7.

ECOLOGY

7. Ecology

7.1 Introduction

7.1.1 The core study area contains a wide range of habitats. All of the area has been influenced by the proximity to residential areas in Discovery Bay. Some areas are highly modified, others retain an essentially natural character. Given the proximity to Discovery Bay, the opportunity to manage the area for long-term conservation would be difficult.

7.2 The Regulatory Environment

Hong Kong Regulations and Guidelines

7.2.1 The Hong Kong Government regulations relevant to the present project include the following:

- the Forests and Countryside Ordinance (Cap. 96) which protects both natural and planted forests, including mangroves;
- the Forestry Regulations which provide for protection of specified local wild plant species;
- the Wild Animals Protection Ordinance (Cap. 170) which provides for the protection of listed species of wild animals (excluding fish and marine invertebrates) by prohibiting the disturbance, taking or removal of such animals, their nests and eggs; and
- the Fisheries Protection Ordinance (Cap. 171) which is intended to promote the conservation of fish and other forms of aquatic life within the waters of Hong Kong, to regulate fishing practices and to prevent activities detrimental to the fishing industry.

Ramsar Treaty

7.2.2 Through the United Kingdom, Hong Kong is a Party to *The Convention on Wetlands of International Importance Especially as Waterfowl Habitat* (the *Ramsar Convention*). Contracting parties to the Ramsar Treaty are required to designate at least one wetland for inclusion in a 'List of Wetlands of International Importance.' Within Hong Kong, the Mai Po/Inner Deep Bay wetland was the first wetland considered for Ramsar Convention listing. It was proposed for designation as a Ramsar Wetland of International Importance in March 1995. None of the wetlands in the Master Plan 6.0(A) study area are known to qualify as Ramsar Convention wetlands.

7.2.3 Article 1 of the Ramsar Convention defines wetlands as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters.' All wetland habitats in the study area, including intertidal coastlines, mudflats, mangroves, and estuaries, qualify as wetlands under this definition.

7.2.4 Article 3.1 of the Ramsar Convention provides that the contracting parties 'shall formulate and implement their planning so as to promote as far as possible the wise use of wetlands in their territory'. The wise use concept was defined in 1987 as 'the sustainable utilisation of wetlands for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem'.

Country Parks, SSSIs and Special Areas

7.2.5 There are no Country Parks, Sites of Special Scientific Interest (SSSIs) or Special Areas near the proposed development area. The nearest such area is Lantau South Country Park, some 4km south-west of Yi Pak Wan. There is, however, a proposed extension of Lantau North Country Park which would bring its eastern boundary within 400m of the development area at Yi Pak Wan and within 200m at Sam Pak Wan (AFD Map: *Lantau North Extension*, Plans 1c & 1d, dated 5/93). The proposed Country Park extension was under consideration by AFD at the time of writing.

7.3 Study Materials and Methods

Flora

7.3.1 The initial studies were conducted in autumn 1994 to identify the key ecological issues. Field surveys were performed on the proposed Discovery Bay North development site on 17 and 23 November, 1994. The rocky shore of Yi Pak Wan and Yi Pak Hill were surveyed non-systematically. Major habitats of terrestrial vegetation were noted and dominant flora were recorded. The objective was to establish the conservation significance of the study area, and particularly to determine whether species of plants which are protected by local regulations or international convention occur in the study area. Plants were identified to species level where possible.

7.3.2 Further field surveys were conducted for major habitats in April 1995. Major habitats of terrestrial vegetation were classified according to commonly used criteria (Hong Kong Government, 1968). Plants were identified to species level where possible to determine the presence of protected, rare or endangered species. The purposes of the second study were:

- to supplement the initial baseline information with detailed vegetation surveys during winter 1994/95 and spring 1995;
- to determine the conservation importance of vegetation in the study area; and
- to examine whether plant species which are protected under local regulations occur within the study area.

7.3.3 Marine macroalga were surveyed as part of transect studies of the boulder and cobble shore within the study area. A general shoreline survey was also performed to assess intertidal algal diversity. These surveys were conducted during winter and spring seasons in early 1995 in response to a request from AFD at the Environmental Study Management Group meeting to discuss the IAR (HKR, 1994a).

Fauna

7.3.4 Aquatic fauna were surveyed using hand nets and traps in the streams and estuaries. The occurrence and distribution of organisms along the boulder and rocky shoreline were surveyed using belt transects. Terrestrial and avian fauna were surveyed non-systematically to cover all available habitats and to maximise species representation in the sample results.

7.3.5 Avifauna surveys were conducted in January, February, March and April, 1995 to document species presence in the study area and to identify important bird habitats. Surveys were conducted in all habitats to be affected by the proposed development at Yi Pak Wan and Sam Pak Wan. Nests, perches, roosts, feeding areas and other important bird habitats were recorded. Species presence and abundance estimates were made visually and through vocal recognition.

7.3.6 Amphibian, reptilian and mammalian fauna were surveyed by searching for animals or their burrows, trails, droppings or other signs of regular use. All major habitats were surveyed.

7.4 Existing Flora

General Study Area Flora

7.4.1 Five major types of vegetation in the study area were identified: shrub woodland, shrub grassland, grass/disturbed areas, mangroves/mangrove associated vegetation and backshore vegetation (Figure 7.1).

7.4.2 In general, the site is a frequently disturbed area. Much of the vegetation in the area has been subject to surface disturbance by construction or fire in recent years. The most recent fire occurred between November 14 to 16, 1994. This fire extensively burned the study area including Tai Che Tung, Yi Pak Au and down to Lau Fa Tung. Only the relatively mesic habitats such as the backshore, ravine, riparian and foothill regions survived the fire. The plant species recorded during the 1994 and 1995 surveys are listed in Table 7.1.

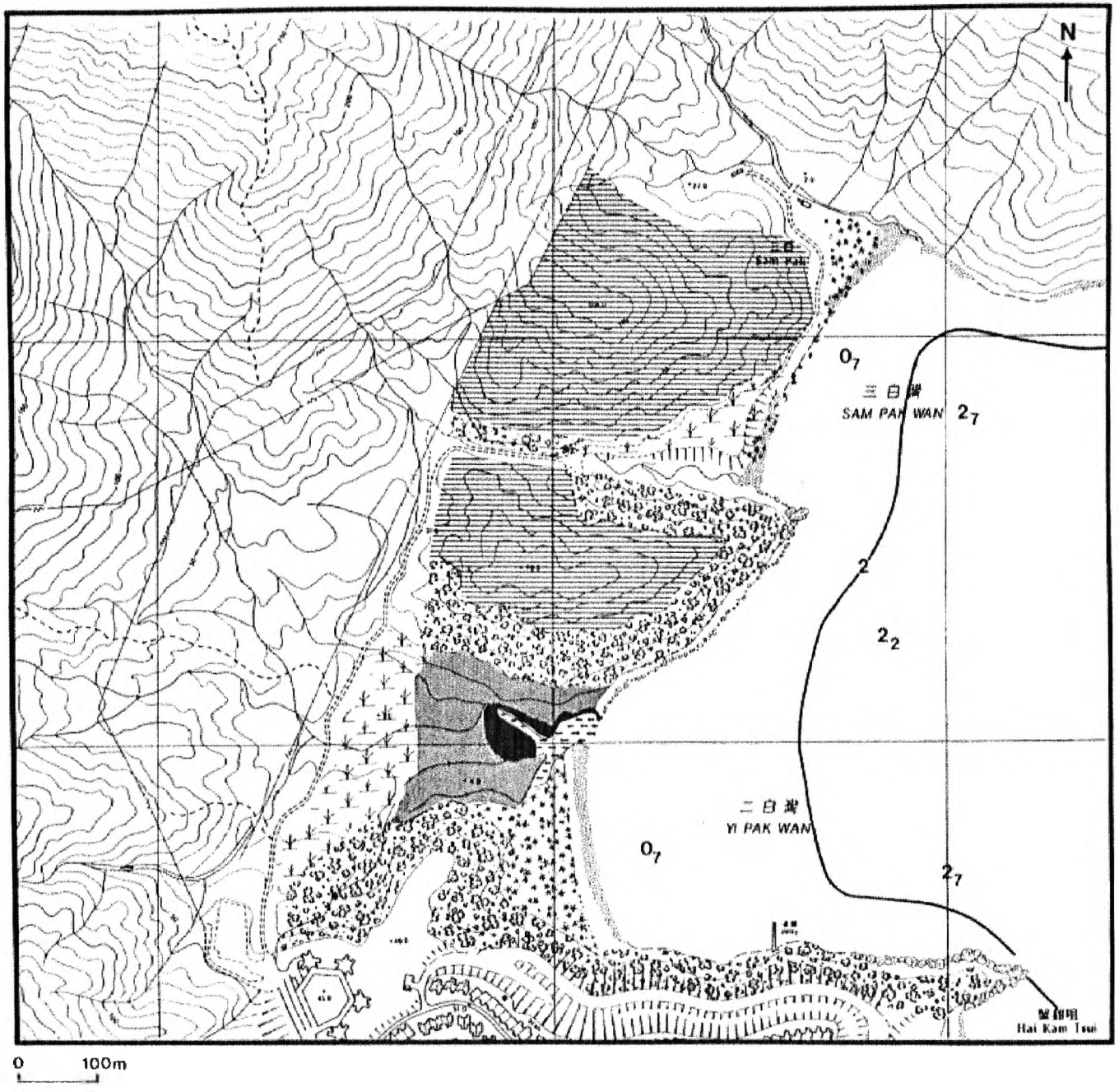

Figure 7.1
Discovery Bay North Habitat Map

Table 7.1 Species List and Abundance of Flora at the Discovery Bay North Development Site

Scientific Name	Habit	Habitat			
		Woodland	Grass/ shrubland	Streamside	Coastal area
Acronychia pedunculata	tree	++			
Adina pilulifera	shrub	++			
Adinatum flabellatum	fern	+			
Aporusa dioica	tree	++			
Aralia chinensis	tree		++		
Archidendron lucidum	tree	++			
Ardisia punctata	shrub	++			
Artocarpus hypargyreus	tree		+, planted		
Arundinella setosa	grass		+++		
Aster baccharoides	herb		++		
Baeckea frutescens	shrub		+++		
Berchemia lineata	shrub			++	
Bidens pilosa	herb		++		
Blechnum orientale	fern	++	++	++	+
Breynia fruticosa	shrub		++		
Bridelia tomentosa	tree	++		++	
Cassytha filiformis	climber		++		
Casuarina equisetifolia	tree	rare	++, planted		
Cerbera manghas	tree	+			
Chrysanthemum indicum	herb	++			
Cleistocalyx operculatus	tree			+++	
Conyza bonariensis	herb		++		
Cratoxylum cochinchinense	tree	++		++	
Daphniphyllum oldamii	tree	++			
Desmos cochinchinensis	climber	++			
Dianella ensifolia	herb		++		
Dicranopteris linearis	fern	+++	+++		
Embelia laeta	climber		+++		
Embelia longifolia	climber	++	++		
Emilia sonchifolia	herb		++		
Erythrina variegata	tree		+, planted		
Eucalyptus tereticornis	tree		+, planted		
Eupatorium japonicum	herb		++	++	
Eurya chinensis	shrub	+++			
Ficus fistulosa	tree	++		++	
Glochidion eriocarpum	shrub	+	++		
Glochidion lanceolatum	tree	++		++	
Glochidion wrightii	tree			++	
Gynura bicolor	herb		++		
Helicteres angustifolia	shrub		++		
Hibiscus tiliaceus	tree				+++
Ilex asprella	shrub	+++			
Ipomoea brasiliensis	climber				+++
Ischaemum indicum	grass		+++		
Lantana camara	herb	++	++	+++	++
Lespedeza formosa	shrub		+		
Leucaena leucocephala	tree		++, planted		
Litsea glutinosa	tree	+++			
Litsea rotundifolia	tree	+++	++	++	
Lonicera confusa	climb	++			
Lygodium japonica	fern	+++	++		
Macaranga tanarius	tree			++	
Maesa japonica	shrub	+			

Table 7.1 Species List and Abundance of Flora at the Discovery Bay North Development Site (continued)

Scientific Name	Habit	Habitat			
		Woodland	Grass/ shrubland	Streamside	Coastal area
Melastoma sanguineum	shrub		++		
Microcos paniculata	tree	+++			
Mikania guaco	climber	+++	+++	+++	+++
Miscanthus floridulus	grass	+++			
Musa sp.	herb		++, planted		
Mussaenda pubescens	climber		++		
Neyraudia reynaudiana	grass		+++	++	
Paederia scandens	climber	++	++	++	
Panicum sarmentosum	grass		++		
Pennisetum polystachyum	grass		+++		
Phoenix hanceana	palm	+	+		
Phyllanthus cochinchinensis	shrub	++			
Phyllanthus emblica	tree		++		
Psychotria rubra	shrub	++		++	
Pteridium aquilinum	fern		++		
Pteroloma triquetrum	climber			++	
Pueraria phaseoloides	climb	++		++	++
Rhaphiolepis indica	tree	+++	++		
Rhodomyrtus tomentosa	shrub	++	+++		
Rhus hypoleuca	tree	++	++		
Rhus succedanea	tree	++	++		
Rhyncospora rubra	sedge		++		
Rourea microphylla	climb	+++			
Rubus reflexus	climber	++	+++		
Sapium discolor	tree	++			
Sarcandra glabra	herb	+			
Scaevola sericea	tree				++
Schefflera octophylla	tree	++		++	
Scleria herbecarpa	sedge		+		
Scolopia chinensis	tree	+			
Smilax china	climber	++	++	++	
Smilax lanceifolia	climber	++	+++	++	
Sterculia lanceolata	tree	++		++	
Strophanthus divaricantus	shrub		++		
Symplocos laurina	tree	++	++		
Tetracera asiatica	climb	+++			
Thespesia populnea	tree			+	
Trema orientalis	tree	+		+	
Vaccinium bracteatum	shrub		+		
Wedelia prostrata	climber			++	
Wikstroemia indica	shrub		+		
Youngia japonica	herb		+		
Zanthoxylum avicennae	tree	+			
Zanthoxylum scandens	climber	++	++	++	

Boldfaced species were recorded during April 1995 surveys.
Abundance: +rare; ++occasional; +++common.

Table 7.2 Mangrove Species Represented in Yi Pak Stand, Lantau Island, November 1994

Species	Abundance Rank (1 = highest)
Acanthus ilicifolius	5
Aegiceras corniculatum	1
Avicennia marina	6
Bruguiera gymnorrhiza	4
Excoecaria agallocha	3
Kandelia candel	2

7.4.9 Propagules of *B. gymnorrhiza*, *K. candel* and *A. corniculatum* had established on the seaward edge of the mangal. All three species were subjected to deposition of up to 0.3m of coarse sand at the seaward periphery of the mangal during autumn 1994. Affected trees survived through the winter. Mature *K. candel* trees produced many immature propagules during early winter and spring 1995. Both *K. candel* and *A. corniculatum* are widespread in Hong Kong and typically occur in mangals throughout the Territory. *A. marina* and *B. gymnorrhiza* are considered to be of relatively limited distribution in Hong Kong. *A. marina* reproduction has been limited in recent years throughout Hong Kong due to poor production of propagules possibly resulting from insect herbivory of the flowers.

7.4.10 The area of the mangrove was estimated to be about 0.6 ha from 1:5000 scale topographic maps and 1993 aerial photos (Survey and Mapping Office, Buildings and Lands Dept.).

Backshore and Mangrove Associated Vegetation

7.4.11 The beach at Yi Pak Wan has a typical profile, with a berm of sand at the top of the beach colonised by backshore vegetation. The common species are listed in Table 7.3. On the landward side of the berm, the backshore vegetation merges with the enclosed mangrove stand behind the beach.

Shrubland and Grassland

7.4.5 This is the major vegetation type in the study area of Yi Pak Au and Yi Pak Hill. These large areas of shrubland/grassland have been maintained by frequent hill fires. Within these areas, continuous successional stages from grassland/fernland to shrubland were recorded. They were all very similar in composition, but varied in species dominance. Therefore, they are described together in this report.

7.4.6 In general, the grassland was dominated by *Arundinella setosa, Cymbopogon citratus* and *Ischaemum* spp. with some shrub species such as *Rhodomyrtus tomentosa, Rhaphiolepis indica* and *Eurya chinensis*. The fernland was dominated by *Dicranopteris linearis*, with a mixture of other grass and shrub species. The shrubland was dominated by *Rhodomyrtus tomentosa, Rhaphiolepis indica, Gardenia jasminoides* and *Diospyros vaccinioides* mixed with some ferns and grasses.

Coastal and Estuarine Flora

7.4.7 The proposed development site encompasses areas of backshore, mangrove, estuarine, intertidal and sub-tidal habitats. Backshore habitats are represented by the sand berm and mangrove associated vegetation, and small estuaries are formed by the tidal lagoons and sand spits at the mouths of both Yi Pak and Sam Pak streams. Sand and boulder shorelines are represented in the intertidal zone.

Mangrove

7.4.8 The stand of mangroves is mainly confined to the site behind Yi Pak beach which is inundated by the tide via the lagoon and its drainage channel at the northern tip of the beach. Freshwater enters the stand through four streams. The major species in this mangal are shown in Table 7.2. *Aegiceras corniculatum* is the dominant species, closely followed by *Kandelia candel*. There were also good numbers of *Bruguiera gymnorrhiza* and *Acanthus ilicifolius* at the site. Only a few individuals of *Avicennia marina* were found. There was no clear evidence of spatial zonation of species in this mangal, although *Excoecaria agallocha* was mainly confined to the landward fringes. Excluding *A. marina*, individual trees of other species reached 3m in height. This height is typical for western Hong Kong mangroves. Some trees of *B. gymnorrhiza, A. corniculatum* and *K. candel* were over 3m in height.

Table 7.3 Backshore Vegetation Behind Yi Pak Beach, Lantau Island, November 1994 to April 1995

Species	Common Name
Hibiscus tiliaceus	Hibiscus
Pandanus tectorius	Screw-pine
Caesalpinia cristia	Gray Nickers
Vitex rotundifolia	
Scaevola sericea	Sea Lettuce
Cerbera manghas	Cerbera
Ipomoea brasiliensis	
Pueraria phaseoloides	Wild Kudzu vine
Zoysia sinica	Seagrass
Saccharum arundinaceum	
Pennisetum sp.	

7.4.12 Around the landward fringes of the mangroves, there is a transition from mangrove to hillside vegetation with the higher zoned mangrove *Excoecaria agallocha* and common mangrove associates such as *Pandanus tectorius* giving way to grasses (*Saccharum arundinaceum, Neyraudia reynaudiana*), shrubs (*Phoenix hanceana)* and some cultivated species (*Musa paradisiaca*).

7.5 Existing Fauna

Overview

7.5.1 The core study area contains a wide range of habitats ranging from upland grass/ scrub cover to estuarine areas. Some habitats are highly modified while others remain relatively undisturbed.

Yi Pak Stream Fauna

7.5.2 The main stream draining into Yi Pak lagoon is channelled in the section immediately below the existing Discovery Bay residential area for approximately 200m. The lower 200m remains in its natural state. However, the stream has been heavily impacted by runoff from nearby earthworks and previous construction activities. Little remained of interest ecologically. While there were many juvenile marine fish (e.g. *Mugil cephalus, Pampus argenteus*) in the lower, tidal reaches of the stream, only freshwater gobies

(*Ctenogobius duospilus*) and a flat-headed goby (*Glossogobius giuris*) were recorded in the upper reaches.

Estuarine Fauna

7.5.3 The fauna of the mangrove and the estuary was neither abundant nor diverse. Mudskippers (*Periophthalmus cantonensis*) were present, and many small sesarmid crabs inhabited the softer mud along the edges of drainage channels within the mangrove. The mangrove floor was rather hard-packed earth, which may deprive the usual array of mangrove/mudflat invertebrates of suitable habitat. There was also a marked absence of gastropod species. A shell belonging to the maritime pulmonate snail *Ellobium polita* was found, which may indicate the presence of this species in the mangrove stand, although no live specimens were recorded. This species is of limited distribution in Hong Kong.

Yi Pak Beach Fauna

7.5.4 The profile of Yi Pak beach consists of a berm at the very back of the beach covered in characteristic vegetation (Table 7.3), an upper beach and a lower beach. The fauna was restricted to Ocypodid crabs with their burrows on the upper beach, along with strandline fauna such as litter cockroaches (*Opisthoplatia orientalis*). The high number of shells on the lower beach testifies to sub-littoral populations of *Tapes philippinarum* and *Donax* sp. The low diversity of the beach fauna is typical for such a habitat.

Sub-Tidal Fauna

7.5.5 The sub-tidal substrate of Discovery Bay is generally soft silt and sand. Average values for the particle size distribution of the sediment are shown in Table 7.4.

Table 7.4 Particle Size Analysis (%) of Discovery Bay Sub-Tidal Sediment

Gravel	Sand	Silt	Clay
1	10	57	31

Source: APH, 1993.

7.5.6 As is generally the case in Hong Kong, polychaetous annelids and molluscs dominate the benthic infauna. Benthic surveys carried out as part of the Lantau and Western Harbour Development Studies Environmental Survey (APH, 1993) indicated that the benthic community at Discovery Bay was of low diversity and species richness relative to samples from, for example, Chi Ma Wan further south. The values of $H^{'}$ are similar to those reported by Shin (1988) for the infauna of beach sediments in Hong Kong. The five dominant species during the winter were all polychaetes (*Notomastus latericeus*,

Paraprionospio pinnata, Glycera chiori, Terebellides stroemi and *Aglaophamus lyrochaeta).* During the summer survey, *Glycera* and *Terebellides* were replaced by *Lumbrinereis* spp. and a nemertean (*Nemertea* sp.) in the list of the five dominant species.

7.5.7 The abundance and biomass of the benthic infauna shows strong seasonal trends, with far greater numbers of organisms during December than June (Table 7.5). As is typical of such communities in Hong Kong, diversity does not vary as much, but may be affected by variations in the abundance of some species (Ong Che and Morton, 1991).

Table 7.5 Benthic Community Statistics, Discovery Bay, December 1991 and June 1992

	Species per 0.15 m^2	Individuals per m^2	Wet weight	H' *	J' **	SR ***
December 1991	5	80	11.25	1.23	0.77	1.61
June 1992	3	20	2.80	1.09	1.00	0.66

Source: APH, 1993

* Shannon-Weaver Diversity Index
** Pielou Evenness Index
*** Margalef's Species Richness Index

Intertidal Fauna

Boulder

7.5.8 The exposed stretch of boulder shore to be affected by the proposed development runs from the southern section of Sam Pak Wan to the southern end of Yi Pak Wan. This type of shoreline is very common in Hong Kong. High-zoned on these boulders were species of *Nodolittorina* and the hydrobiid *Zebina tridentata*, plus many sea-slaters (*Ligia exotica).* Numerous crabs were present, such as the sesarmid *Parasesarma pictum,* and grapsids *Grapsus albolineatus* and *Gaetica depressa.* The most numerous gastropod was the top-shell, *Monodonta australis*, with *Lunella coronata* and *Nerita* sp. also abundant lower down the shore. Also common was the limpet *Colisella dorsuosa.* Lower down the beach, the attached fauna was dominated by rock oysters (*Saccostrea culcullata*), many with a surrounding stubble of the red alga *Gelidium pusillum.*

Cobble/Mud

7.5.9 The shoreline to be affected along the southern edge of Yi Pak Wan is more sheltered than the boulder shore to the north. The high shore is again bedrock/boulder, but the mid and lower intertidal zones are of a shallow gradient, with many small to medium rocks embedded in fine sand and mud. *Nodolittorina* sp. again dominated the upper eulittoral, with *Nerita albicella* appearing slightly lower down. In the lower half of the intertidal zone, rocks embedded in the mud were thickly covered with the bivalve *Chama reflexa*, with clusters of *Barbatia viriscens* growing in crevices. The dominant gastropods here were *Lunella coronata* and the whelk *Morula musiva*. Large aggregations of *M. musiva* (over 1000 per m^2) could be found on the lower faces of some larger rocks. Also recorded was the common anemone *Haliplanella luciae*, with a second, burrowing species also present, possibly *Paracondylactis hertwigi*.

Intertidal Alga

7.5.10 The macroalga in Hong Kong are seasonal in nature, being most abundant during the winter/spring months and all but disappearing during summer (Hodgkiss and Lee, 1983). This was found to be the case during surveys of the Yi Pak Wan shoreline, where no alga were recorded during the autumn survey, but were in evidence during late winter/spring. During March, the rocks in the lower eulittoral and sub-tidal zones along the northern edge of Yi Pak Wan were thickly covered with the brown algae *Petalonia fascia*. Areas of *Gomontia* sp. were found higher up the shore. Patches of *Brachytrichia maculans* were also recorded. Detached specimens of *Colpomenia sinuosa* were collected from Yi Pak beach. None of these species are rare in Hong Kong.

Fisheries

7.5.11 Yi Pak Wan falls within the northern sub-area of the Western Harbour sector of Hong Kong's fishing grounds. Medium intensity demersal, pelagic and fry fishing occurs in the Western Harbour sector (P. Gaiger, pers. comm.; Fisheries Officer, Agriculture & Fisheries Department, Hong Kong). Shallow embayments such as Yi Pak Wan are known to be nursery grounds for marine fish (e.g. Snapper, Sea-bream), where the fry are seasonally concentrated between March and April, sometimes extending into June (APH, 1993). The coastal waters of Discovery Bay and Penny's Bay are also used by penaeid shrimp and hang-net (mid-water) trawlers (P. Gaiger, pers. comm.), and small craft from Peng Chau, Cheung Chau and Mui Wo also fish these waters. The estimated quantity and value of fish caught in the northern sub-area by small craft during 1989-90 were: adult fish - 2181 tonnes / HK$30.82M; fry - 1.31 million/HK$ 2.74M (APH, 1993).

Birds

7.5.12 Birds were surveyed on the site during summer (May 16, June 5 and 7, 1994), autumn (November 17 and 24, 1994), winter (January 12, February 2 and 26, 1995), and spring (April 5, 15 and 17, 1995). Surveys were conducted from within one hour of sunrise through sunset. Sightings and vocalisation records of birds were documented. Survey routes were followed to cover all major habitats. The results of bird surveys are shown in Table 7.6.

7.5.13 51 species of birds were recorded on the site over all seasons. 31 species were recorded during summer and autumn and 20 additions were made during winter and spring. 27 families were represented. Two families were represented by four species each (*Alcedinidae* or kingfishers, and *Motacillidae* or pipits and wagtails). All other families were represented by three or fewer species. 16 species were recorded during summer 1994, 15 additional species were recorded during autumn 1994 and 19 species were added during winter 1994/95 and spring 1995. Most of the species recorded are common residents or seasonal visitors to Hong Kong, and would be expected to occupy habitats such as those in the study area.

7.5.14 Of particular interest with regard to the utility of the area for birds feeding on aquatic prey are the Cormorant, the egrets and Night Heron, the four species of kingfisher and the Common Sandpiper. These birds were observed foraging on Yi Pak Wan, the sand beaches, in the lagoons behind the beaches and along the streams feeding the lagoons. Foraging by these species demonstrates that the bay and the estuaries support vertebrate prey selected by avian predators. Additionally, the presence of four species of kingfisher within the relatively small survey area suggests that the site is a preferred foraging habitat. Only the White-breasted and Common Kingfisher were observed during spring 1995 surveys, suggesting that these species may nest in the vicinity. The four species of kingfisher recorded on the study site represent all the resident species of kingfisher in Hong Kong.

7.5.15 A pair of Black-eared Kites was observed during November 1994 perched in the woodland above the Yi Pak Wan estuary and in a large *Eucalyptus* sp. tree. Courtship behaviour was not observed during autumn, but one bird was observed carrying nesting material. During April 1995, a nest was located in the *Eucalyptus* sp. tree in the estuary and one young Black-eared Kite was observed in the nest. Both adults were observed either in the nest tree perched above the nest or foraging over scrub-grass habitats nearby. Neither bird tended the nestling during observations on April 17, 1995, as the chick was apparently old enough that brooding was no longer required. The nest was checked on May 9, 1995. The chick was still in the nest and was attended by both adults. The post-natal moult was nearly complete and down feathers were visible only on portions of the chick's body. The chick could not yet fly. The nesting attempt is considered to have been successful.

Table 7.6 Results of Bird Surveys at Yi Pak and Sam Pak, Lantau Island, Summer and Autumn 1994, Winter 1994/95 and Spring 1995

Common Name	Species	Status[1]	Abundance[2]	Habitat[3]
Cormorant	*Phalacrocorax carbo*	W	1	bay
Little Egret*	*Egretta garzetta*	R	1	beach, estuary
Night Heron*	*Nycticorax nycticorax*	R	1	estuary
Reef Egret*	*Egretta sacra*	R	1	estuary
Black-eared Kite*	*Milvus lineatus*	R	1	estuary, scrub-grass
Boneli's Eagle	*Hieraaetus fasciatus*	R	1	soaring over all areas, coast
Unidentified accipiter	*Accipiter* sp.	?	1	soaring over scrub-grass
Kestrel	*Falco tinnunculus*	WV	1	soaring over scrub-grass, coast
Chinese Francolin*	*Francolinus pentadeanus*	R	2	shrubland
White-breasted Waterhen*	*Amaurornis phoenicurus*	R	2	estuary
Common Sandpiper*	*Actitis hypoleucos*	R	1	beach
Spotted Dove*	*Streptopelia chinensis*	R	3	estuary, woodland, shrubland
Rufous Turtle Dove	*Streptopelia orientalis*	PM/WV	2	estuary, woodland, shrubland
Emerald Dove*	*Chalcophaps indica*	R	1	woodland
Koel*	*Eudynamis scolopacea*	R	2	woodland, estuary
Indian Cuckoo*	*Cuculus micropterus*	S	1	woodland
Greater Coucal*	*Centropus sinensis*	R	3	backshore, estuary, woodland
Lesser Coucal*	*Centropus bengalensis*	R	1	estuary
Collared Scops Owl*	*Otus lempiji*	R	1	Sam Pak Wan coastal woods
Pied Kingfisher*	*Ceryle rudis*	R	1	estuary
Common Kingfisher*	*Alcedo atthis*	R	1	estuary, bay
Black-capped Kingfisher*	*Halcyon pileata*	R	1	estuary, bay
White-breasted Kingfisher*	*Halcyon smymensis*	R	1	estuary
Barn Swallow	*Hirundo rustica*	S,M	3	estuary, shrubland, woodland
Tree Sparrow*	*Passer montanus*	R	3	scrub-grass, woodland, residential
Richard's Pipit	*Anthus richardi*	R,M,W	1	scrub-grass
Olive-backed Pipit	*Anthus hodgsoni*	WV	1	residential park
Grey Wagtail	*Motacilla cinerea*	WV	1	revegetated slopes
White Wagtail	*Motacilla alba*	WV	2	estuary, disturbance area
Crested Bulbul*	*Pycnonotus jocosus*	R	4	woodland, estuary, scrub-grass,
Chinese Bulbul*	*Pycnonotus sinensis*	R	4	woodland, estuary, scrub-grass
Red-vented Bulbul*	*Pycnonotus aurigaster*	R	3	open pine scrub, woodland/ orchard
Magpie Robin*	*Copsychus saularis*	R	3	woodland, scrub-grass, estuary

Table 7.6 Results of Bird Surveys at Yi Pak and Sam Pak, Lantau Island, Summer and Autumn 1994, Winter 1994/95 and Spring 1995 (continued)

Common Name	Species	Status[1]	Abundance[2]	Habitat[3]
Blackbird	*Turdus merula*	WV	1	estuary, coastal woods
Yellow-bellied Prinia*	*Prinia flaviventris*	R	2	scrub-grass, stream
Plain Prinia*	*Prinia inornata*	R	2	estuary, scrub-grass
Dusky Warbler	*Phylloscopus fuscatus*	WV	2	estuary, scrub-grass
Narcissus Flycatcher	*Ficedula narcissina*	PM	1	woodland
Common Tailorbird*	*Orthotomus sutorius*	R	3	woodland, shrubland
Black-faced Laughing Thrush*	*Garrulax perspicillatus*	R	3	woodland, estuary, shrubland
Great Tit*	*Parus major*	R	2	estuary, woodland
Japanese White-eye*	*Zosterops japonica*	R	3	woodland, estuary, shrubland
Rufous-backed Shrike*	*Lanius schach*	R	1	scrub-grass, backshore
Black Drongo*	*Dicrurus macrocercus*	SV	2	estuary, shrubland
Hair-crested Drongo*	*Dicrurus hottentottus*	SV	1	estuary, shrubland
Magpie*	*Pica pica*	R	3	estuary, shrubland
Blue Magpie*	*Urocissa erythrorhyncha*	R	2	backshore shrubland, estuary
Jungle Crow*	*Corvus macrorhynchus*	R	1	estuary, scrub-grassland
Crested Mynah*	*Acridotheres cristatellus*	R	4	shrubland, estuary, woodland
Masked Bunting	*Emberiza spodocephala*	WV	2	woodland, estuary, shrubland

* = species potentially breeding on site

[1]R = resident; PM = passage migrant; WV = winter visitor; SV = summer visitor

[2]1 = 1 to 5 birds; 2 = 5-10 birds; 3 = 10-50 birds; 4 = 50-100 birds

[3]Habitat use ranked in order of importance

7.5.16 The Hong Kong Bird Watching Society reported a pair of adults and one juvenile Brown Fish Owl (*Ketupa zeylonensis*) at Yi Pak Wan in 1988 (Chalmers, 1988). This was the first record of Brown Fish Owl nesting in Hong Kong. Since then, a second nesting pair produced one young in Sai Kung during spring 1993 (Leven *et al.*, 1994). Although no indication of current use of the Yi Pak Wan site by Brown Fish Owls was observed, this species is considered difficult to locate. It is secretive, nocturnal and typically not vocal (G. Carey, pers. comm.; Hong Kong Bird Watching Society). Therefore, it may have been overlooked during surveys conducted to date. The probability of observing Brown Fish Owls at Yi Pak Wan may be greater during late spring and early summer if there is a nesting pair which produces young.

7.5.17 Observation of an individual Collared Scops Owl at Sam Pak Wan suggests that this area may be used by nesting owls. A breeding attempt may have occurred in spring 1995.

7.5.18 Observation of the Narcissus Flycatcher on 5 April 1995 was interesting in that the species is considered 'scarce but widespread' in Hong Kong (Viney *et al.*, 1994). It is a passage migrant typically observable in April. It was observed foraging for insects on mature trees (with closed canopy) around the village ruins west of the estuary at Yi Pak Wan.

7.5.19 Habitats preferred by wintering birds were the estuary and associated woodland or shrubland. Upland slopes and hill tops such as Yi Pak Hill were not preferred habitats.

7.5.20 13 of the 51 recorded bird species are not likely to nest on the site (Table 7.6). The remaining 38 species may nest within the study area. All birds, their nests and nest contents are protected by the Wild Animals Protection Ordinance (Cap. 170).

Reptiles and Amphibians

7.5.21 The Asiatic Painted Frog (*Kaloula pulchra*) was recorded calling in the Yi Pak and Sam Pak areas during spring 1995. In both cases, the habitat used was the lower reach of the stream near the estuary. This species is common in Hong Kong, particularly in the New Territories (Karsen *et al.*, 1986).

Mammals

7.5.22 No evidence of mammals was recorded within the study area. As reported following summer 1994 surveys (HKR, 1994a), small mammal burrows were seen on the hill immediately north of the Yi Pak streams. These were probably rat burrows, possibly those of the Chestnut Rat (*Niviventer fulvescens*), a common hillside rat in Hong Kong.

7.5.23 Droppings of a civet (probably the Masked Palm Civet, *Paguma larvata*) were recorded in Yi Pak during the early 1990s (D. Melville, pers. comm.; Executive Director, World Wildlife Fund for Nature, Hong Kong). The Masked Palm Civet is protected in Hong Kong under the Wild Animals Protection Ordinance (Cap. 170). In India, the species is protected under Appendix III of CITES (Convention on International Trade in Endangered Species) (Wilson and Reeder, 1993). In Guangdong Province, China, the Masked Palm Civet is not listed as a protected species. No signs of Masked Palm Civets were recorded during winter/spring 1995.

7.6 Potential Impacts on Ecological Resources

Potential Impacts on Terrestrial Flora

7.6.1 No protected or endangered species were recorded in the study area during winter/spring 1995 or during earlier surveys. Habitat loss due to construction of the development is estimated in Table 7.7.

Table 7.7 Coastal/Marine Habitat Loss due to Construction and Operation of Discovery Bay North

Habitat	Approximate Length/Area
Mobile sand beach	0.47 km
Rocky shore	0.31 km
Mangrove	0.6 ha
Mangrove associated vegetation	2.1 ha
Backshore vegetation	2.3 ha
Sub-tidal	5 ha

7.6.2 A major portion of the proposed development will be constructed on shrubland and grassland. Loss of these habitats is not predicted to be a significant impact because they have been disturbed by previous earth moving projects or by fire. Low species and structural diversity of these habitats results in low conservation significance. No plant species of conservation interest were recorded in these habitats during winter/spring 1995.

Potential Impacts on Terrestrial and Avian Fauna

7.6.3 The greatest impact to avifauna will be the loss of habitat. Both breeding and wintering bird communities can be expected to decline in species representation and population numbers due to habitat loss. Birds using the site are known to feed on flying insects, arboreal insects, fruits, freshwater/marine vertebrates and invertebrates, and carrion. The availability of all of these forage sources would decline under the existing development design. In particular, relatively undisturbed natural vegetation would be lost in both Yi Pak and Sam Pak Wan, thereby reducing the extent of available habitat in these areas. Species which rely on the estuarine habitat would be lost, and species with broader ranges of habitat preference and greater tolerance for human habitation would dominate.

7.6.4 The nest site of greatest conservation importance in a territorial context may be that of the Black-eared Kites in the Yi Pak Wan estuary. Although Black-eared Kites may number over 1000 birds in Hong Kong during winter, the number of breeding pairs is considered to number only around 30 (Viney *et al.*, 1994). The Black-eared Kite is a secretive nester, selecting remote sites. The availability of nesting habitat for the Black-eared Kite in Hong Kong has declined due to progressive urbanisation of remote, forested sites with mature trees (Viney *et al.*, 1994). The breeding season for Black-eared Kites in Hong Kong extends from December through May. As noted above, the pair nesting at Yi Pak Wan began courtship and territory establishment during November 1994. The chick was not fully feathered when observed in mid-April 1995 and was still in the nest in May. The breeding attempt was successful.

7.6.5 Should the project proceed as planned, the Yi Pak pair of Black-eared Kites would be displaced. The nest and nest tree would be lost as they are located in the Yi Pak Wan estuary. The only potential alternative nest sites in the vicinity are at Sam Pak so it is possible (although unlikely) that the birds would relocate there. However, general construction disturbance and increased human activity would probably preclude continued use of the site and would result in abandonment of the nesting territory. Removal of the Black-eared Kite nest from Yi Pak requires a permit from AFD and should be undertaken before the breeding season which usually extends from January to April. There is no historical precedent for such a permit due to the small number of sites supporting nesting Black-eared Kites in Hong Kong.

7.6.6 Should the Brown Fish Owls still occupy Yi Pak, they would also probably be displaced by the proposed development. These owls are also secretive nesters with apparently very restrictive criteria for nesting territory selection. There is only one other known nesting territory in Hong Kong due to the limited availability of suitable nesting sites for Brown Fish Owls.

7.6.7 The Collared Scops Owl may occupy a breeding territory at Sam Pak. This species is reasonably common in Hong Kong and its distribution may be underestimated (Chalmers, 1989). The Sam Pak area would be developed only to a limited extent so it is possible that a nesting pair of Collared Scops

Owls would continue to occupy this territory following completion of the development.

7.6.8 Impacts on mammalian fauna would be primarily loss of habitat for burrowing small mammals. This would apply also to mid-sized mammals such as the Masked Palm Civet if it still occupies the site.

Reptiles and Amphibians

7.6.9 Reptiles and amphibians were not recorded during the November 1994 surveys, but the Asiatic Painted Frog was recorded during spring 1995. Reptiles and amphibians are not active during late autumn and early winter. Any amphibians and reptiles occupying the areas which will be disturbed by the Discovery Bay North development would potentially be subject to significant impacts due to their relatively low mobility and narrow range of habitat preference. The availability of mesic, lowland habitats will decline within the site boundary following completion of the project.

Potential Impacts on the Proposed Country Park Extension

7.6.10 It is not anticipated that the proposed development will encroach onto areas included in the proposed extension to the North Lantau Country Park. The western limit of the Discovery Bay North development would be located within 400m of the park extension near Yi Pak and within 200m at Sam Pak. In both cases, areas within the proposed Country Park extension would be at higher elevations than the proposed residential development. Therefore, park visitors would have a view seaward over the development. This would be similar to the existing situation in South Lantau Country Park, and in many other country parks in the Territory.

Potential Impacts to Coastal Zone Habitat Resources

Coastal Shrubland and Woodland

7.6.11 The rocky shore and coastal vegetation between Yi Pak Wan and Sam Pak Wan would be lost due to construction. This type of coastal habitat is not uncommon in Hong Kong and is not of conservation concern based on its simple floristic composition. The *Hibiscus/Cerbera/Scaevola* association typical of this habitat is widespread throughout the Territory and was not found to be of conservation importance based on species composition.

Mangrove/Estuary

7.6.12 The primary impact of the development would be loss of the estuary and associated vegetation at Yi Pak. The species group of greatest concern at Yi Pak Wan is the mangroves. Occurrence of at least five mangrove species in this small estuary indicates that the site is of conservation interest. The mangrove/mangrove associate/backshore vegetation community represents a potentially valuable wetland ecosystem. Such coastal wetland habitats represent an increasingly rare vegetation type in Hong Kong due to the development of coastal infrastructure projects including the Chek Lap Kok

airport and associated developments. Absence of mangrove vegetation from the remaining undeveloped portions of the Lantau coastline contributes to the conservation interest of Yi Pak Wan.

7.6.13 Mangroves are a local and regional conservation concern due to loss of mangrove habitat resulting from urbanisation (Yipp *et al.*, 1993). Mangroves occur at 4 other locations along the South Lantau shoreline, at Chi Ma Wan, Pui O, Yi O San Tsuen and Tai O. Only the Yi O San Tsuen site is relatively unaffected by anthropogenic habitat degradation. However, mangrove cover at this site is sparse and the area of closed canopy is limited. The Tai O site has been considered as a potential mangrove restoration site by AFD to compensate for mangroves lost at Tung Chung due to construction of the Chek Lap Kok airport.

7.6.14 Loss of mangroves is known to result in ecological impacts on estuarine food chains (Odum *et al.*, 1982), fisheries (Lewis *et al.*, 1985; Meynell and Qureshi, 1993) and shoreline stabilisation (Carlton, 1974; Meynell and Qureshi, 1993; Villacorta and van Wetten, 1993). Mangroves can provide important habitats for resident and migratory avifauna and thus enhance local biodiversity. The near absence of mangrove vegetation from the remaining undeveloped portions of the Lantau coastline contributes to the conservation interest of Yi Pak Wan.

7.6.15 The 1993 estimate for the total extent of mangrove habitat in Hong Kong was 270 ha (RHKJC, 1994). 0.6 ha of mangrove habitat would be lost due to the Discovery Bay North development. This loss constitutes 0.22% of the remaining total mangrove habitat in the Territory estimated in 1993. The development plan includes proposals to compensate for the loss of mangrove by establishment of new mangrove plantings (see Section 7.7)

Shoreline

7.6.16 The proposed development will lead to the loss of approximately 310m of intertidal boulder shore between Yi Pak Wan and Sam Pak Wan. This is not considered to be a significant impact. Mitigation will be possible through the recreation of a boulder shore along suitable stretches of the new shoreline of the development (see Section 7.7).

7.6.17 The rocky shore and coastal vegetation between Yi Pak Wan and Sam Pak Wan would also be lost. However, this type of coastal habitat is not uncommon in Hong Kong and is not of conservation concern based on its simple floristic composition.

Beach Habitat

7.6.18 The 280m long natural sand beach at Yi Pak Wan would be lost as well as the large sand berm running along the back of this beach. The berm supports a plant community typical of such habitats. 190m of sand beach as well as primary and secondary sand spits and lagoons at the southern end of Sam Pak beach would also be lost. These areas provide shelter for juvenile marine fish.

Sub-Tidal Zone

7.6.19 The reclamation proposed under Master Plan 6.0(A) would cover an estimated 5 ha of the inshore seabed. The significance of this impact in relation to the local fisheries is discussed later in this section.

Summary of Potential Coastal Habitat Impacts

7.6.20 Unavoidable adverse impacts of the proposed development on the coastal areas of Yi Pak and Sam Pak will therefore be the combined loss of:

- Yi Pak and Sam Pak beaches - a total of 470m of natural sand beach;
- beach-associated vegetation - the large sand berm running along the back of Yi Pak beach supports a plant community typical of such situations, but increasingly rare in Hong Kong;
- primary and secondary sand spits and lagoons on Yi Pak and Sam Pak beaches which provide shelter for juvenile marine fish;
- wetland behind Yi Pak beach and associated with the tidal lagoon; this includes a diverse stand of mangroves, including at least 5 of the 8 mangrove species occurring in Hong Kong, plus mangrove associates and reeds;
- Yi Pak stream, providing freshwater input to the mangroves and associated vegetation; and
- approximately 5 ha of seabed and the subsequent possible impacts to local fisheries.

7.6.21 There are no potential areas on-site, and none known off-site, which would compensate entirely for the loss of the areas listed above. Thus, the Discovery Bay North development would have residual impacts on the Yi Pak and Sam Pak coastal habitats.

Potential Impacts to Commercial Fisheries

Cumulative Impacts of Projects in the Area

7.6.22 Construction of Container Terminals 10 and 11 (CT10/11) will result in a significant loss of coastal habitat and will undoubtedly have some negative impacts on the local fisheries. The proposed development at Discovery Bay North is much smaller than CT10/11 but will contribute to the cumulative negative impacts on fisheries in the Discovery Bay area (Table 7.8).

Table 7.8 Cumulative Coastal/Marine Habitat Loss of Importance to Fisheries due to Construction of CT10/11 and Discovery Bay North

Habitat	Approximate Length or Area Lost		Cumulative Total Loss
	CT10/11	Discovery Bay	
Mobile sand beach	0	0.47 km	0.47 km
Rocky shore	3.5 km	0.31 km	3.81 km
Mangrove	0	0.6 ha	0.6 ha
Sub-tidal	27 ha	5 ha	32 ha

7.6.23 Cumulative impacts on fisheries will arise from loss of benthic habitat and associated organisms (many of which are prey species for fish), a probable decline in water quality leading to reduced primary productivity, declining fish stocks and the loss of fishing opportunities due to reclamation and restrictions on fishing due to increased vessel activity in the area. This may lead to increased fishing pressure on other areas. The loss of shallow sub-tidal areas within Discovery Bay will reduce the preferred habitat of juvenile fish, as will the loss of intertidal rocky and sandy shorelines, with their associated flora and fauna, which are used by juvenile fish at high tide.

7.6.24 Further negative impacts to local fisheries arising solely from the Discovery Bay North development will result from the destruction of two tidal lagoons behind the Yi Pak and Sam Pak beaches, and the associated mangrove/marsh area at Yi Pak. Estuarine and mangrove habitats have special importance because they serve as significant nursery areas and their productivity supports important food webs. Mangroves provide ideal habitat for juvenile fish and crustaceans, where the abundance of decomposing detritus from the plants and epibionts growing on the submerged plant surfaces provide a rich source of food (Norse, 1993; Ledec and Goodland, 1988). In other parts of the world, destruction of such habitats has led to corresponding decreases in fish/crustacean yields offshore, while conversely the creation/restoration of similar habitats has produced improved yields (Norse, 1993; Davis, 1993). Economic evaluations of the dollar value of mangroves for fisheries ranges from US$133/km^2 for crabs in Sabah, Malaysia, to US$277,235/km^2 for shrimp and finfish on the Malaysia peninsula (Thorhaug, 1990).

7.6.25 The loss of rocky shore and mangrove areas can be compensated. However, the sandy shore will be a net loss due to the project. The feasibility of creating viable new rocky shore and mangrove habitat has been demonstrated in several recent projects in Hong Kong.

7.7 Impact Avoidance and Mitigation

Mitigation for Losses of Upland Flora

7.7.1 Loss of upland habitats on the site is unavoidable with development of Discovery Bay North. Loss of shrubland and grassland can be mitigated by revegetation of disturbed sites peripheral to the development immediately following completion of construction. A plan for restoration of vegetation on the site is included in Section 6.

7.7.2 Native species of trees and shrubs indigenous to the site and valuable to wildlife are specified for use in the revegetation plan. Disturbance of the surrounding areas during construction should be minimised. All areas of woodland and shrubland vegetation not required for project construction should be fenced so as to preclude access by heavy equipment.

7.7.3 Shrubland and grassland, if protected from fire, will succeed to more diverse secondary forest and can provide more valuable habitats for wildlife. In view of the devastation to the northern portion of Lantau Island during November 1994 caused by wildfire, it is recommended that provision be made for fire fighting in natural areas around the construction site throughout the construction phase. This would include the development of protocols for requesting assistance from the Government departments responsible for fire control. On-site provisions for fire fighting should include tools and equipment for manual fire control. Construction contractors should be required to assign personnel to fire fighting duty when needed. The use of fire by contractors should be controlled.

7.7.4 As recommended in Section 6, the planting of shrubs and trees on upland sites adjacent to the development would accelerate the successional process on degraded sites and contribute to impact mitigation. In addition to these proposals, restoration of the 0.45 ha former plant nursery area at the northern end of Sam Pak should be carried out as part of the proposed development. Extensive shrub and tree planting using the species included in the planting scheme for Woodland Belt 1 (see Sections 6.7.18 and 6.7.19) should follow general clean-up of the site to remove the remaining evidence of the nursery. Although the site is extensively forested with exotic species (*Acacia* sp., *Casuarina* sp.), there is abundant potential for habitat enhancement using indigenous species. The result of habitat enhancement would be increased diversity of wildlife use of the area.

Mitigation for Loss of Estuary and Mangrove

Review of Options and Approaches

7.7.5 Loss of the Yi Pak Wan estuary and associated vegetation would be complete. Avoidance options are not available under the development plan which calls for a fill to +6 mPD in the estuary area. Mitigation of mangrove habitat loss is proposed in the form of a mangrove mudflat to be created at the south-eastern corner of the development along the southern coast of Yi Pak Wan.

7.7.6 The following paragraphs discuss wetland mitigation projects which have been carried out locally, regionally and in other areas of the world. The purpose of this review is to provide a background against which the merits of the proposed mangrove restoration plan can be judged.

7.7.7 Transplantation of mangroves to mitigate habitat losses in Hong Kong has been employed at Tin Shui Wai Creek (Chan, 1993) and at Kau Sai Chau (RHKJC, 1994). Mangrove creation or restoration is also proposed as mitigation for losses at Tung Chung due to construction of the Chek Lap Kok airport. However, this project has not yet begun.

7.7.8 The Tin Shui Wai Creek site was transplanted using *K. candel* propagules during the summers of 1990 and 1991. The purpose of the project was to mitigate the impacts of mangrove loss due to river channelling. The project was considered successful based on high survival rates of planted propagules plus facilitation of natural mangrove colonisation of the site due to the impact of the seedlings grown from planted propagules (Chan, 1993).

7.7.9 The Kau Sai Chau project began in summer 1994 and continues to date. Both propagules and seedlings of *K. candel* and *B. gymnorrhiza* were transplanted at four sites. Each of the four sites supported mangroves and was undisturbed by any form of human impact. The objective was to extend the mangrove coverage at each of the sites. Survival rates varied from 32% to 100% 4 to 6 months after transplanting.

7.7.10 These projects suggest that mangrove transplantation is a viable mitigation strategy for Hong Kong in areas where the transplanted mangrove forms an extension of an existing mangrove habitat. In both cases, the planted mangrove occupied an area contiguous with undisturbed mangroves. In such circumstances, it should be expected that the probability of success would be higher than when attempting to create a new mangrove stand on a site where none existed. This expectation is supported by restoration projects elsewhere.

7.7.11 Extensive mangrove transplantation projects in Pakistan and the Philippines have been implemented with positive results in cases where mangroves were replanted in areas degraded only by excessive cutting (Lewis *et al.*, 1985 in Lewis, 1990a; Meynell and Qureshi, 1993; Villacorta and van Wetten, 1993). In these projects, the impetus for restoration arose from loss of fish production or from accelerated soil erosion following the removal of mangroves.

7.7.12 In North America and the Caribbean, mangroves have been transplanted with varying degrees of success since the late 1960s. Technical guidelines have been formulated for planning and implementation of mangrove creation and restoration based on the long history of experimentation (Lewis, 1990a and 1990b). Critical factors for successful wetland establishment were listed by Lewis (1990a) as follows:

- correct elevations for the target plant species;
- adequate drainage provided by gradual slopes and sufficient tidal connections;
- appropriate site selection to avoid wave damage;
- appropriate plant materials; and
- protection from human impacts.

7.7.13 Recolonisation by wetland fauna may be more problematic. Comparisons of fauna on created versus control wetlands suggest that up to 15 years may be required for macrofauna in the created marsh to resemble that of control marshes (Sacco et al., 1988 in D'Avanzo, 1990).

Mangrove Restoration at Yi Pak Wan

7.7.14 It is proposed that a mangrove stand be created at Yi Pak to mitigate loss of the existing mangrove behind the Yi Pak beach (Figure 7.2). Restoration would involve the creation of an entirely new mangrove; thus, it is doubtful whether the ecological function of the Yi Pak mangrove stand could be replaced. This is due to the differences between the existing and proposed sites in terms of the surrounding landscape and vegetation, hydrology and the degree of exposure to wave action.

7.7.15 The creation of a new mangrove area will not fully replace the form and function of the existing Yi Pak wetland. It will, however, provide a comparable mangal habitat within a secure management situation. Together with the created rocky shoreline, the general ecological function of the existing shoreline can be maintained in a way which will be compatible with the development of Discovery Bay and the Lantau Port.

7.7.16 The Yi Pak site lies partially within the leased land boundary and presents fewer land or management issues than alternative sites. Restoration at this site is technically feasible.

7.7.17 Creation of a mangrove habitat at Yi Pak would require construction of a mud flat behind a seawall. Prior to the design and construction of a replacement mangrove mudflat, the existing Yi Pak mangrove stand should be thoroughly described. Total area, species richness, relative dominance, plant height and stem diameter should be recorded or estimated prior to disturbance.

7.7.18 The design of the replacement mangrove area should aim for an area approximately 3 times larger than the area to be lost due to development. This replacement ratio would meet the general expectation of AFD for mitigation of impacts to woodlands, and is in agreement with mitigation expectations elsewhere (Kruczynski, 1990).

7.7.19 Creation of a mangrove estuary at Yi Pak would require completion of the following tasks:

- design and construction of a seawall to contain the mangrove substrate (dredged marine muds);
- design and construction of a salt/fresh water control gate in the seawall to regulate levels of freshwater and tidal flows;
- design and installation of a solid waste exclusion device to prevent the accumulation of floating solid waste in the estuary;
- sourcing and deposition of dredged sediments in the estuary for use as a mangrove planting and growth substrate;
- sourcing and planting of mangrove propagules on the created mudflat;
- monitoring mangrove (and other plant) survival and growth; and
- replacing plants which do not survive.

7.7.20 Creation of mangrove planting substrates behind seawalls or other wave barriers is practised in Hong Kong at Kau Sai Chau, and at North American locations. Lewis (1990a) noted that it is '...well documented that mangroves are not generally suitable plant materials for exposed or eroding shorelines unless some offshore protection is provided.' For the proposed project, a seawall would serve two purposes. Firstly, it would enclose the mudflat to prevent a seaward loss of sediments. Secondly, a seawall would reduce wave energy, simulating the role of the berm at the back of the existing Yi Pak beach.

7.7.21 The design and installation of water control structures would be a routine engineering and construction task. It would, however, be important to incorporate a feature for excluding floating solid waste from the mangrove. The solid waste trap would, unfortunately, be likely to prevent the natural establishment of mangrove propagules brought in on the tide from other Hong Kong locations. Therefore, it would be important to collect such propagules and plant them during the monitoring phase of the mangrove creation project. The trap must be designed to allow the passage of fish between the bay and estuary.

7.7.22 Sediments for use in construction of the planting substrate should be sourced from the Yi Pak Wan estuary. This would ensure the provision of sediments which are suitable for mangrove establishment and growth. It will, however, constrain the construction programme to the extent that sediments must be either moved directly to the created mangrove site or stockpiled elsewhere for later transfer.

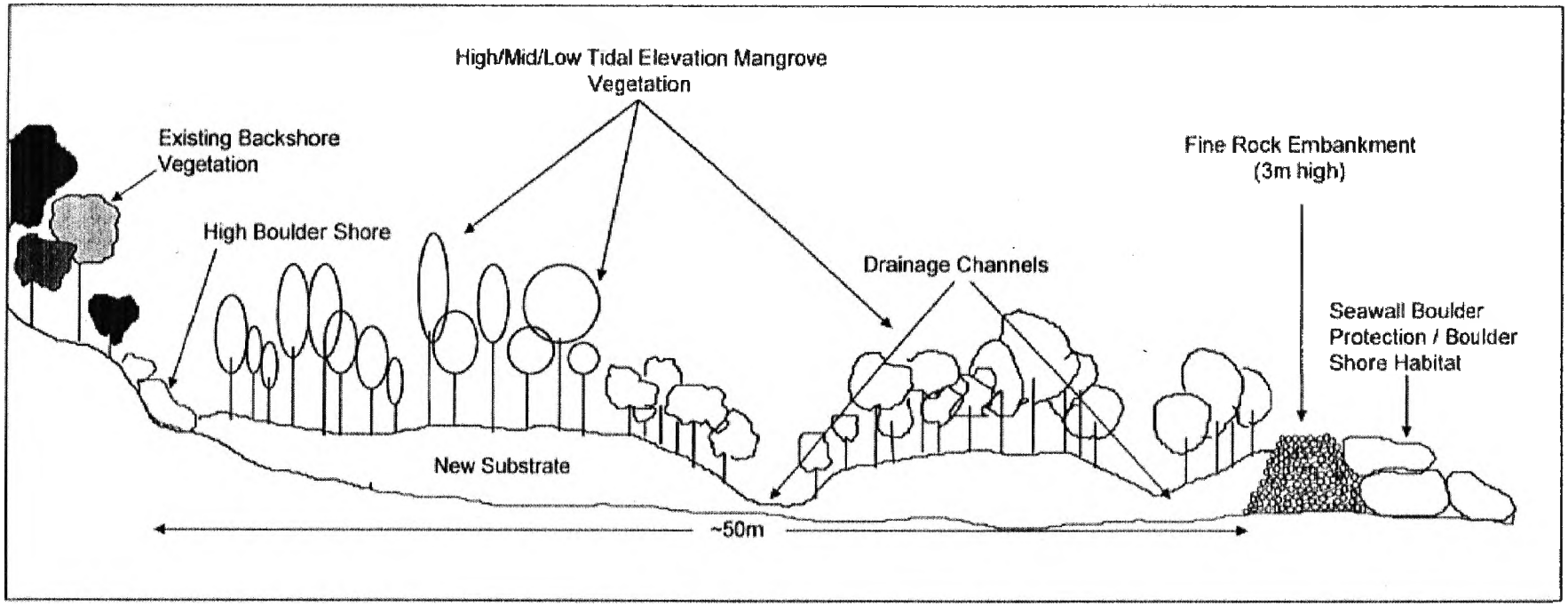

Figure 7.2
Cross-Section of Mangrove Restoration Area at Yi Pak (conceptual)

7.7.23 The detailed specification of the planting substrate should be incorporated into the detailed design of the created mangrove. In general terms, the substrate should not be flat, but should provide variations in levels. The stream feeding the mangrove with fresh water should follow a sinuous path across the substrate. This will ensure the provision of sub-surface fresh water supply across the mangrove area.

7.7.24 Sourcing planting materials, planting and monitoring would be the same for any site in the Discovery Bay area. The primary considerations include sourcing and planting propagules or seedlings in proportions which, allowing for mortality, will result in an approximation of the existing community composition. Propagules and seedlings can be collected locally or purchased from Guangdong Province sources.

7.7.25 The creation of the mangrove transplantation area at Sam Pak was considered at an early stage of the project. The Sam Pak area is a more suitable mangrove transplantation site due to the more favourable physical characteristics of the bay (in terms of topography, natural freshwater supply, less seaward exposure) in comparison to the Yi Pak site. However, the Sam Pak site is outside the area of the seabed leased to Hong Kong Resort Company Limited. Given Government land policy, access to the Sam Pak site will probably not be possible. Consequently, detailed plans for the creation of the mangrove mudflat at the Yi Pak site have been progressed.

Mitigation for Loss of Shoreline

7.7.26 Restoration of the boulder shoreline along the new seawall for the Discovery Bay North development will be a relatively straightforward mitigation measure that will enhance the value of the area for marine life and help mitigate the high impact of the project on the coastline of Yi Pak and Sam Pak. Factors important in restoring the diversity of microhabitats available to intertidal and sub-tidal biota are:

- the overall gradient of the shoreline - this will determine the width of the eulittoral zone and thus the area available for colonisation;
- the elevation of the new shoreline - the top of the shore should extend to above the mean spring high tide level to provide the full range of conditions in relation to tidal inundation/aerial exposure; and
- the variety of boulder/stone size and relative distribution of sizes down the shore - natural rocky shorelines provide a wide variety of shelter/exposure regimes and a corresponding diversity of available habitats. These conditions need to be restored if the new shoreline is to replace to any extent the function of the original.

7.7.27 The simplest way to meet these requirements is to survey the existing shoreline before the start of construction and record the factors detailed above. A photographic record will also help to achieve realistic habitat restoration.

7.7.28 The length of the boulder shore lost with Master Plan 6.0(A) would be approximately 310 m^2. A similar length (265m) of replacement rocky shore is proposed. The new boulder shore would form part of the seawall for the mangrove transplantation area at Yi Pak and should compensate for the loss of the existing section of rocky shore.

7.7.29 Habitat enrichment can also be achieved in the design of any submerged structures such as jetty pilings and support structures.

Mitigation of Impacts on Terrestrial and Avian Fauna

7.7.30 The primary impacts to birds will be the loss of nesting and wintering habitats in the Yi Pak Wan estuary. Of the 51 species of birds recorded on the site, 38 species probably nest locally. Most important from a conservation perspective are the Black-eared Kites and possibly the Brown Fish Owls.

7.7.31 To mitigate impacts to the Black-eared Kite, it is recommended that the nest be relocated to the Sam Pak area prior to onset of construction at Yi Pak. A comparable nest tree should be selected and the existing nest relocated. Site preparation should include bracing and other supports as needed. Nest relocation should be undertaken only after fledging of the young from any breeding season. Under no circumstances should the nest be moved at any time if occupied by adults or young or between November and May, even if unoccupied. A written permit from AFD is required to authorise the movement of any bird nests in Hong Kong. It must be emphasised that nest relocation will not ensure that the Black-eared Kites will continue to occupy the Yi Pak territory during or after project construction.

7.7.32 Should nesting Brown Fish Owls be located at Yi Pak, a similar procedure should be carried out for relocation only if the nest is located such that it would be destroyed during construction.

7.7.33 Mitigation of impacts to other avifauna, reptiles, amphibians and mammals can be best achieved by habitat enhancement on the slopes above the works area and in the Sam Pak catchment, particularly a 0.3 ha hillside/riparian area to the north-west of Sam Pak beach (Figure 7.3). Recommended procedures include the use of the shrub and woodland planting mixes recommended in Section 6 for woodland areas. Planting at Sam Pak will include areas of off-site mitigation outside the planning boundary. However, as there are few suitable sites for extensive woodland habitat restoration on-site, off-site mitigation areas are necessary to minimise the impact of habitat loss. Early revegetation of the hill slopes within HKR's lease boundary should be considered to provide some cover for birdlife displaced from the site.

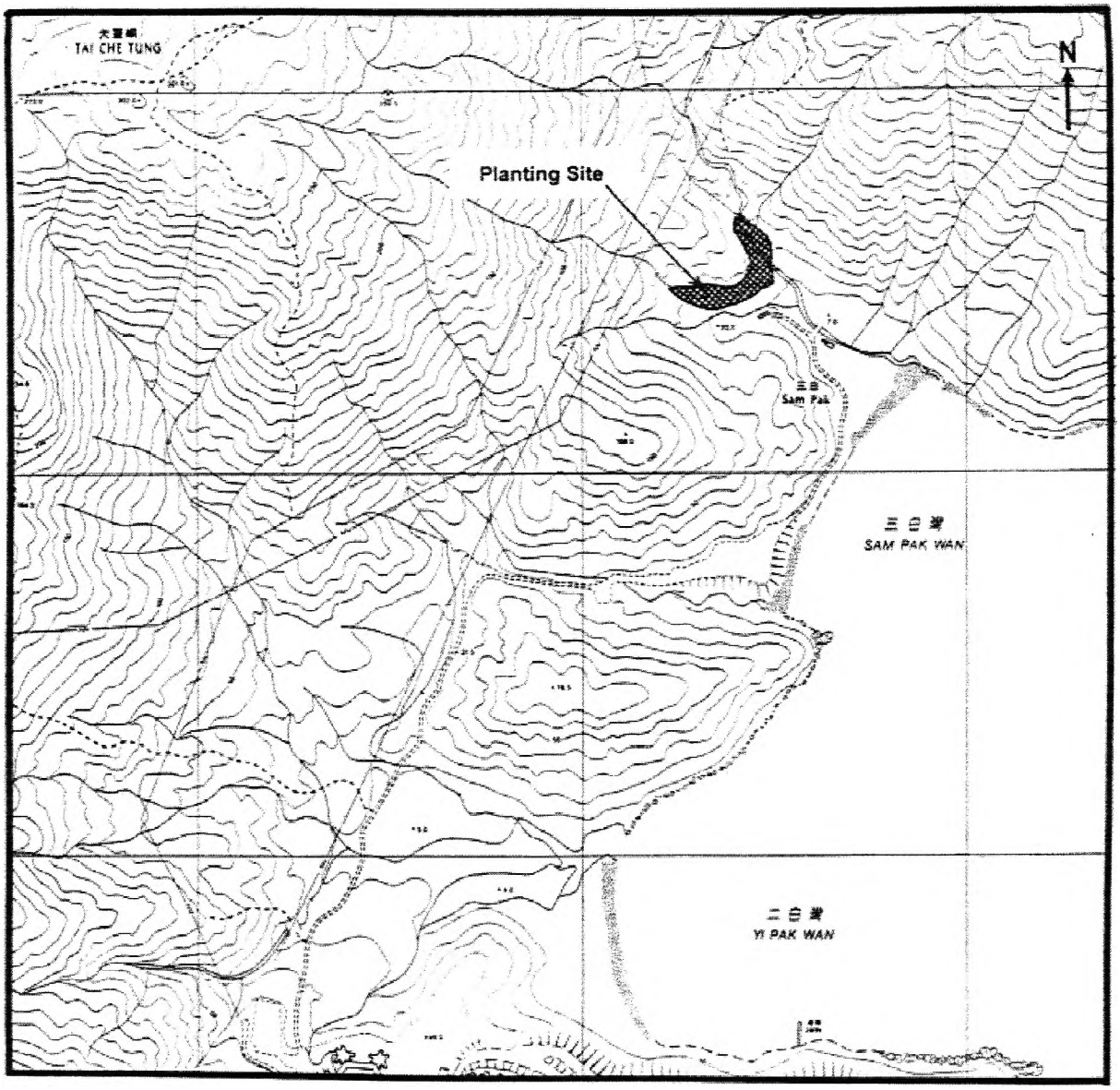

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Figure 7.3
Sam Pak Catchment Planting Site

Mitigation of Impacts on Commercial Fisheries

7.7.34 Mitigation of the impacts on local fish nurseries from the loss of the Yi Pak mangrove stand, lagoon and inshore shallows centres around the creation of habitats that will perform the same function in the life cycles of marine life in terms of complexity and productivity. A range of microhabitats can be created by placement of suitably sized rocks and boulders sub-tidally along the new shoreline of the development. This can be addressed as part of the boulder shore mitigation plan. Alternatively, reef modules constructed from bamboo poles, concrete and old tyres provide shelter for fish and settlement opportunities for algae and invertebrates that the fish may then feed on.

7.7.35 Other mitigation methods include the placement of fish decoys constructed from bamboo and palm leaves and floating in an upright position. Algal growth on the poles and leaves would provide food for juvenile/small fish. These methods have proven effective in the Philippines (Villacorta and van Wetten, 1993), and could play a role here in preventing any impacts to the local fisheries that may result from the development.

Yi Pak Stream Restoration

7.7.36 The stream channel between the proposed water feature and the proposed Yi Pak mangrove transplantation site should be designed and constructed with the objective of restoring ecological function as far as possible. The following guidelines are adapted from National Research Council (1992) for stream restoration, and should be followed for design of the Yi Pak stream:

- Restore the natural sediment and water regime. *Regime* refers to at least two time scales: the daily to seasonal variation in water and sediment loads, and the annual to decadal patterns of floods and droughts. Organisms in large flood plain rivers in tropical and temperate zones depend on highly predictable seasonal flooding;
- Restore a natural channel geometry, if restoration of the water and sediment regime alone does not;
- Restore the natural riparian plant community, which then becomes a functioning part of the channel geometry and floodplain/riparian hydrology. This step is necessary only if the plant community does not restore itself upon achievement of objectives 1 and 2; and
- Restore native aquatic plants and animals if they do not recolonise on their own.

7.8 Residual Impacts

7.8.1 Residual ecological impacts of the proposed development would be the loss of coastal, intertidal and estuarine habitats. These habitats are subject to sustained development pressure in Hong Kong and throughout East Asia (Scott and Poole, 1989) and it is therefore important that all possible measures are taken to compensate for the losses. There may also be residual ecological impacts on birds of prey through the loss of breeding territory.

7.8.2 Given the development of the Lantau Port and other infrastructure projects on North Lantau, the current proposals include compensation measures to maintain coastal ecological resources within the plans for ongoing development of the Port area. The loss of ecological habitat is significant but the proposals provide maximum compensation for loss of habitats and opportunities for long-term protection for the compensating areas.