                                     | <i>Ardea cinerea</i>          | Abundant winter visit to Deep Bay associated with freshwater marsh, aquaculture ponds and bunds, wet agriculture, rivers and drainage channels.  |
| Little Egret                                   | <i>Egretta garzetta</i>       | Wetlands including intertidal mudflats, gei wai, also aquaculture ponds, wet agriculture, marsh and banks of rivers and streams  |
| <i>Local conservation concern</i>              |                               |  |
| Black-crowned Night Heron                      | <i>Nycticorax nycticorax</i>  | Coastal and subcoastal wetlands, including aquaculture ponds, marsh, mangrove, intertidal mudflats, riverine wetlands  |
| Cattle Egret                                   | <i>Bubulcus ibis</i>          | Freshwater marsh, aquaculture pond, wet agriculture.   |
| Collared Crow                                  | <i>Corvus torquatus</i>       | Primarily in Deep Bay, including rocky and sandy shores, intertidal mudflats, gei wai, aquaculture ponds   |
| Crested Serpent Eagle*                         | <i>Spilornis cheela</i>       | Hillside, woodland, rocky hilltops, undisturbed small marshes, abandoned wet paddies   |
| Little Grebe                                   | <i>Tachybaptus ruficollis</i> | Gei wai, aquaculture ponds particularly those with emergent and submerged vegetation   |
| Little Ringed Plover                           | <i>Charadrius dubius</i>      | Low lying land close to freshwater: wet agriculture, reclaimed land, freshwater marsh, aquaculture ponds (particularly when drawn down) & coastal areas adjacent to freshwater streams       |
| Pied Kingfisher                                | <i>Ceryle rudis</i>           | Fresh, brackish and saltwater wetlands including aquaculture ponds, gei wai, sheltered bays.   |
| Striated Heron                                 | <i>Butorides striatus</i>     | Mangroves and inter-tidal mudflats   |
| Temminck's Stint                               | <i>Calidris temminckii</i>    | Feeds and roosts in drawn down aquaculture ponds. Also forages in freshwater marsh.  |
| White-throated Kingfisher                      | <i>Halcyon smyrnensis</i>     | Golf courses, gardens, aquaculture ponds.  |
| Wood Sandpiper                                 | <i>Tringa glareola</i>        | Low lying areas of freshwater marsh, wet agricultural land and aquaculture ponds in the New Territories particularly Long Valley. During spring passage observed on the intertidal mudflats. |

\* Survey data indicate that these species only occur in the area occasionally and are unlikely to depend on the site.

### **Summary of predicted ecological impacts**

#### **Habitats**

14.1.26 Ecologically valuable habitats (ie of moderate value and above) affected by the potential impacts of the proposed development identified above are summarised in Table 14-3. The potential impacts under Options 1A and 1B on habitats are similar, although the effects of habitat fragmentation are expected to be slightly greater under Option 1B than 1A.

Table 14-3 Summary matrix of potential impacts on habitats

| Habitat                                    | Habitat loss | Habitat fragmentation | Disturbance | Pollution | Soil compaction | Hydrological disruption |
|--|--------------|-----------------------|-------------|-----------|-----------------|-------------------------|
| Intertidal forested wetlands               |              |                       | X           | X         |                 |                         |
| Permanent rivers, streams and creeks       |              |                       |             |           |                 |                         |
| Ditches and drainage channels              | X            |                       |             |           |                 | X                       |
| Aquaculture pond (actively managed)        | X            |                       | X           | X         | X               |                         |
| Reedbed                                    |              | X                     | X           | X         |                 |                         |
| Permanent freshwater marsh and pools       |              | X                     | X           | X         |                 |                         |
| Seasonally flooded (wet) agricultural land |              | X                     | X           | X         |                 |                         |
| Dry agricultural land                      |              |                       | X           | X         |                 |                         |
| Inactive agricultural land                 |              |                       | X           | X         |                 |                         |
| Orchard                                    |              |                       |             |           |                 |                         |
| <i>Fung-shui</i> woodland                  |              | (X)*                  | X           | X         |                 |                         |
| Semi-natural secondary woodland            |              |                       | X           | X         |                 |                         |

Note: \* only if egret present

14.1.27 The habitats affected the most directly are aquaculture ponds, however, the establishment of the WNR will compensate for habitat loss and disturbance caused by the proposed development. The *Fung-shui* woodland to the south west of the Proposed Development Area was initially considered to be highly sensitive due to the presence of an egret. The potential effect of flightline obstruction was analysed and a decision was made to relocate the development to minimise flightlines obstruction. Subsequent surveys have now demonstrated that this egret has been abandoned (see for example Anon 2005) significantly reducing the likelihood of flightline obstruction the potential effects.

#### Species

14.1.28 The major potential species impacts associated with the proposed development relate to:

- Disturbance to birds caused by the construction and operation of the proposed development, including the WNR; and,
- Fragmentation – in particular the obstruction of flightlines of birds moving to and from the egret (although this impact will be of lesser significance if the egret remains abandoned).

#### Constraints on design

14.1.29 The ecological impacts summarised above and described in the EIA Report may potentially be mitigated for through the enhancement or re-creation of a number of wetland habitat types. There may, however be constraints affecting the restoration and management of wetland habitats at Fung Lok Wai and consequently the potential for impact mitigation. Potential constraints are therefore reviewed on the basis of the site description above and summarised in Table 14-4 below.

Table 14-4 Potential physical constraints on the creation of a Wetland Nature Reserve at Fung Lok Wai.

| Key factors                   | Assessment of constraint  |
|-------------------------------|---|
| Size and location of the site | The site is relatively large (approximately 80.1 ha) and dominated by aquaculture ponds (fishponds that are managed, currently unmanaged, and the intervening bunds), which are contiguous with others in the Mai Po Inner Deep Bay Ramsar site and wider Deep Bay area. It is therefore essential that the habitats within the proposed WNR remain |

| Key factors                                     | Assessment of constraint   |
|---|--|
|   | ecologically linked and compatible with the surrounding habitats.  |
| Water quantity                                  | Although Hong Kong has a high level of rainfall there is a long period of dry weather in winter when evaporation and transpiration exceeds rainfall. Therefore freshwater marsh, reedbeds and shallow ponds are susceptible to drying out. Fishponds currently rely on direct rainfall, but the creation of other shallow wetlands may require additional inputs during the dry season. Water is available from run-off from the residential site and two adjacent catchments.   |
| Topography, water depth and water level control | There is little variation in ground levels over the site. Although this is principally advantageous for the creation of ponds and freshwater marsh, it reduces the potential for moving water between water bodies by gravity alone. Although the land is low lying flooding with saltwater due to storm surges is likely to be a rare.  |
| Water quality                                   | Data on water quality in the existing courses entering the site are not available. However, visual inspection of the catchments indicates that these are dominated by semi-natural vegetated habitats with no obvious sources of pollution. It is therefore anticipated that water quality from these catchments will be adequate for most wetland habitats. Run-off from the residential development will require screening and removal of litter, oil and similar pollutants and excessive silt loads during high rainfall events. |
| Substrate                                       | The clay soils over the site are impermeable and therefore suitable for the creation of permanent waterbodies. The soils hold high levels of sulphide which may cause acidification problems in aerobic conditions. High salinity, aluminium and iron levels may also limit the establishment and growth of some plant species.  |
| Vegetation establishment                        | Many wetland plants are already present on the site and may provide source populations. Commercial sources of wetland plants (e.g. reed seedlings) are readily available. Opportunistic sources may also become available through the development of other wetlands in Hong Kong.  |
| Vegetation growth                               | Plant growth is rapid in Hong Kong due to the warm and wet climate. Vegetation management measures (such as mowing or grazing) may therefore be necessary to maintain low growing, open and varied plants communities within freshwater marsh habitats. Soil conditions (see above) may, however, retard plant establishment and growth. There are a number of exotic species that cause problems to native wetland vegetation and considerable management will be required to control them.   |
| Disturbance                                     | There are numerous sources of disturbance to birds and other sensitive fauna on the site, including fish-farming operations, scattered dwellings and the proposed residential development itself. Disturbance reducing measures will be required to enhance the use of the site by many species of waterbird.  |

### **Engineering**

14.1.30 Weak structural integrity of bunds (in aquaculture ponds) is a potential constraint on the access and operation of heavy construction machinery, such as excavators. Fish farmers, however, currently routinely use heavy machines such as bulldozers in pond management (as it is existing practice to periodically re-profile fishponds). Furthermore the site is criss-crossed by a network



of tracks and roads. This suggests that, in practice, there should be no significant constraint on access for machines such as excavators and bulldozers required for the pond enhancement works proposed.

- 14.1.31 The pond enlargement process will result in the creation of longer bunds than currently exist. Bund re-formation works will need to be undertaken in a controlled manner to ensure that bund strength is retained.

#### **Hydrology / Drainage**

- 14.1.32 The main constraint on the design of the wetland mitigation scheme is the highly seasonal rainfall in Hong Kong. Typically there is a period of water deficit (i.e. rainfall is exceeded by evapotranspiration) from September to March. Without an additional source of water it is not normally possible, to maintain permanent shallow wetlands, such as those required in the proposed freshwater marsh complex mitigation area. Permanent wetlands may be retained by storing sufficient water to overcome the deficit period, but such wetlands are then inundated by water which is too deep for many of the wetland target species over the much of the annual cycle. Average monthly rainfall evaporation and deficits are indicated in Figure 14-2.

- 14.1.33 Potential water sources include run-off from the residential development roofs and hard standing and stream flow from small hillside catchments to the south of the site (Catchments A and B, Figure 14-3).

- 14.1.34 The outfall to the Tai River, which provides drainage for the area, is tidal. An outfall is required, therefore, that is resistant to tidal erosion and which, by means of a tidal flap, allows one way flow and prevents saline water intrusion.

#### **Soils**

- 14.1.35 The soils present at the site consist of poorly drained marine clays. These are sufficiently impermeable to maintain wetland conditions or aquaculture ponds (fishponds that are managed, currently unmanaged, and the intervening bunds) over the site as demonstrated by the current presence of such habitats, which are in the main solely maintained by direct rainfall inputs.
- 14.1.36 They are, however, acid sulphate soils which can lead to highly acidic conditions when these are disturbed and dried. Nevertheless vegetation such as *Phragmites* does spontaneously recover on bunds and therefore the maintenance of basic vegetation cover is unlikely to be constrained. However, care with soil handling or remedial measures (e.g. application of lime) may be needed to establish more sensitive and diverse wetland vegetation of high ecological value within the marsh areas of the site.

#### **Water Quality**

- 14.1.37 The sources of water for the WNR are direct rainfall and run-off from the proposed Development Area and existing catchments immediately to the south of the proposed Development Area.

- 14.1.38 Using run-off from developed catchments can lead to eutrophication and toxic metal pollution problems. Studies of the water quality characteristics of urban run-off in the United States (USEPA, 1983), for example, indicated that average total phosphorous concentrations in run-off from residential and commercial sites tend to exceed targets for shallow non-eutrophic wetlands. Guidelines for total phosphorus in freshwater wetlands tend to be in the region of 10-60 micrograms l<sup>-1</sup> (eg ANZECC 2000).

- 14.1.39 The study of residential and commercial sites in the United States also found copper concentrations of 53 micrograms l<sup>-1</sup>, lead at 238 micrograms l<sup>-1</sup> and zinc at 353 micrograms l<sup>-1</sup>. In comparison recommended maximum levels for the protection of aquatic life for these metals are 19 micrograms l<sup>-1</sup>, 9 micrograms l<sup>-1</sup> and 241 micrograms l<sup>-1</sup> respectively (Missouri Department of Natural Resources 1996).

- 14.1.40 In Hong Kong Binnie Consultants Ltd (1997) also found that total phosphorus in run-off from developed catchments tends to exceed guidelines for wetlands (average TP >420 micrograms l<sup>-1</sup>) although heavy metals were below the guidelines proposed by the Clean Water Commission above. Furthermore, published river water quality data for Hong Kong (eg EPD 2002) also indicates that levels of heavy metals in rivers in the Deep Bay area tend, on average, to be below these recommended levels.

- 14.1.41 The existing catchments that will supply water to the WNR are dominated by dense semi-natural scrub and woodland vegetation, are only partially developed and, like the proposed development, contain only housing with no commercial use. There are no apparent point sources of pollutants, such as pig farms etc. Water from catchment flow is likely to be of relatively low nutrient content and Biological Oxygen Demand (BOD). It is also anticipated that suspended solids (mainly silt) in runoff during heavy rainfall periods is relatively low due to the existing dense vegetation cover in the catchments. In addition, it is likely that the concentrations of toxic heavy metals in the runoff will be below levels that could prove problematic for aquatic ecosystems.
- 14.1.42 As most run-off will be associated with heavy rainfall, it is anticipated that any pollutants from the residential site will be sufficiently diluted to ensure that a suitable water quality standard is achieved for the wetland. Nevertheless, as an initial precaution, run-off water from the residential site will be passed through traps to remove oil and grease and sand and gravel filters to reduce silt loads and particulate organic matter prior to discharging into the ditch and the storage pond. A high proportion of heavy metals and phosphates are normally bound to sediments and organic matter, the removal of silt will therefore considerably reduce the levels of these pollutants.
- 14.1.43 Run-off water from the catchments and development area will be stored for long periods before entering the wetland area any remaining silt that is present will be able to settle out of the water. This will further significantly reduce pollutant levels (from the residential run-off and catchments A and B). Periodic silt removal from the storage pond will therefore be required.
- 14.1.44 In summary, although there are no major obstacles to the creation of a WNR at Fung Lok Wai, possible constraining factors may be the low level of the site, soil salinity and pH, disturbance and the need for active and long-term management of the vegetation and water-bodies.

## 14.2 Mitigation objectives

### Management goals and objectives of the Wetland Nature Reserve

- 14.2.1 The key goal of the WNR is the conservation of Species of Conservation Importance, specifically to mitigate habitat loss and disturbance during the construction and operation of the Residential Development. It is intended that the WNR will maintain populations of Species of Conservation Importance at better than baseline levels (as established through ongoing monitoring). In the long-term it is anticipated that the WNR will sustainably support a more diverse flora and fauna than that currently found at Fung Lok Wai.
- 14.2.2 As described above the key strategies for achieving this are:
- Completion of construction works associated with the WNR in advance of commencement of the noisiest works associated with the construction of the Residential Development.
  - Staged construction (to minimise impacts caused by the WNR works themselves).
  - Intensive interim management of ponds during the construction phase of the Residential Development.
  - Long-term sympathetic management of ponds during the operation phase of the Residential Development.
- 14.2.3 The importance of the wetland habitats at Fung Lok Wai derives primarily from the resources they provide for Species of Conservation Importance and in particular wetland birds such as herons and egrets. Some aspects of traditional aquaculture practice on site, such as periodic draining of ponds, have increased the attractiveness of aquaculture ponds to birds. On the other hand the small and uniformly steep sided form of the ponds limits (those that are managed, currently unmanaged, and the intervening bunds) their potential. With more sympathetic management the value of aquaculture ponds at Fung Lok Wai could be significantly higher.
- 14.2.4 A key objective is to improve the overall attractiveness of the aquaculture ponds at Fung Lok Wai for species dependent on wetland habitats. This will be achieved through a reconfiguration of the ponds to create fewer, larger ponds and the creation of a complex of freshwater marsh habitats. Increasing fishpond size is expected to benefit wetland birds as there is evidence many species prefer larger, less enclosed waterbodies to the small ponds which typify most aquaculture practices. The removal of some bunds is predicted to have low or negligible impact on flora or

fauna as their intrinsic ecological value is low and no Species of Conservation Importance were found to be reliant on them. The complex of freshwater marsh habitats proposed will provide a range of additional habitats for birds and other flora and fauna, including dragonflies.

14.2.5 Apart from the site formation works of the marsh and residential developments (which will be carried out concurrently to shorten the disturbance), pond enhancement works and marsh construction will be completed before construction of the Residential Development commences. This will ensure that compensation is achieved during both construction and operation phases of the Residential Development. To minimise disturbance caused by WNR construction itself, these works will be staged. The sequence of construction is outlined in Figure 13-13.

14.2.6 Functional enhancement will be achieved through enhancement of both the ponds and the approach to aquaculture management. The management approach during the construction phase will be more intensive as a greater degree of functional enhancement is required to compensate for the high level of disturbance anticipated during this period. Disturbance levels during the operation phase are predicted to be lower and hence the focus of long-term management within the WNR will be focused on sustainably maintaining populations of Species of Conservation Importance and increasing overall biodiversity.

#### **Interim management (Construction Phase)**

14.2.7 As indicated within Section 13 a total of 4 hectares of wetland will be lost under the footprint of the Proposed Development Area. In addition to this, functional habitat loss has been identified through quantification of impacts of disturbance on Species of Conservation Importance. To achieve full compensation for the most sensitive wetland species (see Section 13.9) it will be necessary, during the construction phase to approximately double the carrying capacity of ponds unaffected by disturbance. If the requirement to compensate for the disturbance to these most sensitive species is met, full compensation for the impacts of direct habitat loss and disturbance to less-sensitive Species of Conservation Importance is likely to be achieved, as long as appropriate habitat is provided. Mitigation for other impacts on both birds and other Species of Conservation Importance are addressed later in this section. Wetland management principles established previously indicate that such enhancement is readily achievable for waterbirds (BBV 2002, M. Leven pers. comm., AEC 2004, 2006a, 2006b).

14.2.8 It is anticipated that if wetland functionality is maintained there should be no significant decrease in species numbers within the Study Site despite impacts of disturbance in some areas of the site. So the targets for species of conservation importance are to maintain at least the baseline levels within the Study Site.

#### **Long-term Management (Operation Phase)**

14.2.9 Once construction is completed the WNR will be placed under a long-term management designed to compensate for the lower levels of disturbance caused by the operation of the Residential Development. Based on traditional aquaculture practices the management during this period is intended to both maintain populations of Species of Conservation Importance and to increase overall biodiversity.

14.2.10 Under normal conditions bird population numbers fluctuate readily between seasons and years as a result of a variety of factors, including temperature, migratory patterns, food availability and human disturbance. Changes resulting from such factors cannot easily be accounted for. Hence the importance of the Fung Lok Wai site for wetland birds should be taken in the context of the Mai Po Inner Deep Bay Ramsar site as a whole, so that monitoring takes yearly fluctuations in bird activity within Deep Bay into account.

14.2.11 Significant changes will be used to guide appropriate management within an adaptive management framework.

#### **Habitat condition targets**

14.2.12 The EcIA Report identifies the habitat requirements of each Species of Conservation Importance identified and concludes that the most appropriate form of wetland mitigation in the Fung Lok Wai area is the enhancement of aquaculture ponds (fishponds that are managed, those that are currently unmanaged, and the intervening bunds) over the majority of the mitigation area combined with the establishment of shallow freshwater marsh.

- 14.2.13 Ponds managed for commercial aquaculture in the Deep Bay area are full for most of the time and their use by birds is severely limited due to their relatively steep sides, deep water and their frequent lack of marginal vegetation. These characteristics also limit their use by other species and hence aquaculture ponds tend to have relatively low biodiversity compared to many wetland habitats.
- 14.2.14 The management of fish ponds for commercial aquaculture, however, creates a key by-product in the form of abundant “trash fish” – small, non-commercial fish and invertebrates including *Gambusia affinis* (Mosquito Fish), *Macrobrachium nipponense* (a prawn) and *Oreochromis mossambicus* (a species of Tilapia).
- 14.2.15 When ponds are drained down during the winter months for harvesting, large concentrations of birds can be observed foraging in the shallow water for trash fish. As only a small proportion of fishponds are drained at any one time, and only for short periods, the spatial distribution of feeding birds is highly dynamic and variable as birds seek out ponds as they are drained. ‘Feeding bottlenecks’ may occur if there are insufficient ponds to support foraging bird populations.
- 14.2.16 The main objectives of enhancing aquaculture ponds are, therefore, to:
- Increase the value of aquaculture ponds to herons and egrets outside harvesting periods (i.e. draw-down), by increasing food resources and food availability and by reducing disturbance effects. Enhancement of the value of ponds to such birds outside harvest periods could reduce the potential for ‘feeding bottlenecks’ thereby possibly reducing the area of aquaculture ponds needed to support the population.
  - Increase their overall biodiversity value and suitability for other non-bird Species of Conservation Importance, such as some mammals (eg Eurasian Otter), amphibians and reptiles, whilst maintaining their current important functions for herons, egrets and other water birds.
- 14.2.17 Figure 14-4 indicates the location of the proposed area of enhanced aquaculture ponds. These will be placed away from the development area to minimise disturbance impacts. They would also be contiguous with the main area of ponds in the WCA and Mai Po Inner Deep Bay Ramsar site as a whole. Maintaining a contiguous area for compensation, which is linked, with an existing area of recognised conservation importance is of significant ecological value.
- 14.2.18 The design of the wetland habitats of the WNR and the mitigation targets defined below are informed by best practice in wetland design and are consistent with principles and guidance established in key publications including, Hawke & José (1996), Benstead *et al.* (1997, 1999) and McMullon & Collins (2004). With respect to fishponds these targets are designed to maximise the area available for birds that feed by wading into shallows by specifying targets for shallow water (defined as water less than 10cm in depth). To maximise accessibility and to minimise the “enclosure” of the ponds, targets have been included to maintain open bund and island habitats through the maintenance of bare ground and / or short vegetation. An undesirable feature of fishponds, particularly those that are not actively managed, is their tendency to become infested with undesirable weed species. Once established such infestations can be costly and time-consuming to remove. A specific target is included, therefore, to ensure that any infestations are kept to a minimum and to prompt early action on control.
- 14.2.19 The specific aquaculture pond habitat targets for the mitigation area are indicated in Table 14-5.

Table 14-5 Mitigation targets for enhanced fishponds

| Mitigation issue   | Target  |
|--|---|
| Enhancement of aquaculture pond area                     | 61.7 ha. (including bunds, control structures and potential alternative egretty)        |
| Shallow fish pond area (i.e. < 10cm depth)               | More than 20% (excluding aquaculture ponds that are dry for maintenance)                |
| Cover of undesirable invasive species and exotic species | Less than 10% of vegetation cover (excluding open water marsh area)                     |
| Plant cover on bunds and islands (in aquaculture ponds)  | Vegetation of height >10cm to comprise less than 5% plant cover on more than 75% of the |

|   |  |
|---|--|
|   | area of aquaculture pond bunds and islands   |
| Area under traditional polyculture fish pond management systems             | 70-90% of the fish pond area<br>(Excluding bunds and ponds that are dry for maintenance)   |
| Area set-aside from fish farming and under specific conservation management | 10 - 30% of the fish pond area<br>(Excluding bunds and ponds that are dry for maintenance) |

14.2.20 The targets for the marsh habitat reflect the desire to create a habitat that is dominated by a diverse mosaic of wetland microhabitats and plant species. Open water is desirable within certain sections but should be limited to allow the growth and establishment of communities associated with permanently wet habitats. It is anticipated that the area of open water will fluctuate seasonally (greater extent during the wet season) thus promoting the growth of communities associated seasonally inundated wetlands. As with fishponds there is potential for establishment of undesirable and exotic weed species and a specific target is included to prompt early and effect control of any infestations. The specific targets for the Marsh Habitat mitigation area are indicated in *Table 14-6*

*Table 14-6 Mitigation targets for Marsh Habitat*

| Mitigation issue  | Target  |
|---|---|
| Creation and maintenance of a total of freshwater marsh habitat in Favourable Condition | 14.4 ha. (including essential structures, e.g. water control structures, and other habitats e.g. bunds)<br>Freshwater marsh habitats are defined as areas where wetland hydrological conditions, or wetland soils are present or where wetland plants are dominant, with shallow water (average < 1m) and wetland plant species cover greater than 30% of the area. |
| Cover of wetland plant species  | More than 90% established vegetation  |
| Cover of undesirable invasive species and exotic species                                | Less than 10% of vegetation cover   |
| The average depth of water  | 30 – 50 cm (outside drawn down periods for maintenance)   |
| Area of open water (i.e. unvegetated water)   | 20-30%.   |

### **Species population targets**

14.2.21 The mitigation targets for Species of Conservation Importance associated with fishpond habitats are summarised in Table 14-7 (see Section 13.9 for the derivation of these) Banded Krait and Many-banded Krait have been excluded from this table because they have little reliance on fishpond habitats..

*Table 14-7 Mitigation targets for Species of Conservation Importance associated with fishpond habitats*

| Species                      | Mitigation target (population increase) |                 |
|------------------------------|---|-----------------|
|                              | Construction phase                      | Operation phase |
| <b>Birds</b>                 |   |                 |
| Black-faced Spoonbill        | Double                                  | Increase by 45% |
| Chinese Pond Heron           | Increase by 61%                         | Increase by 32% |
| Great Cormorant <sup>1</sup> | Double                                  | Increase by 41% |
| Great Egret                  | Double                                  | Increase by 45% |
| Grey Heron                   | Increase by 61%                         | Increase by 32% |
| Little Egret                 | Increase by 92%                         | Increase by 33% |
| Cattle Egret                 | Increase by 33%                         | Increase by 32% |

| Other species          |         |         |
|------------------------|---------|---------|
| Common Rat Snake       | Present | Present |
| Indo-Chinese Rat Snake | Present | Present |
| Mangrove Water Snake   | Present | Present |

Notes:

<sup>1</sup> If Great Cormorant numbers exceed mitigation targets it may be necessary to implement controls on the size of the population. The implementation of such controls will be determined in the context of the Adaptive Management framework and in discussion with AFCD

14.2.22 As the Marsh Habitat will be new habitat there are no existing animal populations associated with marsh habitats upon which to base mitigation targets. In addition it is anticipated that the Marsh Habitat will be subject to disturbance arising during the operation phase due its proximity to the residential development. Nevertheless there are a range of bird species that would be expected to use the Marsh Habitat. Management of the marsh habitats will focus on ensuring that these “primary” species (see Table 14-8) are present. In addition there are a range of other species that are associated with marsh habitats. Whilst it is desirable that these species are present, they will not form the primary focus of management effort. In addition it is expected that the marsh habitat will support a range of amphibian, reptile and invertebrate species.

Table 14-8 Species Expected to Use the Marsh Habitat

| Primary Species<br>(Presence expected)   | Secondary Species<br>(Presence desirable)   |
|--|---|
| <b>Birds</b><br>Little Egret (R)<br>Chinese Pond Heron (R)<br>Great Egret (W)<br>Grey Heron (W)<br>Eurasian Teal (W)<br>Black-winged Stilt (W)<br>Pintail / Swinhoe’s Snipe (P / W)<br>Common Snipe (W)<br>Zitting Cisticola (W) | Japanese Quail (P / W)<br>Eurasian Coot (W)<br>Pheasant-tailed Jacana (P)<br>Greater Painted Snipe (R)<br>Black-winged Stilt (B)<br>Richard’s Pipit (P / W)<br>Bluethroat (P / W)<br>Pallas’s Grasshopper Warbler (P)   |
| <b>Reptiles</b><br>Common Rat Snake<br>Checkered Keelback  | Chinese Soft-shelled Turtle<br>Burmese Python   |
| <b>Amphibians</b><br>Asian Common Toad<br>Günther’s Frog<br>Paddy Frog<br>Brown Tree Frog<br>Marbled Pygmy Frog  | Chinese Bullfrog<br>Three-striped Grass Frog<br>Spotted Narrow-mouthed Frog   |
| <b>Dragonflies</b><br>At least 20 species  | Species typically associated with marsh or reedbed habitats:<br>Marsh Dancer ( <i>Onchyargia atrocyana</i> )<br>Scarlet Dwarf ( <i>Nannophya pygmaea</i> )<br>Marsh Skimmer ( <i>Orthetrum luzonicum</i> )<br>Sapphire Flutterer ( <i>Rhyothemis triangularis</i> )<br>Four-spot Midget ( <i>Mortonagrion hirosei</i> ) |

Key: R – resident; W – winter; P – passage; B - breeding

**Public access objectives**

- 14.2.23 Under the management zoning of the Comprehensive Conservation strategy and Management Plan (Aspinwall Clouston and Wetlands International 1997) the adjacent areas within the Ramsar site have been designated as Public Access Zones (PAZ). The broad aim of these is to facilitate public access to the site for educational and appropriate recreational purposes.
- 14.2.24 There will be no public visitation to the site during the construction phase, when the site is under the interim management regime.
- 14.2.25 During the operational phase it is proposed that public access to the WNR will only be allowed on a restricted basis at a level that will not conflict with the over-riding objectives of nature conservation. The primary objective of visitation will be education. To facilitate access a small number of marked footpaths and hides for viewing birds and other wildlife in a variety of habitats will be provided. Interpretive materials including information boards and leaflets etc. will also be provided.

**14.3 Detailed design and construction methods****Overview of design and relationship with surrounding habitats**

- 14.3.1 The proposed WNR will comprise two key elements (Figure 14-4):
- a large expanse of retained, but ecologically enhanced, **aquaculture ponds**, including a potential alternative egret; and,
  - an area of created 'natural' **freshwater marsh**.
- 14.3.2 There are three key features of this proposed layout:
- 14.3.3 *First*, the majority of the aquaculture ponds (fishponds that are managed, those currently unmanaged, and the intervening bunds) on the site are maintained, including all those within the Ramsar site boundary. This avoids the loss or detrimental modification of any wetland area within the Mai Po Inner Deep Bay Ramsar site and maintains the large open contiguous block of aquaculture pond habitat in the area.
- 14.3.4 *Second*, the location of the proposed area for the creation of natural wetlands will maximise the potential for ecological links with the following complementary adjacent habitats:
- Scrub, woodland and particularly wetland habitats to the south of the site;
  - inter-tidal mangrove habitats along the former Tai River outfall; and,
  - the wetland creation at Hong Kong Wetland Park (HKWP).
- 14.3.5 These habitats may provide sources for the natural spread and establishment of some plants and animals within the wetland area. In addition they will provide additional shelter, food or breeding sites for wetland species and ecological 'corridors' which may facilitate dispersal.
- 14.3.6 *Third*, as the created wetland will contain abundant tall reedbeds, as well as other tall wetland vegetation and scattered trees, this will serve as a buffer between the residential development and the fishponds. This will reduce disturbance of birds feeding within the fish ponds.
- 14.3.7 Figure 14-5 indicates the location and layout of habitats within the proposed WNR. The total area of the various habitats is summarised in Table 14-9. The total area of wetland within the site will be approximately 76.1 ha. This represents a slight net increase in area of water body, from the current situation, through enlargement of most fishponds and the consequent loss of dividing bunds.

Table 14-9 The area of habitats in the proposed WNR

| Habitat type    | Area (ha) | Percentage of site |
|-----------------|-----------|--------------------|
| Fish pond area* | 61.7      | 77.0%              |
| Marsh complex   | 14.4      | 18.0%              |

|                                     |             |              |
|-------------------------------------|-------------|--------------|
| <b>Total wetland</b>                | <b>76.1</b> | <b>95.0%</b> |
| <b>Residential development site</b> | <b>4.0</b>  | <b>5.0%</b>  |
| <b>SITE TOTAL</b>                   | <b>80.1</b> |              |

NOTE: \*Including potential alternative egretty. All figures are approximate

### **Aquaculture pond area**

#### **Rationale**

- 14.3.8 As acknowledged in the Comprehensive Conservation Strategy and Management Plan for the Mai Po Inner Deep Bay Ramsar Site (Aspinwall Clouston & Wetlands International – Asia Pacific, 1997) and discussed previously in this proposal, fish ponds are particularly important habitats in the Deep Bay area for resident and migratory herons and egrets.
- 14.3.9 Under typical management, however, fish ponds do not provide optimal habitat conditions for herons and egrets and are particularly poor for many other water birds. In particular, they have relatively steep and uniform banks which limits the abilities of herons, egrets and waders to reach food sources. The lack of aquatic plants (due to the presence of plant eating fish and their high nutrient status and associated turbidity) also reduces their suitability for many aquatic macro-invertebrates. The lack of aquatic plants and invertebrates in turn limits their use by duck species.
- 14.3.10 Reeds and other tall emergent and bund (in aquaculture pond) vegetation can provide good habitats for insects and other invertebrates that, in turn, provide food for other animals including passerine birds. Existing reeds at Fung Lok Wai, however, occur in scattered patches and relatively narrow strips, probably because bund and emergent vegetation is frequently cleared by pond operators to maintain access. These are of limited value as breeding habitat and provide little cover for larger species.

#### **Objectives**

- 14.3.11 In order to increase their value for Species of Conservation Importance and to enhance their overall biodiversity it is proposed that the ecological functions of most of the aquaculture ponds (fishponds that are managed, those currently unmanaged and the intervening bunds) will be maintained and the following enhancements made:
- **The size of some ponds will be increased (Figure 14-6).** This will increase their suitability for herons and egrets, which tend to avoid smaller ponds, particularly where these are enclosed by vegetation. It will also facilitate reprofiling works.
  - **Selected bunds will be reprofiled** to provide shallow sloping and irregular margins to increase feeding opportunities and efficiency for herons, egrets, waders, rails and crakes etc.
  - **Emergent vegetation will be allowed to develop** (and where necessary established by planting) on some pond margins, to provide increased cover and feeding habitats for insects and other invertebrates, amphibians, reptiles, birds (e.g. bitterns, smaller herons, rails, crakes and some passerines) and mammals. Vegetation will be encouraged to develop in areas that require screening from disturbance (e.g. along footpaths and near dwellings and roads etc) and where exposure of ponds to prevailing trade winds may cause significant erosion problems. Bands of emergent vegetation will also be linked across the site to provide continuous ecological corridors linking similar and complimentary habitats within and off the site (see Figure 14-7 for illustrative layout).
  - **Unvegetated muddy shallows that will be intermittently exposed as muddy islands will be created** in some of the larger ponds, from the part removal of existing bunds, to provide enhanced feeding and roosting opportunities for herons, egrets and waders. These shallows will be exposed as muddy islands by slightly reducing water levels, as and when required (e.g. during heron breeding periods and peak wader migration).
- 14.3.12 Three ponds (2, 3 and 11) will be permanently taken out of fish production. Two of these (3 and 11) will be drained and then allowed to partially refilled with rain water to provide shallow ‘natural’ lakes of high value to waterfowl (as occurred at Mai Po Nature Reserve). The other small pond (2) will be used to establish a reedbed to provide cover and nesting sites for the birds



in the aquaculture pond area.

### **Works**

- 14.3.13 As indicated in Figure 14-6, 31 ponds (approximately 47.0 ha.) will be consolidated to 18 larger pond, which will continue to be managed as aquaculture ponds and 6 (approximately 10.27 ha.) will be taken out of production (consolidated into 3 larger ponds) and managed as rain fed ponds for duck and other water birds.
- 14.3.14 Where indicated in Figure 14-6, bund material currently separating ponds will be lowered and side cast to create shallow sloping margins to islands and / or shoals. Actual levels to be attained on each modified bund are based on generic designs indicated in Appendix 14-1. The generic designs to be used for each modified bund are as follows (according to bund numbers given in Figure 14-6):
- Design Type A- 4, 12, 14, 15
  - Design Type B- 7, 11, 16
  - Design Type C- 6
- 14.3.15 Remaining bunds to be modified will be used to create unvegetated muddy shallows as indicated in Figure 14-6. Each area of shallows will rise at a slope 1:20 from the indicated waterline, based on Initial Operating Levels. The below water level slope will be as shallow as feasible.
- 14.3.16 Each pond will drained, dried and reprofiled on a three-year to five cycle as typically currently carried out on aquaculture ponds. During this process each pond bund will be reprofiled to create as shallow a slope as feasible according to the properties of the bund material.
- 14.3.17 In addition, following reprofiling, further works will be undertaken under the direction of the WNR Reserve Manager to provide variation in the shoreline profile along the typical waterline. This will be carried out by using a backhoe to create indentations along the water line (at the Initial operating Level) by small-scale excavations and pressing down with the back of the excavator bucket on the bund. Approximately 30% of the margins of each pond should be worked in this way to create a 'scalloped edge' with shallow shelves just below the Initial Operating Level (10 –30 cm depth).
- 14.3.18 To facilitate vehicle access to all parts of the site, for water level management and other activities, some works on the remaining bunds will be necessary. The tops of the bunds may require some vegetation clearance and strengthening with a geofabric to enable them to be used as access-ways. Current practice is to use some stone fill to form the running surface and it is proposed to extend this where necessary.
- 14.3.19 An earth covered floating platform seeded with *Paspalum distichum* will be placed in each operating aquaculture pond to provide additional foraging areas for herons and egrets etc and potential breeding sites for some water birds (such as Little Grebe) as well as shelter for fish and aquatic invertebrates.
- 14.3.20 The engineering requirements for the construction of the ponds will only consist of installation of a series of adjustable sluices or similar water control devices to interconnect the ponds (Figure 14-7). Ponds 2, 3 and 11 will be connected to the central drainage watercourse with adjustable sluices or similar water control devices set at low levels to maintain shallow water by allowing excess water to flow over the sluice and by gravity to the watercourse (Channel Y).
- 14.3.21 Other sluices will be installed to facilitate general water management on the site and allow storm water run-off, where necessary, via Channel Y. A drainage pipe will be installed to connect Ponds 12 and 18 (and interconnected ponds) to Channel Y.
- 14.3.22 All fishpond water will be obtained by direct rainfall and will be retained and re-circulated during drain-down periods as necessary. In any one year two ponds will be used as reservoir ponds as a contingency measure to ensure that pond water levels are kept within tolerance levels. No surface or groundwater water supplies will be used for aquaculture pond operations. Note: the reservoir ponds referred to here are not the same as the Storage Pond which will hold water for use in Freshwater Marsh habitats.

### Pond enhancement works

14.3.23 Enhancements will be staged to reduce disturbance. To facilitate this, the existing aquaculture ponds have been divided into 3 Sectors (Figure 14-13). Reprofiling works will be conducted sequentially and systematically within these sectors to avoid concurrent activity within the WNR. The sequence of construction works is summarised in Figure 13-13 and the management strategy for these ponds, including during construction, is outlined in Section 14.4 below. The purpose of this management strategy is to mitigate disturbance effects at all stages of the construction programme.

14.3.24 On acquisition of the site, the ponds in Sector 1 will be enlarged and reprofiled as indicated in Table 14-10.

Table 14-10 Pond enhancement schedule.

(Bund numbers are indicated in Figure 14-6. Estimated duration includes pond drain down and construction works but excludes filling time.)

| Bund removal sequence | Estimated duration |
|-----------------------|--------------------|
| <b>Sector 1</b>       |                    |
| 1                     | 2 weeks            |
| 2,3                   | 3 weeks            |
| 4                     | 2 weeks            |
| 5                     | 2 weeks            |
| 6                     | 2 weeks            |
| 7                     | 2 weeks            |
| <b>TOTAL</b>          | <b>13 weeks</b>    |
| <b>Sector 2</b>       |                    |
| 9                     | 2 weeks            |
| 10, 29                | 4 – 5 weeks        |
| <b>TOTAL</b>          | <b>6 – 7 weeks</b> |
| <b>Sector 3</b>       |                    |
| New bund creation     | 4 weeks            |
| 8                     | 2 weeks            |
| 12                    | 2 weeks            |
| 11, 14                | 3 weeks            |
| 15, 16                | 3 weeks            |
| <b>TOTAL</b>          | <b>14 weeks</b>    |
| <b>TOTAL DURATION</b> | <b>34 weeks</b>    |

14.3.25 As indicated above construction of the marsh area is programmed to coincide with site formation works associated with the residential development. To avoid excessive disturbance due to construction activities, pond enhancements in Sector 3 will be delayed until completion of works on the constructed marsh. Construction of the marsh is expected to take 9 months (refer to Figure 13-13 for the timing of these activities).

14.3.26 Once constructed, Ponds 2, 3 and 11 will be managed under a different regime involving partial drainage to a specified depth (depending on the time of year) and then maintained at prescribed levels.

### Vegetation establishment

14.3.27 There are no areas of vegetation or individual plant species or specimens which should be conserved in situ or transplanted. No protection of existing vegetation is, therefore, necessary in the aquaculture pond (fishponds that are managed, those currently unmanaged and the intervening bunds) or freshwater marsh area (described below). Indeed in many instances the deliberate removal of existing vegetation of limited ecological value will be required.

14.3.28 A list of the species to be established on the islands and along the aquaculture pond margins and bunds is provided in Table 14-11 below.

14.3.29 Areas to be planted with these species are indicated in Figure 14-7. On the remaining bunds natural regeneration of vegetation will be allowed, but with 25% of these kept as largely bare banks to provide foraging and/or loafing areas. The areas kept bare will be rotated on an annual basis at the discretion of the WNR Reserve Manager.

Table 14-11 Wetland species to be established in the aquaculture pond mitigation area

| Species                     | Approx. density (no. m <sup>-2</sup> ) | % cover  | Growth form | Approx. height for planting (cm) |
|-----------------------------|--|----------|-------------|----------------------------------|
| <i>Phragmites australis</i> | 4                                      | 100      | Monostands  | >20 cm                           |
| <i>Paspalum distichum</i>   | Broadcast seed                         | 0 – 100* | Monostands  | N.A.                             |

Notes: \* *Paspalum distichum* seed to be broadcast on permanently dry and seasonally wet areas. Overall percentage of cover along bunds to be 25 – 75% around each pond.

14.3.30 Trees and shrubs will be planted on some bunds to provide cover and to screen sensitive areas of the wetland from disturbance sources, such as the residential development and vehicle use. However, care will be taken to ensure that planting does not impede flight lines for birds or fragment the contiguous areas of open aquaculture pond habitat.

14.3.31 Only species that are native to the area will be planted on the bunds, including fruit bearing trees such as China-berry (*Melia azadarach*) (a species considered to be naturalised in Hong Kong) which are known to be attractive to Red-billed Starlings and other passerines.

#### **Potential alternative egretty**

14.3.32 To compensate for potential disturbance to the the previous Shing Uk Tsuen egretty which was located to the south-west of the proposed Development Area, a potential alternative egretty will be constructed within the aquaculture pond area (Figure 14-6). The potential alternative egretty will duplicate in size the Shing Uk Tsuen egretty (approximately 2,000 m<sup>2</sup>).

14.3.33 To minimise potential disturbance, this alternative site has been constructed as far as possible from the proposed development area but also away from the perimeter of the WNR. Furthermore a location has been selected where the base of the egretty can be constructed around existing bunds which possess mature trees.

14.3.34 Upon the base mature or semi-mature specimens of *Bambusa eutuloides* will be planted as a central core around which mature or semi-mature *Celtis sinensis* and *Ficus macrocarpa* will be planted to provide cover and structure. These trees will be raised off-site.

14.3.35 The egretty will be planted as early as possible in the construction programme to provide sufficient time for maturation of vegetation and establishment.

#### **Freshwater Marsh Complex**

##### **Rationale**

14.3.36 Although aquaculture ponds are habitat for species of conservation importance they are less attractive for other species and tend to have low overall diversity. The enhancement measures identified above will go some way toward increasing the diversity of wetland habitats and species within Fung Lok Wai.

14.3.37 Although largely lost from Hong Kong, freshwater marsh habitat potentially provides a much more diverse environment and can support a wider range of species.

14.3.38 Marsh habitat that is varied and composed of a mixture of permanent open lakes of various depths, reedbed and seasonally inundated areas dominated by grass, sedge and other freshwater marsh species provides breeding habitat for amphibians, reptiles and invertebrates such as dragonflies. Such habitat is botanically diverse (compared to aquaculture ponds) and also provides good year round foraging habitat for herons and egrets as well as, potentially, globally threatened species such as grey headed lapwing. It can also provide suitable breeding habitat for a

number of locally rare freshwater marsh birds, including, for example, painted snipe, watercock and chestnut bittern.

14.3.39 Increased aquatic fauna will also provide more predictable and sustainable food resources for herons and egrets and other waterbirds throughout the year. Aquatic vegetation is also more likely to be abundant in such lakes which in turn provides favourable habitat for winter populations of wildfowl. Seasonal exposure of mud, through small reductions in water levels would also provide feeding areas for wading birds.

#### **Objectives**

14.3.40 A freshwater marsh complex composed of three distinct regions is proposed (Figure 14-8):

- A relatively large area of permanent marsh comprising a series of interconnected lakes and reedbeds;
- Seasonal marsh dominated by tussocky grasses and sedges and temporary pools; and,
- A storage pond.

14.3.41 The practical design of the proposed freshwater marsh complex incorporates the following principles:

- The water supply will be from direct rainfall supplemented by run-off from the residential development and catchments A and B (see Figure 14-3).
- Treated effluent will not be discharged into the wetland and there will be no reliance on groundwater.
- The marsh area will not flood surrounding land and residential developments.
- The lakes within the marsh area will eventually discharge via Channel X or, during storm events, via Channel Y (see Figure 14-3) into the Tai River outfall.

14.3.42 Water control structures will be installed at the locations indicated in Figure 14-8 to facilitate water management within the marsh complex.

#### **Permanent marsh area**

14.3.43 The majority of the constructed marsh area will comprise a series of interlocking shallow (mostly < 0.5m) and deep lakes, the latter acting as refuges for fish and other species requiring greater depths (see Figure 14-9). Reeds and other emergent associated vegetation will be established on the margins of these lakes.

14.3.44 The reedbeds will provide screening from disturbance for herons and egrets, and fingers of reed will create further seclusion. The vegetation will also provide an important habitat for invertebrates, especially dragonflies, potentially including the rare damselfly *Mortonagrion hirosei*, which is confined to reedbeds (Wilson 1995). Reedbeds are also important feeding, nesting and roosting habitats for a wide range of passerine birds, e.g. migrant warblers.

14.3.45 Water levels will be allowed to fluctuate with seasonal patterns in rainfall but will be kept within defined limits to prevent drying out or flooding of susceptible vegetation through controlled release of water from the storage pond. Water will also be released judiciously to reduce the rate at which levels drop during the transition between wet and dry seasons.

14.3.46 Varying ground levels in the reedbed will provide a variety of water depths; allowing some areas of reed to dry out during the dry season and others to remain inundated all year round.

14.3.47 A small number of islands would also be incorporated to maximise shoreline length and provide areas that are subject to less disturbance for further secure feeding and roosting sites for herons and egrets.

#### **Seasonal marsh area**

14.3.48 A segment of the western part of the marsh complex will be managed as seasonal wetland receiving water from direct rainfall, and, during wet months, from the permanent marsh area. When water exceeds a pre-determined depth within the permanent marsh area water will flow into the seasonal marsh area via a sluice placed between the two areas.

14.3.49 The seasonal freshwater marsh area will include a number of temporary pools and a greater range of plant species than the reed fringes of the permanent marsh area. These habitats hold different

communities of plants and animals to permanent wetland bodies and so its inclusion as a distinct habitat will further enhance biodiversity within the proposed WNR.

14.3.50 Temporary pools are not able to sustain populations of fish and other predators and are therefore particularly valuable for certain aquatic invertebrates and as breeding sites for various amphibia, such as, potentially, the narrow-mouthed frog. As water levels naturally drop in temporary ponds then muddy shorelines are exposed. These provide particularly good feeding areas for a range of waterbirds, including herons and egrets, as well as various crakes, rails and waders. There is a potential to provide additional habitat for species not previously recorded at Fung Lok Wai. For example, the presence of seasonally wet grazed areas interspersed with deeper pools may attract Greater Painted Snipe. Similarly the presence of seasonal marsh adjacent to the deeper pools with emergent and floating vegetation of the permanent marsh area, including lotus *Nelumbo nucifera*, may also attract Pheasant-tailed Jacana.

14.3.51 Excess water with the seasonal marsh area will gather at the northern end and exit via channel Y into the Tai River outflow.

#### **Storage pond**

14.3.52 To maximise capacity, the storage pond will not have shallow margins or contain islands, but will have reed fringes to provide shelter and disturbance free-zones. Its proposed area will be approximately 3 ha with an average depth of approximately 3 m (maximum water level 3.7 m PD, bund level 4.0 m PD) and thus will have a storage capacity of approximately 90,000 m<sup>3</sup>.

14.3.53 Run-off from the residential site and catchments A and B will be transported to the storage pond via a pipe or channel system integrated into the residential development area.

#### **Security of water supply**

14.3.54 The long-term sustainability of the proposed natural wetland system is dependent on adequate year-round water supplies.

14.3.55 Although the north-west New Territories receives a high average annual rainfall, during the dry winter period evaporation exceeds rainfall and wetland areas start to lose water. There is a risk, therefore, that water levels may drop and shallow wetlands may dry out. It is essential, therefore, to establish that there will be sufficient water available to maintain the desired water depths for the wetland habitats during the winter. A monthly water quantity budget has been developed and from this feasible water levels predicted. This is provided in detail in Appendix 14-2.

14.3.56 From this water budget it is predicted that the capacity of the storage pond will be sufficient to maintain water levels within the target levels. Currently, the water budget predicts that the water level in the storage pond will not drop below approximately 29 megalitres in the dry season, leaving a reserve of approximately 33% capacity even during the driest scenario tested Figure 14-10. This is considered to be sufficient to cope with the typical variation in rainfall levels observed in Hong Kong, especially as there is predicted to be a substantial surplus of water available to fill the storage pond in summer.

14.3.57 The maximum water demand to meet target levels would peak at about 250,000 litres per day during November.

14.3.58 A number of structures are proposed to enable manipulations of the water levels across the site (see Figure 14-8). The storage pond will be connected to the lakes within the natural wetland area by adjustable sluices. This will allow transfer of water to the lakes either by flow over the sluice, or, when water levels in the storage pond fall below those of the lakes, by means of a pump. A sluice on the storage pond connected via drain Y will allow rapid discharge of surplus run-off water from the catchments and residential area (e.g. during storms) without affecting the other ponds.

14.3.59 The lakes will also allow discharge of water via an adjustable sluice into drainage channel X if required. The western end of the lakes will also have an adjustable sluice to provide water to the freshwater marsh area which will then exit via channel Y into the Tai River outflow.

14.3.60 Water can be re-circulated through the site, if water stagnation becomes a problem, via a pipe linking the south-west corner of the site and the storage pond (see Figure 14-8).

**Details of Marsh Habitat creation works**

14.3.61 The successful establishment of freshwater marsh habitat will require a carefully structured approach to the key wetland construction stages outlined below.

**Major earthworks**

14.3.62 Major earth works will be required to achieve the broad profile of the freshwater marsh hydrological unit. These works can only be conducted during the dry season when the substrate is sufficiently firm for heavy equipment to enter onto the site. Once the underlying profile of the hydrological unit has been achieved waterproof clay linings/curtains may be required at appropriate locations to prevent water leakage (it is possible that the clay based bund material (from aquaculture ponds) upon which the marsh will be created may be sufficiently impermeable that clay lining is not required, however, this will need to be confirmed at the time of construction).

**Water control structures**

14.3.63 Water control structures should be installed before the top soiling and fine profiling is conducted.

**Top soiling and fine profiling**

14.3.64 Top soiling and fine profiling of the soil can only be conducted during the dry season when the soil is sufficiently dry for the fine contouring to be implemented. The topsoil should only be applied if there is sufficient time to implement planting thereafter, otherwise it may be washed away by heavy monsoonal rain.

14.3.65 A typical composition for topsoil would be 55% aquaculture pond bund material, 30% CDG, and 15% river sand, although the exact specification should be considered further at the detailed design stage and light of the specific qualities of the material sourced. Experience in other wetland contexts indicates that pond material needs to be augmented with Calcium Oxide at a rate of 0.68kg/m<sup>3</sup> to neutralise pH. However, the precise rate of augmentation will need to be determined at the time of construction.

14.3.66 A typical sequence for top soiling and profiling could be as follows:

- Establish basic land formation, with (if required) clay or water proof curtains in place (and tested).
- Carry out detailed levelling survey, with marker posts placed throughout the hydrological unit showing:
  - operational water levels and invert level of outlet control structures; and,
  - 100mm increments from top water level to invert level of outlet control structure.
- The profiling is entirely dependent on the range of water level control offered by the outlet control structure(s) and all levelling must be carried out in relation to this. Hence the need to have all control structures in place before earthworks can commence. There may also need to be some calculations made in relation to hydraulic heads (the rise in water level generated by restricting flows over a weir).
- Carry out rough ground marking showing significant areas of any shallow (emergent) underwater spoil benches roughly in line with the design drawings.
- Fill areas with specified soil mix.
- As appropriate to the desired land form, carry out fine level soil manipulation with an aim of creating a random surface profile with local ridges and furrows on level shallow benches and carry out local profile detailing (small pools and hummocks) on the marginal slopes but with a general overall fall as specified.
- The top 300mm of soil needs to be placed very carefully and compaction minimised. A settlement factor of at least 15% must be allowed for.
- All levels to be checked prior to machinery leaving each working area to avoid the need for further movement of machinery.

**Flooding and checking integrity of the hydrological unit**

14.3.67 Prior to planting, each hydrological unit should be flooded with water and left for at least one week. The water level should be checked and monitored regularly using a gauge board to determine whether the levels drop more rapidly between rainfall events than would be expected from evaporation alone. This would indicate whether waterproofing is incomplete or faulty. The water level can be expected to drop slightly initially since the clay will absorb water.

14.3.68 To avoid time consuming and costly abortive works, the hydrological unit should be checked before soiling works are undertaken. If the hydrological unit is not intact, then the clay curtain should be removed, re-laid and the flooding exercise implemented again to confirm whether the unit is water tight.

### **Planting**

14.3.69 To facilitate successful establishment of the plants in the newly constructed marshes, planting should commence in April and May prior to the onset of the monsoon rains to coincide with the plant growing season. Sufficient resources should be provided for in the programme to ensure that planting can be completed within one growing season. Planting will include the following stages:

- Ensure that the marsh is an intact hydrological unit ie. any clay curtains and control structures are sealed, intact and functional.
- Ensure that all earthworks are complete and levels checked.
- Set outlet control structures to an appropriate level (eg c. 100mm) below operational (final) water levels to expose most of the bed of the shallow wetland margins where emergent plants are to be placed. Each plant to be introduced should have a depth/hydrology assessment made of it (ie. the maximum, minimum and optimal depth tolerances and the ability/requirement of the plant to withstand seasonal variation in water levels). It is assumed that planting plans have been formulated on the basis that species capable of the deeper tolerance ranges are located in the deeper parts of the marsh and surface wet or seasonally inundated species are at the higher levels.
- The general planting procedure would then be to plant species according to the layout in the planting plans (e.g. in mono-specific blocks (circles) of 5m diameter, or smaller depending on available suitable water depth/profile, with gaps of c 1-2 metre between to allow natural expansion of the species blocks or some natural colonisation). Colour coded markers would be placed prior to planting with each colour representing a species and each marker the centre of the planting block. Plants would then be planted according to the specified planting density, which should depend on the size/growth form of species and planted material. In this way the site botanist and ecologists can plan the very specific layout prior to planting.
- In handling the plant material, the following is essential:
  - Plants, particularly rhizomes, need to be kept moist and out of direct sunlight at all times;
  - In planting rhizomatous species, damage to the rhizome can be made during firming in with tools or boots. If the substrate is soft enough plants can be pushed gently into the wet ground. Otherwise the rhizomes will be planted in dug holes and soil replaced with only gentle firming. Plug plants can be simply placed into a whole made by a suitable-sized dibber. Submerged plants must be planted underwater and are normally just pushed into the bottom sediments. In some case it may be necessary to weigh down the plant with an attached stone/weight prior to the plant developing established roots;
  - Many aquatic plants will not survive if dug from wet nursery soils and left standing in water at the planting site, prior to re-planting. Wherever possible, plants should be lifted, transported and re-planted within 24 hours. Where this is not possible, plants should be dug into holding areas of wet soil, not just stacked in shallow water alone. The soil will need to be kept wet or covered in some way to reduce water loss;
  - Soils/pots must be checked for non-target species and unhealthy, or otherwise substandard plants, and these must be appropriately discarded prior to transplanting.

### **Management of water levels**

14.3.70 Following planting, water levels should be maintained at initial target levels. The water level should be gradually raised to the operational level as the plants grow, this approach will also

effectively control the establishment and spread of weeds. Throughout this time water levels should be carefully controlled to protect plants from drying out (i.e. a source of water to counter evapotranspiration) or from being flooding (i.e. sporadic heavy rainfall).

### Vegetation

14.3.71 A list of the species to be established in the freshwater marsh mitigation areas is provided in Table 14-12. The planting list is derived from those native species known from remaining fresh water marshes in Hong Kong (e.g. Luk Keng Marsh, Liu Pok Marsh). However, all such wetlands are highly modified by man and/or domestic animals and therefore 'true natural' wetland plant communities in Hong Kong cannot be easily identified. A variety of potential mix options are shown for seasonally inundated habitats and a more detailed planting plan will be produced indicating the locations of these mixes prior to commencement of marsh construction.

14.3.72 The proposed planting therefore includes a relatively long list of native species to accommodate the likelihood that not all planted species will necessarily thrive in the particular conditions to be created. Thus the approach is to facilitate natural selection as far as possible.

Table 14-12 Species to be established in the Marsh Habitat area  
(planting zones are shown in Appendix 14-3)

| Mix / species                                     | Total area (m <sup>2</sup> ) | Shoots (number) | Density (m <sup>-2</sup> ) | % Cover | Minimum height (mm) |
|---|------------------------------|-----------------|----------------------------|---------|---------------------|
| <b>1. Floating plants (permanently inundated)</b> |                              |                 |                            |         |                     |
| <i>Nymphaea spp.</i>                              | 30                           | 5               | 15                         | <1      |                     |
| <i>Nelumbo nucifera</i>                           | 30                           | 5               | 15                         | <1      |                     |
| <b>2. Permanently inundated mix</b>               |                              |                 |                            |         |                     |
| <i>Vallisneria natans</i>                         | 5210                         | 5               | 12                         | 45      | 500                 |
| <i>Ottelia alismoides</i>                         | 5210                         | 5               | 12                         | 45      | 500                 |
| <i>Hydrilla verticillata</i>                      | 1160                         | 5               | 20                         | 10      | 500                 |
| <b>3. Reed bed</b>                                |                              |                 |                            |         |                     |
| <i>Phragmites australis</i>                       | 16475                        | 3               | 10                         | 100     | 800                 |
| <b>4. Seasonally inundated mix A</b>              |                              |                 |                            |         |                     |
| <i>Bacopa monnieri</i>                            | 690                          | 5               | 20                         | 25      | 150                 |
| <i>Sagittaria trifolia</i>                        | 690                          | 5               | 20                         | 25      | 500                 |
| <i>Polygonum barbatum</i>                         | 550                          | 5               | 20                         | 20      | 500                 |
| <i>Eleocharis equisetina</i>                      | 827                          | 5               | 20                         | 30      | 300                 |
| <b>5. Seasonally inundated mix B</b>              |                              |                 |                            |         |                     |
| <i>Eleocharis dulcis</i>                          | 550                          | 5               | 20                         | 20      | 300                 |
| <i>Polygonum glabrum</i>                          | 680                          | 5               | 20                         | 25      | 300                 |
| <i>Schoenoplectus mucronatus</i>                  | 827                          | 5               | 20                         | 30      | 600                 |
| <i>Cyperus malaccensis</i>                        | 680                          | 5               | 20                         | 25      | 600                 |
| <b>6. Seasonally inundated mix C</b>              |                              |                 |                            |         |                     |
| <i>Sagittaria guyanensis</i>                      | 827                          | 5               | 16                         | 30      | 500                 |
| <i>Saururus chinensis</i>                         | 550                          | 5               | 16                         | 20      | 500                 |
| <i>Eleocharis tetraquetra</i>                     | 690                          | 5               | 16                         | 25      | 500                 |
| <i>Cyperus malaccensis var. brevifolius</i>       | 690                          | 5               | 16                         | 25      | 500                 |
| <b>7. Seasonally inundated mix D</b>              |                              |                 |                            |         |                     |
| <i>Ludwigia ascendens</i>                         | 960                          | 5               | 16                         | 35      | 500                 |
| <i>Polygonum hydropiper</i>                       | 550                          | 5               | 16                         | 20      | 500                 |
| <i>Polygonum juncundum</i>                        | 550                          | 5               | 16                         | 20      | 500                 |
| <i>Colocasia esculenta</i>                        | 690                          | 5               | 16                         | 25      | 500                 |
| <b>8. Seasonal / grazed marsh mix E</b>           |                              |                 |                            |         |                     |
| <i>Fimbristylis complanata</i>                    | 1810                         | 5               | 12                         | 20      | 400                 |
| <i>Fimbristylis subbispicata</i>                  | 2270                         | 5               | 12                         | 25      | 400                 |
| <i>Cyperus halpan</i>                             | 1810                         | 5               | 12                         | 20      | 400                 |
| <i>Scirpus juncoides</i>                          | 1810                         | 5               | 12                         | 20      | 400                 |
| <i>Fimbristylis nutans</i>                        | 1360                         | 5               | 12                         | 15      | 400                 |
| <b>9. Seasonal / grazed marsh mix F</b>           |                              |                 |                            |         |                     |
| <i>Fimbristylis miliacea</i>                      | 1360                         | 5               | 12                         | 15      | 300                 |



| Mix / species  | Total area (m <sup>2</sup> ) | Shoots (number) | Density (m <sup>-2</sup> ) | % Cover | Minimum height (mm) |
|--|------------------------------|-----------------|----------------------------|---------|---------------------|
| <i>Fimbristylis ferruginea</i>                             | 1360                         | 5               | 12                         | 15      | 300                 |
| <i>Fuirena umbellata</i>                                   | 1810                         | 5               | 12                         | 20      | 300                 |
| <i>Rumex japonicus</i>                                     | 1810                         | 5               | 12                         | 20      | 300                 |
| <i>Cyperus falbelliformis</i>                              | 1360                         | 5               | 12                         | 15      | 300                 |
| <i>Scirpus littoralis</i>                                  | 1360                         | 5               | 12                         | 15      | 300                 |
| <b>10. Mixed herbaceous</b>                                |                              |                 |                            |         |                     |
| <i>Fimbristylis ferruginea</i>                             | 1070                         | 3               | 12                         | 10      | 300                 |
| <i>Scirpus juncooides</i>                                  | 1600                         | 3               | 12                         | 15      | 300                 |
| <i>Cyperus halpan</i>                                      | 1600                         | 3               | 12                         | 15      | 300                 |
| <i>Saururus chinensis</i>                                  | 1600                         | 3               | 12                         | 15      | 300                 |
| <i>Polygonum barbatum</i>                                  | 1600                         | 3               | 12                         | 15      | 300                 |
| <i>Eleocharis equisetina</i>                               | 1070                         | 3               | 12                         | 10      | 300                 |
| <i>Nepenthes mirabilis</i>                                 | 2140                         | 3               | 12                         | 20      | 200                 |
| <b>11. Herbaceous plants on aquaculture pond bund area</b> |                              |                 |                            |         |                     |
| <i>Leersia hexandra</i>                                    | TBC                          | 5               | 12                         | 30      | 500                 |
| <i>Eragrostis unioloides</i>                               | TBC                          | 5               | 12                         | 30      | 500                 |
| <i>Lepironia articulata</i>                                | TBC                          | 5               | 12                         | 40      | 500                 |
| <b>12. Bamboo clumps (planted at 50 cm centres).</b>       |                              |                 |                            |         |                     |
| <i>Bambusa vulgaris cv. Vittata</i>                        | 620                          |                 |                            | 100     | 2000                |
| <i>Bambusa vulgaris cv. Wamin</i>                          | 620                          |                 |                            | 100     | 2000                |

Note: At least 5% of the areas need to be bare mud and water.

### **Access and Fencing**

14.3.73 The Wetland Nature Reserve is designated as “Private Land Zone” under the Ramsar Conservation Strategy and Management Plan as it is under private ownership. Adjacent to it is a band of Public Access Zone”. The proposed Wetland Nature Reserve can be integrated with the “Public Access Zone” forming a logical extension of this zone. Whilst conservation is the prime objective of the Wetland Nature Reserve, limited public access will be allowed on a restricted basis (prior booking will need to be made with the reserve manager) so as not to create disturbance to birds. Residents of the development will not have privileged use of the WNR.

14.3.74 It is proposed that footpaths and hides will be provided in part of the site. A plan of the indicative footpath network subject to detailed design of the WNP is included Figure 14-12. This shows that the footpaths will be limited to the southwest and west of the site, in order to:

- avoid high levels of disturbance in the core area of aquaculture ponds;
- provide easy access to the footpaths from the Site access; and,
- include the full range of habitats types within the site.

14.3.75 To further avoid disturbance to wildlife within the site, the footpaths will be screened by tall vegetation or artificial screens where necessary. Footpaths will be raised on board walks (an indicative design is included in Appendix 14-4) in the wetter and more sensitive habitats or follow existing bunds.

14.3.76 Hides will be built at a number of locations to provide view points over the main habitat types on the site (lakes and reedbeds, freshwater marsh and aquaculture ponds). A design for a hide is provided in Appendix 14-5.

14.3.77 Occasional guided tours (prior booking with the reserve manager will be required) can also be provided. Some educational facilities can be provided, including information boards at the site entrance, inside hides and at appropriate locations alongside the footpaths. These will provide basic information on the ecology and conservation importance of the wetland habitats, information on the management and cultural aspects of fish farming and its importance for wildlife.

14.3.78 The emphasis on access would be to provide simple 'low-key' facilities that would primarily be used by people with an interest in natural history. Picnicking and similar activities will not be allowed within the WNR. The maximum number of visitors that can be accommodated without

causing unacceptable levels of disturbance could be limited to the number of seats / space available in the hides. Discussions with the Reserve Manager at Mai Po indicate that a cautious approach is appropriate and that, during the initial stages of WNR management, visitor numbers are kept low. Numbers of visitors can be increased at the discretion of the reserve manager as experience in the management of the WNR grows.

14.3.79 Facilities for visitors will be kept to a minimum, but will include toilets, a shelter with drinks machine and a small car park. The location of these facilities is indicated in Figure 14-12.

14.3.80 Vehicular access to the wetland mitigation areas will be restricted by means of lockable gates to be located at appropriate positions.

14.3.81 The residential development works area will be screened off from the rest of the site before the start of any works, to reduce disturbance to wildlife in the surrounding area. Similarly the freshwater marsh area will be screened off from the surrounding wetland areas during the wetland construction works.

14.3.82 Screening will consist of solid hoarding of at least 2 m height.

#### **Management facilities**

14.3.83 A small office, storage, workshop area and quarters will be constructed for the WNR Reserve Manager and his / her staff. These facilities will take the form of small prefabricated buildings that can be placed in a convenient location. The site for these facilities will be determined once the construction of the WNR is completed. During construction the WNR Reserve Manager will occupy a temporary facility the location of which will be determined during planning for the construction works.

## **14.4 Management Strategy**

### **Management regime stages and programme**

#### **Interim Management**

14.4.1 To compensate for disturbance caused during the construction phase of the residential development and the marsh habitat interim management will be implemented to increase the attractiveness of unaffected ponds to wetland bird Species of Conservation Importance.

14.4.2 Essentially interim management will involve artificially increasing the carrying capacity of ponds for these species through works designed to significantly increase the availability of prey species (trash fish). The following specific actions, which have been implemented as appropriate mitigation at similar sites elsewhere in Hong Kong (eg Binnie, Black & Veatch 2002):

- The fish populations within ponds will vary greatly depending on previous management. A rapid assessment of remaining populations will be carried out and ponds re-stocked, as required, with trash fish species;
- Initial and ongoing correction of water quality, specifically pH to ensure appropriate conditions for fish survival. Although trash fish species are relatively hardy compared to many commercial fish, they can be affected by low pH conditions. If pH drops below 4.5 then peanut residue will be added to raise pH; and,
- Rotational, partial drain down of pairs ponds (excluding Ponds 2, 3 and 11). Once drained down each pair of ponds will be maintained with shallow water < 30 cm deep for a period of 4 weeks.

14.4.3 Under traditional management the production of non-commercial by-product, including prawns and fish, such as Tilapia, that are below marketable weight is in the order of 260 kg/ha/year (See Section 12.4, Aspinwall, 1997 and Primavera, 2000). To achieve the mitigation targets the availability of small fish and prawns will need to be increased to provide enhanced feeding opportunities. Experience from the implementation of a similar approach by KCRC at Lok Ma Chau indicates that optimal stocking densities are likely to be in the range 2-5 times the expected 'normal' biomass of trash fish, ie up to 1,300 kg/ha/year. Imported fish will comprise small Tilapia (target weight approximately 50g / individual). A key reason for the relatively large

increase in stocking density is due to the fact increased prey availability benefits a wide variety of piscivorous birds, including cormorants and ardeids, all of which can be expected to increase in numbers within the mitigation area.

14.4.4 Reference to recent monitoring reports from monitoring of the Lok Ma Chau mitigation works (AEC 2003, 2004, 2006a, 2006b) indicates that the densities implied for key species (Black-faced Spoonbill, Chinese Pond Heron, Great Cormorant, Great Egret and Little Egret) are readily achievable (and have been frequently exceeded). The experience at Lok Ma Chau also indicates that a flexible (adaptive management) approach is required. The effectiveness of mitigation requires careful attention to water quality, adjustment to stocking densities, periodic review of the timing and duration of draw-down and continuous monitoring.

14.4.5 Prior to the commencement of interim management a plan for pond draw-down will be confirmed. This plan will specify the sequence of draw-down ensuring that no pond is drawn-down more frequently than once per calendar year. Particular attention will be given to the stability of re-profiling works (some settling and adjustment is inevitable), the status of fish stocks and water quality. The condition of newly planted *Phragmites* reeds and *Paspalum* will also be monitored and remedial action taken as required to ensure they fully establish.

14.4.6 Interim management will commence at an early stage of the construction of the Residential Development and WNR as described in Section 13.9. In summary, however, the key stages are briefly described below, these stages are shown graphically in Figure 13-13 (dates shown are indicative):

**Pre-Construction Phase I (Jul '10– Sep '10)**

14.4.7 During this phase the developer will take occupation of the site and make preliminary preparations including erection of site fencing. No specific habitat management is envisaged at this stage and all ponds will remain under their current aquaculture regime. All ponds will potentially be available as habitat, that is no ponds will be directly affected by construction activities.

**Pre-Construction Phase II (Oct '10 – Mar '11)**

14.4.8 During this phase pond enhancement works will commence (see above). To minimise disturbance and to maximise the extent of available habitat these works will be undertaken progressively within Sector 1 (the extent of Sector I is approximately 20.4 ha). The works involved in enhancement include the draining of adjacent ponds and the excavation of the intervening bund. This will be done according to the construction plan of the Wetland Nature Reserve. These works are similar to normal pond management activities and are not in themselves expected to cause undue disturbance to birds, nevertheless to minimise potential disturbance impacts, pond enhancement works will be phased.

14.4.9 The maximum area of pond affected by these enhancement activities during this Phase will be 4.2 ha (representing the largest ponds that will be concurrently drained and re-profiled). Prior to, and following enhancement works, the ponds will be filled with water and are considered to be available as habitat for birds and other Species of Conservation Importance.

14.4.10 During these works the ponds located within Sectors 2 (21.3 ha) and 3 (20.1 ha), the area proposed for marshland (14.4 ha) and development area (4.0 ha) will remain under their existing management regime ensuring that, throughout this Phase, at least 76.0 ha of pond will remain as available.

**Pre-Construction Phase III (Apr '11 – Sep '11)**

14.4.11 During this Phase enhancement works will commence in Sector 2 and site clearance will commence in the Development Area. The enhancement works in Sector 2 will follow the same pattern as described above, however, the maximum area affected at any one time will be slightly larger at approximately 6.1 ha. Once the Development Area clearance is complete a further, approximately, 4.0 ha of pond habitat will become unavailable. During this Phase, therefore, the minimum pond area available as habitat will be approximately 70.0 ha.

14.4.12 To compensate for this reduction in habitat area it is proposed to commence interim management in the Sector 1 ponds (all of which were enhanced in Phase II). The interim management strategy is to increase the carrying capacity of ponds by drawing them down for longer periods than is

normal under traditional management and to artificially increase the availability of prey species for wetland birds through stocking of trash fish species. The key elements of the interim management plan include:

- Management of water quality, specifically pH to ensure appropriate conditions for fish survival. Although trash fish species are relatively hardy compared to many commercial fish, they can be affected by low pH conditions. If pH drops below 4.5 then the cause will be investigated and appropriate steps taken to return pH to an appropriate level;
- Rotational, partial drain down of pair ponds. Once drained down each pair of ponds will be maintained with shallow water < 30 cm deep for a period of 4weeks;
- Stocking of trash fish as required to ensure that target carrying capacities are met; and,
- Minimising human presence to limit disturbance.

**Pre-Construction Phase IV (Oct '11 – Mar '12)**

14.4.13 Interim management will continue at Sector 1 (20.4 ha) and commence at Sector 2 ponds (21.3 ha). In addition interim management will also be implemented in Sector 3 ponds (20.1 ha, although these are yet to be enhanced). No pond enhancement works will be undertaken during this Phase. Creation works will commence within the marshland area, while site clearance continues in the development area, making approximately 14.4 ha and 4.0 ha, of pond area unavailable, respectively. Consequently a minimum of 61.8 ha of pond area will be available, all of which will be under interim management.

14.4.14 During this phase the physical activities associated with marsh creation works will be completed with planting taking place in the following Phase.

**Pre-Construction Phase V (Apr '12 – Sep '12)**

14.4.15 Interim management will continue at Sector 1 (20.4 ha) and 2 ponds (21.3 ha). Ponds in Sector 3 will undergo enhancement occupying a maximum of 3.8 ha at any one time while the remaining 16.2 ha of pond area will be kept under interim management. Planting of marshland habitats will take place followed by approximately 12 months of establishment. For the purposes of this assessment it is assumed during this period that all the marshland habitat (14.4 ha) will be unavailable as habitat (although it is actually likely that some species will begin to make use of it). Site clearance and preparation works will continue in the development area (4.0 ha). Thus a minimum of 57.9 ha of pond area will be available, all of which will be under interim management.

**Pre-Construction Phase VI (Oct '12 – Jun '13)**

14.4.16 Marsh establishment will continue (and hence assumed to be unavailable). Interim management will continue at Sector 1 (20.4 ha), 2 (21.3 ha) and 3 ponds (20.1 ha) resulting in a total area of available pond area of 61.71 ha, all of which is under interim management.

**Construction Phase (Jul '13 – Sep '16)**

14.4.17 Construction works are programmed to commence in July 2013. During this phase all pond enhancement works will be completed and a total area of 61.8 ha of ponds will be under interim management in Sectors 1, 2 and 3. Marsh establishment is expected to be substantially complete (although maturation will continue over several additional years). Consequently there will be an additional 14.4 ha of marshland habitat available.

14.4.18 The commencement of construction works will result, however, in the generation of substantially higher levels of noise and vibration and hence disturbance than was experienced during Pre-Construction Phases. It is assumed, therefore, that sections of wetland habitat adjacent to the construction area will be functionally unavailable to species that are sensitive to disturbance. The extent of these areas was assessed in Section 13.8 and are summarised in Figure 13-12 and Table 13-55.

14.4.19 The key strategy for mitigating these disturbance effects is to maintain interim management in all of the enhanced Sector 1, 2 and 3 ponds. It is anticipated that interim management will increase the carrying capacity of these ponds sufficiently to off-set temporary functional habitat loss associated with the displacement of birds from areas affected by construction phase disturbance.

14.4.20 The objective, therefore, during this Phase is to provide habitat of sufficient quality to maintain

the numbers of birds observed during the baseline. To gain an indication of the existing carrying capacity of the Fung Lok Wai wetlands, the survey data obtained during the baseline survey were analysed to identify the maximum number of birds recorded. These data were then converted to densities by dividing the maximum number of individuals observed within the within the Study Site by the extent of wetland in the Study Site (approximately 80.1 ha). The Study Site sits within a larger area of wetland habitat, for comparison this table also shows the maximum and mean number of individuals of Species of Conservation Importance observed within the total Assessment Area. These are also shown as densities achieved by dividing the counts by the extent of wetland within the Assessment Area (approximately 170.6 ha of wetland). These data are shown in *Table 13-59*.

### **Marsh construction and establishment**

- 14.4.21 The Constructed Marsh Area and the Development Area are adjacent to each other. This provides an opportunity for reducing disturbance associated with construction by combining activities involved in heavy earthworks, such as pond removal and site formation. These activities have, therefore, been programmed to occur at the same time.
- 14.4.22 An additional advantage of the concurrence of these activities is the ability to immediately relocate soil removed from the development area to the marsh area where it can be used for site formation. This process obviates the need for temporary storage areas for this material.
- 14.4.23 Once site formation works for the constructed marsh area have been completed it is anticipated that top-soiling and ground shaping can be completed within the same dry season. Planting works are programmed to commence with the on-set of the wet season when the ground is moist, increasing the likelihood of plant survival.
- 14.4.24 During the first twelve months after planting, the condition of plants must be closely monitored. Any plants that die or fail to thrive should be replaced. Any emerging weeds should be removed as soon as they are detected, preferably by hand, but if they become established or otherwise difficult to remove then limited application of appropriate herbicides should be considered as a last resort. During the establishment period water levels must also be closely monitored as these will have a significant bearing on the performance of young plants.
- 14.4.25 Establishment management actions should be reviewed after the first year.

### **Long-term management**

#### **Aquaculture pond management**

- 14.4.26 During this phase all of the enhanced aquaculture ponds will be managed according to the long-term management plan outlined below and their performance monitored.
- 14.4.27 As described above the majority of the target species of conservation occurring within the site benefit from traditional fish farming activities. The enhancement of the aquaculture ponds within the mitigation area will therefore include the continuation of active traditional fish farming management in each on most of them.
- 14.4.28 In most respects aquaculture pond management will represent a continuation of existing fish polyculture practices, which can be briefly characterised as a three stage process:
- Stocking – introduction of fish as fingerlings or juveniles (as determined by availability) at a density of about 14,000 fingerlings per hectare (lower for juveniles). The species stocked also tend to be determined by market availability and price but typically include carp (such as, for example, bighead, common carp, grass carp), mullet (eg grey mullet) and Tilapia;
  - Rearing – Through the year fish farmers typically add food to promote fish growth. The type of food added depends on price, availability, stage of growth and the personal preferences of the fish farmer, but could include, for example, corn meal, peanut cake, wheat bran, rice bran, biscuit, brewery waste, soya bean and vegetation clippings. If the pH of the pond drops then farmers will adjust water back to normal levels through the addition of lime or peanut residue. The timing and quantity of such additions is dependent entirely on water quality conditions. Aeration devices may also be employed if oxygen levels fall below critical levels for fish survival.

- Harvesting – when fish are ready for harvesting pond levels are dropped and fish captured. Commercial fish are removed and sold, however, trash species will be left in the shallow water of the pond and these form an excellent food source for birds such as herons and egrets.
- 14.4.29 The main long-term management enhancement of the ponds will be to regulate and extend the period of draw-down for harvesting. Under current fish-farming practices harvesting is carried out in winter by reducing the water depth of the pond (by pumping water to another pond for storage) and the gradual netting of the stock over a couple of weeks. However, the precise dates of harvesting are dependent on market prices and this can result in food-resource ‘bottle-necks’ if no or few ponds are drained at any one time. Draw down of the ponds will therefore be carried out on a regular basis irrespective of the market value of fish.
- 14.4.30 Draw-down periods will also be for a fixed time of 20 days. This is longer than normal and will thus further increase feeding opportunities thereby further reducing potential feeding bottle-necks.
- 14.4.31 It is also proposed that at any one time approximately 25% of the aquaculture pond area will be taken out of production (on a rotational basis) for one season. This will provide additional shallow water habitats that will be used by targets species such as herons and egrets.
- 14.4.32 The operating water levels for each pond will be specified once survey and re-profiling works have been completed. The following levels are to be specified for each pond which are illustrated schematically in Figure 14-14:
- **Initial Operating Level (IOL)** level for ponds when filled / refilled during the winter after drain-down or harvesting. IOL is set so that water level is coincident with any shelves in the bund such that created shallows are created. Typical IOLs for fish ponds would be in the range 1.2 to 1.9m above base.
  - **Maximum Operating Level (MOL)** indicate the level above which water must be removed from the pond by sluice drainage or pumping (off-site or to other ponds as appropriate). In practice the MOL will be determined for each based on its the height and structural integrity. Typically MOL would be in the range of IOL + 0.3m (+/- 0.1m).
  - The MOL for the rain fed ponds will be more specific. Pond 2 will be set a max of 1.0m. Pond 3 will be set to a max depth of 0.5m from May to July, raised to 0.8m between August and April. Pond 11 will be set to a max depth of 0.3m from May to July, raised to 0.6m between August and April.
  - **Low Operating Level (LOL)** is expressed as a range within which pond level is maintained during periods of set-aside. LOL range is typically 0.1-0.3 m in order to maintain sufficient depth to prevent acid soil problems. Soil exposed to air may become acidic. If water quality (and productivity) is affected by acidic leachate being flushed into the pond by run-off then appropriate measures may be required to neutralise the affects (such as, for example, application of lime or fertilizers).
- 14.4.33 If water levels exceed target levels, then water will be pumped to other ponds for storage. Decisions on the use of excess water will be made by the WNR Reserve Manager according to site conditions and requirements at the time.
- 14.4.34 Water levels will be monitored (via a permanent gauge board in each pond) at least weekly from the start of the trial, or within one day of heavy rainfall events (i.e. > 100 mm of rain in the NW Territories over 24 hours).
- 14.4.35 Ponds will be used in a 5 year rotational sequence of fish farming / shallow set-aside ponds (with no fish stocking). Thus approximately six of ponds will be set-aside from production in any one year, two of which will be used as a contingency reservoir pond. The long-term management programme for the aquaculture ponds (other than those ponds that are to be retained as Rain-Fed ponds) is described below in Table 14-13. The sequence of use of each pond is based on a start in January of each year (with stocking) and assumes that all ponds have been joined where intended and all water control structures have been installed.
- 14.4.36 The sequence of drain-down, harvesting and refilling for each set of ponds is not of critical conservation management importance. This can therefore be carried out as required to reduce

pumping and water loss from the system.

14.4.37 When ponds are drained down for harvesting, water levels must be maintained at or below Low Operating Levels for at least 20 days. No more than two ponds may be drained-down for harvesting at any one time.

14.4.38 After year 5 it is likely that the sequence will be repeated, but modifications may be made, as part of ongoing revisions of the Operational Management Plan (see below), as a result of lessons learnt from the monitoring of use of the ponds by target Species of Conservation Importance and their prey populations.

Table 14-13 Long-term pond management (5 year cycle)

| Pond | Year 1          | Year 2                         | Year 3                         | Year 4                         | Year 5                         |
|------|-----------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| 1    | Set-aside       | Fish production (Fill from 7)  | Fish production                | Set-aside (Move to 6)          | Fish production (Fill from 7)  |
| 4    | Fish production | Set-aside (Move to 5)          | Fish production (Fill from 5)  | Fish production                | Fish production                |
| 5    | Set-aside       | Reservoir (Fill from 4)        | Fish production (Move to 4)    | Fish production                | Set-aside (Move to 9)          |
| 6    | Fish production | Fish production                | Set-aside (Move to 7)          | Fish production (Fill from 1)  | Fish production                |
| 7    | Fish production | Set-aside (Move to 1)          | Fish production (Fill from 6)  | Fish production                | Set-aside (Move to 1)          |
| 8    | Reservoir       | Set-aside (Move to 12)         | Fish production (Fill from 12) | Fish production                | Fish production                |
| 9    | Fish production | Fish production                | Reservoir (Fill from 13)       | Set-aside (Move to 12,13)      | Fish production (Fill from 5)  |
| 10   | Fish production | Fish production                | Fish production                | Reservoir (Fill from 14)       | Fish production (Move to 14)   |
| 12   | Set-aside       | Fish production (Fill from 8)  | Set-aside (Move to 8)          | Fish production (Fill from 9)  | Fish production                |
| 13   | Fish production | Fish production                | Set-aside (Move to 9)          | Fish production (Fill from 9)  | Fish production                |
| 14   | Fish production | Fish production                | Fish production                | Set-aside (Move to 10)         | Fish production (Fill from 10) |
| 15   | Set-aside       | Fish production (Fill from 16) | Fish production                | Fish production                | Reservoir (Fill from 17)       |
| 16   | Reservoir       | Fish production (Move to 15)   | Set-aside (Move to 18)         | Fish production (Fill from 18) | Fish production                |
| 17   | Fish production | Reservoir (Fill from 18)       | Fish production (Move to 18)   | Fish production                | Set-aside (Move to 15)         |
| 18   | Fish production | Set-aside (Move to 17)         | Reservoir (Fill from 16, 17)   | Fish production (Move to 16)   | Set-aside (Move to 19)         |
| 19   | Fish production | Fish production                | Fish production                | Fish production                | Reservoir (Fill from 18)       |
| 20   | Fish production | Fish production                | Fish production                | Reservoir (Fill from 21)       | Fish production (Move to 21)   |
| 21   | Fish production | Fish production                | Fish production                | Set-aside (Move to 20)         | Fish production (Fill from 20) |

**Note: Refer to Fig 14-1 for the location of ponds**

**Set-aside**

Maintain within LOL limits. Empty and allow to dry for 30 days between 1 October and 15 December.

**Fish production**

Stock between 1 January and 1 March. Drain down to LOL for at least 20 days and harvest 1 November – 14 February (of subsequent year).

**Reservoir**

Maintain water levels up to Max Level through year. Use as storage pond and for maintaining target levels in other ponds if necessary



Table 14-14 General management actions for the Fung Lok Wai WNR

|    | Action   | A. Construction Phase  | B. Long-term Management Phase  | Notes  |
|----|--|--|--|--|
|    | <b>Water Control</b>   |  |  |  |
| W1 | Measure water levels and adjust sluice heights or pump accordingly to meet target levels (see <i>Figure 14-14</i> ). | Inspect and adjust as necessary every 48 hrs (April – September) every week at other times | Inspect and adjust as necessary every 48 hrs (April – September) every week at other times |  |
| W2 | Inspect condition of water control structures and water courses and repair / maintain as necessary                   | Weekly   | Weekly   |  |
| W3 | Inspect condition of pumps and water supply structures and repair / maintain as necessary                            | Weekly   | Weekly   |  |
| W4 | Clear catchpits / sluices  | Weekly   | Weekly   | Also after flooding / heavy rainfall                                     |
| W5 | Remove sediment  | Not required   | As required  | WNR Reserve Manager to determine requirement                             |
|    | <b>Structural maintenance</b>  |  |  |  |
| S1 | Inspect condition of paths / bunds and repair / maintain as necessary  | Weekly   | Weekly   | Also after any flood events  |
| S2 | Inspect condition of fences and gates and repair / maintain as necessary   | Weekly   | Weekly   | Also after any flood events  |
| S3 | Inspect condition of hides / signs / visitor facilities and repair / maintain as necessary                           | Weekly   | Monthly  | Also after any storm events  |
|    | <b>Vegetation management</b>   |  |  |  |
| V1 | Replacement of dead or poorly growing plant material   | Weekly or on the advice of the WNR Reserve Manager   | When Action Level exceeded   | Carry out during the late dry season / early wet season (February – May) |
| V2 | Removal / substitution of exotic / undesirable invasive plants (weeding)   | Weekly   | Removal when Action Level exceeded   |  |
| V3 | Pest control   | On the advice of the WNR Reserve Manager   | On the advice of the WNR Reserve Manager   | According to methods approved by the WNR Reserve Manager                 |
| V4 | Selective cutting or pruning and removal   | On the advice of the WNR Reserve Manager   | On the advice of the WNR Reserve Manager   |  |
| V5 | Ditch clearance  | Not required   | Remove all reed rhizomes from 25% of ditch length annually                                 | Remove by hand in 3 m sections on alternating banks                      |
| V6 | Grazing by water buffalo or manual grass cutting as appropriate  | Not required   | Light grazing after one year, under supervision of the WNR Reserve Manager                 | Leave 20% ungrazed in any one year on 5-year rotation.                   |
|    | <b>Other actions</b>   |  |  |  |
| O1 | Inspect for dumping / rubbish and remove   | On all visits  | On all visits  | Consult management team regarding water pollution or toxic materials     |
| O2 | Inspect and maintain signs   | Monthly  | Monthly  |  |

**Other management actions**

- 14.4.39 Other management actions to be taken over the WNR area are outlined in Table 14-14.
- 14.4.40 Water levels will be adjusted within the freshwater marsh according to year to year site conditions and ecological requirements for target species. These target water levels will be set by a suitably qualified ecologist within the site management team after inspection of the site and water monitoring data.
- 14.4.41 Water levels may be allowed to drop to below ground level to allow access for maintenance when necessary.
- 14.4.42 In addition to the management of the fish farming system, some management of the aquaculture pond bund vegetation will also be undertaken. This will mainly involve the control of tall vegetation such as reeds. Although some patches of reed should be encouraged to develop for cover and screening purposes these must be controlled as ponds that are enclosed by tall vegetation tend to be avoided by many of the larger herons and egrets.
- 14.4.43 Management will also be carried out of undesirable invasive weeds if necessary.
- 14.4.44 Vegetation shall only be removed by cutting and removal of roots / rhizomes by hand or machine (e.g. backhoe). The use of herbicides will not be allowed, unless deemed to be necessary (e.g. for treating some invasive species) by the WNR Reserve Manager in consultation with an appropriately qualified ecologist.
- 14.4.45 Grass clippings can be placed in fish ponds as a feed supplement for herbivorous fish such as carp, however, more substantial vegetation will be disposed of off-site in an appropriate manner.
- 14.4.46 Great Cormorant are known to predate upon fish within aquaculture ponds. The level of predation predicted in the EIA was not considered to be significant in terms of the ability of the WNR to achieve its conservation targets, primarily because the mitigation targets for this species are relatively low. During the operational phase the target density is 0.08 birds ha<sup>-1</sup>. Nevertheless, the level of predation will be monitored and appropriate (non-lethal) measures implemented to limit predation if it reaches unsustainable levels. Non-lethal measures could include, for example, wires spaced at between 5m and 7.5m. This is known to be effective at deterring cormorants, and has been used successfully at carp ponds of up to 4ha in size. Wires would be used selectively within ponds to balance the need for fish production and to maintain population levels for the purposes of achieving mitigation targets.

**Responsibilities**

- 14.4.47 The management arrangements for the WNR are addressed in more detail at Section 15.
- 14.4.48 Upon the completion of the construction of the WNR, the Development Site will be sub-divided into two portions: the WNR portion and the residential portion. The operation and management of the WNR will be independent from the management of the residential development. The WNR will be managed by the proponent until a designated successor such as an independent Foundation is identified to the satisfaction of EPD or its agents.. The residential development, which will be under strata-titled ownership will be independently managed by the property manager appointed by the owners of the residential development. The residents in the residential development will neither have privilege over the general public for access to the WNR nor the liability of its maintenance.

**Operational Management Plan**

- 14.4.49 Once the WNR is operational the HCMP will be replaced by an Operational Management Plan (OMP) with detailed specifications and timings for management actions during long-term management. The OMP will take into account any modifications that were found to be necessary in the design and establishment methods used for creating the habitats, the degree of success in establishing the habitats and any changes in the factors affecting them. Management actions will also need to respond appropriately to the outcome of monitoring where it is found that Action Levels and Limits as defined in Section 14.5 are exceeded.
- 14.4.50 The OMP will be a working document and reviewed annually, so that proposed actions are modified according to progress, monitoring results and other relevant events. The OMP will be

thoroughly revised every five years. The five-year revision will include a through analysis of all monitoring data and a review of the vegetation communities that have established, with an identification of areas to be cleared and replanted.

14.4.51 Reviews of the OMP and monitoring results will be signed off by the relevant authority under the EIAO.

**Contingency measures**

14.4.52 Measures have been included in the design, construction methods, management and monitoring proposals that aim to ensure the successful establishment and long-term sustainability of the wetland as effective compensation habitat for key target species.

14.4.53 The wetland designs also have in built contingency measures for key factors affecting wetland establishment, especially regarding water supply, water retention and plant establishment. These include:

- The collection and storage of water from the surrounding catchment and site run-off to supplement direct rainfall supplies to the freshwater marsh area.
- The use of fishponds as reservoirs (on a rotational basis) to maintain water levels within target tolerances if required (a practice not normally deemed necessary by fish pond operators)
- The use of a clay base liner if tests indicate that water losses from the freshwater marsh wetland are outside tolerable limits. Further potential contingency actions if required could include placement of impermeable membranes in specific problem areas or insertion of vertical plates (or membranes) at the edge of the wetland to reduce lateral seepage.
- High planting densities to accommodate poor plant survival (and reduce potential weed growth).

14.4.54 Routine construction and establishment phase and long-term management actions, such as weed clearance, replanting, thinning and water level control will also be undertaken. These also aim to ensure the successful establishment and long-term sustainability of the wetland cells.

14.4.55 In addition, specific contingency actions will be defined in a Contingency Action Plan (to be prepared by the Contractor prior to the development of the wetland construction Method Statement) and agreed before commencement of works. As a minimum, contingency measures will be prepared for potential:

- inadequate water supply;
- failure of water pumping system;
- damage to sluices and drainage structures;
- pollution of water supply;
- direct pollution of wetland cells by toxic substances (e.g. from spillage's / dumping);
- unacceptable plant survival rate or growth during the 2 year establishment phase;
- invasion by exotic or other undesirable plant species;
- flooding of the site and other potential effects from storm events.

14.4.56 Intensive monitoring will be carried out of the physical and ecological performance of the wetland mitigation area during the construction and establishment phases and in the long-term. The monitoring will be carried out in relation to defined "Action Levels" and "Limits" (see Section 14.5) which trigger appropriate actions to rectify problems. Where necessary these will include actions defined in the Contingency Action Plan.

## **14.5 Monitoring and action plans**

**General requirements**

14.5.1 The following sections outline the monitoring requirements to ensure that the WNR is achieving its objectives during the various phases of its operation.

- 14.5.2 The start of the construction phase is dependent on the approval of the EIA and the preparation of a detailed project timetable. Detailed ecological monitoring will be undertaken from the commencement of works subject to the preparation of a detailed Environmental Monitoring and Audit Manual. It is intended that the data obtained from monitoring will inform the adaptive management of the WNR, consequently it is important that there is flexibility in the variables that are measured, the frequency and timing of survey and the methods used. The monitoring programme will, therefore, be reviewed periodically to ensure that it is achieving its aims.
- 14.5.3 After completion of the lease modification/land exchange, an environmental committee will be set up to advise on and monitor the effectiveness of the proposed mitigation measures of the construction of the Project according to the HCMP and the EIA report. The function and membership of the environmental committee shall be in line with those of the Lok Ma Chau Spur Line project. A list of members and terms of reference of the environmental committee shall be submitted to the Director of Environmental Protection for prior approval.
- 14.5.4 The key criteria by which the success of mitigation will be assessed are the provision of appropriate habitats and the maintenance of populations of Species of Conservation Importance. The specific targets for habitats and species are summarised in Section 14.2 above.
- 14.5.5 During the construction and operation phase a monitoring programme will be carried out of the ecological attributes proposed in *Table 14-15* according to the EM & A Manual. The schedule shall be reviewed, updated and revised prior to construction and operation of the WNR for the approval of the relevant authorities. Once construction is completed monitoring will also be undertaken during the long-term operation of the WNR. Prior to the implementation of long-term monitoring, survey methods and frequency will be reviewed in light of the outcomes of construction phase monitoring.

*Table 14-15 Ecological monitoring programme for Fung Lok Wai WNR*

| Ecological attribute                                 | Number of measurements  | Timing             | Frequency of measurement   |   |
|--|---|--------------------|--|---|
|  |   |                    | Construction phase   | Long-term management phase  |
| <b>Habitats</b>                                      |   |                    |  |   |
| Vegetation map                                       | All of WNR  | Wet and dry season | On completion of construction works  | After completion of construction works survey every 6 months (wet and dry season) for first 5 years at which point frequency of survey will be reviewed |
| <b>Plant species</b>                                 |   |                    |  |   |
| Survival, health and growth of plant species planted | <i>Aquaculture ponds:</i><br>Visual assessment of all areas                           |                    | Monthly for one year on completion of enhancement works                                | Annually thereafter   |
|  | <i>Constructed marsh habitat:</i><br>100 randomly marked plants in each planting zone |                    | Weekly for first 2 months after planting, then monthly for remainder of the first year | Quarterly in second year after planting then annually thereafter  |
| Plant species richness, relative abundance and cover | <i>Aquaculture ponds:</i><br>Continuous visual assessment                             |                    | Continuous   | Continuous  |

| Ecological attribute   | Number of measurements   | Timing                         | Frequency of measurement   |   |
|--|--|--------------------------------|--|---|
|  |  |                                | Construction phase   | Long-term management phase  |
| Frequency and cover of alien and invasive plant species      | <p><i>Constructed marsh habitats:</i><br/>Ten 1m x 1m quadrats per planting zone</p> <p>Continual visual assessment of alien and invasive species abundance will also be conducted by the WNR management staff</p> | Wet and dry season             | 6 monthly during establishment   | 6 monthly (wet and dry season) for first 5 years at which point frequency of survey will be reviewed  |
| <i>Dragonflies:</i> species richness and abundance           | Establish representative transects throughout WNR  | March – November               | During interim management period: Monthly during March, September, October and November. Twice monthly during April – August | During long-term management period: Monthly during March, September, October and November. Twice monthly during April – August. Frequency of monitoring to be reviewed after 5 years. |
| <i>Aquatic invertebrates:</i> species richness and abundance | <i>Aquaculture ponds:</i><br>Five benthic cores and dip nets within 5 fish ponds   | End of wet season (Aug / Sept) | Annually during interim management period  | Annually  |
|  | <i>Constructed marsh habitat:</i><br>Five benthic cores and dip nets at five locations   | Wet and dry seasons            | During establishment: 6 monthly during wet and dry season  | Thereafter 6 monthly during wet and dry seasons.<br><br>Frequency of monitoring to be reviewed after 5 years.   |
| <i>Freshwater fish:</i> species richness and abundance       | <i>Aquaculture ponds:</i><br>Record species, abundance, average length and average mass of all species removed at harvesting   |                                | Every two months (throw and drag netting) during interim management period   | Annually at harvesting and every two months (throw and drag netting).<br><br>Frequency of monitoring to be reviewed after 5 years.  |
|  | <i>Constructed marsh habitat:</i><br>Netting within representative areas of the permanent marsh  |                                | Every two months (throw and drag netting) during establishment   | Thereafter every two months (throw and drag netting).<br><br>Frequency of monitoring to be reviewed after 5 years.  |

| Ecological attribute  | Number of measurements  | Timing            | Frequency of measurement   |  |
|---|---|-------------------|--|--|
|   |   |                   | Construction phase   | Long-term management phase   |
| <i>Amphibians</i> : species richness and abundance  | Establish representative transects throughout WNR   | April – November  | During interim management period: monthly during period April - November | Thereafter monthly during period April – November.<br><br>Frequency of monitoring to be reviewed after 5 years.  |
| <i>Reptiles</i> : species richness and abundance  | Establish representative transects throughout WNR   | April – November– | During interim management period: monthly during period April - November | Thereafter monthly during period April – November.<br><br>Frequency of monitoring to be reviewed after 5 years.  |
| <i>Birds</i> : species richness and abundance (see above for specific details on bird monitoring) | <i>Aquaculture ponds</i> :<br>Each pond   |                   | Weekly during interim management period                                  | Weekly monitoring supplemented by opportunistic records at other times. More frequent monitoring may be required during specific management activities (eg pond draw down) |
|   | <i>Constructed marsh habitat</i> :<br>Each marsh type (ie seasonal marsh and permanent marsh) |                   | Weekly during interim management period                                  | Weekly monitoring supplemented by opportunistic records at other times   |
| <b>Hydrology</b>  |   |                   |  |  |
| Water surface level   | <i>Aquaculture ponds</i> :<br>One gauge board per pond  |                   | Daily during interim management period                                   | Weekly and after heavy rain  |
|   | <i>Constructed marsh habitat</i> :<br>Two gauge boards per marsh type                         |                   | Daily during establishment   | Weekly and after heavy rain  |
| <b>Water chemistry</b>  |   |                   |  |  |
| Water quality variables:<br>pH<br>BOD   | <i>Aquaculture ponds</i>  |                   | Monthly during interim management period                                 | Monthly  |

| Ecological attribute  | Number of measurements   | Timing | Frequency of measurement                 |  |
|---|--|--------|--|--|
|   |  |        | Construction phase                       | Long-term management phase                                       |
| DO<br>Ammonia concentration<br>Conductivity<br>Turbidity<br>Temperature<br>Suspended solids<br>Salinity               | <i>Constructed marsh habitat:</i><br>At representative locations within each marsh habitat             |        | Monthly during establishment             | Monthly  |
| Water quality variables:<br>Total oxidised nitrogen<br>Total phosphorus concentration<br>Orthophosphate concentration | <i>Aquaculture ponds</i>   |        | Once on completion of enhancement works  | Monthly for first year at which point frequency will be reviewed |
|   | <i>Constructed marsh habitat:</i><br>At representative locations within each marsh habitat             |        | Once on completion of construction works | Monthly for first year at which point frequency will be reviewed |
| Heavy metals (Cadmium, Copper, Nickel, Lead, Zinc, Mercury)   | <i>Aquaculture ponds:</i><br>Representative aquaculture ponds adjacent to the active construction area |        | Once on completion of works              | Annually thereafter  |
|   | <i>Constructed marsh habitat:</i><br>At representative locations within each marsh habitat             |        | Once on completion of works              | Annually thereafter  |

### Reporting

14.5.6 All data recorded during monitoring will be recorded on standardised pro formas. Each year a summary report will be produced by the WNR Reserve Manager detailing the outcomes of monitoring and indicating any remedial actions taken or required.

#### **Event and action plan for ecological attributes**

14.5.7 The results of the ecological monitoring shall be compared with Action Levels and Limits detailed in Table 14-16 and corrective actions taken accordingly.

### 14.6 HCMP Reporting and Review process

14.6.1 This is a draft document and key details presented here, including, for example, stocking densities and monitoring requirements are to be finalised subject to the endorsement of AFCD or other appropriate authority. The frameworks for such details are given in this section below and if changes are required in light of the changing environment / baseline, such changes would need to be agreed with AFCD or relevant authorities. This draft HCMP shall, therefore, be reviewed, updated and revised prior to the construction of the WNR and submitted for the approval of the relevant authorities.

14.6.2 The regime documented in the HCMP (and during the operational phase, the OMP) will be reviewed on an ongoing basis, for example, every 5 years (or as otherwise required) and submitted for approval by the relevant authorities.

14.6.3 An annual monitoring report detailing the results of monitoring undertaken as outlined in Section 14.5, the achievement of objectives and any adaptive modifications to the HCMP (or OMP) and its objectives will be reviewed and submitted for approval by the appropriate authorities.

Table 14-16 Key Action Levels and Limits and their associated management actions

|   | Action level   | Action   | Limit   | Action   |
|---|--|--|---|--|
| <b>Plant species</b>                                    |  |  |   |  |
| Survival, health and growth of plant species planted    | <75% survival of any planted species   | Check soil and water conditions; replace dead material. If survival rate does not increase implement contingency plan  | <30% survival of any planted species  | Implement contingency plan                       |
|   | > 10% fungal or pest infestation of any species with >50% loss of vegetative growth                    | Remove dead and infected material, identify pest / infection   | > 30% fungal or pest infestation of any species with >50% loss of vegetative growth                     |  |
| Plant species richness, relative abundance and cover    | <75% species survival within planted areas   | Within first 2 years of establishment: Replace plants and check soil and water conditions<br><br>After 2 years: on direction of WNR Reserve Manager implement contingency plan | <50% species survival   |  |
| Plant community composition                             | Wetland plant species comprise <95% of vegetation  | Review observed water levels against targets   | Wetland plant species comprise <90% of vegetation   |  |
|   | Frequency or cover of any individual species is <50% or >200% of proportion allocated in planting plan | Replace or remove plants as necessary  | Frequency or cover of any individual species is <10% or >1000% of proportion allocated in planting plan |  |
| Frequency and cover of alien and invasive plant species | Alien species >5% of total cover   | Remove plants as necessary   | Alien species >10% of total cover   |  |
| <b>Animal species</b>                                   |  |  |   |  |
| <i>Dragonflies</i> : species richness and abundance     | No increase from baseline over 2 consecutive years   | Review management actions  | Decline from baseline over 2 consecutive years  | Investigate causes and review management actions |



|  | Action level   | Action  | Limit   | Action   |
|--|--|---|---|--|
| <i>Aquatic invertebrates</i> : species richness and abundance  | Establish action levels after 2 years of monitoring*   | Establish actions after 2 years of monitoring*  | Establish action levels after 2 years of monitoring*              | Establish actions after 2 years of monitoring*   |
| <i>Freshwater fish</i> : species richness and abundance  | Establish action levels after 2 years of monitoring*   | Establish actions after 2 years of monitoring*  | Establish action levels after 2 years of monitoring*              | Establish actions after 2 years of monitoring*   |
| <i>Amphibians</i> : species richness and abundance   | No increase from baseline over 2 consecutive years   | Review management actions   | Decline from baseline over 2 consecutive years                    | Investigate causes and review management actions   |
| <i>Reptiles</i> : species richness and abundance   | No increase from baseline over 2 consecutive years   | Review management actions   | Decline from baseline over 2 consecutive years                    | Investigate causes and review management actions   |
| <i>Birds</i> : species richness and abundance<br><b>Provisional: These actions and levels to be agreed with AFCD</b> | <i>Aquaculture ponds</i> :<br><50% baseline richness and / or abundance in one year<br>OR<br><80% baseline richness and / or abundance for 3 consecutive years | <u>Construction phase</u><br>Investigate causes of decline eg reference to monitoring data from other locations within HK and overseas.<br>Review construction practices<br><u>Operation phase</u><br>Investigate causes of decline eg reference to monitoring data from other locations within HK and overseas.<br>Review management practices | <50% baseline richness and / or abundance for 3 consecutive years | <u>Construction phase</u><br>Undertake detailed investigation of causes. Reduce disturbance effects caused by construction (eg noise) until causes identified<br><u>Operation phase</u><br>Undertake detailed investigation of causes. Implement short-term management actions aimed at increasing numbers |
|  | <i>Constructed marsh habitat</i> :<br>Establish action levels after 2 years of monitoring*   | Establish action levels after 2 years of monitoring*  | Establish action levels after 2 years of monitoring*              | Establish action levels after 2 years of monitoring*   |
| <b>Hydrology</b><br>Water surface level  | <i>Aquaculture pond</i> :<br>Level >100mm above or below target  | Adjust as required  | <i>Aquaculture pond</i> :<br>Level >200mm above or below target   | Review levels, implement contingency plan  |

|                                | Action level  | Action   | Limit  | Action   |
|--------------------------------|---|--|--|--|
|                                | <i>Constructed marsh habitat:</i><br>Level > 25mm above or below target |  | <i>Constructed marsh habitat:</i><br>Level > 100mm above or below target |  |
| <b>Water chemistry</b>         |   | Double water quality and vegetation survival rate monitoring, identify problem and implement plan to rectify |  | Identify alternative water source until problem is rectified |
| pH                             | Outside range 5.5 – 7.5   |  | Outside range 4 – 8  |  |
| BOD                            | >6.0mg/l  |  | >9mg/l   |  |
| DO                             | Within the ranges 51-70% or 121-130% saturation                         |  | <50% or >130% saturation   |  |
| Ammonia concentration          | >2mg/l  |  | >5mg/l   |  |
| Salinity                       | >1ppt   |  | >3ppt  |  |
| Total oxidised nitrogen        | >3mg/l  |  | >10mg/l  |  |
| Total phosphorus concentration | >1mg/l  |  | >3mg/l   |  |
| Orthophosphate concentration   | >0.1mg/l  | 1mg/l  |  |  |

Note: \* - The action levels and actions will be established after 2 years for the communities of those species groups (ie aquatic invertebrates, freshwater fish and marsh bird species) which are currently not features of the existing FLW fauna. That is action levels and actions can only be established once the communities have become established and it becomes clear what their composition and relative abundance is.

## 14.7 References

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