TERRITORY DEVELOPMENT DEPARTMENT

Agreement No. CE 49/2000
Design of Ecological Mitigation Measures and Landscaping Works and Assessment of Land Contamination for Eastern Main Drainage Channel for San Tin

Ecological Habitat Management Plan (Final)

30 November 2001

Approved By _____

(Director)

REMARKS:

The information supplied and contained within this report is, to the best of our knowledge, correct at the time of printing.

MCAL accepts no responsibility for changes made to this report by third parties.

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1. INTRODUCTION

1.1 Background

1.1.1 The San Tin Eastern Main Drainage Channel (EMDC) project involves the construction of an approximately 2.4km long drainage channel, low-flowing pumping station, inflatable dam, associated road system, constructed wetlands and landscaping works to alleviate flooding risk in the San Tin area. The EMDC is located on the western side of San Sham Road, and runs adjacent to San Sham Road from Castle Peak road to Shenzhen River. The general layout plan of the EMDC is shown in Figure 1.1.

1.1.2 In February 1997, Territory Development Department (TDD) commissioned an Environmental Impact Assessment (EIA) Study for the Main Drainage Channels and Poldered Village Protection Schemes for San Tin (hereinafter called the San Tin EIA Report), which included the EMDC, the Western MDC, and the village flood protection works for San Tin villages and Chau Tau Tsuen. The San Tin EIA Report was endorsed by Advisory Council on the Environmental (ACE) on 19 July 1999 and approved by the Director of Environmental Protection on 14 September 1999. A detailed assessment of the potential environmental impacts has been provided, and appropriate mitigation measures for incorporation into the engineering design of the drainage channel have been identified in the San Tin EIA Report. Environmental monitoring and audit (EM&A) requirements have been identified and detailed in a separate EM&A Manual.

1.1.3 The San Tin EIA report identified the primary ecological impact of the project as loss of wetlands, and associated effects on wetland-dependant species. One of the key mitigation measures proposed in the report was the creation of wetlands to compensate for the loss of fishponds and marshes brought about by the Project. The main habitat mitigation measure is the construction of approximately 3.43ha of compensatory freshwater wetland east of the EMDC.

1.1.4 The New Territories North Development Office of TDD is the project proponent for the EMDC and the Drainage Projects Division of the Drainage Services Department (DSD/DP) is the implementation agent for the Project. DSD/DP will be responsible for designing and supervising the construction of the civil works under the Project. The Project is tentatively programmed to commence construction in end 2002 for completion in end 2005.

1.1.5 Maunsell Consultants (Asia) Limited (MCAL) have been commissioned by TDD to undertake the Design of Ecological Mitigation Measures and Landscaping Works and Assessment of Land Contamination for EMDC for San Tin (the Assignment), with technical support from Urbis Ltd. The Assignment shall include the formulation of an Ecological Habitat Management Plan (EHMP) for the ecological mitigation measures for the EMDC Project, as recommended in the San Tin EIA Report.

1.2 Objectives of the EHMP

1.2.1 The principal objective of the wetland design, as recommended in the San Tin EIA Report and supplemented by the clarification letter to the World Wide Fund for Nature Hong Kong, is to recreate wetland habitats which will promote colonisation by key "target species" which are considered to be of high conservation value in the area, and are likely to derive significant benefit from the compensatory habitat. To meet these criteria, the EHMP shall include management objectives, target species for habitats to be created, habitat

management/maintenance requirements, monitoring programme, remedial/contingency action plan and implementation schedule. The EHMP will form the basis for the detailed design of the constructed wetlands. The EHMP will also address the other ecological mitigation measures recommended in the San Tin EIA Report, these being :

- Grasscrete Lining of EMDC;
- Plantings on Outer Embankment of EMDC;
- Tidal Channel;
- Tsing Lung Tsuen Drainage Channel; and
- Flood Storage Pond at San Tin Villages.

1.3 Structure of the Report

1.3.1 The remainder of the EHMP is organized as follows:

- ***Section 2*** reviews the main objectives of the Assignment and identifies key design considerations;
- ***Section 3*** outlines the abiotic and biotic characteristics of the compensatory wetlands;
- ***Section 4*** describes the selection of target species, and details their ecology and habitat requirements;
- ***Section 5*** describes the compensatory habitats in detail, giving examples of water regimes, plant species, use by target species and other taxa in comparable habitats elsewhere in HK;
- ***Section 6*** describes the monitoring programme for the constructed wetlands, through refinement of the EM&A Manual for the Project;
- ***Section 7*** discusses the regular management & maintenance required to optimise wetland community structure and function; and
- ***Section 8*** presents an implementation schedule for the construction and management of the constructed wetlands.

2. GENERAL DESIGN CONSIDERATIONS

2.1 Overview

2.1.1 In this section, the main aims of the compensatory wetland programme are introduced, and the key design considerations needed to meet these aims are outlined.

2.2 Original habitats

2.2.1 One of the objectives of this project was to provide suitable resources for fauna currently supported by habitats that will be lost to the development.

2.2.2 The project site is typical of lowland areas across much of NWNT, with a mix of active and abandoned fishponds, streams/nullahs, marshes, agricultural land, plantation and urbanized areas.

2.2.3 The San Tin EIA Report identified that the affected man-modified wetland habitats comprising fishponds, stream/nullahs and marshes were primarily used as foraging grounds for birds.

2.2.4 The loss of these wetland habitats will be compensated by constructing wetlands to create freshwater and possibly brackish-water habitats, including ponds and marshes, attractive to waterbirds and also to other wetland dependent wildlife, such as invertebrates and amphibians.

2.3 Target species

2.3.1 The NWNT as a whole is an area of high ecological significance, and the compensatory wetlands will be designed to suit the habitat requirements of indigenous species. However, as each species utilising the area has slightly different requirements, it would be an unrealistic goal to try and create wetlands to accommodate the needs of all species. Therefore wetland design will focus on creating habitats suitable for a group of key target species identified during the San Tin EIA Report, these species being:

- Snipe (Common Snipe, Pintail Snipe, Swinhoe's Snipe and Painted Snipe)
- Ardeids (Little Egret, Cattle Egret, Great Egret, Grey Heron, Night Heron, Chinese Pond Heron)
- Red-billed Starling
- Chironomids
- *Orthetrum Luzonicum*
- Narrow-mouthed Frog

2.3.4 It is anticipated that if suitable habitats can be created for the target species, other species with similar requirements will colonise the area.

2.4 Habitat types

2.4.1 The design of the created habitats is dependent on three factors:

- *Key features of existing habitats* – Habitats will be designed to replace, and where possible enhance the ecological value of existing habitats at the site

- ***Habitat requirements of target species*** – Habitat design will be guided by the known habitat requirements of target species (for details refer to Section 4).

- ***Site constraints*** – The size and shape of the project area will determine the exact nature of the habitats to be created.

2.4.2 With reference to the criteria listed in 2.4.1, four distinct habitats are to be included in the compensatory wetlands:

Pond/open water

2.4.2.1 Area characterised by grass covered, gently sloping banks, with deep water (typically over 2000 mm), to retain water throughout the year.

Permanent marsh

2.4.2.2 Area characterised by submerged/emergent vegetation standing in or adjacent to large areas of shallow bodies of water (not more than 100 mm deep), with gently sloping banks, and have a fairly constant supply of water in order to remain permanently wet throughout the year.

Seasonal Marsh

2.4.2.3 Area characterised by emergent vegetation standing in or adjacent to shallow bodies of water which have a seasonally fluctuating water supply, making them wet during the summer months and dry during the winter months.

Terrestrial Margins

2.4.2.4 Marginal areas that do not retain standing water, supporting grasses, scrub and woodland vegetation.

2.4.3 In addition to providing suitable habitats for target taxa, managing the site to increase habitat heterogeneity will attract a greater number of other species, thus increasing the overall biodiversity of the site.

2.5 Adjacent habitats

2.5.1 The habitat types will be linked to reduce the edge to area ratio, thereby minimising edge effects, and allow fauna to disperse freely across the habitats.

2.5.2 Additionally, the San Tin EMDC wetlands will be ecologically linked with compensatory reedbeds being developed as part of the Lok Ma Chau Boundary Crossing (LMCBC) project.

2.6 Sustainability

2.6.1 By creating a water regime for the wetland, which is self-sustaining as far as is practicable, human intervention and active maintenance can be minimised without compromising the quality of water supplies and ecological functions of the wetland.

3 CHARACTERISTICS OF CREATED WETLANDS

3.1 Overview

The following general principles considered in the design of the wetland and terrestrial habitats include:

- Provide suitable landform and profile, vegetation communities and water regime that is known to attract target species in similar areas,
- Wherever feasible, slopes shall be designed to be capable of re-vegetation. The slope gradient shall allow the slope to be safely planted and maintained,
- Earthworks shall aim, as far as possible, to blend with the surrounding and adjacent landforms. The angle of slope shall relate to the natural angle of slopes in the area. To ensure a subtle transition between newly formed sloped and existing landform, limited additional grading may be necessary at the crest of the slope,
- All plantings, while providing an ecological and utility function, shall be chosen for low maintenance and arranged to provide maximum aesthetic value, to enhance the site and surrounding land uses,
- Random planting of trees in groups or individually along the outer embankments of the new EMDC to simulate the former landscape pattern. The number of trees should be kept to a minimum to ensure that flight paths to and along the wetlands remain open to Ardeid species,
- Grass / herb vegetation to be established to the inner inclined sides of the channel (and to the base where possible),
- Screen between channel and San Sham Road to reduce the impact of the road and kiosk and integrate the channel with the existing landscape, and
- Account for known land contamination. Assess, and if necessary, remove to ensure healthy growth of vegetation.

3.2 Permanent Open Ponds

General description	Body of circulating open water with submerged vegetation in depths and marginal and emergent vegetation at the edges. Minimum depth - 1000mm. Max. depth – 3000mm. Average depth 2500mm.
Purpose	Support lotus and other submergent aquatic vegetation. Provides foraging opportunities for target Ardeid species (especially the larger Ardeids – Grey Heron and Great Egret) and habitat for Chironomids, Odontates and Narrow-mouthed Frog. Provides water supply for permanent marsh areas.
Water regime	Water sourced from rain, mains and pumped feed from EMDC via. storage pond and possibly ground water. Drainage of surplus water in the event of a flood will be via. an overflow, set at a prescribed level in the pond, into the EMDC below the inflatable dam.
Soil / liner	Layer of hydric soils over clay liner over compacted inert materials to form.
Typical plant species	Examples of plant species include *Bacopa monniera, Chara spp., Utricularia spp., Lemna minor* and *Juncus spp.* at margin

3.3 Permanent Marshes

General description	Large area of slow moving shallow water with predominantly emergent vegetation and marginal vegetation at the edges. Shallow bank profiles and variable bed topography. Minimum depth - 100mm. Max. depth – 150mm. Vegetation structure: height 500mm – 1000mm, overall coverage approx. 80%.
Purpose	Support emergent and marginal sedges and herbs that grow in shallow water and saturated ground. Provide foraging opportunities for target Snipe and Ardeid species, and habitat for Chironomids, Odontates and Narrow-mouthed Frog.
Water regime	Water sourced from rain, mains and pumped feed from EMDC via. storage pond and possibly ground water. Drainage of surplus water in the event of a flood will be via. an overflow, set at a prescribed level in the pond, into the EMDC, below the inflatable dam.
Soil / liner	Clay liner over compacted inert materials to form. 150 mm layer of hydric soils or decomposed granite for planting. In narrow parts of the site, it may be necessary to utilise artificial pond liners.
Typical plant species	Examples of plant species include: *Alternanthera sessilis, Ammania multica, Cardamine flexuosa, Cyperus mallaccensis, Digitaria disctichum, Hygrophilla salicifolia, Ipomaea repiens, Kyllinga monocephala, Leersia hexandra, Ludwigia ascandens, Ludwigia*

octovalis. Oenanthe javanica. Panicum repens. Polygonum hydropiper. Ranunculus scleranthus. Rotala indica. Rumex martius....

3.4 Seasonal Marshes

General description	Swale form with variable depth and width. Seasonal variation in water levels – up to 1000 mm deep in summer and 0 mm in winter. Predominantly emergent vegetation in inundated areas and marginal vegetation at the edges of saturated areas with lower and upper bank terrestrial plantings on the sides of the swale. Minimum depth of swale: 1500 mm and max. depth of swale: 2500 mm below ground levels.
Purpose	Support emergent and marginal vegetation tolerant of variable soil moisture conditions. Provide foraging opportunities for target Snipe and Ardeid species (especially Cattle Egret) and habitat for Chironomids, Odontates and Narrow-mouthed Frog. Terrestrial plantings to supply nesting, roosting and perching for Ardeid species.
Water regime	Water sourced from seasonal rain i.e. wet in summer, dry in winter. If ground water is successfully intercepted, water levels will fluctuate seasonally and likely provide constant water supply / saturation and/or inundation in parts. Drainage of surplus water in the event of a flood will be via. an overflow, set at a prescribed level, into the EMDC.
Soils	Soils largely native with amenity soils for terrestrial plantings.
Typical plant species	Examples of plant species include: *Cyperus spp. Juncus spp., Elaeocharis spp.*

3.5 Terrestrial habitats

General description	Plantable land above the maximum high water marks of the permanent and seasonal marshes and pond. Predominantly terrestrial trees, shrubs and bamboo species ranging from lower bank, upper bank and terrace plantings. Variable levels and drainage patterns reflected in vegetation.
Purpose	Support terrestrial plantings that provide for amenity screening and habitat. Provide roosting, perching and nesting opportunities for target Ardeid species and foraging grounds for Cattle Egret.
Water regime	Seasonal irrigation by rainfall sufficient to maintain terrestrial vegetation. Drainage towards wetlands wherever practicable.
Soils	Soils largely native with amenity soils for terrestrial plantings.

Typical plant species — Examples of plant species include : *Alternanthera sp., Bidens rubra, Breynia fructicosa, Celtis sinensis, Commelina communis, Dicranopteris linearis, Ficus microcarpa, Ficus superba, Ipomaea aquatica, Lantana camara, Litsia glutinosa, Litsea rotundifolia, Macaraanga tanaris, Melia azedarach, Panicum repens, Paspalum conjugatum, Pinus massonica, Rhaphiolepsis indica, Rhodomyrtus tomentosa, Sapium sabiferum.*

3.6 Proposed Layout of the Constructed Wetland

The San Tin EMDC Constructed Wetlands will comprise approximately 3.43 ha of land, distributed in a linear arrangement between the EMDC and San Sham Road, varying in width from 3m to 60m. This is an area of current or former fishpond and associated village / settlement sites.

The created habitats will mitigate the potential effects of the proposed EMDC development, in the form of amenity improvements with terrestrial tree, bamboo and shrub plantings for screening and a variety of wetland types, which will result in increased wildlife. The terrestrial and wetland habitats will:

- Incorporate key features of the original habitats that they are modelled on,
- Incorporate the habitat requirements of the target species,
- Create a diversity of habitat conditions, mainly seasonal marsh, permanent marsh, permanent ponds and terrestrial habitats, and
- Be contiguous as far as practicable, to provide maximum opportunities for utilisation by fauna.

The scope of the project is extensive and includes:

- Constructed Wetland East of EMDC – approximately 3.43ha of compensatory freshwater and possibly brackish-water wetland habitats,
- Grasscrete Lining of EMDC – provide approximately 4.5 ha (the bottom area of the channel) of seasonal or year-round wetland, and 2.5ha of terrestrial grassy habitat.
- Plantings on Outer Embankment of EMDC – re-vegetate tops and outer embankments to provide about 2.23ha of terrestrial habitat, comprising mostly hydroseeded grassy habitats with planting of scattered stands of trees and bamboos for use by Ardeid species.
- Tidal Channel – provide about 1ha of tidal wetland habitat on an earthen bottom for natural colonisation by inter-tidal flora and fauna, with active management minimised.
- Flood Storage Pond at San Tin Villages – allow a minimum water level and sediment to accumulate on concrete bottom of the 2.2ha pond already constructed, and minimise management of vegetation on grasscrete banks.

- Tsing Lung Tsuen Drainage Channel – minimise cut back of vegetation on grasscrete banks along the upper embankment of the concrete channel already constructed.

4. TARGET SPECIES

4.1 Overview

4.1.1 Wetland habitats in NWNT are known to support a high diversity of species, most notably avifauna. The compensatory wetlands will be designed to provide habitats for species currently or historically using the project area and adjacent regions in the NWNT.

4.1.2 As the large number of species utilising wetlands in NWNT each have slightly different habitat requirements, it would be an unrealistic goal to try and design the compensatory wetlands to accommodate the needs of all species. Therefore wetland design will focus on creating habitats suitable for a group of key target species identified during the San Tin EIA. The six groups of organisms selected as target 'species' are as follows:

- Snipe (Common Snipe, Pintail Snipe, Swinhoe's Snipe and Painted Snipe)
- Ardeids (Little Egret, Cattle Egret, Great Egret, Grey Heron, Night Heron, and Chinese Pond Heron)
- Red-billed Starling
- Chironomids
- *Orthetrum Luzonicum*
- Narrow-mouthed Frog

4.2 Habitat requirements of target species

4.2.1 The following section gives a brief account of the ecology, habitat requirements, and conservation status of the selected target species.

Snipe

4.2.2. Several species of Snipe and related birds have been recorded in Hong Kong. Three of the most widespread are the Common Snipe (*Gallinago gallinago*), the Pintail Snipe (*Gallinago stenura*) and Swinhoe's Snipe (*Gallinago megala*). All three species are passage migrants and winter visitors to the SAR, and tend to reside in wet, marshy habitats (Viney *et al.*, 1994). *G. stenura* and *G. megala* have a particular preference for wetland agricultural areas, (i.e., abandoned paddy fields, watercress and water-spinach fields) over other wetland habitat types (Leven, 1998).

The Painted Snipe (*Rostratula bengalensis*) is not a 'true' snipe, although it has similar habitat preferences to the three species mentioned above. Until quite recently, it too was considered a passage migrant and winter visitor to Hong Kong (Chalmers, 1986). However, breeding birds have since been observed at four locations in the Northern New Territories (Lok Ma Chau, Tin Shui Wai, Long Valley, and Kam Tin, Leader, 1997).

Painted Snipe have a wide global distribution, with breeding populations being found in Africa, the Middle East and throughout Asia (Snow *et al.*, 1998). Over this range, they utilise a number of wetland habitats, including freshwater swamps and marshes interspersed with deep pools, soft muddy patches, thick shrub vegetation and reed beds (Snow *et al.*, 1998). In the Thai-Malay Peninsula, Painted Snipe largely depend upon wet agricultural land for breeding and foraging (Wells, 1999). This pattern is repeated in Hong Kong: breeding sites at both Kam Tin and Long Valley are in similar wet agricultural habitats. Due to their status as potential sites for

development, the wetland habitats at both Kam Tim and Long Valley have been studied extensively. The sites are dominated by a patchwork of inactive or abandoned wet agricultural land and seasonal/permanent marsh. The birds appear to favour shallow freshwater marshland that is dominated by a dense mix of low herbaceous vegetation (Leven, 1998). At Long Valley, Painted Snipe prefer vegetation around 0.5-1m in height with an overall coverage of approximately 80%. Dominant plant species include the grasses *Panicum repens*, *Digitaria disctrichum*, *Leersia hexandra*; and herbaceous plants *Ranunculus sceleratus*, *Rumex martius*, *Polygonum hydropiper*. The agricultural habitats utilised by Painted Snipe at Kam Tin have been inactive for longer than those at Long Valley, and consequently have a more diverse plant community (Binnie, Black & Vetch, 2000). Details of the plant species found in Painted Snipe habitats at Kam Tin are given in Table 4.1.

Table 4.1 Plant Species Composition of the Preferred Habitat for Painted Snipe at Kam Tin (after Binnie, Black & Veatch, 2000)

Species	Common Name	Relative Abundance*	Notes	Commercial Availability
Alocasia macrorrhiza	Alocasia	Uc	Common on damp slopes/banks, often close to streams	
Alternanthera sessilis	-	C	Low-growing, herbaceous plant. Emergent	✓
Ammania baccifera	Small-leaved water amaranth	C	Annual herb	
Apulda mutica	-	C	Grass 1-2m, common on woodland edges	
Cardamine flexuosa	Bitter cress	C	Annual Herb Weed in moist places	
Cyperus malaccensis	-	C	Sedge- grows at riversides and especially damp/swampy soils	✓
Cyperus pilosa	-	Uc	Sedge	✓
Coix lachyme-jobi	Job's tears	R	-	✓
Commelina nudiflora	Day flower	Uc	Herb common on swampy ground	✓
Cuscuta chinensis	-	Uc	-	
Echinochola crus-galli	Barnyard millet	C	Grows in swampy ground, weed in paddy fields	
Eichhornia crassipes	Water hyacinth	Uc	Exotic species	✓
Eleusine indica	Yard/Goose grass	Uc	Waste ground/roadsides	
Elipta prostrata	-	Uc	Herb Common in rice fields and ditches	
Floscopa scandens	-	Uc	Perennial Herb of wet places	✓
Hedychium coronarium	Ginger lily	Uc	Tall (1-2m) herb	✓
Hygrophila salicifolia	Willow-leaved hygrophila	C	Herb of wet places, up to 80cm high	✓
Ipomoea reptens	Water spinach	C	Muddy ground, rice paddies, or floating on water	
Kyllinga monocephala	-	C	Common Perennial sedge in grassland	
Leptochloa chinensis	-	C	Common annual of waste fields and paddy fields	
Ludwigia ascendens	Water primrose	C	Perennial herb, shallow areas of quiet water	✓
Ludwigia octovalis	Water primrose	C	Perennial herb, shallow areas of quiet water	
Ludwigia perennis	Water primrose	Uc	Perennial herb, shallow areas of quiet water	
Mikania micrantha	Mile-a-minute	C	Fast Growing, invasive exotic	

			species	
Oenanthe javanica	Water celery	C	Perennial herb of damp habitats. Emergent	
Panicum repens	Panic grass	Vc	Common grass and marshland species	✓
Paspalum conjugatum	Hilo grass/ Buffalo grass	Vc	Common in fields	
Paspalum distichum	Knotgrass/ water couch	Vc	Grass of wet places	✓
Pennisetum alopecuriodes	Chinese pennisetum	R	Common on banks/roadsides	
Pennisetum purpureum	Elephant grass/ Napier grass	Uc	-	
Philydrum lanuginosum	Wooly grass	R	-	✓
Polygonum hydropiper	Water pepper/ Smartweed	C	Annual herb of paddy fields and similar habitats	
Ranuncula soleratus	-	C		
Rotala indica	Indian rotala/ Tooth cup	C	Annual herb found in margins of ponds and streams, sometimes partially submerged	✓
Rumex maritimus	Dock	Vc	Annual herb common in paddy fields and abandoned land	✓
Sporobolus fertilis	Rat's tail	Uc	Grass, 50-100cm, often found on waste-ground and rubbish tips	
Wedelia trilobata	Yellow wedelia	Uc	Exotic species	
Sesbania cochinchinensis	Sesbania	Uc	Annual shrubby herb (2-3m) grows on swampy land	

***Relative Abundance**
VC – Very Common
C – Common
UC – Uncommon
R - Rare

(4.2.2 cont.)
Painted Snipe are becoming increasingly threatened in Hong Kong as developments lead to the loss of their preferred habitats. Of the four recorded breeding sites, it is now known that only two, Kam Tin and Long Valley, support breeding populations (Leven, 1998). Given the degradation of breeding grounds at Kam Tin (HKBWS, 2001), and the proposed and current developments at both Kam Tin and Long Valley, the conservation of existing habitats, and creation of new habitats suitable for this species is of paramount importance if populations are to be maintained in the SAR. Furthermore, it is anticipated that the creation of habitats suitable for Painted Snipe will also provide new habitats for other Snipe species in Hong Kong

Ardeids

1.2.3 The San Tin district forms part of a substantial system of wetlands in the North West New Territories, comprised of a number of habitat types including *gei wei*, active and abandoned fishponds, drainage channels, rivers, wet agricultural lands, and permanent/seasonal marshes.

The region as a whole is utilised by significant numbers of Ardeids (Herons and Egrets). In the area of EMDC project, studies carried out for the San Tin EIA Report identified six species of Ardeid to be common in the study area: Little Egret (*Egretta garzetta*), Cattle Egret (*Bubulcus ibis*), Great Egret (*Casmerodius albus*), Grey Heron (*Ardea cinerea*), Night Heron (*Nycticorax*

nycticorax), and Chinese Pond Heron(*Ardeola bacchus*). These species have been selected as Target species for the compensatory habitats.

A number of recent studies in Hong Kong have noted the importance of actively managed fishponds to ardeid species (see Aspinwall & Company, 1997; and references therein). Observations in the field have demonstrated that fishponds are the preferred feeding ground for many ardeids, and data analysis has revealed significant correspondence between heron and egret occurrence and fishpond distribution (Aspinwall & Company, 1997). The ponds provide a rich supply of food, especially when commercial fish are being collected. During harvesting, ponds are gradually drained by pumping water into surrounding ponds to facilitate the collection of commercial fish. After their removal, large numbers of remaining small fish (e.g., *Gambusia*) and invertebrates (e.g., *Macrobrachium*) are available for bird feeding.

Ardeids generally roost in dense, low vegetation (<0.5m) on bunds and islands, and nest in stands of trees and bamboo. The location and size of egretries is clearly related to the availability of nearby foraging sites (Melville *et al.*, 1994). Over 70% of egretries found in Hong Kong are situated in the North West New Territories, where extensive wetland habitats provide ample feeding resources (Aspinwall & Company, 1997).

In addition to fishponds, ardeids in Hong Kong utilise many other wetland habitats. Wet agricultural land, for example, is of particularly importance for breeding populations of Cattle Egrets, especially where Water Buffalo are present (Leven, 1998). Ardeids can also be observed foraging in rivers, drainage channels and marshes.

Red Billed Starling

4.2.4 The Red-billed or Silky Starling (*Sturnus sericeus*) is a winter visitor to Hong Kong. Preferred habitats of the starling include open lowland areas (including agricultural land) and coastal mangroves, where they can often be found in large flocks (Viney *et al.*, 1994). Other studies have shown they also use fishpond bunds as foraging sites (Aspinwall & Company, 1997). Red-Billed Starlings were found to be relatively common in the EMDC project area during field studies conducted in 1997-1998 (ERM, 1999). Despite its widespread and abundant local distribution, the Red-Billed Starling is classified globally as a near threatened species (Collar *et al.*, 1994).

Chironomids

4.2.5 The larvae and pupae of chironomids are found in all but the most heavily polluted of Hong Kong freshwaters. Species most commonly associated with fishponds and marshes in the North West New Territories are from the sub-families chironominae and orthocladinae (Salas & Gallacher, 2001). Large numbers of adults congregate on grasses and reeds around ponds and marshes, where they serve as a valuable food source for insectivorous birds such as swifts, martins and warblers (Melville *et al.*, 1994).

Larval chironomids are found in similarly large numbers in the soft bottom sediments of ponds and marshes. The diversity and abundance of chironomids in lentic habitats is dependent on a variety of factors. Similar to other macroinvertebrate taxa, high chironomid diversity tends to be associated with relatively unpolluted wetlands that support abundant emergent, submerged and floating vegetation (Salas & Gallacher, 2001). Immature chironomids provide an important food source for some species of wading bird (Ashley *et al.*, 2000), and also play an central role

in aquatic community structure and function, forming a large part of the diet of predatory insects (e.g., dragonfly nymphs, aquatic beetles) and fish.

Moderately nutrient enriched habitats contain few species of chironomid, but may support high densities of pollution tolerant taxa (e.g., *Chironomus*). These larvae can thrive in these oxygen poor environments as they possess haemoglobin, allowing them to make better use of what little oxygen is available.

Orthetrum luzonicum

4.2.6 Odonates (dragonflies and damselflies) are amongst the most conspicuous and intensively studied invertebrate groups in Hong Kong, with over 100 species having been recorded to date (Wilson, 1995).

As the nymphs of odonates are aquatic, all species are dependent upon freshwater/brackish habitats during part of their life cycle. The type of freshwater inhabited depends entirely on the requirements of a given species. For example, the nymphs of *Zygonyx iris* are confined to the fast-flowing riffle sections of streams, whereas *Agriocnemis femina* prefer well-vegetated marshes. Despite these differences, it is possible to make a few generalisations about the preferences of species occupying broadly similar habitats. Species associated with lowland, lentic habitats tend to have the following requirements:

- Odonates nymphs are generally more diverse and abundant in habitats supporting emergent, aquatic and floating vegetation (Salas & Gallacher, 2001). Water plants provide shelter for adults and nymphs, and egg laying sites for adults. Additionally, heavily vegetated habitats often support high densities of other aquatic insects (such as chironomids), which are important prey items for dragonfly nymphs (Streever *et al.*, 1995; Salas & Gallacher, 2001).

- In Hong Kong, most dragonflies spend the colder months of the dry season as nymphs, and therefore require ponds or marshes that retain some water all year round.

- Freshwater aquatic invertebrates, including dragonfly nymphs, are sensitive to many forms of pollution (Dudgeon & Chan, 1996; Gallacher, 2000; Salas & Gallacher, 2001). The distribution of most dragonfly species is therefore limited to habitats with adequate water quality.

One dragonfly species, *Orthetrum luzonicum*, has been selected as a target species for the compensatory wetland. This dragonfly is widespread in Hong Kong, and abundant around its preferred habitat of well-vegetated permanent marshes (Wilson Pers. Comm.). Although not a rare species, the colonisation of wetlands by *O.luzonicum* will serve as an important indicator for the overall success of the project. The presence of *O.luzonicum* at the wetlands will indicate that suitable conditions have been created to support other species dependant on permanent marshland.

Spotted Narrow mouthed frog 侧纹姬蛙

4.2.7 The Narrow mouthed frog (*Kaloplirynus interlineatus*) was previously thought to be rare in Hong Kong (Lai & Ng, 1972), and was recorded from only a limited number of locations: Kam Tin, Fanling, Shek Fong, and Lam Tsuen (Romer, 1979). However, a recent study (Lau, 1998)

has shown that this species can be found in lowland areas across much of the New Territories. The frog is distributed over a range of terrestrial habitats, including cultivated and abandoned fields, shrubland, plantations and forest.

In the wet season, Narrow-mouthed frogs move into marshland areas to breed. Lau (1998) noted that breeding sites for this species shared a number of common features. Sites were surrounded by abandoned agricultural land, forest and/or grassland. Most were seasonal lentic habitats, having a mud/silt substrate, and ranging in size from 10-100m^2. At the majority of sites, canopy cover was sparse, and marginal macrophyte cover ranged from medium to dense. Extensive stands of emergent hydrophytes were present at most sites.

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5 HABITAT CREATION

5.1 Overview

Habitat creation will provide 3.43ha of compensatory freshwater wetland habitat and 2.23 ha of terrestrial habitat comprising mostly hydroseeded grassy habitat with scattered tree, shrub and bamboo plantings for use by target Avifauna, Chironomids, *Orthetrum luzonicum*, and Narrow-mouthed Frog.

The approach to the design of the habitats is to create the soil and water conditions, which will support vegetation communities that are considered optimum in order to encourage the target faunal species to colonise the area and continue to support them in as sustainable manner as is practicable. It is expected that if the right habitat conditions for the target species are created, then colonisation will occur naturally. The design will take as references the four broad types of habitat communities listed in Table 5.1 below.

Table 5.1 – Habitat Type Requirements of Vegetation and Target Faunal Species

Habitat	Land form / hydrology	Vegetation	Fauna
Permanent pond	Characterised by very slow moving water body, with deepest sections typically 3000 mm throughout the year, and with gently sloping banks.	Vegetation typically herbaceous and floating, rooted with floating leaves and rooted and submerged.	Snipe species described in Table 4.2.2 Ardeid species Chironomids *Orthetrum luzonicum* Narrow mouthed frog
Permanent marshes	Area characterised by shallow, very slow moving water body (typically 50 – 150 mm deep). Gentle bank profiles, and a fairly constant supply of water in order to remain permanently inundated throughout the year.	Submerged, emergent and marginal vegetation. Standing in or immediately adjacent to large bodies of shallow water.	Snipe species described in Table 4.2.2 Ardeid species Red-billed Starling *Orthetrum luzonicum* Chironomids Narrow mouthed frog
Seasonal marshes	Variably shallow to deep swale that may intersect ground water level in deeper sections where soils may be inundated seasonally, making them wet during the summer months and poorly drained to dry during the winter months. Poorly to moderately drained on lower banks.	Characterised by emergent (in deeper sections) and marginal vegetation in bottom of swales. Lower bank grassy and/or shrubby terrestrial riparian plants merging with marginal vegetation in shallower sections.	Snipe species described in Table 4.2.2 Ardeid species Red-billed Starling Chironomids *Orthetrum luzonicum* Narrow mouthed frog
Terrestrial	Lower banks, upper banks (riparian), terraces and generally elevated, moderately to free drained areas that do not retain standing water.	Typically supporting grasses, shrubs and medium to tall woodland vegetation.	Snipe species described in Table 4.2.2 Ardeid species Red-billed Starling Narrow mouthed frog

5.2 Details of Created Habitats

The project area is long and linear and the proposed wetland creation is situated between and alongside the proposed EMDC and the existing Shenzhen Border Crossing Facilities. As discussed in previous documentation, the shape of the site is a constraint to the creation of sustainable wetlands, due to the unfavourable wetland edge to area ratio. In this respect, the wetland habitats will utilise maximum space available on the site, to provide for the wetland habitat requirements of the target species, with terrestrial plantings relegated to the edges for screening and the provision of terrestrial habitat.

As the project area, in its current state, is not inclined towards lowland wetland habitat, the water regime will need to be engineered to function successfully. The proposed storage pond is located in the widest available part of the site, and up-slope of the main wetland areas. The site levels fall towards the Shenzhen River, and this allows for water to be gravity fed from the storage pond, to the permanent marshes and pond without pumping. Water will however, need to be pumped into the storage pond from the EMDC. Water circulation otherwise would require bunding to change levels and this would prove costly and an inefficient use of space. In flood events, excess water in the pond and marshes will drain through overflow pipes and into the EMDC, down stream of the inflatable dam.

Ground water levels are an uncertainty due to the potential of the ground water levels to be affected with construction of the EMDC. The permanent pond and marshes will require a watertight seal to ensure against water loss in the drier months and saline intrusion from tidal water pressure from the adjacent Shenzhen River. An impervious clay liner will be laid over a layer of inert, compacted material. Over top of the clay seal, a layer of hydric soils or decomposed granite will be laid down for planting purposes.

The large pond at the north of the site will be hydrologically separated from the adjacent permanent marshes due to the interception of a proposed concrete drainage channel. Land either side of the drainage channel will be above the high water level and planted with terrestrial plants. Water moving from the permanent marshes towards the pond may either need to flow through a narrow open channel with reinforced sides and bottom.

Drainage of the pond and permanent and seasonal marshes in the event of flooding will be via the EMDC via overflow pipes. Where back flow is a potential hazard, the pipes, will be fitted with valves.

Hydrology

Hydrological Model – A hydrological model to simulate the water balance is developed for the proposed wetland based on the data of rainfall, evaporation and potential evapo-transpiration recorded by the Hong Kong Observatory (HKO) from 1991 to 1999. Loss due to seepage is also accounted by assuming the depth of pond lining layer in the proposed wetland is approximately equal to the average depth of pond deposit in the existing ponds in the vicinity. As loss due to evaporation, potential evapo-transpiration and seepage is usually higher than the contribution from rainfall during the dry season, water supply from external sources is required.

In addition, a portion of storm water received by the wetland from heavy rainstorms is required to be discharged to the San Tin Channel in order to ensure that the water depth within the permanent marsh is not too excessive. Hence, the actual contribution from rainfall is reduced which exacerbates the demand for water supply from external sources. Based on the modeling

results, the average and maximum annual amounts of water required by the wetland are about 24,500 m^3 and 35,000 m^3, respectively, and the average and maximum annual amounts of water discharged from the wetland are about 8,300 m^3 and 20,500 m^3, respectively.

5.2.1 Permanent Open Ponds

There are two ponds. One a true deep pond, located at the northern most end of the site and the other is a shallow pond located at the site of the existing Western Reed Bed 1. They have shallow embankment profiles of approx. 4:1 in the deepest pond and 12:1 in the shallow pond, to extend the habitat of emergent and submerged vegetation. The deep pond shall be approx. 3000 mm deep x approx. 3600 m2 at the base, not accounting for the sloped sides. The shallow pond shall be 1500 mm deep x approx. 2000 m2 at the base, not accounting for the sloped sides.

Plant species would include a range of floating and rooted hydrophytes, planted into the substrate to a maximum depth of 1500 mm and merging into emergent permanent marsh plantings at the edges of the ponds.

Construction of the ponds shall allow for a stable and compacted layer of inert material, a compacted clay liner and a final layer of hydric soils and/or completely decomposed granite for planting.

Drainage of the pond shall allow for the maintenance of a desired maximum water level below the top of the EMDC embankment and adjacent land areas. The overflow control structure would discharge into the EMDC downstream of the inflatable dam with an inlet in the centre of the pond set at the desired maximum water level. Outflow into the EMDC will be a pipe and valve mechanism above the maximum water level of the Shenzhen River. Design for management shall allow drainage of the pond to facilitate the removal of sediments, which are likely to accumulate over time.

5.2.2 Permanent Marshes

The permanent marshes cover 3.43 ha between the EMDC and Sam Shan Road. They are located along the top of the eastern edge and for the majority of the length of the EMDC, especially the northern half, north of the proposed storage pond.

Water depths will vary between 0mm at the margins and 150mm at the deepest sections, with 100mm being the average water depth. The bed of the permanent marshes will undulate throughout to provide a diversity of depths and floral and faunal habitats. The permanent marsh will be shelved where it meets the pond. At irregular intervals, large rocks will be placed at the margin of the marshes to provide terrestrial and wetland habitat and refuge for a variety of fauna.

As with the permanent ponds, excavation of the marsh areas shall allow for a layer of compacted inert material, a compacted clay liner and a final layer of hydric soils and/or completely decomposed granite as a planting layer. Levels will allow for the permanent marshes to receive water from the storage ponds through simple gravity feed.

Planting will consist of emergent and marginal plants with a small range of submerged plants. They shall be planted at the recommended spacing to allow for spread, competition and final natural adjustments to water depth.

5.2.3 Seasonal Marshes

Seasonal marshes are located in one contiguous length along the top of the eastern side of the EMDC, at the southern end of the project area. Swale width varies between 2m – 15m and depth between 1500 m and 2000 mm below ground level. Ground water levels vary between 500 – 1000 mm below ground level. Proposed water levels in the seasonal marsh will be 1000mm at the deepest points in summer and 0 mm in winter. The form and levels of the swale will be irregular to create a diversity of habitats and hydrological gradients.

The form of the swales shall be irregular and the embankment profiles constructed with shallow gradients to encourage the growth of emergent and marginal vegetation. It may be possible to intercept the seasonally fluctuating ground water at the deepest section to inundate the soils during the wetter months. The same principle applies to the shallow sections of the swale, which will be very poorly drained or saturated for the same period; otherwise the swale will depend upon seasonal rainwater.

The swale will be excavated and lined with a layer of hydric soils in deeper sections and otherwise soils native to the site except at the top of the banks where typical amenity landscape soils formed by mixing CDG with soil ameliorating materials such as rotted sawdust may be applied. Drainage of the swale will be into the EMDC.

Plantings will consist of emergent and marginal plants in deeper sections and marginal and riparian shrubs in shallow sections. Parts of the banks of the swale may be planted with appropriate turf grass species.

5.2.4 Terrestrial Habitats

The terrestrial habitats will include the areas of land above the maximum high water levels of the marshes and ponds (approx. 2.23 ha.). These areas will be broken down into three separate hydrological gradients, ranging from very poorly drained to moderately well drained. They are:

- Lower bank (riparian)
- Upper bank (riparian)
- Terrace

These zones relate to lower sides of the swale, topsides of the swale and all other terrestrial areas. Variability in levels and subsequent drainage of the terrace will be reflected in the choice of tolerant species. Wherever practicable, all levels will drain towards the wetlands.

Target bird species will be provided with perching, roosting and nesting sites for the Ardeids and Red Billed Starling and Snipe species (described in Table 4.2.2) nesting sites amongst specified tree groupings and low grassy areas. These trees and other tree plantings will also provide screening of the Shenzhen Border Crossing area and reduce the scale of container storage areas and truck parks. The plantings will consist of stands of trees and multi-layered

plantings with the full component of multi-specific ground covers, shrubs and canopy trees. Other mixes of tree and shrub plantings will provide termination to the fish pond bunds where they intercept the project area, plantings adjacent to roads and under the proposed rail over bridge. Grassy areas are proposed for sides of swales, the sides and bottom of the EMDC and a large proportion of the western side of the project area. Where structures are proposed, these will be screened with tree and shrub plantings and/or suitable climbing plants.

It should be noted that all plants would be native to the site and planting profiles provided from examples of similar wetland and terrestrial land types in the nearest possible vicinity. All plants will be gathered from the nearest possible source.

Every attempt shall be made to minimise the felling of existing trees. Existing individual specimens of trees or tree groups of high amenity value shall be preserved on site as far as possible as valuable landscape and visual resources of the environment and be blended in with the new development of this project. If tree felling is unavoidable, tree transplanting shall be considered for accessible and suitably sized trees. Tree removal either by felling or transplanting shall need approval from relevant authorities according to WBTC No. 24/94. Compensatory tree planting shall be included as part of the landscape works for the project. At a minimum, the same number of trees shall be replanted as those felled. Semi-mature trees of suitable species shall replace any mature trees proposed to be felled, with valid justification, and the replacement quantity shall not be less than the number of mature trees that are proposed to be felled.

5.3 Landscape Mitigation Measures

Mitigation measures to reduce the impacts of the EMDC on the existing landscape character and landscape resources of the area, and to ameliorate impacts on visually sensitive receivers, include:

- Refinement of the works (including temporary access and working areas) in order to minimise impact on existing vegetation,
- Random planting of trees in groups or individually along the outer embankments of the new EMDC to simulate the former landscape pattern,
- Screen planting to reduce impact of storage and trucks to affected properties.
- Grass / herb vegetation to be established to the inner inclined sides of the channel (and to the base where possible) in consultation with CE/MN DSD and the O&M party.
- Grasscrete Lining of EMDC – provide approximately 4.5 ha (the bottom area of the channel) of seasonal or year-round wetland, and 2.5ha of terrestrial grassy habitat, with active management efforts minimised to allow natural colonisation by vegetation.
- Tidal Channel – provide about 1ha of tidal wetland habitat on an earthen bottom for natural colonisation by inter-tidal flora and fauna, with active management minimised.

- Flood Storage Pond at San Tin Villages – allow a minimum water level and sediment to accumulate on concrete bottom of the 2.2ha pond already constructed, and minimise management of vegetation on grasscrete banks,

- *Planting on Outer Embankment of EMDC* – re-vegetate tops and outer embankments to provide about 2.23ha of terrestrial habitat, comprising mostly hydroseeded grassy habitats with planting of scattered stands of trees and bamboos for use by Ardeid species, and

- *Tsing Lung Tsuen Drainage Channel* – minimise cut back of vegetation on grasscrete banks along the upper embankment of the concrete channel already constructed.

5.3.1 Tidal Portion of EMDC

The tidal portion of EMDC is immediately down stream of the inflatable dam and is saline to brackish. Water levels are dependent upon tides/lunar cycles and flood events. The project area concerns the embankments only, which will be hydroseeded and feature random terrestrial plantings for roosting and perching. However, the tidal portion of the EMDC will provide a potential foraging ground for larger Ardeid species.

5.3.2 Grasscrete Lined Main Drainage Channel

The EMDC will be lined with grasscrete on the sides and bottom. The channel sides (approx. 25000 square metres) and the channel bottom (approx. 45000 square metres) will be hydroseeded.

The low flow channel should be altered to be more permeable and support wetland vegetation. It should have grasscrete on the bottom and low concrete nib walls either side to retain the low flow. The width should increase to 2000 mm in the lowest section, which will be 500 mm deep, and be adjacent to another wider section, say 4000 mm wide and 250 mm deep. This will allow a wider saturated area to develop. The low flow channel would be allowed to meander over the bottom of the channel rather than in a straight line. It is anticipated that the wetland vegetation that would develop in the MDC will provide a potential foraging ground for Ardeid species and other wading birds.

5.3.3 San Tin Flood Storage Pond

The pond will be maintained with water in the bottom due to village feng shui requirements. It will thus have potential to provide compensation for wetland habitat loss. The pond has grasscrete banks at a 1:2 slope, and a concrete bottom. As the pond has been constructed, there is no scope to alter the design or bottom composition. The limitations of the impermeable bottom can be partly overcome by allowing a semi-natural bottom to develop through the accumulation of sediment over time.

Water levels in the pond will be maintained at between 300 – 850 mm and therefore marginal vegetation such as grasses, reeds and sedges, growing in the grasscrete and bottom sediments will eventually form a fringe around the edges to provide a potential foraging ground for

Ardeid species. Management of the pond should ensure the periodic removal of sediments does not reduce the habitat of established marginal plants.

6. MONITORING

6.1 Overview

6.1.1 Monitoring is necessary to determine whether a re-creation project has been successful. In this section, details are given of a monitoring programme designed to evaluate the relative success of the created wetland habitats at San Tin. The monitoring programme is based upon the regime outlined in the San Tin EIA Study EM&A Manual. Additionally, reference is made to the material presented in Appendix B of the Brief, which provides a clarification of the monitoring strategies outlined in the EM&A Manual. The monitoring programme will incorporate the following key ideas:

- *Reference habitats* – The proposed monitoring programme will identify suitable reference habitats: measurements taken at sites with similar hydrological, biogeochemical and ecological structure and functions to the created wetlands will facilitate the development of standards against which habitat recreation efforts can be evaluated (Brinson & Rheinhardt, 1996).

- *Indicators* – Once reference habitats have been identified, key indicators of the structure and functioning of these habitats can be selected. These may be abiotic (e.g., water quality), or biotic (e.g., plant communities) parameters.

- *Indicator objectives* – Values of key indicator functions at reference sites will allow objectives to be set for the created habitats.

6.2 Selecting Reference Habitats

6.2.1 The selection of reference sites for the proposed monitoring programme is hampered by a lack of complete data sets from Hong Kong wetlands. Table 6.1 lists the sites upon which the various recreated habitats are to be based. Unfortunately, data from these sites, which are known to support the target species, is incomplete. Information from other local sites will therefore be used to supplement data from selected reference sites. For example, no benthic macroinvertebrate data is available from Long Valley and Kam Tin, so records from freshwater marshes in the Deep Bay area and other regions in the NT will be used.

Table 6.1 – Reference sites for created wetland habitat types

Habitat Type	Local Example
Terrestrial	Fish pond bunds, scrub and woodland, Mai Po Nature Reserve
Permanent Marsh	Abandoned agricultural wetland, Long Valley and Kam Tin
Seasonal Marsh	Abandoned agricultural wetland, Long Valley and Kam Tin
Permanent Pond	Freshwater ponds, Mai Po Nature Reserve (biodiversity area BMZ10)

6.3 Selecting Indicators

6.3.1 The main aim of the project is to attract selected target species to the created wetlands. However, because of external factors (e.g., natural spatial and temporal variation in target species populations, human activities and pollution outside the site boundary) beyond the

control of those managing the habitats, there is no way of guaranteeing that target species will establish themselves in the compensatory wetlands, even if optimal habitat conditions are created.

6.3.2 These factors present difficulties in using the establishment of target species as a measure of the success of the project. Therefore, other measures of success or failure must be selected to serve as more reliable indicators of the projects relative success. Keddy (1999) gives a list of guidelines useful for selecting indicators of wetland habitat quality:

- ***Ecological significance*** – Closely related to maintenance of essential environmental processes (e.g., water-level fluctuations) and ecosystem functions (e.g., primary production).
- ***Macro scale*** – measuring the state of entire systems or key processes rather than small pieces or selected key species.
- ***Pragmatic*** – guided by measurable or empirical attributes of systems rather than conceptual or theoretical concepts and notions.
- ***Sensitive*** – quick response to stresses and perturbations, to minimise lag and give maximum response times for decision-makers.
- ***Simple*** – easy to measure, therefore inexpensive.

6.3.3 Using these criteria, the following abiotic and biotic indicators have been selected for the proposed monitoring programme in addition to the Target Species:

- ***Water Quality*** – A key factor influencing the composition of wetland communities, particularly salinity and organic enrichment.
- ***Water Depth*** – To encourage the establishment of suitable vegetation, water depth needs to be closely controlled. Optimum water depth will differ in each of the created habitats.
- ***Plant communities*** – Features of plant communities such as species composition/richness, percentage cover and height, are important determinants of the faunal communities wetlands are capable of supporting.
- ***Benthic macroinvertebrates*** – The species richness and composition of benthic macroinvertebrate communities have been shown in previous studies to be good indicators of overall wetland habitat quality.

6.4 Indicator Objectives

6.4.1 Values from key indicator functions at reference sites and other local wetlands will allow objectives to be set for the created habitats. If these objectives are met, then the wetland creation scheme will have succeeded in its primary goal of creating habitats suitable for the target species.

6.4.2 It is worth noting that these objectives may be subject to revision. As monitoring proceeds in this and similar wetland creation schemes across Hong Kong, newly collected and analysed data may suggest different objectives as more suitable indicators of successful wetland creation.

Target Species

6.4.3 Objectives for the use of the compensatory wetlands by target species are given in Appendix B of the Brief, and are summarised in Table 6.2. For reasons discussed in section 6.3, the indicator objectives in table 6.2 cannot be used as effective measures of the success of habitat creation. It is intended that indicator objectives for target species are used as guides to promote the effective management of the created habitats.

Table 6.2 - Monitoring Objectives for Selected Target Species

Target Species	*Baseline data available*	*Proposed operational phase monitoring*	*Indicator objectives*	*Notes*
Snipe	Categorical abundance data are available for two species of snipe. *Gallinago gallinago* and *G. stenura*. *Gallinago megala* and *Rostratula hengalensis* were not recorded during 1997-98 field studies*. Presence/absence data for these species is presented under Annex 3-E(1) of the EIA Report.	Avifauna will be surveyed using a direct count method. Both the EMDC, the area downstream of the inflatable dam and the constructed wetlands will be surveyed four times a year, as specified in the San Tin EIA Report *EM&A* manual.	Presence of species on site	The two species recorded in the project area in 1997-98 were regarded as uncommon. The remaining two 'snipe' species were not present during the detailed surveys in 1997-98. The presence of any snipe species in the constructed wetlands is therefore considered a suitable objective
Ardeids	Quantitative abundance data were recorded for the six Ardeid species found to be common in the project area in 1997-1998		Species richness and overall densities comparable to those recorded prior to the development.	Six species of Ardeid were common in the project area in 1997-98. During winter (when Ardeid density is highest) an average of 17.58 (SD 9.88) were recorded in the project area.

Red billed starling	Categorical abundance data were recorded for this group in 1997-1998		Categorical abundance comparable to those recorded prior to the development	Categorical data were collected for this species during the 1997-98 surveys, where the red-billed starling was classified as common in the project area. It is difficult to provide specific density targets for this species, as they have a very 'patchy' distribution across the Northern N.T. moving between feeding sites in large flocks of several hundred birds.
Chironomids	Quantitative abundance data of adult chironomids from two sites within the project area were recorded for this group in 1997-1998	Three grassy areas within the constructed wetlands will be sampled. Sampling methodology will follow techniques used to collect baseline data in 1997	Densities comparable to those recorded prior to the development	An average of 37 (SD 22.2) adults were caught per 15 sweep nets in Spring 1997
Orthetrum luzonicum	Presence/absence data were recorded for this species in 1997-1998	Relative abundance will be recorded during monitoring of other target species.	Presence of species on site	This species was found in only one small section of the project area during 1997-98 surveys. It is therefore considered that any record of the species utilising the constructed wetlands to be a suitable objective
Narrow Mouthed Frog	Not recorded in the project area	Relative abundance will be recorded during monitoring of other target species/macroinvertebrates	Presence of species on site	This species has never previously been recorded in the project area. It is therefore considered that any record of the species utilising the constructed wetlands to be a suitable objective

* - A 12 month ecological survey was undertaken during 1997-98 for the Main Drainage Channels and Poldered Village Protection Scheme for San Tin. NWNT: Environmental Impact Assessment Study. 1999 (The San Tin EIA Report)

Water Quality

6.4.4 Water quality data collected from a number of inactive ponds and marshes across the SAR are given in Appendix 1. These data show large variations in the water quality of wetlands across Hong Kong: sometimes even adjacent ponds exhibit marked differences in water chemistry. As a result, the specific water quality objectives for the created wetland, given in Table 6.3, are quite broad.

Table 6.3 – Proposed water quality objectives for the created wetlands

Parameter	Unit	Value
Salinity	(g/Kg)	< 2.0
Conductivity	(µS/cm)	< 800
Dissolved Oxygen	(mg/l)	> 4.5
pH	-	4.0 - 7.0
Turbidity	(NTU)	< 20.0
Suspended solids	(mg/l)	< 18.0
BOD_5	(mg/l)	< 15
NH_3-N	(mg/l)	< 1
TP	(mg/l)	< 1

Water Depth

6.4.5 Table 6.4 details the water depths appropriate for the various habitat types to be incorporated in the created wetlands, along with notes describing flow regimes. Values are based on observed water depths in reference wetlands.

Table 6.4 – Water depth of different habitat types within the created wetlands

Habitat Type	Typical Average Water Depth	Through Water Flow
Terrestrial	0	Seasonal irrigation by natural rainfall sufficient to maintain terrestrial vegetation.
Permanent Marsh	0-200 mm rough surface to allow variations	Permanently wet, maintained by regular flow of water either from rain or groundwater, supplemented by irrigation water during the winter months. Typical flows would be of the order of 1-2 litres per second depending on the cross-sectional width of the wetland area perpendicular to the line of the flow.
Seasonal Marsh	0-1000 mm	Seasonal supply of water by natural rain sources, with marshes filling up to 1000 mm deep in the summer months and slowly drying out in the winter months. No through flow required.
Pond	Greater than 1500 mm	Permanently wet with a minimum water depth of 1000 mm maintained by rain or artificial water source. No specific through flow required, but sufficient water movement (water input / outflow / aeration etc.) to prevent stagnation

Plant communities

6.4.6 The indicator objectives for plant communities are focussed on the creation and maintenance of vegetation utilised by target species. Details of these communities have already been given in Sections 4; therefore the following review of plant community objectives is a summary.

Seasonal/Permanent Marshes

6.4.6.1 Of the selected target species, Painted Snipe have the most specific habitat requirements in terms of vegetation (Section 4.2.2). It is anticipated that if marshland plant communities can be created to suit this species, the created habitats will also be of use to other target species. The key plant community objectives for marshes in the created habitat can be summarised thus:

- Vegetation structure: height approximately 0.5m, overall coverage approximately 80%
- Dominant plant species to include the grasses *Panicum repens*, *Digitaria disctrichum*, *Leersia hexandra*; and herbaceous plants *Ranunculus sceleratus*, *Rumex martius*, *Polygonum hydropiper*.
- Establishment of a similar plant community to Table 6.5 (excluding exotics, these species were found to be common or very common in Kam Tin habitats supporting populations of Painted Snipe).

Table 6.5 Common plant species found in Painted Snipe habitats, Kam Tin

Species	Common Name	Notes
Alternanthera sessilis	-	Low-growing, herbaceous plant, emergent
Ammania baccifera	Small-leaved water amaranth	Annual herb
Apulda mutica	-	Grass 1-2m, common on woodland edges
Cardamine flexuosa	Bitter cress	Annual Herb Weed in moist places
Cyperus malaccensis	-	Sedge- grows at riversides and especially damp/swampy soils
Echinochola crus-galli	Barnyard millet	Grows in swampy ground, weed in paddy fields
Hygrophila salicifolia	Willow-leaved hygrophila	Herb of wet places, up to 80cm high
Ipomoea reptens	Water spinach	Muddy ground, rice paddies, or floating on water
Kyllinga monocephala	-	Common Perennial sedge in grassland
Leptochloa chinensis	-	Common annual of waste fields and paddy fields
Ludvigia ascendens	Water primrose	Perennial herb, shallow areas of quiet water
Ludvigia octovalis	Water primrose	Perennial herb, shallow areas of quiet water
Oenanthe javanica	Water celery	Perennial herb of damp habitats. Emergent

Panicum repens	Panic grass	Common grass and marshland species
Paspalum conjugatum	Hilo grass/ Buffalo grass	Common in fields
Paspalum distichum	Knotgrass/ water couch	Grass of wet places
Polygonum hydropiper	Water pepper/ Smartweed	Annual herb of paddy fields and similar habitats
Ranuncula scleratus	-	
Rotala indica	Indian rotala/ Tooth cup	Annual herb found in margins of ponds and streams, sometimes partially submerged
Rumex maritimus	Dock	Annual herb common in paddy fields and abandoned land

Terrestrial Habitats

6.4.6.2 Lists of common plant species found in various terrestrial habitats in the NWNT are given in Appendix 2. The following objectives are based on these data.

- Vegetation Structure: (app. 90% cover, a mix of different habitat types)
- Establishment of similar plant community listed in Table 6.6.

Table 6.6 – Common Terrestrial Plant Species found adjacent to wetlands in NWNT

Grassland	**Shrubland**	**Tree/Bamboo stands**
Panicum sp. *Alternanthera* sp. *Commelina communis* *Ipomoea aquatica* *Lantana camara* *Bidens rubra* *Paspalum conjugatum*	*Eurya chinensis* *Evodia lepta* *Ficus pumila* *Ilex puescens* *Litsea cubeba* *Litsea rotundifolia* *Rhaphiolepsis indica*	*Ficus microcarpa* *Litsea glutinosa*

Ponds and open waters

6.4.6.3 Little information available concerning the floral community composition of ponds in the study area. The following objectives have therefore been based on limited data collected by Dudgeon and Chan (1996).

- Maintenance of areas of deep (>1500mm) open water (approximately 75% of pond surface area)
- Establishment of a similar plant community to Table 6.7

Table 6.7 - Emergent, Submerged and Floating Plant Species Common in Hong Kong Ponds

Vegetation Type	Emergent	Submerged	Floating
Species	Dominated by grasses & sedges. *Juncus* sp. present at some sites	*Bacopa monniera* *Chara* spp. *Utricularia* sp.	*Lemna minor* L.

Aquatic macroinvertebrate communities

6.4.7 Previous research has shown this macroinvertebrate communities to be useful indicators of general habitat quality in freshwaters (e.g., Karr & Chu, 1999). Two aspects of community structure; species richness and indicator taxa, are proposed for inclusion in the monitoring programme.

Species richness

6.4.7.1 Salas & Gallacher (2001), in a survey of freshwater marshes and ponds in the Deep Bay area, suggested that macroinvertebrate species richness could serve as an indicator of water quality/general habitat quality (see Table 6.8). An average of 27 macroinvertebrate taxa were recorded in a territory wide survey of wetlands carried out by Dudgeon & Chan (1996). Therefore, a suitable objective for the created wetlands would be a macroinvertebrate community with a taxon richness comparable to this average.

Table 6.8 - Relationship between macroinvertebrate taxon richness and water quality/Habitat Integrity

Taxon Richness	Water Quality/ Habitat Integrity
0-10	Very Bad
11-20	Bad
21-30	Fair
31-40	Good
Above 41	Excellent

Species composition

6.4.7.2 Salas & Gallacher (2001) identified several macroinvertebrate taxa that were indicative of good habitat quality in Deep Bay area wetlands. These included:

Agriocnemis, Cloeon, Diplonychus rusticum, Culex, Ceriagrion, Orthetrum, Helochares, Polypedilum, Diplacodes, Paraplea and Notonectidae

The presence of these taxa at the created habitats would suggest they were of comparable quality.

6.5 Monitoring

6.5.1 Monitoring as described in Section 6.2 of the San Tin EIA Study EM&A Manual will allow those managing the compensatory wetlands to determine if the majority of indicator objectives are being met. In the Manual, ecological monitoring is specified to be undertaken by an ecologist appointed by TDD. The following section summarises the monitoring detailed in the EM&A Manual, and briefly describes additional monitoring required for Target Species and Benthic macroinvertebrates.

Monitoring Bird Use of Project Area

6.5.2 Avifaunal surveys of the MDC (both upstream and downstream of the inflatable dam) and the constructed wetland will be carried out four times a year, at three month intervals, for a period of three years starting from the completion of construction. The surveys will be conducted over three non-consecutive days during early morning for each sampling session, accounting for tides, which will influence Ardeid numbers in particular. Reporting will cover species and numbers of birds, numbers and proportions of wetland dependent birds, note-worthy behavior.

Monitoring of Fish and Invertebrates in Constructed Wetland Area

6.5.3 Fish: Fish will be sampled with fine-mesh cast nets at three locations in the constructed wetlands. Captured fish will be identified to species and measures for standard length. The weight of the total catch for each cast will be recorded.

Benthic Invertebrates: At the same sampling locations used for fish, three grab-samples will be taken at each site using a $0.1m^2$ van Veen grab. Samples will be preserved and identified to the lowest possible taxonomic level.

Chironomid Adults: Three sampling locations for chironomid flies will be selelcted within the constructed wetland area. These should be located in areas dominated by grassy or reedy vegetation rather than open water, and should be widely separated from each other. The dominant vegetation of the sampling site should be recorded. Chironomids should be sampled using a sweep net of 1.5mm mesh size. Fifteen sweeps should be made at each site. Results should be reported as total individuals per 15 sweeps.

Monitoring for fish, benthic invertebrate and chironomid flieswill be carried out twice a year at six-month intervals, for a period of three years following completion of wetland construction

Water Quality monitoring

6.5.4 Parameters including dissolved oxygen, temperature, pH, turbidity, water depth, suspended solids, and ammoniacal nitrogen will be recorded in the same locations as the fish/invertebrate sampling locations. Baseline water quality data will be collected immediately after the completion of wetland construction, during mid ebb tide, for four days per week for four consecutive weeks. Afterwards, the water quality monitoring will be carried out at the same time as the monitoring for fish, benthic macroinvertbrates and chironomid flies.

Monitoring of plant communities

6.5.5 Vegetation on the eastern embankment, constructed wetland, and western embankment will be monitored annually for the first three years of channel operation, and subsequent monitoring requirement to be reviewed at the end of the three year monitoring period.

Target Species

6.5.6 Routine monitoring of birds and macroinvertebrates described in the above sections will reveal the presence of Snipe, Ardeids, Red-billed Starlings or chironomids in the project area. The monitoring of the target species not included in the EM&A Manual monitoring programme is described in Appendix B of the Brief:

- ***Orthetrum luzonicum*** – This species may be searched for during routine monitoring of avifauna/chironomids.
- ***Narrow-mouthed frog*** – This species may be searched for during routine monitoring of avifauna/chironomids: Sampling should be focused during the frogs breeding season (Late-spring/summer), where adults and tadpoles can be expected to populate the seasonal marsh.

Aquatic Macroinvertebrate Communities

6.5.7 In addition to the collecting methods described in the EM&A Manual, all habitats in the created wetlands should be sampled with a sweep-net (D-framed, 500µm mesh). Pushing a net through emergent/submerged vegetation, and also sweeping areas of open water, have been found to be amongst the most effective methods of sampling wetland macroinvertebrate richness and diversity (Cheal *et al.*, 1993; Turner & Trexler, 1997; Salas & Gallacher, 2001). Samples should be preserved and organisms identified to the lowest possible taxonomic level.

6.6 Remedial Strategies

6.6.1 It is anticipated that the indicator objectives outlined in this section will be met following the planting and subsequent colonisation of the created wetlands by native flora and fauna. Indicator objectives will be maintained through appropriate management techniques, as described in Section 7.

6.6.2 Remedial Program

Failure to meet specified indicator objectives will result in the implementation of the following remedial program:

- *Review of wetland components* Monitoring data collected from the wetlands will be reviewed to determine why specific indicator objectives are not being achieved

- *Review of management techniques* Management strategies will be examined to determine the changes needed in order to meet indicator objectives.

- *Implementation of revised management techniques* – Refined management strategies will be implemented.

- *Monitoring of relevant wetland components* - The response of different aspects of the wetland habitat and community will be monitored to evaluate the success of remedial strategies

7 MANAGEMENT AND MAINTENANCE

7.1 Overview

The wetlands will be under the management responsibility of AFCD. AFCD will maintain the wetland planting works and would maintain supporting facilities for the wetland including pumps and water control structures.

The future management and maintenance of the wetland also influences the design. Given the layout, the variable nature of the water source and the sensitivity of the wetland habitats to change, it was considered that a manual system with regular site supervision and control would be needed.

The wetland system would rely on simple 'low-tech' control devices e.g. water gauges and manually controlled sluices, which would be longer lasting and easier to replace than an electronic system. It would also be advantageous to have regular checks of the system by trained personnel, rather than relying on science, especially in anticipating problems and responding to accidents etc. A semi-automatic system is not considered to be sufficiently responsive to potential changes.

It is envisaged that AFCD will manage the system as part of a wider body of wetlands, and that dedicated management personnel would be employed and trained to monitor and maintain the system. Details of the wetland operating systems, including requirements for staff and equipment for maintenance will need to be set out in an O&M manual, which will be prepared by the Landscape Consultant and updated by the Contractor during construction.

Responsibility for maintenance of the vegetation in the constructed wetland will be with AFCD, while responsibility for land administration will rest with the Lands Department.

The management and maintenance requirements for the wetlands will be specified in detail in the design and tender documents to a level equivalent to the OMP. However, the design process will allow for the habitats to be 'fitted' to the site, allowing for the timing of operations and occasional on-site direction. The contractor will also be required to manage and maintain the wetlands during the 12-month establishment period, during which time the maintenance operations may be adjusted. All long-term management operations and essential reference data relating to the design of the constructed wetlands will be set out in a Constructed Wetlands Operation Manual. A draft manual will be produced by the Landscape Consultant for the contractor to confirm and finalise as part of the construction process.

The Contractor will undertake active maintenance of the constructed wetland during a 12 month Establishment Period, to ensure the healthy establishment of the vegetation species, and to confirm the functioning of the water circulation systems. At the end of the Establishment Period, once the constructed wetland is functioning as proposed, and the Constructed Wetlands Operation Manual for the constructed wetland has been finalised, the wetlands will be handed-over to AFCD, the long-term maintenance organisation.

7.2 General inspections

The following inspections are recommended and should be accounted for in long term planning for the project:

- Monthly visual assessment of water quality of water abstracted from the EMDC.
- Monthly inspection of water pumping and control structures.
- Monthly inspection of planting for signs of insect or fungal attack and any necessary remedial actions.
- Regular inspections of all areas to note signs of trespass (especially incidents of fly tipping or the presence of feral cattle.
- Water levels above and below each of the control structures in all water bodies shall be assessed on a monthly basis to ensure that the water levels are at the prescribed operating ranges. Sufficient water shall be maintained in the storage pond at all times to ensure adequate flow through the freshwater marsh and associated ponds. Where there is insufficient water from rainfall, water shall be abstracted from the EMDC and obtained from mains.

7.3 Water management

The water levels above and below each of the control structures in all water bodies shall be assessed on a regular basis to ensure that the water levels are at the prescribed operating ranges. Sufficient water shall be maintained in the storage pond at all times to ensure adequate flow through the freshwater marsh and associated ponds. Where there is insufficient water from rainfall, water shall be abstracted from the EMDC and obtained from mains.

The future management of the water circulation system and the growth of vegetation within the wetland will need to be sufficiently adaptable to be able to overcome the problems of silting up, invasion by weed species and potential succession to seasonal marsh if water balance is too low.

Detailed water quality specifications will be set with reference to the specific habitat designs and water quality data from existing wetlands within the locality. Water for initial filling and management during the establishment period should be regularly monitored against these parameters, to establish the basis for the future water management regime of the wetlands.

The target habitats can only be created if the correct land use and water regime can be sustained. The water requirement of the wetlands is a function of the evaporation and evapo-transpiration losses, outflows versus rainfall and other external sources. Any hydrological function (pumping, management of water control structures etc...) required to maintain the wetland would need to be continued in perpetuity, with consequential recurrent maintenance cost. The hydrological system should be designed as far as possible both to meet the ecological objectives and to be self-maintaining. The hydrological system is expressed both through the supply of water from external sources, but also the shaping of ground levels and the design of water control structures, to retain water to given depths.

The design of the water circulation system, for the majority of the area, will be a gravity system based on simple piped connections and adjustable weir structures between water bodies and at the discharge points. The system will be designed to allow the easy regulation of water input and through flow to ensure that the various habitats are kept in optimum condition.

Throughout the establishment works and operational life of the wetlands, the level of the water circulating through the wetlands needs to be carefully managed through the operation of all pumping equipment, water control structures and discharges.

7.4 Dredging, de-silting and draw-downs

Following accounts for the tasks that need to be undertaken to ensure the wetlands do not silt up and change the succession to seasonal marsh over time. De-silting will need to be a mechanical process with the water drained from the wetlands for brief periods of time to remove excess deposits, which will be undertaken by AFCD.

- Periodic measurement of water depths and assessment of pond/wetland soil profiles.
- Dredging and de-silting of ponds and swales as necessary to maintain water depth to the level required to support vegetation.

7.5 Vegetation management

The intended vegetation communities will be established through the planting of aquatic and terrestrial species. The range of plant species required within the various habitats will be based on the range of plant species required in the various habitats and also those observed growing in similar habitats in neighbouring areas. Although it is clear that these species are suited to the wetland conditions in Hong Kong, the commercial sourcing and propagation of plant species will need to be fully examined in the Design Phase. Previous constructed wetland projects indicate that the factors which influence the success of establishing the proposed wetland habitat types include: identification of species for propagation; obtaining permissions to take plants from native areas; the establishment and maintenance of propagation nurseries; the timing of plant production; and the handling, storage, and planting of species.

Adequate measures for the protection of existing vegetation shall be specified. Existing vegetation identified and to be retained shall be protected from disturbance by robust fencing and hoarding. Penalties for tree damage shall be considered for inclusion in the contract documents to enforce these requirements. The protection of existing vegetation shall also be applied to those trees which are identified for transplanting out of the project site but for some reasons still remain within the project site after contract commencement, during the period between contract commencement and the physical removal of the trees.

Establishment of vegetation communities (and thereby the soil and water regimes required to support them) similar in the range and composition species characteristic of the intended habitat type (Tables 6/2 and 6/3) and similar to those identified in local examples (Table 6/1) as being representative of the habitat type, will be the benchmark for determining success.

Management responsibilities include:

- Monthly inspection of plantings for signs of insect or fungal attack and any necessary remedial actions,
- Removal of any invasive weed species that colonise the area, replacement of dead or damaged plants,
- Minimise cut back of vegetation on grasscrete banks of Tsing Lung Tsuen drainage channel along the upper embankment of the concrete channel already constructed.

8 IMPLEMENTATION

8.1 Time schedule

Construction of the wetlands is scheduled for completion by the end of 2005. The construction sequence would include:

- sourcing and preparation of plant material
- site clearance, and any necessary tree felling and transplanting
- excavation to required formation levels for all areas and construction of storage pond
- construction of water supply and control devices
- lining, soiling and profiling works
- initial filling with water
- planting
- establishment works, management, maintenance and monitoring
- hand over

It is anticipated that the works would take approximately 12-15 months to complete, although this may be extended over a longer period to allow for co-ordination of the works with those of the EMDC, and to allow earthworks to take place within the dry winter months and initial filling with water (which may take 4 weeks) and subsequent planting (8 - 12 weeks) to be undertaken in the wetter summer months.

As the wetlands abut the EMDC for their entire length, the sequence of the works will need to be co-coordinated with those for the main civil engineering works for the EMDC, so completed wetland areas are not damaged in the process.

As the reed beds are due to be completed by the end of 2003, prior to the construction of the EMDC in 2005, arrangements will need to be made to ensure their continued operation during the course of the work. The intended source of water for the Western Reed Beds is the San Tin River, but this will be diverted and the connection to it severed by the EMDC. Temporary pumping equipment and pipe work (possibly via a temporary pipe bridge over the line of the EMDC) will need to be installed prior to commencement of the main excavation works for the EMDC, to provide water from unaffected sections of the San Tin River Channel. This temporary arrangement will need to be kept in operation for the duration of the contract. At this time a second system of pipes allowing abstraction from the EMDC will need to be put into operation to feed the reed beds, prior to decommissioning of the water supply from the San Tin River.

Within the wetland construction work, the replacement reed bed, alongside the WR 2, 3, and 4 will need to be constructed (together with necessary water supply, circulation and discharge facilities) and put into operation prior to decommissioning of WR1. Once this has been commissioned and handed over to ArchSD, the area of WR1 can then be cleared and converted into part of the permanent marsh. As the permanent marsh cannot be fully completed and put into operation without the WR1 area, the commissioning of the replacement reed bed is critical to the completion of the constructed wetlands.

Table 8.1 Project Interfaces

Projects	Commencement	Completion
Main Drainage Channels and poldered village protection schemes for San Tin, NWNT Phase 3, part I – Eastern Main Drainage Channel for San Tin (PWP Item No. 73CD)	end 2002	end 2005
KCRC East Rail Extension – Sheung Shui to Lok Ma Chau Spur Line and Northern Link	(to be determined)	(to be determined)
Expansion of Kiosks and Other Facilities at Lok Ma Chau Boundary Crossing – Remaining Works	November 2000	September 2003
Improvement to San Tin Interchange	(to be determined)	(to be determined)

8.2 Construction responsibilities

TDD will construct the wetlands as part of the EMDC construction works, let to commercial landscape contractors as a specialist sub-contract to the main works.

8.3 Management responsibilities

The Contractor will undertake active maintenance of the constructed wetland during a 12 month Establishment Period, to ensure the healthy establishment of the vegetation species, and to confirm the function of the water circulation systems. At the end of the Establishment Period and the Constructed Wetlands Operation Manual for the constructed wetland has been finalised, the wetlands will be handed-over to AFCD, the long-term maintenance organisation.

Table 8.2 outlines the management and maintenance responsibilities of the involved organisations.

Figures 3.1 - 3.3 provide typical cross sections through the project site and further illustrate maintenance responsibilities.

Table 8.2 Management and Maintenance Responsibilities

EMDC Constructed Wetlands	Management	Maintenance
Water pumping system for Constructed Wetlands, including mains connection, water meter, pumps to abstract water from EMDC and pipe-work.	AFCD	AFCD
Water storage and control structures for Constructed Wetlands (weirs / overflows etc...).	AFCD	AFCD
Fencing on eastern side of project area, access paths etc...	AFCD	AFCD
Wetland planting and soiling profiles within Constructed Wetlands.	AFCD	AFCD
Tree, shrub and screen planting alongside San Sham Road and boundary crossing area.	AFCD	AFCD
Land administration.	LandD	LandD
Rubbish / solid waste removal not in EMDC.	FEHD	FEHD
Tidal portion of EMDC.	DSD	DSD
Grasscrete lined channel of the EMDC.	DSD	DSD
Tree groups, fence and grass areas on embankments along EMDC access road.	LCSD	LCSD
Road and road embankment.	HyD	HyD

APPENDICES

Appendix 1 Water quality of freshwater ponds and marshes in the New Territories

Parameter	Deep Bay Area	*K. interlineatus* Habitats	Lok Ma Chau 1	Lok Ma Chau 2	Marshes	Ponds
Turbidity	3.1 (1.2)[1]	-	76.0 (NTU)[3]	28.0(NTU)	-	-
Suspended solids (mg/l)	-	5.9-21.3	-	-	-	-
Conductivity (µs)	1925.2 (858)	135-408	-	-	511.9(1751.3)	65.3(34.6)
Salinity (mg l^{-1})	990 (461)	-	-	-	0.43(1.36)[4]	0.14(0.38)
pH	4.7 (1.7)	6.3-6.7	9.2	9.0	6.24 (0.59)	6.32(0.71)
Dissolved Oxygen (mg/l)	61.2 (21.9)[2]	0.2-8.6	13.0	13.0	5.08(1.31)	6.54(0.64)
BOD_5 (mg/l)	-	1.9-5.5	28	14	-	-
Phosphates (mg/l)	0.3 (0.5)	0.71-26	-	-	12.0(5.45)	12.6(3.69)
Total Phosphorous	-	-	0.2	0.1	-	-
Total N (mg/l)	-	0.03-7.50	-	-	-	-
Total inorganic N	-	-	0.02	0.02	-	-
NO_2 and NO_3 as N	-	-	0.02	0.02	4.21(2.72)	4.41(1.01)
Ammonia (mg/l)	1.7 (2.1)	-	<0.01 (as N)	<0.01 (as N)	0.587(2.16)	0.07(0.15)
E.Coli (cfu/100ml)	-	-	60	150	-	-

Deep Bay: Average values from 15 inactive fishponds and marshes in the Deep Bay Area, standard deviation given in brackets. (after Salas & Gallacher, 2001)

[1] – Turbidity visually estimated on a 1-5 scale (1 – low, 5 – high)

[2] – Dissolved oxygen given as percentage saturation

K.interlineatus habitats: Range of values obtained from wetlands used as breeding sites by Narrow-mouthed frogs (after Lau, 1998)

Lok Ma Chau 1 & 2: Data from unmanaged fishponds alongside Lok Ma Chau Boundary Crossing (after Binnie, 2000)

[3] – NTU - Nephelometric Turbidity Units
Marshes & Ponds: average values from 21 marshes and 7 ponds in the New Territories and Outlying Islands, standard deviation given in brackets (after Dudgeon & Chan, 1996)

[4] – Salinity given in parts per thousand

Appendix 2 Common terrestrial plant species in NWNT

Habitat Type	**Fish pond bunds**	**Fish pond bunds**	**Fish pond bunds**	**Grassland/shrubland**	**Fung-Shui woodland**
Location	**Mai Po/Inner Deep Bay**	**Long Valley**	**San Tin**	**Long Valley**	**Mai Po Village**
Source	Mai Po/Inner Deep Bay Conservation & Management Plan	Anon, 1995 (cited in Binnie, 2000)	San Tin EMDC EIA (ERM 1999b)	Binnie (2000)	Young (1993)
Grasses/ herbs	*Panicum maximum* *Panicum repens* *Alternanthera sessilis* *Alternanthera philoxeroides* *Commelina communis* *Ipomoea aquatica* *Lantana camara* *Mikania micrantha* (exotic) *Bidens rubra*	*Panicum maximum* *Paspalum conjugatum* *Alternanthera sessiles* *Commelina nudiflora* *Mikania micrantha* (exotic)	*Alternanthera sessilis* *Bidens pilosa* *Centella asiastica* *Commelina nudiflora* *Digitaria* sp. *Gynura bicolor* *Melia azedarach* (exotic) *Mikania micrantha* (exotic) *Panicum maximum* *Paspalum* spp. *Pennisetum purpureum* (exotic)	*Arundinella setosa* *Cymbopogon* sp. *Eulalia* sp. *Ishaemum* sp. *Dicranopteris linearis (fern)*	n/a
Shrubs	n/a	n/a	n/a	*Rhodomyrtus tomentosa* *Breynia fructicosa* *Litsea rotundifolia* *Rhaphiolepis indica*	n/a
Trees	*Macaraanga tanaris* *Celtis sinensis* *Melia azedarach* *Sapium sabiferum* *Ficus mirocarpa* *Ficus superba* *Carica papaya*	*Melia azedarach* *Ficus microcarpa* *Dimocarpus longan* *Clausena lansium*	*Melia azedarach* *Albizia lebbeck*	n/a	*Ficus microcarpa* *Litsia glutinosa* *Pinus massonica*

Appendix 3 Plant Lists for Wetland and Terrestrial Habitat Creation

Habitat A
Buffer
Bambusa textilis
Cladium mariscus
Cyperus malaccensis
Phragmites sp.
Schoenoplectus littoralis
Typha angustifolia

Habitat B
Roosting material
Coix lacryma-jobi
Eleocharis equisetina
Eleocharis plantagineiformis
Eleocharis spiralis
Fimbristylis subbispicata
Lepidosperma chinensis
Phragmites sp.

Habitat C
Striated refugia
Alocasia odorata
Colocasia esculenta
Cyperus involucratus
Hedychium coronarium
Lasia spinosa
Musa paradisca
Nelumba nucifera
Nymphaea spp.
Phragmites spp.

Habitat D
Cultivated: butterflies
Alpinia katsumadai
Buddleia asiatica
Cyclosorus gongylodes
Davallia divaricata
Davallia tenuifolia
Diplazium esculantum
Floscopa scandens
Hedychium coronarium
Hygrophila salicifolia
Impatiens chinensis
Iris speculatrix

Habitat E
Cultivated: birds
Ipomoea aquatica
Oenanthe javanica
Polygonum glabrum
Polygonum hydropiper
Polygonum jucundum
Sagittaria trifolia

Habitat F
Cultivated: buffer, shade
Musa paradisica

Habtitat G
Cyperus diffusus
Cyperus radiatus
Polygonum barbatum
Polygonum hydropiper
Rumex maritimus
Scoparia dulcis

Habitat H
Wetland ferns
Adiantum flabellulatum
Alsophila podophylla
Alsophila tomentosa
Asplenium lanceum
Asplenium nidus
Blechum orientale
Brainea insignis
Gleichenia dichotoma
Lygodium japonicum
Microsoria fortuni
Nephrolepis cordifolia
Onychium japonicum
Osmunda regalis
Platycerium alcicorne
Pronephrium simplex
Pseudodrynaria coronare
Pteris serrulata
Pteris vittata

Habitat I
Lower Bank
Hedychium coronarium
Nepenthes mirabilis
Rhodomyrtus tomentosa

Other shrubland spp.
Pandanus tectorius
Passiflora moluccana
Phoenix hanceana
Rhapis excelsa

Habitat J
Rock wetland
Acorus gramineus
Acorus. gramineus
Centella asiatica
Drosera oblanceolata
Drosera spathulata
Eriocaulon nantoense
Fimbristylis spathacea

Habitat K
Shade and fruit for fauna
Albizia lebbek (bats & birds)
Bridelia tomentosa

Habitat L
Rare wetland
Blyxa japonica
Carex pumila
Diplacrum caricinum
Drosera indica
Eleocharis acutangula
Equisetum debile
Eriocaulon australe
Eriocaulon cinereum
Eriocaulon sexangulare
Fimbristylis acuminata.
Fimbristylis complanata
Juncus effusus
Lipocarpha chinense
Lipocarpha microcephala
Scirpus ternatanus

Habitat M
Freshwater marsh
Bacopa monnieri
Bulbostylis barbata
Cardamine flexuosa
Colocasia esculenta
Commelina diffusa
Curcuma aromatica
Cyperus malaccensis
Cyperus pilosus
Diplacrum caricinum
Eleocharis congesta
Eleocharis dulcis
Eleocharis plantagineiformis
Eleocharis spiralis
Eleocharis tetraquetra
Eriocaulon sexangulare
Fimbristylis complanata
Fimbristylis ferruginea
Fimbristylis subspicata
Fuirena umbellata
Glochidion hirsutum
Ficus fistulosa
Ficus microcarpa
Garcinia sp.
Rhynchospora chinensis

Habitat N
Floating wetland
Nymphaea spp.

Habitat 0
Marginal plants
Cyperus malaccensis
Eleocharis plantagineiformis
Schoenoplectus littoralis

Habitat P
Wet woodland
Hypolytrum nemorum

Habitat Q
Woodland and pond mosaic
Diplacrum caricinum
Glochidion hirsutum
Pandanus tectorius
Viburnum oderatissimum

Habitat R
Grassland and pond mosaic
Chrysopogon acicularis
Coix lacryma-jobi
Hermarthria compressa
Microstegium ciliatum
Panicum repens
Paspalum orbiculare
Sphaerocaryum malaccense

Habitat S
Reed filterbeds
Phragmites australis
Phragmites vallatoria
Nelumba nucifera
Nymphaea spp.
Rorippa nasturtium-aquaticum

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Main Drainage Channels and Poldered Village Protection Schemes for San Tin, North West New Territories Phase 3, Part I – Eastern Main Drainage Channel for San Tin
Draft Ecological Habitat Management Plan

WWF-HK Comments & Responses

Comments Received	Reference	Letter Date	Contact:	Page No.
1. World Wide Fund for Nature Hong Kong	(3) CHK/ DMR 47/01	29 August 2001	Karen Woo	3
Comments	**Responses**			
Thank you for your letter of 21 August 2001 and the enclosed draft Ecological Habitat Management Plan (EHMP) regarding the captioned project.				
We have preliminarily reviewed the draft EHMP and should be grateful if you would clarify the following issues:				
1) Section 2.4 habitat Types				

Comments	Responses
It is noted that a total of 3.43ha of compensatory freshwater east of the EMDC would be recreated, including pond/open water, permanent marsh, seasonal marsh and terrestrial margins. However, there is no detailed description of the locations and total areas of these four habitat types. I should be grateful if you would illustrate the locations of these compensatory freshwater habitats on the layout plan of the captioned project and advise the total areas of these habitats, In addition, please also illustrate on map how the EMDC mitigation wetlands would be ecologically linked with the compensatory reedbeds (e.g., the existing Western Reed Bed 1 mentioned on page 23) being developed for the Lok Ma Chau Boundary Crossing project.	The attached site plans show the preliminary locations of the four types of habitat. These plans will be included in the Final EHMP Report. The areas of each of the four habitat types are as follows: Permanent Marsh: 19200m2 Seasonal Marsh: 3000m2 Permanent Pond: 2500m2 Terrestrial Habitats: 9600m2 Please note: the precise areas and locations of each habitat type may be subject to minor changes during subsequent phases of this project Ecological linkage of the EMDC compensatory wetlands and Lok Ma Chau Border Crossing mitigatory reedbeds will result from the close proximity of the two habitats. It is anticipated that wildlife will move between and utilise both of these habitats.
2) Section 3.2 Permanent Open Pods, Section 3.3 Permanent Marshes and Section 3.5 terrestrial Habitats	
We note that the purpose of recreating the Permanent Open Ponds and the marshes is for providing foraging habitats for some fauna species, e.g., Narrow-mouthed frog. Yet, it is unclear how the survival of tadpoles would be ensured in these ponds and marshes when they are newly constructed. Would you please explain how the tadpoles would be able to survive in the ponds without being predated by other fauna.	It is unlikely that habitats will prove suitable to all target species in the period immediately after construction. Once adequate vegetative cover is established, it is anticipated that the habitats will resemble wetlands known to support target species, and should therefore provide adequate cover to ensure some of the smaller target species avoid predation.
It is also noted that the water regime proposed for the Permanent open Ponds and Permanent Marshes would rely on the water from rain, mains and pumped feed from EMDC. Would you please advise us the proportion of water sourced from EMDC that would be pumped into the permanent ponds and marshes as compared with other possible sources, and if the water quality from the EMDC would be suitable for the growth of the proposed wetland plant species and other wildlife?	To maintain operable water levels in the wetlands during the drier months, water levels will be supplemented by sources additional to rainfall, of which the EMDC and mains have been discussed as probabilities. Dependent upon requirements, water from either or both sources would be pumped into the Storage Pond, subjected to a 14-day turnaround period for settling (for water from EMDC) and evaporation of chlorine (from mains water). The feasibility of these general principles is to be subjected to further detailed investigation.

Comments	Responses
Moreover, we noted that some wetland and terrestrial plant species are proposed on pages 9 to 11 for planting at the mitigation areas. Would you please state clearly what ecological functions they would play in the recreated wetlands or the associated margin habitats as well as how they would benefit the recolonisation of the target fauna species?	Plant species present in habitats known to support the target species elsewhere in Hong Kong were considered.
3) Section 5.3.2 Grasscrete Lined Main Drainage Channel	
It is noted that the EMDC will be lined with grasscrete on the sides and bottom and the channel bottom will be hydroseeded. Would you please advise us the total length of the channel that would be grasscreted and hydroseeded and illustrate on map the corresponding locations of these two portions?	The bottom of the channel to be grasscreted is approximately 45000m2 and the aggregate of the channel sides is approximately 25000m2. Please refer to the attached site plan for more details.
4) Section 6.3 Selecting Indicators	
In Section 6.3.1, it is stated that '...because of external factors (e.g., human activities, pollution) beyond the control of those managing the habitats, there is no way of guaranteeing that target species will establish themselves in the compensatory wetlands, even if optimal habitat conditions are created.' Would you please provide some effective and enforceable measures (e.g., restricted access to the maintenance road of the EMDC except with permission) that can help avoid the external factors from adversely impacting on the recreated wetlands?	The EMDC and channel sides/verges will form an effective barrier between the compensatory wetlands and the maintenance road, limiting access to the wetlands. Screen Planting and fencing along the Eastern Boundary will limit access from the Lok Ma Chau Boundary Crossing area. Much of the northern section of the compensatory habitats fall within the closed border area, limiting access to those without a valid permit.

5) Section 6.4.3 Target Species	
We note that the indicator objectives are listed in Table 6.2 for the target species. However, it seems that they are too general (e.g., presence or absence of the target species) and cannot provide the necessary quantitative comparison against the baseline ecological data. We would recommend that quantitative performance criteria be formulated to assess the level of success of the mitigation habitats under your project. For example, both the occurrence and the relative abundance of Snipe, *Orthetrum luzonicum* and Narrow-mouthed Frog as compared to the baseline can be used as criteria for assessing the level of success of the mitigation wetlands. Similarly, apart from densities, species richness for the Ardeids before and after the construction of recreated wetland can be formulated as an effective performance criteria to assess the ecological function of recreated wetlands for waterbirds to forage.	Noted. Measures of Ardied species richness could prove a useful indicator of wetland success. Table 6.2 will be revised. Monitoring suggested in the EHMP will record the relative abundance of all target species in the created wetlands. Specific abundance/density targets were not set for certain species because detailed abundance data did not form part of the San Tin EMDC EIA report. Narrow mouthed frogs were not recorded in the study area during baseline surveys. Consequently, no specific abundance/density objectives could be set for this species.
Meanwhile, the floristics and structure of wetland vegetation can also be regarded as a performance criteria for assessing the ecological condition of the recreated wetland plant communities.	Noted. Section 6.4.6 describes indicator objectives for plant community species and structure in different created habitat types
6) Section 7.2 General inspections	
It is noted that the proposed long term inspection of water quality of water abstracted from the EMDC would be visually assessed only. We consider that a quickly on-site measurement of, for example, DO, pH and salinity may be more effective to monitor the water quality in the long run.	Monitoring of wetland water quality parameters for 3 years after wetland construction is specified in the San Tin EIA Report EM&A manual (1997)
7) Other Comments	
The full reference of 'Sales & Gallacher (2001)' is missing on pages 20 and 36.	Noted. The full reference is shown below and will be given in the text: Salas, M. & Gallacher, D. (2001) Survey of Freshwater Macroinvertebrates in the Mai Po Inner Deep Bay Ramsar Site. Unpublished Report for the AFCD: 103pp
Thank you for your kind attention and we look forward to these issues being resolved as soon as possible in order that the commencement of the project will not be unduely delayed.	

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Draft Ecological Habitat Management Plan

WWF-HK Further Comments & Responses

Comments Received	Reference	Letter Date	Contact:	Page No.
2. World Wide Fund For Nature Hong Kong	**(4) CHK/DMR 47/01**	**6 September 2001**	**Karen Woo**	**2**
Comments	**Responses**			
I refer to the fax of your environmental consultant, Mr. David Gallacher of Maunsell Environmental Managements Consultants Ltd., dated 5 September 2001 responding to our comments on the captioned drafr EHMP.				
We note your consultant's response on page 4 that the 'Monitoring suggested in the EHMP will record the relative abundance of all target species in the created wetlands. Specific abundance/density targets were not set for certain species because detailed abundance data did not form part of the San Tin EMDC EIA report. We should be grateful if you or your consultant would specify what the 'certain species' are that cannot be set with specific abundance/ density targets or objectives. In addition, would you please also clarify how 'the relative abundance of all target species in the created wetlands' would be measured and how it would be used as performance criteria for the evaluation of the level of success of your mitigation wetlands	Table 6.2 has been expanded to include this information. Please find a copy of this table attached for your reference.			

Comments	Responses
Moreover, we note from your consultant's response that the EMDC compensatory wetlands and Lok Ma Chau Border Crossing (LMCBC) mitigation reedbeds would be in close proximity and it is anticipated that wildlife will move between and utilise both of these habitats. However, one of the conditions for the DEP's approval of the EIA Report of the captioned project is that 'The applicant shall liaise and negotiate with the Architectural Services Department on the integration of mitigating wetland for this project and the upgrading works of the Lok Ma Chau Border crossing facilities'.	Meetings and discussions have been made with ASD and the integration scheme which has obtained support from ASD is as follows – swapping a piece of LMCBC western reedbed area (W1) located downstream with a piece of equal area of EMDC constructed wetland located upstream next to the other LMCBC western reedbeds (W2, W3 & W4), as shown in the attached Figure. This arrangement would result in better sizing of both reedbeds and constructed wetlands. The advantages of these changes would be: a more efficient shape for reed bed and permanent marsh area; easier internal water circulation system; and easier operation/maintenance.
As such, would you please advise what intergration has been made for the mitigation wetlands under the captioned project and that of the Lok Ma Chau boundary crossing project and how the above two mitigation wetlands would be linked functionally.	As noted in our previous response, the two habitats are adjacent with one another. As such, it is anticipated that wildlife will move between and utilise both of these habitats

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Main Drainage Channels and Poldered Village Protection Schemes for San Tin, North West New Territories Phase 3, Part I – Eastern Main Drainage Channel for San Tin
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Comments & Responses

Comments Received	Reference	Letter Date	Contact:	Page No.
Drainage Services Department	( ) in DP/8/7073CD/17	31 Aug 2001	J.K.S Kwong	2

Comments	Responses
I refer to your above quoted letter dated 16.8.2001 regarding the captioned subject.	
Please be informed that I have the following comments on your draft Ecological Habitat Management Plan:	
(i) Section 5.2	
Para. 5 –You have mentioned that a narrow section of permanent marsh between the proposed reed beds and the EMDC will be changed to terrestrial habitat. Please consider whether such change will reduce the total area of constructed wetland required by the EIA Report.	It will be possible to create a narrow swale with saturated and/or flooded soils in this area. Recently additional area has been added to the constructed wetland site. It has not been decided if this would be allow for more wetland area to be constructed or remain in terrestrial habitat. The requirement in the EIA Report is noted.
(ii) Section 5.2.1	
Para.4- The description "below the inflatable dam" in line 3 is ambiguous. I presume that you mean downstream of the inflatable dam. Please clarify.	This will be changed to read "downstream of the inflatable dam"
(iii) Section 5.3.2	
Para. 1-Planing trees and shrubs on the side of the EMDC (below the max designed water level) will adversely affect the hydraulic performance of the channel. In addition, you are required to seek the agreement of CE/MN, DSD for planting within the EMDC.	Noted. This issue will be discussed with CE/MN, DSD.

(iv) Section 7.1	
(a) Para.1-The wetlands will be under the management responsibility of AFCD instead of DSD. The water control structures and pumping facilities will also be maintained by AFCD. For the management and maintenance responsibility matrix, you can refer to my previous letter ref. DP/8/7073CD/17 dated 8.8.2001.	Noted. The text in this paragraph will be amended accordingly.
(b) Para 5 & 6 –Please clarify whether the contractor in para. 5, who will be required to manage and maintain the constructed wetlands during the Establishment Period, is the same specialist contractor mentioned in para.6. Moreover, I consider that it is more appropriate for you to prepare the Constructed Wetlands Operation Manual instead of the contractor.	Noted. These will be produced with the design and tender details.
(v) Figure 2.6	
I have reservation on your proposed cross section of the dry weather flow channel since it will hamper the flow and lead to siltation. You are also advised to consult CE/MN, DSD for this arrangement as well.	Noted. We will consult with CE/MN, DSD prior to any further design detailing.
(vi) Please also refer to my previous memo ref. DP/8/7073CD/29 on the revised project boundary. It is necessary for you to incorporate the latest changes into your EHMP.	Noted. These areas will be incorporated as either permanent marsh or terrestrial habitat.

Comments Received	**Reference**	**Letter Date**	**Contact:**	**Page No.**
Agriculture, Fisheries and Conservation Department	**AF DVL 12/34 V**	**4 Sept. 2001**	**P. C. C. Lai**	**3**

Comments	**Responses**
Thank you for your draft Ecological Habitat Management Plan (Draft) of the captioned consultancy. Please find below my comments on the draft report:	
1. 2.6.1	
Suggest adding "and ecological functions of the wetland" at the end of the sentence.	Text added.

2. 3.1, 1st bullet point	
Suggest amending the sentence as "Provide suitable landform and profile, vegetation communities and water regime ..."	Noted and amended.
3. 3.1, 4th bullet point	
Suggest adding "Low maintenance" as one of the considerations for the choice of the plantings.	Noted and amended.
4. 5.2, Hydrology	
This section mentions the amount of water required by the wetland based on the result of the hydrological model and that water supply from external sources in the dry season is required. However, the potential water source has not been defined yet. The detailed arrangement for the external sources should be clearly defined in the detailed design.	Noted, the arrangement details will be more clearly defined in the detailed design.
Even if there is no external factor, the occurrence of the target species at a particular site may also be varied due to natural temporal variation.	Noted. The text will be amended as follows: However, because of external factors (e.g., human activities, pollution) beyond the control of those managing the habitats, there is no way of guaranteeing that target species will establish themselves in the compensatory wetlands, even if optimal habitat conditions are created. Additionally, the size of faunal populations can be expected to vary naturally through time, adding to the difficulties of setting quantitative objectives for the target species.
6. 6.4.3, Table 6.2	
The indicator objectives for the target species should be further elaborated. For instance, do "those recorded prior to development" refer to the data should be carried out to assess whether it is representative, statistically reliable as the objectives for subsequent monitoring. The objective value should also be defined in the section after such a review. When we calculate the density, should we calculate from monthly average or yearly average? Do we need to calculate the data for different habitats?	Noted. Table 6.2 will be revised to include more information on the available baseline data, monitoring techniques and indicator objectives. A copy of the table is attached for your reference.
7. 6.4.7.1	

The reference "Sales & Gallacher, 2001" has not been quoted clearly in the reference list.	Noted. The full reference is shown below and will be given in the text: Salas, M. & Gallacher, D. (2001) Survey of Freshwater Macroinvertebrates in the Mai Po Inner Deep Bay Ramsar Site. Unpublished Report for the AFCD: 103pp
8. 6.6	
Remedial strategies are something that should be carried out when the objectives could not be met unexpectedly. Hence, the content of the section at its present form is not desirable. If concrete remedial actions could not be proposed at this stage, the approach to deal with the unexpected failure should be pointed out here. For example, the approach could be started off with a review whether the water quality, plant establishment or management regime could meet the expected targets followed by adaptive management and further monitoring and review programme.	Noted. A new section will be added which reads as follows: 6.6.2 Failure to meet specified indicator objectives will result in the implementation of the following remedial program: *Review of wetland components* – Monitoring data collected from the wetlands will be reviewed to determine why specific indicator objectives are not being achieved *Review of management techniques* – Management strategies will be examined to determine the changes needed in order to meet indicator objectives. *Implementation of revised management techniques* – Refined management strategies will be implemented. *Monitoring of relevant wetland components* - The response of different aspects of the wetland habitat and community will be monitored to evaluate the success of remedial strategies
9. 7	

This section only highlights the concepts on the requirements on water and vegetation management without outlining the tasks in detail. It is mentioned in the 5th paragraph of 7.1 that the management and maintenance requirements for the wetland will be specified in detail in the design and tender document. I presume that the details would be provided in the form of an Operation and Maintenance Plan as mentioned in the Technical Proposal (P.20) submitted by the Consultants for this consultancy and contain all long term management operations and essential reference data relating to the design and operation of the constructed wetland. However, the consultants at the end of the paragraph mentioned that the Constructed Wetlands Operation Manual is to be prepared by the contractor as part of the construction process. It is understood that the management and maintenance requirement may be refined and adjusted during the establishment period and throughout the lifetime of the wetland management, however, the detailed management and maintenance requirements including the long-term management operations should be specificed based on the current understanding and design of the constructed wetland under this consultancy. Such detailed information would be essential for the smooth hand-over and long-term maintenance of the constructed wetland by this department.	The design and tender documents will provide details of the management and maintenance requirements for the constructed wetlands.
10. Table 8.2	
Please refer to the comments of my letter dated 22.8.2001.	Noted.
Should you require any clarification of the above comment, please do not hesitate to contact me on Tel 2150 6932.	

Comments Received	**Reference**	**Letter Date**	**Contact:**	**Page No.**
Territory Development Department	**(50) in NTNRU 2/10/63 pt.13**	**7 Sept. 2001**	**C. S. Kwok**	5

Comments	Responses
I refer to your letter of 16 August 2001 and have the following comments on your draft Ecological Habitat Management Plan (EHMP):-	
General Comments	
(1) Content pages	
The heading of the following sections and subsections are inconsistent. Please rectify?	Noted. The contents page will be amended accordingly
[1.2, 1.3, 1.4, 2.2, 2.4, 5, 5.2, 5.3, 5.3.1, 5.3.2 and 6.5.3.]	
(2) The main adverse criticism is the continued reference to faunal groups as target species. The Brief uses the term Ardeids and snipe. However the consultant should by this stage have clearly identified which Ardeids and which snipe. There are 15 species in the Ardeid group found in Hong Kong only four of which were found in the study area according to the approved EIA report. Similarly only two species of snipe were found in the study area during the baseline study although all four species have been located in the Deep Bay area.	Noted. The focus of habitat creation is to create conditions suitable for all four snipe species and the six common Ardeid species recorded during baseline studies. Section 4.2.3 will be amended to reflect this. Please note, both Annex 3-E(2) and Annex 3-F report six Ardied species to be common in the study area. These six species will be identified in the final EHMP report as the Ardeid target species. Noted. However, we anticipate that the created habitats will prove attractive to other species, including the two 'snipe' species not recorded during baseline surveys (but historically present in the area).

Detailed Comments	
(3) Para 2.3	
The target species must be refined. In order to design habitats the exact species targets and their requirements must be stated. The consultant should state which species have been selected and justify that selection.	Noted. This section is intended to introduce the reader to the factors considered in the design of the wetlands. Details of the target species, their selection and their habitat requirements are described in Section 4
(4) Paras. 3.2-3.5	
Based on the details given none of these habitats will be suitable for snipe. Ardeid species should be identified. The species will vary between habitats.	It is anticipated that seasonal and permanent marshes will provide suitable habitats for snipe species (as described in section 4.2.2). The text under the 'purpose' headings in sections 3.3 and 3.4 will be amended to include this information. Noted. The text will be amended to include the target ardeid species
In Hong Kong Narrow-mouthed Frog is likely to be more successful in the seasonal wetland where predation by fish will be minimal. Such preferences should be noted.	Noted. The preference of this species for seasonal marshland is described in section 4.2.7 (paragraph 2, line 3)
Whilst the ecological value of the created wetlands habitats is likely to be of greater significance, the other wetlands created by those project particulary the tidal portion of the EMDC as a potential foraging site for larger Ardeids, and the recommended wetland vegetation of the low flow channel of the MDC (paras. 5.3.1 and 5.3.2 refer) should be acknowledged.	Noted. Additional text will be added to the end of each paragraph: 5.3.1 However, the tidal portion of the EMDC will provide a potential foraging ground for larger Ardied species 5.3.2 It is anticipated that this wetland vegetation in the MDC will provide a potential foraging ground for Ardieds and other wading birds.
(5) Para 3.3	
No recommendation for liner is made in the Final Review Report. However, it is suggested to use 1000mm thick clay liner in this report. The Final Review Report should be revised accordingly if clay liner is considered to be the best and be adopted.	Noted. The final agreed method to seal the wetlands would be based upon proven durability, short and long term costs and suitability to site conditions. In narrow parts of the site, previously allocated to wetland construction, it may be necessary to utilize artificial pond liners as discussed in the Final Review Report.

(6) Para. 4.2.2	
The EHMP should be clear on which snipe species are to be targeted. This section emphasizes Painted Snipe, although this species was not found in the study area in the baseline study.	Noted. Four snipe species are to be targeted by the EHMP. As stated in section 4.2.2, paragraph 2, the four species found in Hong Kong have similar habitat preferences. Emphasis on the Painted Snipe reflects its threatened status in Hong Kong (as described in the text of this section), and the fact that its habitat preferences are more specific than other snipe species.
Elsewhere, the EHMP appears to use snipe and Painted Snipe interchangeably.	Noted. Text in table 5.1 and section 5.2.4 will be amended, to reflect the EHMP target of attracting four snipe species to the wetlands, rather than just Painted Snipe.
(7) Para 4.2.3	
As discussed above, The EHMP must clearly state which Ardeid species are targeted and the habitat requirements of each species.	Noted. The EHMP will focus on creating habitats suitable for the six Ardeid species found to be common in the project area.
(8) Para 4.2.6	
It is stated that *Orthetrum luzonicum* is widespread in Hong Kong, and abundant in its preferred habitat – well vegetated permanent marshlands. Since Painted Snipe are known to occur in abandoned wet agricultural land and seasonal permanent marsh, and are known to breed in only two existing sites, the presence of *O.luzonicum* is not necessarily a useful indicator for successful Painted Snipe habitat. *O.luzonicum* would appear, however, to be a good indicator of the general health and quality of the created wetland.	Noted and agreed. The fourth and fifth sentences of this paragraph will be removed. The following text will be added: The presence of *O.luzonicum* at the wetlands will indicate that suitable conditions have been created to support other species dependant on permanent marshland.
(9) Table 5.1	
Is Painted Snipe the only snipe to be considered; which Ardeids?	Noted. Please refer to the response to our comments regarding section 4.2.2 (6), and our response to comment (2)
(10) Para 5.3.3	
Please rectify the typo "with water with water" in the 1st sentence of the paragraph.	Noted. The text will be rectified.

San Tin Flood Storage Pond has been completed and successfully planted up by DSD and their agents, the Landscape Unit of HyD. The consultants should update their records, and observe the success or failure of the planting.	Noted.
(11) Table 6.2	
The whole question of target objectives and indicators of success is very difficult when considering biological systems. A number of factors can influence the success or failure of a habitat, in addition to the basic success or failure of the water circulation system and plant establishment. Some external factors can be controlled (e.g. disturbance) some cannot (e.g. nests destroyed by typhoons, excessive winter temperatures).	Noted and agreed. Please refer to section 6.3, which discusses the difficulties of setting specific objectives for target species.
Density of species in the recreated habitat compared to original densities prior to development is reasonable if the created habitats are of the same size and with the same level of fragmentation. However, if the created wetland is smaller or more fragmented than the original area, then enhanced densities are required for adequate compensation.	Noted. Section 3.6.4.17 of the San Tin EMDC EIA report calculates that 9ha of moderate-high value wetland (fishponds) would be lost due to the project, while habitat compensation measures would provide 11.13ha of moderate-high value wetland (flood storage pond, tidal channel, constructed wetlands and grasscrete-lined bottom of EMDC). As such we consider species densities comparable to those recorded in baseline studies to be appropriate objectives for the created habitats.
In addition for species not previously found in the study area there would be no comparable densities to refer to.	Noted. For species not previously recorded in the project area, the presence of the species in the created habitats is considered a successful outcome.

The consultants should explain in more detail the rationale for selecting the various targets and should clearly define these targets. Comparable densities in the EIA Report should be referred to.	Noted, Table 6.2 will be expanded to include this information. Please find attached a copy of the revised table.
The consultants should consider using target ranges rather than single figures to allow some flexibility.	Noted.
Time allowed for targets to be achieved should be discussed.	Noted. We anticipate that more mobile species (birds, insects) will populate the wetlands soon after suitable habitats have developed. Narrow Mouthed frogs, having not been recorded in the area previously, may take longer to move into the wetlands.
The monitoring programme should include triggers, such that if a target, or set of targets is not reached, what remedial activities will be undertaken, and by whom.	Noted. Section 6.6 will be refined.
It has been concluded in the Final Review Report, only soil, water and vegetation are the variables over which control can be exercised to measure the success or failure of the constructed wetland. I presume that the indicator objective given in the Table 6.2 is for the purpose of monitoring and would not be used for evaluation of the success or failure of the constructed wetland.	Noted and agreed.
(12) Para. 6.5	
More detail is required on the monitoring programme, frequency etc. The EHMP should stand-alone. Relevant information from the EM&A Manual should be repeated if necessary.	Noted. Relevant information from the *EM&A* manual will be incorporated into this section.
Who will undertake the monitoring?	Monitoring will be undertaken by an appointed ecologist/TDD
(13) Para. 7.1	
"ACFD" in the 2nd sentence of the 1st paragraph should read "AFCD".	Noted. The text will be amended
The suggestion that the design will develop as part of the construction process is not acceptable.	Noted. This statement was to mean that the construction process and the timing of operations would at least partially drive the design process so to fit the design to the site rather than after the design process was completed.

If the contractor is to undertake the management and maintenance (and monitoring?) of the created habitats for 12 months, this must be clearly stated in the contract documents. Normal establishment maintenance will not be adequate.	Noted.
Since the wetlands are designed by the consultants, the Operation and Maintenance Manual (O&M Manual) of the proposed wetlands should be prepared by the consultants. It is inappropriate to ask the contractor to prepare the O&M Manual for the design works completed by the consultants.	Noted. Details of the management and maintenance of the proposed wetlands will be produced with the design and tender details
1st sentence of the last paragraph – Please delete "Specialist".	Amended.
Last sentence of the last paragraph – "once the constructed wetland is functional and has been demonstrated" is too vague and should be deleted.	Noted and amended.
(14) Para. 8.1	
The bullet point "establishment works" should read "establishment works, management, maintenance and monitoring".	Noted and amended.
(15) Table 8.2	
This table should be carefully reviewed. For example AFCD are unlikely to carry out the maintenance of the water pumping system, EMSD is the more appropriate authority. LCSD will not maintain roadside fencing. Please countercheck.	Noted. Consultation with CE/DP, DSD, AFCD, LCSD and FEHD (YL), is currently taking place to finalise the management and maintenance of the project. The table will be revised in the Final EHMP Report.
The maintenance and management responsibilities should be agreed in principle with the relevant authorities as soon a possible to avoid confusion at later stages.	Noted, consultations with relevant authorities have been undertaken.
(16) Para. 8.3	
1st sentence – Please delete "Specialist".	Noted and amended.

Last sentence – "once the constructed wetland is functional and has been demonstrated" is too vague and should be deleted.	Noted and amended.			
(17) Appendix 3				
The names of some of the habitat creation are illegible. The quality of the table need to be improved. Larger font should be used. This table should be carefully reviewed.	Noted.			
(18) Figure 1.1				
The quality of the drawing is very poor and need to be improved. The labels in the drawing are difficult to read.	Noted.			
(19) Figure 1.2				
The labels of the cross sections in the drawing are difficult to read. The quality of the drawing needs to be improved.	Noted.			
(20) Figure 2.5				
"Storage D-D" in the title of the figure should read "Storage Pond".	Noted and amended			
(21) Figure 2.7				
"Swale with" should read 'Swale width".	Noted and amended			
Comments Received	**Reference**	**Letter Date**	**Contact:**	**Page No.**
Territory Development Department	**((J4) in NTNRU 2/10/63 pt. 13**	**8 September 2001**	**C.S. Kwok**	**1**
Comments	**Responses**			
I refer to the attached KCRC's letter ref. ERE/LMC/LMC/IP756/R00611 of 5 September 2001 addressed to you and copied to me among the others, enclosing their reply on the above draft Ecological Habitat Management Plan (EHMP)				
I wish to confirm that according to the comments given in the KCRC's letter, which is only on EMDC, we presume that they do not have any comments on the EHMP.	Noted.			

Comments Received	Reference	Letter Date	Contact:	Page No.
Drainage Services Department	**( ) in DP/8/7073CD/17**	**10 Oct 2001**	**Kwong Ka-sing John**	**3**
I refer to your above quoted letter dated 26.9.2001 regarding the captioned subject.				
Please find below my comments on your EHMP:				
(i) Section 5.2, para.3:				
There is a need for an impervious clay liner for the permanent pond and marshes to avoid lowering of water level. For ease of construction, please consider the use of geosynthetic drainage layers instead.	Synthetic liners/drainge layers cause considerable maintenance problems. Impervious caly liners will be used wherever possible.			
(ii) Section 5.2, paragraph on Hydrology				
The average and maximum annual amounts of water required by the wetland have been assessed to be 24,500 m^3 and 35,000 m^3. Please state the probable source of water supply suitable for the required quantities.	The most probable supply of water will be from mains supply. Details will be confirmed in the detailed design stage.			
(iii) Section 5.2.2, para. 4				
The proposed structure for the permanent pond lining seems complex. Please consider the feasibility of my comment under item (i) above.	Please refer to our response to comment (i)			
(iv) Section 5.2.4, para.3				
It is noted that "Grassy areas are proposed for sides of swales, the sides and bottom of the EMDC ...". Please ensure that details of the proposed grassy areas are acceptable to CE/MN DSD, the O&M party for the sides and bottom of the EMDC.	Noted. Details of these design features to be agreed in detailed design stage			

(v) Section 5.3	
The proposal under this section (including sections, 5.3.1, 5.3.2, 5.3.3) affects the operation and maintenance of the existing floodwater storage pond under San Tin Villages VFP as well as the proposed San Tin EMDC. You are advised to consult CE/MN, DSD on this.	Noted. Details of the operation and management of these features to be agreed in detailed design stage.
(vi) Section 6.5.1	
I suppose the ecological monitoring mentioned here is a post-project monitoring lasting for several years after the completion of the ecological habitats. If this is the case, please re-consider whether the monitoring work be best carried out another party rather than by an ecologist appointed by the contractor.	Agreed. Further to discussions with TDD, could AFCD take on the responsibility for monitoring?
(vii) Section 6.6	
Please advise which party will be responsible for the remedial strategies.	AFCD will be Responsible for management and remedial strategies
(viii) Section 7.1, para. 4	
It seems not appropriate for the Contractor to prepare the O&M manuals regarding "details of the wetlands" operating system, including requirements for staff and equipment for maintenance".	Noted. Please refer to our response to comments received from AFCD: Section 7.1
(ix) Section 7.1, para. 6	
Please clarify the identity of the Landscape Consultant who will be producing the Constructed Wetland Operation Manual. It seems more appropriate for the designer of the wetland to write the operation manual.	Noted. Please refer to our response to comments received from AFCD: Section 7.1
(x) Section 7.4	
Supposedly, the dredging, de-silting and draw-down work will be carried out by AFCD.	Confirmed. Management and maintenance of the compensatory habitats will be carried out by AFCD
(xi) Section 8.1, para. 1	
(23) According to the present programme, the construction of the San Tin EMDC will commence in September 2003 for completion in September 2005. Landscape softwork will usually commence after the completion of the civil work and hence it is doubtful whether constructed wetlands will be completed by end 2005.	Noted.

(25) (xii) Section 8.1, para. 4	
(27) More details on the water supply and discharge system for the Western Reed Beds are required in order to decide on the temporary reprovisioning works.	Noted. A request for information has been made to ASD. Details to follow in detailed design report

Comments Received	**Reference**	**Letter Date**	**Contact:**	**Page No.**
Agriculture, Conservation & Fisheries Department	**AF DVL 12/34 VI**	**15 Oct 2001**	**Patrick Lai**	

6.3.1	
It seems that the examples of the external factors given in the paragraph are something that can be controlled by management. It could be argued that occurrence of such factors may reflect the optimal conditions have not been reached. Please consider rewording the paragraph from the second sentence along the line of "However, it would be quite difficult to conclude as to whether and when the species would establish themselves in the mitigation area within the monitoring period. More importantly, the baseline data for the target species, which were only collected in one particular year, would not be statistically reliable for establishing quantifiable / measurable monitoring target for evaluation. The occurrence of the species in a particular site also depends on a number of factors (e.g. natural temporal variation, availability of food sources, predators and disturbance in the vicinity) and may show a high temporal variation, not to mention the human induced errors such as difference in sampling effort and methodology."	Noted. The text will be amended to read: The main aim of the project is to attract selected target species to the created wetlands. However, the use of specific population sizes of these species as a measure of project success poses a number of difficulties. Because of external factors (e.g., natural spatial and temporal variation in target species populations, human activities and pollution outside the site boundary) beyond the control of those managing the habitats, there is no way of guaranteeing that target species will establish themselves in the compensatory wetlands, even if optimal habitat conditions are created.

6.3.2	
The amendment made in the paragraph suggests that more reliable indicators other than "establishment of target species" are selected to measure relative success. However, the revised Table 6.2 also sets the indicator objectives for target species. Please clarify.	Noted: The primary aim of this project is to create habitats suitable for target species, and ideally, all indicator objectives listed in Table 6.2 would be met. However, if suitable habitat conditions are created, but target species indicator objectives are not reached, it should not be concluded that the project has failed. As discussed in our response to the previous comment (6.3.1), measures of density/abundance for most of target species may be affected by factors beyond the control, and are therefore cannot be relied upon as overall indicators of success or failure. The following text will be added to section 6.4.3: For reasons discussed in section 6.3, the indicator objectives in table 6.2 will not be suitable measures of the overall success of habitat creation. Their inclusion in the monitoring programme will, however, facilitate the effective management of the habitats. If the objectives are not achieved, remedial strategies can be implemented to determine why. If appropriate, changes to management strategies can then be effected to encourage target species utilisation of the habitats.
6.4.6	
A number of plant species were listed in the section and the establishments of the species were used as one of the objectives. Please clarify whether such species will be recommended for planting in the wetland. If yes, whether they are commercially available in the market.	We will specify only those plants that are appropriate to the target ecology of the wetlands and associated fauna. Plant availability is likely to be a constraint that may limit plant selection and influence planting management procedures. If necessary, we would try and create mechanisms that allow for some flexibility in the timing of planting to allow greater capacity for the use of less common plants.
6.4.6.1, 3rd bullet point	
In order to allow flexibility, suggest deleting "20" or reword to indicate that not all species listed in the table need to be established in order to meet the objective. Indeed, it may be more practical to specify to the Genus level only for the objective on plant community as some species of the same genus will have similar characteristic and structure for providing the required habitat. Table 6.5 should be used as a reference only.	Noted. Text will be amended to read: Establishment of a similar plant community to Table 6.5 (excluding exotics, these species were found to be common or very common in Kam Tin habitats supporting populations of Painted Snipe).

Table 6.5	
Ludwigia ascandens should read Ludwigia adscendens. Ranuncula soleratus should read Ranuncula scleratus.	Noted. Typographical errors will be corrected
6.4.6.2, 2nd bullet point	
See comment above (Item 4) on the objective on plant community.	Please note that with one exception (the commonly planted *Camelia hongkongensis*) all these species are naturally widespread and very common in Hong Kong. We feel these indicator objectives are suitable and easily obtainable.
Table 6.6	
Suggest deleting "Camellia hongkongensis, Rhododendron simsii" as these species should not be common in wetland.	Noted, these species will be omitted from Table 6.6
Suggest deleting "Pinus massoniana" as this species has seldom been planted Tlex puescens should read Ilex pubescens	Noted. This species will be removed. Noted and corrected
Litsia glutinosa should read Litsea glutinosa.	Noted and corrected
6.4.6.3, 2nd bullet point	
See comment above (Item 4) on the objective on plant community.	Please refer to our response to comment 6.4.6.2, 2nd bullet point
6.5.7	
It seems that the term "benthic" should be deleted from the title as the methodology described in the paragraph is not referring to the collection of benthic organisms. Moreover, the monitoring frequency for this group has not been specified.	Noted. "benthic" will be replaced with "aquatic"
7.1	

It was indicated that the EHMP would contain an Operation and Maintenance Plan (OMP) containing details of the long term management operations as mentioned in the technical Proposal (P.20) submitted by the Consultants for this consultancy. In the response to my previous comment, the Consultant indicated that such details would be provided in the design and tender documents. Please clarify whether the details on maintenance requirement to be given in the design and tender documents will be able to give the level of details comparable to the OMP. Moreover, in the sixth paragraph, the paragraph is amended that to read "the Constructed Wetlands Operation manual (CWOM) will be produced by the Landscape Consultant for the Contractor". Please clarify the difference between an OMP and CWOM. If they are equivalent, they should be prepared under this consultancy and confirm and modified where appropriate by the Landscape Consultant for the Contractor.	The details of the operation and management of the wetland are dependent on the specific design, as such the issue was addressed in only broad terms in the EHMP, but will be fully detailed in the design and tender documents, to a level equivalent to the OMP. These will include . • the maintenance operations required to be undertaken and where checking is proposed, necessary responses to specific event will be specified • their frequency • the equipment and staff required to undertake them • the parties responsible for undertaking them OMP and CWOM are largely synonymous, with the plan looking more at overall objectives and policies and the Manual looking more at detail. We consider, now that they should be combined. We confirm that they will be produced as part of the design package, with the detail to be confirmed by the Contractor during construction.
Table 8.2	
Please revise according to my comments given on the responsibility matrix under separate cover.	