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Trial on Improvements to the  
High-tide Roosting Habitat  
for Migratory Waterbirds at  
*Gei wai #16/17 Mai Po*  
Nature Reserve 2005/06

FINAL REPORT : AFCD/SQ/21/05



# CONTENTS

Chapter		Page
	<b>EXECUTIVE SUMMARY</b>	<b>ii</b>
<b>1.</b>	<b>INTRODUCTION</b>	<b>1</b>
1.1	Background	1
1.2	Aims	2
1.3	Approach	2
<b>2.</b>	<b>METHODS</b>	<b>3</b>
2.1	Study Area	3
2.2	Earthmoving Works	3
2.3	Waterbird Monitoring	5
2.4	Indicator of Success	7
<b>3.</b>	<b>RESULTS</b>	<b>7</b>
3.1	Earthmoving Works	7
3.2	Waterbird Monitoring	8
<b>4.</b>	<b>DISCUSSION</b>	<b>11</b>
4.1	Waterbird Monitoring Results	11
4.2	Effectiveness of Enhancement Works	12
4.3	Effectiveness of Waterbird Monitoring	13
4.4	Timetabling and Resources	13
4.5	Indicator of Success	13
<b>5.</b>	<b>RECOMMENDATIONS</b>	<b>13</b>
5.1	Habitat Management	13
5.2	Monitoring	14
<b>6.</b>	<b>CONCLUSION</b>	<b>15</b>
<b>7.</b>	<b>REFERENCES &amp; BIBLIOGRAPHY</b>	<b>17</b>
	<u>Appendices</u>	
I	Project Photographs	19
II	Design Sketches of the Reprofiled and Newly Created Islands	22
III	Data Tables	23
	<u>Tables</u>	
1.	Winter Anatidae Count Dates, Times and Associated Tidal Conditions : Winter 2005/06.	6
2.	Survey Dates, Times and Associated Tidal and Waterlevel Conditions for the Waterbird Area Use Study.	6
3.	Final Dimensions of the Reprofiled Island and New Islands.	7
4.	Winter Anatidae Count Summary : Winter 2005/06.	9
5.	Comparison of the Anatidae Count Data between <i>Gei wai</i> #16/17 and the Ramsar Site : Winter 2005/06.	9
6.	Abundance of Waterbird Groups and Species on <i>Gei wai</i> #16/17 during Spring 2006.	10
7.	Comparison of Shorebird Groups (Waterbird Groups 3 & 6-11 Only) on <i>Gei wai</i> #16/17 and the Ramsar Site at High Tide during Spring 2005 & Spring 2006.	11
	<u>Figures</u>	
1.	Location of <i>Gei wai</i> #16/17.	4
2.	Location of Enhancement Works in <i>Gei wai</i> #16/17.	4
3.	Cross-section Sketch of the Embankment, Ditch and Vegetation Removal Works.	5
4.	Zonation of Islands and Open Water Habitat in <i>Gei wai</i> #16/17.	7
5.	Earthmoving Works in <i>Gei wai</i> #16/17 and Land Area Changes.	8
6.	Peak Monthly Winter Anatidae Counts in <i>Gei wai</i> #16/17 : Winter 2005/06.	9
7.	Individual Anatidae Species Trends in <i>Gei wai</i> #16/17 : Winter 2005/06.	9

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[Cover photo: Flock of Red-necked Stint *Calidris ruficollis* with a Greater and Lesser Sand Plover. Photo by: Neil Fifer]

## EXECUTIVE SUMMARY

- i The Mai Po Inner Deep Bay Ramsar Site is listed as a Shorebirds Network Site in the East Asian – Australian Flyway and supports between 20,000-30,000 shorebirds during the spring migration period. Under periods of low tide in the Bay, these birds primarily feed and roost on the extensive inter-tidal mudflat areas. When tide heights exceed 2.1m the majority of birds fly inland to find areas of shallow water or mud to roost safely (known as high-tide roosts) before flying back out to Deep Bay to feed as the tide recedes.
- ii The World Wide Fund For Nature Hong Kong has since 1986 successfully managed two high-tide roosts (*gei wai* #11 and *gei wai* #16/17) inside Mai Po Nature Reserve. The larger of these, *gei wai* #16/17, is an 18.22 ha area of shallow open water containing twenty-eight islands. Since 1999, a rolling annual programme of earthmoving works has been carried out to enhance the key features of the *gei wai* in order to attract more waterbirds.
- iii A precursory study upon the high-tide roost area in 2005 (Anon, 2005a) identified the need for further enhancement works. In particular the reprofiling of one of the large earth islands, measures to reduce visual and noise disturbance from vehicles using the Education Centre access track, and the reinstatement of former open water areas which had been lost to vegetation encroachment. Data from the study also accurately pinpointed under-utilised locations for the possible establishment of small islands. Therefore in late summer 2005, landscaping and habitat creation works were undertaken, but on a trial basis to investigate potential methods to improve the *gei wai* for the benefit of waterbirds (primarily shorebirds).
- iv The aims of the project are:
  - To investigate waterbird usage of different areas within the *gei wai* #16/17 high-tide roost during spring migration.
  - To determine if the reprofiling of Island no.1 and creation of 3 new small islands can create conditions that attract a greater number of spring shorebirds.
  - To reduce disturbance to waterbirds inside *gei wai* #16/17 caused by vehicles using the Education Centre access track.
  - To better understand wintering Anatidae use of *gei wai* #16/17 to inform future habitat management decisions.

### **Earthmoving Works**

- v A 10-week period of enhancement works created several new features and enhanced others. The main physical outputs being:
  - A successful reprofile of the large Island (known as 'no. 1') - an increase in feeding edge by 19.7m (+12.7%), reduction in mean height above the *gei wai* operational waterline from 45.3cm to 8.0cm and an increase in the feeding edge:surface area ratio by +35.0%.
  - The creation of 3 new small islands of varying dimensions and designs - surface areas ranging between 12.6-80.8m<sup>2</sup>, mean heights above the operational waterline ranging from 8.4-12.1cm and a mixture of conventional bay and kidney designs.
  - The reinstatement of a 1.6 hectare area of former open water *gei wai* along the northern boundary to shallow water at a mean depth of 28.3cm (range 22.8-37.3cm) below the operational waterline.
  - The construction of a 570m long by 1m high embankment between the *gei wai* and adjacent Education Centre access track to reduce visual and noise disturbance from nearby vehicles.
  - The excavation of a 570m long by 1m deep ditch along the outermost edge of the northern *gei wai* water boundary to prevent re-encroachment of vegetation.

- The creation of a grass barrier ('soft screen') along the entire length of the 570m embankment to further reduce visual and noise disturbance from nearby vehicles.

### **Waterbird Monitoring**

- vi In spring 2006, all waterbirds using the *gei wai* were counted and mapped on 12 occasions. A comparison of the results against the 2005 baseline data set shows waterbird numbers increased on *gei wai* #16/17 by +13.2% and the number of species recorded with a mean count >5.0 increased by +27.8%. The number of spring shorebirds increased by +13.8% which is significant because shorebird numbers on the Ramsar Site increased only by +8.6% during the same period. This suggests that collectively all of the enhancement works undertaken on the *gei wai* in late summer 2005 had a beneficial effect upon waterbirds.
- vii A Waterbird Area Use Study before and after treatment (i.e. spring 2005 and spring 2006) revealed a greater density of birds within the newly enhanced areas of the *gei wai*. In area Zone 6, containing the 3 new small islands, waterbird groups benefiting most were 'Ardeidae' (+300.0%), 'Avocets and Stilts' (>+4000%), 'Calidrids' (+444.4%), 'Godwits and Dowitchers' (+2500%), and 'Plovers' (+472.0%). In area Zone 7 containing the reprofiled Island no. 1, waterbird groups showing large changes include 'Avocets and Stilts' (>+2000%), 'Calidrids' (-90.8%) and 'Plovers' (+191.2%). Also new waterbirds belonging to the 'Curlews and Whimbrels' and 'Godwits and Dowitchers' groups were attracted to this zone (i.e. not previously recorded in 2005). Collectively, the total number of shorebirds increased by +499.4% in Zone 6 and +36.8% in Zone 7.
- viii Between October 2005 and April 2006, fifteen bi-weekly roosting Anatidae counts were completed on *gei wai* #16/17 to better understand the importance of the high-tide roost to this group of birds. Results show that up to 5% of the known Ramsar Site wintering Anatidae utilised *gei wai* #16/17 with usage noticeably confined to the first half of winter (before mid January). Peak counts occurred in February (1,309 individuals) and December (1,005 individuals) with 5 species recorded of which Common Teal (mean count = 116.5, peak count 594) and Northern Pintail (mean = 113.1, peak = 980) were the two most abundant.

### **Discussion/Recommendation**

- ix The 10-week period of enhancement works successfully created several new high-tide roost features and reprofiled an existing one. Waterbird numbers (including all shorebird groups) are shown to react positively to the treatment and therefore the chosen indicator of success attained, and the earthmoving works deemed successful.
- x The 1999-2005 enhancement programme changed the interior of the *gei wai* substantially and no additional major earthmoving works are considered necessary in the near future. Focus should now be upon fine-tuning the existing management operations such as waterlevel manipulation (Calidrids are identified as a potential focus bird group) and vegetation control (particularly island grasses and surrounding trees).
- xi Usage of the *gei wai* by wintering Anatidae is now better understood and a baseline data set obtained for future reference. The preliminary finding that Anatidae usage may be related to availability of fodder in early winter, if verified through further monitoring, could be valuable for habitat management of the *gei wai* to improve its attractiveness to Anatidae.
- xii Technical expertise gleaned from this trial and the previous 5 years work can now be applied to the proposed conversion of *gei wai* #21 into a high-tide roost in 2008. This serves to maximise the potential and primary function of the new high-tide roost.

## 1. INTRODUCTION

### 1.1 Background

- 1.1.1 The Mai Po Inner Deep Bay Ramsar Site is an important wetland for migratory waterbirds being listed as a Shorebirds Network Site and an Anatidae Network Site in the East Asian – Australasian Flyway (1996). The Ramsar Site can support 20,000-30,000 shorebirds on their northward migration and is a key staging post along the flyway. The principal feeding habitat for these birds during their stop over is the inter-tidal mudflat of Deep Bay providing abundant benthic food during low tide. However under high tide conditions (> 2.1m) the littoral mudflat areas are inundated and the majority of birds, particularly those with shorter legs fly inland to find areas of shallow water or soft mud to roost safely (known as high-tide roosts) before flying back out to Deep Bay to feed as the tide recedes.
- 1.1.2 Since 1986, WWF Hong Kong has successfully managed two high-tide roosts (*gei wai* #11 and *gei wai* #16/17) at the Mai Po Nature Reserve (MPNR). The largest of these is *gei wai* #16/17 (18.22ha), also known as the ‘scrape’. This roost was created in the mid 1980s by removing the earth bund separating *gei wai* #16 and #17 thus creating a large contiguous expanse of open water. Removal of grasses and other interior vegetation from within the *gei wai* enlarged the area and created shallow water/wet mud areas for roosting shorebirds (and other waterbirds). The bund material was piled up and landscaped to form three large independent islands in the centre of the *gei wai*, along the former line of the dismantled bund.
- 1.1.3 WWF Hong Kong currently manages the *gei wai* #16/17 high-tide roost in accordance with the prescriptions set out in the 2006-2010 Mai Po Marshes Wildlife Education Centre and Nature Reserve Management Plan (WWF-HK, 2006); careful manipulation of water levels (sluice gate control), regular flushing (temporary or partial draindown and refilling) and vegetation control (cutting and occasional herbicide treatment) on the islands and boundary areas. Such management ensures favourable conditions - shallow open water areas, good standard of water quality and non-vegetated islands - for waterbirds.
- 1.1.4 In the late 1990s, local birdwatchers, overseas conservation experts and WWF Hong Kong staff collectively observed a low usage of the three large earth islands by shorebirds. It was hypothesised that the islands were too high above the waterline (up to 1.5m), hence their land surface had low moisture content and thus was often dry and hard. Such conditions are generally unsuitable for shorebirds because (1) they can not penetrate (probe) the surface for food and (2) the surface is often invaded by terrestrial grasses making it inaccessible and thus unusable for roosting. Therefore, since 1999, significant landscaping work has been undertaken upon two of the large islands to promote their attractiveness to waterbirds. Work upon the remaining island (known as ‘no. 1’) was partially completed in 2003.
- 1.1.5 A study upon spring waterbird distribution inside *gei wai* #16/17 (Anon, 2005b and Anon, 2005c) highlighted a comparative low bird usage of Island no. 1 and the immediate surrounding areas. The same study also recognised (1) the need to reduce visual disturbance and noise levels from the nearby Education Centre access track for the benefit of waterbirds inside *gei wai* #16/17, and (2) the loss of a 1.60 hectare area of open water inside the *gei wai* since 1986 to vegetation encroachment along the northern most boundary, which may be creating ‘enclosed conditions’ undesirable for some waterbird species i.e. contributing to potential disturbance from predatory birds through concealment.
- 1.1.6 The current hydrological regime being operated at the *gei wai* provides in all-year-round shallow water, which is favourable for shorebird roosting. However, because shorebird dependency upon the *gei wai* is greatest during migration periods (mid-March to

late-May and mid-August to late-October), low water levels outside these dates may not be necessary. In December 2005, MPNR supported at least 5,500 wintering Anatidae inside Ponds #15a-b, #20a-f and #24f-g (Data combined from Anon, 2005d & WWF-HK, 2005b). In respect of the site's importance to this group of waterbirds, higher water levels inside *gei wai* #16/17 during the winter period could attract even more Anatidae into MPNR. However contemporary winter usage of the waterbody is not known.

1.1.7 Based upon previous management activities and a desire to maximise the waterbird potential of the *gei wai*, WWF Hong Kong commenced a series of enhancement works in August 2005 including the reprofiling of the unfinished large earth island no. 1.

1.1.8 High-tide roost design has received reasonable scientific research attention, but specific waterbird requirements for island habitats (i.e. dimensions, orientation, etc.) are under-researched. Existing knowledge tends to concern breeding activity on high-tide roosts rather than roosting needs (a safe place to preen, digest and assimilate their food and rest). However the following design principles are applicable to island reprofiling works:

- a) Certain bird species show preference for particular shaped islands, i.e. long, narrow islands are thought to attract Avocet but are avoided by Black-headed Gull (RSPB, 2002a).
- b) Making the island margins crenellated provides sheltered bays and increases the length of edge for feeding birds (RSPB, 2002a).
- c) The creation of a series of smaller islands can attract a greater number of birds (RSPB, 2002a).
- d) Set-back distances from sources of disturbance are important considerations. For breeding waders a minimum distance of 100m is required (Rodgers & Smith, 1995) although screens/barriers can reduce the minimum distance.
- e) Islands less than 500mm in height are used more regularly by roosting waders (RSPB, 2002a & U.S. Fish and Wildlife Service, 2004).
- f) Shorebirds generally prefer to use areas of soft mud surrounded by water at a depth of less than 4cm (Isola *et al.* 2000).
- g) Newly created roost features should simulate characteristics of natural roost areas where possible (Lawler, 1995).
- h) A small shelf or raised earth mound can provide shelter from wind and rain (Lawler, 1995).

## 1.2 Aims

1.2.1 The aims of the project are:

- To investigate waterbird usage of different areas within the *gei wai* #16/17 high-tide roost during spring migration.
- To determine if the reprofiling of Island no.1 and creation of 3 new small islands can create conditions that attract a greater number of spring shorebirds.
- To reduce disturbance to waterbirds inside *gei wai* #16/17 caused by vehicles using the Education Centre access track.
- To better understand wintering Anatidae use of *gei wai* #16/17 to inform future habitat management decisions.

## 1.3 Approach

1.3.1 The project involved three distinct work phases:

- *Phase I.* A 10-week period of earthmoving works using heavy machinery and trucks to carry out:
  - (1) Reprofiling work to lower the height of Island no.1 to be within 20cm of the operational waterline. The target height (<20cm) conforms to basic design principle **e)** (section 1.1.8) and is derived from previous island

enhancement work experience, which is shown to maintain a saturated mud surface.

- (2) Reshaping the perimeter margins on Island no. 1 according to design principle **b**).
  - (3) Creation of 3 smaller islands (design principle **c**)) in close proximity to Island no. 1.
  - (4) Removal of boundary vegetation/silt to reinstate former areas of the *gei wai* and increase the total area of open water available to waterbirds.
  - (5) Excavation of a 1m deep ditch along the northern boundary of the *gei wai* to limit vegetation re-encroachment.
  - (6) Creation of a 1m high earth embankment along the northern boundary of the *gei wai*.
  - (7) Grass planting along the earth embankment to create a soft screen and reduce disturbance from vehicles using the abutting access track.
- *Phase II*. Ornithological monitoring during spring migration period (to assess the efficacy of the earthmoving works) and winter period (to better understand Anatidae usage):
    - (1) Waterbird counts and area use observations inside *gei wai* #16/17 during spring 2006.
    - (2) Anatidae counts inside *gei wai* #16/17 during winter 2005/06.
  - *Phase III*. Production of project reports – Waterbird Report (Anon, 2006b) and Final Report.

1.3.2 *Phase I* work was carried out in late summer and autumn 2005 because MPNR is a sensitive wildlife area and subsequently all major work operations are restricted to particular seasons or months. Wintering Anatidae arrive in Hong Kong from late October and remain until early April the following year. This is immediately followed by the spring migration period, which normally finishes in early June. Therefore to minimise disturbance to migratory waterbirds, enhancement works proceeded between August and late October

## **2. METHODS**

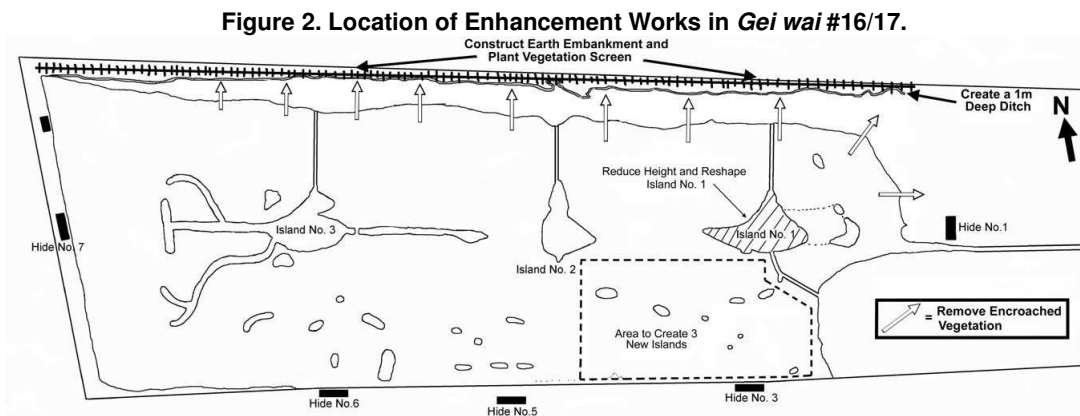
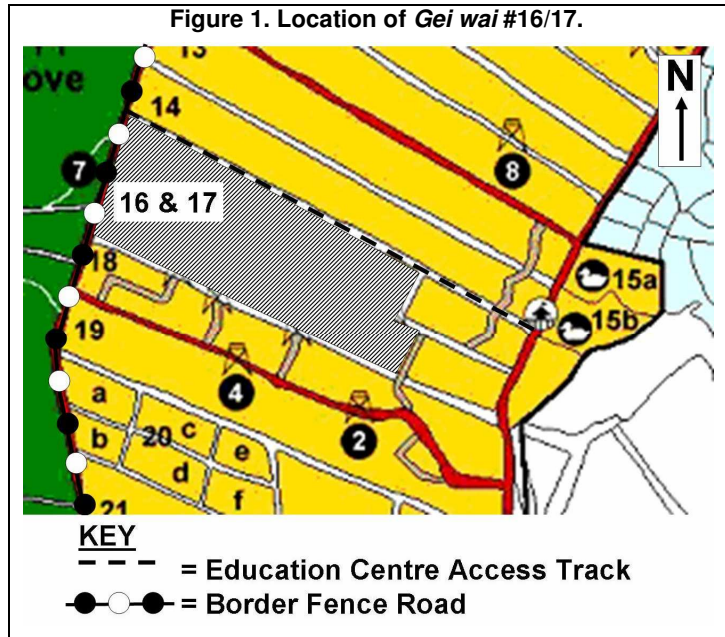
### **2.1 Study Area**

2.1.1 The project boundary encompasses the entire 18.22 ha high-tide roost at *gei wai* #16/17 (Figure 1) and includes all of the existing three large and twenty-five small islands (Figure 2). The western boundary abuts a single-lane tarmac road (occasionally used by Border Police, the Agriculture, Fisheries and Conservation Department and WWF Hong Kong vehicles) and the northern boundary runs parallel to a narrow stone-surfaced access track leading to the WWF Education Centre. Other boundaries join natural vegetation or *gei wai*.

### **2.2 Earthmoving Works**

2.2.1 Prior to the commencement of earthmoving works, both seaward end sluice gates were opened during a low tide and the *gei wai* partially drained. A 7-day period of drying followed, whereby any remaining water (collected in low-lying areas) evaporated and the exposed *gei wai* substrate of the work area hardened through sun and wind exposure.

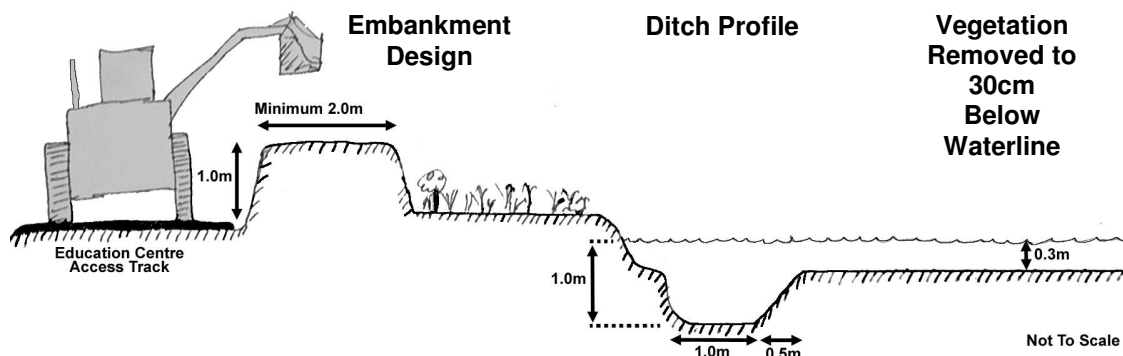
2.2.2 Three grade 1 workman and a contractor, operating 2 backhoe, 2 bulldozers and 2 tipper trucks, commenced a 10-week period of earthmoving work at the end of August 2005 (Appendix I). The locations of all work activities are shown in Figure 2.



- 2.2.3 To allow heavy machinery and vehicles safe access onto Island no. 1, the existing access bund had to be widened to 2m and strengthened by placing and compacting spoil from nearby locations.
- 2.2.4 The proposed new shape of Island no. 1 was marked out (Appendix II) and all earth outside the markers removed. Using an automatic level and staff, the island's surface height was lowered close to the operational waterline. The operational waterline refers to the 46.0cm mark on the former *gei wai* #16 sluice gate fixed gauge board (the '46.0cm' level does not relate to any other level outside the *gei wai* and therefore has no significance to Chart Datum).
- 2.2.5 Excess spoil from reprofiling work on Island no. 1 was reused to construct three small islands (Appendix II) in the enhancement zone (Figure 2) by tipping spoil at the selected location and landscaping with a small bulldozer. Use of an automatic level ensured accurate attainment of the desired heights above the operational waterline. The location of each island was chosen by identifying the most under-utilised areas within the zone as shown by the 2005 spring Waterbird Area Use data set (Anon, 2005b).
- 2.2.6 After heavy machinery had finished work upon the islands, the outermost edge of each island was reprofiled using handheld spades (Appendix I). This replaced the 'hard edge' (acute angle) left by the bulldozer with a gentler shallow margin more suitable for feeding shorebirds.

- 2.2.7 Tipper trucks transported all remaining spoil from the *gei wai* to the proposed embankment location. Two backhoes and a bulldozer used the spoil to construct a 1m high x 2m (minimum) wide embankment along the interface between the track and *gei wai* (design shown in Figure 3).

**Figure 3. Cross-section Sketch of the Embankment, Ditch and Vegetation Removal Works.**



- 2.2.8 To reinstate former areas of open water rank vegetation and silt had to be removed from the northern boundary of the *gei wai* (Figures 2 and 3). A combination of backhoe (using a gentle scraping action) and bulldozer moved the material to the outer edges of the *gei wai*. Cleared areas were set at 30cm below the operational waterline using an automatic level.
- 2.2.9 To prevent vegetation re-encroaching onto the cleared areas, a 1m deep ditch was excavated along the outer edge of the water body (Figures 2 and 3).
- 2.2.10 Upon completion of the earthmoving works in late October, all machinery and equipment withdrew from the work site. Then the *gei wai* reflooded and flushed over the following days as a precautionary measure to reduce any potential oxidation impact caused by sun-baking on the substrate.
- 2.2.11 In June 2006, two species of grass; *Panicum* spp. and *Pennisetum purpureum* (Napier Grass), were transplanted to the newly created embankment (Appendix I). Rows of grasses spaced approximately 30cm apart were planted to create a natural barrier and provide an additional food source for seed-eating birds.

## 2.3 Waterbird Monitoring

- 2.3.1 Two waterbird counts were undertaken to (1) assess the effectiveness of the works for spring waterbirds and (2) assess Anatidae usage of the *gei wai*. Reference to Anon 2006b should be made for a comprehensive account of the monitoring activities and presentation of full data sets.

### **Anatidae Count**

- 2.3.2 Between late October 2005 and late April 2006, fifteen bi-weekly Anatidae counts were completed on *gei wai* #16/17 (Table 1). Each one being undertaken during high tides (where possible) and within 1-2 days of the Hong Kong Bird Watching Society Monthly Ramsar Site Waterbird count to facilitate better data interpretation (as recommended in Anon, 2005d). During January and February, two extra counts were completed to coincide with the expected peak influx of Anatidae.

**Table 1. Winter Anatidae Count Dates, Times and Associated Tidal Conditions : Winter 2005/06.**

Date	Sunset <sup>1</sup> (Time)	Observation Period	Tide <sup>1</sup>		
			Preceding Condition	Height <sup>2</sup>	Condition <sup>3</sup>
31 October 2005	17:47	17:02 – 18:02	0.8m@15:57	1.3m	↑
14 November 2005 <sup>4</sup>	17:40	16:55 – 17:55	0.8m@15:32	1.7m	↑
30 November 2005	17:38	16:53 – 17:53	1.1m@15:26	1.8m	↑
19 December 2005 <sup>4</sup>	17:43	16:58 – 17:58	1.3m@17:24	1.7m	↑
29 December 2005	17:49	17:04 – 18:04	1.2m@14:34	1.8m	↑
09 January 2006	17:56	17:11 – 18:11	1.0m@11:51	2.1m	↑
15 January 2006	18:00	17:15 – 18:15	1.1m@16:03	1.2m	↑
23 January 2006 <sup>4</sup>	18:06	17:21 – 18:21	2.0m@16:14	1.8m	↓
07 February 2006	18:15	17:30 – 18:30	2.1m@17:10	2.0m	↓
20 February 2006 <sup>4</sup>	18:23	17:38 – 18:38	2.1m@14:05	1.4m	↓
27 February 2006	18:26	17:41 – 18:41	0.9m@16:21	1.5m	↑
09 March 2006	18:30	17:45 – 18:45	0.5m@01:56	2.1m	↔
22 March 2006 <sup>4</sup>	18:35	17:50 – 18:50	2.4m@13:57	1.4m	↓
18 April 2006 <sup>4</sup>	18:44	17:59 – 18:59	2.7m@12:07	0.8m	↓
25 April 2006	18:47	18:02 – 19:02	0.7m@15:18	1.4m	↑

1 – Data from the HK Observatory (tide data relates to Tsim Bei Tsui tidal station)

2 – At mid-point of observation period

3 – General tidal condition during observation period (↑ = Rising, ↓ = Falling, ↔ = coincides with max or min tide)

4 – Dates selected to be within 1-2 days of the HKBWS Monthly Ramsar Site Waterbird Count.

### Waterbird Count and Area Use Study

2.3.3 During April and May 2006, the location and number of all waterbirds (classification provided in Anon, 2006b) using *gei wai* #16/17 was recorded on 12 separate occasions (Table 2) and mapped using a grid system (Figure 4). Survey dates had to be selected to (1) coincide with the expected peak shorebird migration period in Hong Kong (April and May), (2) be conducted during high Deep Bay daytime tides (greater than or equal to 2.5m) because these are known to increase the number of waterbirds inside MPNR (Anon, 2002 & Anon, 2005d) and (3) mimic (where possible) the 2005 survey dates used for the baseline data set (Anon, 2005b).

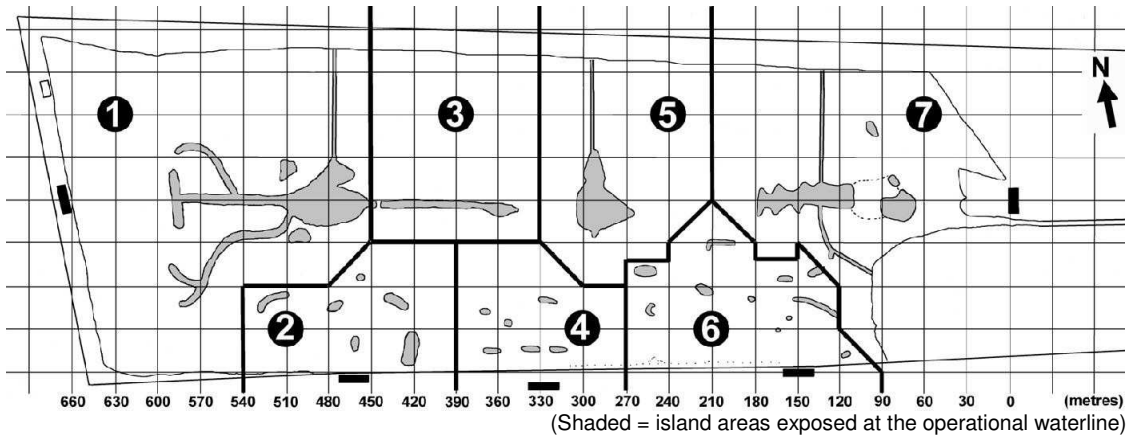
**Table 2. Survey Dates, Times and Associated Tidal and Waterlevel Conditions for the Waterbird Area Use Study.**

Date	Water depth <sup>1</sup> at start (cm)	Count 1 (Time)	High Tide <sup>2</sup>	Water depth <sup>1</sup> at start (cm)	Count 2 (Time)
01 April 2006	44.5	10:14 – 10:14	2.5m @ 11:44	46.0	12:14 – 13:14
15 April 2006	46.0	09:13 – 10:13	2.5m @ 10:47	46.5	11:17 – 12:17
16 April 2006	45.5	08:40 – 09:40	2.6m @ 11:10	47.0	11:40 – 12:40
17 April 2006	46.5	09:06 – 10:06	2.7m @ 11:36	47.5	12:06 – 13:06
02 May 2006	43.0	09:25 – 10:25	2.6m @ 11:55	41.0	12:25 – 13:25
13 May 2006	42.0	08:09 – 09:09	2.6m @ 09:39	44.0	10:09 – 11:09
14 May 2006	44.0	07:36 – 08:36	2.8m @ 10:06	45.0	10:36 – 11:36
16 May 2006	44.0	08:40 – 09:40	2.9m @ 11:10	46.0	11:40 – 12:40
17 May 2006	42.0	09:19 – 10:19	2.8m @ 11:49	44.5	12:19 – 13:19
19 May 2006	42.0	11:06 – 12:06	2.5m @ 13:36	43.5	14:06 – 15:06
26 May 2006	41.0	07:25 – 08:25	2.6m @ 08:55	41.5	09:25 – 10:25
27 May 2006	39.0	07:53 – 08:53	2.7m @ 09:23	43.5	09:53 – 10:53

<sup>1</sup> – Fixed gauge board located at the former *gei wai* #16 sluice gate. 46.0cm is regarded as the normal operational water line.

<sup>2</sup> – Data from HK Observatory (relates to Tsim Bei Tsui tidal station).

Figure 4. Zonation of Islands and Open Water Habitat in *Gei wai* #16/17.



## 2.4 Indicator of Success

2.4.1 Success will be assessed according to the following indicator – ‘A higher number of spring waterbirds utilising the newly reprofiled island, newly created smaller islands and reinstated area of open water, than compared with the number using the respective habitats before earthmoving works began’.

## 3. RESULTS

### 3.1 Earthmoving Works

3.1.1 Enhancement work on Island no. 1 successfully reprofiled the island (Figure 5 and Appendix II) in accordance with the original design specifications. The main outputs being:

- Crenulated edges with 7 ‘headlands’.
- Reduction in the mean height above the operational waterline from 45.3cm to 8.0cm (Table 3).
- Increased feeding edge (margin) by 19.7m (+12.7%).
- An increase in the feeding edge to surface area ratio by +35.0%.

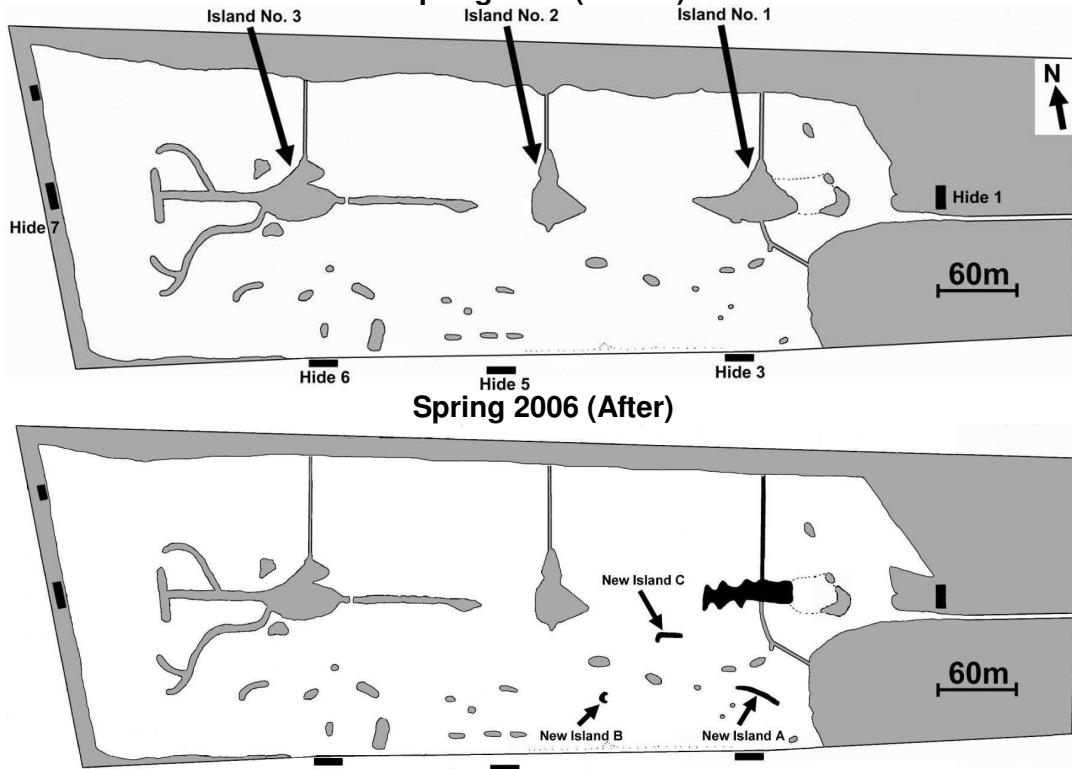
Table 3. Final Dimensions of the Reprofiled Island and New Islands.

	Island No.1		Island A	Island B	Island C
	Before	After			
Surface Area (m <sup>2</sup> )	480	401	80.0	12.6	36.6
Mean Height* (cm)	45.3	8.0	11.8	12.1	8.4
Maximum Length (m)	59.2	58.0	36.1	5.3	20.75
Maximum Width (m)	38.8	25.1	4.6	4.0	6.4
Margin Length (m)	154.6	174.3	72.8	18.4	42.7

\* - Above the operational waterline

3.1.2 Three new small islands were successfully created in the enhancement zone, each of differing size and shape (Appendix II). The largest, Island A, is a traditional elongated ‘bay’ design with a surface area of 80.0m<sup>2</sup> set at a mean height above the operational waterline of 11.8cm. It is purposely located in close proximity to Bird-watching Hide No. 3 and intended to include a leeward side for sheltered feeding/roosting. Island B, a conventional ‘kidney’ design of 12.6m<sup>2</sup> area is set at 12.1cm (mean height) above the operational waterline. Island C is a mixed ‘kidney’ and ‘bay’ design created at a mean height of 8.4cm and 36.6m<sup>2</sup> in area.

**Figure 5. Gei Wai #16/17 Before and After Earthmoving Works.**  
**Spring 2005 (Before)**



- 3.1.3 A 570m long by 1m high embankment was constructed along the intended alignment between the Education Centre access track and *gei wai*. Width varied between 2-5m, being widest in sections nearer to other earthmoving works, that generated larger volumes of spoil i.e. Island no. 1.
- 3.1.4 A 1.6ha area of former *gei wai* was reinstated along the northern boundary. Mean depth below the waterline was 28.3cm ranging between 22.8-37.3cm, being shallower in areas closest to the northern boundary.
- 3.1.5 A 570m long by 1m deep ditch was excavated along the outermost edge of the northern *gei wai* water boundary as per the original design specifications.
- 3.1.6 Grasses were successfully planted on top of the newly created embankment in rows of 3-6 individuals (Appendix I) dependant upon embankment width (section 3.1.3). Approximately 5% of the grasses died after transplanting and had to be replaced 4 weeks later.

### **3.2 Waterbird Monitoring**

#### **3.2.1 Winter Anatidae Count Data**

Over the winter period the highest peak monthly counts occurred in February (1,309) and December (1,005) (Table 4 & Figure 6). Peak monthly counts greater than 350 birds occurred in each of the 4 months between October and February. In the remaining months - March and April - peak counts were less than 50 individuals.

- 3.2.2 In total, 6 Anatidae species were recorded. However a single male Falcated Duck (recorded on 18th April 2006) is considered to be of 'uncertain origin' and therefore omitted from the data set (refer Anon, 2006b). Common Teal, with a mean count of

116.5 individuals and high count of 594 (29 December) and Northern Pintail (mean = 113.1, peak = 980 on 07 February) were the two most abundant species. Collectively these two species comprise 74.5% of the entire Anatidae winter data set. Of the remaining species, a count of 310 Garganey (31 October 2005) is among the highest in Hong Kong in recent years (refer Anon, 2006b).

Table 4. Winter Anatidae Count Summary : Winter 2005/06.

Species	Count Date														
	31-Oct-05	14-Nov-05	30-Nov-05	19-Dec-05	29-Dec-05	09-Jan-06	15-Jan-06	23-Jan-06	07-Feb-06	20-Feb-06	27-Feb-06	09-Mar-06	22-Mar-06	18-Apr-06	25-Apr-06
Common Teal	11	61	376	140	<b>594</b>	223	0	0	312	0	0	30	0	0	0
Eurasian Wigeon	42	69	<b>82</b>	55	21	62	8	0	8	3	0	7	4	0	0
Garganey	<b>310</b>	0	8	0	5	0	0	0	0	0	0	5	0	0	0
Northern Pintail	43	123	160	80	175	61	14	0	<b>980</b>	0	61	0	0	0	0
Northern Shoveler	0	149	51	30	<b>210</b>	5	8	0	9	0	28	3	0	1	0
<b>TOTAL</b>	<b>*406</b>	<b>402</b>	<b>*677</b>	<b>305</b>	<b>*1005</b>	<b>*351</b>	<b>30</b>	<b>0</b>	<b>*1309</b>	<b>3</b>	<b>89</b>	<b>*45</b>	<b>4</b>	<b>*1</b>	<b>0</b>

Numbers in **bold** = Highest species or total count in *gei wai* #16/17 during the winter period.

\* = Taken as the monthly peak count.

Figure 6. Peak Monthly Winter Anatidae Counts in *Gei wai* #16/17 : Winter 2005/06.

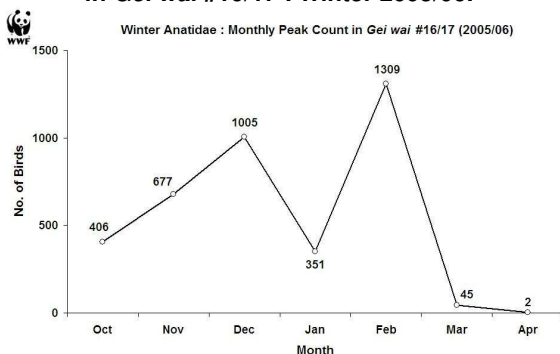
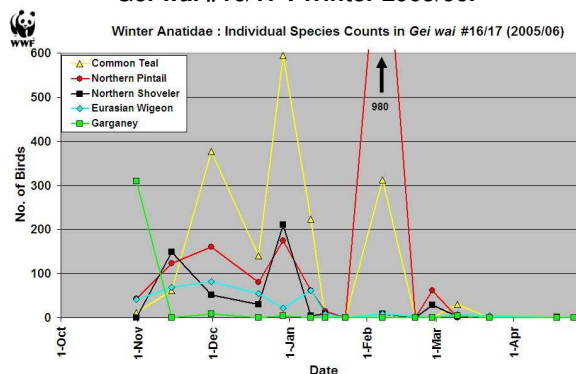


Figure 7. Individual Anatidae Species Trends in *Gei wai* #16/17 : Winter 2005/06.



3.2.3 Winter count trends (Figure 7) show that, with the exception of the 7<sup>th</sup> February 2006 count, Anatidae generally ceased using the *gei wai* for roosting after early January. Also, use of the *gei wai* by Garganey was almost entirely confined to October.

3.2.4 A comparison between the Ramsar Site Anatidae and *gei wai* #16/17 Anatidae count data sets (Table 5) shows that ~ 5% of the Ramsar birds utilised the *gei wai* for roosting in November and December 2005.

Table 5. Comparison of the Anatidae Count Data between *Gei wai* #16/17 and the Ramsar Site : Winter 2005/06.

<i>Gei wai</i> #16/17		Ramsar Site*		<i>Gei wai</i> #16/17 /Ramsar (%)
WWF-HK Count Date	Total no. of Anatidae	HKBWS Count Date	Total no. of Anatidae	
14-Nov-05	402	13-Nov-05	7355	5.5%
19-Dec-05	305	18-Dec-05	6150	5.0%
23-Jan-06	0	22-Jan-06	3241	0%
19-Feb-06	3	19-Feb-06	9571	<0.1%
22-Mar-06	4	19-Mar-06	2921	0.1%
18-Apr-06	1	16-Apr-06	113	<0.1%

\* - HKBWS data (Anon, 2006d).

### Waterbird Counts : Spring 2006

- 3.2.5 In 2006, the total number of waterbirds counted on *gei wai* #16/17 varied between 613 (27<sup>th</sup> May) and 5,971 (17<sup>th</sup> April) individuals (mean = 2,471.2). The total number of species recorded from all 12 counts was 56 (mean = 30.8) with a peak species count of 38 on 17<sup>th</sup> April.
- 3.2.6 The most abundant waterbird groups were 'Tringa' (mean = 1045.0) and 'Avocets and Stilts' (mean = 695.8) (Table 6) accounting for 70.4% of the entire spring data set. Pied Avocet (mean = 654.1), Common Redshank (mean = 318.5), Common Greenshank (mean = 316.7) and Marsh Sandpiper (Mean = 287.7) (Table 6) were the four most abundant species in 2006. Twenty-three species had mean counts >5.0 individuals. The counts of Nordmann's Greenshank (max count 5 – 19<sup>th</sup> May), Swinhoe's Egret (max count 1 – 4 dates in May) and Black-faced Spoonbill (max count 27 – 15<sup>th</sup> April) are of conservation interest (Birdlife International, 2000).

**Table 6. Abundance of Waterbird Groups and Species on *Gei wai* #16/17 during Spring 2006.**

2006			2006		
Mean Count		Waterbird Group	Mean Count		Species*
Range	Value		Range	Value	
>100	1045.0	9 (Tringa)	>250	654.1	Pied Avocet
	695.8	3 (Avocets & Stilts)		318.5	Common Redshank
	322.6	6 (Calidrids)		316.7	Common Greenshank
	106.2	10 (Scolopacidae other)		287.7	Marsh Sandpiper
50-100	90.1	7 (Godwits and Dowitchers)	100-250	237.7	Red-necked Stint
	88.5	11 (Plovers)		112.5	Spotted Redshank
25-50	49.0	8 (Curlews and Whimbrels)		100.8	Terek Sandpiper
	35.7	4 (Gulls & Terns)	50-100	86.3	Black-tailed Godwit
	26.2	1 (Ardeidae)		25-50	42.4
0-25	9.5	2 (Black-faced Spoonbill)	41.9		Black-winged Stilt
	1.9	12 (Waterbirds other)	41.8		Curlew Sandpiper
	0.8	5 (Anatidae)	40.3		Eurasian Curlew
			35.3		Grey Plover
5-25	0.8	5 (Anatidae)	32.3		Gull-billed Tern
			23.1		Great Knot
			10.6	Sharp-tailed Sandpiper	
			10.3	Great Egret	
			9.5	Black-faced Spoonbill	
			9.2	Grey Heron	
			8.7	Wood Sandpiper	
			8.3	Whimbrel	
			6.1	Pacific Golden Plover	
			5.3	Red Knot	

\*Species <5.0 mean count not shown.

### Waterbird Counts : Spring 2005 & 2006 Comparison

- 3.2.7 The mean waterbird count increased by +13.2% in 2006. Significant changes in the number of 'Avocets and Stilts' (+670.5%) are primarily responsible (refer to Appendix III for comparative data sets). 'Scolopacidae other' (+140.8%), 'Curlews and Whimbrels' (+71.3%) and 'Calidrids' (-47.6%) also show notable changes.
- 3.2.8 Mean species diversity decreased from 31.5 to 30.8, but the total number of species recorded increased by 1 between the spring periods. Species with mean counts greater than 5.0 individuals (refer to Appendix III for comparative data sets) increased by 27.8% in 2006.

### Shorebird Group Comparison Between *Gei wai* #16/17 and the Ramsar Site

- 3.2.9 Shorebird groups (i.e. waterbird groups 3 & 6-11 only) were more evenly represented on the *gei wai* after the 2006 earthmoving works (Table 7). Large increases are seen in 'Avocets and Stilts' (mainly Pied Avocet) and 'Scolopacidae other' (particularly Terek Sandpiper). 'Calidrids' were considerably less represented in 2006 (-50.4% decline).

**Table 7. Comparison of Shorebird Groups (Waterbird Groups 3 & 6-11 Only) on *Gei wai* #16/17 and the Ramsar Site at High Tide during Spring 2005 & Spring 2006.**

Waterbird Group	2005			2006		
	Mean Count			Mean Count		
	A - 16/17 <sup>1</sup>	B – Ramsar <sup>1</sup>	A:B	A - 16/17 <sup>1</sup>	B – Ramsar <sup>1</sup>	A:B
3 (Avocets and stilts)	90.3	968.2	9.3%	695.8	1501.9	46.3%
6 (Calidrids)	615.9	582.5	~100%	322.6	649.9	49.6%
7 (Godwits and dowitchers)	92.2	246.6	37.4%	90.1	236.8	38.0%
8 (Curlews and whimbrels)	28.6	24.8	~100%	49.0	60.3	81.3%
9 (Tringa)	1133.7	1966.9	57.6%	1045.0	2243.6	46.6%
10 (Scolopacidae other)	44.1	115.4	38.2%	106.2	150.8	70.4%
11 (Plovers)	102.3	121.1	84.5%	88.5	140.6	62.9%

<sup>1</sup> – Data from Anon 2006b

### **Waterbird Area Use Data**

3.2.10 The mean waterbird density (per hectare) inside *gei wai* #16/17 increased between years from 178.7 to 187.1 (+4.7%). Waterbird density increased in four zones (1, 5, 6 and 7) and declined in the other three zones between the two periods (refer to Appendix III for data tables). Zone 6 (+419.6%), Zone 1 (+101.8%), Zone 3 (-77.3%) and Zones 2 & 4 (both ~ -50%) witnessed significant changes.

3.2.11 Notable bird group results include:

- An increase in 'Avocets and Stilts' in all zones except Zone 3.
- 'Ardeids' increased considerably in Zones 3 and 6, but declined in Zones 2 and 1.
- 'Curlews and Whimbrels' showed a spatial redistribution between years and a strong preference for Zones 3, 4 and 7 in 2006.
- 'Tringa' showed a strong preference in 2006 for Zone 1, whilst Zones 2, 3 and 4 all declined significantly.
- 'Plovers' showed a clear preference for Zones 6 and 7 (containing the newly profiled island and 3 islands) in 2006 and moved away from their more generalised distribution in 2005 (Zones 2-5).
- The distribution of 'Gulls and Terns' remained unchanged between years with Zone 3 being preferred.
- The density of shorebirds (groups 3 & 6-11) increased by +499.4% in Zone 6 and +36.8% in Zone 7.

## **4. DISCUSSION**

### **4.1 Waterbird Monitoring Results**

#### **Anatidae**

4.1.1 Up to 5% of the known Ramsar Site wintering Anatidae utilised *gei wai* #16/17 with usage noticeably confined to the first half of winter (before mid January). Availability of suitable fodder may be responsible for the observed cessation of usage. For example observations noted Anatidae feeding upon internal grassy vegetation which had flourished whilst the *gei wai* was temporarily drained for earthmoving works (late August to late October). Once this vegetation disappeared from the *gei wai* (grazed or died back), Anatidae numbers declined, creating a distinctly biased negative skew favouring the pre-January period. This phenomenon is not witnessed in other ponds or *gei wai* inside MPNR which adhere to a classic bell-shaped data distribution between October to April (refer to Anon, 2006c). There were no habitat management operations undertaken at the *gei wai* during the study period (other than the routine water exchange undertaken for every *gei wai*) and no known disturbance events which could have influenced Anatidae behaviour in such a way as to explain their uncharacteristic low

usage (near absence) from January onwards. This suggests the availability of fodder may be the dominant factor influencing Anatidae usage. This 'unplanned', but potentially beneficial side effect of the earthmoving activities (i.e. not a direct consequence of the enhancement works) may have implications for future management.

### **Waterbirds**

- 4.1.2 Post enhancement works, the mean no. of waterbirds using *gei wai* #16/17 increased by +13.2% and the number of waterbird species with mean counts >5.0 increased by +27.8%. These findings suggest that in 2006, the *gei wai* attracted higher numbers of the more common waterbird species than in 2005 and may now be providing more universal/generic conditions for waterbirds.
- 4.1.3 The Waterbird Area Use study showed waterbirds to be more spatially widespread within the *gei wai* in 2006. In general, waterbirds reduced their dependency upon the centralised areas of the *gei wai*.

### **Shorebirds (waterbird groups 3 & 6-11)**

- 4.1.4 The mean number of shorebirds increased by +13.8% on *gei wai* #16/17 from 301.0 in spring 2005 to 342.5 in spring 2006. Data from Anon 2005a and Anon 2006a shows the mean number of shorebirds recorded from the Ramsar Site during the equivalent survey period (31<sup>st</sup> Mar – 25<sup>th</sup> May), increased from 4,949 to 5,375. This represents a +8.6% natural variation in shorebird numbers between years. Therefore, the increase on *gei wai* #16/17 being considerably greater than the natural variation, is of significance.
- 4.1.5 Shorebird densities in the enhancement zones are shown to increase after treatment. In Zone 6, containing the 3 new smaller islands, shorebird density increased by +499.4%. Attributing this solely to the new islands is problematic, but the enhancement works increased the total number of islands in this zone from 8 to 11, a measure which is known to attract greater numbers of birds (RSPB, 2002a). For each island, their locations were chosen based upon the 2005 data results which showed their footprint areas to be associated with very low shorebird densities. During the 2006 study the land surface areas of Islands B and C regularly attracted good numbers of shorebirds (Island A to a lesser extent). In Zone 7, containing the reprofiled Island no. 1, shorebird density increased by +36.8%. Similarly such a change is difficult to assign to the reprofiling works, but the new design adheres to the basic principles (Section 1.1.8) and a positive reaction is therefore a likely outcome. Interestingly, Island no. 3, which received major enhancement works in 2004, was far more attractive to shorebirds in the second spring period after completion (i.e. 18 months later).
- 4.1.6 The two-year data set (spring 2005 and spring 2006 combined) shows that 58.7% of shorebirds recorded from within the Ramsar Site, roost inside *gei wai* #16/17 during high tide. The importance of which is furthered by the fact that the *gei wai* occupies only 1.3% of the total Ramsar Site area.

## **4.2 Effectiveness of Enhancement Works**

- 4.2.1 All components of the island earthmoving works were successfully completed in accordance with the original project intentions and design. The main outputs being (1) a total addition of 153.6m feeding edge and (2) the creation of 530.2m<sup>2</sup> of island surface area within the desired height range, and (3) the creation of 3 small islands (each <100m<sup>2</sup>).
- 4.2.2 A 1.6ha area of open water inside *gei wai* #16/17 which had been lost to encroachment since 1987 was successfully reinstated at a mean depth of 28.3cm below the operational waterline, just above the intended depth of 30cm.

- 4.2.3 Both the embankment and ditch were constructed in accordance to the design specifications. The embankment width varied between 2-5m, creating a non-linear alignment (i.e. more natural) along the water interface, increasing the total length of feeding edge for waterbirds.
- 4.2.4 Planting works along the entire length of embankment created a suitable density of grasses to form a natural screen. The effectiveness of the screen will not be known until spring 2007 when the grasses are more mature and better established.
- 4.2.5 Unlike previous earthmoving work years since 1999, it was not necessary to fully drain the high-tide roost because the main work area, being located at the landward end of the *gei wai*, is more elevated. This provided waterbirds, particularly those breeding, with continued use of ~50% of the *gei wai* during the work period. It is noted that the predominant species breeding on *gei wai* #16/17 over the previous 3 summer seasons has been the Black-winged Stilt and the earthmoving works commenced at the end the breeding season for this species when all new birds had fledged.
- 4.2.6 The use of an automatic level and staff greatly improved the precision of setting heights for the embankment, new islands, reprofiled island and also correct depths for the ditch and *gei wai* substrate below the reinstated area.

### **4.3 Effectiveness of Waterbird Monitoring**

- 4.3.1 The twelve waterbird counts (and mapping work), produced a large and sufficient data set suitable for comparing waterbird usage of the enhanced areas and assessing the indicator of success (section 4.5.1). It proved necessary to change several of the count dates from those originally planned because of unusual tidal conditions in Deep Bay. Also several counts dates were rescheduled by a 1-2 day margin to take advantage of more suitable tide conditions.
- 4.3.2 The fifteen Anatidae counts provided extremely useful data upon bird usage of the *gei wai* in a season not normally associated with its primary function. The information now provides a baseline for future study and has identified a potential management prescription for further consideration.

### **4.4 Timetabling and Resources**

- 4.4.1 Phase I and Phase II were both completed on schedule. Phase III being completed several months after that stipulated in the agreed contract. The original project costing for all works proved accurate and all assigned resources consumed. Three additional man-days proved necessary to complete Phase III of the project.

### **4.5 Indicator of Success**

- 4.5.1 Results show that waterbird density in the area containing the newly reprofiled Island no. 1 (Zone 7), increased by +38.1% after enhancement works. Waterbird density also increased by +419.3% in the area containing the three new islands (Zone 6). As per the previous discussion in Section 4.1.5 these changes are likely to arise from the enhancement works and therefore the indicator is deemed to have been successfully achieved.

## **5. RECOMMENDATIONS**

### **5.1 Habitat Management**

- 5.1.1 The newly planted natural grass screen along the top of the embankment should be cut at least once a year to prevent growth of unwanted woody vegetation. A one-off cut in early June (only during Deep Bay low tides) is recommended to avoid disturbance to

waterbirds and ensure the grasses are able to produce seed in late summer. This management would promote the continuation of a grass dominated sward, ensure the barrier remains low enough to not create 'enclosed' conditions and provide food for seed-eating birds.

- 5.1.2 It is known that tall trees in close proximity to a high-tide roost can lead to a reduction in the number of shorebirds nearby because of a threat of ambush by birds of prey (Lawler, 1995). Therefore consideration should be given to maintaining trees (and other vegetation) to create a low profile landscape surrounding the *gei wai*. Guidance is provided by Lawler (1995) such that at a distance of 30m from the roost area, visual barriers (i.e. trees) should be no more than 2m in height.
- 5.1.3 The current *gei wai* #16/17 water level regime being operated during spring passage could, if fine-tuned, be more suitable for smaller Calidrid shorebirds, particularly *Calidris ruficollis* (Red-necked Stint). Peak passage for these birds extends from the end of March to the first week of May (Carey, *et al.* 2000) and water levels could be lowered by up to 5cm between these dates to attract greater numbers into the *gei wai*. However many of the island surfaces would subsequently dry out and become unfavourable for most shorebird species. To overcome this problem numerous shallow runnels (~10cm) could be dug across each of the affected islands to irrigate water into the centralised areas of each island.
- 5.1.4 Since becoming operational in the mid-1980s, the high-tide roost's constant demand for shallow water has negatively impacted upon those areas situated at the landward end of the *gei wai*. In particular Sub-pond #17b, now unrecognisable as a pond, is overgrown with terrestrial vegetation including climbers. It is recommended to sever hydrological links between *gei wai* #16/17 and Sub-pond #17b by blocking the two connecting channels at the northwest and southwest corners of Sub-pond #17b. This will help achieve the management intention for the sub-pond which is to 'adjust conditions in favour of creating an open freshwater roosting area...' (WWF-HK, 2006).
- 5.1.5 In recent years, *gei wai* #16/17 attracted breeding pairs of Black-winged Stilt (sixteen in 2006) and Greater-painted Snipe (two in 2005), both of which are of local conservation interest and therefore worthy of management attention. In particular grasses on many of the islands flourish during the summer season, reducing the availability of suitable breeding areas. In respect of the increasing number of birds nesting on the islands, a vegetation management regime should be considered to maintain a balance between the area of suitable island surface available, frequency and duration of human disturbance caused by each cutting operation and the retention of some cover to escape disturbance from predatory birds.

## 5.2 Monitoring

- 5.2.1 Should further Anatidae monitoring be required at MPNR, recommendations to improve the quality of data collection and interpretation include:
- Conduct counts at other ponds or *gei wai* to provide a more comprehensive understanding of wintering Anatidae within MPNR. In particular all freshwater ponds (#20a-f, #24a-g, #15a-b) and *gei wai* #8.
  - Continue to coincide one count per month with the HKBWS monthly Ramsar Site waterbird count to facilitate a better understanding of wintering Anatidae importance of MPNR in a Deep Bay context.
  - Continue to conduct counts at periods of high tide in Deep Bay (it is noted that very few tides over 1.8m coincide with evening count times during October, November or December).
  - Record all Spot-billed Duck sightings to taxa/race level to provide information for a currently under-researched area of ornithology in Hong Kong.

- 5.2.2 If resources are available, it is recommended to further study winter Anatidae usage of the *gei wai* to inform management decisions by (1) investigating if the observed early winter Anatidae use of *gei wai* #16/17 is related to the establishment of grassy vegetation in late summer whilst temporarily drained down and (2) varying water depth to determine an optimal winter regime.
- 5.2.3 Spring shorebird data relating to *gei wai* #16/17 should be extracted from the HKBWS Ramsar Site shorebird counts (under a service contract funded by AFCD) and analysed every five years to determine the percentage of shorebirds utilising the *gei wai*. Therefore it is not necessary to continue direct counting.
- 5.2.4 Further enhancement of the existing MPNR high-tide roosts or the construction of new high-tide roosts, such as the proposed conversion of *gei wai* #21 (WWF-HK, 2006), should consider the current level of provisions available to shorebirds and the demand for them. In particular, it is noted that despite the extensive earthmoving works between 1999 and 2005 several shorebird groups remain under-represented on *gei wai* #16/17. Plausible explanations are known for 'Godwits and Dowitchers' and 'Tringa' which are known to congregate at the *gei wai* #11 high-tide roost and similarly the absence of 'Avocets and Stilts' can probably be attributed to sizeable numbers of Pied Avocet remaining on the flooded inter-tidal mudflats at high tide. Conversely, 'Plovers' are under-represented and no other suitable high-tide roost is known inside or in close proximity to MPNR. The information needed to address this issue could be gleaned from the existing HKBWS spring shorebird monitoring programme if the current recording methodology is slightly revised.
- 5.2.5 Waterlevel readings should continue to be collected from *gei wai* #16/17 each spring. Levels can then be correlated with the HKBWS shorebird count data to provide more information for the calculation of an optimal water regime.

## 6. CONCLUSION

- 6.1 The 10-week period of enhancement works successfully reprofiled and created the high-tide roost features according to the original intentions of the project. Waterbird monitoring before and after treatment revealed a greater density of birds to be associated with the enhanced areas of the *gei wai*. Waterbird groups 'Ardeidae' (+300.0%), 'Avocets and Stilts' (>+4000%), 'Calidrids' (+444.4%), 'Godwits and Dowitchers' (+2500%), and 'Plovers' (+472.0%), benefited most in the zone which includes the 3 new small islands. 'Avocets and Stilts' (>+2000%), 'Calidrids' (-90.8%) and 'Plovers' (+191.2%) showed large changes in the zone which includes the reprofiled Island no. 1. Also new waterbirds belonging to the 'Curlews and Whimbrels' and 'Godwits and Dowitchers' groups were attracted to this zone (i.e. not previously recorded in 2005).
- 6.2 Usage of the *gei wai* by wintering Anatidae is now better understood and a baseline data set obtained for future reference. The preliminary findings, if verified through further monitoring, could have a valuable input into habitat management of the *gei wai* to improve its attractiveness to Anatidae.
- 6.3 A comparison between spring 2005 and spring 2006 waterbird data on *gei wai* #16/17 showed a total number increase of +13.2%. Also the number of species recorded with a mean count >5.0 increased by +27.8%. The number of spring shorebirds increased by +13.8%, which is significant because shorebird numbers on the Ramsar Site increased only by +8.6% during the same period. This suggests that collectively all of the enhancement works undertaken on the *gei wai*, not just island related works, had a beneficial effect upon waterbirds.
- 6.4 The continuous 6-year enhancement programme has undoubtedly improved the high-tide roost's key features for waterbirds and no additional major earthmoving works

inside the *gei wai* are considered necessary in the near future. Focus should now be upon fine-tuning the existing management operations such as waterlevel and vegetation control.

- 6.5 The various technical procedures employed, decisions made and study findings, serve to increase the overall management experience and knowledge of high-tide roosts. This expertise can now be applied to the proposed conversion of *gei wai* #21 into a high-tide roost in 2008 to ensure it's primary function and potential is fully maximised.

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## APPENDIX I – Project Photographs



**1. Work commencing on Island no. 1**

**2. New Island B**

**3. Bulldozer shaping Island A**

## APPENDIX I – Project Photographs

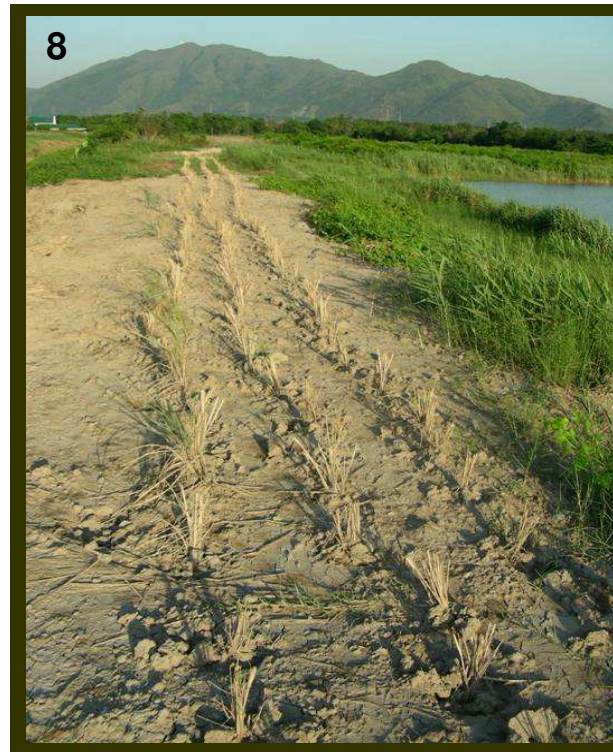


**4. Bulldozer removing silt to reinstate areas of open water**

**5. View of the 1m deep ditch, reinstated area and embankment (partial)**

**6. Completed embankment showing Ardeidae roosting**

## APPENDIX I – Project Photographs

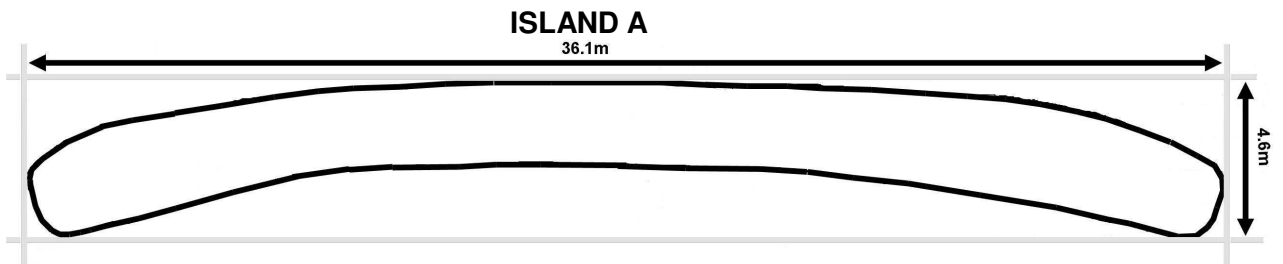
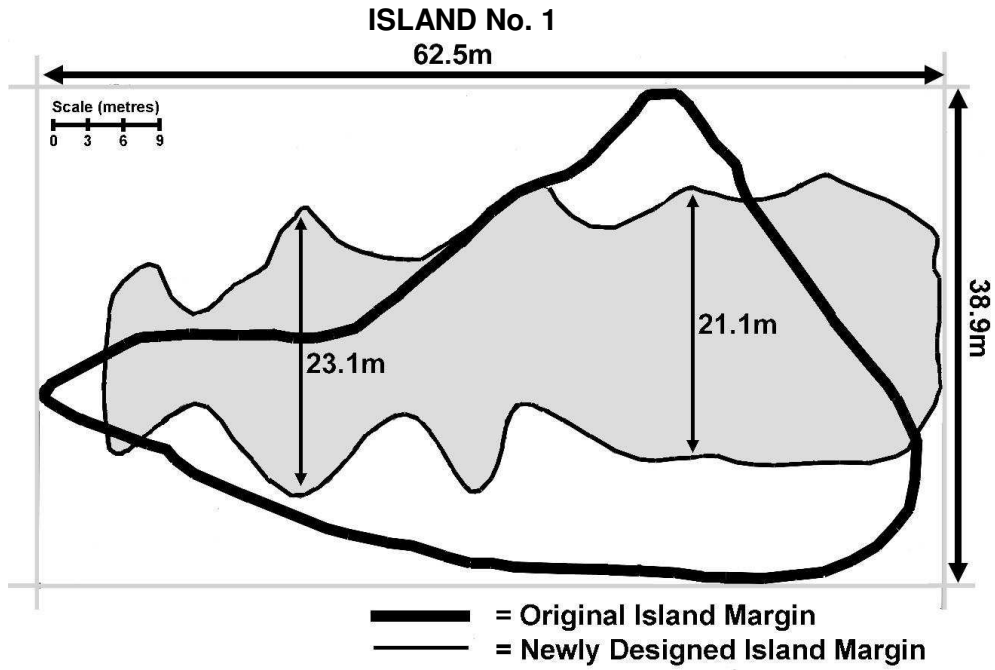


**7. Example of leveling (reinstated area works)**

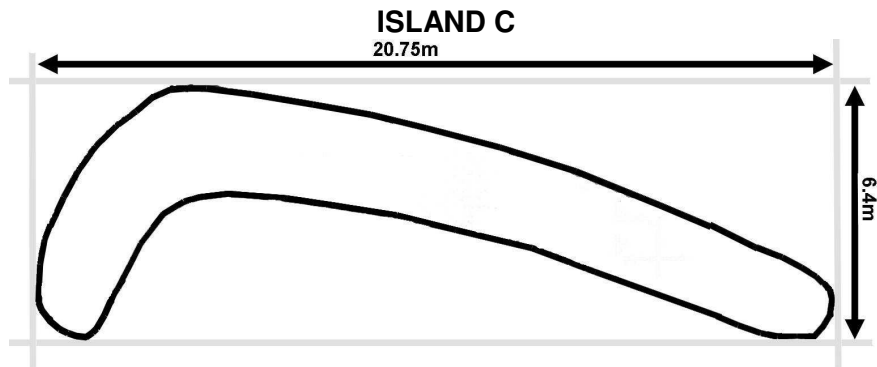
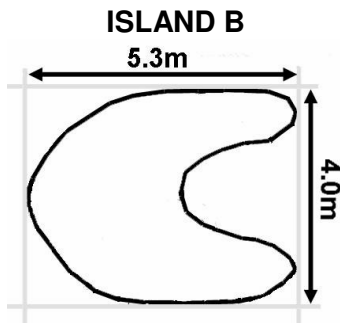
**8. Transplanted grasses along the embankment**

**9. Reducing the 'hard edge' on Island A**

### APPENDIX II. Design Sketches of the Reprofiled and Newly Created Islands



(NOT TO SCALE)



APPENDIX III. Data Tables

Table a. Abundance of Waterbird Groups and Species on *Gei wai* #16/17 during Spring 2005.

2005			2005		
Mean Count		Waterbird Group	Mean Count		Species*
Range	Value		Range	Value	
>100	1133.7	9 (Tringa)	>250	496.7	Marsh Sandpiper
	615.9	6 (Calidrids)		424.5	Red-necked Stint
	102.3	11 (Plovers)		323.8	Spotted Redshank
50-100	92.2	7 (Godwits and Dowitchers)	100-250	186.4	Common Greenshank
	90.3	3 (Avocets & Stilts)		164.8	Curlew Sandpiper
25-50	44.1	10 (Scolopacidae other)		122.6	Common Redshank
	31.2	4 (Gulls & Terns)	50-100	90.9	Greater Sand Plover
	28.6	8 (Curlews and Whimbrels)		89.5	Black-tailed Godwit
27.7	1 (Ardeidae)	68.2		Pied Avocet	
0-25	12.4	2 (Black-faced Spoonbill)	25-50	36.2	Terek Sandpiper
	5.1	5 (Anatidae)		27.5	Gull-billed Tern
	0.4	12 (Waterbirds other)	5-25	22.1	Black-winged Stilt
		19.4		Eurasian Curlew	
		17.5		Little Egret	
		16.1		Great Knot	
		12.4		Black-faced Spoonbill	
		8.2		Whimbrel	
			5.4	Great Egret	

\*Species <5.0 mean count not shown

Table b. Mean Waterbird Group Densities within each Zone in *Gei wai* #16/17 during Spring 2005.

Waterbird Group		Mean Waterbird Group Density (per hectare) : 2005						
		ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7
1	Ardeidae	2.4	5.1	1.0	4.5	2.4	0.3	1.7
2	Black-faced Spoonbill	0.0	0.0	0.2	7.7	2.2	1.3	0.1
3	Avocet & Stilts	1.9	1.8	18.8	4.0	27.9	3.2	2.8
4	Gulls & Terns	3.2	0.0	12.4	0.4	0.2	0.0	0.0
5	Anatidae	0.2	2.4	0.1	1.4	0.7	3.5	0.2
6	Calidrids	60.8	23.4	106.1	49.0	59.1	1.1	58.7
7	Godwits & Dowitchers	0.1	1.3	40.5	3.4	20.4	0.1	0.0
8	Curlews & Whimbrels	2.4	10.6	3.3	0.9	0.3	0.0	0.0
9	Tringa	41.3	122.8	262.6	319.8	61.2	24.9	13.1
10	Scolopacidae other	6.5	1.6	2.7	1.5	6.5	0.1	0.9
11	Plovers	13.7	3.8	6.2	1.7	18.4	1.6	2.2
12	Waterbirds other	0.0	0.0	0.1	0.0	0.1	0.1	0.1
<b>TOTAL</b>		<b>132.6</b>	<b>172.8</b>	<b>454.0</b>	<b>394.2</b>	<b>199.4</b>	<b>36.3</b>	<b>79.8</b>
<b>OVERALL RANK</b>		<b>5</b>	<b>4</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>7</b>	<b>6</b>

Table c. Mean Waterbird Group Densities within each Zone in *Gei wai* #16/17 during Spring 2006.

Waterbird Group		Mean Waterbird Group Density (per hectare) : 2006						
		Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
1	Ardeidae	1.1	1.2	3.6	1.8	3.4	1.3	2.3
2	Black-faced Spoonbill	0.4	1.1	0.4	0.1	0.9	1.4	1.2
3	Avocet & Stilts	3.5	8.6	6.4	95.1	143.1	140.7	61.0
4	Gulls & Terns	2.0	0.0	16.7	0.1	0.0	0.0	0.3
5	Anatidae	0.1	0.0	0.0	0.5	0.0	0.0	0.0
6	Calidrids	66.3	0.2	2.9	1.6	11.4	6.2	5.4
7	Godwits & Dowitchers	9.7	0.0	5.2	19.4	8.3	3.3	2.0
8	Curlews & Whimbrels	1.4	0.0	6.6	16.5	0.0	0.0	7.3
9	Tringa	145.7	72.7	58.0	67.4	65.1	26.7	23.6
10	Scolopacidae other	24.6	0.0	1.1	0.1	0.1	0.1	0.7
11	Plovers	12.3	0.3	1.9	0.4	3.6	9.0	6.5
12	Waterbirds other	0.4	0.0	0.1	0.0	0.0	0.0	0.0
<b>TOTAL</b>		<b>267.5</b>	<b>84.1</b>	<b>102.9</b>	<b>202.9</b>	<b>235.9</b>	<b>188.5</b>	<b>110.2</b>
<b>OVERALL RANK</b>		<b>1</b>	<b>7</b>	<b>6</b>	<b>3</b>	<b>2</b>	<b>4</b>	<b>5</b>